VFC Index - Watershed (Plan)

Program:	Watershed
IDEM Document Type:	Plan
Document Date:	9/20/2017
Security Group:	Public
Project Name:	Browns Wonder-Sugar Creek WMP
Plan Type:	Watershed Management Plan
HUC Code:	05120110 Sugar
Sponsor:	Clinton County SWCD
Contract #:	5-1
County:	Clinton
Cross Reference ID:	70406416; 80216637
Comments:	Boone, Hamilton

Additional WMP Information

Checklist:	2009 Checklist
Grant type:	205j
Fiscal Year:	2014
IDEM Approval Date:	9/20/2017
EPA Approval Date:	9/20/2017
Project Manager:	Chelsea Cottingham

A PROJECT OF THE CLINTON COUNTY SOIL & WATER CONSERVATION DISTRICT

Browns Wonder Creek – Sugar Creek Watershed Management Plan

Covering portions of Boone, Clinton, and Tipton Counties (HUC: 0512011001)

Trisha McClain – Clinton Co. SWCD

5/1/2017

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement A305-5-1 to the Indiana Department of Environmental Management. The contents of this document do not reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Acronym List

AIMS – Assessment Information Management System (IDEM)

BWSC – Browns Wonder Creek-Sugar Creek Watershed

cQHEI – Citizen's Qualitative Habitat Evaluation Index

IBI – Index of Biotic Integrity

IDEM – Indiana Department of Environmental Management

IDNR – Indiana Department of Natural Resources

ISDA – Indiana State Department of Agriculture

INSA – Indiana Smallmouth Alliance

LARE – Lake and River Enhancement Program

mIBI – Index of Biotic Integrity (based on macroinvertebrates)

MS4 – Municipal Separate Storm Sewer System

NASS – National Agricultural Statistics Service

NPS – Non-Point Source

NRCS – USDA Natural Resources Conservation Service

QHEI – Qualitative Habitat Evaluation Index

SWCD – Soil and Water Conservation District

USEPA – United States Environmental Protection Agency

USDA – United States Department of Agriculture

USGS – United States Geological Service

Section 1: Watershed Community Initiative

1.1 Community Efforts

A watershed refers to much more than just the water that flows through our local ditches, streams, creeks, and rivers. It also encompasses all of the land that drains water to these waterbodies (Indiana Department of Environmental Management). Watershed planning recognizes and evaluates the close relationship between downstream water quality and upstream land management. It is because of this connection, between land and water, that watershed planning has become the standard for developing long-term community goals and objectives for improving local water quality. It allows for environmental resources, such as soil and water to be managed effectively across sociopolitical divides. This watershed planning project evaluates these land-water relationships in the Browns Wonder Creek-Sugar Creek Watershed (BWSC); a headwater subwatershed of the Sugar Creek Watershed which drains into the Wabash River (Figure 1).

Interest in water resources has long been held by residents and stakeholder groups in the Sugar Creek Watershed. Recreationally, the occurrence of public lands such as Shades and Turkey Run State Parks has made Sugar Creek one of the most significant recreational rivers in the State of Indiana. Biologically, Sugar Creek supports reputable fisheries, evident by fishing regulations to preserve opportunities for trophy fish and successful service-based guide operations for fishing trips. However, despite these exceptional qualities, Sugar Creek has various water quality concerns that are prevalent across rural, agricultural watersheds in the Midwest. Concerns such as: sedimentation from erosion, excessive levels of nutrients, and bacteria are commonly cited by residents and stakeholders alike. Given the lack of sustained environmental baseline evaluations, the severity and occurrence of these resource concerns have been widely debated by various stakeholder groups. It is also important to note that, while downstream reaches of Sugar Creek have become widely used for recreation and environmental uses, the headwaters of Sugar Creek has not historically been associated with those types of public values. The Browns Wonder-Sugar Creek Watershed (BWSC) encompasses an agriculturally-dominated landscape without public land and recreational access (Figure 13 & 18). This dynamic creates a balancing act of varying water uses and values as well as linking public use downstream with upstream private land management and development. It is this dynamic that has been a significant driver for local groups to begin discussing watershed planning activities and priorities.

Figure 1. An Overview of Browns Wonder- Sugar Creek Watershed

Previous water quality monitoring has been completed as part of the Indiana Department of Environmental Management's (IDEM) statewide Integrated Water Monitoring and Assessment Program. These activities are completed by IDEM in an annual rotation across 9 major drainage basins, completing one basin per year, to fulfill federal requirements of the Clean Water Act. The primary purpose of this sampling effort is to identify which Indiana waters meet state and federal water quality standards. These designated requirements have been established to protect recreational, human health, and environmental benefits for the public. These benefits, or "designated uses", are referenced in Title 327, Article 2 of the Indiana Administrative Code. Based on the most current assessment, 17 stream segments equating to approximately 75 miles of waterways, in the BWSC watershed have been identified as not meeting one or more of these designated standards (Table 1). These results have generated interest, and concern, from stakeholder groups to complete a more detailed baseline to better understand these impairments and to develop community-led, non-regulatory solutions to address them.

Table 1. Listed Impaired Waterways in Browns Wonder- Sugar Creek Watershed (IDEM 303d 2014)

Name	AUID	Length (miles)	Impairment
Barnes Ditch	INB1015_T1006	3	Escherichia Coli (*E. coli*) Impaired Biotic Communities
Browns Wonder Creek /Hoskins Ditch	INB1014_03/ INB1014_T1003	8	Impaired Biotic Communities
Buntin Ditch	INB1016_T1008	5	Escherichia Coli (*E. coli*)
Davis Ditch	INB1015_T1005	3	Escherichia Coli (*E. coli*) Impaired Biotic Communities
Mallott Ditch	INB1011_05	2	Impaired Biotic Communities
Mud Creek	INB1013_T1004 INB1013_T1007	5	Impaired Biotic Communities
Padgett Ditch	INB1013_T1005	4	Impaired Biotic Communities
Scott Wincoup Ditch	INB1012_T1007	5	Impaired Biotic Communities
Spring Creek	INB1017_T1004	9	Escherichia Coli (*E. coli*)
Storms Ditch	INB1012_T1005	3	Escherichia Coli (*E. coli*)
Sugar Creek [Barnes Ditch Subwatershed]	INB1015_03	5	Escherichia Coli (*E. coli*) Impaired Biotic Communities
Sugar Creek [Mallott Ditch Subwatershed]	INB1011_02	6	Impaired Biotic Communities
Rose Ditch-Browns Wonder Creek/ Ross Ditch	INB1014_T1004	13	Impaired Biotic Communities
Stowers Ditch	INB1012_T1005	2	Impaired Biotic Communities

As early as 2009, local Soil & Water Conservation Districts (SWCD) and interested stakeholders such as the Friends of Sugar Creek and state conservation agencies began discussing opportunities to initiate watershed planning activities in the Sugar Creek Watershed. These discussions continued sporadically until late 2010, when the Boone and Clinton County SWCDs jointly applied for funding from the Lake and River Enhancement Program (LARE) of the Indiana Department of Natural Resources (IDNR) to complete a Watershed Diagnostic Study. The intent of this study was to establish a baseline assessment of local water quality conditions. This was done by compiling past data, collecting new water samples, and developing conservation priorities that would address water quality issues identified in the BWSC Watershed. In conjunction with these baseline efforts, the Boone and Clinton County SWCDs began public outreach efforts to promote watershed activities in the community and gather public input. The water quality sampling, and associated Watershed Diagnostic Study, was completed in 2012. This water sampling effort also happened to coincide with one of the most significant drought periods on record. This fact raised some concerns from local groups on how adequately the water quality conditions were characterized and was a factor in initiating a more comprehensive sampling effort represented by this Watershed Management Plan.

Since the completion of the 2012 Watershed Diagnostic Study for the BWSC Watershed, water quality improvement efforts have been completed through funding from the IDNR LARE program as well as the Clean Water Indiana Program from the Indiana State Department of Agriculture. These continued efforts have been focused on providing increased conservation technical assistance and financial cost-share to landowners in the BWSC Watershed, to begin implementation recommendations from the 2012 Watershed Diagnostic Study. These on-going implementation efforts have also provided further justification for the Boone and Clinton County SWCDs to complete a more comprehensive planning project. This watershed planning project will incorporate these continued implementation efforts while developing a more complete watershed plan to sustain future community-led, conservation programs.

1.2 Community Involvement and Stakeholder Concerns

Following the completion of the 2012 Watershed Diagnostic Study, a local steering committee compiled of community residents, local government officials and technical staff formed to provide coordinated oversight for watershed planning and implementation in the BWSC Watershed. Signed project partners and technical staff are listed within Table 2. Signed project partners are partners that have submitted signed Letters of Support. Essentially, signed project partners agreed to provide support throughout the entire watershed planning process. Residents of the community were invited to steering committee meetings, public meetings and stakeholder meetings to provide personal input. In addition, a community survey was distributed across the Browns Wonder- Sugar Creek Watershed to provoke community involvement and to develop a social baseline within the watershed. Please note, that watershed planning is an adaptive process and invitations are open-ended for involvement. The overall progress and success of planning efforts are dependent on engaged residents and landowners who provide insight on water quality concerns and/or objectives and strategies for addressing those concerns.

Table 2. Steering Committee Members and Project Partners

Technical Steering Committee	
Scheryl Vaughn	Boone County SWCD
Brian Daggy	Boone County SWCD
Leah Harden	Clinton County SWCD
David Beard	Clinton County SWCD Supervisor, Clinton Co. Stakeholder
Jerry Batts	Clinton County SWCD Supervisor, Clinton Co. Stakeholder
Dustin Johnson	Clinton County SWCD Supervisor, Clinton Co. Stakeholder
Matt Kelley	Clinton County SWCD Supervisor, Clinton Co. Stakeholder
Clint Orr	Clinton County SWCD Supervisor, Clinton Co. Stakeholder

Trevor Laureys	Indiana State Department of Agriculture
Ron Turco	Purdue University, Department of Agronomy
Megan Heller Haas	Purdue University, Department of Agronomy
Brandy Daggett	USDA Natural Resources Conservation Service
Angie Garrison	USDA Natural Resources Conservation Service
Jeff Woods	USGS Indiana Water Science Center
Signed Project Partners	
Allen Mohler	Boone County SWCD Supervisor, Boone Co. Stakeholder
Chris Branaman	Boone County SWCD Supervisor, Boone Co. Stakeholder
Danny Dunbar	Boone County SWCD Supervisor, Boone Co. Stakeholder
Ben Lawson	Boone County SWCD Supervisor, Boone Co. Stakeholder
Kathy Clawson	Boone County SWCD Supervisor
Ken Hedge	Boone County Surveyor
Josh Uitts	Clinton County Commissioners
Scott Shoemaker	Clinton County Commissioners
Steve Woods	Clinton County Commissioners
Dan Sheets	Clinton County Surveyor
Elizabeth Norris	Friends of Sugar Creek
Brenden Terrill	Indiana Smallmouth Alliance
Jordan Seger	Indiana State Department of Agriculture
Curt Emanuel	Purdue University Cooperative Extension Service, Clinton Co. Stakeholder
Britt Reese	Purdue University Cooperative Extension Service, Boone Co. Stakeholder
Robert Lawson	USDA Natural Resources Conservation Service
Stakeholders	
Ed Bowman	Clinton Co. Stakeholder
Harold Kinsler	Clinton Co. Stakeholder
Mike Caddell	Clinton Co. Stakeholder
David Rodgers	Boone Co. Stakeholder
Doug Mark	Boone Co. Stakeholder
Tom Dull	Boone Co. Stakeholder

Community outreach regarding watershed issues began during the 2012 Watershed Diagnostic Study and has continued during subsequent watershed planning and implementation projects. Three public meetings, one field day, and one workshop were originally held over the course of 2011-2014. These coordinated events, aimed to increase general awareness about various water quality and land use management concerns as well as identify local resource concerns. In addition to coordinating educational events, SWCD newsletters and direct mailings were distributed to local residents and agricultural producers to help provide further education and outreach.

Past public outreach efforts have been expanded upon in an effort to continue providing an open dialogue among steering committee members and watershed residents and landowners. Multiple forms of outreach and communication have been used to encourage public input on watershed concerns. These efforts have included press releases to local media, social media updates through Facebook, town hall meetings, workshops, field days, direct mailings, project brochures and social indicator surveys. The list of watershed concerns shown below has been, and will continue to be, an ongoing list of values, priorities and concerns that local residents and landowners have within the watershed (Table 3). The order shown below does not indicate any level of relative priority or significance. Discussions also focused on important values and priorities as well as positive land management activities occurring in the watershed. Results from these discussions have also been included.

Table 3. Stakeholder Values, Priorities, and Concerns

Watershed Values and Priorities
Keep resources (i.e. topsoil and nutrients) on the farm
Drainage
Focus on non-regulatory options for land management
Protecting scenic and environmental qualities of Sugar Creek
Positive Watershed Activities
Use of cover crops reduces nutrient and sediment loss, alleviates compaction, and increases organic matter
Installing tile drainage increase infiltration and decreases surface erosion
Group networking programs and roundtables allow for local evaluation of conservation practices
Promotion of controlled tile drainage practices (e.g. Drainage Water Management) reduces runoff volume
Watershed Concerns
Lack of buffer strips allows for nutrient and sediment loss
Lack of cover crops allows for nutrient and sediment loss
Occurrence of surface drains leads to sediment runoff
Logjams/Beaver dams increase streambank erosion and flooding
Lack of knowledge on environmental regulations
Lack of knowledge and awareness of natural resource problems
Installing tile drainage increases runoff volume and transports pollutants
Lack of conservation assistance
Loss of forested woodlots
Loss of farmland
Open dumping into streams
Stormwater runoff from streets, rooftops, and parking lots
Soil erosion from construction sites
Soil loss from agricultural fields
Streambank erosion
Decrease in soil organic matter and increased compaction
Excess nutrients and sediment in surface waters
Flooding in local towns & country roads
Improper management or lack of septic systems
Livestock have open access to waterways

A total of three public meetings were held from 2014-2016. These meetings strived for three things which would be as follows:

1. Maintain a communication link between watershed coordinators and local residents throughout the watershed planning process

2. Provide an opportunity for local concerns and priorities to be documented and included in the watershed plan
3. Build and strengthen community networks which will enable water quality goals and objectives to be met through the implementation of future conservation programs.

All public meetings were advertised and promoted through the local media, social media sites, SWCD newsletters, direct mailings, and public flyers in an effort to make sure watershed residents were aware of these opportunities. In addition, an ongoing list of interested residents was maintained throughout the planning process; resident's information was collected at prior events such as stakeholder meetings, public meetings, field days and workshops. Some residents were contacted directly through email, phone and face-to-face interaction at the office. The first public meeting was held on the evening of November 13th, 2014 at the Kirklin Community Center with 12 attendees representing local agricultural producers and conservation agencies. Attendees of this first meeting were provided a short description of the BWSC Watershed Planning Project and what type of environmental and social monitoring activities would be completed. The remainder of the evening was dedicated to open discussion of local water quality and land use concerns, which were subsequently documented on a flip-chart for the group. The second & third public meeting were integrated into our annual SWCD winter workshop & meeting on March 4th, 2015 (86 attendees) & March 1st, 2016 (57 attendees) at Arborwood in Frankfort, IN. Those who attended were local agricultural producers and conservation agencies. Attendees were presented with historical changes within agriculture in Clinton County as well as a comparative analysis of agriculture in the Netherlands vs. Indiana. In addition, attendees were exposed to the ongoing efforts conducted within the BWSC Watershed and the cost-share opportunities available to BWSC residents who are interested. Two workshops and two field days were also hosted as part of the BWSC Watershed Planning Project.

Workshops

Conservation Drainage Workshop*:* On June 30, 2015 the Clinton County SWCD, along with its partners hosted a Conservation Drainage Workshop. The main purpose of the workshop was to highlight and discuss a variety of conservation practices such as saturated buffers, controlled tile drainage, and blind inlets, that would help manage drainage. By showcasing effective management strategies, local agricultural producers could effectively address drainage issues that would improve soil health and water quality. The event was held at Dull's Tree Farm and had 41 attendees representing a diverse mixture of local agricultural producers, academics and conservation agencies. The workshop prompted producers to inquire about blind inlets. In fact, a local producer implemented 4 blind inlets outside the BWSC in fall of 2015 due to attending the workshop.

What's Happening in Modern Agriculture Workshop**:** On June 21, 2016, the Clinton County SWCD partnered with Boone County SWCD and Clinton County Purdue Extension to host a "What's Happening in Modern Agriculture Workshop," that gave local producers the opportunity to receive Private Applicator Recertification Program (PARP) credit. The main purpose of the workshop was to provide a general understanding of the economic shifts occurring in modern agriculture and how to implement cost-effective best management practices. It also showed the various benefits modern technology (i.e.

drone) can have on an operation. The overall goal of the workshop was to provide local agricultural producers the opportunity to improve efficiencies on their farm, especially during economic hardship. The event was held at Dull's Tree Farm and had 40 attendees representing local agricultural producers, academics and conservation agencies.

Field Days

2015 Clinton County Cover Crop Field Day & Tour (April 14th & 15th): The Clinton Co. SWCD led a cover crop tour across Clinton County to inform local producers about the benefits of cover crops and discuss cover crop management in local corn-soybean farm operations. Approximately 12 local producers attended the field day on April 14th and 13 local producers attended the event on April 15th. Attendees had the opportunity to see various cover crop species, ask questions, and network with other Clinton County producers to learn more about approaches, strategies, and cover crop species that are working locally. Local Clinton County SWCD and NRCS staff provided informal discussion about cover crop benefits, with examples from in-field soil cores and shallow digs.

2016 Clinton County Soil Pit Tour (March 31st): The Clinton Co. SWCD led a soil pit tour that informed local producers about the benefits of cover crops and discuss cover crop management in local corn-soybean farm operations. There were 17 local producers, landowners, technical staff and seed distributors that attended this event. There were two sites that were included within the tour which showcased a long-term cover crop producer and a beginner cover crop producer who incorporates manure into their operation. In addition to the tour, attendees were invited to participate in a panel discussion that was led by Dan Perkins which gave attendees an opportunity to learn about various farming techniques, ask questions, and network with local farmers. Clinton County SWCD and NRCS staff provided informal discussion about cover crop benefits, with examples from in-field soil cores and shallow digs.

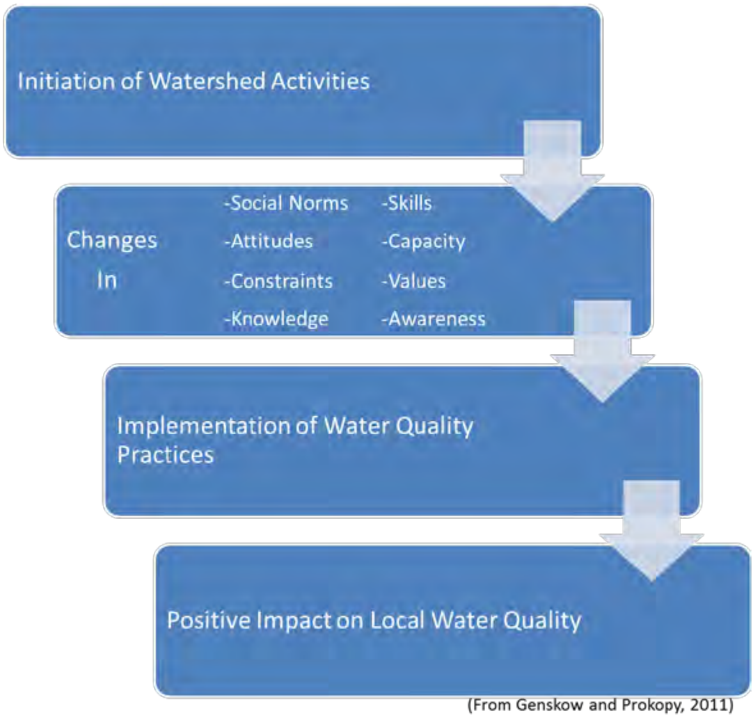

Figure 2. Concept Map of Social Indicator Use in Watershed Projects

1.3 Social Indicators

Historically, watershed planners have relied on environmental indicators (e.g. water monitoring data, land use metrics, etc.) to develop water quality goals and track the effectiveness of implementation strategies. However, many projects have struggled to show environmental change due to challenges such as landscape scale and time. In other words, how does one effectively measure impact across a watershed that has many different types of land use, under varying levels of management, across variable weather conditions? And when will such a change be observable? This is a very difficult question to answer and one that often requires time (i.e. decades) and extensive resources to adequately evaluate. More recent work has looked to evaluating the social component of land use decision, which adds an additional component that can help detect change and predict positive impacts on local water quality conditions (Figure 2).

Social indicators refer to metrics that evaluate capacity, skills, awareness, knowledge, values, beliefs, and behaviors of watershed stakeholders (Genskow and Prokopy, 2011). In turn, changes in these metrics will often lead to changes in land use decision making resulting in positive impacts on local water quality. Using survey methods from the Social Indicator Planning & Evaluation System (SIPES) for Nonpoint Source Management, information was collected from local residents and landowners to develop a social baseline in to order to obtain a better understanding about local attitudes, awareness, and behaviors relating to local water quality issues.

1.4 Social Indicator Survey

Annual surveys were developed, distributed and analyzed through the Social Indicators Data Management & Analysis (SIDMA) tool for the purpose of understanding local watershed residents. Surveys were sent to local stakeholders who attended each event held by SWCD including a small and large community survey, which identified local resource concerns. A baseline was developed in order to evaluate and monitor social trends. This was done by evaluating capacity, skills, awareness, knowledge values, beliefs and behaviors of local stakeholders.

In January 2012, a small community survey (n=15 total respondents: 25% return rate) was distributed across the watershed to determine which, resource concerns stakeholders were most concerned about (Table 4). By identifying key communal resource concerns achievable goals and objectives can be formulated which will help guide future conservation efforts.

Table 4. Community views in 2012 about resource concerns in Browns Wonder- Sugar Creek Watershed

Resource Concerns **Stakeholders were asked on a scale of 1 (Not Serious) to 4 (Extremely serious) how concerned they were about particular resources.*	**Percentage**
Urban trees and forested woodlots (loss of)	**53%**
Loss of farmland	**53%**
Soil erosion from streambanks	**47%**
Soil erosion from construction sites	40%
Open dumping into streams	40%
Stormwater runoff from rooftops and parking lots	38%
Stormwater runoff from streets and highways	38%
Natural area, open (green) space, & historic site loss	33%
Invasive non-native (exotic) plants & animals	33%
Rural field erosion (soil loss)	27%

Top 3 Resource Concerns

In 2015, a small community survey and in 2016 a large community survey (n=23 total respondents: 15% return rate) was distributed across the watershed to determine which resource concerns were most prevalent among stakeholders. Stakeholders were asked how concerned they were about particular resources within their community. The biggest concern among stakeholders was streambank erosion and channelization (stream modification). The remaining top concerns were littering in waterways, surface water run-off from impervious pavement and field erosion from cropland (Table 5). By identifying key communal resource concerns, achievable goals and objectives were formulated which will help guide future conservation efforts.

Table 5. Resources concerns identified by local stakeholders in 2016 large community view survey

Resource Concerns **Stakeholders were asked on a scale of 1 (Not Serious) to 4 (Extremely serious) how concerned they were about particular resources.*	**Percentage**
Stream modification /channelization	**24%**
Soil erosion from streambanks	**23%**
Open dumping into streams	**18%**
Stormwater runoff from impervious pavement	14%
Rural field erosion (soil loss)	13%
Crop production (irrigation)	5%
Manure from farm animals	4%
Removal of riparian vegetation	4%

Top 3 Resource Concerns

Section 2: Description of Browns Wonder-Sugar Creek Watershed

2.1 Geologic History of the Browns Wonder Creek – Sugar Creek Watershed

The BWSC Watershed lies on a bedrock plateau just off the Cincinnati Arch, which was a significant bedrock formation stretching from southeast Indiana towards the northwest (Figure 3). Prior to glaciation, these bedrock surfaces were subject to continuous erosion processes which created lower lying bedrock valleys, including the noted Teays River Valley. This valley represents an ancient flow path that is followed loosely today by portions of the Wabash River (Indiana Geological Survey, 2011). The bedrock surfaces within the BWSC watershed consist primarily of limestone, black shale, and siltstone spanning in age from roughly 400 to 300 million years old.

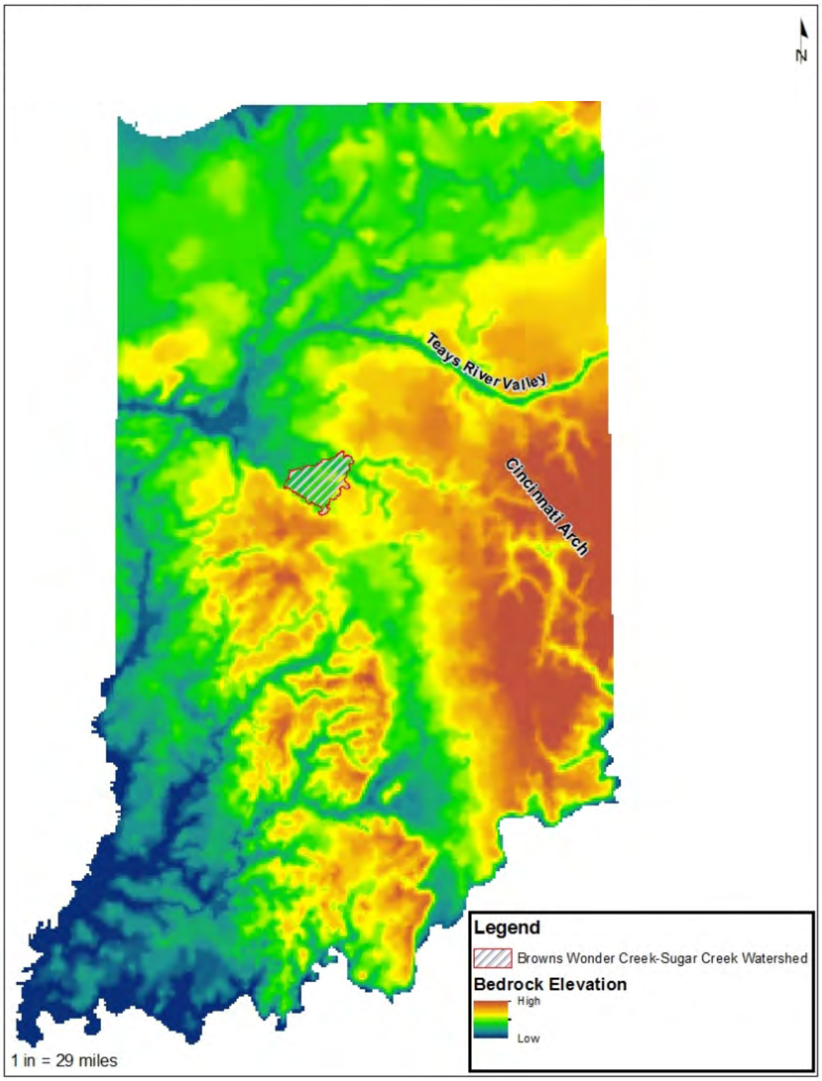

Figure 3. Bedrock Elevations of Indiana and the Browns Wonder Creek-Sugar Creek Watershed (Indiana Geological Survey, 2011)

With the onset of the Ice Age roughly 2 million years ago, periods of glacial advance and retreat further carved out the Indiana landscape and deposited eroded materials in over top of the bedrock. The most noted of these glacial periods was known as the Wisconsin-age and occurred roughly 50,000 years ago stretching east-west across the northern two-thirds of the state. This is the period which deposited much of the material that characterizes central and northern Indiana today. The BWSC Watershed is covered to a large extent by glacial till, an unsorted mixture of sediments and rock, with lower portions of the watershed consisting of alluvium and outwash deposits (i.e. sorted sands and gravels) suggesting a glacial meltwater path following what is now Sugar Creek (Figure 4). It is this glacial meltwater, flowing down towards the present day Wabash River, that likely cut down to the bedrock resulting in the picturesque cliffs and bluffs found in Shades and Turkey Run State Park, south and west of Crawfordsville, Indiana.

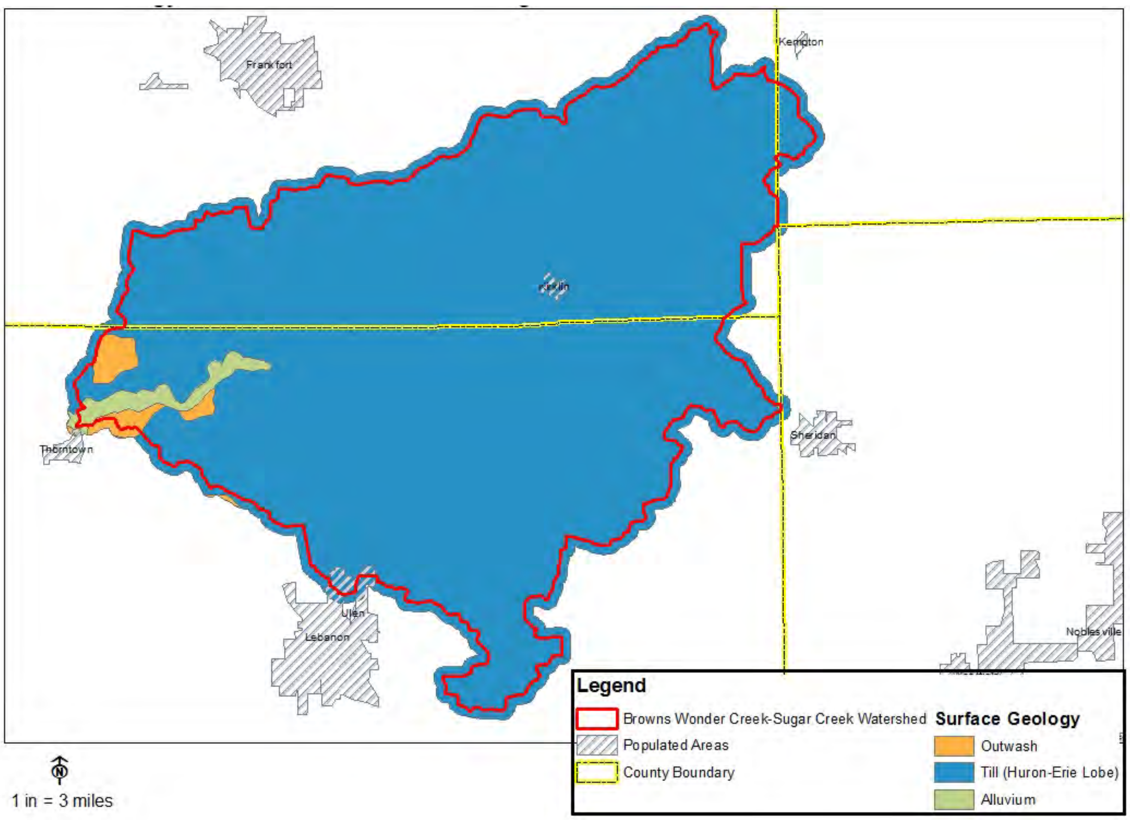

Figure 4. Surface Geology of the Browns Wonder Creek-Sugar Creek Watershed (Indiana Geological Survey, 2011)

The glacial till found within the BWSC Watershed is part of the Tipton Till Plain resulting from the Huron-Erie Lobe of the Wisconsin Glaciation stretching from northern Ohio southwest across Indiana. This layer of till varies, on average, from roughly 250 to 400 feet thick. Underlying aquifers are scattered throughout the glacial deposits in buried sand and gravel seams. The most hydrologically productive of these unconsolidated aquifers corresponds to a “U” shaped band stretching across a lower lying bedrock valley (Figure 5). This aquifer can be up to 225 feet thick and has the potential to yield up to 1,500 gallons per minute (Frankenberger, 2000). Other groundwater sources can be found within broken bands of sand and gravel as well as fractures within the underlying bedrock, but generally these areas have a lower yield potential. Groundwater supplies the public water supply for the Town of Kirklin and Lebanon Utility Service with wells established in sand and gravel aquifers. Currently Cool Lake Golf Course, located on the Browns Wonder Creek, is the only significant groundwater user for irrigation purposes. This facility has both a groundwater well and surface intake on Cool Lake.

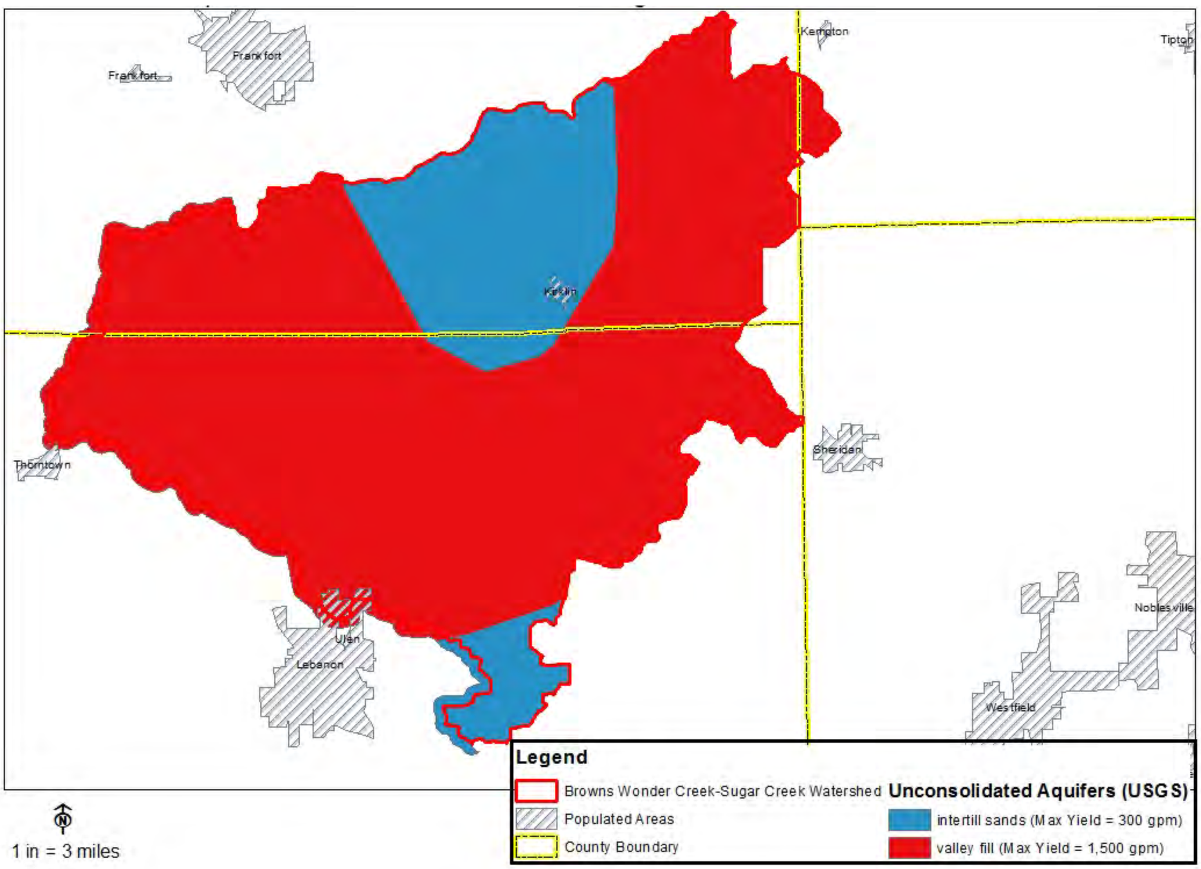

Figure 5. Unconsolidated Aquifers of the Browns Wonder Creek-Sugar Creek Watershed (Indiana Geological Survey, 2011)

2.2 Topography of the Browns Wonder Creek – Sugar Creek Watershed

Current day topography of the BWSC Watershed generally slopes from an east to west direction, draining towards the Town of Thorntown. The highest portion of the watershed occurs along the southeastern border of the drainage area which is part of a broad plateau that stretches diagonally across Boone County (Figure 6). Overall, the landscape is gently sloping with an average slope being just over 1%. More aggressively sloped lands are located along primary drainage areas including Mud Creek, Browns Wonder Creek, Spring Creek, and along the main stem of Sugar Creek.

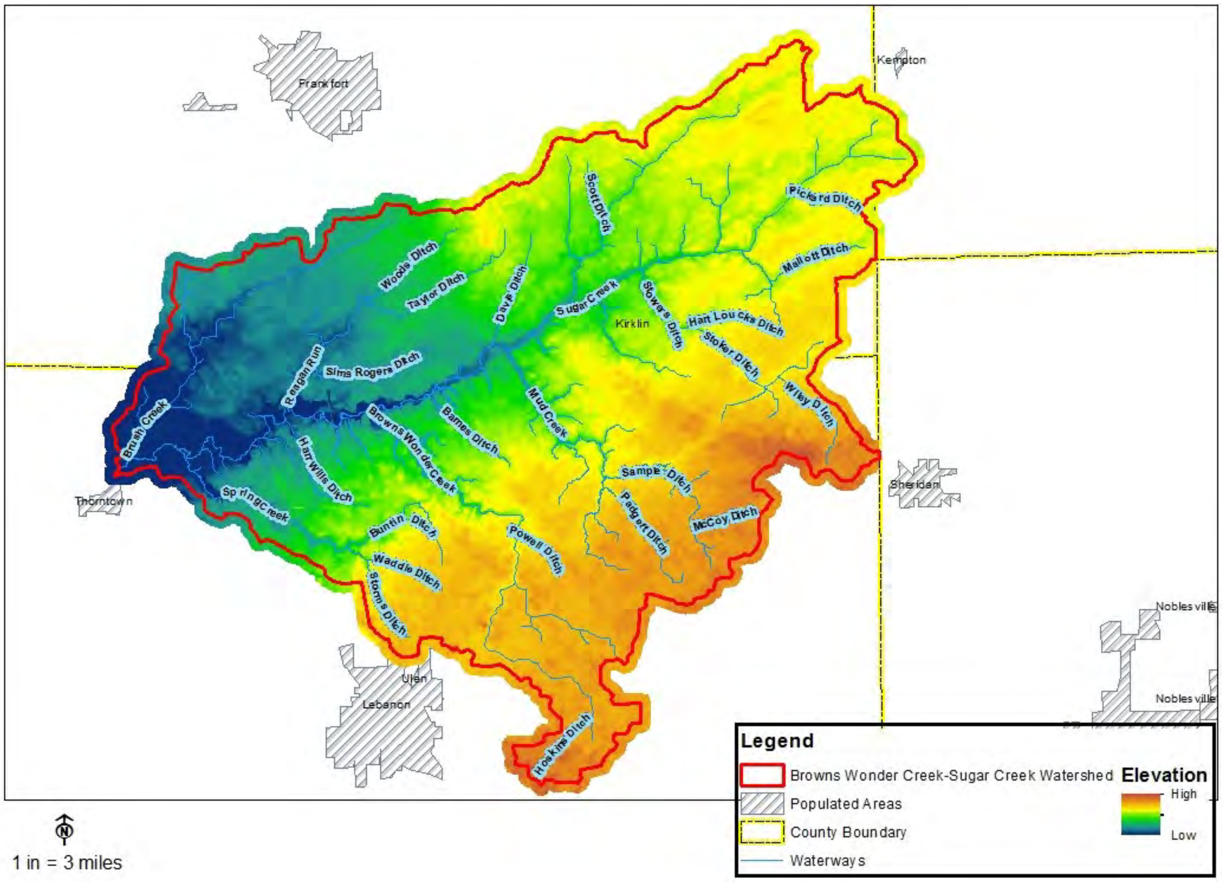

Figure 6. Topography of the Browns Wonder Creek-Sugar Creek Watershed (Indiana Geological Survey, 2011)

2.3 Hydrologic Conditions in the Browns Wonder Creek – Sugar Creek Watershed

The post-glacial period (since about 15,000 years ago) in the BWSC Watershed was very much defined by water and erosion. In an 1886 report by Maurice Thompson, the state geologist, early conditions of Frankfort were described as containing stretches of prairie in the southern region. These prairies were formed on old glacial lake beds that gradually filled from erosional processes during the glacial retreat. In addition to prairies, Thompson documented wetland habitat. These wetland habitats formed from "frequent depressed areas of considerable extent" across the broad plateau through Boone County (Thompson, 1886). At the time of this report, Thompson described extensive drainage operations occurring in the area through the installation of surface ditches and underground tiles. By 1884 there was an estimated 1,622 miles of tile and 13 miles of surface ditches constructed in Boone County. These activities, still today, remain a priority of landowners in the watershed to protect and enhance the agricultural productivity of the region. However, more recently, these activities have also raised some concern in regards to excessive drainage and loss of wetlands resulting in flooding issues, streambank erosion, and loss of valuable topsoil and nutrients from the agricultural fields they are meant to enhance. New approaches to managing tile drainage, such as drainage water management which relies on a water level structure at the outlet of a tile to control when and how much water is released to receiving streams, have been documented as an interest among landowners in the watershed as a way to mitigate some of the negative impacts of these widespread drainage practices.

While it's difficult to assess the overall extent of underground tiles and surface drains in the BWSC watershed because many are privately owned and not formally documented. Many counties in Indiana have established a public network of tiles and drains maintained by the County Surveyor. Current estimates of this infrastructure are shown in Table 6 and Figure 8, data was extracted from 2014 GIS data provided by Boone & Clinton County Surveyors. The total county regulated drainage area in the BWSC watershed is approximately 79% of the total watershed area indicating a relatively large amount of hydrological modification of natural drainage patterns.

Table 6. County Regulated Drainage Infrastructure of the BWSC (County Surveyor's Office, 2014)

Watershed Totals	
Subsurface Tile	154 miles
Open Ditch	78 miles
Legal Drains	95,259 acres (79%)

Due to the abundance of manmade drainage existing in the watershed, a limited number of wetland areas still exist in the BWSC Watershed (Figure 7). According to the National Wetland Inventory (2014) of the U.S. Fish and Wildlife Service (USFWS), total wetland acreage is only 2% of the total watershed drainage area (186 square miles). Average size of these wetlands varies by type and use. Wetland types such as "riverine" (those directly within and tied to the waterway itself) and "freshwater forested/shrub wetland" (those dominated by woody vegetation and commonly located in close proximity to waterways) have considerably larger average sizes than "freshwater emergent wetlands" (those dominated by annual and perennial non-woody vegetation and commonly occur across the landscape). This is likely related, at least to some extent, to the ease of clearing and draining as well as spatial location on the landscape (e.g. risk of flooding). The variation across wetland type is also echoed by examining the percent of each wetland type that is currently being cultivated per the 2014 USGS National Land Cover Database (Table 7). There has been some concerned voiced from landowners regarding the loss of forested woodlots, a portion of which likely include freshwater forested/shrub wetlands.

Freshwater ponds and lakes are very different wetland types, existing across the landscape due to both natural and manmade causes and for a variety of land uses. For example, a number of mapped freshwater ponds are borrow pits from road and rail construction projects as well as sand or gravel sources used during early periods of development in Boone and Clinton Counties. Others have been built near residential areas for recreational or aesthetic reasons. Approximately 41% of mapped freshwater ponds are defined as being excavated and 12% diked or impounded. All three lakes mapped here are manmade, excavations occurring in what is likely an old channel path of Sugar Creek and is used more or less for recreational purposes.

Figure 7. Wetlands of the Browns Wonder Creek-Sugar Creek Watershed (National Wetland Inventory & USGS National Land Cover Database, 2014)

Table 7. Percentage of Wetlands in the Browns Wonder Creek-Sugar Creek Watershed (National Wetland Inventory & USGS National Land Cover Database, 2014)

	% Mapped as Cultivated Cropland
Freshwater Emergent Wetland	21
Freshwater Forested/Shrub Wetland	13
Riverine	1

Based on the 2008 National Hydrography Dataset published by the USGS, there is an estimated 214 miles of flowing surface waters in the BWSC Watershed (Figure 8). As noted above, many of these miles, especially in what are classified as Canal/Ditch or Stream/River (Intermittent), are managed primarily for a drainage purpose even though most would be considered naturally occurring first and second-order headwater streams. The relative frequency of smaller, primarily intermittent (i.e. seasonal), waterways throughout the watershed shows a significant and critical component of protecting water quality in Sugar Creek. Intermittent streams can be easily overlooked by landowners who may manage these critical hydrologic connections as gullies by filling in the area with material and debris. Open dumping into waterways was another concern listed by watershed landowners. These areas, and the non-cultivated lands adjacent to them, do offer opportunities for recreation, primarily hunting, as well as scenic qualities. Recreation on the water is more focused on the main stem of the Sugar Creek, and most notably, downstream of Mechanicsburg (Figure 17). However, while scenic and environmental qualities were noted as valuable characteristics of the BWSC by landowners, recreation is largely limited by public access which is more common downstream of Thorntown.

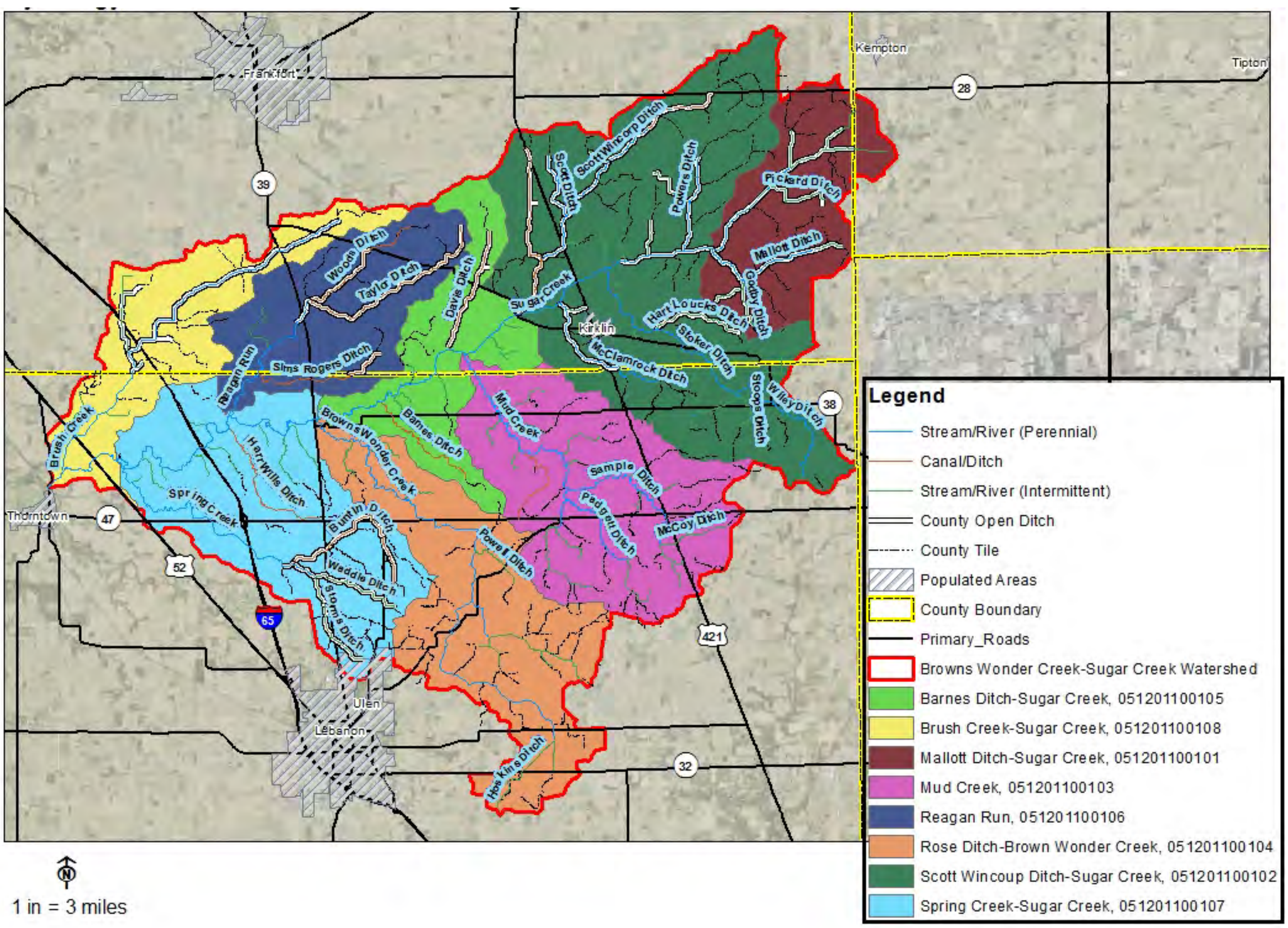

Figure 8. Hydrology of the Browns Wonder Creek-Sugar Creek Watershed (USGS National Hydrography Dataset, 2008)

2.4 Soil Characteristics of the Browns Wonder Creek – Sugar Creek Watershed

Similar to hydrology, today's soil characteristics in the BWSC watershed are, to an extent, an echo of the glaciers' role in shaping the landscape. The general soils associations, or series, can be described, to a large extent, as a function of their geologic landscape position (Figure 9). Soil association data was derived from the State Soil Geographic (STATSGO) Database (1994), which is a digital general soil association map developed by the National Cooperative Soil Survey, U.S. Department of Agriculture. The broad ridge across Boone County consists primarily of Celina soils, a moderately well drained series of soils which are associated with glacial till plains and moraine deposits. As the glaciers receded back north and the landscape began to "defrost", meltwater cut a channel along what is now Sugar Creek and deposited a wealth of eroded materials, or alluvium, which helped form the deep, well drained soils of the Genesee series and the more clay-dominated and poorly drained Ambraw series. Moving away from the meltwater channel onto the geologic floodplains and terraces we see the Algiers series, a somewhat poorly drained group of soils which are characterized by eroded materials and floodwater deposits overlying a darker, more organic-rich soil which was likely indicative of historical glacial wetlands or swamps. Finally moving to the Drummer series soils found along the northern boundary of the BWSC watershed. These poorly drained soils formed on very flat or depressional glacial outwash and till plains.

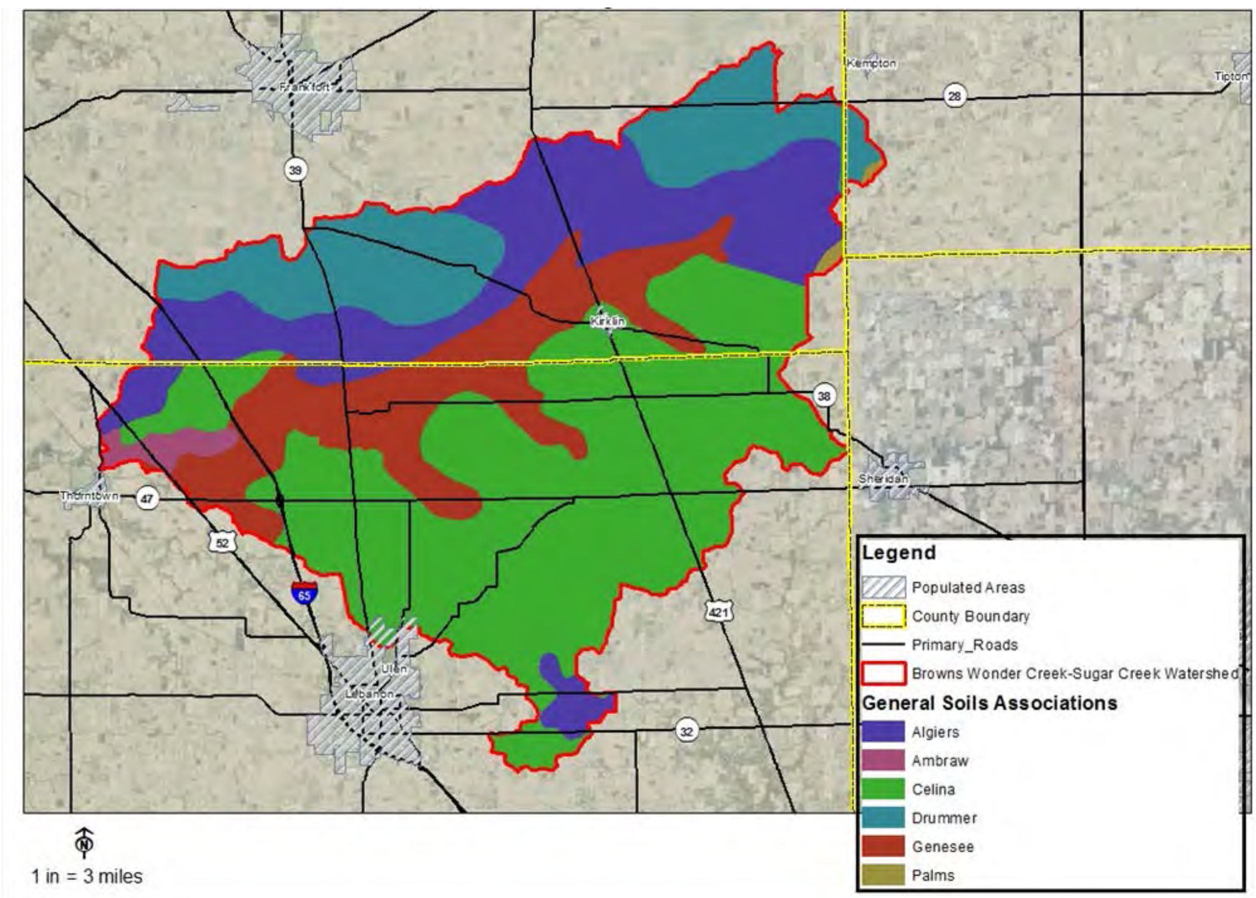

Figure 9. Soils Associations of the Browns Wonder Creek-Sugar Creek Watershed (National Cooperative Soil Survey, 2014)

Soils continued to develop following the glaciers. Through processes such as erosion, deposition, leaching, flooding, and the onset of land management by humans. Due to these processes it led to the development of complex soil mosaic that are seen today. Among its unique soil characteristics, there is no karst prevalent in the BWSC Watershed. However, one common thread through the BWSC watershed is that we live in an agriculturally productive landscape (Table 8). The classifications were designated in the 2015 SSURGO Database which were identified by Indiana Geological Survey (IGS) and the National Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA) personnel.

Table 8. Farmland Classification of Soils in the Browns Wonder Creek-Sugar Creek Watershed (SSURGO Database, 2015)

Farmland Classification	% of Watershed Soils
Prime Farmland	11%
Prime Farmland if Drained	86%
Prime Farmland if Drained and Protected from Flooding	<1%
Prime Farmland if Protected from Flooding	1%
Not Prime Farmland	2%

While roughly 77% of the watershed is classified as a hydric soil (Figure 10) (Soil Survey Geographic (SSURGO) Database, 2015), with the installation of artificial drainage, much of this can be managed as prime agricultural land. This realization is also held strongly by many landowners throughout the watershed, with a high value placed on drainage and farmland preservation.

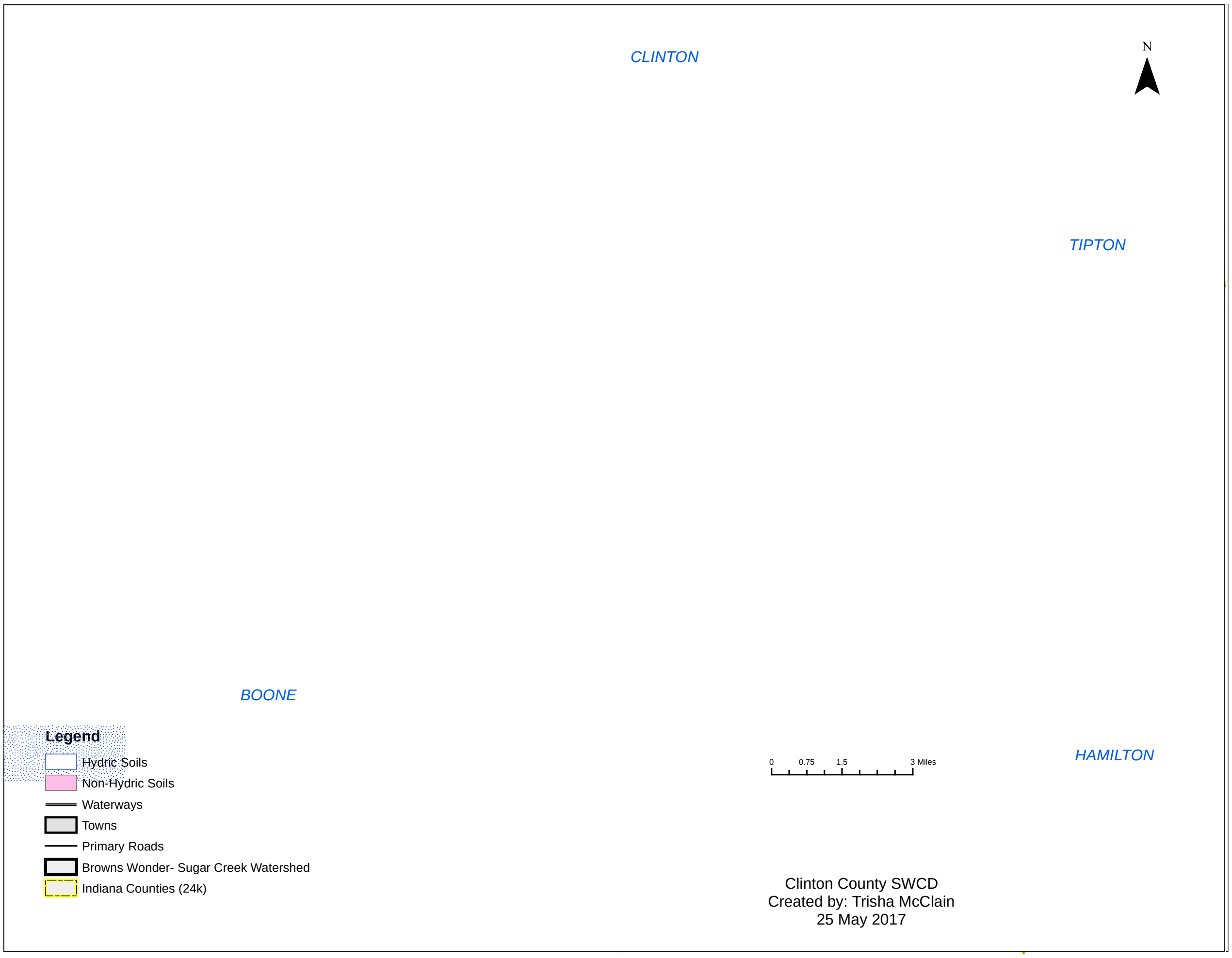

Figure 10. Hydric Soils of the Browns Wonder Creek-Sugar Creek Watershed (SSURGO Database, 2015)

But not all land within the BWSC Watershed is best suited for growing crops. This is another concept held by watershed landowners, who noted concerns regarding sediment and nutrient runoff from agricultural lands; impacts to soil quality and health; runoff and water management issues; and loss of wooded areas. Using the Land Capability Classification System that was pioneered by the Soil Conservation Service, a standard system used by the USDA-NRCS, we can get a sense of the risk involved with agricultural cultivation. The method was one of the first efforts to guide conservation and land use planning by grouping soils according to their relative productivity and risk or impact from limiting factors such as erosion. The goal of this system was to achieve sustainable agricultural production across the country by focusing on row crops by identifying the most productive acres while encouraging alternative land uses such as timber production, pasture and hayland, and wildlife habitat on marginal acres where soil quality would decrease over time under a tillage-dominated management. Land classes and subclasses are shown in Table 9. The classes, as described by USDA-NRCS, indicate the most intensive tillage that could be used while permanently maintaining the soils. Farmers could cultivate Class I without special practices, while Class II could be used with simple practices. Class III required complex or intensive practices, and Class IV was not recommended for continuous cultivation. Class V, because of topography, stoniness, erosion, poor drainage, or some other feature could not be used for even occasional cultivation. Classes VI through IX were reserved for grazing regions. The first three of these classes, VI through VIII, applied to grazing land that should be managed with an increasing degree of care; while Class IX was land unsuited to grazing.

While it's important to understand that this classification system was not explicitly developed to identify highly erodible soils, as this is more a function of current factors such as climate, soil physical characteristics, and topography. Cross-referencing the list of classified highly erodible soils from Boone and Clinton Counties' Soil Survey, shows that it does have a high degree of concurrence in the BWSC Watershed with the added benefit of identifying soils that have historically had significant erosion. Based on the Land Capability Classification System, an estimated 1% to 5% of soils within the BWSC Watershed have severe agricultural limitations (Class 3 or higher) related to erosion and water management, respectively (Figure 11). Most of these soils lie alongside Sugar Creek and its major tributaries.

Table 9. Land Capability Classification Designations (USDA-NRCS)

Land Capability Class	
Class 1	Soils have slight limitations that restrict their use
Class 2	Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices, or both
Class 3	Soils have severe limitations that reduce the choice of plants or require special conservation practices, or both
Class 4	Soils have very severe limitations that restrict the choice of plants or require very careful management, or both
Class 5	Soils have little or no hazard of erosion both have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover
Class 6	Soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover
Class 7	Soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife
Class 8	Soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for esthetic purpose
Subclass	
e	is made up of soils for which the susceptibility to erosion, or history of past erosion, is the dominant problem or hazard affecting their use
w	is made up of soils for which excess water is the dominant hazard or limitation affecting their use (e.g. poor drainage, wetness, high water table, overflow)
s	is made up of soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture-holding capacity, low fertility that is difficult to correct, and salinity or sodium content
c	is made up of soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use

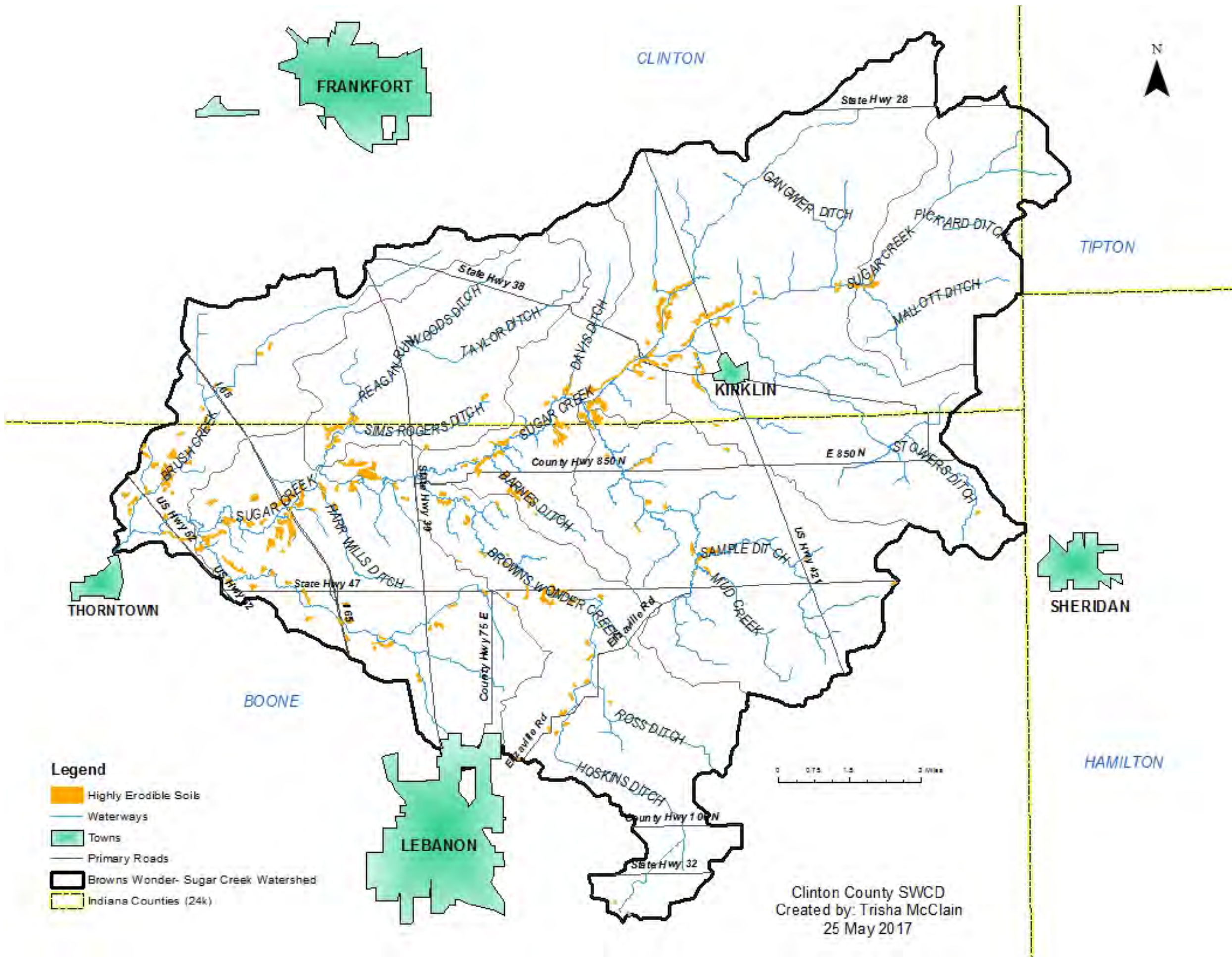

Figure 11. Highly erodible soils (HEL) within Browns Wonder-Sugar Creek Watershed (SSURGO Database, 2015)

Another noteworthy soils evaluation is that of the Nitrate Leaching Index developed by the USDA Natural Resources Conservation Service (Field Office Technical Guide (FOTG)). This index combines measures of precipitation and soil infiltration capabilities that determine the extent water is able to soak below the crop rooting zone. When this occurs, dissolved nitrogen travels with water and is incapable of being taken up by the crop and thus is more vulnerable to entering groundwater and nearby waterbodies. This can be significant when these soils have subsurface drainage tile installed; as this increases hydrologic connectivity to nearby waterbodies and expedites the export of dissolved nutrients. Within the BWSC Watershed over half, 54%, of the soils have a Nitrate Leaching Index Rating of High (Figure 12). Of these, over 90% are also classified as hydric soils and likely have some subsurface tile installed, if they are being cropped.

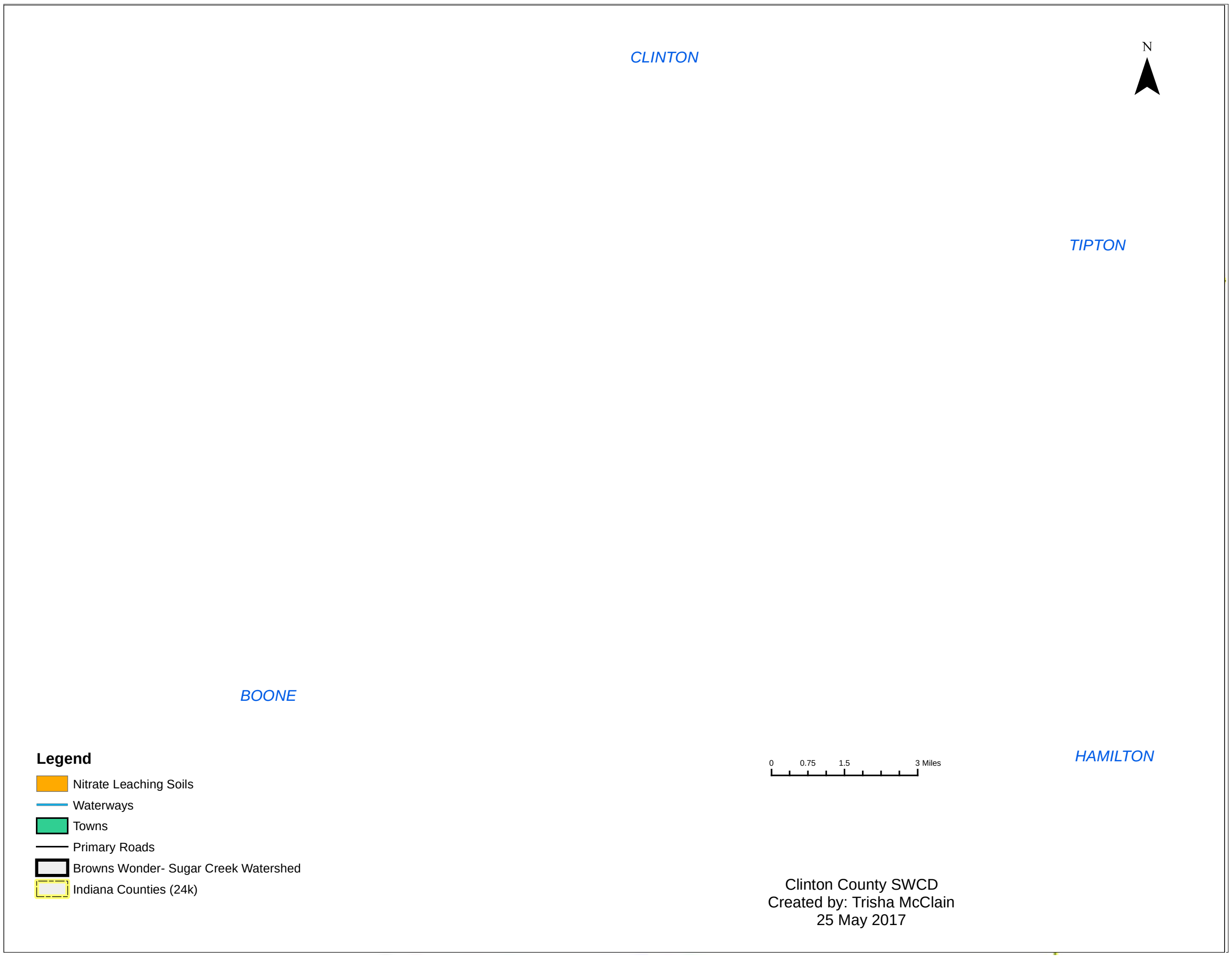

Figure 12. Nitrate Leaching Index of the Browns Wonder Creek-Sugar Creek Watershed (USDA-NRCS FOTG)

While certain components of the soil and landscape characteristics influence erodibility or potential for leaching are inherent (e.g. soil texture, site topography, etc.), management of those soils can often mitigate their risk. The concept of managing agricultural soils based on ecological and biological principles have received renewed focus from a variety of local, state, and federal conservation agencies.

The Conservation Cropping System Initiative (CCSI), integrating a system of practices that work in tandem to effectively address nonpoint source pollution, focuses on improving overall soil health and function in the field instead of trying to filter out or capture already mobile environmental pollutants at the edge of the field. This method of conservation is being promoted heavily in Indiana and other Corn Belt states among local, state, and federal conservation agencies. For example, No-till, or the planting of crops without the occurrence of tillage, has long been promoted as a way to improve certain aspects of soil quality while also reducing erosion. When combined with complimentary practices, such as cover crops (unharvested crops between cash crops), active nutrient and pest management, and the advent of modern precision farming technologies; a conservation cropping system is born. Together these practices can achieve a much larger impact than when implemented individually. Lengthened periods of vegetative cover protects the soil from erosion and increases the uptake of any excess fertilizer, preventing nutrient loss from the field. Also, the lack of soil disturbance and prevalence of plant roots throughout the year stimulate biological processes in the soil. These biological processes have positive impacts on soil nutrient cycling, organic matter development, and improvements in soil structure. Technological advancements in equipment, in conjunction with site-specific fertilizer and pest control programs, allow for more precision and efficiency in applying fertilizers and chemicals which minimizes losses to the environment. However, adoption of this farming approach has been fairly localized and yet to become standard operating procedure in the Midwest. Making changes in land management is a complex decision, impacted by a variety of factors such as societal and family values, available resources, and site conditions among others. Regarding the adoption of no-till practices, it's a story of two crops (Figure 13) (Tillage Transect Data- Indiana State Department of Agriculture (ISDA), 2013).

No-till management when growing soybeans has consistently been the norm in both Boone and Clinton counties over the past 10 years, while adoption for corn has yet to exceed 20%. Some reasons for adoption that have been noted by agricultural producers in the watershed have been related to more efficient use of labor and equipment and protection of soil quality. Whereas, some reasons for not adopting have been centered on yield impacts and difficulty in managing the cool, wet spring field conditions. Anecdotally, the adoption of cover crops continue to grow in both counties, in some part fueled by governmental financial assistance programs, as well as the adoption of precision farm technologies which can often be financially justified by reducing overall fertilizer and chemical costs across the farm.

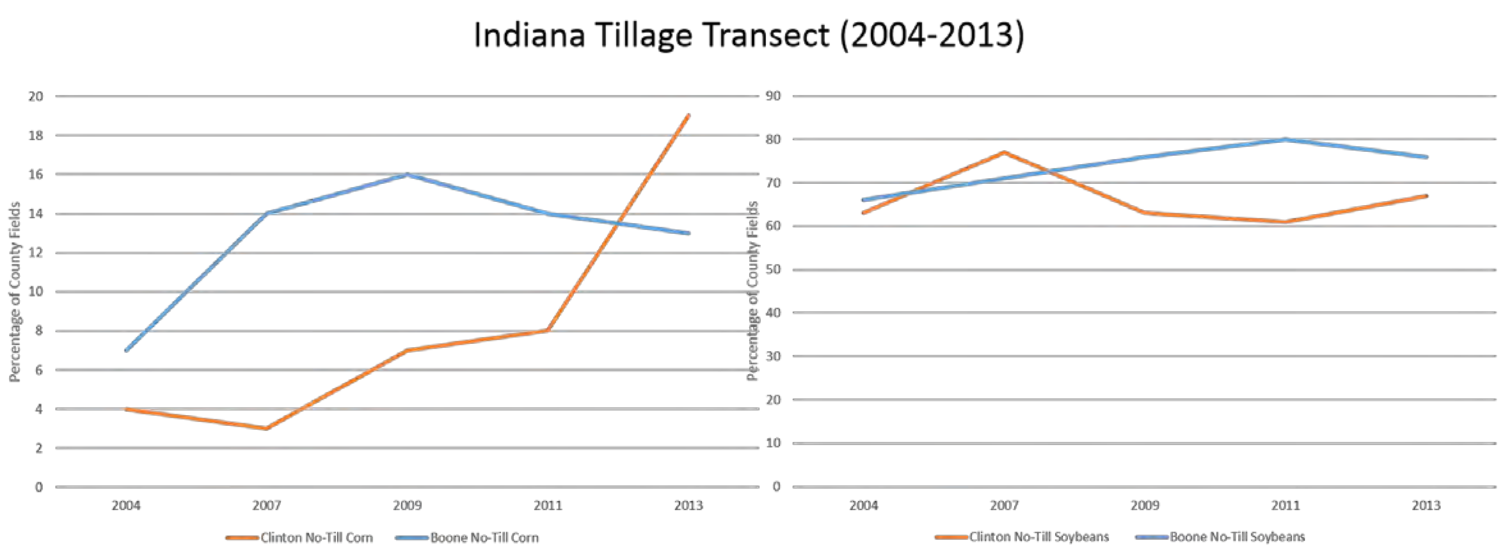

Figure 13. No-Till Adoption in the Browns Wonder Creek-Sugar Creek Watershed (ISDA, 2013)

While agriculture dominates the landscape, and discussion of soils, in the BWSC watershed, more domestic issues such as the prevalence and impact residential septic systems and sewage disposal deserves some mention. Over 99% of the soils in the BWSC watershed have a rating of "Very Limited" for use in septic tank absorption fields (Figure 14) (SSURGO Database, 2015). Often site limitations for septic tank absorption fields would indicate: seasonal soil saturation, ponding or flooding, and slow infiltration rates. Negative impacts that result from these site limitations would be poor absorption rates and lateral seepage from sloping soils. Poor septic ratings indicate that often special design or installation procedures are required (e.g. perimeter drains) along with poor expected long-term performance requiring more frequent maintenance.

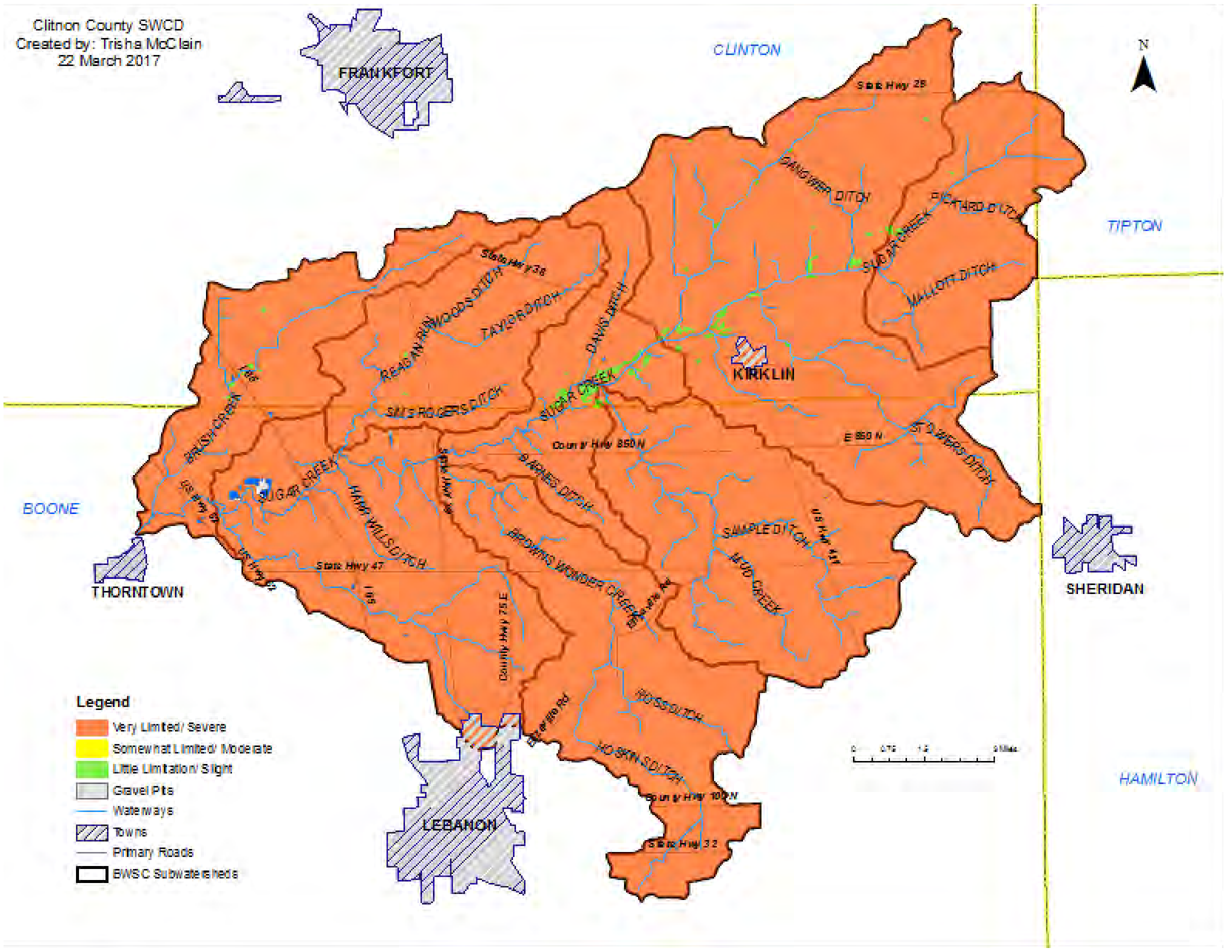

Figure 14. BWSC Septic System Suitability (SSURGO Database, 2015)

Based on estimates from the National Small Flows Clearinghouse there are at least 1,615 documented septic systems in the BWSC watershed. Considering these estimates are based on surveys from 1992 and 1998, and the fact that a number of old systems may also be present that have not been formally documented, the total number of septic systems is likely to be larger. The spatial distribution of these decentralized wastewater systems does correlate, to an extent, to the occurrence of small, unincorporated rural communities which do not possess formal sewer infrastructure (Figure 15) (Boone & Clinton Co. Surveyor's GIS Data, 2014). These specific areas may be more susceptible to water quality impacts from poorly performing wastewater systems. Currently, the Town of Kirklin is the only community within the BWSC watershed with centralized wastewater facilities. Incorporated areas of Lebanon and Thorntown also occur in the watershed but their facilities discharge outside of the current boundaries of interest and are assumed to have minimal impact in the BWSC watershed.

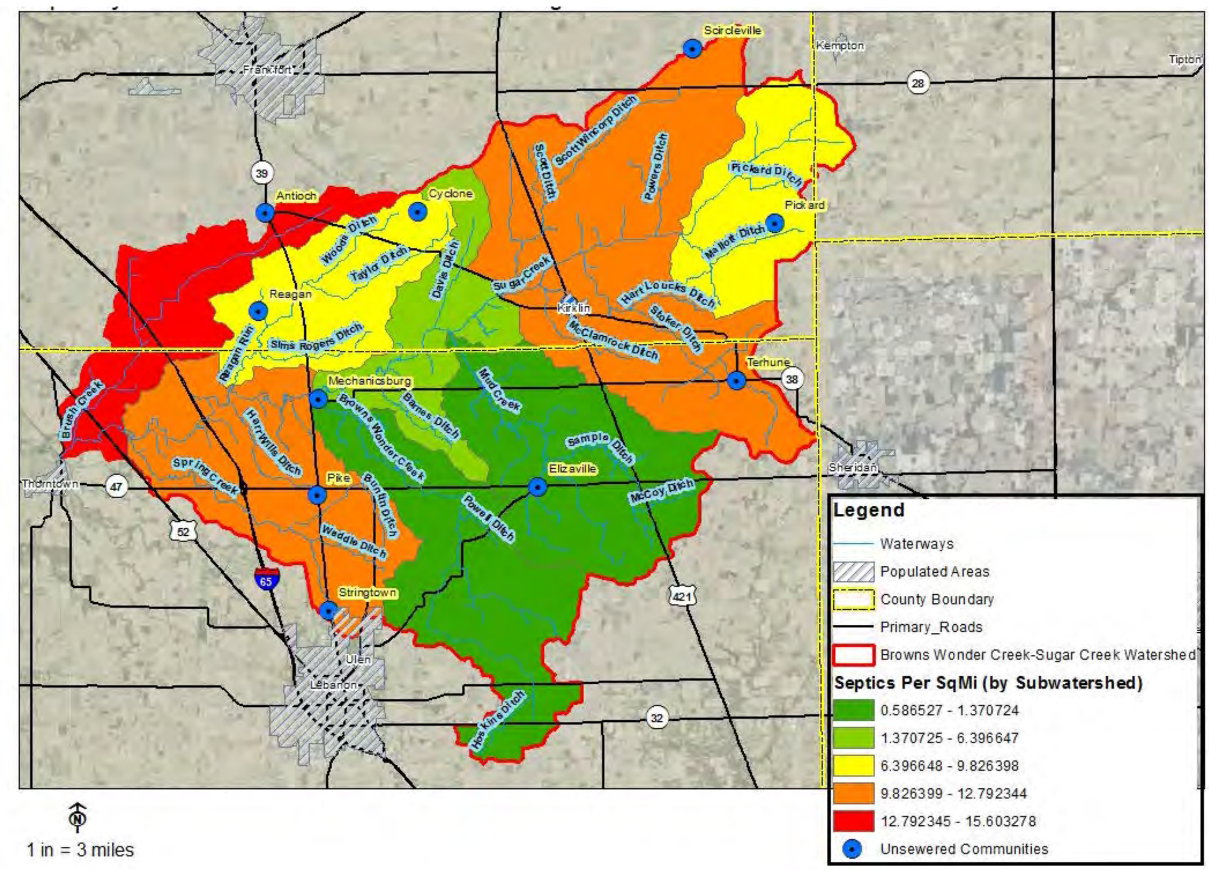

Figure 15. Septic Systems of the Browns Wonder Creek-Sugar Creek Watershed (County Surveyor's GIS Data, 2014)

2.5 Land Use of the Browns Wonder Creek – Sugar Creek Watershed

The BWSC Watershed is one where the slogan "Corn is King" rings true; maybe better suited would be "Crops are King". Based on the 2011 National Land Cover Dataset (NLCD), produced by the United States Geological Survey (USGS), nearly 90% of land in the watershed is managed as cropland (Figure 16). Much of this is devoted to corn and soybean production (Table 10). Over the past 15 years, acres devoted to soybeans has stayed fairly constant whereas corn acres have trended up and grass/pasture has trended down (Figure 17). This situation can decrease landscape diversity and increase cropping intensity within the watershed which has been shown to impact local wildlife and can impact water quality through increased drainage and runoff. Farm statistics from the 2012 Census of Agriculture for each county are listed in Table 11.

While the overall number of acres treated with commercial fertilizers and soil amendments decreased over the last 5 years, the use of manure as a fertilizer remained level or increased in Boone and Clinton Counties and both counties showed increased use of nematicides to treat soil pathogens. Water quality impacts from manure (i.e. wildlife, pet and/or livestock) is highly site specific based on geographic location, management, and weather. Livestock and manure application are typically done on agricultural landscape. While forested and developed areas are likely exposed to wildlife and pet waste. If manure runoff or leaching does occur into local waterways, it can cause an increase in nutrient levels, biological oxygen demand, and *E. coli*. This has been one situation where the use of cover crops has been encouraged and implemented by local producers as a way to slow down field runoff. This has both financial and environmental benefits by keeping manure fertilizer in the field where it can be used to increase soil health and provide nutrients to growing crops. Impacts from pesticides, including nematicides, can have negative consequences on aquatic communities if allowed to enter nearby surface waters.

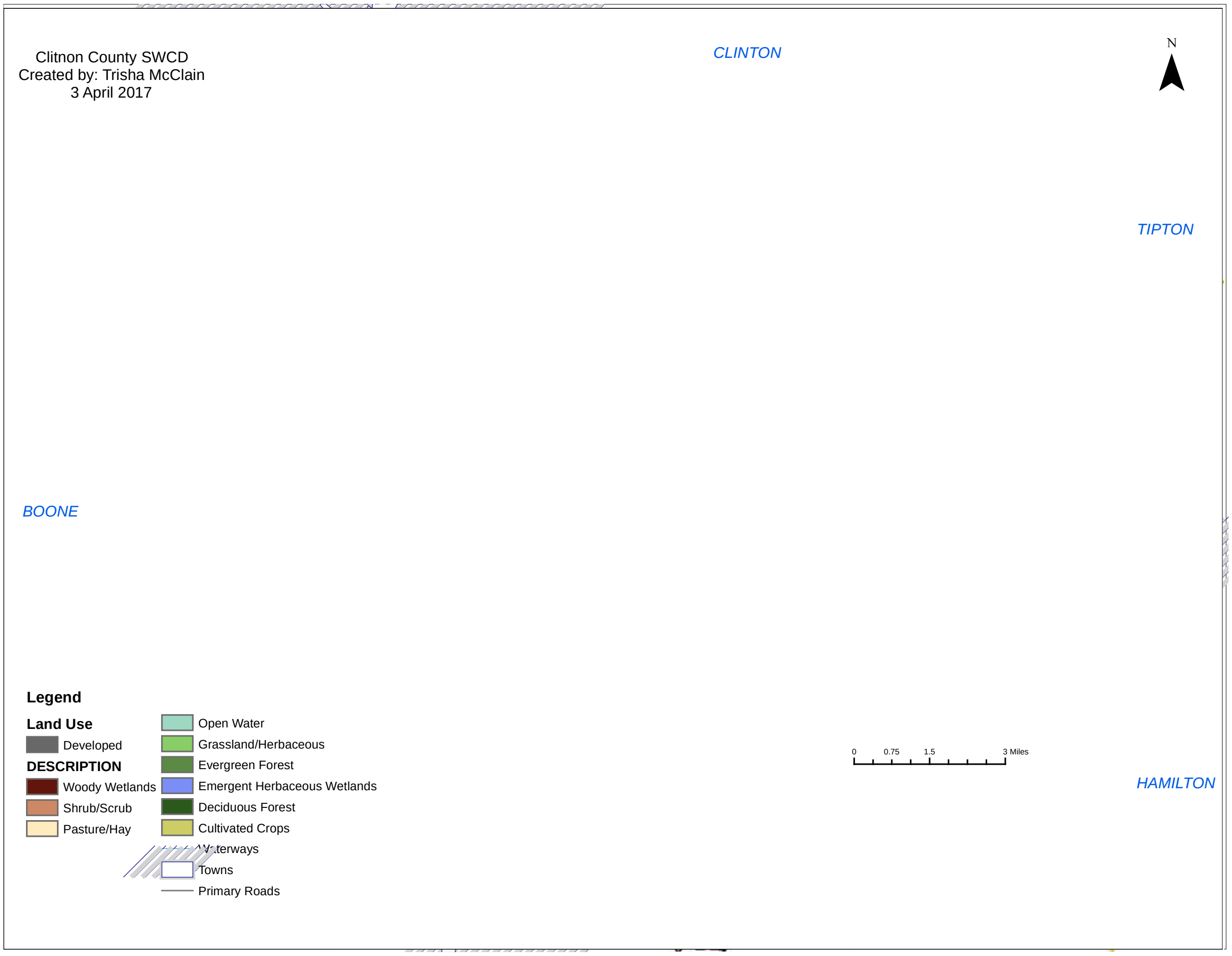

Figure 16. Land Use within the BWSC (NLCD, 2011)

Table 10. Cropland Use in the Browns Wonder Creek-Sugar Creek Watershed (NLCD, 2011)

Cropland Data Layer (NASS)	Total Acres (2014)	% of Total Area
Cultivated Crops	99,605	82%
Barren/ Fallow	16	<0.01%
Grass/Pasture	7,016	6%
Developed Area	7,853	7%
Deciduous Forest	5,417	4%
Winter Wheat	603	<0.01%
Shrubland	12	<0.01%
Open Water	166	<0.01%

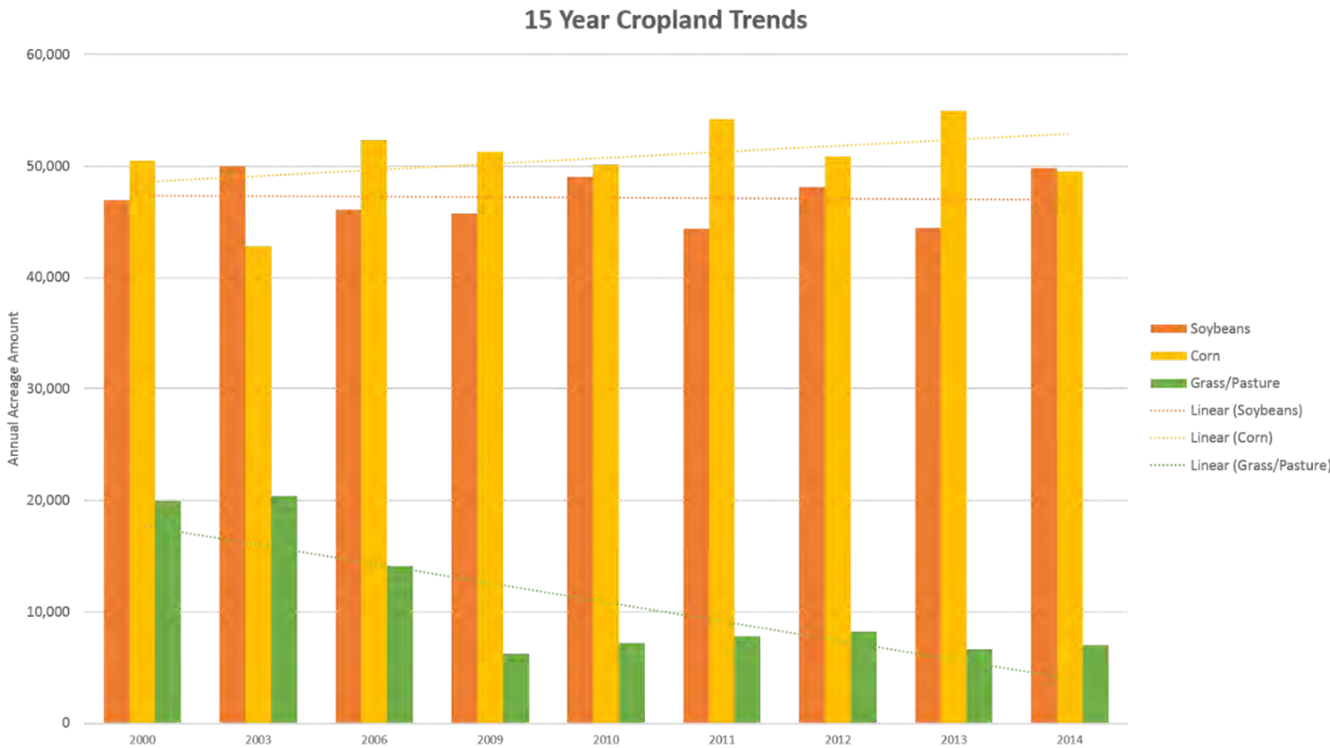

Figure 17. 15 Year Cropland Trends in the Browns Wonder Creek-Sugar Creek Watershed (NLCD, 2011)

Table 11. 2012 Census of Agriculture Statistics for Boone and Clinton Counties

	Number of Farms (% Change from 2007)	Average Farm Size (% Change from 2007)	Net Change of Acres Receiving Fertilizers and/or Soil Amendments	Net Change of Acres Receiving Manure	Net Change of Acres Receiving Insecticides	Net Change of Acres Receiving Nematicides
Boone	607 (4%)	365 (-5%)	-7.3%	-5.2%	-11.6%	64.1%
Clinton	597 (-14%)	374 (2%)	-10.3%	94.3%	-31.7%	44.7%

The remaining developed and undeveloped land, approximately 6% and 4% respectively, is concentrated along waterways, county roads, and highways. In this case, much of the developed land uses classified as “Developed, Open Space”. This land use designation is defined as, “areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purpose” (U.S. Geological Survey, 2014). Using imperviousness ratios as defined in the USGS National Land Cover Database, it is estimated that total watershed imperviousness is approximately 1.6%. This is well below development impact thresholds that have been documented in studies such as the Impervious Cover Model, developed by the Center for Watershed Protection (Center for Watershed Protection, 2003). Also, the low occurrence of imperviousness conflicts with some local

concern that water quality is being negatively impacted by developed or developing areas. However, it is important to note that imperviousness thresholds illustrate *potential* impacts rather than actual impacts and many other landscape characteristics are able and likely to impact local stream quality (e.g. quality and extent of forested areas along streams, agricultural intensity, impervious pavement, etc.). A more accurate statement is that watersheds with low imperviousness have the potential to achieve a higher quality stream network than those with high imperviousness.
Undeveloped land uses are weighted more heavily towards forested and areas of woody vegetation which are comprised of primarily deciduous trees and shrubs. These undeveloped, non-crop areas are concentrated along waterways or landscape depressions (i.e. wetlands) which are unconducive to development or cropping due site conditions (e.g. flooding/ponding, high slope, low soil fertility, etc.). A further distinction is that many of the forested areas which are located along streams and waterways occur more frequently in downstream sections of Sugar Creek. This means that many of the upstream portions of Sugar Creek, and associated tributaries and ditches, are largely unbuffered which supports local concerns. To further describe local watershed concerns and how they relate to land use within BWSC, local concerns are listed below (Table 12). Concerns listed below are based on social indicator surveys collected throughout the planning process. Each concern is marked with an "X" if that local concern falls within that land use classification (i.e. Agricultural, Rural or Urban). Overall, the table showcases the variety of concerns throughout the watershed & the commonality as well as differences among concerns across different communities (i.e. agricultural, rural & urban).

Based on remote sensing imagery produced by USGS, relatively little land use change has occurred over the period from 2001-2011, in spite of local concern about the loss of farmland and forested areas in the watershed. Much of the documented increases in development and/or loss of farmland are focused primarily on the north side Lebanon along Storms Ditch. A handful of other isolated areas in the watershed do occur where a loss of farmland is attributed to construction of ponds and increases in development along county roads.

Table 12. Comparison of Watershed Concerns and Land Use (Social Indicator Surveys, 2012 & 2015)

Watershed Concerns	Agricultural	Rural	Urban
Lack of buffer strips allows for nutrient and sediment loss	×	×	×
Lack of cover crops allows for nutrient and sediment loss	×		
Occurrence of surface drains leads to sediment runoff	×		
Logjams/Beaver dams increase streambank erosion and flooding	×	×	
Lack of knowledge on environmental regulations	×	×	×
Lack of knowledge and awareness of natural resource problems	×	×	×
Installing tile drainage increases runoff volume and transports pollutants	×	×	
Lack of conservation assistance	×	×	×
Loss of forested woodlots	×	×	

Loss of farmland	×		
Open dumping into streams	×	×	×
Stormwater runoff from streets, rooftops, and parking lots			×
Soil erosion from construction sites			×
Soil loss from agricultural fields	×		
Streambank erosion	×	×	×
Decrease in soil organic matter and increased compaction	×		
Excess nutrients and sediment in surface waters	×	×	×

2.6 Local Planning Efforts in the Browns Wonder Creek-Sugar Creek Watershed

The BWSC Watershed covers portions of Boone, Clinton, and Tipton Counties. Each county has undergone various planning efforts to help guide future development and growth across their area. In relation to water quality within the BWSC Watershed, these planning efforts were reviewed to take into consideration how local communities are planning for their water resources. Figure 18 shows general zoning and planning boundaries for the watershed while Table 13 provides general descriptions of the different zoning classification within BWSC Watershed (Boone County Area Plan Commission, 1998; Clinton County Area Plan Commission, 1993).

Table 13. General Zoning & Planning Classifications
(Boone County Area Plan Commission, 1998 & Clinton County Area Plan Commission, 1993)

Classification	Type	Definition
A-1	General Agricultural	The Agricultural Zoning District is intended to maintain the rural and scenic qualities by preserving farm land and significant open lands while allowing landowners a reasonable return on their holdings.
R-1 & R-2	Residential District	This district is established for the purpose of low density single-family dwelling control and to allow certain public facilities.
B-5	Agricultural Business	This district is established as a buffer generally between commercial and residential districts permitting selected business and professional uses having limited contact with the public.
LB	Local Business	This district is designed and located in neighborhoods to accommodate the primary needs of that locality. This district would place convenience and necessity facilities close to consumers in limited areas close to residences.
Corp.	Corporations	This district is established for all types of industrial uses requiring both enclosed and unenclosed spaces for storage, manufacturing, and fabricating.
I-1	Light Industry	This district is established to accommodate light industrial uses in which all operations, including storage of materials would be confined within a building, and would include warehousing operations.

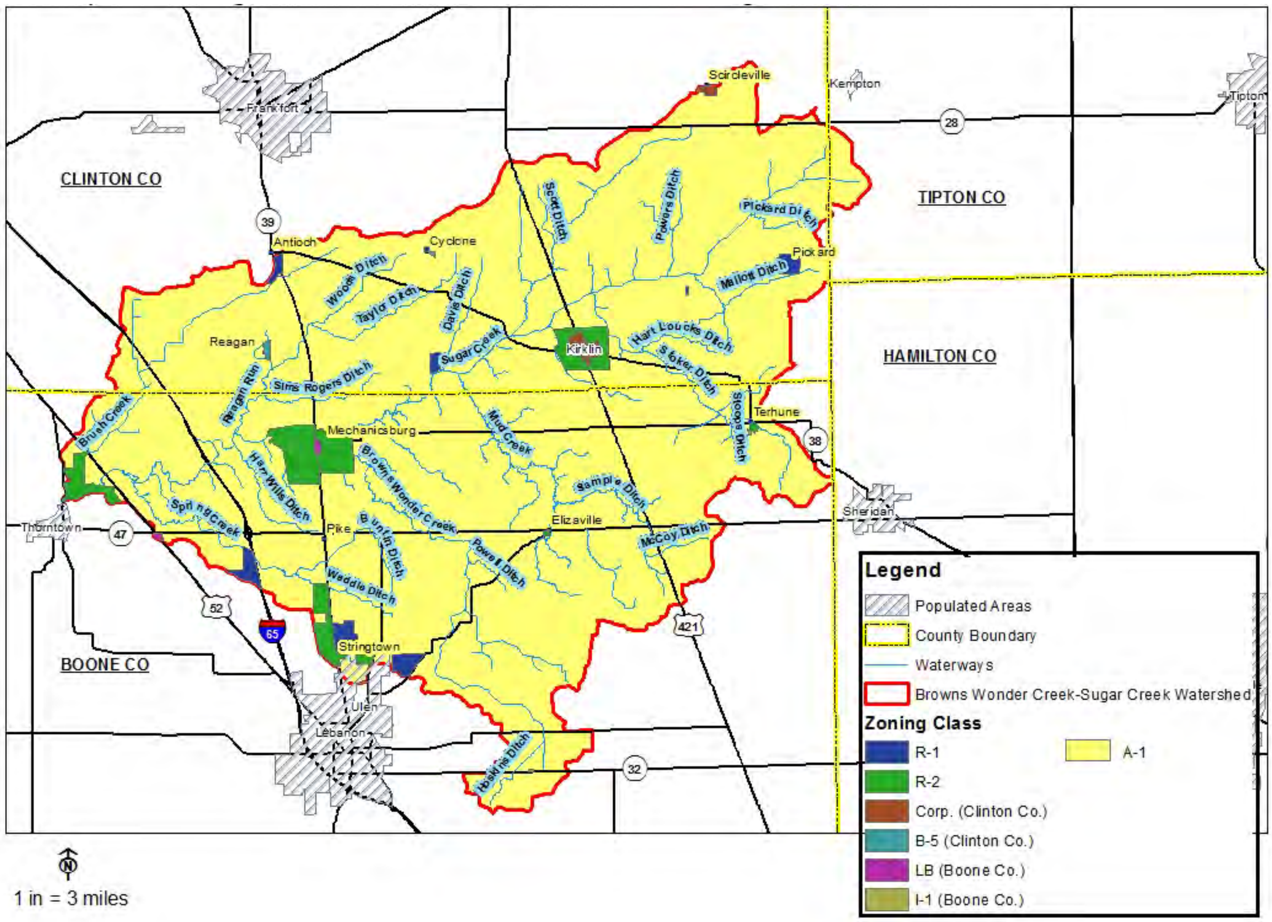

Figure 18. Development Zoning Classes for the Browns Wonder Creek-Sugar Creek Watershed (Boone County Area Plan Commission, 1998 & Clinton County Area Plan Commission, 1993)

Similar to current land use and planning priorities for each county, much of future land use is zoned for agriculture. This has commonly been a priority held by local residents and stakeholders as well. There are a number of planning goals and objectives documented within county comprehensive plans to encourage "sustainable" farming (Boone County Area Plan Commission, 2010; Clinton County Area Plan Commission, 2012). In these planning documents, there was specific focus on protecting against nutrient and sediment runoff from farmland. Also, planning goals encouraged, and in some cases recommended requiring, conservation buffers to be established on agricultural lands as a way to reduce offsite environmental impacts and land management disputes.

All county governments in the watershed have established zoning and subdivision control ordinances as tools to guide future development (Boone County Area Plan Commission, 1998; Clinton County Area Plan Commission, 1993). Residential development priorities, as seen by the zoning maps, are focused primarily around existing developed towns and communities. Long term goals identified in county comprehensive plans also encourage changes to existing ordinances to promote conservation-based approaches to development as ways to protect environmentally sensitive areas and manage stormwater. These goals relate directly to stakeholder concerns of water quality impacts from construction sites and urban runoff.

Land drainage and the management of local streams and wetlands are also recognized in each of the county comprehensive plans. Priorities for both allowing necessary drainage but also proactively managing flooding issues can be found in each of the long term planning documents. This creates an interesting dichotomy in regards to how water and runoff is managed within these communities in the future. However, this opposing view of water management isn't new and has been voiced during stakeholder meetings where landowners prioritize increasing agricultural drainage but also openly recognize the consequences related to pollutant runoff and flooding. Many of the communities list planning priorities to protect and enhance existing floodplains, stream corridors and wetland areas as potential approaches to manage flooding while reducing environmental impacts from adjacent land uses. However, specific timelines and strategies for implementation of these planning priorities do not appear to be well defined at this point.

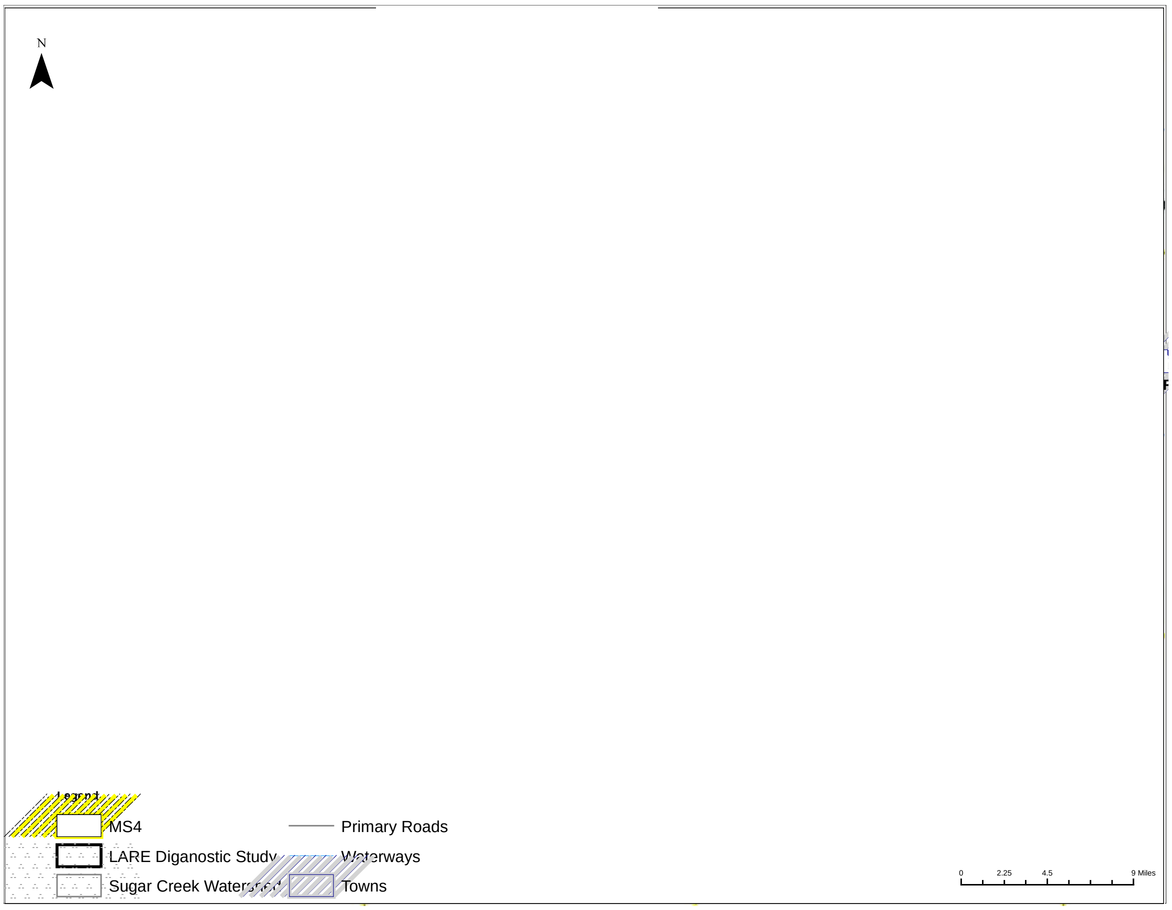

Figure 19. Planning Efforts for the Browns Wonder Creek - Sugar Creek Watershed (Storm Water Master Plan, 2008)

There have been few watershed management plans which have included the BWSC watershed. The City of Lebanon Municipal Separate Storm Sewer System (MS4) represents a very small portion of the BWSC watershed (Figure 19). Based on the most recent Storm Water Master Plan, which was completed in 2008, planned stormwater upgrades include new storm sewer and open ditch construction (M. D. Wessler & Associates, Inc., 2008). These upgrades would service, in preparation for future development from farm ground, 247 acres on the north side of Lebanon and outfall to Storms Ditch. In addition to a

MS4 each county is response for reviewing RULE 5 construction plans, which is a permitting process that ensures ongoing construction addresses resource concerns such as sedimentation and erosion, if the construction site is disturbing 1 acre or more of soil. Each county evaluates their own RULE 5 submissions and currently there are no RULE 5 enforcements required, but as the counties continue to develop and grow there is a potential for enforcement of RULE 5 construction or unmanaged urban sprawl.

In 2002, the Sugar Creek Watershed Restoration Action Strategy was completed by Wittman Hydro Planning Associates, Inc. per contract with the IDEM Office of Water Quality (Wittman Hydro Planning Associates, Inc., 2002). This document was divided into two parts. Part One included information on background watershed characteristics (e.g. applicable water quality regulations, land use patterns, relevant stakeholder groups, etc.). Part Two identifies water quality concerns and recommended implementation strategies. Many of the concerns and implementation strategies are similar to those mentioned by local stakeholders and residents including: streambank erosion, drainage and runoff from urban and agricultural lands, and lack of environmental education and outreach. As noted in the Executive Summary of this document, the project focused broadly on the entire Sugar Creek Watershed and that subwatershed plans would need to be developed to address local concerns and develop site-specific restoration strategies.

That is where current planning efforts have picked up to focus more specifically on the BWSC watershed. In 2012 the Boone and Clinton County SWCD's secured funding through the IDNR-LARE Program to complete a Watershed Diagnostic Study with the intent of characterizing local water quality issues and recommending restoration strategies (Commonwealth Biomonitoring, 2013). The study, which was completed by Commonwealth Biomonitoring, included water quality sampling as well as desktop GIS analysis of the BWSC Watershed. Water quality concerns identified during this study included aquatic habitat impairments due to sediment and limited stream buffers, elevated phosphorus levels, and excessive *E. coli* concentrations at various sites across the watershed. These water quality impairments were considered conservative estimates as sampling was conducted during a drought year which would limit pollutant runoff in many of the potential sources in the watershed. Recommended restoration strategies included increasing the adoption of filter strips, cover crops, grass waterways, and nutrient management plans as ways to decrease water quality impacts.

2.7 Rare, Threatened, and Unique Plants and Animals of the Browns Wonder Creek-Sugar Creek Watershed

The BWSC watershed is home to a number of unique and significant plants and wildlife. In Indiana, the IDNR maintains a statewide inventory of these plants and wildlife as part of the Indiana Natural Heritage Data Center (Indiana Department of Natural Resources, 2015). This inventory is maintained as part of a Natural Heritage Network which is a worldwide system of Heritage Programs that help to establish baseline documentation for establishing priorities for protecting unique and sensitive plants and wildlife. Table 14 lists records from the Indiana Natural Heritage Data Center which have been documented in the BWSC watershed. Currently, there no documented vascular plants that are threatened or endangered within the watershed. The presence of these species listed below, are sparse & sporadic because over 80% of BWSC land is in farmland; which reduces the presence of key habitats such as grassland, prairie, wetlands, and old forests that these species depend on. Based on the 2011 National Land Cover Dataset, identified habitat (rivers, wetlands, grassland, and mature forests), essential for the species listed in Table 14, occupy only 7% (approx.9,000 acres) of the total landscape (Figure 16). Protection & implementation of these remaining habitats are essential to ensure success of these species.

Table 14. Rare, Threatened, and Unique Wildlife of the Browns Wonder Creek - Sugar Creek Watershed

Species							
Common Name	**Latin Name**	**Type**	**Habitat**	**GRANK**	**SRANK**	**SPROT**	**Last Recorded Observation**
American Badger	Taxidea taxus	Mammal	Grasslands, Prairie	G5	S2	SSC	1989, 1991
Cerulean Warbler	Dendroica cerulea	Bird	Mature Woodlands	G4	S3B	SE	1994
Kidneyshell	Ptychobranchus fasciolaris	Mollusk	Small-Medium Rivers (Sand, Gravel)	G4G5	S2	SSC	1991, 2009
Least Bittern	Ixobrychus exilis	Bird	Wetlands	G5	S3B	SE	2011
Longsolid	Fusconaia subrotunda	Mollusk	Medium-Large Rivers (Gravel)	G3	SX	SE	1991
Marsh Wren	Cistothorus palustris	Bird	Wetlands	G5	S3B	SE	1997
Purple Lilliput	Toxolasma lividus	Mollusk	Small-Medium Streams (Sand, Gravel)	G3Q	S2	SSC	1991
Sedge Wren	Cistothorus platensis	Bird	Wetlands, Grasslands	G5	S3B	SE	2001, 2010
Virginia Rail	Rallus limicola	Bird	Wetlands	G5	S3B	SE	1993, 2014
Wavyrayed Lampmussel	Lampsilis fasciola	Mollusk	Small-Medium Streams (Sand, Gravel)	G5	S3	SSC	1991, 2007
GRANK (Global Heritage Rank): G1 - Critically Imperiled Globally; G2 - Imperiled Globally; G3 - Rare or Uncommon Globally; G4 - Widespread and Abundant Globally but with Long Term Concerns; G5 - Widespread and Abundant Globally; Q - Uncertain Rank							
SRANK (State Heritage Rank): S1 - Critically Imperiled in State; S2 - Imperiled in State; S3 - Rare or Uncommon in State; SX - State Extirpated; B - Breeding Status							
SPROT (State Regulatory Protection Status): SE - State Endangered; SSC - State Species of Special Concern							
Definitions:	State Endangered - Any animal species whose prospects for survival or recruitment within the state are in immediate jeopardy and are in danger of disappearing from the State.						
	State Species of Special Concern - Any animal species requiring monitoring because of known/suspected limited abundance or distribution or because of a recent change in legal status or required habitat						

Historical Habitat and Biological Data

Since 1945 the Browns Wonder- Sugar Watershed (BWSC) has had biological and habitat assessments. In 1945, a state-wide fish survey was conducted. Results were compiled into a fisheries survey referred to as The Fisheries of Indiana. The survey was conducted at two locations within the watershed. A total of 43 species were collected indicating a diverse fish community within these areas. Some species believed to be extirpated from Indiana were discovered such as, brindled madtom, river chub, rosyfish shiner and brook silverside (LARE Diagnostic Study 2012).

Around 1973 Indiana Department of Natural Resources (IDNR) conducted a habitat and biological assessment that indicated excellent habitat for fish communities. During sampling the bluebreast darter, a small perch species known for high water quality was discovered (Huffaker, 1973). Currently, the species is listed on the state's endangered/threatened species list. Later IDNR conducted a fish survey (2000) a total of 1,355 fish which included 33 species in 8 different families. Those fish collections identified upper Sugar Creek as one of Indiana's best streams in terms of species diversity and sport fish populations (Keller, 2000).

Fisheries biologist from DePaw University conducted a two year fish survey (1988 & 1989) that collected fish at 30 sites that stretched the entire length of Sugar Creek; only four are located within BWSC. The study revealed a healthy habitat and fish community except at the most upstream site near Kirklin. The results indicated that there was a reduction in fish communities due to poor water quality (Gammon et al., 1991).

Both biological and habitat assessments in the form of Index of Biological Integrity (IBI) and Qualitative Habitat Evaluation Index (QHEI) have been conducted throughout the Browns Wonder-Sugar Creek Watershed by the Indiana Department of Environmental Management (IDEM). There are 30 different sites within the watershed, sampling has been done in 1999, 2004 and 2005 (Figure 20). Assessments of both IBI scores and QHEI scores have been compared on the subwatershed scale (p. 44).

2.8 Summary of the Browns Wonder Creek-Sugar Creek Watershed

Brown's Wonder- Sugar Creek Watershed is comprised of 8 subwatersheds: Barnes Ditch- Sugar Creek, Brush Creek- Sugar Creek, Mallott Ditch- Sugar Creek, Mud Creek, Reagan Run, Scott Wincoup Ditch- Sugar Creek and Spring Creek- Sugar Creek. The Brown's Wonder- Sugar Creek Watershed land use is predominantly agriculturally based. The combination of rich, productive soils formed during and after periods of glaciation, along with a relatively flat topography has generated an excellent landscape for agriculture. And it is this agricultural legacy that continues to define the watershed today. The landscape was further "enhanced" for agricultural production with draining of wetlands and construction of widespread artificial drainage networks. Drainage has been, and continues to be, a priority for developing communities in the BWSC watershed. But it is this enhancement that has also generated a number of modern-day concerns for local residents including localized flooding, actively eroding streams/ ditches, and increased pollutant runoff.

Trends in land use have also begun to highlight environmental and water quality concerns among local residents. Agricultural intensity has increased over the past 15 years with a net loss of grasslands, pastures, wetlands, and woodlots while gains have been documented in row crop agriculture. It is this intensive production agriculture that has been brought under the national spotlight regarding environmental impacts. Recent examples include impacts to the Toledo (OH) drinking water supply, lawsuits between Des Moines (IA) water utilities and upstream agricultural counties, and the Gulf of Mexico hypoxic zone. While this local land use shift has been prioritized by county planning agencies, supplemental recommendations from these planning agencies on increasing the adoption of agricultural conservation practices have struggled to keep pace. Through stakeholder and public meetings, local residents have called for increased promotion and use of practices such as conservation buffers, cover crops, soil health management, erosion control, and improved access to conservation assistance as approaches to combat local water quality issues.

The BWSC watershed, or otherwise considered the Sugar Creek drainage upstream of Thorntown, IN, encompasses an agriculturally-dominated landscape without public land and recreational access which is more common downstream. While non-agricultural land uses represent less than or equal to 10% of the entire land area in the BWSC watershed, concerns relating to water quality have been voiced by residents. This dynamic between upstream and downstream stakeholders as well as agriculture verse non-agriculture creates a balancing act of varying water uses and values, with the public use downstream being linked to upstream private land management and development. Most of the current and future development will likely focus on low density residential growth in and around Kirklin, Lebanon, Mechanicsburg, and Thorntown. Local planning agencies are playing an active role in the community, with the implementation of local zoning and subdivision ordinances as well as a number of conservation strategies targeted towards (re)development per county comprehensive plans. This dynamic is a significant driver for local groups to begin discussing watershed planning activities and priorities.

Section 3. Environmental and Water Quality Data

3.1 Water Quality Targets

Water quality targets for this project have been divided into three separate categories; Primary Non-Point (NPS) Source Targets, Environmental Health Targets, and Secondary NPS Targets (Table 15). Specifically, Primary NPS Targets are those parameters where pollutant loads can be estimated and tracked. Environmental Health Targets are those which describe stream system health (i.e. stream physical habitat and biological communities). Loads cannot necessarily be calculated for environmental targets but they can be useful in evaluating “interpreted” responses to changes in land use management and pollutant loading. Since these physical and biological variables are under constant exposure to changing conditions, and different organisms are more or less capable of certain water quality and physical environmental conditions, one can start to evaluate overall water quality across varying scales of time based on what organisms live there. Last, Secondary NPS Targets are those parameters where load cannot be calculated but can still provide relevant information regarding background conditions and impacts from Primary NPS Targets. For example, dissolved oxygen concentrations that fall below target levels may be a response of high phosphorus loads in the stream leading to excessive algae growth and subsequent decomposition.

Project targets were determined by local stakeholders through public meetings, social indicator surveys & participation at steering committee meetings. Targets were finalized by the established steering committee (Table 2). The steering committee reviewed stakeholder concerns as well as IDEM's 303(d) water quality impairments (impaired biotic communities & *E. coli*). The committee determined that to effectively address water quality concerns within the watershed, targets should be set to values that would adequately address pollutants that would positively impact biotic communities and minimize *E. coli*. loads. The established project targets are values that promote healthy biotic communities, which is the most prevalent impairment within the BWSC Watershed.

Table 15. Primary and Secondary Non-Point Source Targets

Primary NPS Targets		
Pollutant	**Concentration**	**Source**
Nitrogen (Nitrate+Nitrite)	≤1.6 mg/L (project target) <10 mg/L (minimum IDEM WQ standard)	Indiana Administrative Code (327 IAC 2-1-6)
Total Phosphorus	< 0.05 mg/L (project target) <0.30 mg/L (minimum IDEM WQ standard)	Indiana Administrative Code (327 IAC 2-1-6)
Total Suspended Solids	< 25 mg/L (project target) <30 mg/L (minimum IDEM WQ standard)	IDEM NPDES Discharge Limit/TMDL Target
E. coli	<235 cfu/ 100ml (single sample) <125 cfu/100 mL (geometric mean of ≥ 5 samples) or not more than 10% **Both values are project targets. Values are dependent on the type of monitoring that occurs*	Indiana Administrative Code (327 IAC 2-1-6)
Environmental Health Targets		
Biological/Habitat Index	**Score**	**Source**
Citizen's Qualitative Habitat Evaluation Index	>60	Hoosier Riverwatch
Index of Biotic Integrity (macroinvertebrates - mIBI or fish - IBI)	>36	IDEM 2014 CALM Hoosier Riverwatch
Qualitative Habitat Evaluation Index	>51	IDEM 2014 CALM
Secondary NPS Targets		
Water Quality Indicator	**Concentration**	**Source**
Dissolved Oxygen	4 mg/L to 9 mg/L **Should not be below 4mg/L longer than 24 hours*	Indiana Administrative Code (327 IAC 2-1-6) Hoosier Riverwatch
pH	>6 and <9	Indiana Administrative Code (327 IAC 2-1-6)
Water Temperature	Monthly Standard	Indiana Administrative Code (327 IAC 2-1-6)
Turbidity	<10.4 NTU	U.S. EPA Ecoregion Criteria (55)

3.2 Completed Studies

Historical Sampling Locations, Indiana Department of Environmental Management (1999-2015)

IDEM's Watershed Assessment and Planning Branch implements various surface water quality monitoring programs across the major river basins in the state. These programs are designed to provide water quality data and evaluation pursuant to requirements set forth by the Clean Water Act and other state-specific initiatives. This data covers physical, chemical, and biological parameters and are housed with IDEM'S Assessment Information Management System (AIMS). Physical, chemical, and biological sampling occurs every 5 years. Parameters and sampling methodologies are specific to individual programs. Sampling activities were conducted between 1999 and 2015. Both current and previous sample sites are documented in Figure 20, some sample sites were not evaluated continually from 1999 to 2015. Each subwatershed description will present the historical sampling site location and the date in which it was evaluated, if information is not presented then data was not collected.

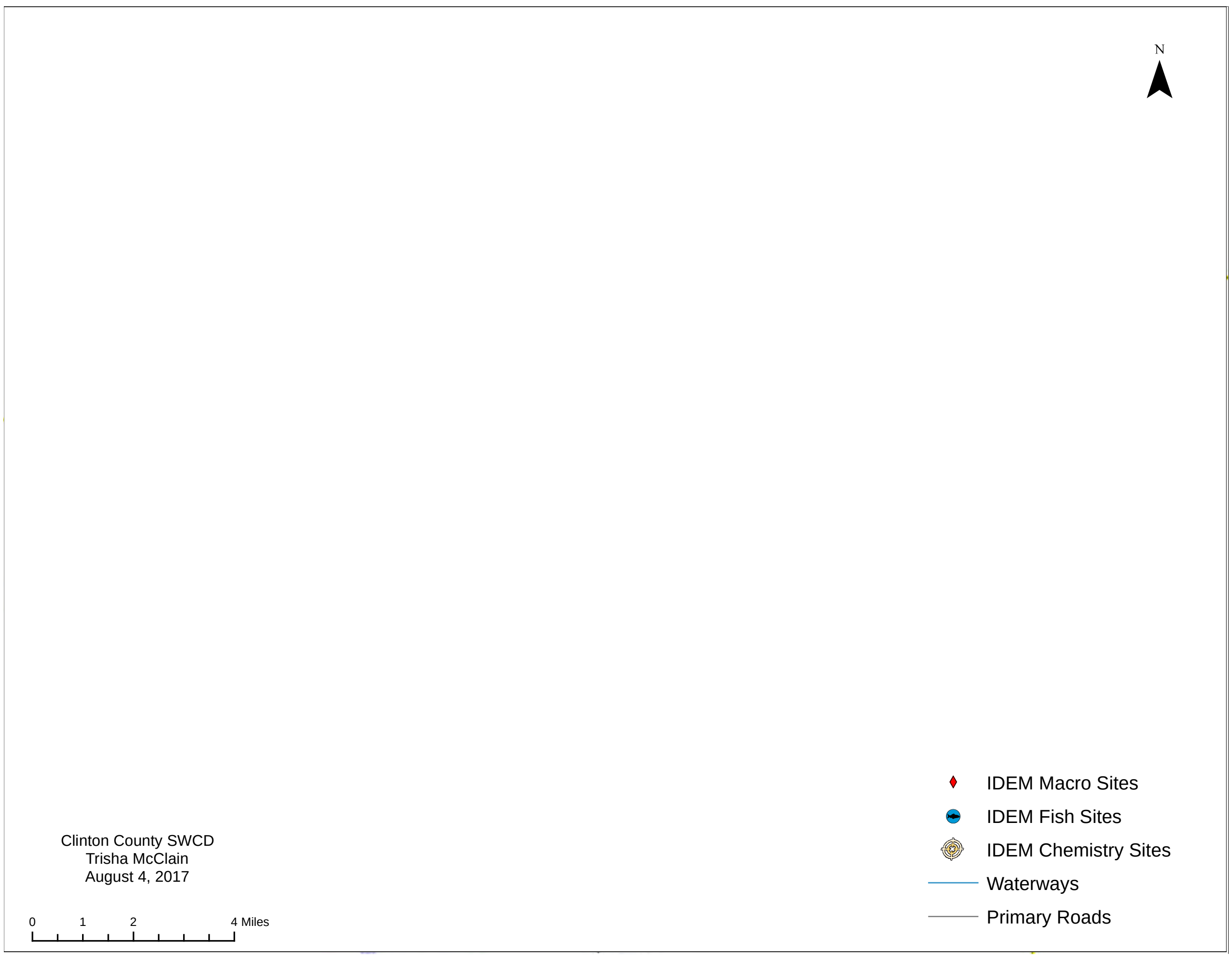

Figure 20. Historical Sampling Locations, Indiana Department of Environmental Management (1999-2015)

Sugar Creek Watershed Diagnostic Study (2012)

In 2011, the Boone and Clinton County SWCD's received funding through the IDNR-LARE program to complete a preliminary watershed diagnostic study to evaluate water quality issues with the BWSC Watershed and prepare implementation strategies.

As part of this project, water chemistry and biological samples were collected at 14 locations within the watershed (Figure 21). All samples were collected in 2011. Biological and stream habitat indices were completed once in November 2011 using U.S. EPA Rapid Bioassessment Protocol III (Genus/Species) evaluating macroinvertebrates and the Qualitative Habitat Evaluation Index (QHEI) to evaluate stream physical habitat based on Ohio EPA methods. The reference site used was located on Walnut Fork (40.0582, -86.8745).

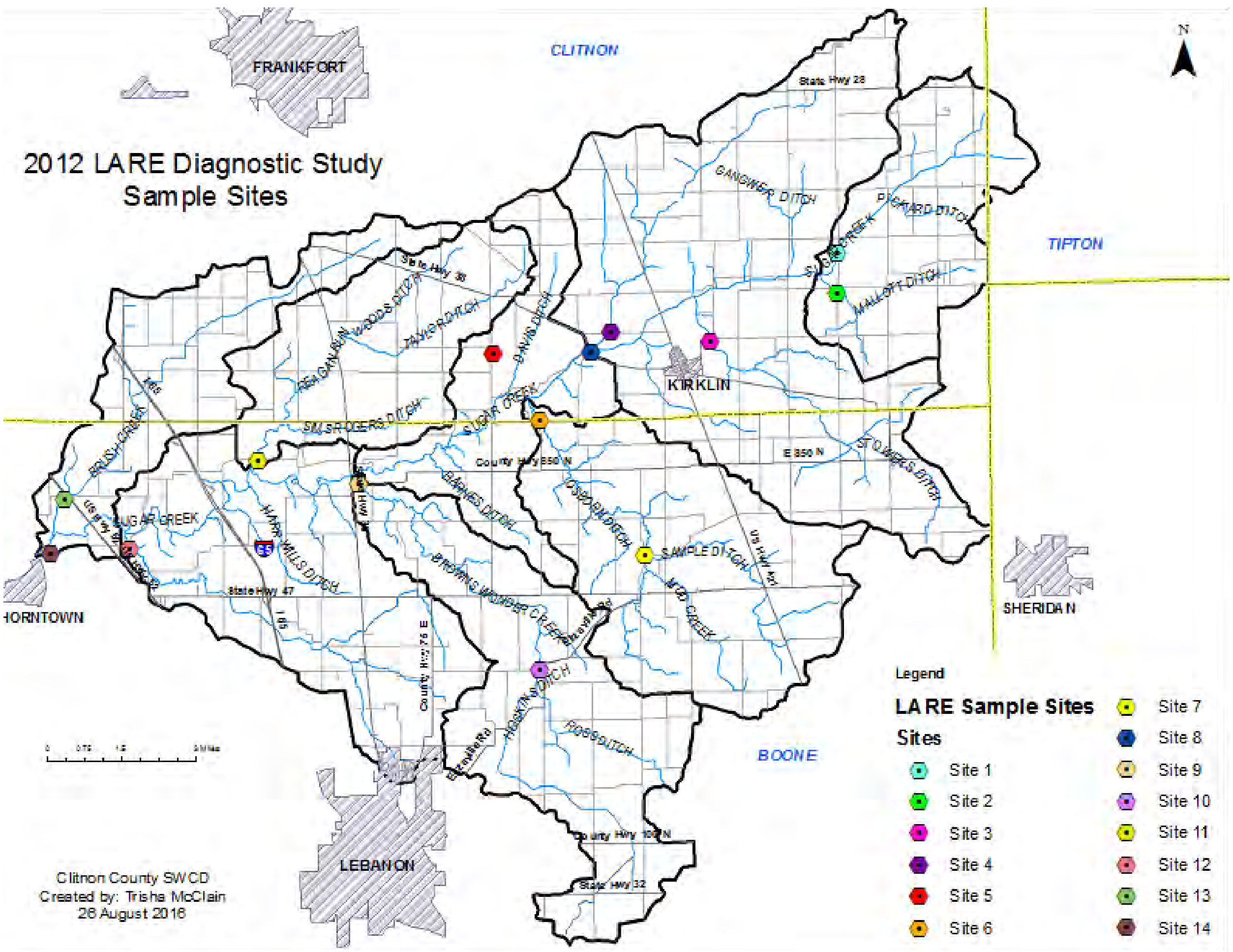

Figure 21. Sampling Locations for the 2012 Sugar Creek Watershed Diagnostic Study

Water chemistry sampling was completed as grab samples occurring once on June 12, 2012 under "normal" streamflow conditions and another on August 10, 2012 following a storm event. It is important to note that 2012 was a significant drought year across much of Indiana, impacting streamflow conditions and subsequently stream loading and pollutant cycling. Dissolved oxygen was measured by the membrane electrode method. The pH measurements were made with a Cole-Parmer pH probe. Conductivity was measured with a Hanna Instruments meter. Temperature was measured with a mercury thermometer. All instruments were calibrated in the field prior to use. Flow was calculated using the nearest U.S. Geological Stream Gauging Station on Sugar Creek at Crawfordsville. Using the known drainage area for each site, the drainage area measured at the gauging station and real-time flow data, flow values can be estimated for each respective sampling location in cubic feet per second (cfs). Samples for nutrient and bacteria analysis were collected as grab samples and returned to the lab using methods approved by the American Public Health Association (APHA, 1992). *E. coli* was measured by the membrane filtration method, using m-coliblue as the growth medium. Nitrate and phosphorus were measured by spectrophotometry. Ammonia was measured by the ion-specific probe method.

3.3 Watershed Inventories

Browns Wonder Creek-Sugar Creek Watershed Planning Project (2015)

Our current efforts have included additional water quality sampling to evaluate water quality in the BWSC watershed. Water chemistry evaluation was completed by Purdue University (January 14th to December 6th of 2015). Sampling occurred bi- weekly over a period of 12 months at 8 sites across the watershed and effectively evaluated 7 of the 8 subwatersheds within BWSC (Figure 22). Sites were determined by public accessibility, stability (i.e. limited change; permanent location) & its location near the confluence of a subwatershed; to ensure accurate, long-term water quality data collection. In addition, the frequency of samples across the watershed, combined with continuous flow data from USGS at the watershed outlet, provided pollutant loads (lbs/day). This information provides essential detail (e.g. across flow regimes, seasons, subwatersheds, etc.) that can aid in future implementation.

Physical stream assessments were completed by trained volunteers at least once between the months of July and October at each of the 8 sites across the watershed. Volunteers were trained to complete Citizen Qualitative Habitat Evaluation Index (cQHEI) assessments, per the Hoosier Riverwatch Program. Since physical metrics of stream quality are less dynamic than chemical metrics, the cQHEI was only sampled once during this project to provide a relative benchmark for past projects. Sampling site locations and water quality parameters are indicated in Table 16. To provide a better representation of the current condition within BWSC there were a series of desktop and windshield surveys conducted.

Desktop surveys used GIS metadata to analyze data that was not collected during windshield surveys. Both surveys give a holistic understanding about the present condition and can help identify trends or changes that occur.

Table 16. Sampling Locations and Water Quality Parameters for the Browns Wonder Creek-Sugar Creek Watershed Planning Project

ID	Site	Latitude	Longitude	Waterway	Drainage	Parameters
SCM	CR200E (Boone)	40.176709	-86.431756	Sugar Creek	97mi^2	Nitrate-Nitrite, Total Phosphorus, *E. coli*, Total Suspended Solids, Dissolve Oxygen, Conductivity, Turbidity, Water Temperature, pH, Stream Flow, cQHEI
SCD	N Sugar Creek Ave (Boone)	40.139231	-86.604817	Sugar Creek	189mi^2	
MuC	CR950N (Boone)	40.177180	-86.413667	Mud Creek	26mi^2	
SCU	SR38 (Clinton)	40.197199	-86.394739	Sugar Creek	63mi^2	
BrW	W Horton Rd (Boone)	40.159200	-86.482800	Browns Wonder Creek	26mi^2	
ReR	W Blubaugh Ave (Boone)	40.166548	-86.521179	Reagan Run	17mi^2	
SpC	N Frankfort Rd (Boone)	40.141027	-86.570355	Spring Creek	13mi^2	
BrC	CR700W (Boone)	40.151843	-86.597534	Brush Creek	15mi^2	

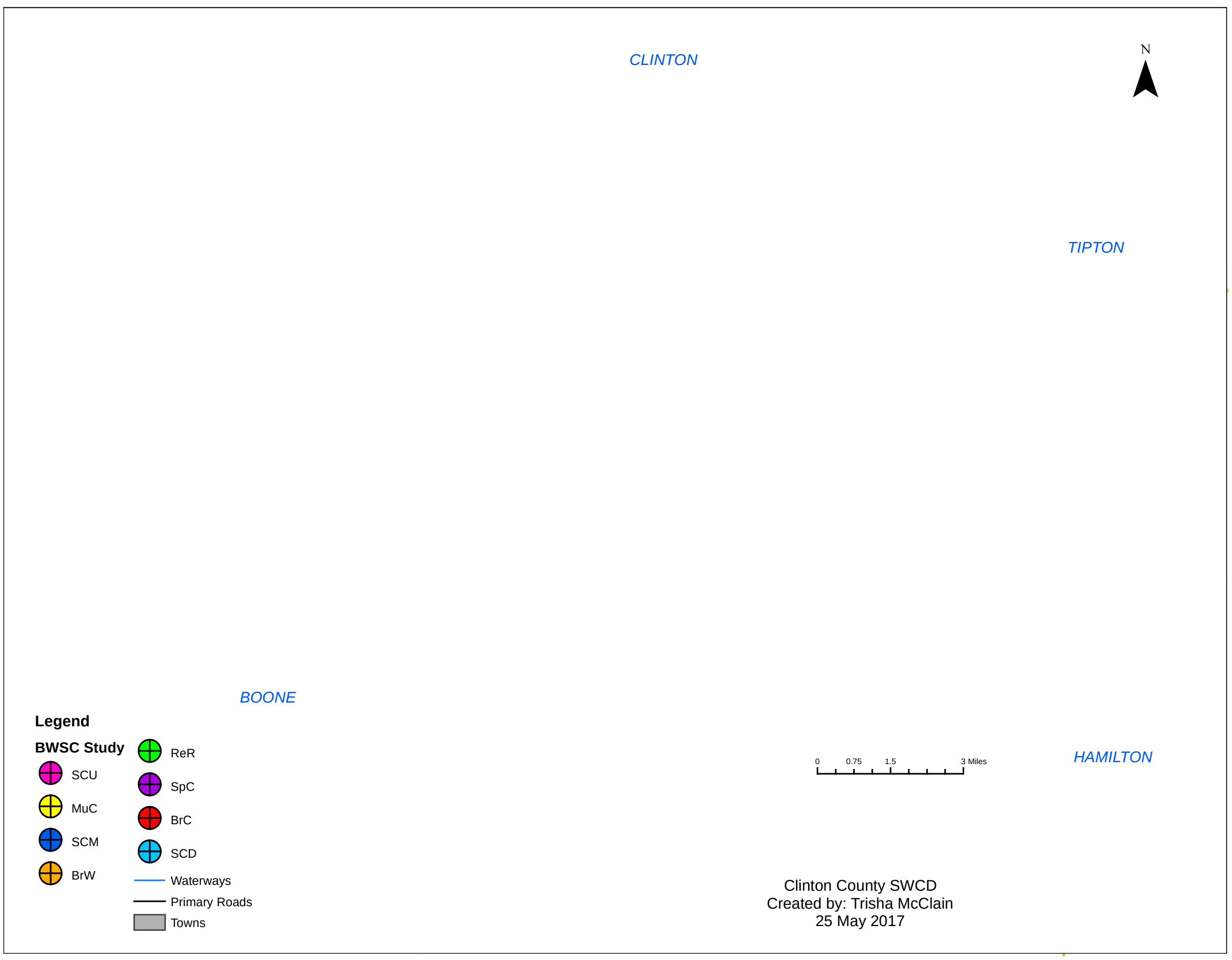

Figure 22. 2015 Sampling Sites for Browns Wonder-Sugar Creek Watershed

Windshield surveys were completed during the months of January to April, 2015. Steering committee members completed visual transects along county roads in the BWSC watershed to evaluate local land use and environmental characteristics (Figure 23). Each participant documented conditions using photographs, GPS units, and field sheets. This information was then compiled, categorized, and input using ArcGIS mapping software. Categories of interest included:

- Areas where conservation practices have previously been implemented
- Locations where field erosion was occurring
- Spots along surface waters which lack vegetated buffers
- Areas were livestock are freely able to access surface waters
- Field locations where tile risers have been installed to drain depressional areas

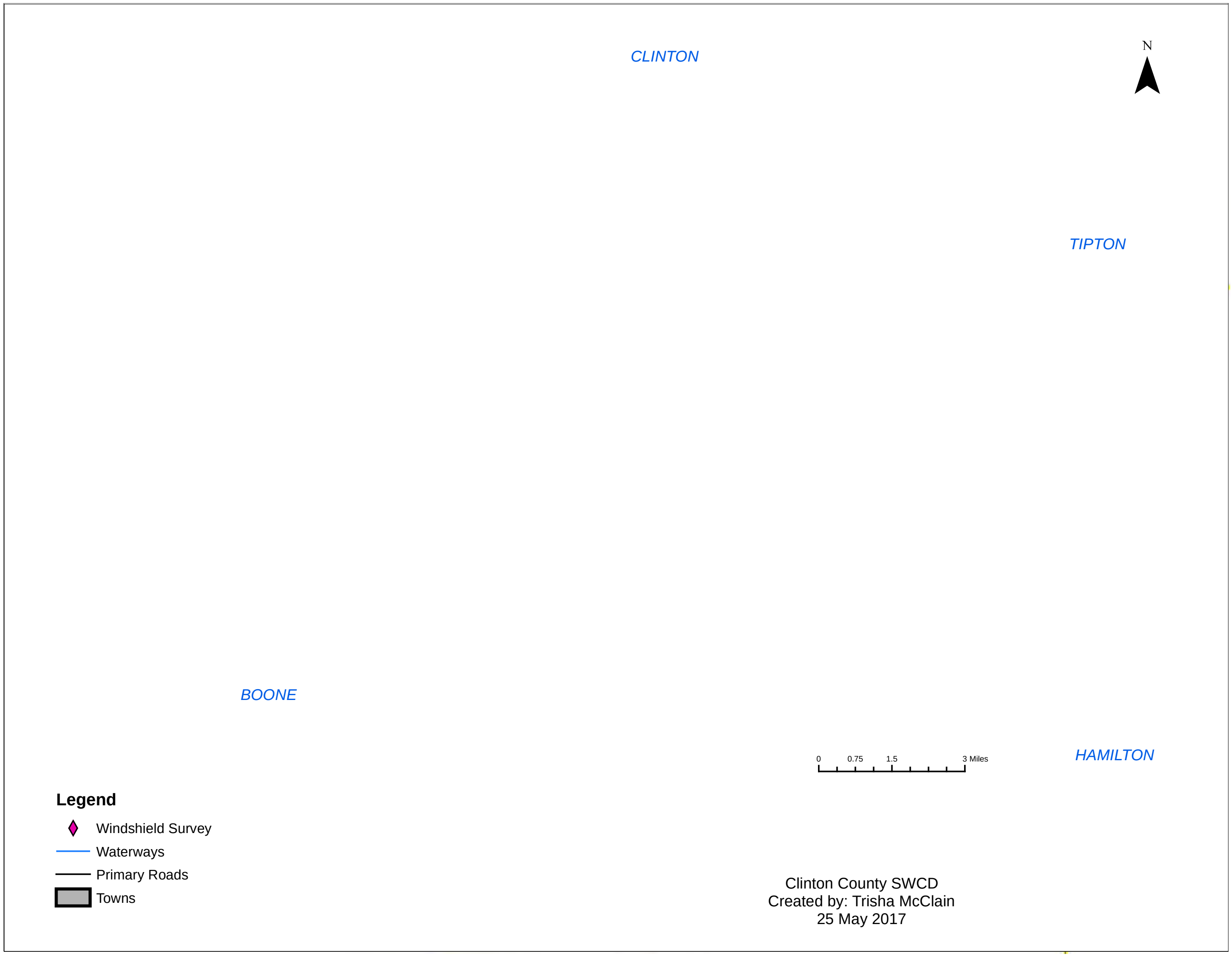

Figure 23. 2015 Windshield Survey Sample Sites in Browns Wonder- Sugar Creek Watershed

Browns Wonder- Sugar Creek planning Project Results (2015)

Water chemistry was completed by Purdue University in 2015 (January 14, 2015 to December 6, 2015). Sampling occurred bi- weekly over the period of 12 months at 8 sites across the watershed (Figure 22). Due to the significant variance in the water quality data the median values for each chemical parameter are represented in Table 17 to provide a general concept of the concentration levels of each pollutant per sample site. On average sample sites exceeded *E.coli* and nitrate-nitrite target values (Table 15). Only 38% of the samples exceeded the total phosphorus target values while none of the sites reached the total suspended sediment (TSS) target values established. However, significantly high TSS values were documented during significant rain events that surpassed 100 mg/L. In addition to water quality analysis chemical data was combined with continuous flow data from USGS at the watershed outlet (Thorntown), which provided pollutant loads (lbs/day) for each sample site which are provided at the subwatershed level relative to each sample site. Along with water quality analysis, habitat was evaluated through cQHEI, which was conducted in mid-October and early December of 2015 (Figure 24). Assessments were only conducted at each site once to provide a relative benchmark. All of the sites, except BrW, have surpassed the target value of 60, which indicates the habitat is suitable for aquatic communities.

Table 17. The median value for each chemical parameter evaluated in the BWSC Planning Project (Jan. 14th to Dec. 6th)

Site ID	*E.coli* cfu/100mL *Target: <235 cfu/100 mg/L*	TSS mg/L *Target: 25 mg/L*	Nitrate-N mg/L *Target: 1.6 mg/L*	T-P mg/L *Target: 0.05 mg/L*
BrC	**443**	4.2	**4.9**	0.05
BrW	192	4.2	**4.6**	**0.09**
MuC	**407**	8.7	**4.2**	**0.1**
ReR	**772**	7	**5.7**	**0.07**
SCU	**291**	7	**3.9**	**0.08**
SCM	**434**	9.4	**5.3**	**0.06**
SCD	166	11.6	**3.5**	**0.07**
SpC	**276**	4.7	**3.5**	0.05

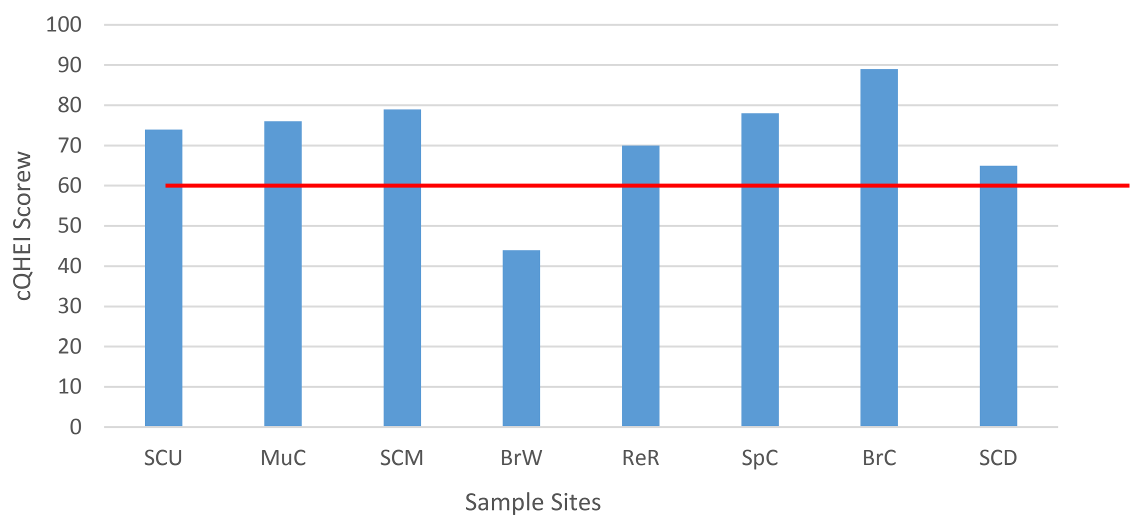

Figure 24. BWSC Citizen Qualitative Habitat Evaluation Index (cQHEI) assessments conducted Oct. 21, Oct. 26 & Dec. 8th of 2015. Scores are arranged in from upper reaches of BWSC to the BWSC outlet (left to right). A cQHEI score ≥60 is able to support biotic life; it is highlighted by the horizontal line.

Section 4. Subwatersheds of the Browns Wonder- Sugar Creek Watershed

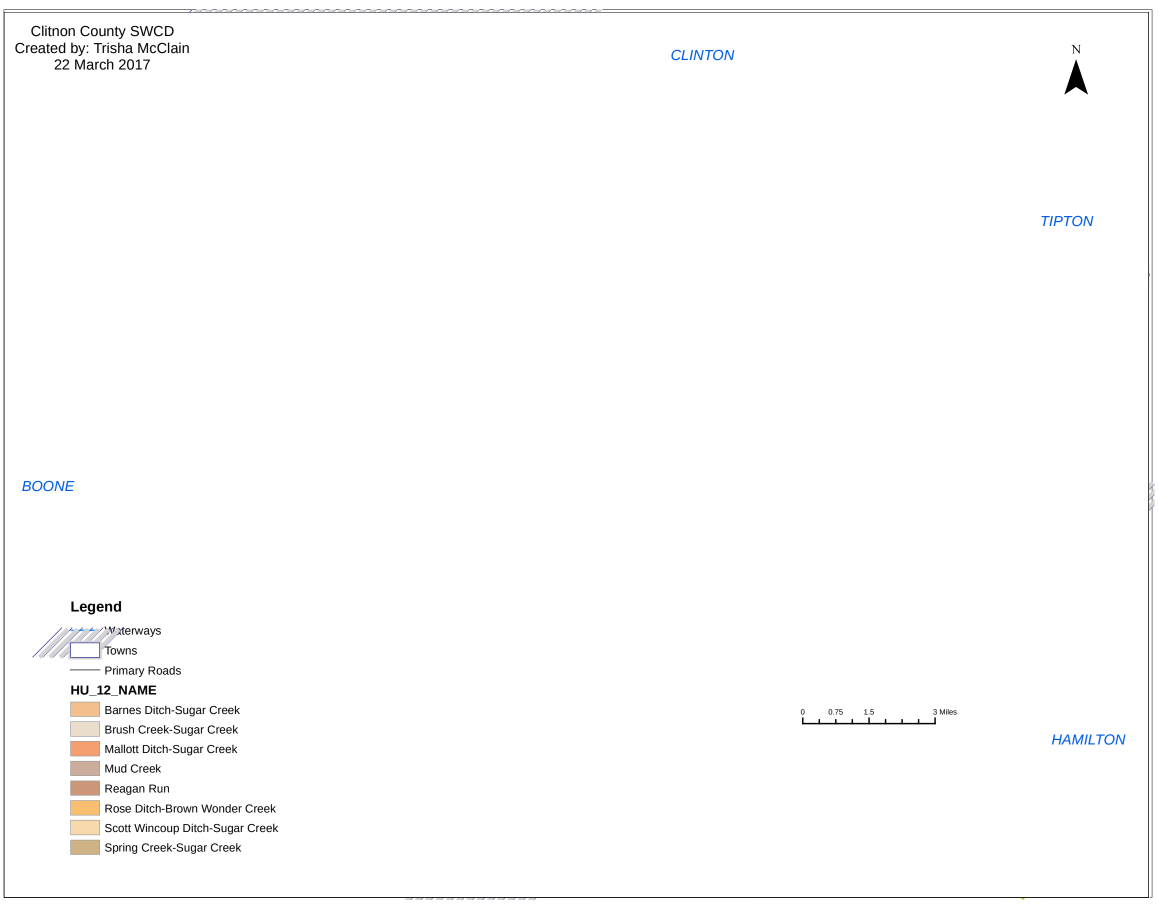

Figure 25. Browns Wonder-Sugar Creek Subwatersheds

Brown's Wonder- Sugar Creek Watershed is comprised of 8 subwatersheds: Mallott Ditch- Sugar Creek, Scott Wincoup Ditch- Sugar Creek, Mud Creek, Rose Ditch-Browns Wonder Creek, Barnes Ditch- Sugar Creek, Reagan Run, Spring Creek- Sugar Creek and Brush Creek- Sugar Creek (Figure 25).

4.1 Mallott Ditch-Sugar Creek (HUC: 051201100101)

Land Use

Mallott Ditch- Sugar Creek Watershed is the most northeastern drainage area of the Brown's Wonder-Sugar Creek Watershed. It is approximately 12,710 acres that is predominantly used as cropland, specifically corn and soybean (Figure 26). The drainage area is about 6 square miles of Clinton County and a small portion of Tipton County. There is about 16 miles of natural waterways within this subwatershed which includes: South Branch Sugar Creek, Pickard Creek, Mallott Ditch, Loucks Ditch and the headwater Sugar Creek. Almost 8 miles of waterways (Mallott Ditch (INB1011_05) and Sugar Creek (INB1011_02)) (Figure 27) have been listed as impaired for biotic communities (Table 1). According to the Clinton County Surveyor's office 93% of the waterways are designated as open ditch. There has been about 15.5 miles of subsurface tile documented and installed within this subwatershed (Figure 27).

Figure 26. Mallott Ditch- Sugar Creek Watershed Landscape (NLCD, 2011)

Figure 27. Mallott Ditch-Sugar Creek Watershed Drainage (Clinton Co. Surveyor, 2014)

Soils within Mallott Ditch- Sugar Creek Watershed are largely hydric (Figure 28). Almost 60% of the land can be classified under hydric soils. Hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems). Hydric soils provide suitable soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. The hydric soils that reside within this watershed are Cyclone silt loam (Cy), Mahalasville silty clay loam (Ma), Patton silty clay loam (Pn), Ragsdale silt loam (Ra), Sable-Drummer silty clay loams (Sc) & Westland silty clay loam (We). Approximately 15 acres are considered Highly Erodible Lands (HEL) according to NRCS soils database, Clinton County and Boone County Soil Survey. According to NRCS there is minimum land that can be classified as Highly Erodible Lands (HEL). In addition to HEL there are soils present that are consider Potentially Highly Erodible Land (PHEL) by NRCS; however, these soil types primarily reside along Sugar Creek and Mallott Ditch (Figure 28).

Figure 28. Mallott Ditch- Sugar Creek Watershed Soils (SSURGO, 2015)

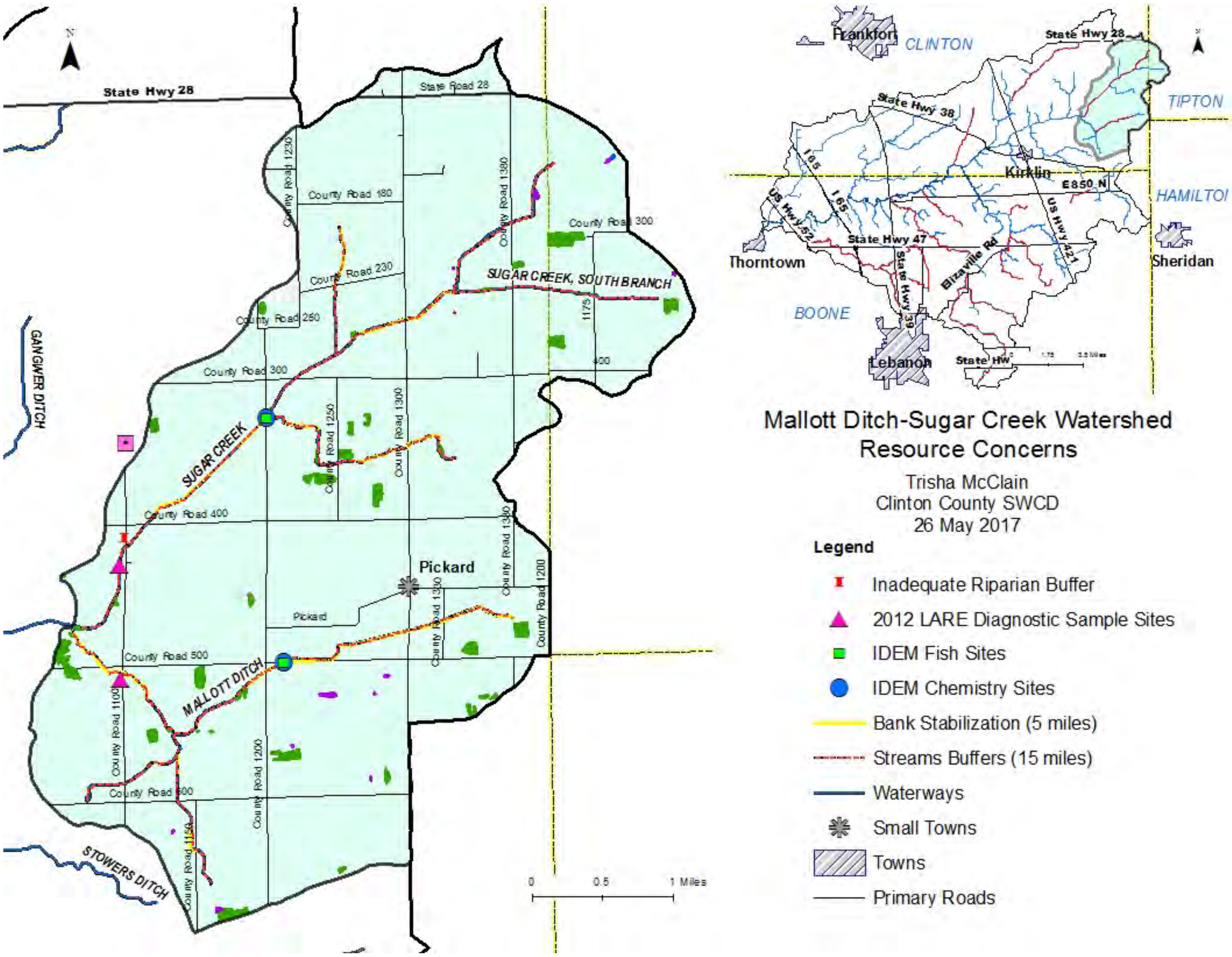

Figure 29. Mallott Ditch-Sugar Creek Watershed Resource Concerns (IDEM, 2015)

Water Quality

IDEM 305(b)/ 303(d)

Approximately 8 miles of the waterways (Sugar Creek (INB1011_02) & Mallott Ditch (INB1011_05)) within the Mallott Ditch- Sugar Creek Watershed are classified as having “impaired biotic communities” (Table 1). Biotic impairments listed within in this subwatershed are a result of a variety of factors. GIS data would suggest that the riparian zone (i.e. the interface between land & a river/stream that is primarily forested or composed of vegetation) is minimal, leaving it exposed to sunlight & extreme changes in weather conditions. High temperatures in warm waterways decrease dissolved oxygen levels, creating anoxic conditions (>2 mg/L); degrading the biotic community. In addition, by having a small riparian zone, pollutants through surface water run-off are less likely to be filtered before entering local waterways; increasing nutrient levels. Surface water run-off from point (subsurface tile) & nonpoint sources have also been identified as a source of high nutrient levels. Current phosphorus levels from 2012 LARE Diagnostic Study & IDEM Historical Sampling, do not support a healthy biotic community. IBI and QHEI scores also indicate that most of the poor biotic communities sampled are a result of habitat instead of water quality because IBI scores surpass QHEI scores (Figure 30).

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study two sites were located in Mallott Ditch- Sugar Creek Watershed. Water quality was assessed on two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 18). Site 1 evaluated Sugar Creek and Site 2 evaluated Mallott Ditch water quality (Figure 29). All of the nutrients evaluated only TSS meet current target values.

Table 18. 2012 LARE Diagnostic Study Water Quality Analysis of Mallott Ditch- Sugar Creek Watershed

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Sugar Creek *(Site 1)*	**172**	**0.3**	**0.15**	**0.4**
Mallott Ditch *(Site 2)*	**48**	**0.5**	**0.28**	**2**
HIGH FLOW (August 10, 2012)				
Sugar Creek *(Site 1)*	**162**	**0.2**	**0.54**	**8**
Mallott Ditch *(Site 2)*	**1,800**	**0.6**	**0.85**	**12.8**

IDEM Historical Sampling (1999-2015)

Chemical, biological and habitat analysis occurred at two locations throughout the Mallott Ditch-Sugar Creek watershed. One was conducted just above Pickard Ditch confluence on CR 1200 E south of CR 300 S while the second was done at the bridge on CR 500 S just east of CR 1200 E. Chemical analysis for both sites occurred on August 16, 2005. On August 5, 2016 habitat (QHEI) & fish communities (IBI) were evaluated. The site located above Pickard Ditch scored a 34 out of 100 while the site on the bridge of CR 500 S received a 30 out of 100 neither of which reached the overall target of 51. The IBI scores were compared with the QHEI scores to determine whether the aquatic communities, within the site, are due to water quality issues or habitat issues. In this particular instance, both IBI scores surpass QHEI scores indicating that habitat is not sufficient enough to support that biotic community (Figure 30). Chemical data, presented in Table 19; reveals that total phosphorus and total suspended sediment exceed current target values.

Table 19. IDEM Historical Sampling Program of Mallott Ditch- Sugar Creek Watershed (1999-2015)

SITES	CR 1200 E south of CR 300 S	CR 500 S just east of CR 1200 E
Chemical Analysis		
Nitrate-Nitrite	0.01 mg/L	0.03 mg/L
Total Phosphorus	0.89 mg/L	0.24 mg/L
Total Suspended Sediment (TSS)	110 mg/L	25mg/L

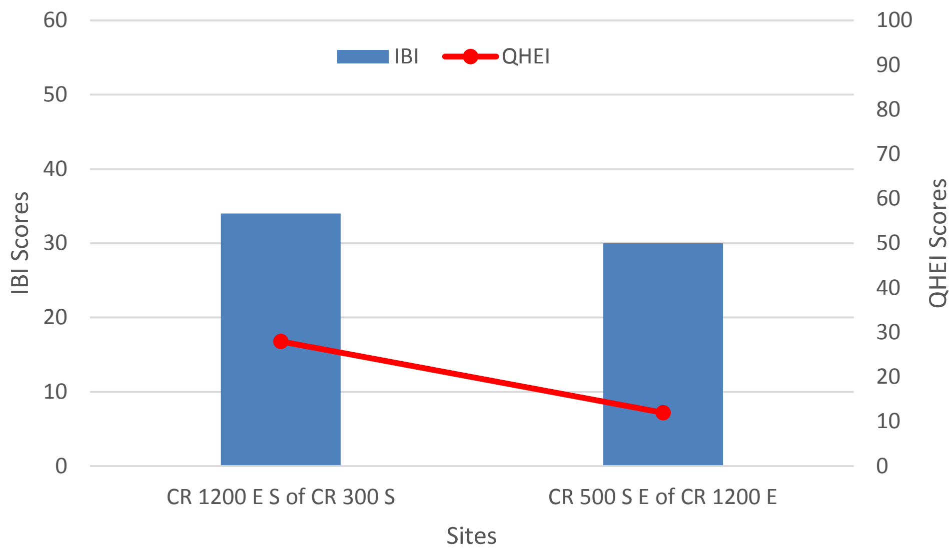

Figure 30. Comparative analysis of Index of Biotic Integrity Index (IBI) score and Qualitative Habitat Evaluation Index (QHEI) scores conducted during IDEM Historical Sampling Program (1999-2015) in Mallott Ditch- Sugar Creek Watershed

Watershed Inventories

Windshield Survey

Limited data was obtained during the 2015 windshield survey in Mallott Ditch-Sugar Creek Watershed. Since the windshield survey is conducted by volunteers and is dependent on accessibility & availability of volunteers, data points were limited within this watershed. Only two points were taken within the watershed and both points indicated an inadequate riparian buffer along Sugar Creek (Figure 29). In this instance, the term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system.

Desktop Survey

The Mallott Ditch- Sugar Creek Watershed has the small town of Pickard; otherwise, there is minimal development within the watershed. Approximately 8 acres are designated as freshwater emergent wetlands while 142 acres are classified as forested/shrub wetlands which are isolated woodlots, scattered across the watershed (Figure 29). Currently there are no active confined feeding operations (CFOs) or NPDES permitted facilities within the Mallott Ditch- Sugar Creek Watershed. After GIS analysis, approximately 15 miles require stream buffers and 5 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events. The term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system.

Mallott Ditch-Sugar Creek Watershed Assessment

Mallott Ditch- Sugar Creek Watershed is the upper most subwatershed in the Browns Wonder-Sugar Creek Watershed, the actions conducted within these 12,710 acres may have direct environmental impact on the watershed such as the biotic impairments designated by IDEM's 303(d) list for Sugar Creek (6 stream miles) and Mallott-Ditch (2 stream miles), but most of the private land management & development that occurs within this subwatershed will accumulate and travel downstream to the other subwatersheds within Browns Wonder-Sugar Creek Watershed.

Mallott Ditch- Sugar Creek Watershed has a robust agricultural industry that occupies both Clinton and Tipton County. Water quality data presented above showcases the immediate concern within this subwatershed would be the 8 miles of impaired stream miles. Habitat and biotic assessments collected throughout the subwatershed would indicate degraded biotic integrity is due to the lack of habitat along stream corridors, not from water quality (Figure 30). This is further justified from the 2011 land use data (Figure 26), which indicates that only 1.4% (172 acres) of the landscape is designated as forested. The forested areas are either small scattered woodlots disbursed across the landscape or shallow wooded corridors along waterways. The lack of a riparian zone, interface between land & a river/stream, is one of the main contributors to poor biotic communities because it leaves waterways exposed to sunlight & changing weather conditions. During the summer months water temperatures increase which decreases available dissolved oxygen, degrading biotic integrity.

There is some additional concern about nutrient export (i.e. total phosphorus) & pathogens within this subwatershed. Water quality from 2005 (IDEM Historical Sampling Program) and the 2012 LARE Diagnostic Study would indicate that total phosphorus often exceeds the targeted value for this project of 0.08 mg/L (optimal concentration for biotic integrity). Land use within this subwatershed is primarily agriculture (92%) and is composed of hydric or poor-draining soils, subsurface drainage tiles are heavily used within the area (15.5 miles) to increase productivity and efficiency of cropland (Figure 27). Subsurface drainage tiles discharges directly into local waterways, serving as a direct conduit for nutrient export. Subsurface drainage tiles are not the only source of nutrient export, nutrients can also be exported through stormwater & agricultural run-off. It is difficult to identify specific sources of run-off, but practices and actions conducted by rural communities as well as local agricultural operations are contributing factors to pollution transported by surface water run-off. In addition to nutrient export, pathogens such as E. coli should be monitored, especially in areas that discharge to Mallott Ditch (site 2) from the 2012 LARE Diagnostic Study (Figure 29). *E. coli* target values during low flow were not exceeded during monitoring (indicating a septic issue), target values in 2012 during high flow were exceeded at Mallott Ditch (Site 2).

The rise in deforestation and industrialized agriculture has resulted in minimal habitat and excessive nutrients to sustain healthy biotic communities. The subwatershed does not showcase significant issues other than 8 miles of impaired biotic communities; however, since it is the upper most subwatershed it is the start of the “problem” and though effects may not be seen within the subwatershed, impacts that occur within this subwatershed are likely being showcased further downstream. Due to the size of the subwatershed, its geographic location within BWSC and since most of the pollutant levels are below project target values the subwatershed has been designated as a Tier 3 Critical Land Area (CLA). Meaning, though there are water quality concerns within the subwatershed, implementation efforts will take high priority in subwatersheds with a higher classification such as Tier 1 CLA or Tier 2 CLA because water quality concerns are higher in Tier 1 & 2 subwatersheds.

4.2 Scott Wincoup Ditch-Sugar Creek (HUC: 051201100102)

Land Use

Scott Wincoup Ditch- Sugar Creek Watershed is the largest subwatershed of the Brown's Wonder- Sugar Creek Watershed, with approximately 35,243 acres (Figure 31). The drainage area is 15 square miles of Clinton and Boone County. The land use within the subwatershed is primarily agricultural cropland (soybeans (16, 529 acres) and corn (14, 245 acres)). There is approximately 40 acres that was difficult to map due to the small acres scattered across the landscape which would include Double Crop Rotation (33 ac), Pop or Orn Corn (1 ac), and Open Water (6 ac). There is about 47 miles of natural waterways within this subwatershed which includes: Ruddell Ditch, Scott Ditch, Scott Wincoup Ditch, Powers Ditch, Stoops Ditch, Stowers Ditch, Hart Loucks Ditch, Wiley Ditch, McClamrock Ditch, and the headwater Sugar Creek (Figure 32). Approximately 7 of those stream miles are listed on IDEM's 303(d) list, as having impaired biotic communities (Scott Wincoup Ditch (INB1012_T1007) & Stowers Ditch (INB1012_T1005)) (Figure 33 & Table 1). According to the Clinton County Surveyor, Scott Wincoup- Sugar Creek Subwatershed has 16 miles of waterways designated as open ditches and there are 36 miles of subsurface drainage tile (Figure 32).

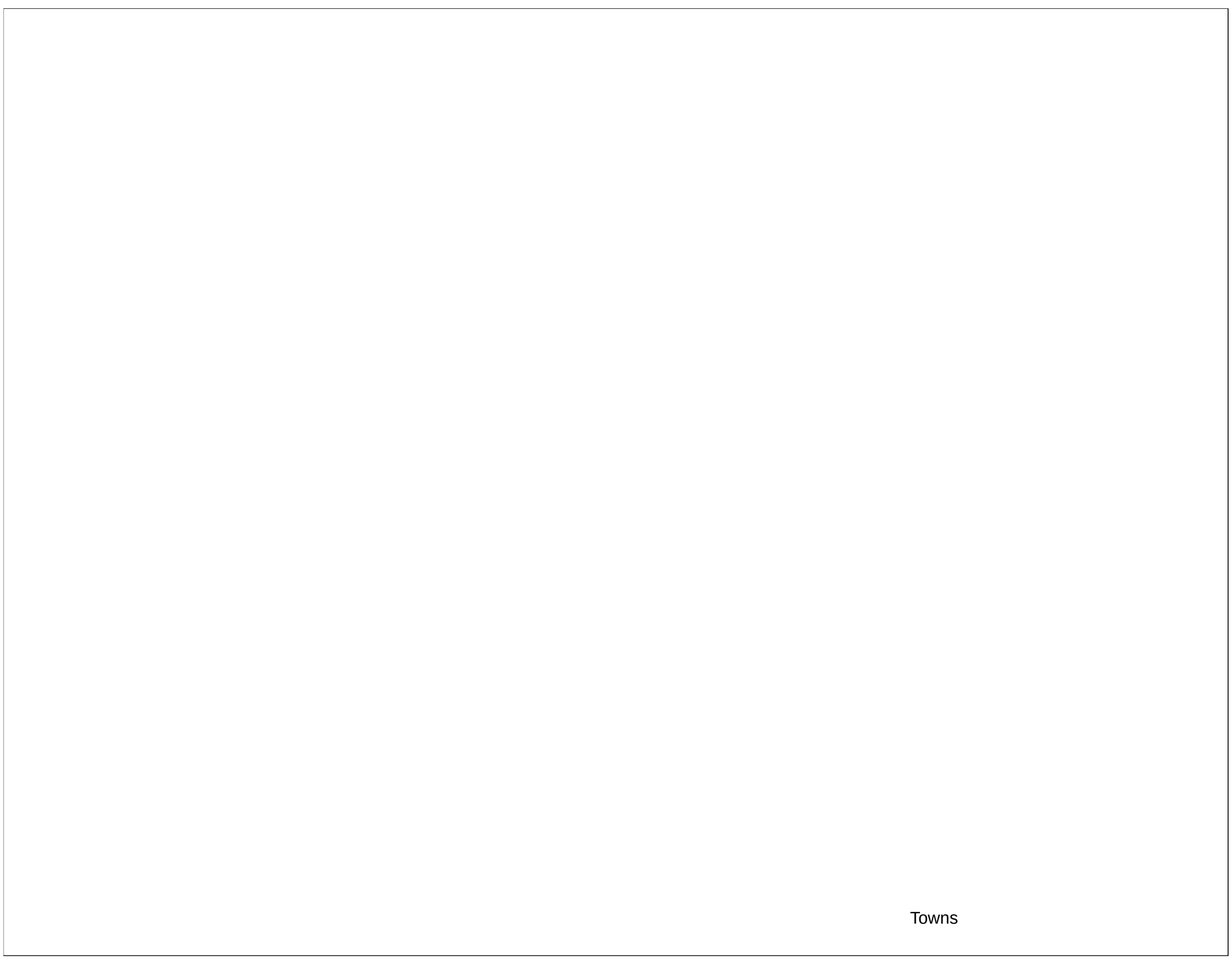

Figure 31. Scott Wincoup-Sugar Creek Watershed Landscape (NLCD, 2011)

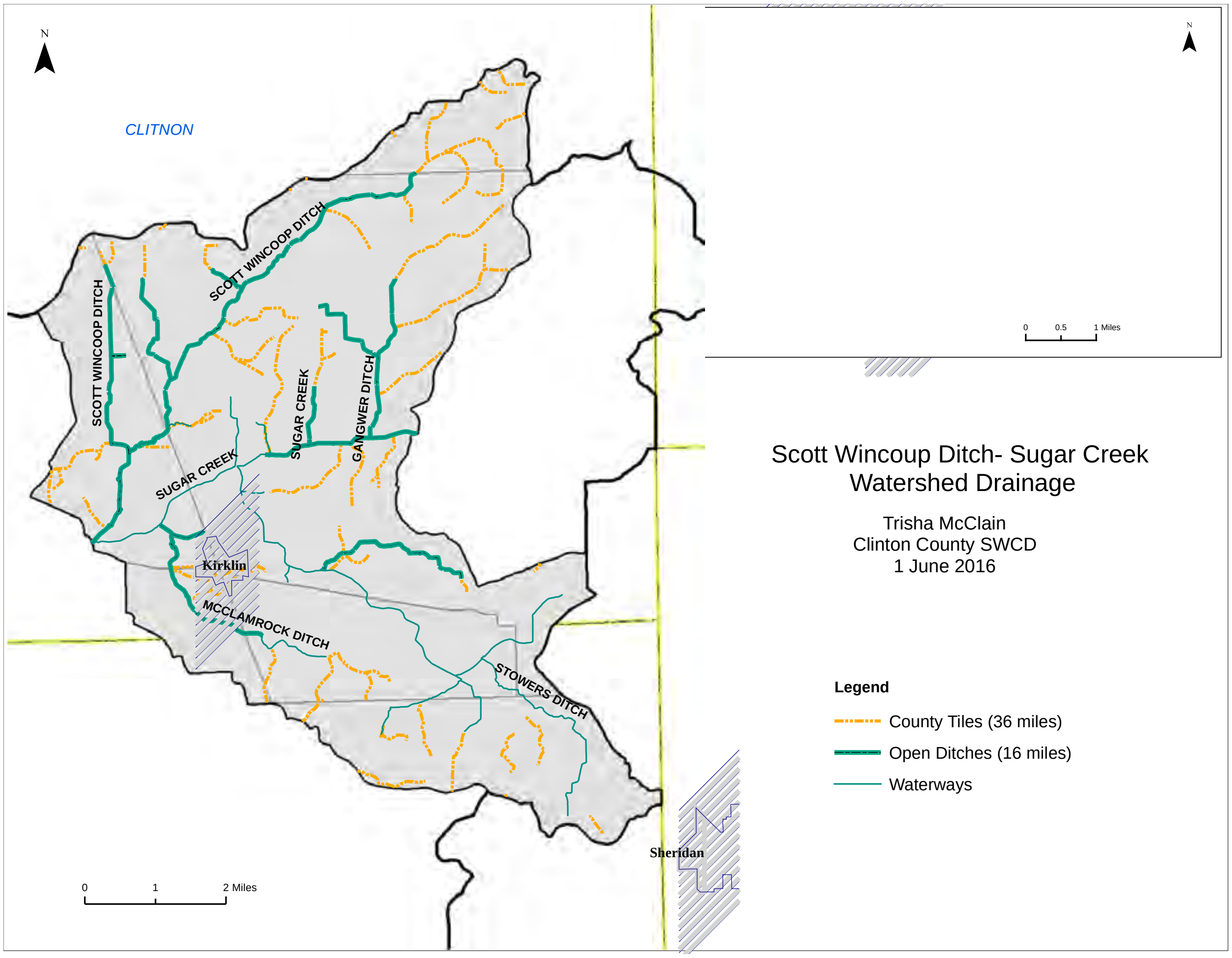

Figure 32. Scott Wincoup Ditch-Sugar Creek Watershed Drainage (Clinton & Boone Co. Surveyor, 2014)

Soils within Scott Wincoup Ditch- Sugar Creek Watershed is predominately composed of hydric soils (Figure 33). Almost 65% of the land can be classified under hydric soils. Hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems). Hydric soils provide suitable soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. Almost 25% of lands can be classified as potentially Highly Erodible Lands (PHEL) according to NRCS and the Clinton County and Boone County Soil Survey. There is some land classified as Highly Erodible Lands (HEL); within this subwatershed, but is located closer to the confluence of Sugar Creek on the eastern side of the watershed.

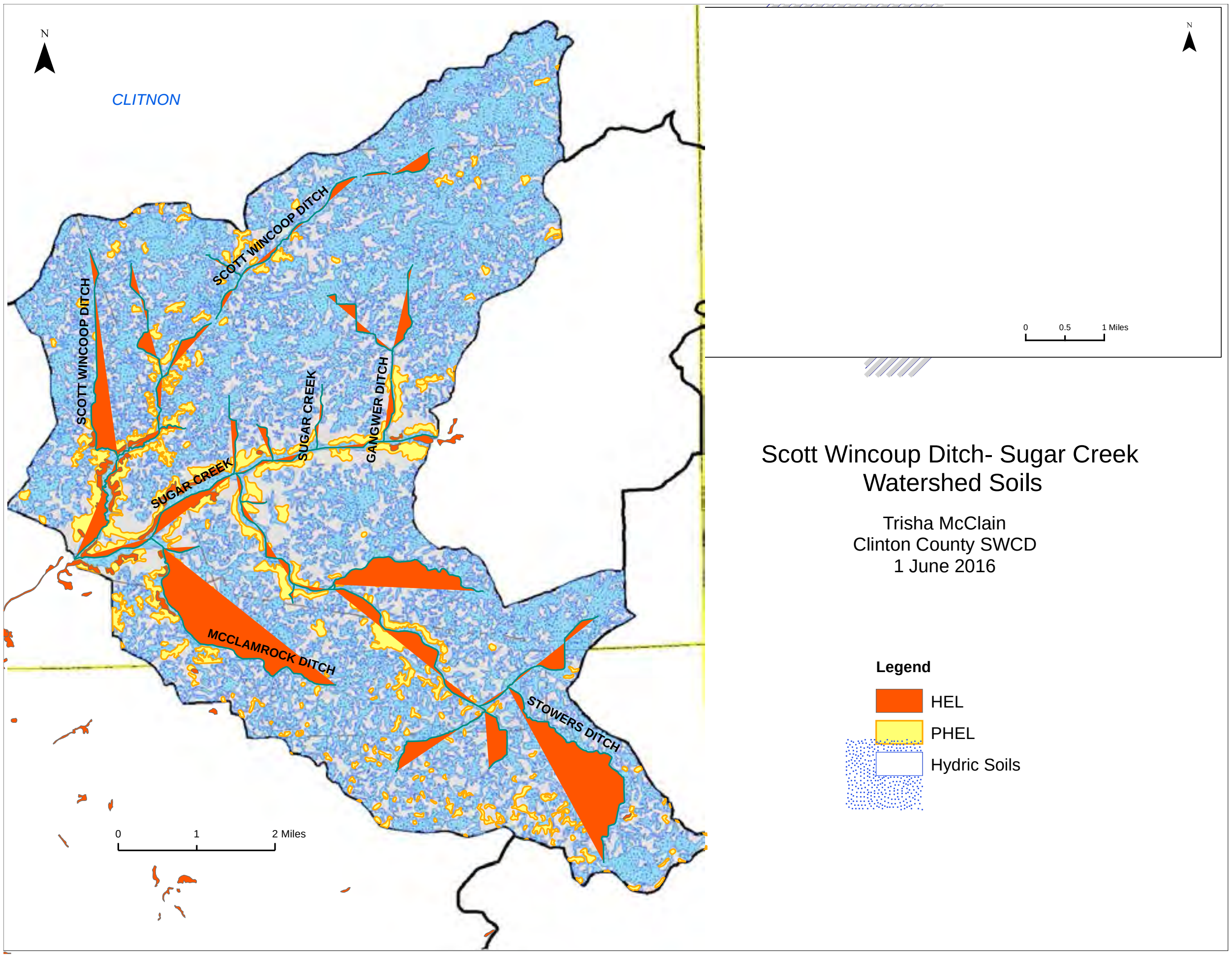

Figure 33. Scott Wincoup Ditch-Sugar Creek Watershed Soils (SSURGO, 2015)

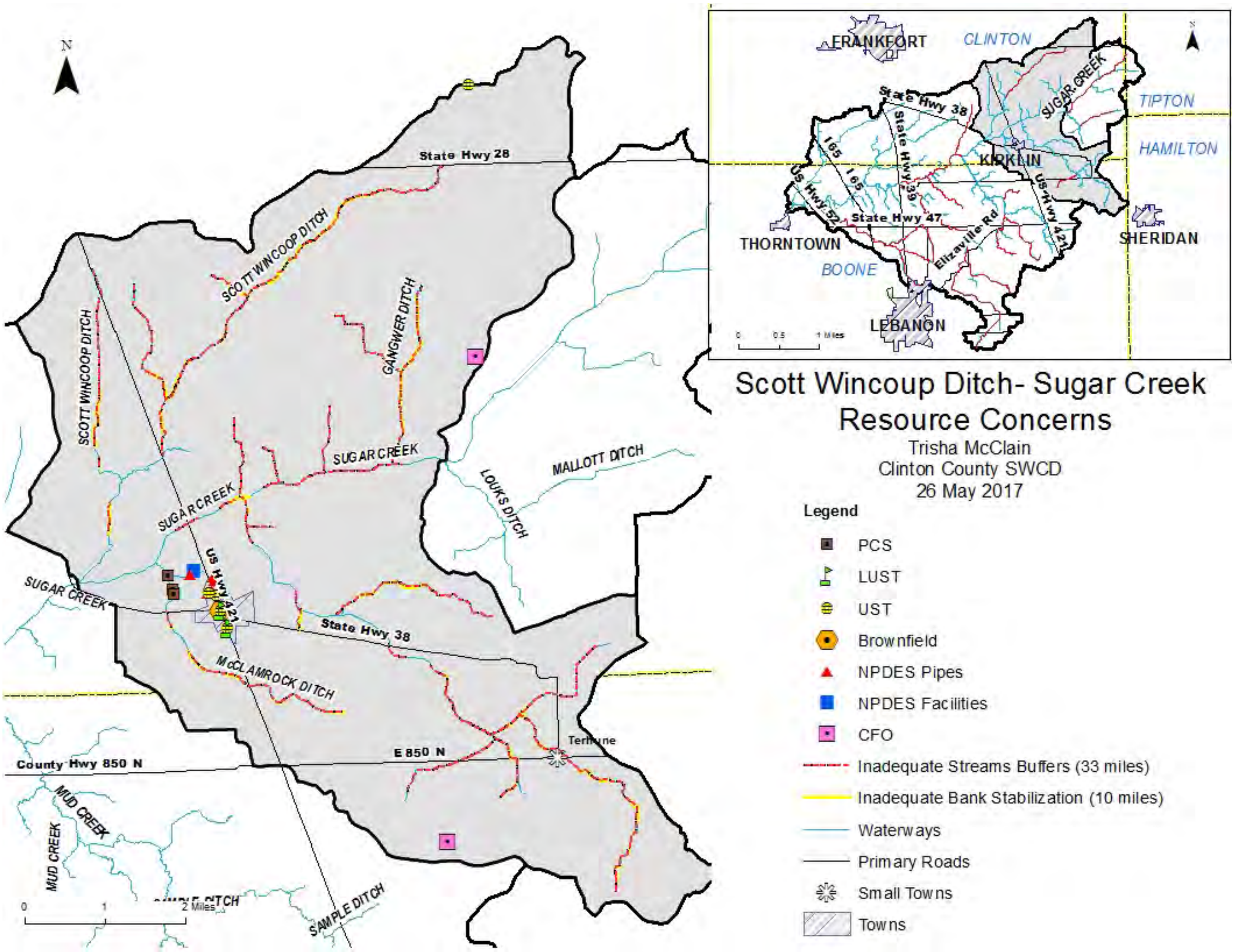

Figure 34. Scott Wincoup-Sugar Creek Watershed Resource Concerns (IDEM, 2015)

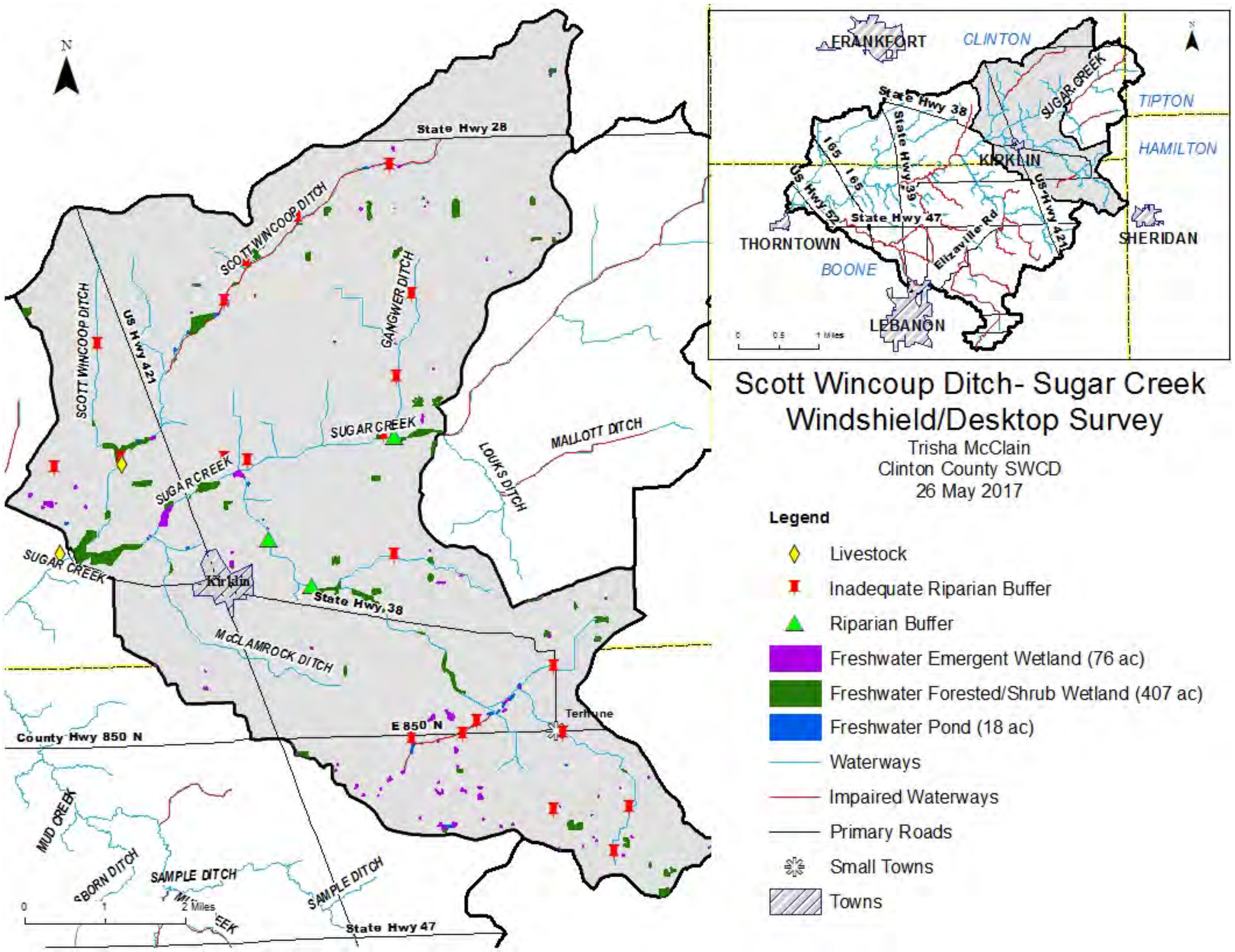

Figure 35. Scott Wincoup- Sugar Creek Watershed Windshield/ Desktop Survey (Clinton Co. SWCD, 2015)

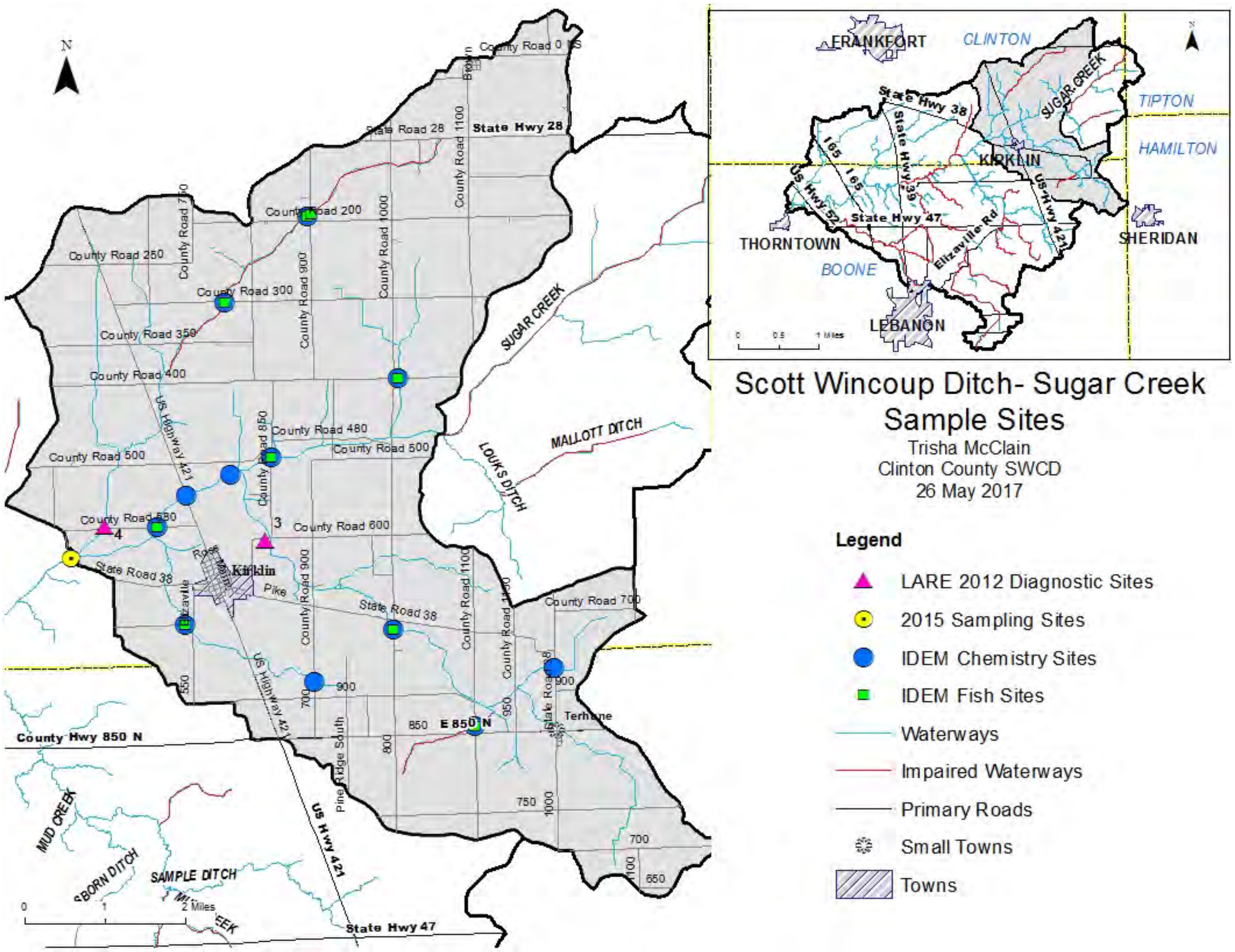

Figure 36. Scott Wincoup Ditch-Sugar Creek Water Quality & Biotic Sample Sites (IDEM, 2015)

Water Quality

IDEM 305(b)/ 303(d)

There is approximately 7 miles of the waterways that have been declared impaired, which would include Scott Wincoup Ditch and Stowers Ditch. Both waterbody impairments are classified as having "impaired biotic communities" (Figure 32 & Table 1). Biotic impairments listed within in this subwatershed is a result of a variety of factors. GIS data would suggest that the riparian zone (i.e. the interface between land & a river/stream that is primarily forested or composed of vegetation) is minimal, leaving it exposed to sunlight & extreme changes in weather conditions. High temperatures in warm waterways decrease dissolved oxygen levels, creating anoxic conditions (>2 mg/L); degrading the biotic community. In addition, by having a small riparian zone, pollutants through surface water run-off are less likely to be filtered before entering local waterways; increasing nutrient levels. Surface water run-off from point (subsurface tile) & nonpoint sources have also been identified as a source of high levels of nutrients. 2015 monitoring efforts indicated nitrogen, phosphorus, turbidity & dissolved oxygen levels do not support a healthy biotic community. IDEM IBI & QHEI scores also indicate that poor biotic communities are a result of habitat instead of poor water quality because IBI scores surpassed QHEI scores (Figure 37). However site CR 300 S W of CR 830 E from IDEM Historical Sampling, indicated poor biotic communities were a result of water quality instead of habitat (QHEI scores surpassed IBI scores).

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study three sites were located in Scott Wincoup- Sugar Creek Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 20). Sites were located on the western portion of the watershed near Kirklin (Figure 35); all pollutants except for TSS surpassed current target values.

Table 20. 2012 LARE Diagnostic Study Water Quality Analysis of Mallott Ditch- Sugar Creek Watershed

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Stowers Creek *(Site 3)*	**90**	**0.6**	**0.42**	**5.6**
Scott Wincoup *(Site 4)*	**241**	**0.7**	**0.3**	**9.2**
HIGH FLOW (August 10, 2012)				
Stowers Creek *(Site 3)*	**638**	**0.7**	**0.14**	**10**
Scott Wincoup *(Site 4)*	**4,760**	**0.5**	**0.16**	**14.8**

IDEM Historical Sampling (1999-2015)

IDEM had sixteen locations for chemical analysis, one *E.coli* sample was taken at CR Road 900 E (40.2589, -86.3382) and both Index of Biotic Integrity (IBI) & Qualitative Habitat Evaluation Index (QHEI) were conducted at nine different sites on August 16, 2005. Results would conclude as the following: a geometric average of 42 MPN/ 100mL in *E. coli*, an average of 0.16 mg/L in Nitrate, 0.21 mg/L in Phosphorous and 9.75 mg/L in Total Suspended Sediment (TSS) (Table 21). The habitat assessment would indicate that the streams are below ideal, but a majority are classified as “Fair to Good”. In regards to Figure 37, the bar graph represents IBI scores while the red line represents QHEI scores. Areas in which there is a gap between the two is an indicator of poor water quality (Site at CR 900 E N of CR 850 N & CR 300 S W of CR 830 E). Habitat is an issue when IBI scores surpass QHEI scores (all remaining sites). When IBI and QHEI scores meet it indicates that the habitat is sufficient for that aquatic community and the stream presents good water quality.

Table 21. IDEM Historical Sampling Program of Scott Wincoup Ditch-Sugar Creek Watershed (1999-2015)

Site	Date Sampled	Latitude	Longitude	Nitrate- Nitrite mg/L	Total Phosphorus mg/L	TSS mg/L
SR 421	6-8-99	40.2083	-86.3672	11	0.13	4
CR 500 S	7-29-99	40.2121	-86.3567	0.14	0.085	13
CR 900 E	7-26-04	40.2589	-86.3382	7.43	0.0895	11.5
CR 400 S	8-16-05	40.2293	-86.3170	0.03	0.57	29
CR 850 E	8-16-05	40.2152	-86.3472	0.14	0.125	10.5
CR 1000 E	8-16-05	40.1838	-86.3186	0.17	0.22	2
CR 900 E N of CR 850 N	8-16-05	40.1661	-86.2994	0.56	0.35	3
CR 700 S	8-16-05	40.1849	-86.3676	1.3	0	3

CR 580 S	8-16-05	40.2026	-86.3741	0.37	0.13	5
CR 200 S	8-16-05	40.2592	-86.3374	0	0.53	40
CR 300 S W of CR 830 E	8-16-05	40.24345	-86.3579	0.06	0.23	23
SR 38	8-16-05	40.1765	-86.2804	0.14	0.19	3
CR 900 E N of CR 900 N	8-16-05	40.1744	-86.3374	0.02	0.28	29
CR 500 S W of SR 421	8-16-05	40.2139	-86.3835	0.18	0.14	9
CR 300 S E SR 421	8-16-05	40.2431	-86.3758	0.05	0.26	18
CR 580 S	8-16-05	40.2002	-86.3738	4.1	0.65	4

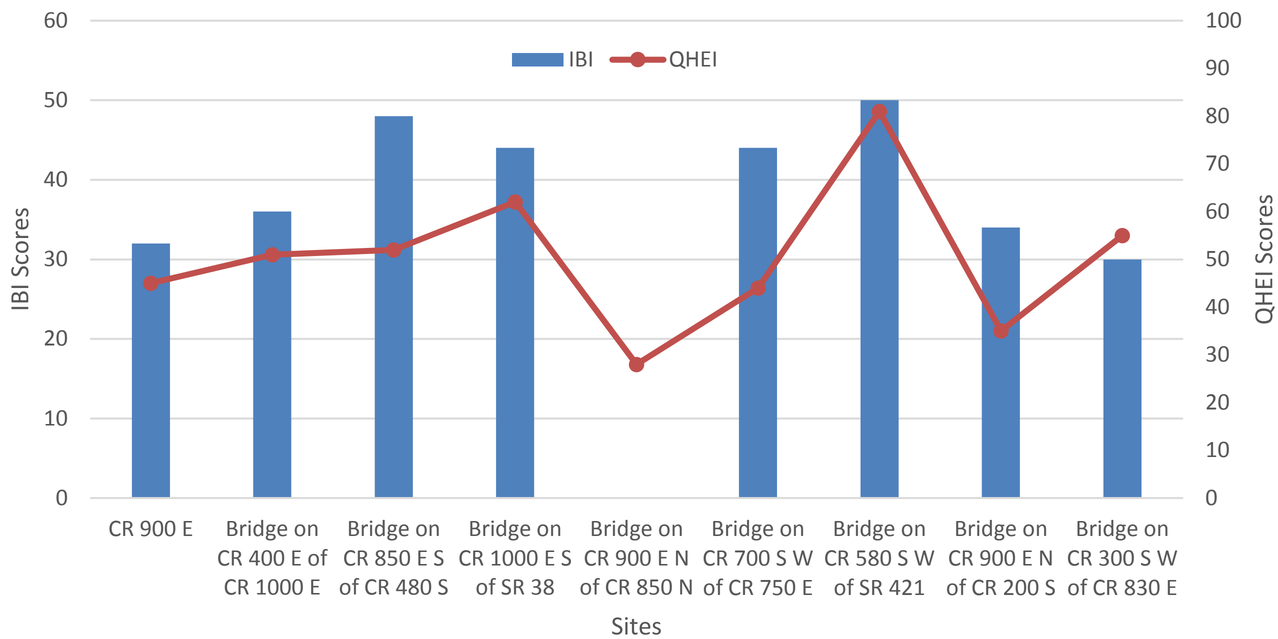

Figure 37. Comparative analysis of Index of Biotic Integrity Index (IBI) score and Qualitative Habitat Evaluation Index (QHEI) scores conducted during IDEM Historical Sampling Program (1999-2015) in Scott Wincoup- Sugar Creek Watershed

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had a sample site at the confluence (outlet) of Scott Wincoup Ditch- Sugar Creek Watershed, labeled site SCU (Sugar Creek-Upstream (SCU); located on State Road 38 in Clinton County. A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 22). Bolded items indicate values that exceed established project target values (Table 15). The cQHEI assessment was conducted on October 21, 2015 with a score of 74; which surpasses project target value (60) & indicates habitat is able to sustain healthy aquatic communities.

Table 22. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at sample site Sugar Creek-Upstream (SCU) located at Scott Wincoup Ditch-Sugar Creek Watershed outlet. Items bolded are values that have exceeded the established target values in Table 14

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=23]	19	174	**291**	**613**	**2,420**	**78%**
TSS mg/L[n=23]	2.1	3.3	7	15	**90**	26%
Nitrate-Nitrite mg/L [n=22]	0.1	0.9	**3.9**	**6.8**	**11.7**	**86%**
T-P mg/L [n=22]	0	0.03	**0.08**	**0.12**	**1**	**50%**
Turbidity NTU [n=17]	6.6	8.7	**15.9**	**28.9**	**105**	**71%**
Dissolved Oxygen [D.O.] mg/L	**3.3**	4	4.3	6.2	**11.5**	29%

Watershed Inventories

Windshield Survey

In the 2015 windshield survey, 22 sites were documented as being "inadequate riparian buffer;" there was an area with a significant presence of livestock and three sites had established riparian buffers (Figure 35). Over the years there have been numerous Confined Feeding Operations (CFOs) (Figure 34), but only two remain active today; noted in Desktop Survey.

Desktop Survey

The Scott Wincoup Ditch- Sugar Creek Watershed has three rural communities (Kirklin, Scircleville & Terhune) and two active confined feeding operations (CFOs) [Sugar Creek Ag LLC & Don E. Orr Sine Farm] (Figure 34). Both CFO operations are compliant & have not received any violations. The Sugar Creek Ag LLC contains Nursery Pigs [450], Finishers [1500] & Sows [194] while Don E. Orr Sine Farm, a larger operation, contains Nursery Pigs [1500], Finishers [3750] & Sows [1350]. Please note, CFOs have been mentioned within the WMP to indicate a potential source of pollutants within the subwatershed. Further action or detail about CFOs will not be described or addressed.

The brownfield is H & H Machinery Moving, located near Kirklin. There have not been any violation reported; data was collected on February 9, 2011. There were two leaking underground storage tanks identified within the watershed [Pepsi-Cola Lebanon & H & H Machinery Moving], all sites have been evaluated and are being monitored with no current issues. There is a National Pollution Discharge Elimination System (NPDES) facility outside of Kirklin, located within the subwatershed (Kirklin Waste Water Treatment Plant [NPDES ID IN0020630]), no violations have been reported. All point sources (NPDES pipes and Pollution Control Standard [PCS] pipes) are considered external outfall that discharges into McClamrock Ditch, no incidents have been reported. An NPDES permit can be individual or general permit and NPDES permit writers calculate end-of-pipe water quality based effluent limits (WQBELs), where necessary, to ensure that receiving waters attain water quality standards. PCS are very similar, they are permits that ensure receiving waters meet their water quality standards but cannot be provided to an individual. Please note information provided about NPDES, PCS & additional resource concerns listed in Table 23 are to provide a general assessment of potential sources that can contribute to water quality concerns within the subwatershed; there will be no additional detail provided.

After GIS analysis, approximately 33 miles require stream buffers and 10 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events (Figure 34). In this instance, the term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system. Approximately 76 acres of emergent wetlands scattered across the watershed, 407 acres of freshwater forested/ shrub wetland and 18 acres are designated as freshwater ponds (Figure 35).

Table 23. Resource Concerns within Scott Wincoup Ditch-Sugar Creek Watershed discovered through windshield and desktop surveys (IDEM GIS Data, 2015)

Resource Concerns that Affect Water Quality	Amount
Brownfield	1
Leaking Underground Storage Tank (LUST)	2
Underground Storage Tank (UST)	6
Confined Feeding Operations (CFO)	2
National Pollutant Discharge Elimination System (NPDES)	Facility:1 Pipes: 8
Facilities that Discharge to Water (pipe) (PCS)	Pipes:6

Scott Wincoup Ditch-Sugar Creek Watershed Assessment

Scott Wincoup Ditch- Sugar Creek Watershed is the largest subwatershed with 35,243 acres. Even though this subwatershed occupies approximately 30% of the total BWSC watershed there is only 7 miles of waterways that are classified as having impaired biotic communities. These impaired waterbodies are Scott Wincoup Ditch (5 stream miles) and Stowers Ditch (2 stream miles). Similar to Mallott Ditch- Sugar Creek Watershed, the subwatershed may appear to have low water quality concerns however impacts will not be completely showcased at this subwatershed level, most of the effects will accumulate and travel downstream to the other subwatersheds within Browns Wonder-Sugar Creek Watershed.

Scott Wincoup Ditch- Sugar Creek Watershed resides in both Clinton and Boone County with nearly 87% of the landscape designated as cropland (soybeans or corn). A robust agriculture can result in a high volume of subsurface drainage tile, which are direct conduits for nutrient export. This subwatershed has approximately 36 miles of subsurface tile. Water quality data would indicate that the immediate concern within this subwatershed would be the 7 miles of impaired stream miles. Biotic degradation can be a result of high nutrient levels (i.e. nitrate, total phosphorus and *E. coli*). Water quality from 2005 (IDEM Historical Sampling Program) and the 2012 LARE Diagnostic Study would indicate that total phosphorus often exceeds the targeted value for this project of 0.08 mg/L (optimal concentration for biotic integrity) while nitrate-nitrite concentrations occasionally exceeded target values of 1.6 mg/L, but concentrations have not exceed standard drinking concentrations (10 mg/L). During 2015 monitoring, on average the subwatershed exceeded target values in *E. coli* [less than 235 cfu/ 100ML], Nitrate [1.6 mg/L], and Turbidity [10.4 NTU]. In addition, habitat and biotic assessments would indicate the degraded biotic integrity is primarily due to the lack of habitat. This is further justified from the 2011 land use data (Figure 31), which indicates that only 2.5% (894 acres) of the landscape is designated as forested. However, there were some IDEM sites that indicated water quality is not suitable to sustain healthy biotic communities (Figure 37).

Scott Wincoup Ditch- Sugar Creek Watershed has been designated as a Tier 1 Critical Land Area (CLA). Based on stakeholder, ecological & environmental concerns, the steering committee considers this subwatershed as a high priority area. Implementation efforts will primarily target Tier 1 Critical Land Areas. The project's implementation strategy is to target conservation efforts towards upstream private land management and development while simultaneously and naturally impacting downstream resources. Scott Wincoup Ditch- Sugar Creek Watershed is the largest subwatershed located in the upper reaches (headwaters) of BWSC and it is the only subwatershed that contains a significantly populated town [Kirklin], which happens to have a NPDES-permitted waste water treatment plant, discharging to McClamrock Ditch. By designating the subwatershed as a high priority area, the project can effectively address water quality concerns and project objectives.

4.3 Mud Creek (HUC: 051201100103)

Land Use

Mud Creek Watershed is approximately 20,945 acres with a drainage area of 26 square miles of Clinton and Boone County. The watershed is dominated by agricultural practices such as corn (9,946 acres) and soybean (7,425 acres). There is approximately 9 acres that could not be placed on the map due to the acres scattered across the watershed which would include a Watermelon Farm (1 ac), and Open Water (8 ac) (Figure 38). There is about 34 miles of natural waterways within this subwatershed which includes: Mud Creek, Osborn Ditch, Sample Ditch, McCoy Ditch, Titus Ditch, Padgett Ditch and the headwater Sugar Creek (Figure 38). Almost 9 miles of waterways (Mud Creek (INB1013_T1004 & INB1013_T1007) &Padgett Ditch (INB1013_T1005)), are declared have impaired biotic communities according to IDEM's 303(d) list (Table 1).

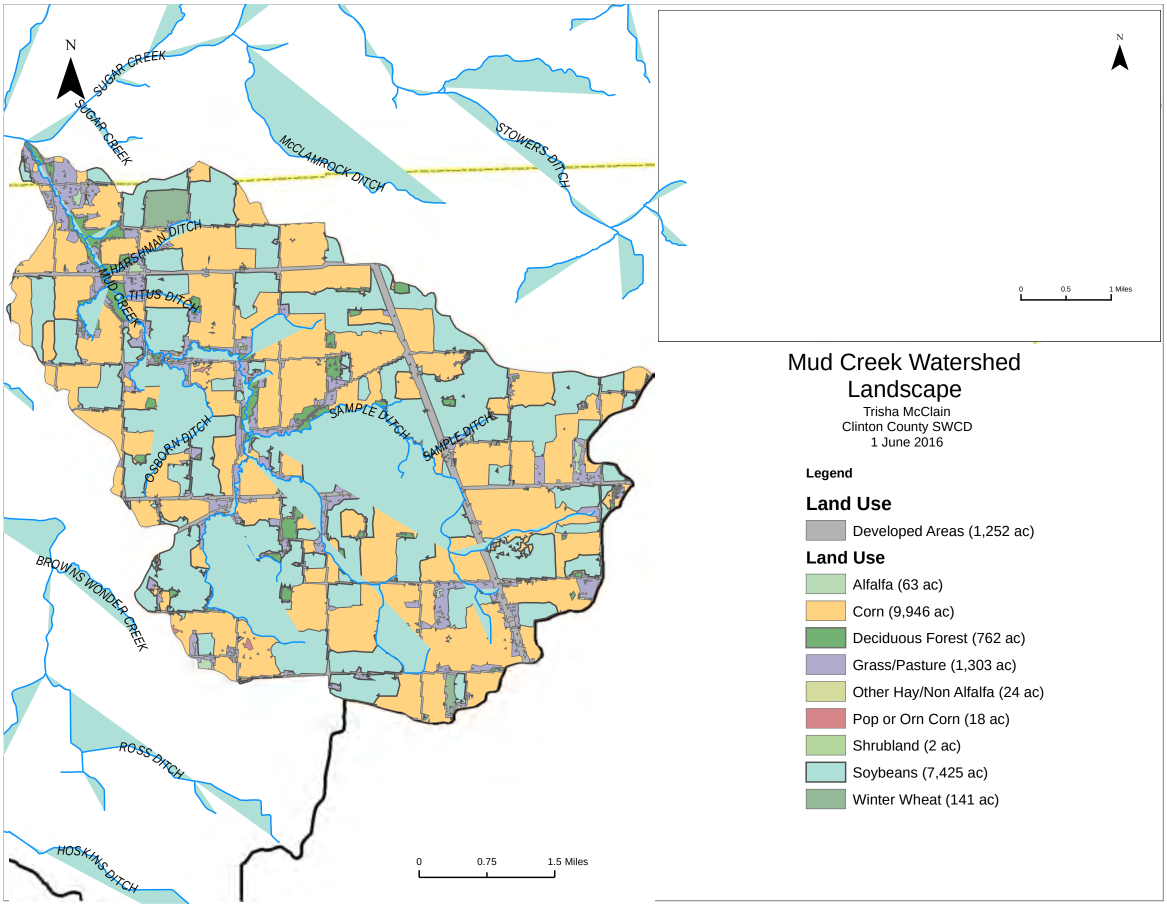

Figure 38. Mud Creek Watershed Landscape (NLCD, 2011)

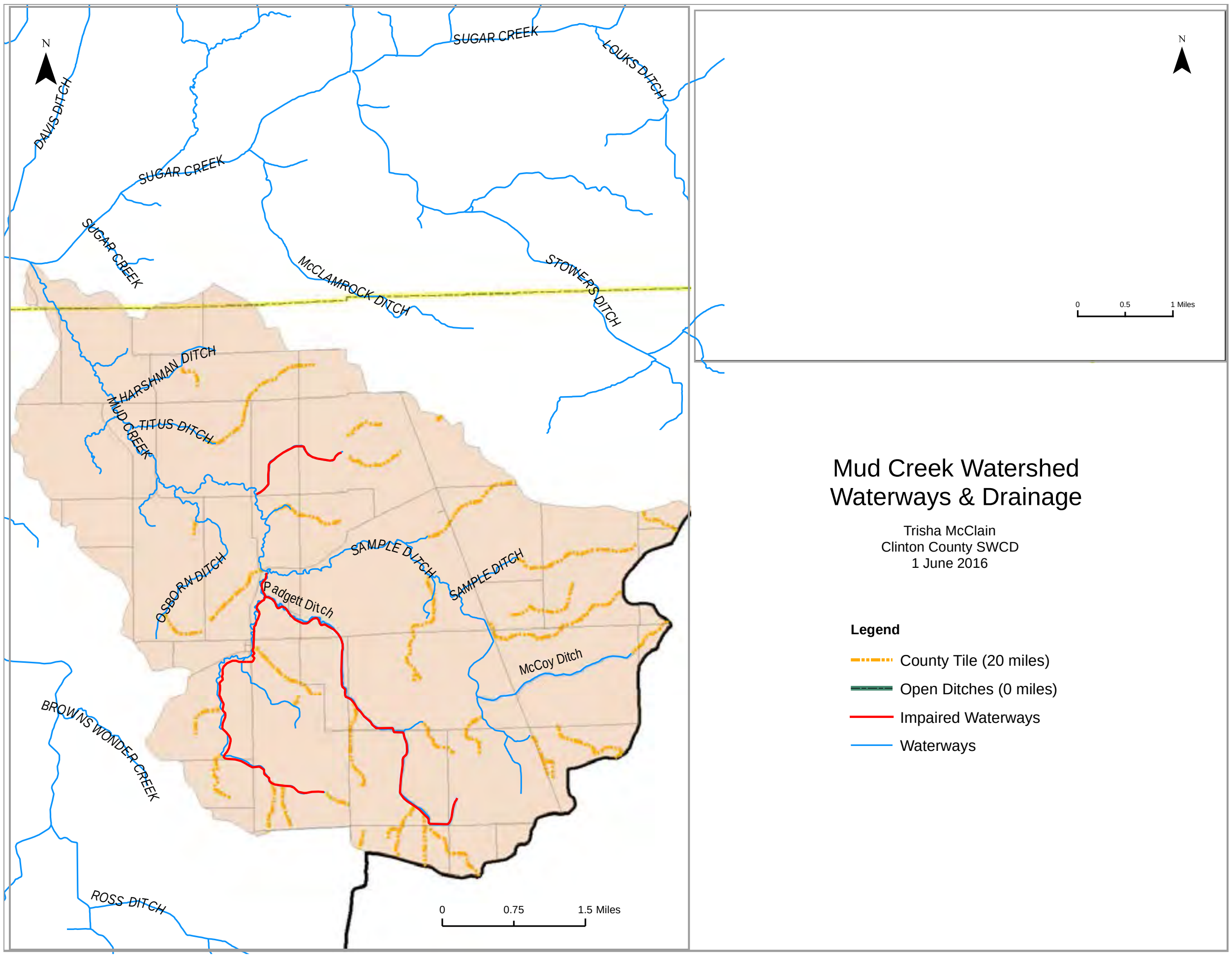

Figure 39. Mud Creek Watershed Waterways & Drainage (Boone Co. Surveyor, 2014)

Soils within Mud Creek Watershed is predominately composed of Treaty silty clay loam (ThrA), 0 to 1 percent slopes & Cyclone silt loam (Cy) hydric soils (Figure 40). Though hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems) it does provide excellent soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. There are only a few areas that contain Highly Erodible Lands (HEL) according to NRCS and the Clinton County and Boone County Soil Survey. However there are a significant amount of soils Potentially Highly Erodible Lands (PHEL), especially in the upper reaches of the watershed (Figure 40). The PHEL soils that dominate this area are Miami silt loam, 2 to 6 percent slopes, eroded (MnpB2) and Williamstown-Crosby silt loams, 2 to 4 percent slopes (WofB).

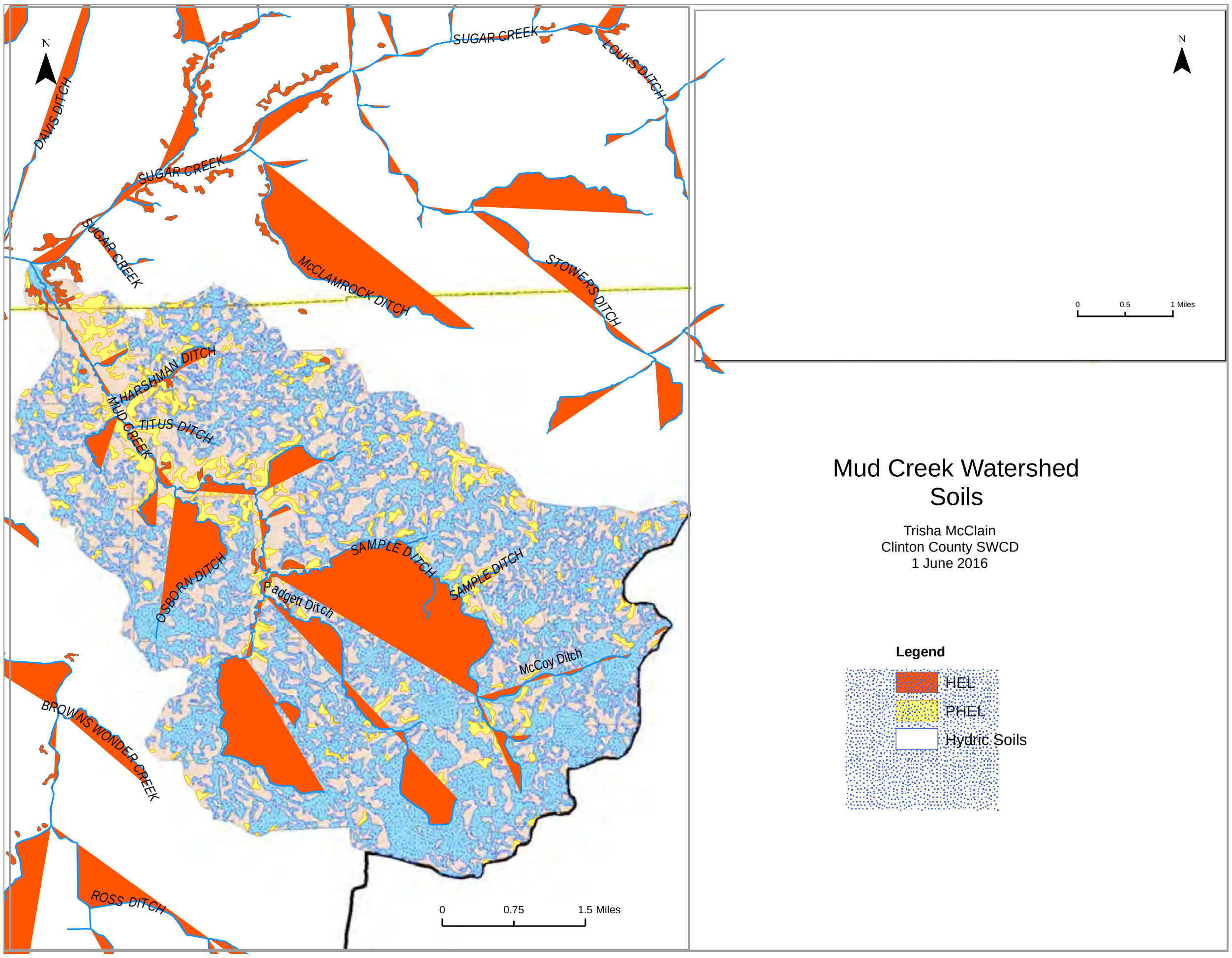

Figure 40. Mud Creek Watershed Soils (SSURGO, 2015)

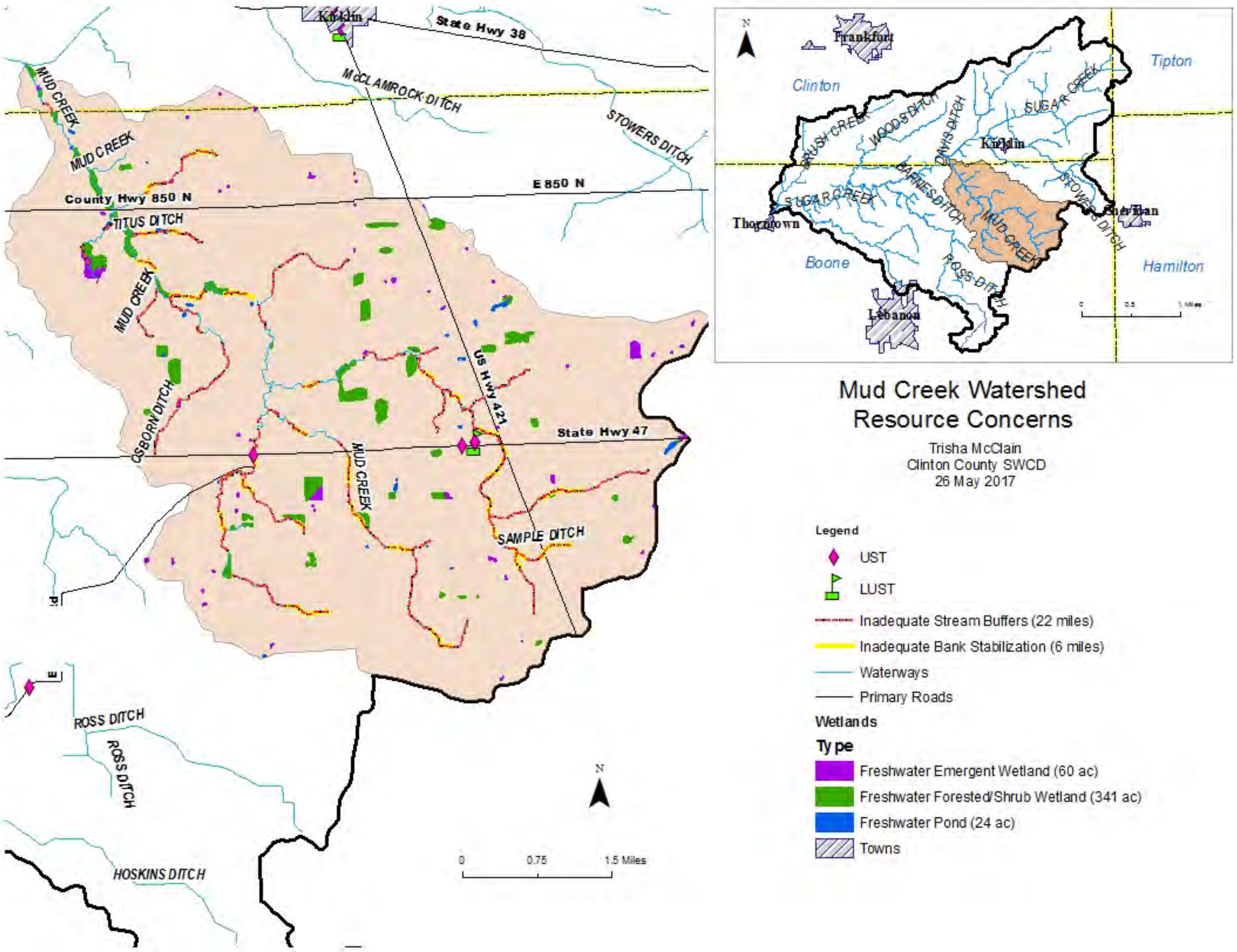

Figure 41. Mud Creek Resource Concerns (IDEM, 2015)

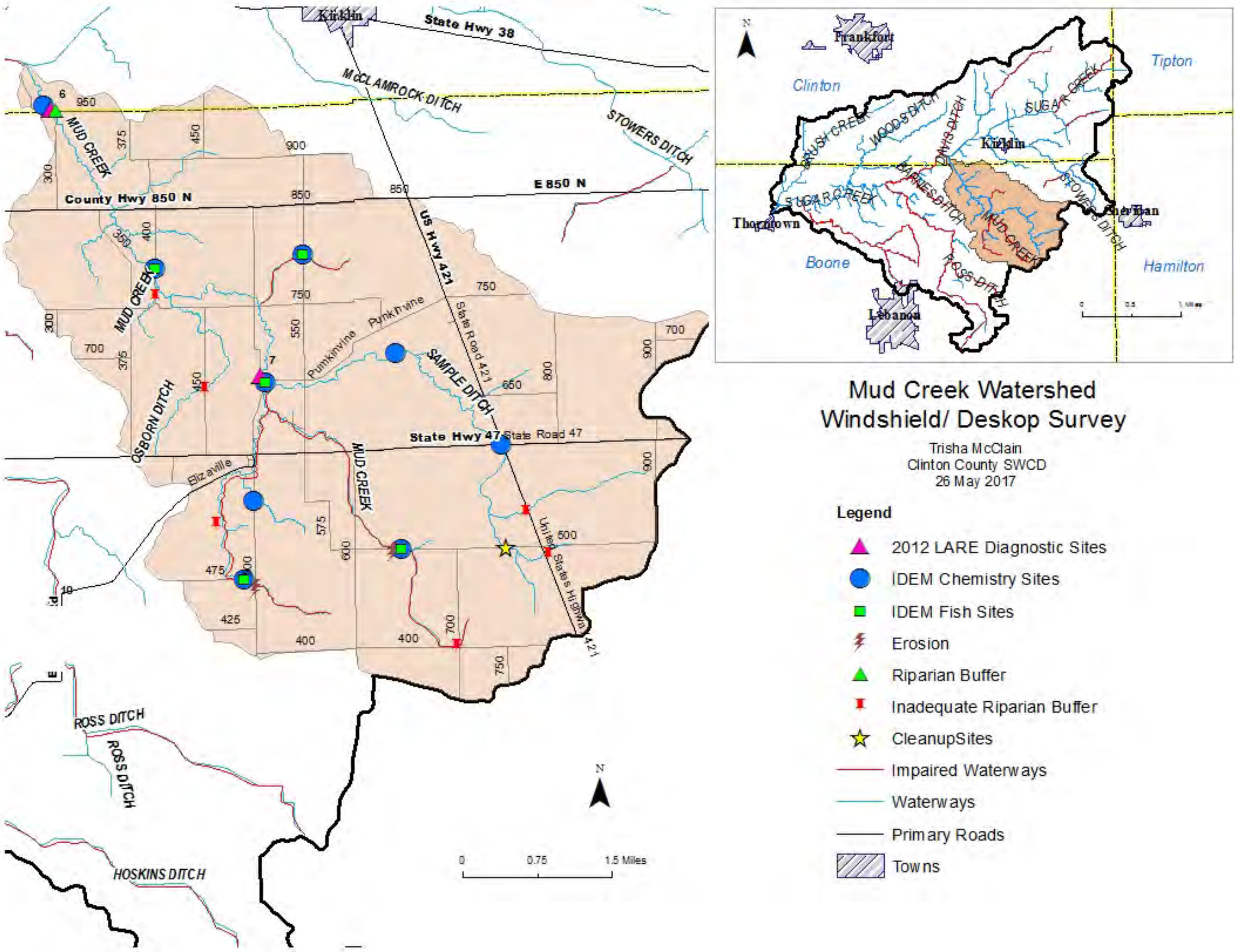

Figure 42. Mud Creek 2015 Windshield/ Desktop Survey (Clinton Co. SWCD, 2015)

Water Quality

IDEM 305(b)/ 303(d)

Approximately 9 miles of the waterways within Mud Creek Watershed which would include: Mud Creek and Padgett Ditch are classified as having "impaired biotic communities". Biotic impairments listed within in this subwatershed are a result of a variety of factors. GIS data would suggest that the riparian zone (i.e. the interface between land & a river/stream that is primarily forested or composed of vegetation) is minimal, leaving it exposed to sunlight & extreme changes in weather conditions. High temperatures in warm waterways decrease dissolved oxygen levels, creating anoxic conditions (>2 mg/L); degrading the biotic community. In addition, by having a small riparian zone, pollutants through surface water run-off are less likely to be filtered before entering local waterways; increasing nutrient levels. Surface water run-off from point (subsurface tile) & nonpoint sources have also been identified as a source of high nutrient levels. 2015 monitoring data resulted in high nitrogen, phosphorus, & turbidity levels, which do not support a healthy biotic community & exceed project target values. IBI and QHEI scores also indicate that most of the poor biotic communities sampled are a result of habitat instead of water quality because IBI scores surpass QHEI scores (Figure 43).

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study two sites were located in Mud Creek Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed & recorded (Table 24). Values exceeded current target values in *E. coli*, nitrate-nitrite and total phosphorus. Sites were located at the confluence of Mud Creek, near the Boone & Clinton County line (Site 6) and the central region of the watershed near Elizaville (Site 7).

Table 24. 2012 LARE Diagnostic Study Water Quality Analysis of Mud Creek Watershed

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Mud Creek *(Site 6)*	**124**	**0.4**	**0.08**	**5.6**
Mud Creek *(Site 7)*	**332**	**0.7**	**0.26**	**0.8**
HIGH FLOW (August 10, 2012)				
Mud Creek *(Site 6)*	**325**	**0.4**	**0.11**	**26**
Mud Creek *(Site 7)*	**2,110**	**0.4**	**0.85**	**21.6**

IDEM Historical Sampling (1999-2015)

IDEM had eight locations for chemical analysis and Qualitative Habitat Evaluation Index (QHEI) & Index of Biotic Integrity (IBI) was conducted at five different sites. Results would conclude as the following: an average of 1.15 mg/L in Nitrate, 0.19 mg/L in Phosphorous and 8.5 mg/L in Total Suspended Sediment (TSS) (Table 25). Nutrient values exceeded or were the current target values at all sites, except for *E.coli* concentrations at base flow on June 12, 2012 for Site 6. TSS met the target value of 25 mg/L, except for Site 6, during high flow. The habitat (QHEI) and biotic (IBI) assessment occurred on August 16, 2005 at five different sample sites. Results would indicate that sites CR 400 E & Pumpkin Ave do not have a sufficient habitat to sustain a healthy biotic community while the remaining sites have poor water quality, which is negatively impacting the biotic community (Figure 43).

Table 25. IDEM Historical Sampling Program of Mud Creek Watershed (1999-2015)

Site	Date Sampled	Latitude	Longitude	Nitrate- Nitrite mg/L	Total Phosphorus mg/L	TSS mg/L
750 S	7-26-04	40.17807	-86.4152	0.197	0.081	6
CR 400 E	8-16-05	40.15416	-86.3943	0.99	0.17	11
CR 550 E	8-16-05	40.15606	-86.366	0.08	0.66	39
CR 725 N	8-16-05	40.13735	-86.3734	1.2	0.18	4
CR 500 N	8-16-05	40.11279	-86.3476	1.9	0.26	15
CR 475 N	8-15-05	40.10846	-86.3775	1.1	0.76	77
SR 47	8-17-05	40.12793	-86.3285	2.1	0.09	6
CR 500 E	8-15-05	40.12009	-86.3756	0.77	0.19	5

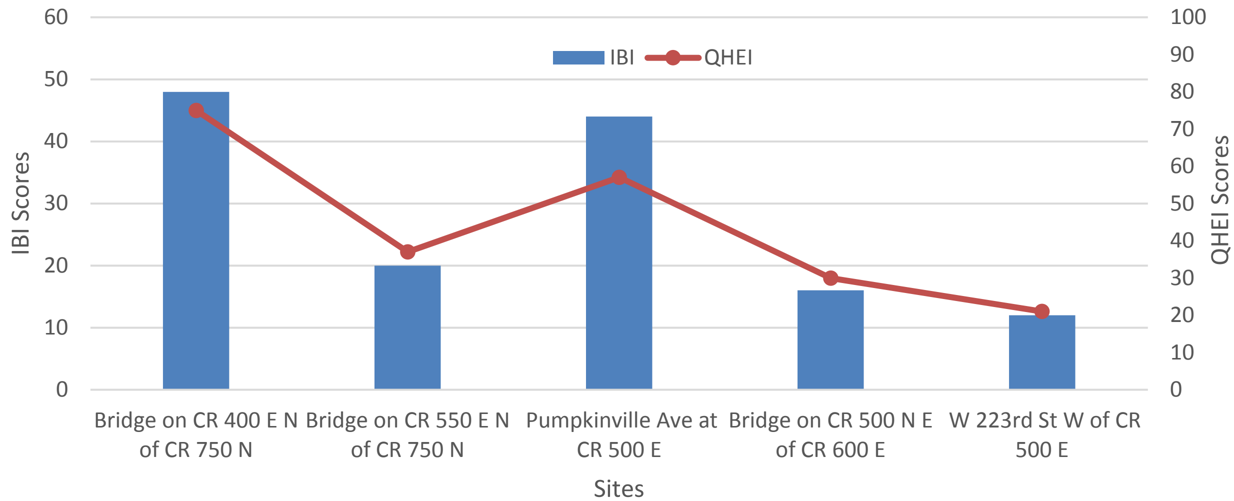

Figure 43. Comparative analysis of IBI and QHEI scores conducted by IDEM through the Historical Sampling Program on Mud Creek Watershed

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had a sample site Mud Creek referred to as MuC that was located at the confluence of Mud Creek and Sugar Creek. A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 26). Bolded items indicate values that exceed established target values (Table 15). The cQHEI assessment was conducted on October 21, 2015 with a score of 76.5; which indicates the habitat is able to sustain healthy aquatic communities and surpasses the project target value of 60.

Table 26. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Mud Creek (MuC) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli **cfu/ 100mL [n=22]**	77.1	182.5	**406.8**	**677.2**	**6,488.2**	**82%**
TSS mg/L [n=22]	2.6	6.2	8.6	21.4	**78.5**	27%
Nitrate-Nitrite mg/L [n=23]	0	0.16	**4.19**	**6.14**	**10.45**	**82%**
T-P mg/L [n=23]	0	0.03	**0.09**	**0.14**	**0.50**	**59%**
Turbidity NTU [n=17]	7.6	**12.1**	**20.8**	**27.3**	**120**	**88%**
Dissolved Oxygen [D.O.] mg/L [n=17]	**2.8**	**3.6**	4.2	6.4	**10.5**	**58%**

Watershed Inventories

Windshield Survey

Mud Creek Watershed indicated nine "inadequate riparian buffers;" primarily in the southern half of the watershed. In addition to inadequate buffers, erosion was prevalent on Mud Creek and Padgett Ditch (Figure 41 & 42). In this instance, the term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system. Livestock were sited twice within Mud Creek Watershed; one being near the eroded area on Padgett Ditch and the other in the northern region.

Desktop Survey

The Mud Creek Watershed has one small town known as Elizaville. The watershed itself has minor development which would include a few churches, eight canals and a cleanup site (an EPA environmental investigation of Exide Battery).
Exide Battery was a general battery company in 987 and continued to manufacture batteries until 1999. Exide's battery manufacturing process produced lead vapors and airborne lead dust. In April 2014, two Underground Storage Tanks (UST) were removed and revealed the presence of solvents in the soil and underground water supply. In 2015, EPA began soil testing and removing contaminated soil from residences that tested positive for lead; cleanup concluded on October 15, 2015. It is important to note, this cleanup effort was focused solely on pollutants tied to the Exide Battery facility and the USTs. The pollutants addressed in this WMP are linked to impaired waters and known water quality concerns from the stakeholder community.

There are two underground storage tanks [Frontier Co Op & Coopertive Seed INC.] and one has been designated as a Leaking Underground Storage Tank (LUST) [Frontier Co Op]. The LUST tank was evaluated in 2003 & there have been no incidents reported (Table 27). Please note that resource concerns listed in Table 27 or described within this section (i.e. cleanup) are to provide a general assessment of potential sources that can contribute to water quality concerns within the subwatershed; there will be no additional detail provided.

Table 27. Resource Concerns within Mud Creek Watershed (IDEM GIS Data, 2015)

Resource Concerns that Affect Water Quality	Amount
Leaking Underground Storage Tank (LUST)	1
Underground Storage Tank (UST)	2
Confined Feeding Operations (CFO)	0

After GIS analysis, approximately 22 miles require stream buffers and 8 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events. The term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system. Approximately 426 acres are designated as wetlands [i.e. emergent, forested/shrub, freshwater pond & riverine]; however, 80% of those wetlands (341 acres) are freshwater forested/ shrub wetlands (Figure 41).

Mud Creek Watershed Assessment

Mud Creek Watershed resides in Boone County with nearly 83% of the landscape designated as cropland (soybeans or corn). Concerns within the watershed would be impaired waterways classified by IDEM, pathogens, sedimentation (turbidity), nitrogen & phosphorus.

Mud Creek (5 stream miles) and Padgett Ditch (4 stream miles) have been listed on IDEM's 303(d) Impaired Waterways list for impaired biotic communities (Table 1). Biotic degradation can be a result of a variety of factors such as poor water quality or poor habitat. Habitat and biotic assessments from IDEM's Historical Sampling, would indicate that degraded biotic integrity is a result of both habitat and water quality. A total of 5 sites were analyzed, two sites showcased habitat deficiencies, two sites showcased water quality deficiencies while the remaining site indicated both habitat and water quality were sufficient to sustain healthy biotic communities. Further justification of a poor habitat within the subwatershed would be minimal forested acres along stream corridors. According to 2011 NLCD data, only 782 acres (0.04%) are considered to be forested. Those forested acres are primarily scattered woodlots or shallow stream corridors; exposing waterways to intense sunlight & promoting hypoxic conditions.

Degraded water quality may be a result of point & nonpoint source pollution. The subwatershed has a robust agricultural industry coupled with hydric soils which has resulted in a significant amount of subsurface tiles (20 miles); serving as direct conduits for nutrient export (i.e. point source pollution). Riparian zones also buffer and filter surface water run-off, so by minimizing vegetation & forested acres it increases nutrient export. High nitrogen, phosphorus & turbidity levels (exceeded target values) were documented in IDEM historical sampling and 2015 BWSC sampling. In addition, the subwatershed exceed *E. coli* project target values (less than 235 cfu/ 100 mL) in historical data (IDEM & LARE) and during 2015 monitoring efforts as well. High pathogen concentration could be a result of livestock having open access to streams from undocumented hobby farms, surface water run-off or septic systems. Since levels tended to rise after significant rain events & would decline at low flow instead of remaining high during low flow, high concentration levels are more likely a result of surface water run-off or livestock open access than a septic system issue.

Mud Creek Watershed has been designated as a Tier 1 Critical Land Area (CLA). Based on stakeholder, ecological & environmental concerns, the steering committee considers this subwatershed as a high priority area. Implementation efforts will primarily target Tier 1 Critical Land Areas. The project's implementation strategy is to target conservation efforts towards upstream private land management and development while simultaneously and naturally impacting downstream resources. By designating the subwatershed as a high priority area, the project can effectively address water quality concerns and project objectives.

4.4 Rose Ditch-Brown Wonder Creek (HUC: 051201100104)

Land Use

Rose Ditch-Brown Wonder Creek Watershed is approximately 20,039 acres of those acres 19,094 acres are designated as cropland, pasture, developed areas and deciduous forests, the remaining 945 acres are designated as open water (i.e. lakes and ponds), wetlands or waterways (Figure 44). The subwatershed is only located within Boone County & has a drainage area of approximately 26 square miles. There is 28 miles of natural waterways within this subwatershed and 21 miles of those waterways (Browns Wonder Creek (INB1014_03), Hoskins Ditch (INB1014_T1003), & Rose Ditch-Browns Wonder Creek (INB1014_T1004)) are listed with biotic impairments (Figure 45). Waterways within the watershed would include: Browns Wonder Creek, Rose Ditch, & Hoskins Ditch. According to county surveyor data, the subwatershed has approximately 28 miles of documented subsurface drainage tiles installed throughout the landscapes. In addition, there is no documented open ditches within the watershed (Figure 45).

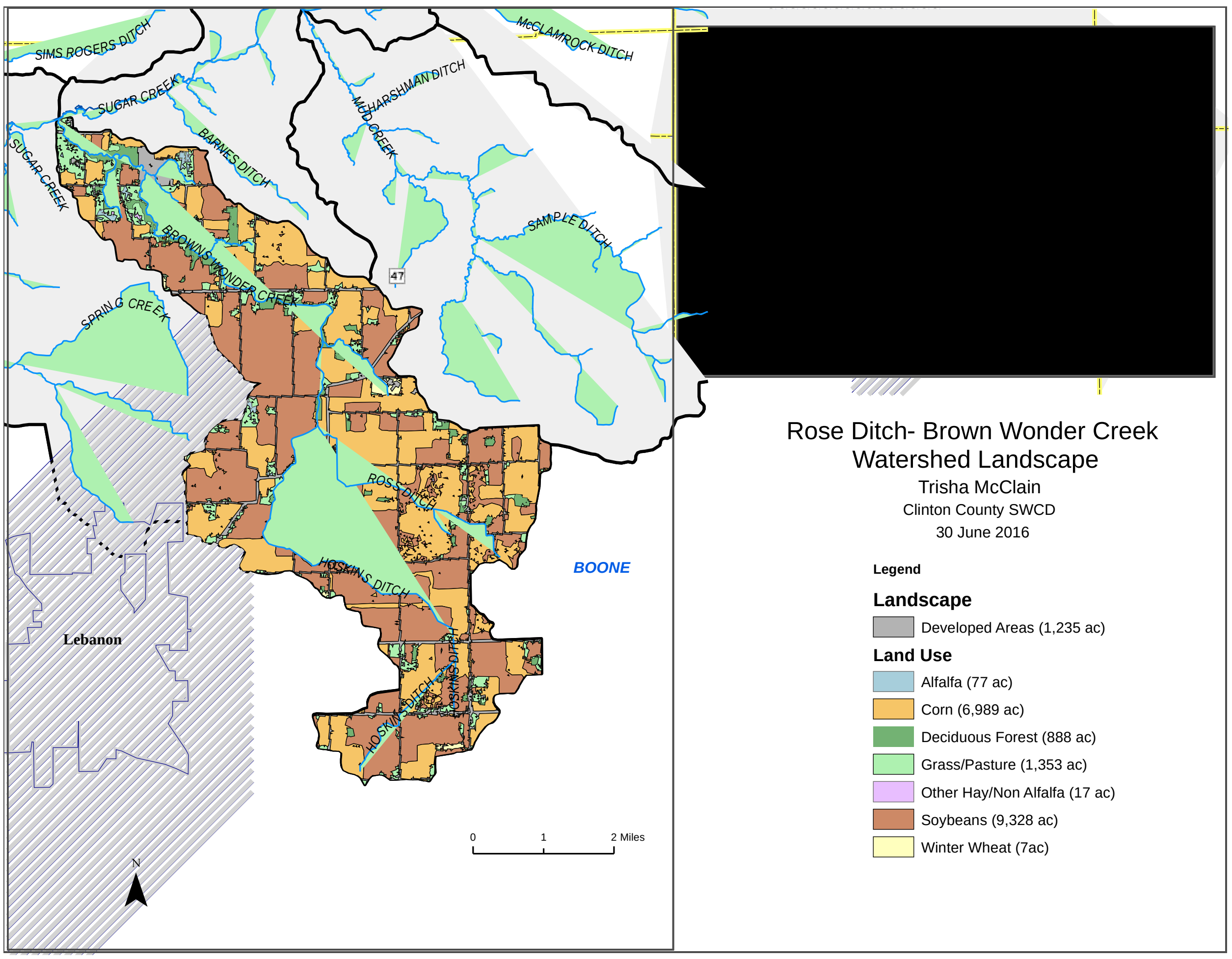

Figure 44. Rose Ditch- Browns Wonder Sugar Creek Watershed Landscape (NLCD, 2011)

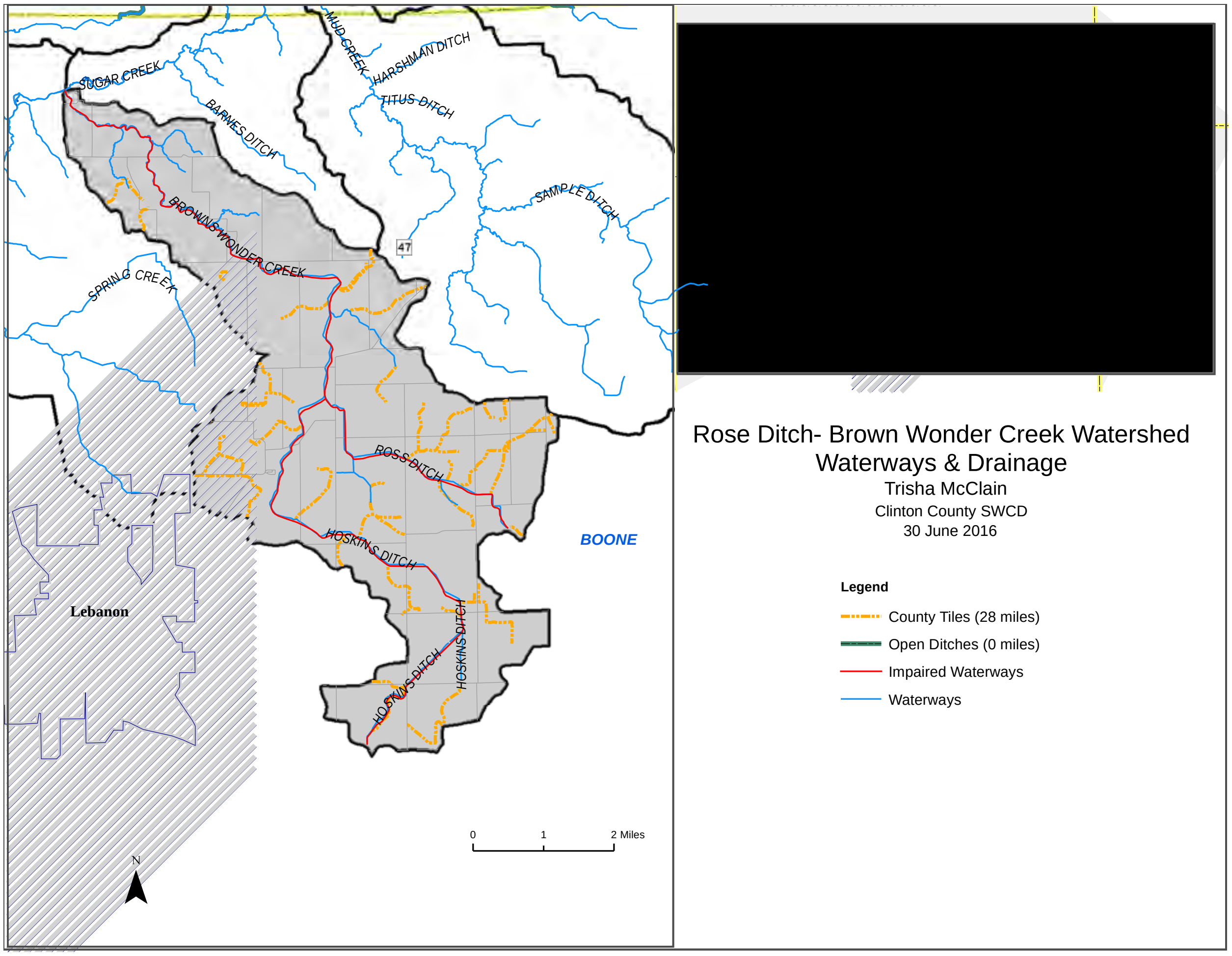

Figure 45. Rose Ditch- Browns Wonder Creek Watershed Waterways & Drainage (Boone Co. Surveyor, 2014)

Soils within Rose Ditch- Browns Wonder Creek Watershed is predominately composed of Crosby silt loam, fine-loamy subsoil, 0 to 2 percent slopes (CudA) (Figure 46). The Hydric soil that dominates this region would be Treaty silty clay loam, with a 0 to 1 percent slope (ThrA). As previously stated, hydric soils are not ideal for septic systems but prove to be excellent cropland soil. In addition, there are Highly Erodible Lands (HEL) within the area, but compared to other subwatershed within BWSC there is minimal presence of HEL soils. However, there is a significant amount of Potentially Highly Erodible Lands (PHEL), especially in the upper reaches of the watershed by the confluence of Browns Wonder Creek and Sugar Creek (Figure 46). The PHEL soils that dominate this area are Miami silt loam, 2 to 6 percent slopes (MnpB2) and Williamstown-Crosby silt loams, 2 to 4 percent slopes (WofB).

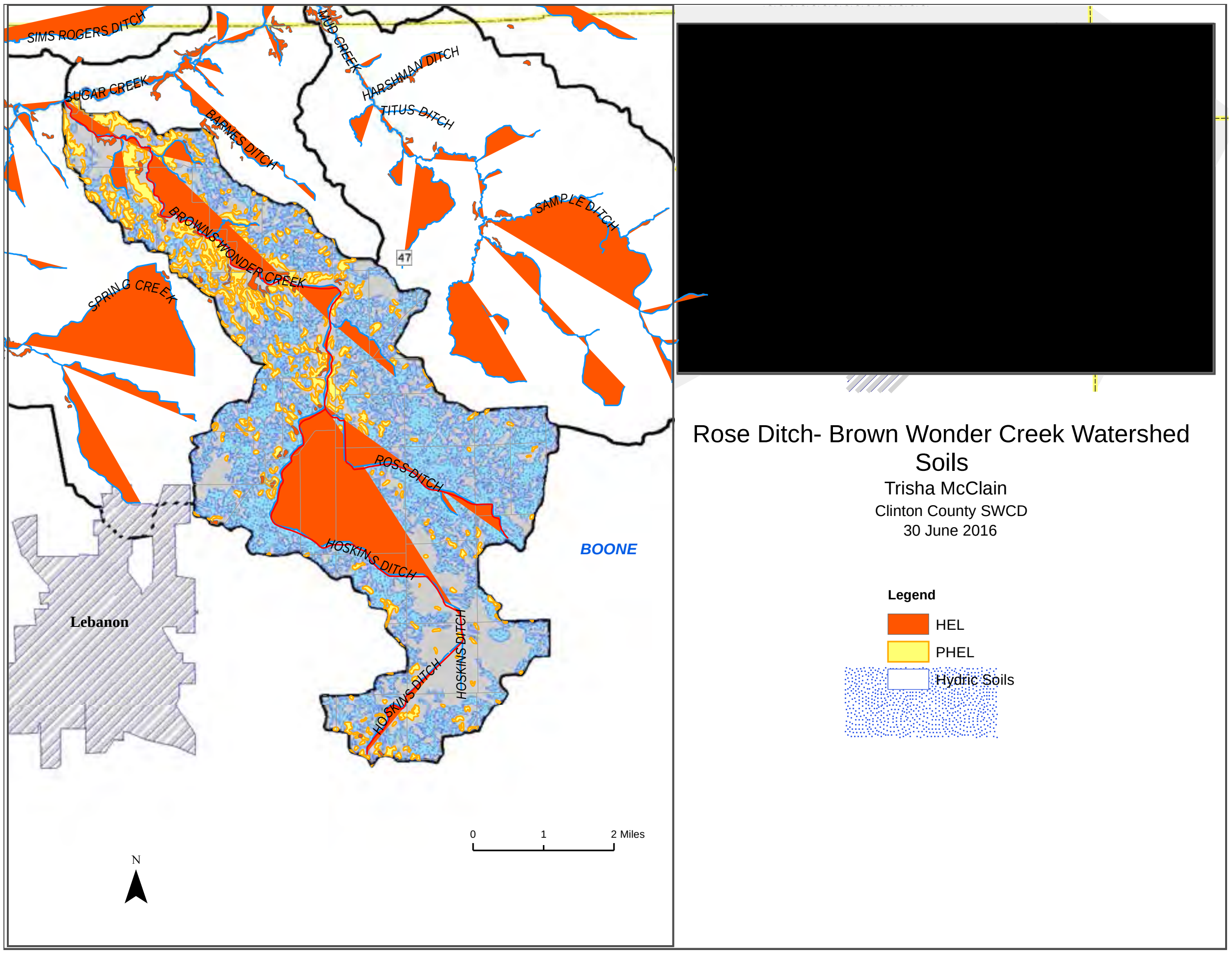

Figure 46. Rose Ditch-Browns Wonder Creek Watershed Soils (SSURGO, 2015)

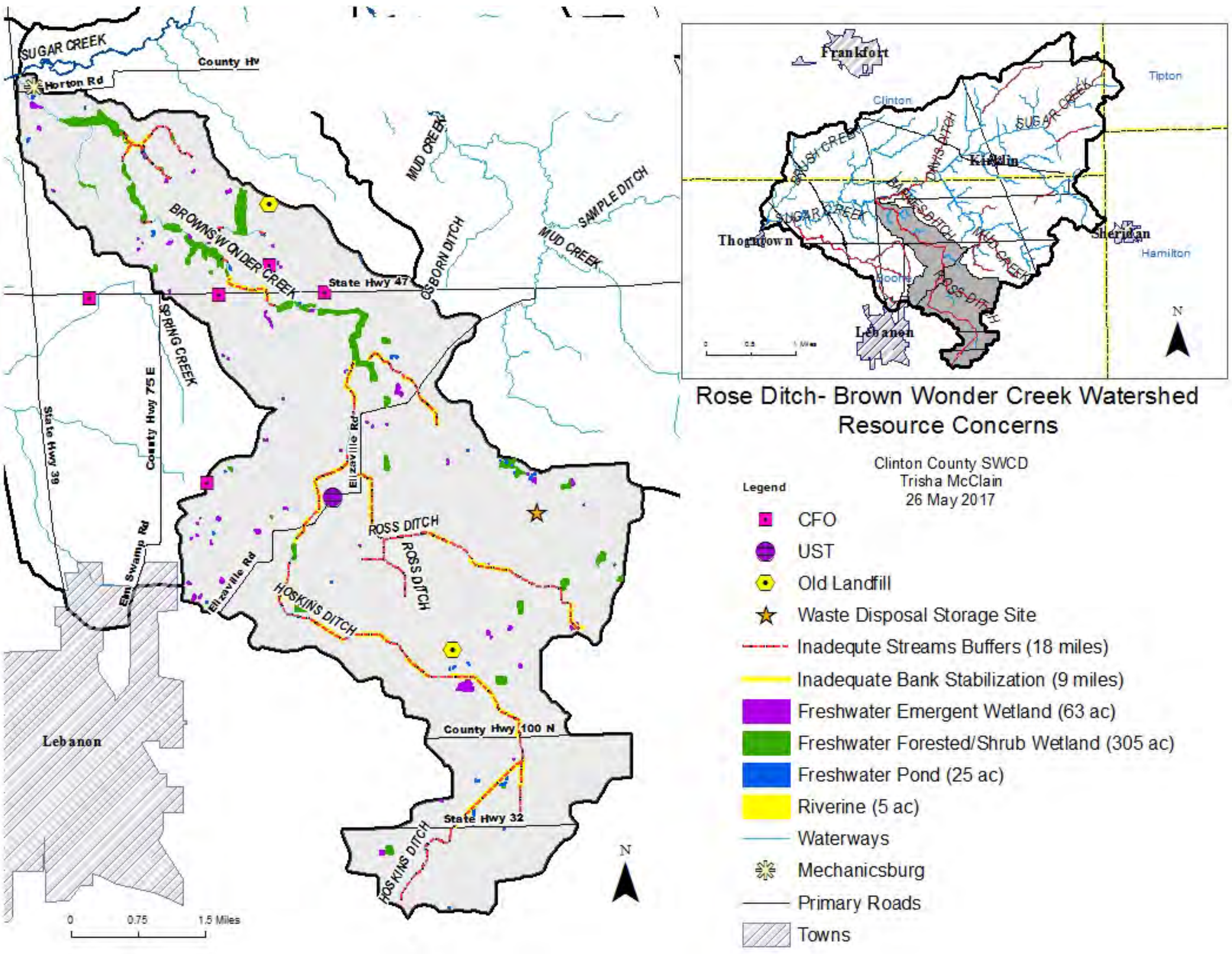

Figure 47. Rose Ditch-Browns Wonder Creek Watershed Resource Concerns (IDEM, 2015)

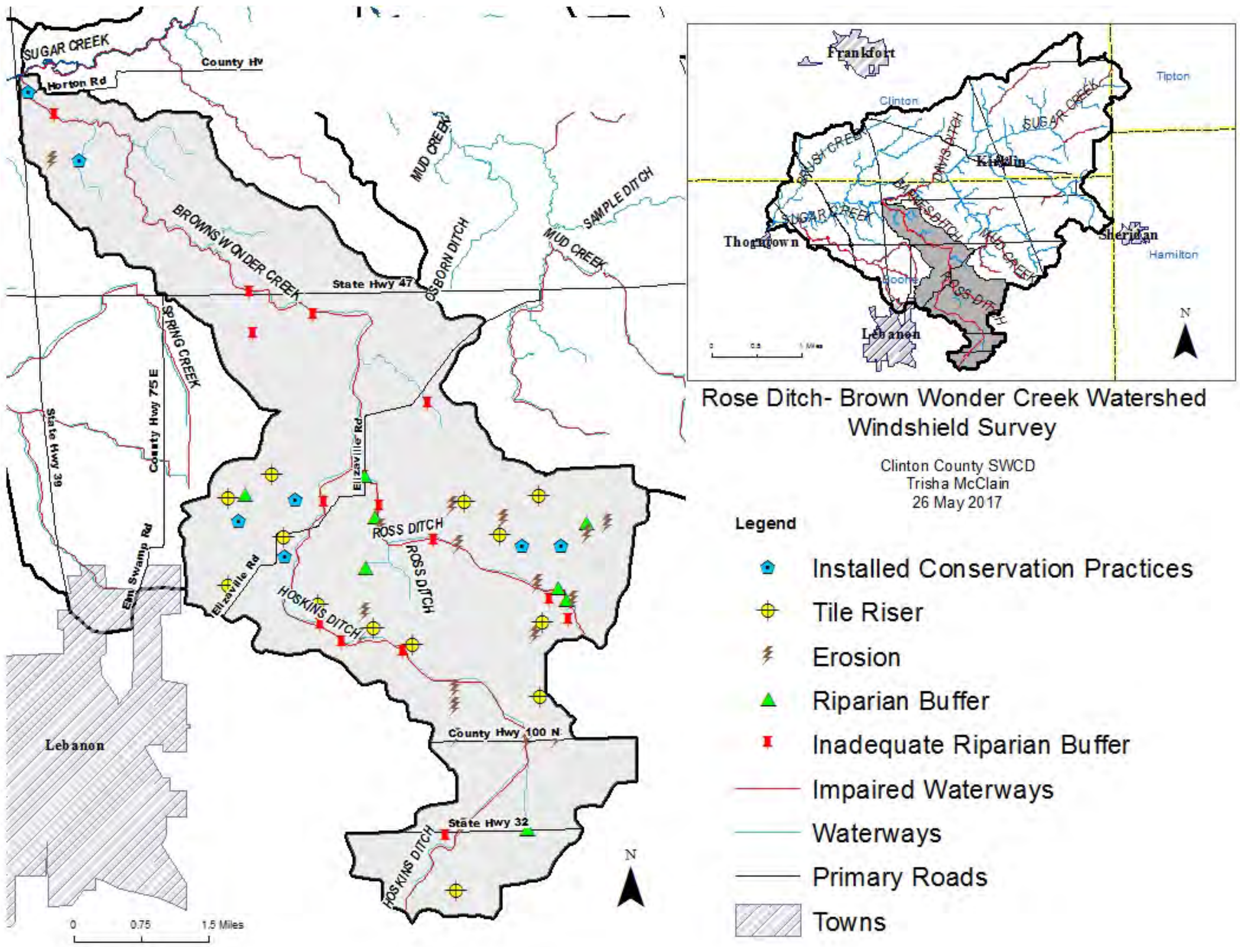

Figure 48. Rose Ditch- Browns Wonder Creek Windshield Survey (Clinton Co. SWCD, 2015)

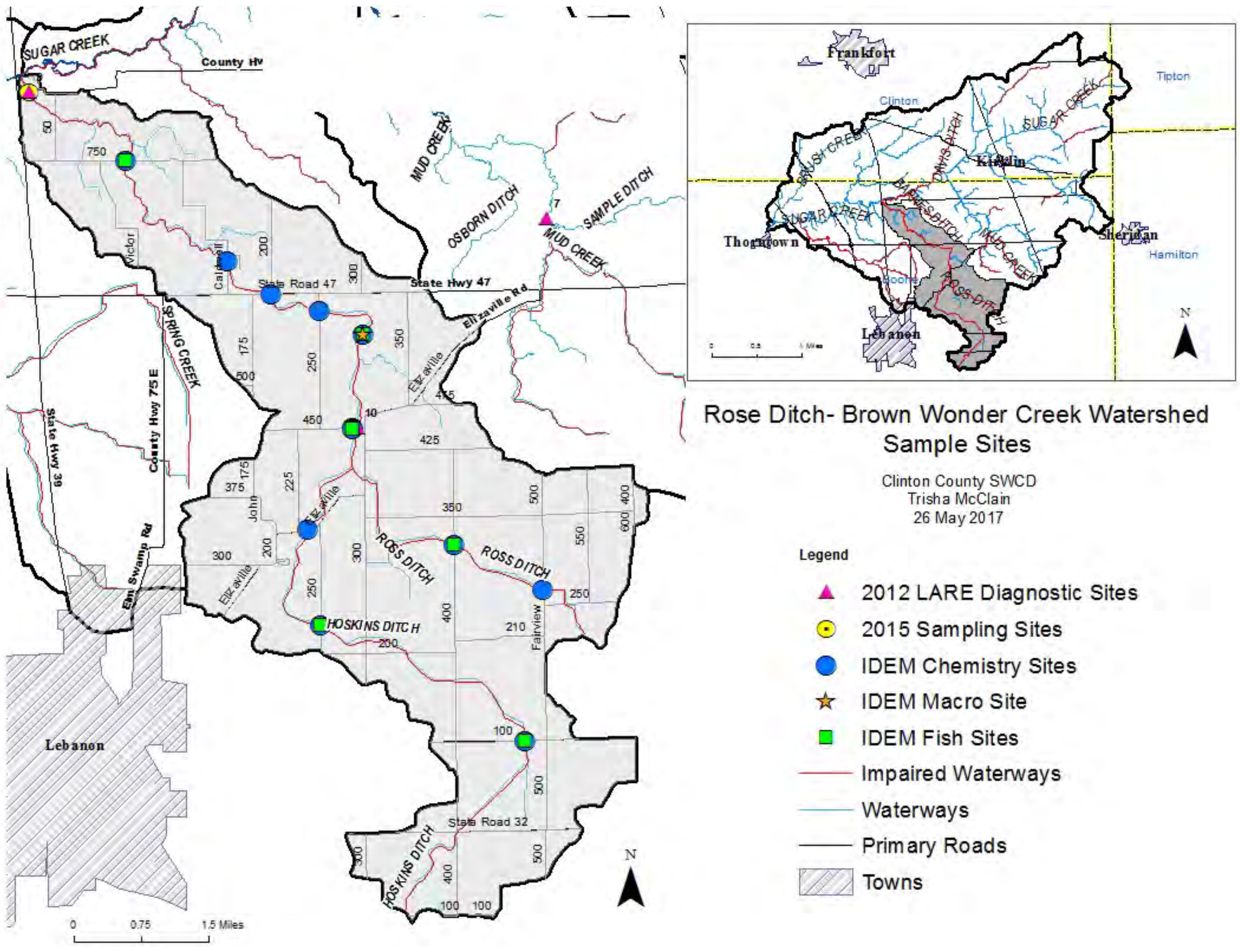

Figure 49. Rose-Ditch Browns Wonder Creek Water Quality & Biotic Sample Sites (IDEM, 2015)

Water Quality

IDEM 305(b)/ 303(d)

Approximately 21 miles of the waterways (Browns Wonder/ Hoskins Ditch Creek-INB1014_03 & INB1014_T1003 (8 stream miles), Rose Ditch-INB1014_T1004 (13 stream miles)) within Rose Ditch-Brown Wonder Creek Watershed are classified as having "impaired biotic communities (Figure 45). Biotic impairments listed within in this subwatershed are a result of a variety of factors. GIS data would suggest that the riparian zone (i.e. the interface between land & a river/stream that is primarily forested or composed of vegetation) is minimal, leaving it exposed to sunlight & extreme changes in weather conditions. High temperatures in warm waterways decrease dissolved oxygen levels, creating anoxic conditions (>2 mg/L); degrading the biotic community. In addition, by having a small riparian zone, pollutants through surface water run-off are less likely to be filtered before entering local waterways; increasing nutrient levels. Surface water run-off from point (subsurface tile) & nonpoint sources have also been identified as a source of high nutrient levels. Current, from 2015 monitoring, nitrogen, phosphorus, & turbidity levels do not support a healthy biotic community. IBI & QHEI scores also indicate that most of the poor biotic communities sampled are a result of habitat instead of water quality because IBI scores surpass QHEI scores (Figure 50).

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study two sites were located in Mud Creek Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 28). An abnormal amount of pathogens were documented during base flow at Site 10. The cause for the spike is inconclusive but could be a result of septic system failures, lack of/ improper septic systems (waste directly discharged to receiving waterways), or livestock having open-access to streams. Sites were located at the confluence of Rose Ditch-Browns Wonder Creek Watershed by Mechanicsburg and the central region of the watershed. Nitrate-nitrite and total phosphorus exceeded target values during both base and high flow at both sample sites.

Table 28. 2012 LARE Diagnostic Study Water Quality Analysis of Rose Ditch-Browns Wonder Creek Watershed

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Browns Wonder *(Site 9)*	**135**	**0.4**	**0.12**	**1.2**
Browns Wonder *(Site 10)*	**3,420**	**0.6**	**0.13**	**2.4**
HIGH FLOW (August 10, 2012)				
Browns Wonder *(Site 9)*	**13**	**0.4**	**0.04**	**1.2**
Browns Wonder *(Site 10)*	**125**	**0.4**	**0.04**	**16**

IDEM Historical Sampling (AIMS)

IDEM had eleven locations for chemical analysis and Qualitative Habitat Evaluation Index (QHEI) was conducted at seven different sites. Results would conclude as the following: an average of 0.94 mg/L in Nitrate, 0.24 mg/L in Phosphorous and 8.27 mg/L in Total Suspended Sediment (TSS) (Table 29). Biotic and habitat assessments were conducted at 7 different locations on August 15, 2005. After review, the IBI and QHEI scores would indicate a habitat deficiency on all the sample sites except Victor Avenue which showcases a water quality issue in regards to the biotic community present (Figure 50). In addition, to conducting IBI and QHEI on August 11, 1999, a Macroinvertebrate Index of Biotic Integrity (MIBI) was conducted (the only one within the Browns Wonder- Sugar Creek Watershed), which received a score of 9.2, indicating poor water quality for the biological community within that area.

Table 29. 2015 Rose Ditch-Browns Wonder Watershed AIMS data

Site	Date Sampled	Latitude	Longitude	Nitrate- Nitrite mg/L	Total Phosphorus mg/L	TSS mg/L
SR 47	8-10-99	40.13	-86.43	0.06	0.09	6
CR 250 E	8-11-99	40.12	-86.41	5.1	0.133	17
CR 100 N	8-15-05	40.05	-86.38	0.02	0.74	38
CR 400 E	8-15-05	40.09	-86.39	0.9	0.29	2

CR 250 E N 200 N	8-15-05	40.07	-86.42	0.38	0.25	4
CR 250 S of SR 47	8-15-05	40.12	-86.42	1.5	0.1	1
CR 750 N	8-15-05	40.15	-86.46	0.9	0.09	2
CR 450 N	8-17-05	40.10	-86.41	0.14	0.13	5
CR 500 E	8-15-05	40.08	-86.38	0.34	0.55	3
Elizaville Rd	8-15-05	40.09	-86.42	0.14	0.16	3
Caldwell Ave	8-17-05	40.13	-86.44	0.86	0.09	10

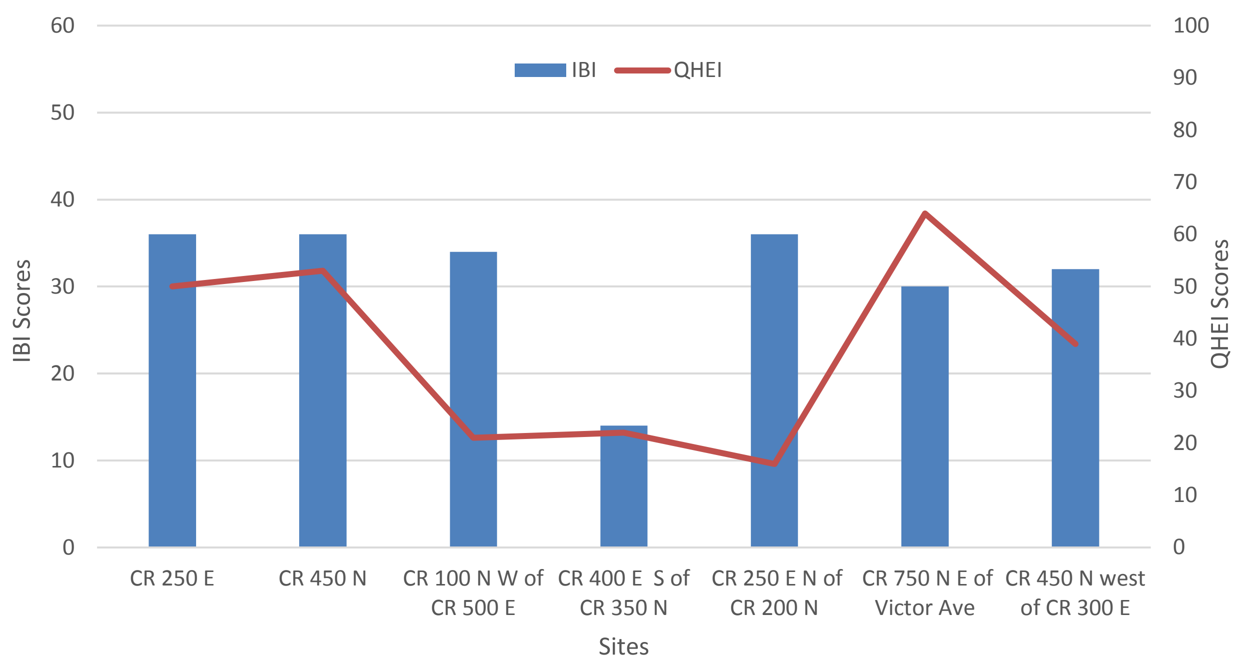

Figure 50. Comparative analysis of IBI and QHEI scores conducted by IDEM through the Historical Sampling Program on Rose Ditch-Browns Wonder Creek Watershed.

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had a sample site within Rose Ditch- Browns Wonder Creek Watershed, labeled BrW which falls at the confluence of Browns Wonder Creek & Sugar Creek. A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 30). Bolded items indicate values that exceed established target values (Table 15). The cQHEI assessment was conducted on October 21, 2015 with a score of 44; which indicate fair habitat for a healthy aquatic community and does not meet the project target value of 60.

Table 30. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Browns Wonder Creek (BrW) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=22]	12.1	77.1	193.7	**361.2**	**2,382.2**	46%
TSS mg/L [n=22]	1.4	2.4	4.1	20.3	**475**	18%
Nitrate-Nitrite mg/L [n=22]	0	0.22	**4.5**	**6.4**	**12.2**	**68%**
T-P mg/L [n=22]	0	0.03	**0.08**	**0.14**	**0.9**	**77%**
Turbidity NTU [n=19]	4.9	9.5	**14**	**28.8**	**731**	**68%**
Dissolved Oxygen [D.O.] mg/L [n=19]	**3**	**3.8**	5.2	7.8	**11.3**	47%

Watershed Inventories

Windshield Survey

During the windshield survey volunteers were able to gather a significant amount of data points which provided a high and diverse amount resource concerns within the Rose Ditch-Browns Wonder Creek Watershed. Rose Ditch-Browns Wonder Creek showcased a variety of resource concerns during the windshield survey that would include: inadequate stream buffers (18 miles), inadequate bank stabilization (9 miles), inadequate riparian buffers (15 sites), tile risers (13 sites), and evidence of erosion (18 sites) (Figure 47 & 48). In this instance, the term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system. The windshield survey also indicate that there were adequate riparian buffers (8 sites) and implemented conservation practices (7) (Figure 48). The term adequate means that the current condition of the site provides proper protection to sustain healthy ecological communities.

Desktop Survey

The Rose Ditch-Browns Wonder Creek Watershed has one small town known as Mechanicsburg and approximately 1,235 acres of developed area. There's approximately 63 acres of freshwater emergent wetland, 25 acres of ponds, 5 acres of riverines and 305 acres of scattered, isolated woodlots of forested/shrub wetland (Figure 47). After GIS analysis, approximately 18 miles require stream buffers and 9 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events. The term inadequate, in this instance, means that the current conditions do not provide the proper protection to sustain a healthy ecological system. In addition, there are four Confined Feeding Operations (CFO) within the watershed that have not received violations. The CFOs are near Lebanon and would include: Morton Farm North which has an operation of only Finishers (2,000); Michalke & Hardin Farm which has an operation of Nursery Pigs (1,000), Sows (303) and Finishers (1,925); Morton Farms Finisher which has an operation of 6,000 Finishers and Wilhoite Family Farms which consists of Finishers (1,050) and Sows (600). Finally, the area did not have any identified leaking underground storage tanks but an underground storage tank was documented near Elizaville Rd under Neese Farm Inc.; no incidents have been reported (Table 31). Please note that resource concerns listed in Table 31 or described within this section are to provide a general assessment of potential sources that can contribute to water quality concerns within the subwatershed; there will be no additional detail provided.

Table 31. Rose Ditch-Browns Wonder Watershed Resource Concerns

Resource Concerns that Affect Water Quality	Amount
Leaking Underground Storage Tank (LUST)	0
Underground Storage Tank (UST)	1
Confined Feeding Operations (CFO)	4

Rose Ditch-Browns Wonder Creek Watershed Assessment

Rose Ditch-Browns Wonder Creek Watershed is approximately 20,039 acres with 21 miles of impaired waterways. Those waterbodies are considered to have biotic impairments which would include: Browns Wonder Creek, Rose Ditch & Hoskins Ditch.

The landscape is 81% cropland with about 888 acres of forested scattered woodlots. The high prevalence of agriculture can result in a high volume of subsurface drainage tile, resulting in high concentrations of nitrate-nitrite and total phosphorus. In historical and current monitoring efforts nitrate has exceeded target values (1.6 mg/L). Total phosphorus tended to exceeded 0.08 mg/L during IDEM historical sampling (1999 & 2005), while nitrate levels were under target values. There was an instance in the 2012 LARE Diagnostic study that *E. coli* levels were extremely high (3,420 cfu/ 100 ML) during base flow which could be due a variety of reasons, but typically that indicates septic system failure or livestock have open access to the stream.

Habitat and biotic assessments would indicate that degraded biotic integrity is a result of habitat rather than water quality even though one site did indicate that water quality was not sufficient. A lack of riparian buffer would result in habitat deficiencies, especially since only 0.04% of the landscape is forested. While water quality deficiencies can be a result of high nutrient levels of nitrate, total phosphorus and *E.coli*. During 2015 monitoring efforts, on average the subwatershed exceeded target values in Nitrate [1.6 mg/L] and Turbidity [10.4 NTU], which could also further justified degraded biotic communities.

Rose Ditch-Browns Wonder Creek Watershed has been designated as a Tier 2 Critical Land Area (CLA). Based on stakeholder, ecological & environmental concerns, the steering committee considers this subwatershed as a priority area, but not the highest priority. Implementation efforts will primarily target Tier 1 Critical Land Areas & once all conservation opportunities have been exhausted implementation will target Tier 2 CLA's. The project's implementation strategy is to target conservation efforts towards upstream private land management and development while simultaneously and naturally impacting downstream resources.

4.5 Barnes Ditch-Sugar Creek (HUC: 051201100105)

Land Use

Barnes Ditch-Sugar Creek Watershed is approximately 14,526 acres with a drainage area of 15 square miles of both Clinton and Boone County. The landscape is dominated by agriculture (>82%), cropland is predominantly planted into corn (6,199 acres) or soybeans (5, 717 acres) (Figure 51). There is about 17 miles of natural waterways within this subwatershed which includes: Barnes Ditch, Sugar Creek and Davis Ditch (Figure 48). According to IDEM's 303 (d) impaired list Sugar Creek (INB1015_03), Barnes Ditch (INB1015_T1006) and Davis Ditch (INB1015_T1005) have been designated with Escherichia Coli (*E. coli*) & Biotic Communities impairments (9 miles). Surveyor data documents about 8 miles of subsurface tile drainage systems have been installed throughout the watershed and data shows that only 4 miles of waterways are considered to be open ditches (Figure 52).

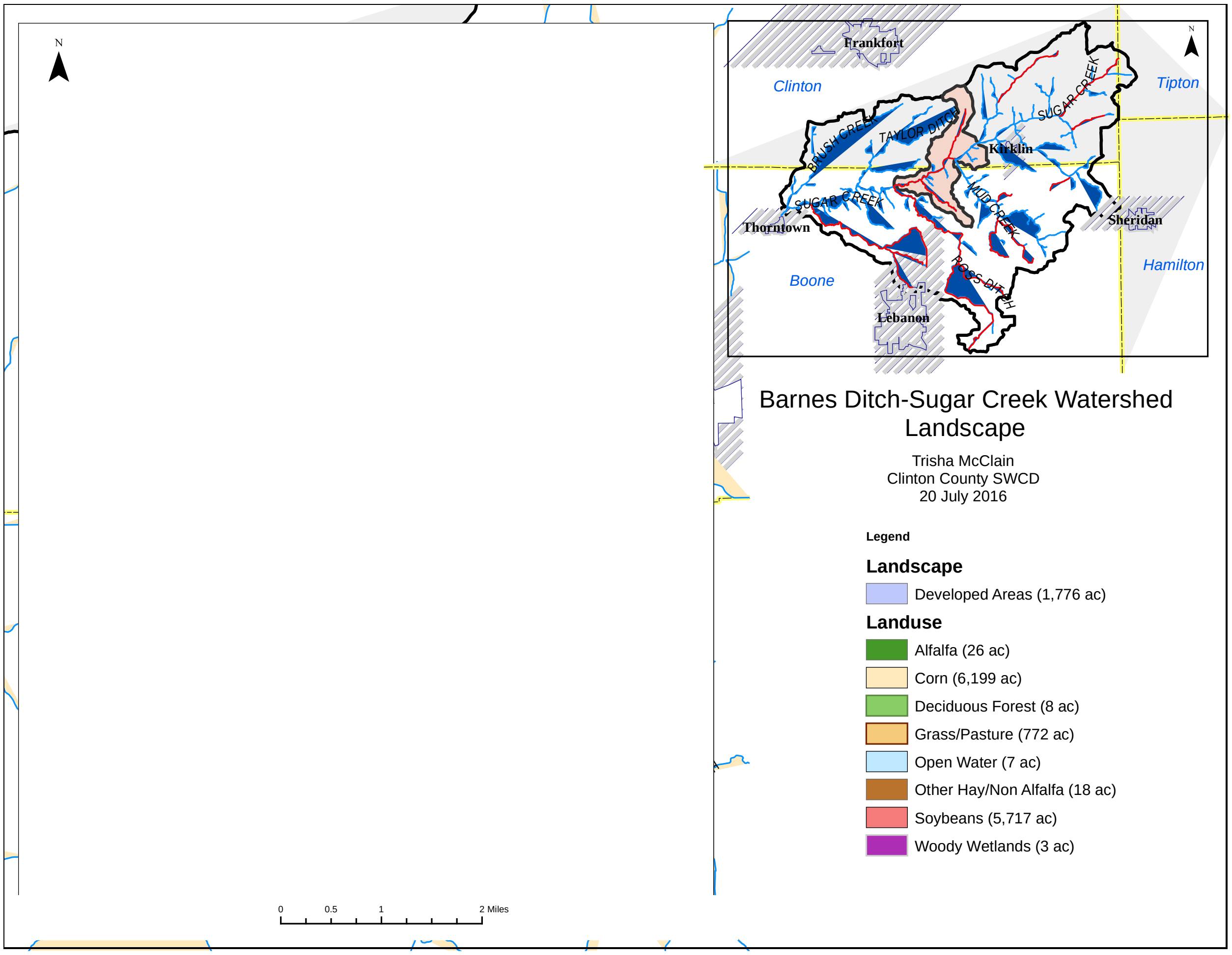

Figure 51.Barnes Ditch-Sugar Creek Watershed Landscape (NLCD, 2011)

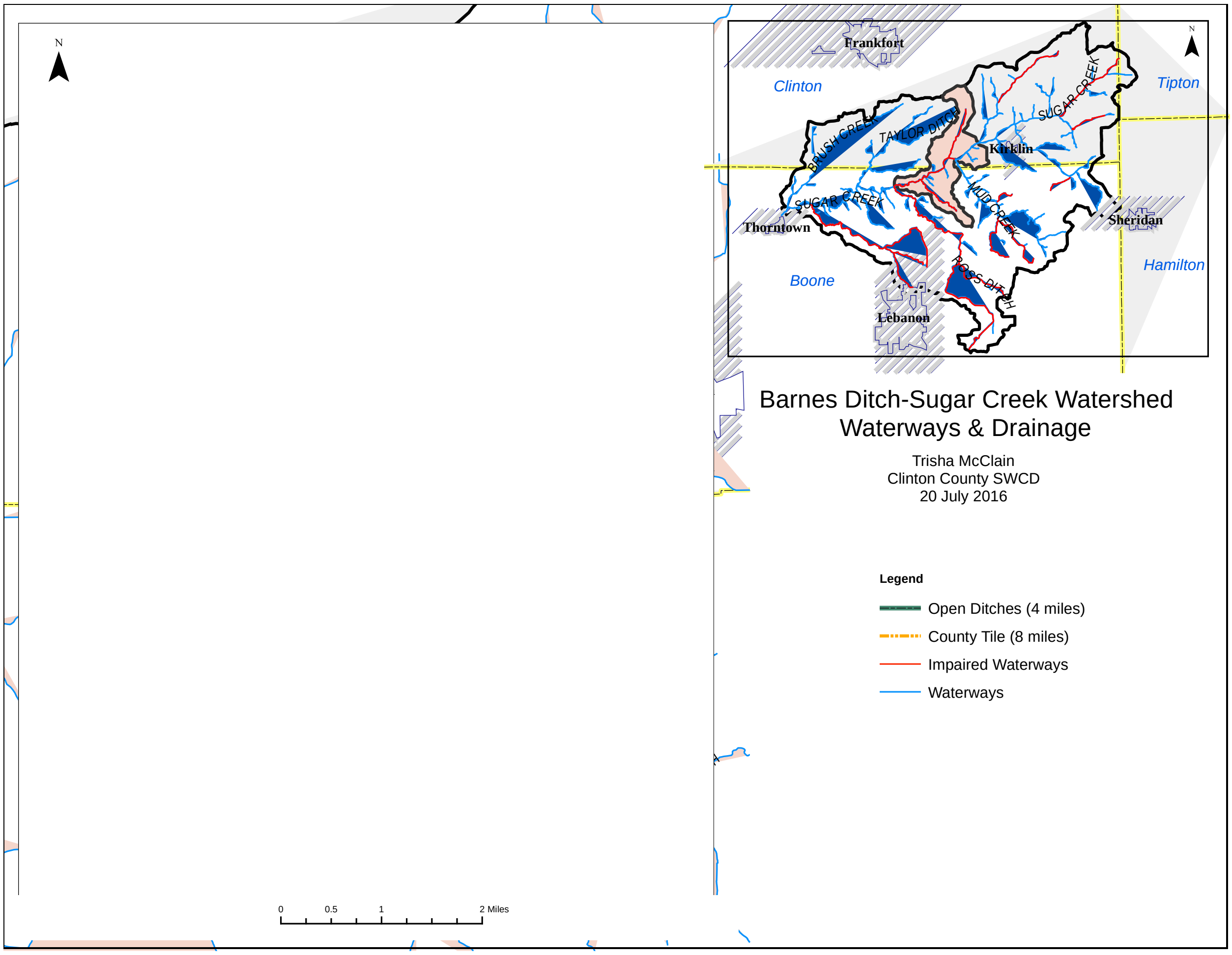

Figure 52. Barnes Ditch- Sugar Creek Watershed Waterways & Drainage (Clinton & Boone Co. Surveyor, 2014)

Soils within Barnes ditch-Sugar Creek Watershed has a large amount of hydric soils in the northern and southern regions of the watershed; areas that tend to be lacking hydric soils are located around Sugar Creek which is dominated by PHEL soils such as MtB (Miami-Crosby silt loams, 2 to 6 percent slopes) & XfuB2 (Miami-Rainsville complex, 2 to 6 percent slopes) (Figure 53). Hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems). Hydric soils provide suitable soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. Other than being composed of mostly hydric and PHEL soils there is some presence of HEL soils (202 acres) which would is predominantly composed of MmoC3 (Miami clay loam, 6 to 12 percent slopes, severely eroded) & SigE2 (Senachwine silt loam, 18 to 25 percent slopes).

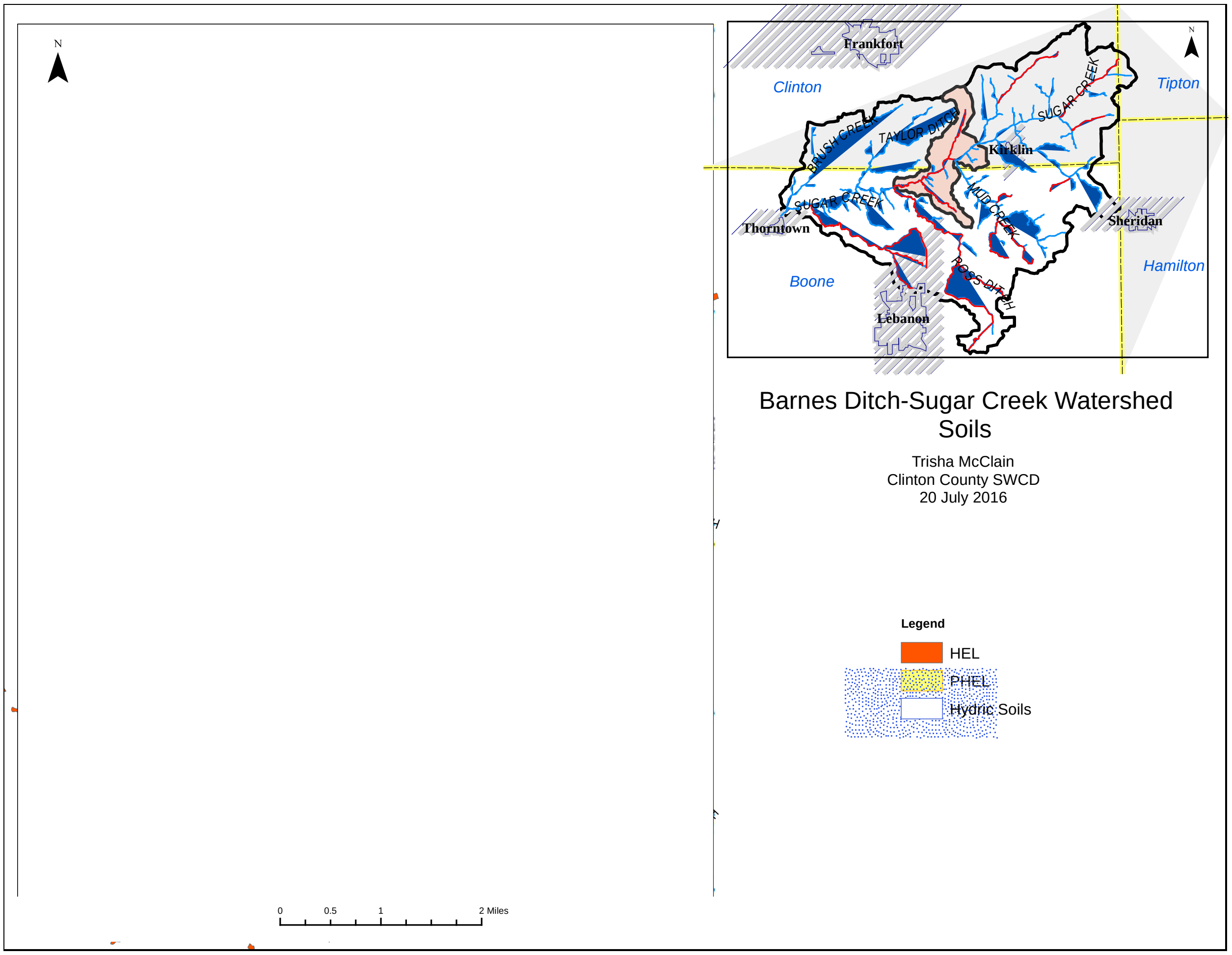

Figure 53. Barnes Ditch- Sugar Creek Watershed Soils (SSURGO, 2015)

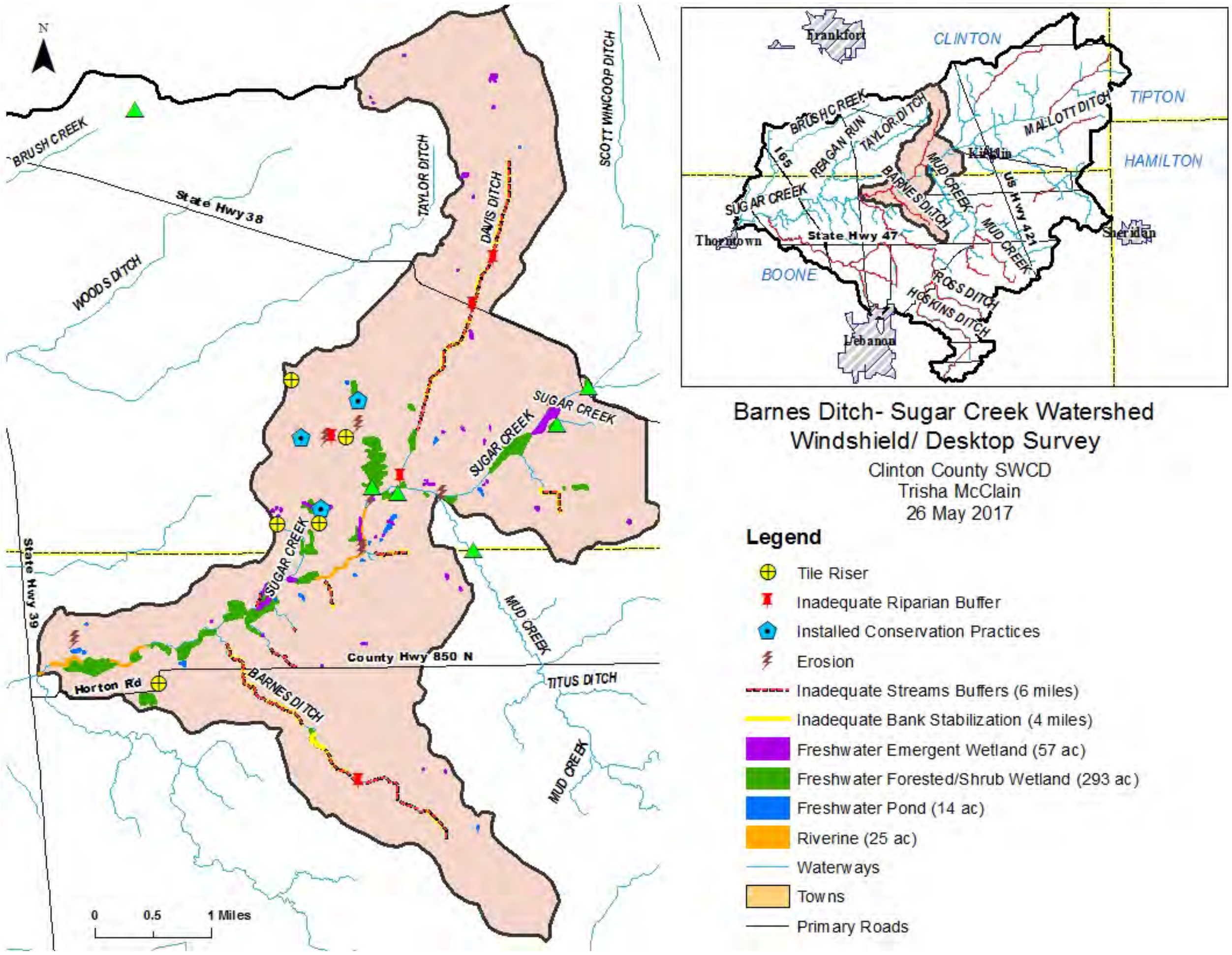

Figure 54. Barnes Ditch- Sugar Creek Windshield/Desktop Survey (Clinton Co. SWCD, 2015)

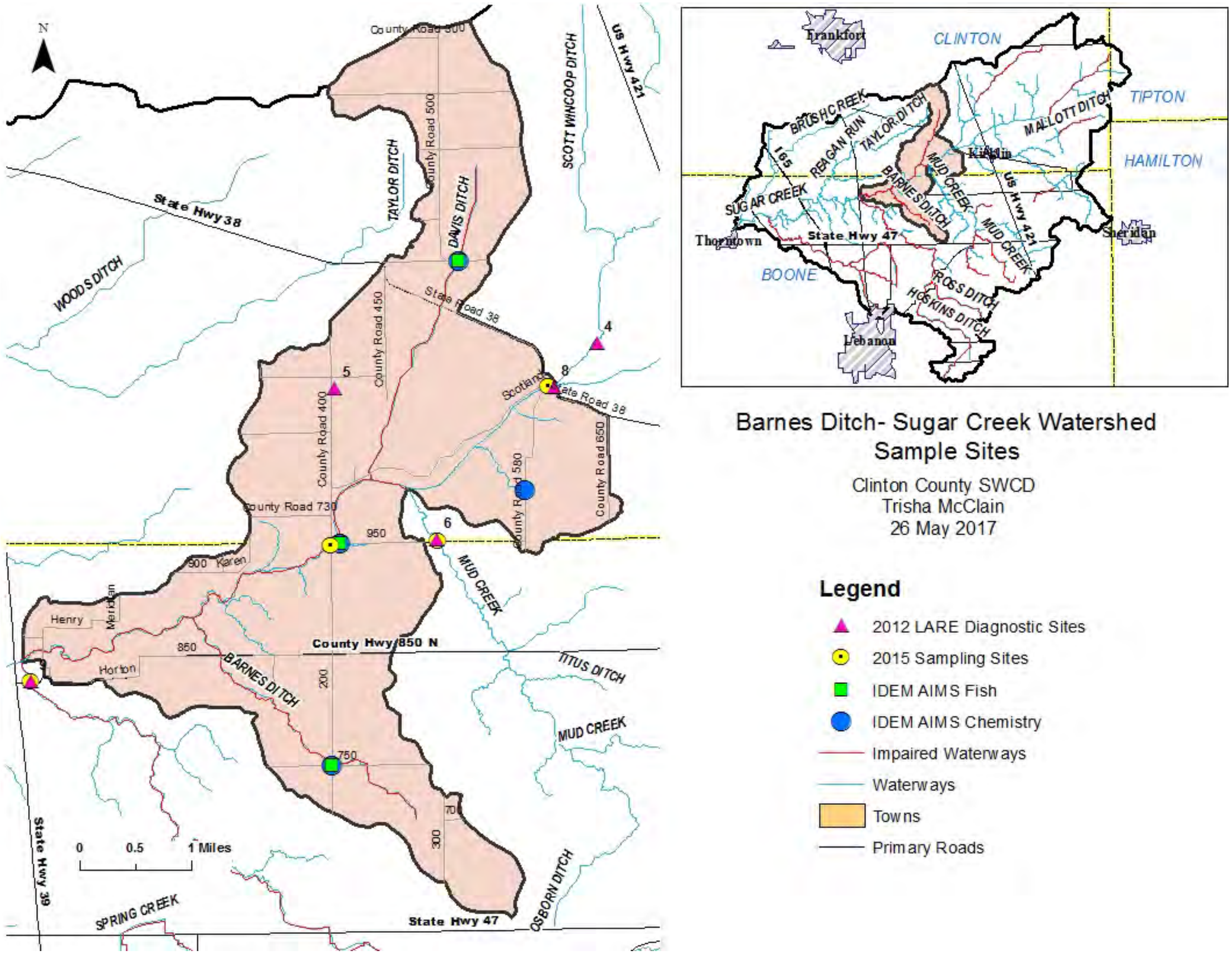

Figure 55. Barnes Ditch-Sugar Creek Watershed Chemical & Biological Sample Sites (IDEM, 2015)

Water Quality

IDEM 305(b)/ 303(d)

Approximately 9 miles of the waterways (Sugar Creek (5 stream miles; INB1015_03), Barnes Ditch (3 stream miles; INB1015_T1006) and Davis Ditch (3 stream miles; INB1015_T1005)) are classified as having Escherichia Coli (*E. coli*) & Biotic Community impairments. Biotic impairments listed within in this subwatershed are a result of a variety of factors. GIS data would suggest that the riparian zone (i.e. the interface between land & a river/stream that is primarily forested or composed of vegetation) is minimal, leaving it exposed to sunlight & extreme changes in weather conditions. High temperatures in warm waterways decrease dissolved oxygen levels, creating anoxic conditions (>2 mg/L); degrading the biotic community. In addition, by having a small riparian zone, pollutants through surface water run-off are less likely to be filtered before entering local waterways; increasing nutrient levels. Surface water run-off from point (subsurface tile) & nonpoint sources have also been identified as a source of high nutrient levels. According to 2015 monitoring, turbidity, *E. coli*, nitrogen & phosphorus levels, do not support a healthy biotic community & exceed project target values. IBI and QHEI scores also indicate that most of the poor biotic communities sampled are a result of habitat instead of water quality because IBI scores surpass QHEI scores (Figure 56). There is one sample site that indicates that water quality is more of a factor to the poor biotic community rather than habitat. High *E. coli* concentrations within the watershed can be due to a variety of factors bur are likely due to livestock having open-access to local waterways, manure application & surface water run-off. Levels may be high from improper or poor management/ installation of septic systems as well because of the amount of residents on a septic system; however, values were not high during low flow which indicates that this is not the primary cause.

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study two sites were located in Barnes Ditch- Sugar Creek Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 32). Sites were located near the inlet of the watershed and by Davis Ditch, but both sites evaluated a portion of Sugar Creek.

Table 32. 2012 LARE Diagnostic Study Chemical Analysis

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Sugar Creek *(Site 5)*	**64**	**0.6**	**0.15**	**0.4**
Sugar Creek *(Site 8)*	**151**	**0.5**	**0.22**	**0.4**
HIGH FLOW (August 10, 2012)				
Sugar Creek *(Site 5)*	**1300**	**0.5**	**0.09**	**18.4**
Sugar Creek *(Site 8)*	**263**	**0.4**	**0.14**	**8.8**

IDEM Historical Sampling (AIMS)

IDEM had three locations for chemical analysis. Results would conclude as the following: an average of 0.77 mg/L in Nitrate, 0.36 mg/L in Phosphorous and 10.7 mg/L in Total Suspended Sediment (TSS) (Table 33). Index of Biotic Integrity (IBI) as well as Qualitative Habitat Evaluation Index (QHEI) assessments were conducted on August 16, 2005 at three different sites. The biological & habitat assessments would indicate that sample sites CR 750 S and CR 200 E do not have adequate habitat to sustain a healthy biotic community while sample site CR 500 S reveals that water quality is impacting the biotic community (Figure 56).

Table 33. IDEM Historical Sampling chemical data for Barnes Ditch-Sugar Creek Watershed

Site	Date Sampled	Latitude	Longitude	Nitrate-Nitrite mg/L	Total Phosphorus mg/L	TSS mg/L
CR 500 S	8-16-05	40.21	-86.41	0.02	0.97	25
CR 750 S	8-16-05	40.18	-86.43	1.85	0.1	3
CR 200 E	8-17-05	40.15	-86.43	0.44	0	4

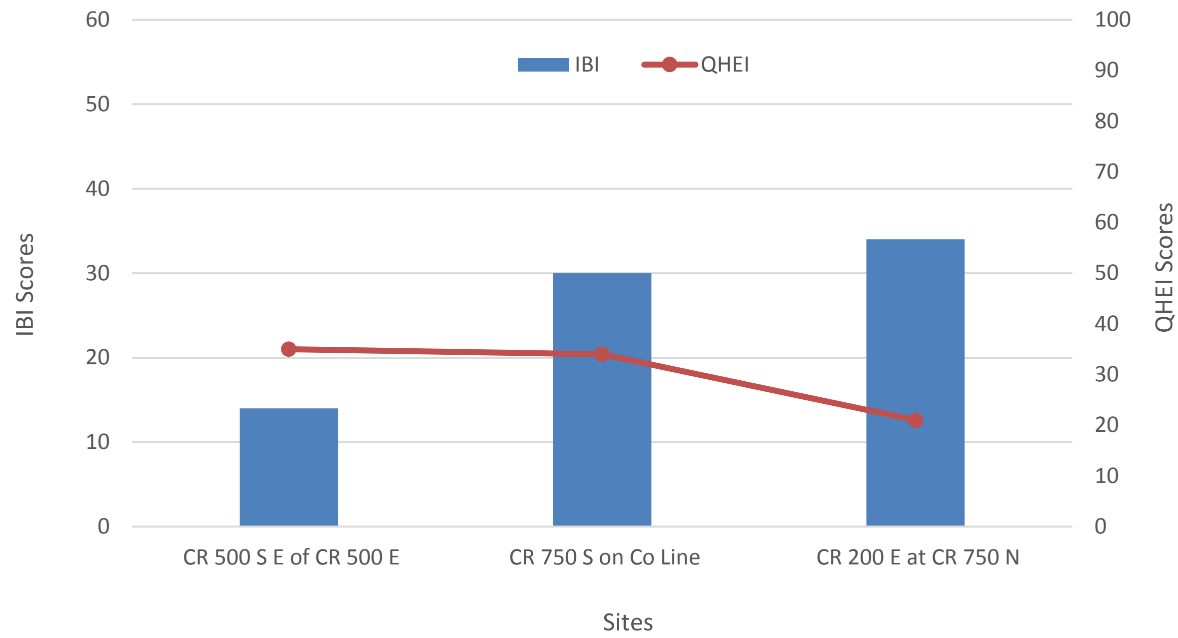

Figure 56. Comparative analysis of IDEM Historical Sampling data for IBI &QHEI scores evaluated in Barnes Ditch-Sugar Creek

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had a sample site at Barnes Ditch- Sugar Creek Watershed outlet, labeled site SCM (Sugar Creek-Midstream). A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 34). Bolded items indicate values that exceed established target values (Table 15). The cQHEI assessment was conducted on October 21, 2015 with a score of 79; which indicates the habitat is able to sustain healthy aquatic communities and surpasses the project target value of 60.

Table 34. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Sugar Creek Midstream (SCM) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=22]	30.9	**203.7**	**433.7**	**613.1**	**4,106**	**90%**
TSS mg/L [n=21]	2.6	7.35	9.4	23.6	**99**	19%
Nitrate-Nitrite mg/L [n=24]	0	0.64	**5.3**	**6.5**	**11.8**	**79%**
T-P mg/L [n=24]	0	0.03	**0.06**	**0.11**	**0.90**	**54%**
Turbidity NTU [n=17]	7.2	**13.7**	**18.1**	**29.2**	**125**	**82%**
Dissolved Oxygen [D.O] mg/L [n=17]	**2.5**	**3.7**	4.4	6.3	10.7	**53%**

Watershed Inventories

Windshield Survey

Barnes Ditch- Sugar Creek Watershed indicated five “inadequate riparian buffers,” which were mostly documented along Davis Ditch. In addition to inadequate buffers, erosion was documented and most prevalent within the central region of the watershed (Figure 54). Though there are resource concerns identified the watershed did have four riparian buffers established along the northern segment of the Sugar Creek as well as three conservation practices implemented.

Desktop Survey

The desktop survey revealed that there is minimal resource concerns present within Barnes Ditch- Sugar Creek Watershed. There are no active CFOs, LUST, or UST during investigation. The closest town would be Mechanicsburg located at the outlet of the watershed (Figure 54). There are a variety of wetlands within the watershed which would include: 57 acres of wetlands, 291 acres of forested wetlands, 14 acres of ponds and 25 acres of riverine. After GIS analysis, approximately 6 miles require stream buffers and 4 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events. The term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system.

Barnes Ditch-Sugar Creek Watershed Assessment

Barnes Ditch- Sugar Creek Watershed has 14,526 acres and about 17 miles of waterways. Approximately 65% of Barnes Ditch- Sugar Creek are classified as having Escherichia Coli (*E. coli*) & biotic community impairments. These impaired waterbodies are Sugar Creek, Barnes Ditch and Davis Ditch. The impacts that are occurring within this watershed may be a result of local impacts as well as the receiving waters of upper subwatersheds.

Nearly 82% of the landscape is designated as cropland of either soybeans or corn. The high prevalence of agriculture can result in a high volume of subsurface drainage tile. Water quality data presented above showcases that nitrate, total phosphorus, turbidity, *E. coli* and habitat are a concern within this subwatershed. Habitat and biotic assessments would indicate the degraded biotic integrity is primarily due to the lack of habitat; however there is a sites that indicate that water quality is not suitable to sustain healthy biotic communities. This is further justified from the 2011 land use data, which indicates that only 8 acres of the landscape is designated as forested area. Pathogens exceeded target values (less than 235 cfu/ 100 mL) in historical data and during 2015 monitoring efforts. This could be a result of livestock having open access to streams from undocumented hobby farms, manure application or surface water run-off since levels tended to rise after significant rain events. If levels are high during low flow then that would indicate more of a septic system issue.

Biotic degradation can be a result of high nutrient levels as well (i.e. nitrate, total phosphorus & *E. coli*). Water quality from 2005 (IDEM Historical Sampling Program) and the 2012 LARE Diagnostic Study would indicate that total phosphorus often exceeds the targeted value for this project of 0.08 mg/L (optimal concentration for biotic integrity) while nitrate-nitrite concentrations occasionally exceeded project target values during IDEM historical sampling, but continual exceed established standard in the 2012 Diagnostic Study. During 2015 monitoring efforts, on average the subwatershed exceeded target values in *E. coli* [less than 235 cfu/ 100ML], Nitrate [1.6 mg/L], Total Phosphorus [0.08 mg/L] and Turbidity [10.4 NTU].

Barnes Ditch- Sugar Creek Watershed has been designated as both a Tier 1 & Tier 2 Critical Land Area (CLA). Based on stakeholder, ecological & environmental concerns, the steering committee considers the northern reaches of this subwatershed as a high priority area while the southern reaches are considered to be a priority but not the highest priority. Implementation efforts will primarily target Tier 1 Critical Land Areas until all conservation opportunities have been exhausted then implementation will target Tier 2 CLA's. The subwatershed was split due to its geographic location, fitting into the project's implementation strategy, & stakeholder willingness. The project's implementation strategy is to target conservation efforts towards upstream private land management and development while simultaneously and naturally impacting downstream resources.

4.6 Reagan Run (HUC: 051201100106)

Land Use

Reagan Run Watershed is approximately 15,063 acres with a drainage area of 17 square miles of Clinton and Boone County**.** Agriculture is the primary land use with 5,711 acres of soybeans and 7,453 acres of corn. Continuous wooded corridors (766 acres) are more prevalent along Reagan Run near the outlet of the watershed. There is about 18 miles of natural waterways within this subwatershed which includes: Reagan Run, Taylor Ditch, Woods Ditch and Sim Rogers Ditch (Figure 57). Currently, there are no waterways that have been listed under IDEM's 303(d) Impaired Waterways List. According to survey data there approximately 8 miles of subsurface tiles installed and 77% of the waterways are designated as open ditches (Figure 58).

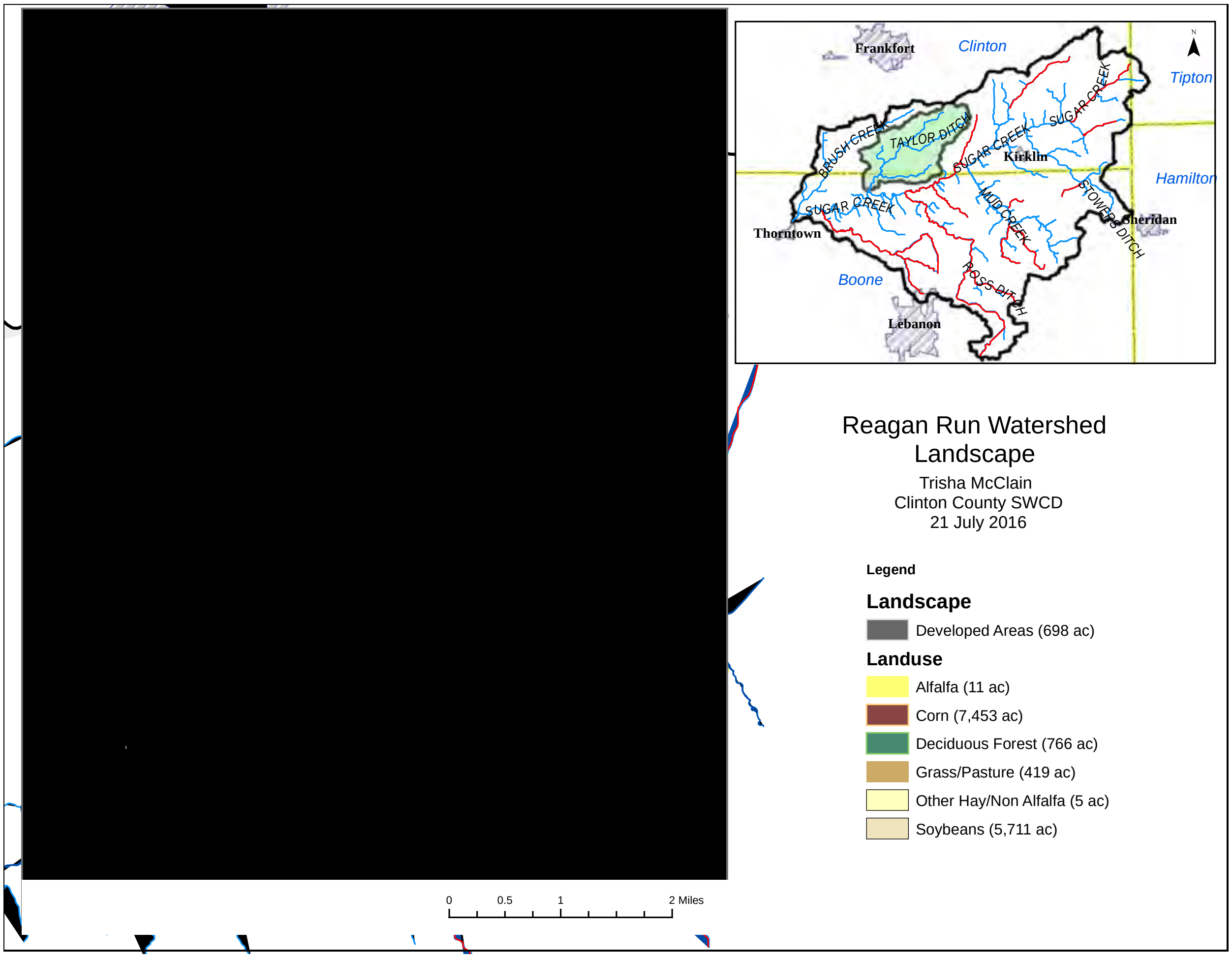

Figure 57. Reagan Run Watershed Landscape (NLCD, 2011)

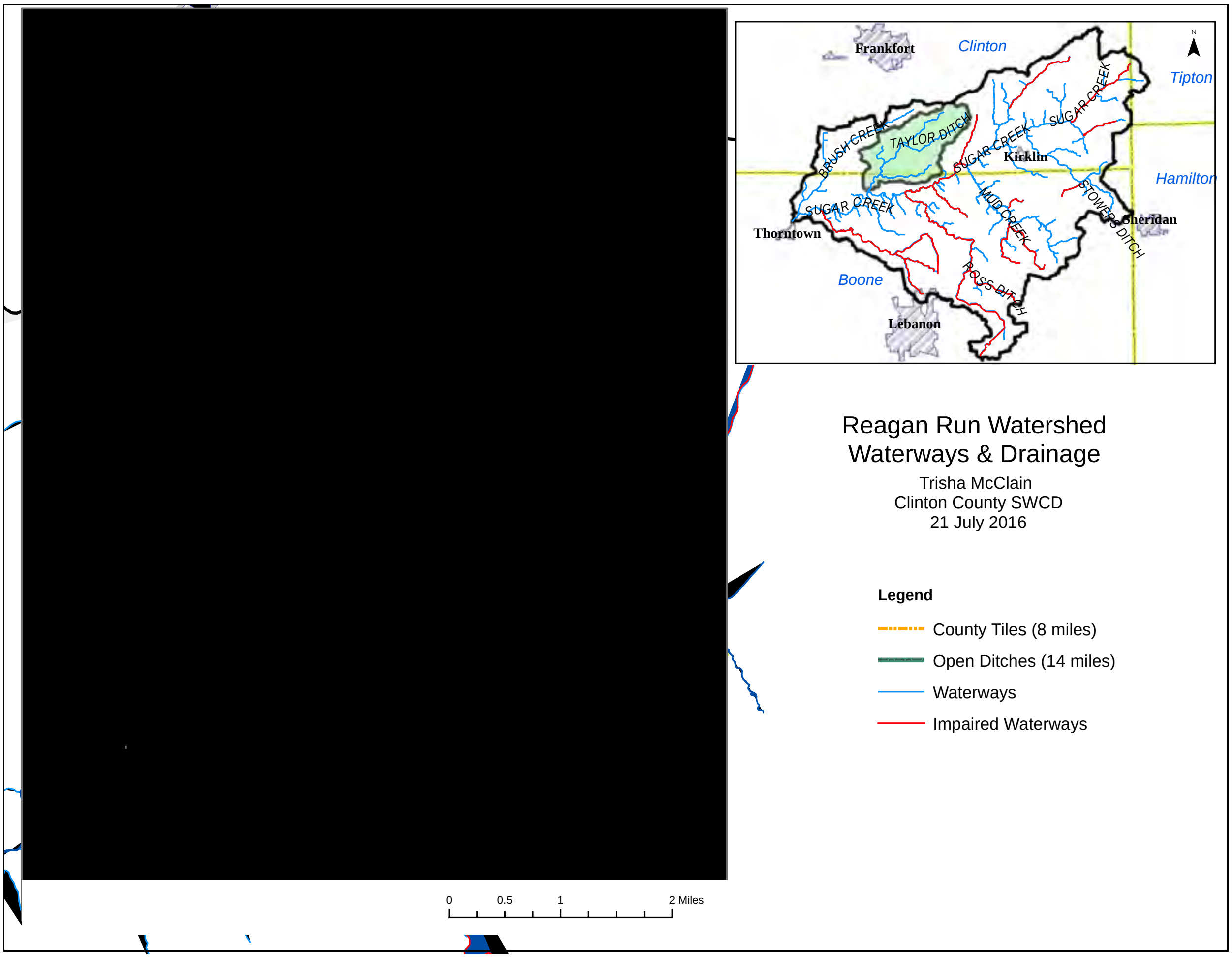

Figure 58. Reagan Run Watershed Waterways & Drainage (Clinton & Boone Co. Surveyor, 2014)

Soils within Reagan Run Watershed is predominately composed of three different types of hydric soils such as Cy (Cyclone silt loam), Pn (Patton silty clay loam) and Ty (Treaty silt loam) (Figure 59). Hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems). Hydric soils provide suitable soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. Potentially Highly Erodible Lands (PHEL) according to NRCS and the Clinton County and Boone County Soil Survey are mostly Miami-Crosby silt loams, 2 to 6 percent slopes (MtB). Most of the PHEL soils within this watershed are located along Sim Rogers Ditch and Reagan run near the outlet of the watershed (Figure 59). Though most of the landscape soils is designated as either hydric of PHEL there is about 42 acres that contain Highly Erodible Lands (HEL) which would include: MnC (Miami silt loam, 6 to 12 percent slopes), MnD (Miami silt loam, 12 to 18 percent slopes), MmoC (Miami clay loam, 6 to 12 percent slopes, severely eroded) & SigE2 (Senachwine silt loam, 18 to 25 percent slopes, eroded).

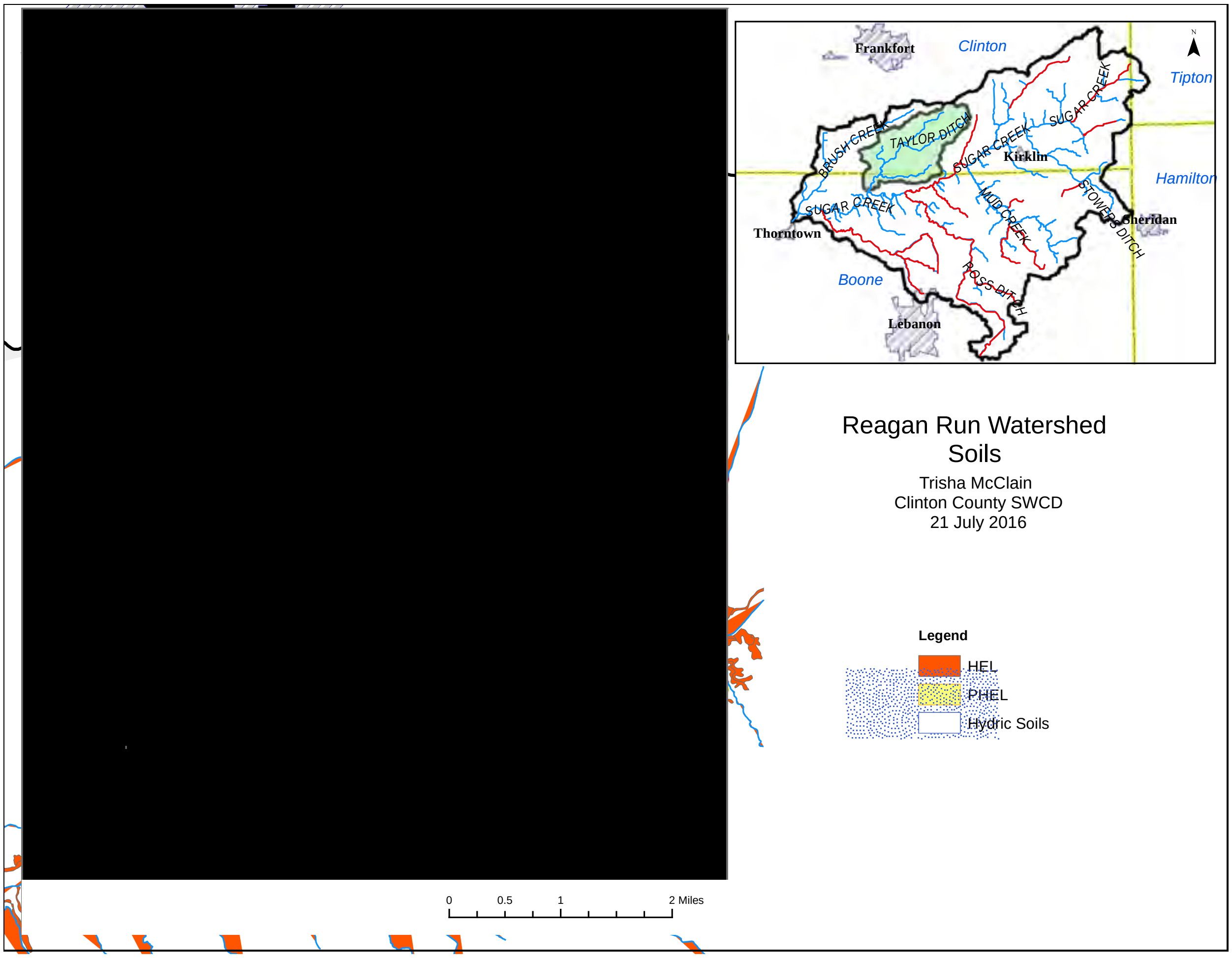

Figure 59. Reagan Run Watershed Soils (SSURGO, 2015)

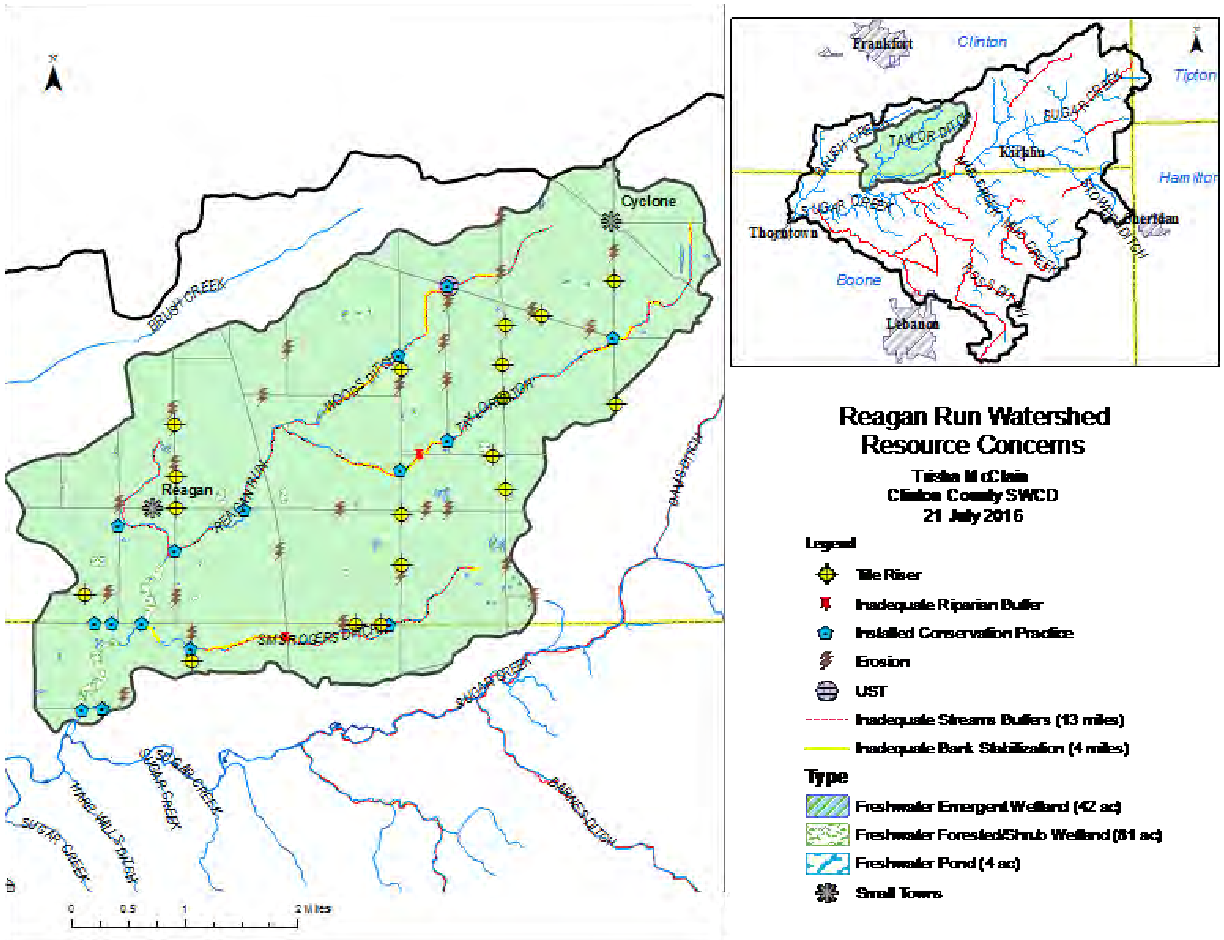

Figure 60. Reagan Run Watershed Resource Concerns (Clinton Co. SWCD, 2015)

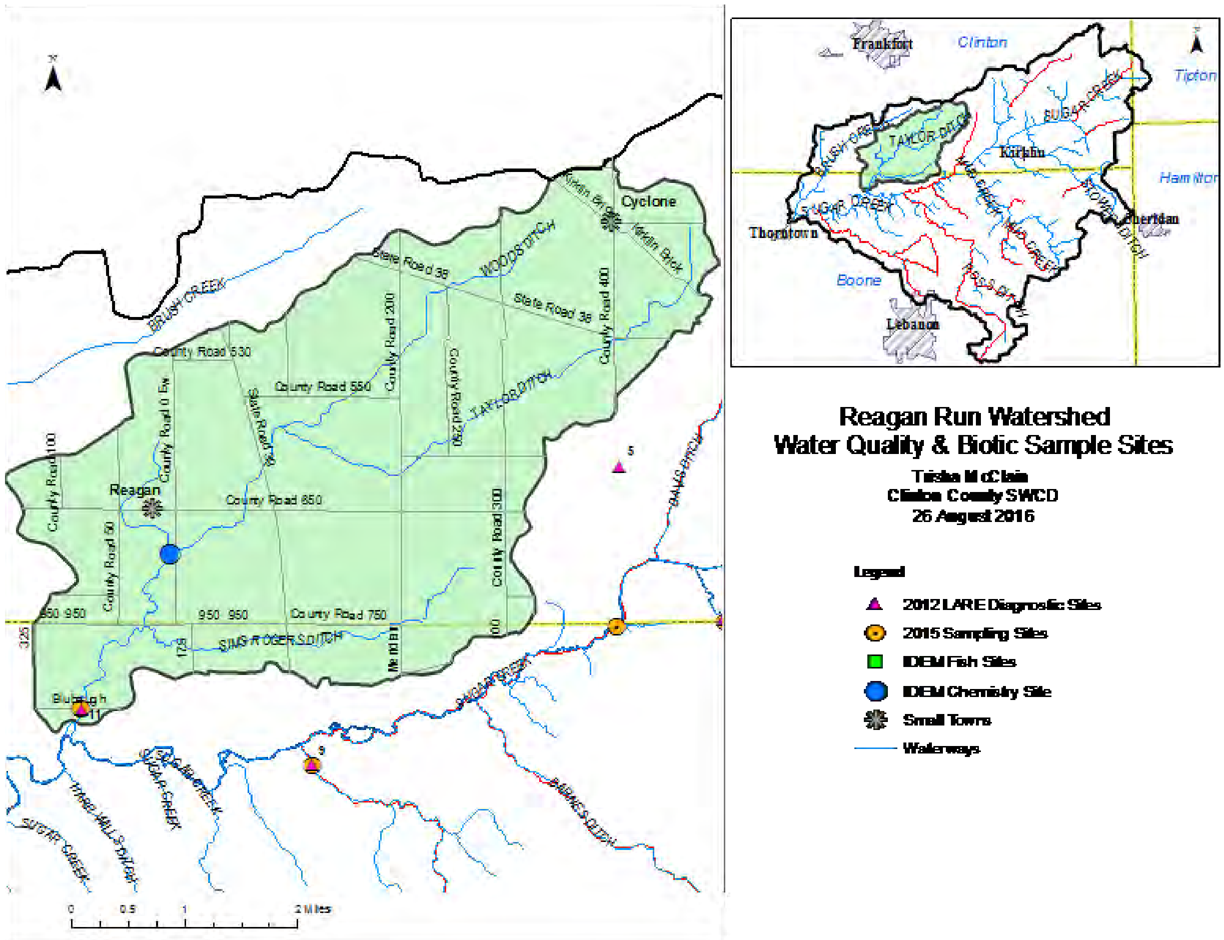

Figure 61. Reagan Run Watershed Water Quality & Biotic Sample Sites (IDEM, 2015)

Water Quality

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study only one site was located in Reagan Run Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 35). The site was located at the confluence of Reagan Run Watershed and was the same sampling location of the Browns Wonder Sugar Creek Planning Project water quality monitoring (Figure 61).

Table 35. 2012 LARE Diagnostic Study Chemical Analysis

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Reagan Run *(Site 11)*	**352**	**0.7**	**0.58**	**2.4**
HIGH FLOW (August 10, 2012)				
Reagan Run *(Site 11)*	**275**	**0.4**	**0.54**	**14.4**

IDEM Historical Sampling (AIMS)

IDEM only analyzed bacteria and pathogens within Reagan Run once in 2009 on CR 0 E / W which resulted in a geometric mean of 1,000 CFU/ 100 mL of E.coli (Figure 61). In regards to habitat and biological assessment there were no evaluations done within the Reagan Run Watershed.

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had a sample site at Reagan Run Watershed outlet, labeled Reagan Run (ReR) which is located in Boone County. A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 36). Bolded items indicate values that exceed established target values (Table 15). The cQHEI assessment was conducted on October 21, 2015 with a score of 70; which indicates the habitat is able to sustain healthy aquatic communities and surpasses the project target value of 60.

Table 36. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Reagan Run (ReR) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=24]	93.4	**322**	**771.7**	**1,299.7**	**10,462.4**	**79%**
TSS mg/L [n=24]	1.8	4.3	7	20.5	**100**	25%
Nitrate-Nitrite mg/L [n=25]	0	0.24	**5.6**	**8**	**13.5**	**76%**
T-P mg/L [n=25]	0	0.04	**0.07**	**0.14**	**2**	**60%**
Turbidity NTU [n=17]	6.7	10.3	**14**	**29.1**	**153**	**71%**
Dissolved Oxygen [D.O] mg/L [n=17]	**3.24**	**3.7**	4.1	6.5	**10.1**	**59%**

Watershed Inventories

Windshield Survey

Per the 2015 windshield survey a variety of different resources concerns were identified within the Reagan Run Watershed (Figure 60). Data would indicate there were two inadequate riparian buffers along Taylor Ditch and Sim Rogers Ditch, 18 tile risers and 27 points indicated erosion problems. There seems to be some efforts already occurring throughout the watershed because 16 conservation practices were implemented with Reagan Run Watershed.

Desktop Survey

The Reagan Run Watershed has two small towns within the watershed boundaries known as Cyclone & Reagan. The watershed itself has minor development (698 acres) (Figure 53). There have been no identified or documented active confined feeding operation or leaking underground storage tank; however, there is an underground storage tank (UST) managed by FW Clark Farm Limited Partnership, which is located on Woods Ditch that has no documented incidents (Figure 60). Please note, the UST mentioned indicates a potential source of pollutants within the subwatershed. Further action or detail about the UST will not be described or addressed. After GIS analysis, approximately 13 miles require stream buffers and 4 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events. The term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system.

Reagan Run Watershed Assessment

Reagan Run Watershed is approximately 15,063 acres with 18 miles of waterways; none of which have been classified as impaired. Water quality impacts showcased within this subwatershed through water quality monitoring are a result of local impacts as well as the receiving waters of upper subwatersheds.

The landscape is 87% cropland with about 766 acres of forested scattered woodlots. The high prevalence of agriculture can result in a high volume of subsurface drainage tile, resulting in high concentrations of nitrate-nitrite, total phosphorus and *E. coli*. Nutrients appear to be the most significant issue within this watershed. There is very little biological and habitat assessment. During 2015 monitoring efforts, on average the subwatershed exceeded target values in *E. coli* [less than 235 cfu/ 100 mL], Nitrate [1.6 mg/L] and Turbidity [10.4 NTU]. During the 2012 LARE Diagnostic Study *E. coli* concentrations exceeded target values during low and high flow. Indicating that high levels of pathogens could be a result of septic system failure, undocumented hobby farms, manure applied to cropland or livestock having open access to streams. Pathogens are difficult to monitor but since there is little evidence of livestock in the windshield survey and there are no active CFOs in this watershed, it is likely to assume the issue is more of a septic system issue or agricultural application.

Reagan Run Watershed has been designated as a Tier 2 Critical Land Area (CLA). Based on stakeholder, ecological & environmental concerns, the steering committee considers this subwatershed as a priority area, but not the highest priority. Implementation efforts will primarily target Tier 1 Critical Land Areas & once all conservation opportunities have been exhausted implementation will target Tier 2 CLA's. The project's implementation strategy is to target conservation efforts towards upstream private land management and development while simultaneously and naturally impacting downstream resources.

4.7 Spring Creek-Sugar Creek (HUC: 051201100107)

Land Use

Spring Creek- Sugar Creek Watershed is approximately 20,555 acres with a drainage area of 13 square miles of Boone County**.** The land use is primarily agriculture with 7,703 acres of soybeans and 6,965 acres of corn. Continuous wooded corridors (1,853 acres) are more prevalent along the main stem of Sugar Creek, Spring Creek & scattered along southern tributaries of the watershed (Figure 62). There is about 37 miles of natural waterways within this subwatershed which includes: Spring Creek, Sugar Creek, Haar Wills Ditch, Buntin Ditch, Waddle Ditch & Storms Ditch (Figure 58). Approximately 17 miles have been listed under IDEM's 303(d) Impaired Waterways List for Escherichia Coli (*E. coli*), which would be: Buntin Ditch (INB1016_T1008), Spring Creek (INB1017_T1004) and Storms Ditch (INB1012_T1005). According to survey data there approximately 18 miles of subsurface tiles installed and 27% of the waterways are designated as open ditches (Figure 63).

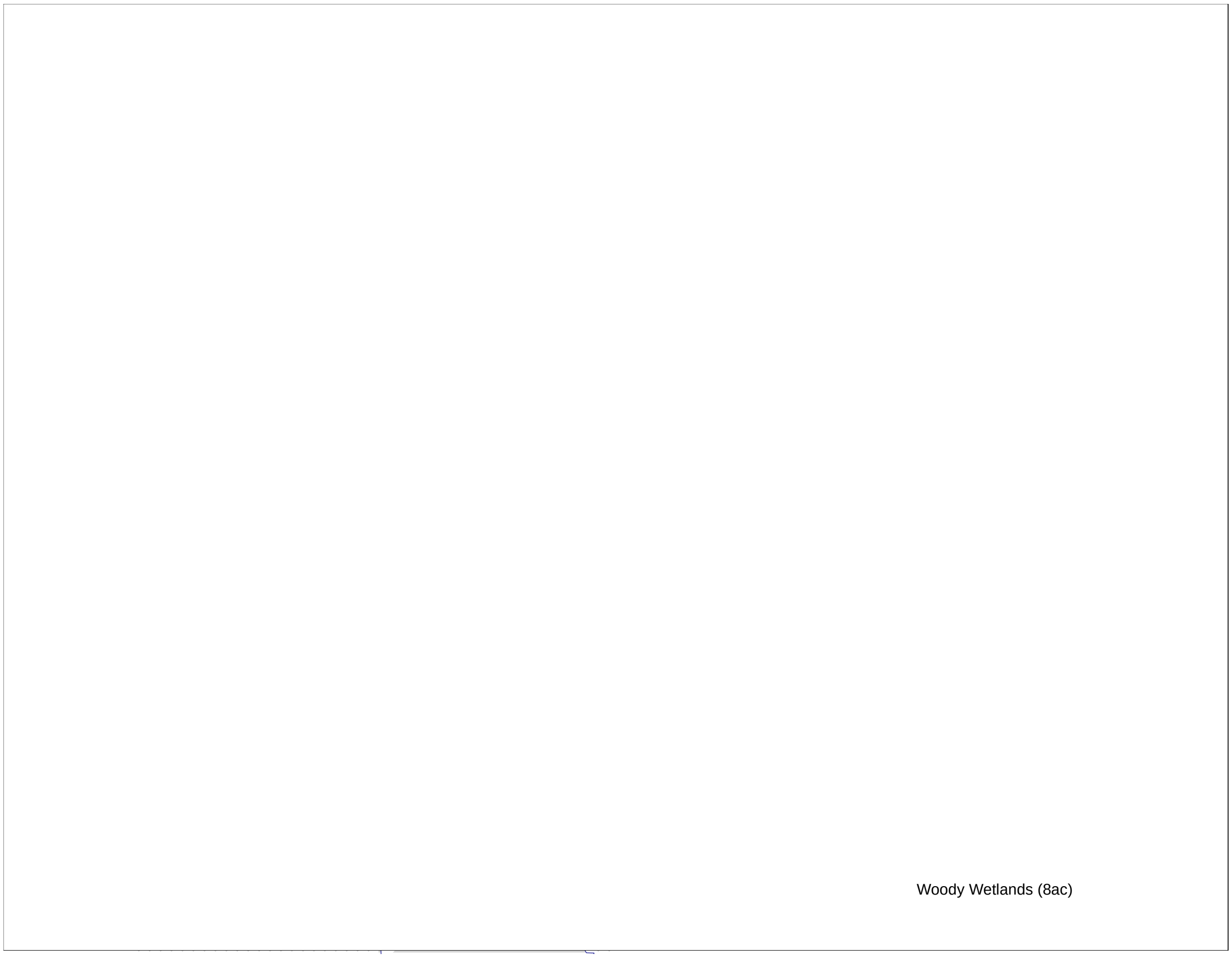

Figure 62. Spring Creek-Sugar Creek Watershed Landscape (NLCD, 2011)

Figure 63. Spring Creek- Sugar Creek Watershed Waterways & Drainage (Boone Co. Surveyor, 2014)

Areas located outside the main stem of Sugar Creek, within the Spring Creek-Sugar Creek Watershed, tend to hydric soils, especially the southern regions of the watershed (Figure 64). Hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems). Hydric soils provide suitable soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. In addition to hydric soils the landscape is composed of both Potentially Erodible Lands (PHEL) and Highly Erodible Lands (HEL). A majority of the PHEL soils within the watershed are MnpB2 (Miami silt loam, 2 to 6 percent slopes, eroded), WofB (Williamstown-Crosby silt loams, 2 to 4 percent slopes) & XfuB2 (Miami-Rainsville complex, 2 to 6 percent slopes, eroded), which are located along Spring Creek, Sugar Creek and Harr Wills Ditch.

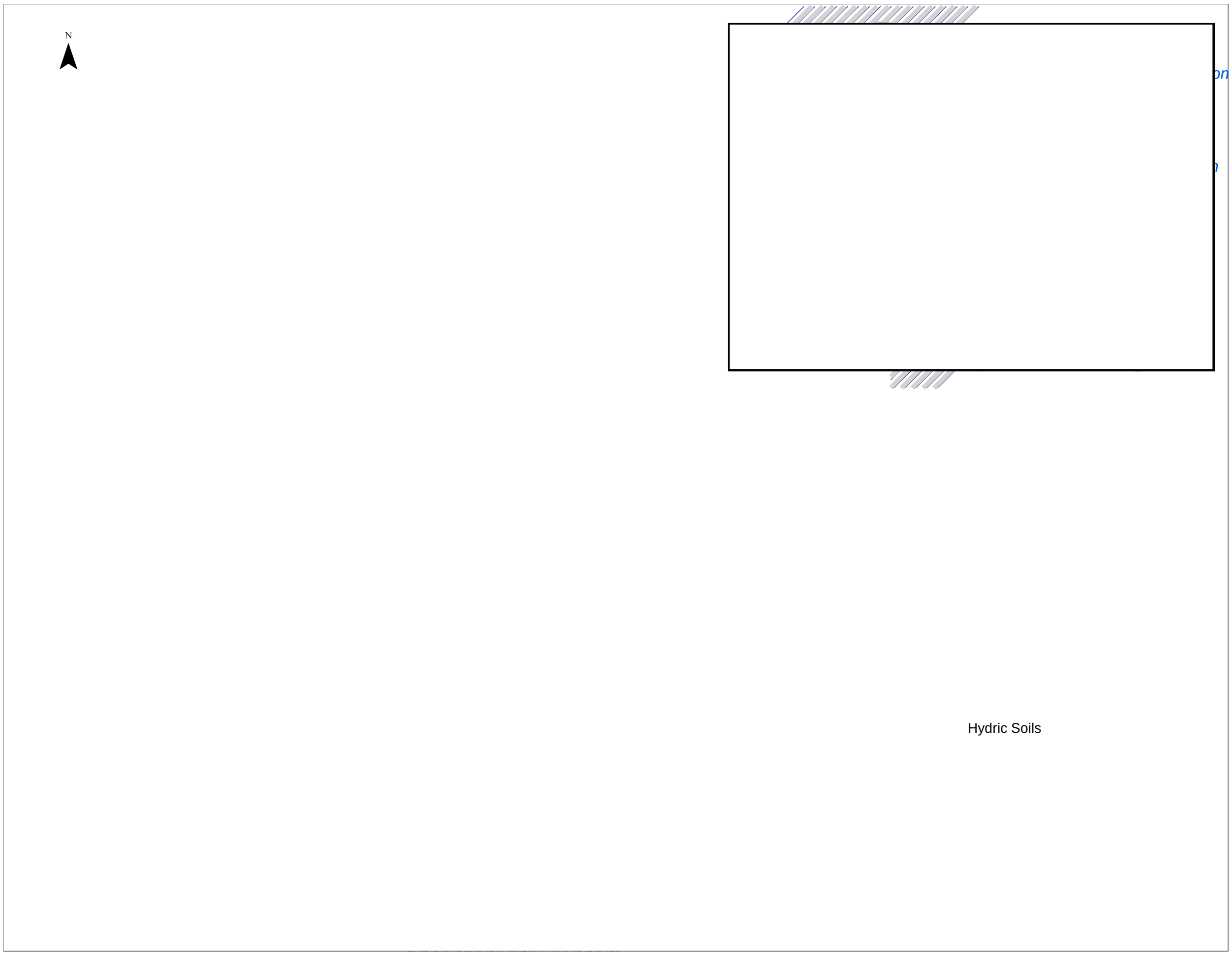

Figure 64. Spring Creek-Sugar Creek Watershed Soils (SSURGO, 2015)

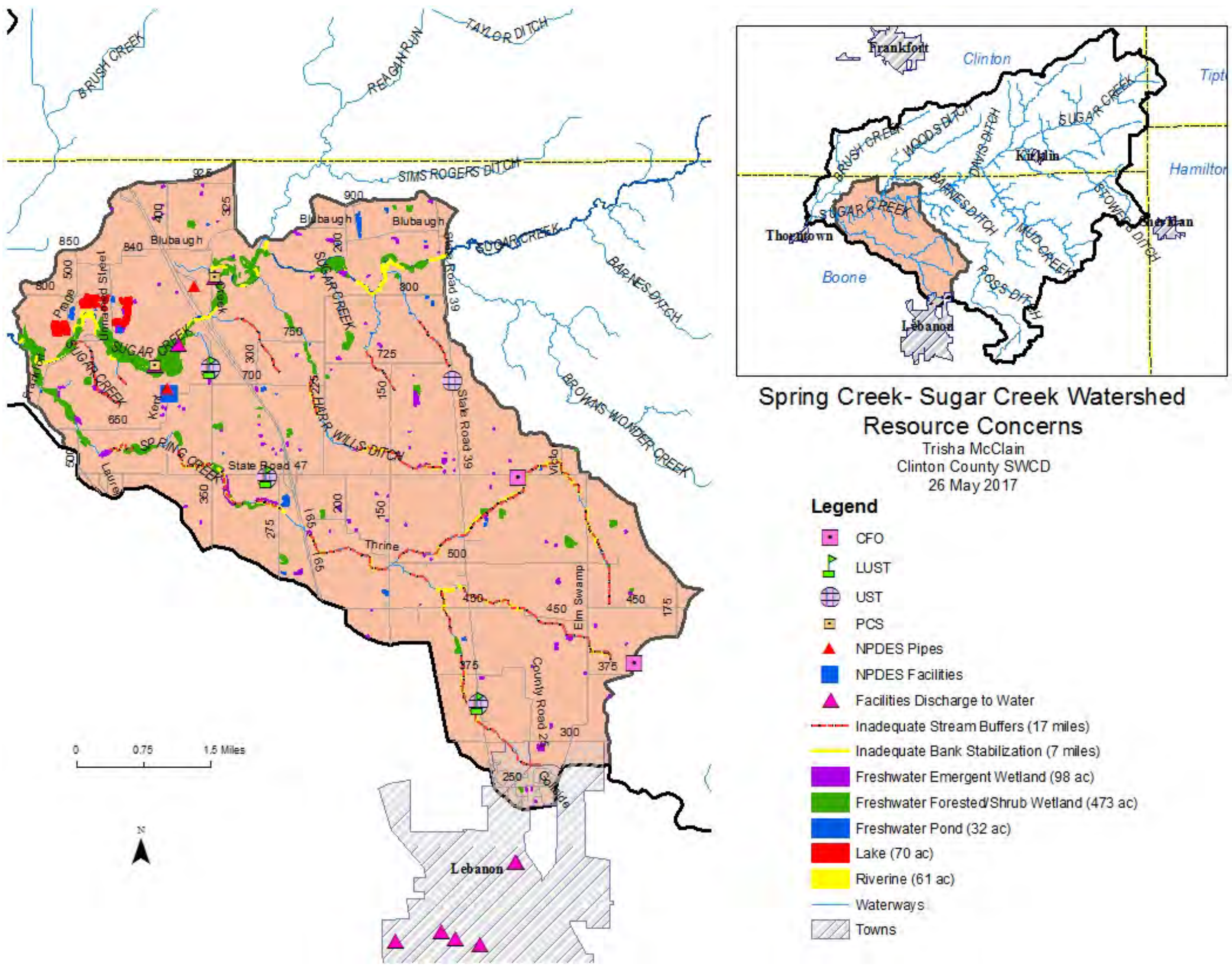

Figure 65. Spring Creek-Sugar Creek Watershed Resource Concerns (IDEM, 2015)

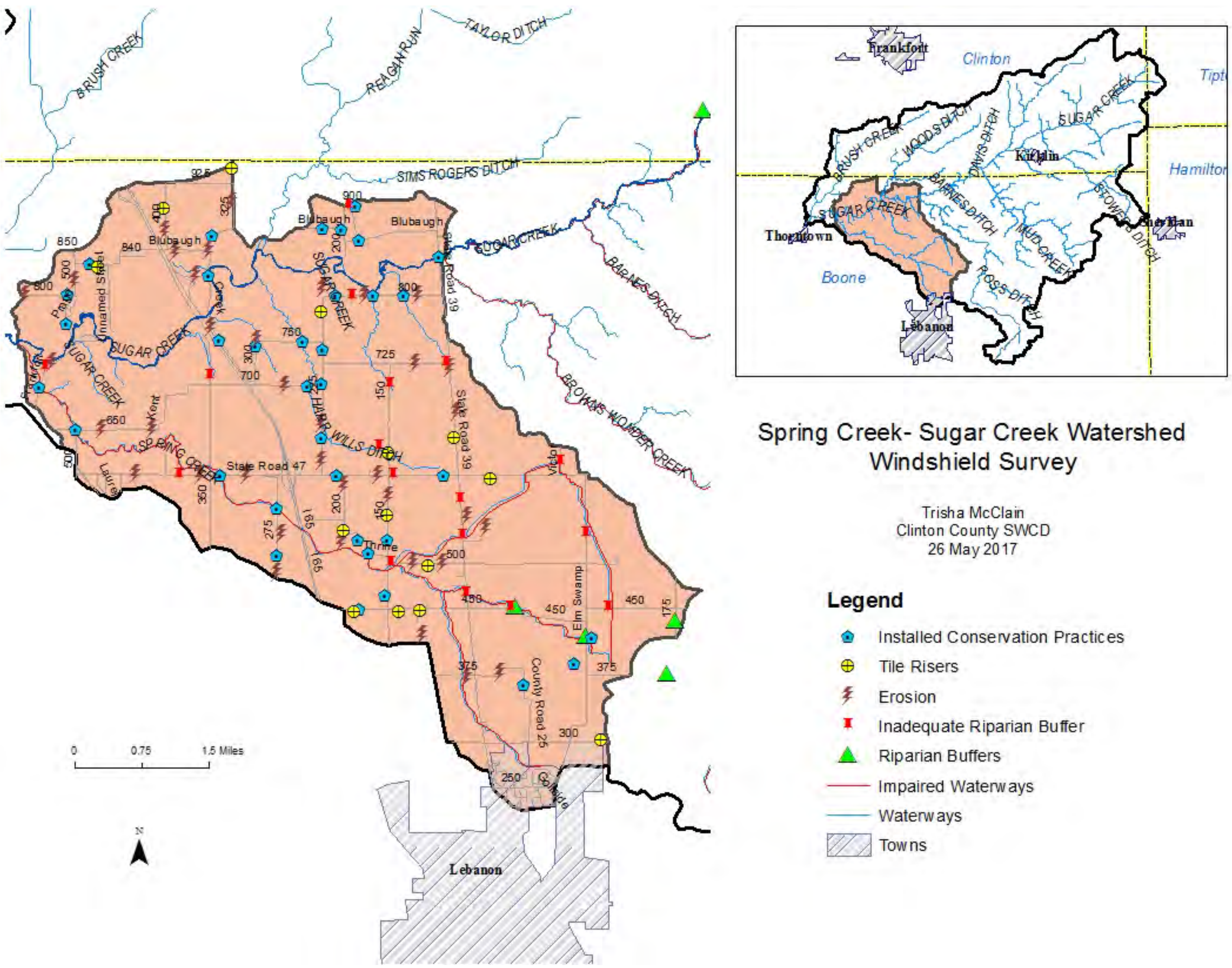

Figure 66. Spring Creek- Sugar Creek Watershed Windshield Survey (Clinton Co. SWCD, 2015)

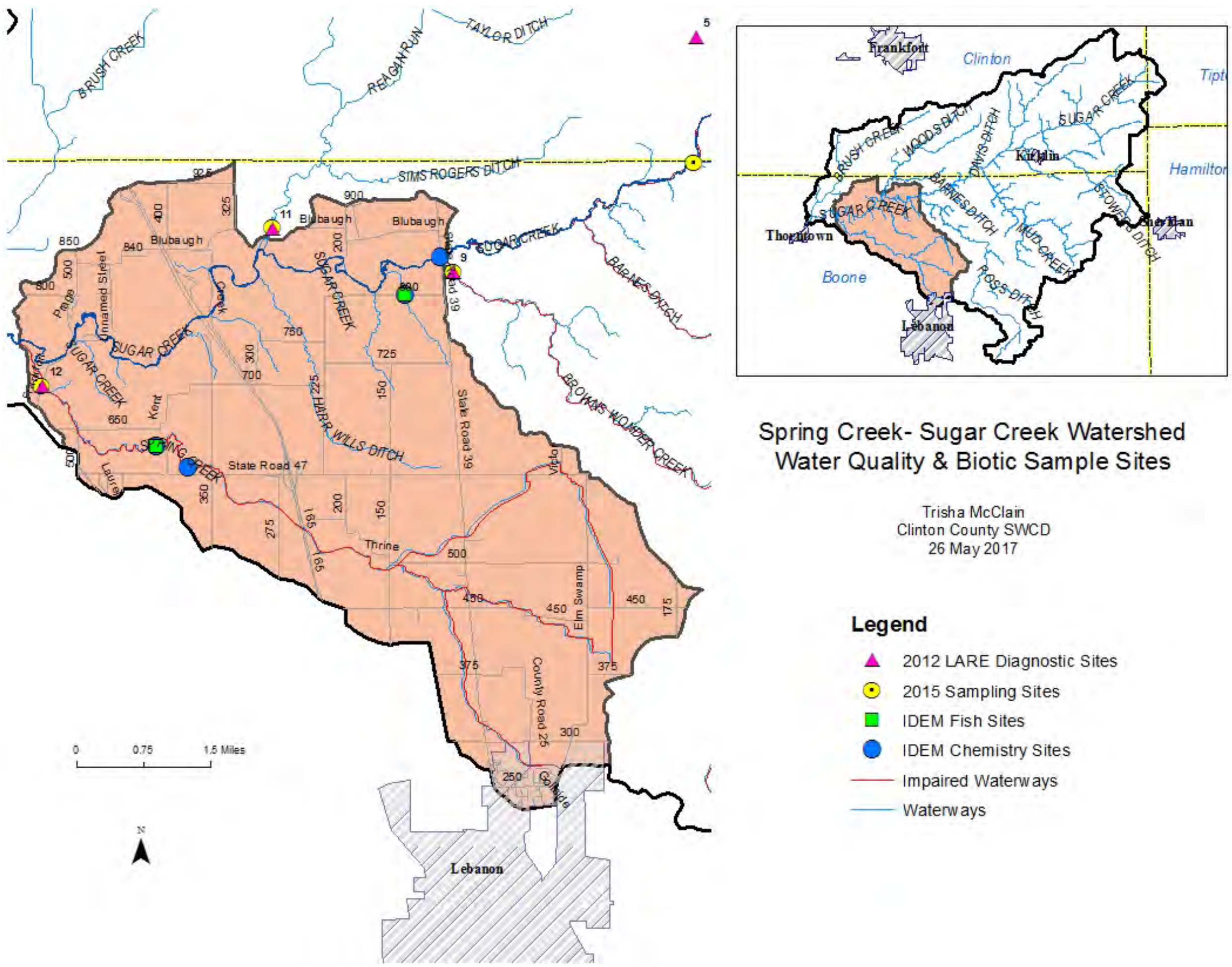

Figure 67. Spring Creek- Sugar Creek Watershed Water Quality & Biotic Sample Sites (IDEM, 2015)

Water Quality

IDEM 305(b)/ 303(d)

Approximately 17 miles (Buntin Ditch (5 stream miles; INB1016_T1008), Spring Creek (9 stream miles; INB1017_T1004) and Storms Ditch (3 stream miles; INB1012_T1005)) have been listed under IDEM's 303(d) Impaired Waterways List for Escherichia Coli (*E. coli*) (Table 15). Sources for pathogens can be due to a variety of factors such as: improper or poor management/ installation of septic systems, livestock have open-access to local waterways, manure application on cropland & through surface water run-off. Since the watershed has poor buffers along waterways, it leaves streams susceptible to run-off during significant rain events. Septic system issues can be identified if *E. coli* concentrations are high during low flow; otherwise high levels are most likely the result of surface water run-off, manure application, or livestock having open-access to streams.

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study only one site was located with Spring Creek Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 37). The site is located at the confluence of Spring Creek and Sugar Creek (Figure 67).

Table 37. 2012 LARE Diagnostic Study Chemical Analysis

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Spring Creek *(Site 12)*	**439**	**1.4**	**0.22**	**2.4**
HIGH FLOW (August 10, 2012)				
Spring Creek *(Site 12)*	**963**	**0.3**	**0.13**	**6**

IDEM Historical Sampling (AIMS)

IDEM had three locations for chemical analysis and Qualitative Habitat Evaluation Index (QHEI) was conducted at two different sites (Figure 67). Results would conclude as the following: an average of 0.77 mg/L in Nitrate, 0.36 mg/L in Phosphorous and 10.7 mg/L in Total Suspended Sediment (TSS) (Table 38). The biological & habitat assessment conducted on August 17, 2005 would indicate that water quality is not sufficient for the biotic community for the sample site on SR 47 while habitat is not adequate to sustain aquatic life the sample site on CR 800 N (Figure 68).

Table 38. IDEM Historical Sampling Program of Spring Creek-Sugar Creek Watershed (1999-2015)

Site	Date Sampled	Latitude	Longitude	Nitrate-Nitrite mg/L	Total Phosphorus mg/L	E.coli CFU/ 100 mL
At SR 39	8-16-05	40.16	-86.48	3	0.06	484.4 (geometric mean)
N of SR 47 E of US 52	7-26-04	40.13	-86.54	1.1	0.12	45 (geometric mean)
CR 800 N	8-17-05	40.15	-86.49	1.5	0.14	n/a

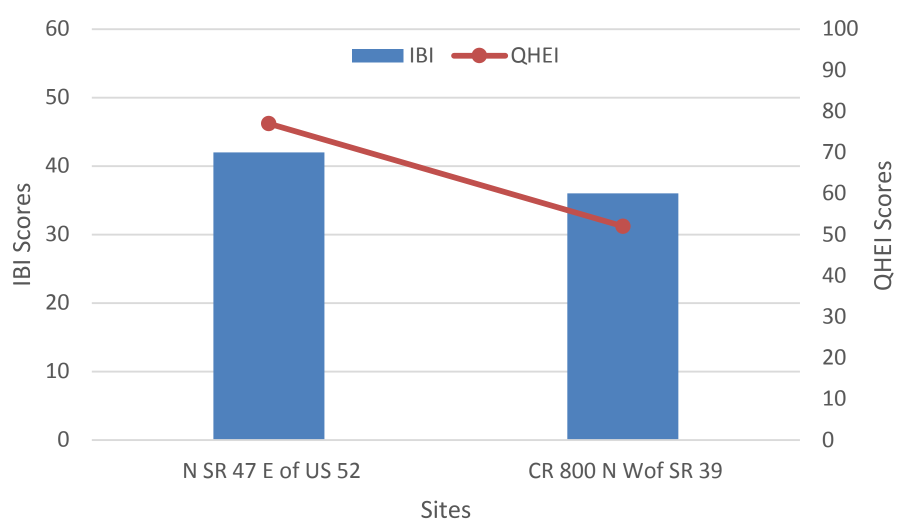

Figure 68. Comparative analysis of IDEM Historical Sampling data for IBI &QHEI scores evaluated Spring Creek- Sugar Creek

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had a sample site at Spring Creek Watershed outlet, near the confluence of Spring Creek and Sugar Creek, labeled site SpC (Spring Creek). A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 39). Bolded items indicate values that exceed established target values (Table 15). The cQHEI assessment was conducted on October 26, 2015 with a score of 78; which indicates the habitat is able to sustain healthy aquatic communities and surpasses the project target value of 60.

Table 39. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Spring Creek (SpC) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=24]	19.3	82.4	**275.5**	**677.4**	**11,198.7**	**66%**
TSS mg/L [n=22]	1	2.9	4.7	6.9	**185**	13%
Nitrate-Nitrite mg/L [n=22]	0.56	**2.4**	**3.5**	**4.5**	**10**	**68%**
T-P mg/L [n=22]	0	0.02	0.04	**0.10**	**0.56**	**59%**
Turbidity NTU [n=17]	5.2	9	**11.7**	**31.1**	**244**	**59%**
Dissolved Oxygen [D.O] mg/L [n=17]	**3**	**3.7**	4.4	6.1	**10.2**	**59%**

Watershed Inventories

Windshield Survey

Per the 2015 windshield survey Spring Creek-Sugar Creek was heavily documented in regards to identified resource concerns as well as identified practices or measures that help manage resource concerns (Figure 65 & 66). Most of the watershed is north of Lebanon, but a portion does reside in the watershed boundaries. Otherwise, minor development occurs and only has two identified small towns known as Pike and Stringtown (located right outside the city Lebanon limits). Data would indicate there were 17 inadequate riparian buffers along Sugar Creek, Spring Creek, Haarwills Ditch & along unnamed Spring Creek tributaries near Pike. The term inadequate indicates that the current conditions do not provide the proper protection to sustain a healthy ecological system. In addition, 14 tile risers primarily centralized around Pike and 37 points were documented indicating erosion problems. The data would indicate that areas with stream impairment or have a tile riser tend to have a higher occurrence of erosion (Figure 66). The windshield survey indicates that residents are taking action in order to address some of the resource concerns, which was evident during sampling because 35 conservation practices were documented as well as three riparian buffers along the headwaters of Spring Creek.

Desktop Survey

The Spring Creek- Sugar Creek Watershed has two small towns within the watershed boundaries known as Pike & Stringtown. The watershed itself has centralized development (3,641 acres), meaning most of the developed areas are roadways and urban development for the City of Lebanon (Figure 62). Data revealed that approximately 734 acres are designated wetlands that would include: emergent wetlands (98 ac), forested wetlands (473 ac), freshwater ponds (32 ac), lakes (70 ac) & riverine (61 ac). After GIS analysis, approximately 13 miles require stream buffers and 7 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events (Figure 65). The term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system.

Some potential sources of pollutants within the subwatershed will be described below. There is an active confined feeding operation (CFO), Cole Warren Farms, which contains 800 finishers. The operations is located on SR 39 & SR 47 near Buntin Ditch, there was a MMP issue in 2011, but it has been resolved. In addition to a CFO, there are 4 underground storage tanks (UST) [Vanierivier Livestock Inc., Pepsi-Cola Lebanon, Jack C Culbertson & Old Indiana Fun Park] located within the subwatershed. 3 of the 4 USTs have been designated as a leaking underground storage tank [Vanierivier Livestock Inc., Pepsi-Cola Lebanon & Old Indiana Fun Park] (LUST) (Table 40).

Point source pollution sites such as NPDES Facilities, NPDES pipes, PCS pipes, & facilities that discharge to waterways are described below. Sugar Creek Lebanon Utility (municipal or water district; MWD) is designated as the NPDES facility (NPDES ID: IN0059153) with an NPDES pipe located on 6940 N Kent RD within this subwatershed. The operation & discharge has an “effective” permit status, the NPDES is considered to be an external outfall. The other active external outfall NPDES pipe (NPDES ID: IN0034428) is for the Lebanon Rest Area. The Lebanon Rest Area in I-65 N, has a CWA permit that was documented as noncompliant for a series of 5 quarters from June 2014-June 2015 with pollutants of nitrogen and *E. coli*, but has maintained compliance since. In addition to NPDES facilities there are facilities that discharge into Spring Creek-Sugar Creek waterways. Of the three facilities only two have a PCS pipe. One facility is the Lebanon Water in Thorntown that has a minor Clean Water Act (CWA) permit; still effective. Within a 5 year period the industry was issued three different notice of noncompliant in 2012, 2014 & 2015. The type of violation was not identified. The remaining facility is the Old Indiana Fun Park in Thorntown; however, the CWA permit has been terminated. Please note, resource concerns described above and listed in Table 40 have been mentioned within the WMP to indicate potential sources of pollutants within the subwatershed. Further action or detail about these will not be described or addressed.

Table 40. Spring Creek- Sugar Creek Watershed Resource Concerns

Resource Concerns that Affect Water Quality	Amount
Leaking Underground Storage Tank (LUST)	3
Underground Storage Tank (UST)	4
Confined Feeding Operations (CFO)	1
NPDES Pipes	2
NPDES Facilities	1
Facility Discharge to Water	3
Pollution Control Standard Pipe (PCS)	2

Spring Creek-Sugar Creek Watershed Assessment

Spring Creek- Sugar Creek Watershed is approximately 20,555 acres. This subwatershed has 37 miles of flowing streams and about 26 miles are classified as having Escherichia Coli (*E. coli*) impairments. The impacts that are occurring within this watershed are a result of local issues as well as upstream land management & development.

Nearly 71% of the landscape is designated as cropland of either soybeans or corn. The high prevalence of agriculture can result in a high volume of subsurface drainage tile. Water quality data presented above showcases that nitrate and total phosphorus are one of the major nutrient concerns. Nitrate and total phosphorus enter waterways through subsurface tile drainage and run-off. Pathogens are another concern within this watershed. Pathogens could be a result of septic system failure, undocumented hobby farms, a CFO, manure applied to cropland or livestock having open access to streams. However, pathogens are difficult to monitor.

Habitat and biotic assessments would indicate the degraded biotic integrity that both habitat and water quality are not suitable to sustain healthy biotic communities. This is further justified from the 201 land use data, which indicates that only 0.09% (1,853 acres) of the landscape is designated as forested area. Biotic degradation can be a result of high nutrient levels as well (i.e. nitrate, total phosphorus & *E. coli*). During 2015 monitoring efforts, on average the subwatershed exceeded target values in *E. coli* [less than 235 cfu/ 100ML], Nitrate [1.6 mg/L], and Turbidity [10.4 NTU].

Spring Creek- Sugar Creek Watershed has been designated as a Tier 1 Critical Land Area (CLA). Based on stakeholder, ecological & environmental concerns, the steering committee considers this subwatershed as a high priority area. Implementation efforts will primarily target Tier 1 Critical Land Areas. The project's implementation strategy is to target conservation efforts towards upstream private land management and development while simultaneously and naturally impacting downstream resources. However, there are significant concerns such as: Nitrogen, Phosphorus & *E. coli* within the subwatershed that need to be immediately addressed. In addition, Spring Creek- Sugar Creek Watershed has the highest amount of forested area (Priority Protection Areas) within the watershed. The project also wants to maintain & further enhance already established habitat such as forested areas to preserve the natural landscape and project areas that can combat water quality concerns.

4.8 Brush Creek-Sugar Creek (HUC: 051201100108)

Land Use

Brush Creek- Sugar Creek Watershed is approximately 13,295 acres with a drainage area of 15 square miles of Clinton & Boone County. The land use is mostly agriculture with 5,514 acres of soybeans and 5,888 acres of corn. Continuous wooded corridors (514 acres) are more prevalent along the main stem of Sugar Creek near the outlet of the watershed. There is about 17 miles of natural waterways within this subwatershed which include: Brush Creek & Sugar Creek (Figure 69). According to IDEM 303 (d) list there are no impaired waterways within the Brush Creek-Sugar Creek Watershed. Surveyor data indicates there is approximately 3 miles of subsurface tiles installed and 2 miles of waterways are designated as open ditches, which happen to be all of Brush Creek and its tributaries (Figure 70).

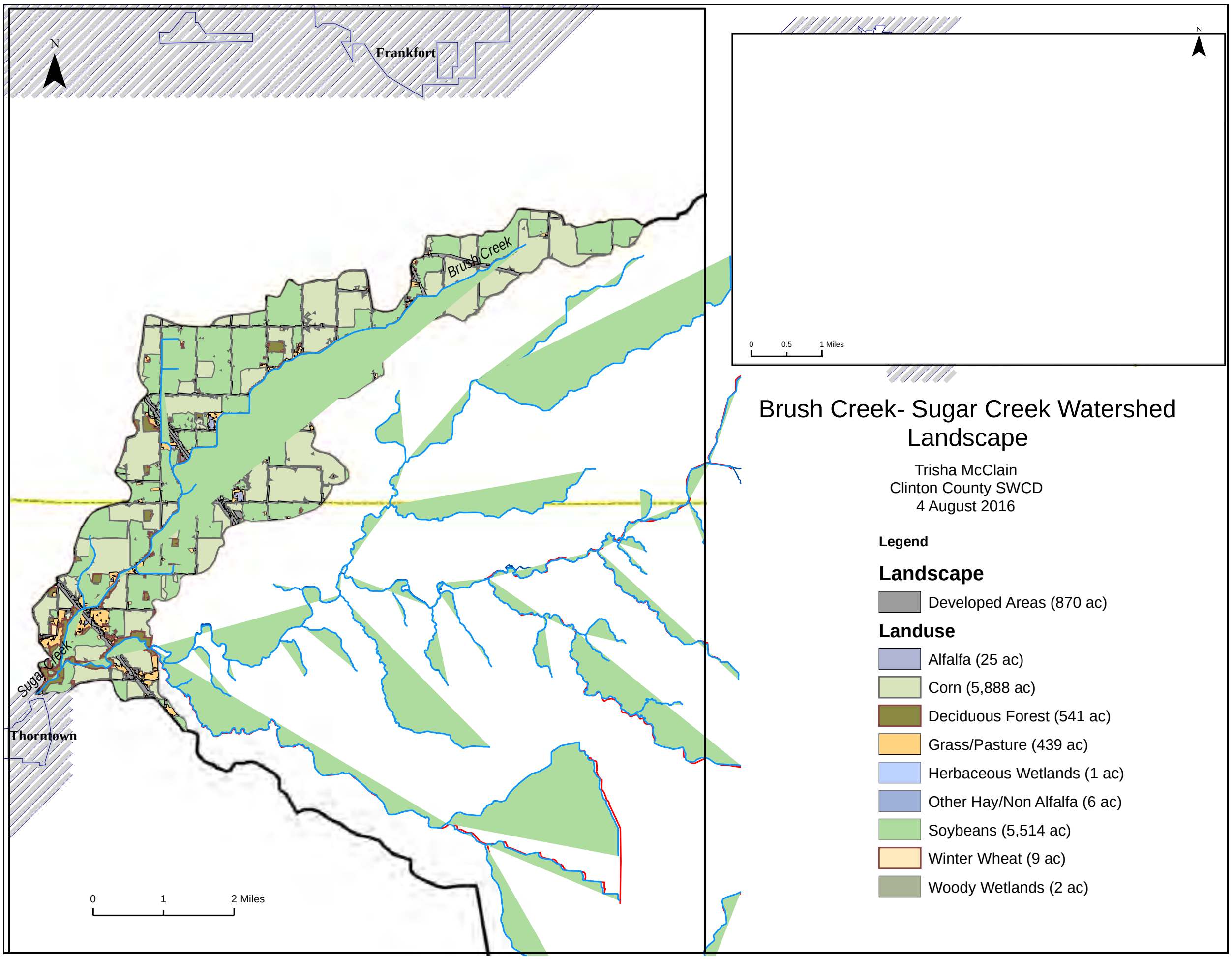

Figure 69. Brush Creek – Sugar Creek Watershed Landscape (NLCD, 2011)

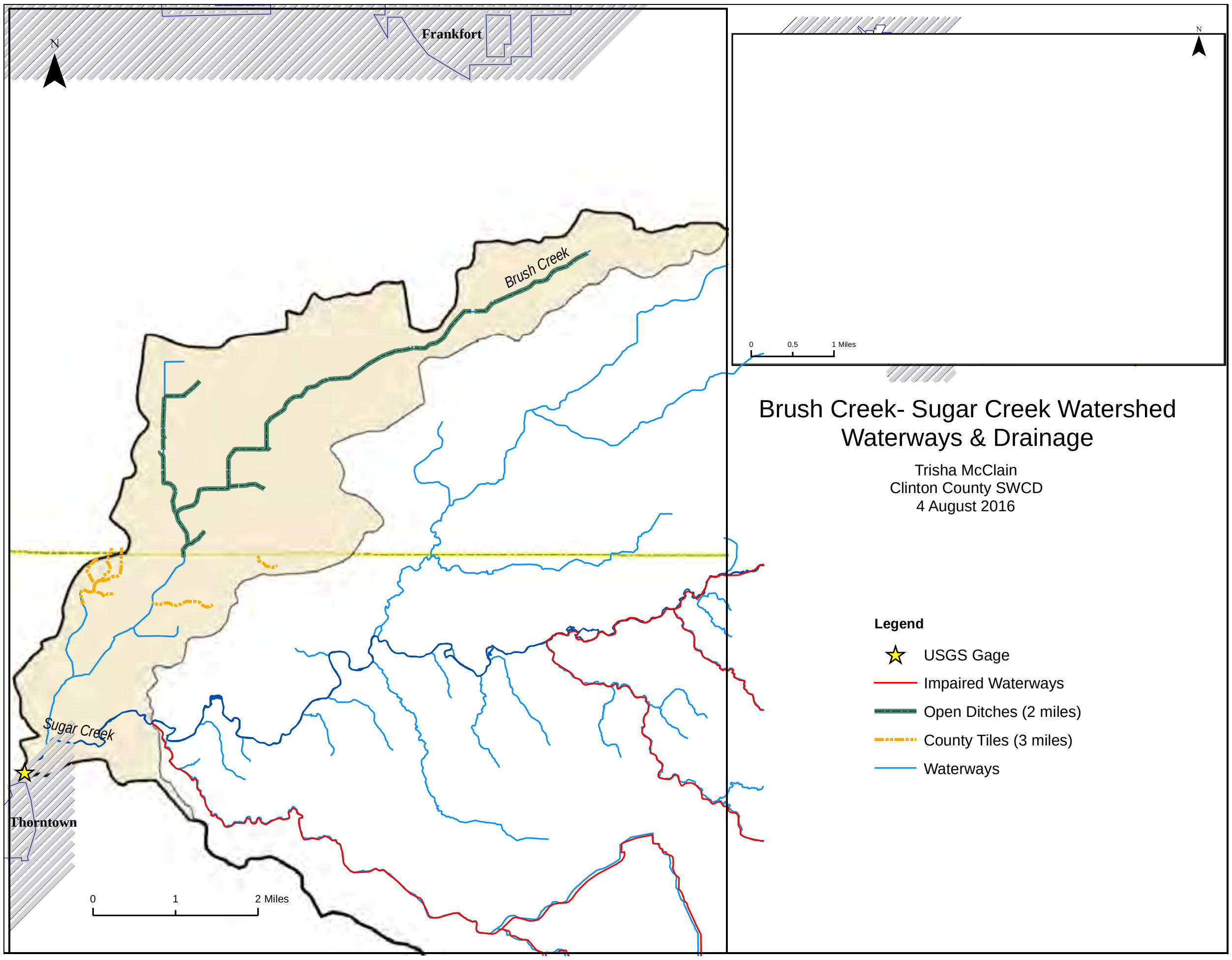

Figure 70. Brush Creek- Sugar Creek Watershed Waterways & Drainage (Clinton & Boone Co. Surveyor, 2014)

The Brush Creek- Sugar Creek Watershed is heavily dominated by hydric soils and Potentially Highly Erodible Lands (PHEL) (Figure 71). There is minor presence of Highly Erodible Lands within the watershed, soils that are present are scattered and typically found along waterways. Hydric soils are not suitable for on-site wastewater treatment facilities (i.e. septic systems). Hydric soils provide suitable soil for crops; however, the soil creates drainage issues for agricultural production if not properly drained. While (PHEL) and Highly Erodible Lands (HEL) leave ground susceptible to erosion if the management of the landscape is not taken into consideration, due to topographic gradient or soil structure. The PHEL soils within this watershed are county specific, areas that reside in Clinton County consist only of MtB (Miami-Crosby silt loams, 2 to 6 percent slopes) while Boone County is dominated by XfuB2 (Miami-Rainsville complex, 2 to 6 percent slopes, eroded), but has some other PHEL soils scattered across the landscape. The HEL soils are found along Brush Creek, especially as you get closer to the confluence of Brush Creek & Sugar Creek. HEL soils are mainly ObxB2 (Ockley silt loam, 2 to 6 percent slopes, eroded).

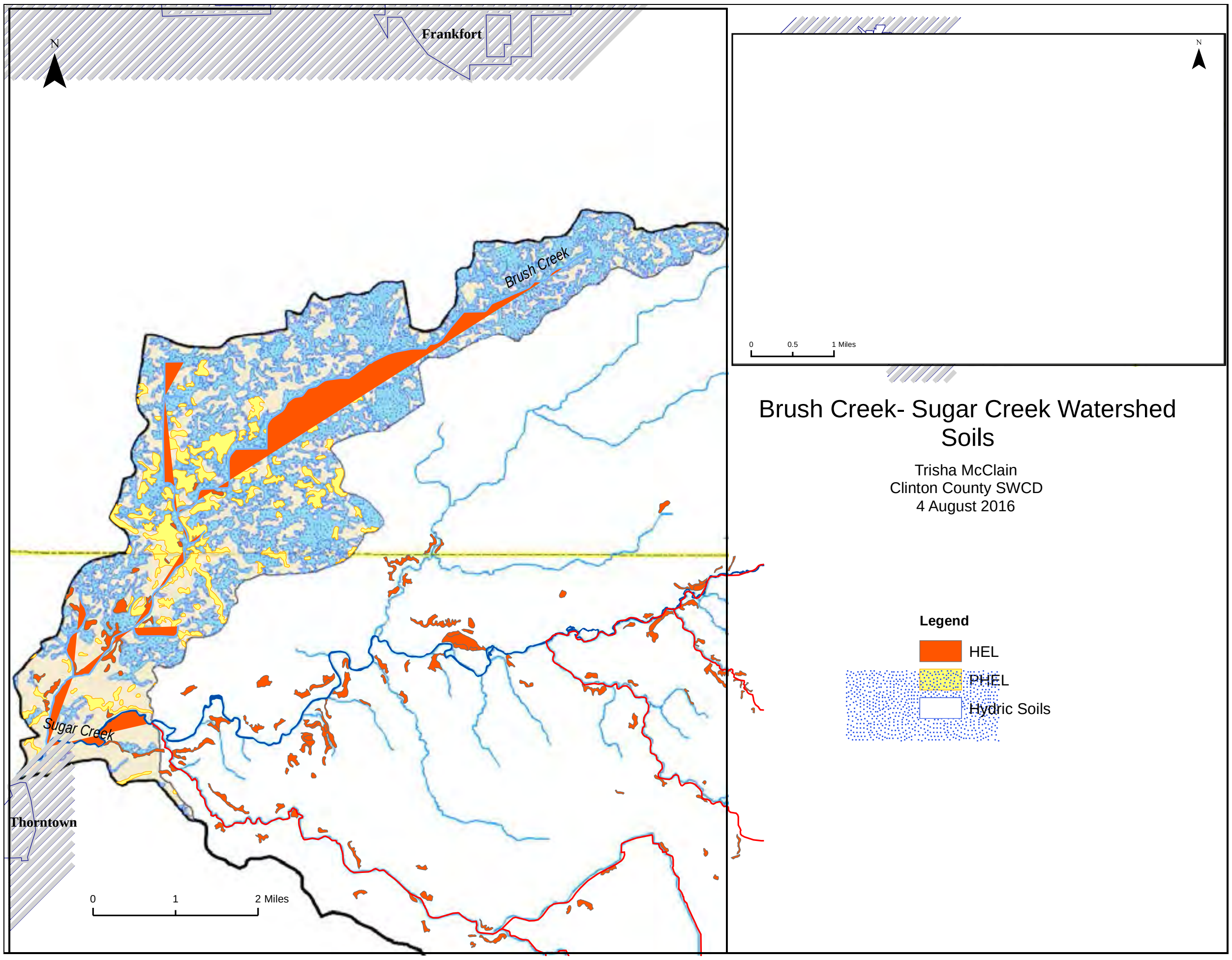

Figure 71. Brush Creek- Sugar Creek Watershed Soils (SSURGO, 2015)

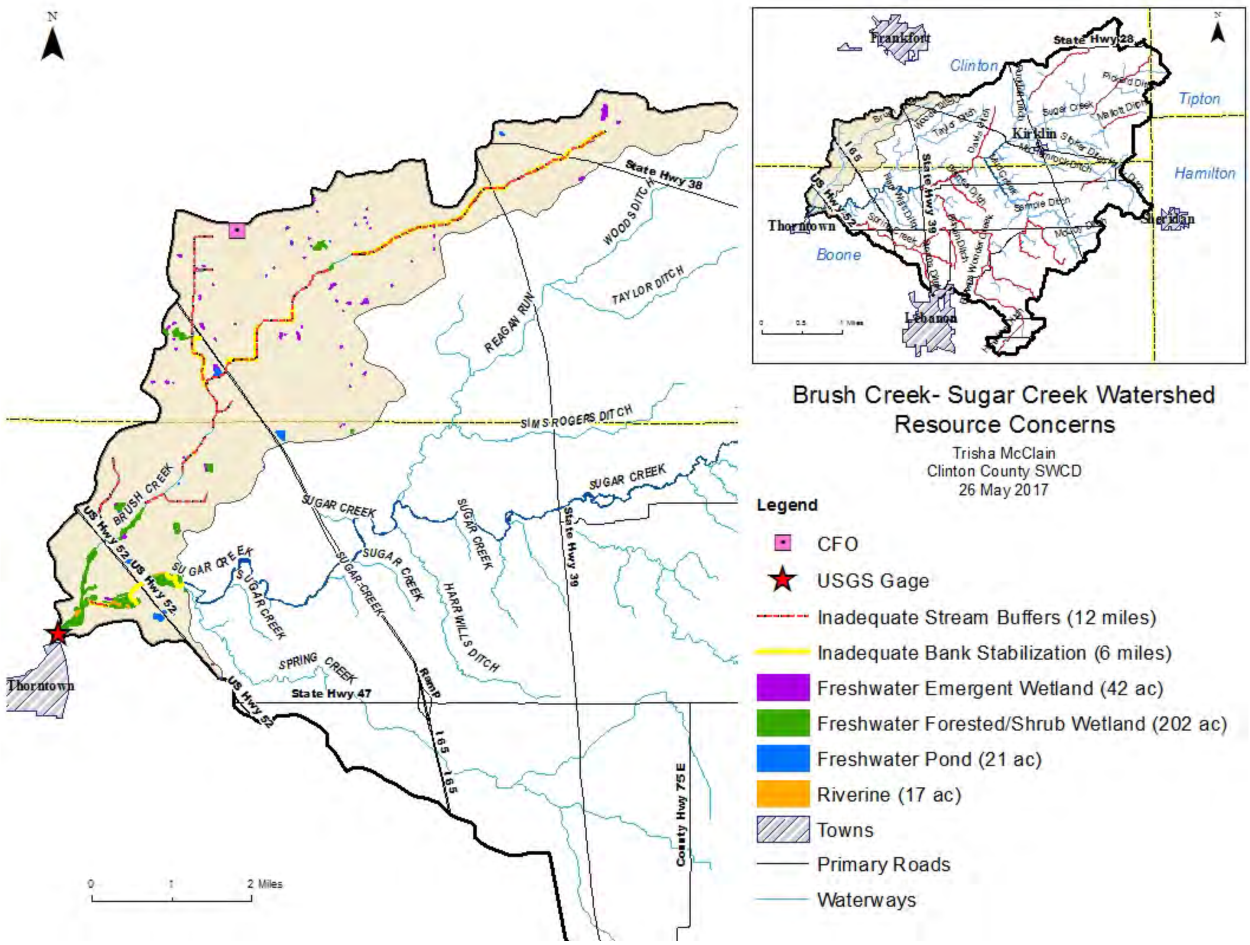

Figure 72. Brush Creek- Sugar Creek Watershed Resource Concerns (NLCD, 2011)

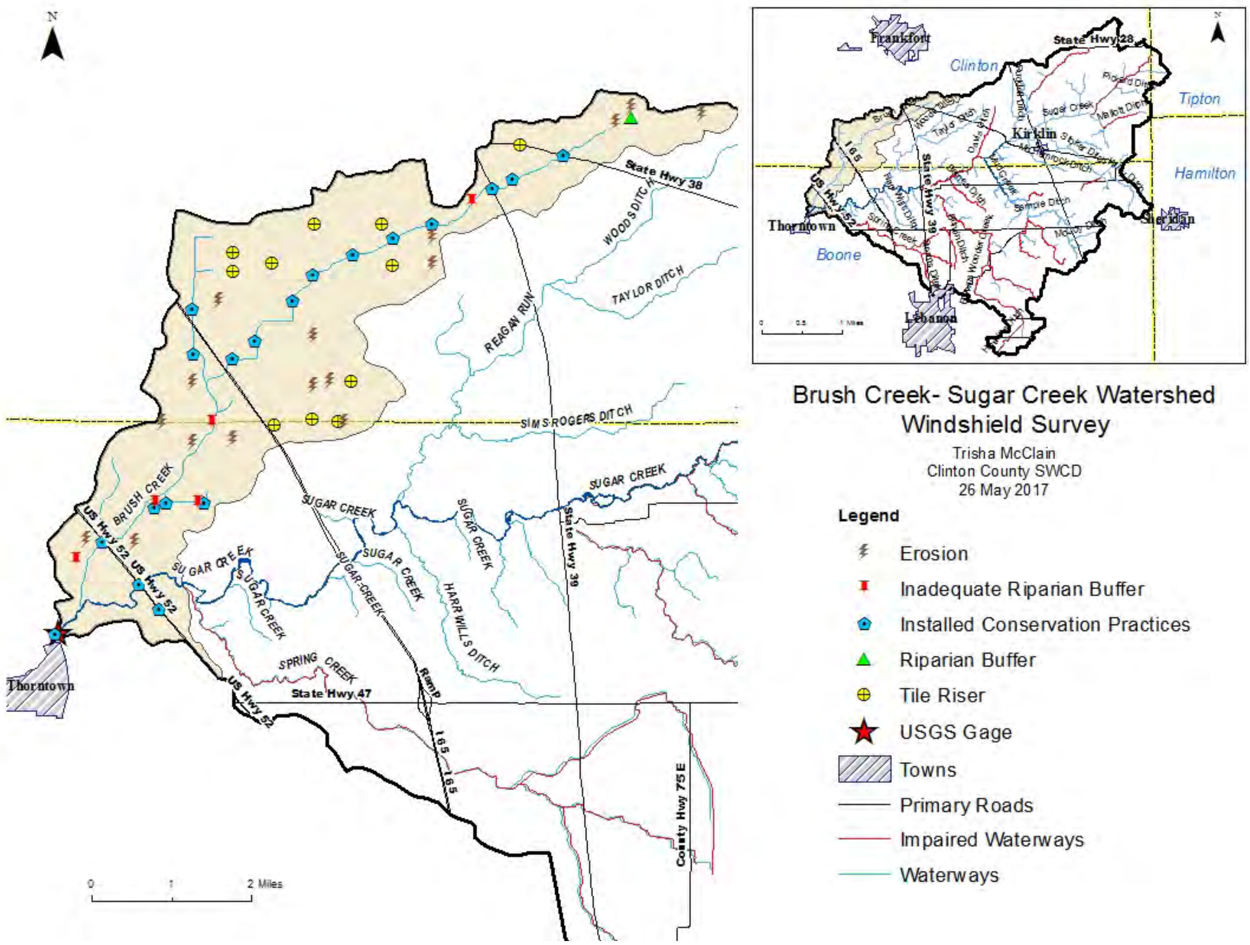

Figure 73. Brush Creek-Sugar Creek Watershed Windshield Survey (Clinton Co. SWCD, 2015)

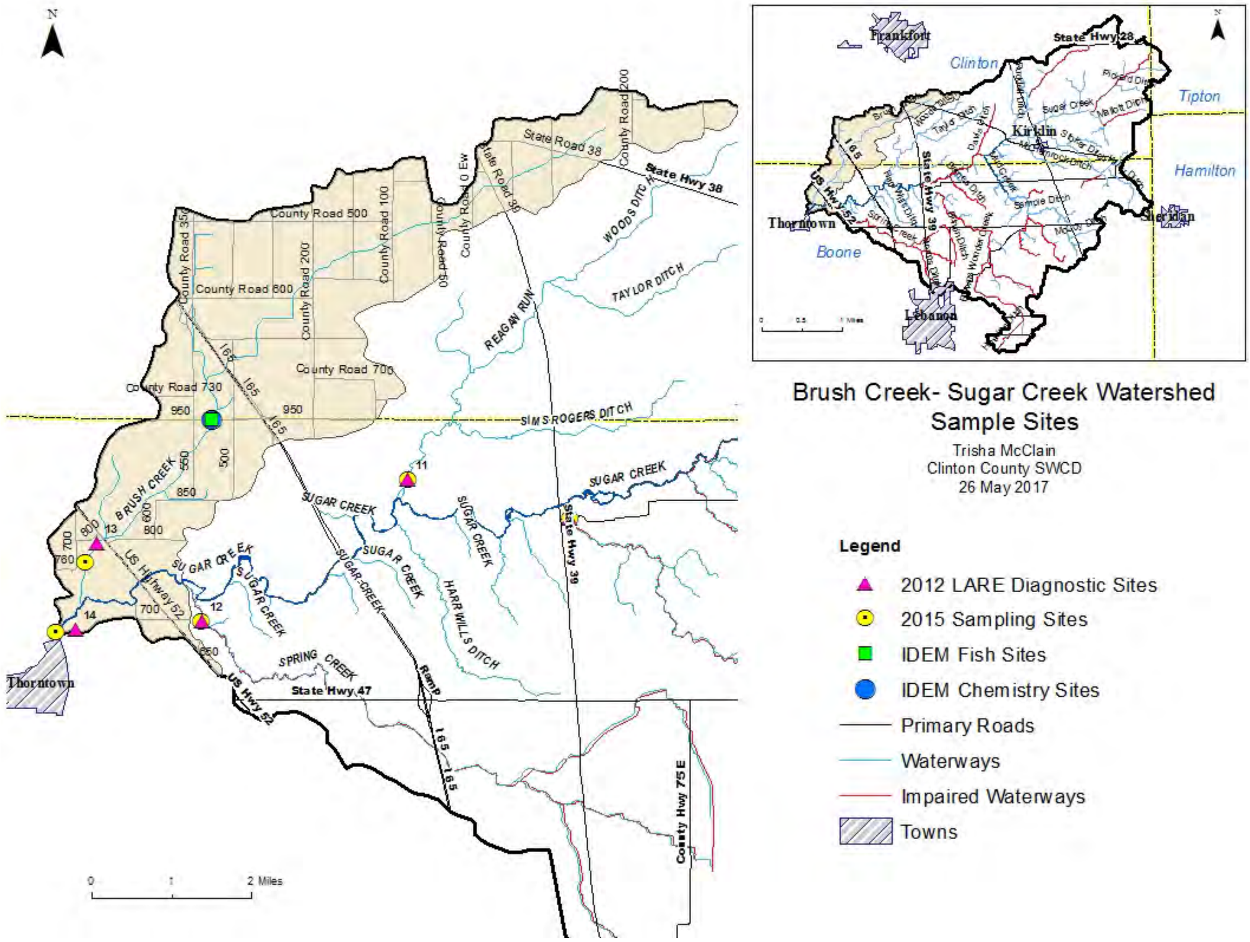

Figure 74. Brush Creek-Sugar Creek Chemical & Biological Sample Sites (IDEM, 2015)

Water Quality

IDEM 305(b)/ 303(d)

There were no identified impaired waterways within the Brush Creek-Sugar Creek Watershed.

2012 LARE Diagnostic Study

Of the 14 samples collected throughout the 2012 LARE Diagnostic Study two sites were located in Brush Creek- Sugar Creek Watershed. Water quality was assessed at two separate occasions by grab samples on June 12, 2012 (base flow) and August 10, 2012 (high flow). Bacteria and nutrients were analyzed (Table 41). Sites were located at the confluence of Brush Creek- Sugar Creek (site 14) and off US Highway 52 of the watershed (site 13) (Figure 74).

Table 41. 2012 LARE Diagnostic Study Chemical Analysis

Site	*E. coli* MNP/ 100mL TARGET: <235 cfu/ 100ml	Nitrate-Nitrite mg/L TARGET: 1.6 mg/L	Total Phosphorus mg/L TARGET: 0.05 mg/L	Total Suspended Sediment mg/L TARGET: 25 mg/L
BASE FLOW (June 12, 2012)				
Brush Creek *(Site 13)*	**543**	**1**	**0.35**	**1.6**
Sugar Creek *(Site 14)*	**116**	**0.6**	**0.22**	**4.4**
HIGH FLOW (August 10, 2012)				
Brush Creek *(Site 13)*	**225**	**0.3**	**0.13**	**6**
Sugar Creek *(Site 14)*	**326**	**0.4**	**0.04**	**11.6**

IDEM Historical Sampling Program (AIMS)

IDEM had no locations for chemical analysis; however, there was Qualitative Habitat Evaluation Index (QHEI) & Index of Biotic Integrity done was conducted on Country Road 750 S in Boone County on July 20, 2004 (Figure 74). The QHEI score was 65, in regard to habitat and a 38 was received for the IBI score. After review, the IBI and QHEI scores would indicate that there is neither a habitat or water quality issue within Brush Creek, the biotic community is healthy.

Browns Wonder- Sugar Creek Planning Project (2015)

The BWSC Planning Project had two sample sites one was at Brush Creek- Sugar Creek Watershed, labeled as BrC while the other was designated as ScD (Sugar Creek downstream, the outlet of the watershed). In addition, a USGS gage station near Thorntown was installed in order to establish pollutant loads (Figure 67). A statistical comparison (minimum, 25th percentile, median 75th percentile & maximum) was conducted on each chemical parameter evaluated (Table 42 & 43). Bolded items indicate values that exceed established target values. The cQHEI assessment was conducted on October 26, 2015 and December 8, 2016 with a score of 89 (BrC) and 65 a (SCD); which indicates the habitat is able to sustain healthy aquatic communities and surpasses the project target value of 60.

Table 42. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Brush Creek (BrC) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=24]	22.6	99	**443**	**579**	**1,414**	**64%**
TSS mg/L [n=24]	1.4	2.4	4.2	17	**87**	16%
Nitrate-Nitrite mg/L [n=23]	0.07	1.6	**4.8**	**6.3**	**36**	**87%**
T-P mg/L [n=23]	0.01	0.03	0.05	**0.1**	**1**	**52%**
Turbidity NTU [n=17]	4.6	**10.5**	**16.6**	**39.3**	**135**	**82%**
Dissolved Oxygen [D.O] mg/L [n=17]	**3.18**	**3.9**	6.3	7.6	**10**	35%

Table 43. A statistical comparison between chemical parameters evaluated during the BWSC Planning Project at Sugar Creek Downstream (ScD) sample site. Items bolded are values that have exceeded the established target values

CHEMICAL PARAMETERS	Minimum	25th Percentile	Median	75th Percentile	Maximum	% Exceedance of Target Values
E. coli cfu/ 100mL [n=24]	22.8	55.7	166	**517**	**4,106**	43%
TSS mg/L [n=24]	2.8	4.6	11.6	16.8	**364**	21%
Nitrate-Nitrite mg/L [n=24]	0.11	0.93	3.5	**5.4**	**11.6**	**79%**
T-P mg/L [n=24]	0	0.04	**0.06**	**0.11**	**1.42**	**68%**
Turbidity NTU [n=17]	**11**	**13.1**	**19.5**	**42.1**	**468**	**100%**
Dissolved Oxygen [D.O] mg/L [n=17]	**3.35**	**3.86**	5.16	6.6	**12.3**	**59%**

Watershed Inventories

Windshield Survey

Per the 2015 windshield survey Brush Creek-Sugar Creek was heavily documented due to the availability of volunteers and road accessibility throughout the watershed. There are no documented towns within the watershed, only outside of it (i.e. Thorntown). Data would indicate there were 5 inadequate riparian buffer that were mostly by the lower reaches of Brush Creek and its tributaries. The term inadequate indicates that the current conditions do not provide the proper protection to sustain a healthy ecological system. In addition, 11 tile risers primarily in the northern region of the watershed and 16 points were documented indicating erosion problems. The windshield survey also indicates that residents are taking action in order to address some of the resource concerns present within the watershed, which was evident during sampling because 19 conservation practices were documented as well as a riparian buffer along Brush Creek (Figure 73). Please note, items documented within the windshield survey provide a general assessment of the subwatershed and identify potential sources of pollutants or management that could be addressing water quality concerns.

Desktop Survey

After review, the Brush Creek- Sugar Creek Watershed did not present any resource concerns other than an active CFO located in the norther region of the watershed. The operation has approximately 750 Finishers and has not been issued any type of violation. Please note, CFOs have been mentioned within the WMP to indicate a potential source of pollutants within the subwatershed. Further action or detail about CFOs will not be described or addressed. After GIS analysis, approximately 12 miles require stream buffers and 6 miles have inadequate bank stabilization and are susceptible to erosion during significant rain events (Figure 72). The term inadequate means that the current conditions do not provide the proper protection to sustain a healthy ecological system.

Brush Creek-Sugar Creek Watershed Assessment

Brush Creek- Sugar Creek Watershed is approximately 13,295 acres with 17 miles of waterways; none of which have been classified as impaired. Water quality impacts showcased within this subwatershed through water quality monitoring are a result of local impacts as well as from upstream watershed land management & development.

The landscape is 86% cropland with about 541 acres of forested scattered woodlots. The prevalence of agriculture can result in a high volume of subsurface drainage tile, resulting in high concentrations of nitrate-nitrite, total phosphorus and *E. coli*. According to historical and current monitoring data, nutrients appear to be the most significant issue within this watershed. During 2015 monitoring efforts, on average the subwatershed exceeded target values in *E. coli* [less than 235 cfu/ 100 mL] and Nitrate. During the 2012 LARE Diagnostic Study *E. coli* concentrations exceeded target values during low flow. Indicating that high levels of pathogens could be a result of septic system failure, undocumented hobby farms, manure applied to cropland or livestock having open access to streams. Pathogens are difficult to monitor but since there is little evidence of livestock in the windshield survey and there are no active CFOs in this watershed, it is likely to assume the issue is more of a septic system issue.

Brush-Creek-Sugar Creek subwatershed is considered to be a Non-Priority Critical Land Area (CLA); meaning the subwatershed will receive little to no conservation efforts. Conservation efforts will be distributed across the subwatershed through education & outreach activities. Though nitrogen & *E. coli* values have exceeded project targets, the steering committee believes conservation efforts conducted upstream in Tier 1 & Tier 2 CLA's will impact Brush Creek-Sugar Creek subwatershed.

Section 5. Review of Watershed Problems and Causes

5.1 Summary of Water Quality

The steering committee (i.e. local stakeholders, governmental officials, & natural resource agencies) has identified specific subwatersheds, through current & historical data collection, that have exhibited chemical (i.e. Phosphorus, Nitrogen & *E. coli*) and biological (i.e. habitat & fish assessments) concern. Those subwatersheds that have been identified with a chemical or biological concern will be referred to as a subwatershed with a water quality problem. The term "water quality problem" is a term specifically used for this project. Water quality problems were evaluated throughout the Browns Wonder-Sugar Creek Watershed (Figure 75) to establish critical land areas. Values from the LARE Diagnostic Study (2012), IDEM Historical Sampling (1999-2015) and Browns Wonder-Sugar Creek Planning Project (2015) (Table 44) were used by the steering committee to determine which subwatersheds exhibited water quality problems & further distinguish implementation prioritization among subwatersheds. Due to the complexity and significant difference between each monitoring event each study had its own individual criteria to identify water quality problems.

The LARE Diagnostic study was based on grab samples which were gathered during base flow (June) and at high flow (August). Samples sites that were designated as having a water quality problem were those that exceeded target values on both collections dates. Values within IDEM's Historical Sampling database were considered to have a water quality problem if at least 50% of the collected samples exceeded target values for each year it was evaluated. Finally, samples from the Browns Wonder-Sugar Creek Planning Project were identified as having a water quality problem if the median, of each sample site, exceeded the target value established in Table 15.

Subwatersheds were considered to be a concern if historical (IDEM Historical Sampling or 2012 LARE Diagnostic Study) & current water quality data overlap, at least twice. The steering committee felt that if a site exceeded target values in multiple monitoring events then that would indicate a trend and would indicated that historically that sample site results in high pollutant concentrations; meaning there is a "water quality problem." Subwatersheds that exhibited a high volume of sample sites with water quality problems would be prioritized in conservation efforts. Water quality problems have been mapped (Figure 75 & 76) and documented.

Total Suspended Sediment (TSS)

Total Suspended Sediment includes anything in the water column that can be particles suspended and dissolved in water (e.g. sediment, sewage, leaf litter or organic algae, etc.) (Frankenberger & Esman 2001). Sediment and other residue are closely related to stream flow and velocity, so the concentrations of TSS should be correlated. Significant concern arises during a storm event because sediment and other residue is typical carried away through surface runoff. Research has shown that TSS has a significant impact on aquatic communities. TSS concentration over 25 mg/L are a resource concern because concentration above 25 mg/L have resulted in drastic declines in fish communities (Waters 1995). According to IDEM the maximum TSS concentration should be 30 mg/L (327 IAC 2-1-6); however, TSS values over 25 mg/L creates biological stress and since the Browns Wonder-Sugar Creek 303d impairments are predominately biological impairments the project target for TSS has been set at 25 mg/L (Table 15). After review the Browns Wonder- Sugar Creek Watershed did not indicate a significant impairment among TSS; however, sample sites that reached 100 mg/L or higher in a single rain event, especially if it occurred constantly over the monitoring period should be considered as a critical land area. Subwatersheds that meet this criteria & should have practices that target TSS are Brush Creek-Sugar Creek, Regan Run, Rose Ditch-Browns Wonder, and Spring Creek-Sugar Creek.

Nitrogen

Nitrogen is critical for plant growth, but high concentrations lead to eutrophication of streams and lakes. Nitrogen is known to be a key component to the epidemic in the Gulf of Mexico known as the hypoxic zone, areas of low oxygen. Nitrogen can travel through surface water runoff or directly discharged (i.e. point source pollution) into waterways. Sources would include fertilized lawns, cropped fields, animal manure, waste water treatment plants, failing septic systems, farm tiles and industrial discharges (Frankenberger & Esman 2001). There are four forms of nitrogen that can be present in water: nitrate, nitrite, ammonia or organic nitrogen. Nitrate and Nitrite are the forms that have been analyzed within the Browns Wonder-Sugar Creek Watershed. Nitrate is the most common form of dissolved nitrogen and travels through water easily while Nitrite is an uncommon form of dissolved nitrogen that typically converts into Nitrate by bacteria in surface water. These forms of nitrogen are often combined (Nitrate-N) because monitoring methods cannot easily distinguish the two forms. Besides nitrite is rarely found in lakes and streams so the total is a close approximate level of nitrate. Concentration of Nitrate-N above 1 mg/L indicate anthropogenic influence (Frankenberger & Esman 2001). Nitrate is generally higher in streams that drain agricultural watersheds, particularly when a large area is drained by subsurface tile drains. The concentration of nitrate-N in tile drains is often above 10 mg/L (Brouder et al., 2005), and tile drains serve as direct conduits for nutrient transport, usually leading to higher concentrations in the receiving stream.

According to IDEM waterways cannot exceed 10 mg/L (327 IAC 2-1-6); which is the standard drinking water standard maximum. However, Ohio EPA suggests that warm water habitat should not exceed 1 mg/L while 1.5 mg/ L has been designated as the dividing line between mesotrophic and eutrophic streams (Dodds et al. 1998). The committee has designated 1.6 mg/L as the project target because it is an achievable value (Table 15). After review, using established criteria mentioned above, eight subwatersheds have been designated as areas with water quality problems & should be prioritized, in regards to Nitrate-N (Figure 75). Subwatersheds that meet this criteria & should have practices that target Nitrate-N would be: Barnes Ditch- Sugar Creek, Brush Creek- Sugar Creek, Mallott Ditch-Sugar Creek, Mud Creek, Reagan Run, Rose Ditch- Browns Wonder, Scott Wincoup Ditch- Sugar Creek & Spring Creek- Sugar Creek.

Phosphorus

Phosphorus is a nutrient required for the basic process of life and is often considered the limiting factor in the growth and biomass of algae. Phosphorus considered as a pollutant comes from runoff from urban areas, construction sites, cropped fields, animal manure, failing septic systems, industrial wastewater treatment plants, confined feeding operations and industrial waste. There are three forms of phosphorus organic phosphorus (bound to plant or animal tissue), orthophosphate (soluble phosphorus) (inorganic form; most available for aquatic communities and algae growth) and polyphosphates (inorganic, converts soluble phosphorus in water), the sum of the three is known as total phosphorus. Eutrophication occurs when additional phosphorus is added to the water and excessive algae and aquatic plants are produced which use up oxygen during decomposition. Although only the dissolved inorganic form of phosphorus (orthophosphate) is readily available to algae or aquatic plants, other forms of phosphorus can be converted to orthophosphate. Therefore, total phosphorus is the most complete indicator of eutrophication potential (Frankenberger & Esman 2001).

According to IDEM values should not exceed 0.30 mg/L (327 IAC 2-1-6). The dividing line between mesotrophic and eutrophic streams with phosphorus concentrations is 0.07 mg/L (Dodds et al. 1998) and to maintain biological integrity in warm water habitats Ohio EPA recommends streams fall under 0.08 mg/L. Since IDEM's 303d impairments in Browns Wonder- Sugar Creek Watershed waterways are dominated by biological impairments, project target values for total phosphorus is 0.08 mg/L. After review, eight subwatersheds have water quality problems & should be prioritized to implement conservation efforts that address phosphorus concentrations (Figure 75). Subwatersheds that meet this criteria & should have practices that target Phosphorus would be: Barnes Ditch- Sugar Creek, Brush Creek- Sugar Creek, Mallott Ditch-Sugar Creek, Mud Creek, Reagan Run, Rose Ditch- Browns Wonder, Scott Wincoup Ditch- Sugar Creek & Spring Creek- Sugar Creek.

Bacteria & Pathogens

Lakes and streams usually contain a variety of microorganisms including bacteria, viruses, protozoa, fungi, and algae. Most of these occur naturally and have little impact on human health. However, some of these microorganisms are a result of fecal pollution and has the potential to cause illnesses and diseases in humans. A particular microorganism that is of concern is referred to as Fecal coliform bacteria or Escherichia Coli (*E. coli*), which is found in the feces of warm-blooded animals, including humans, livestock, and waterfowl. *E. coli* is a specific species of fecal coliform bacteria that enters waterways by failing septic systems, wastewater treatment plants, combined sewer overflows and animal waste (pets, wildlife and livestock). *E. coli* is of concern during the recreation season (April to October); IDEM considers a waterway impaired if a single grab sample exceeds 235 cfu/ 100mL or a geometric mean of ≥ 5 samples exceeds 125 cfu/100 mL. Those same criteria have been set as project target values (Table 15). According to IDEM's impairment list Browns Wonder- Sugar Creek Watershed has approximately 37 stream miles that has Escherichia Coli (E.coli) impairment (Table 1). After review, six subwatersheds have water quality problems & should be prioritized to implement conservation efforts that address *E. coli* concentrations (Figure 75). Subwatersheds that should have practices that target *E. coli* would be: Brush Creek-Sugar Creek, Barnes Ditch- Sugar Creek, Mud Creek, Reagan Run, Scott Wincoup Ditch- Sugar Creek & Spring Creek- Sugar Creek.

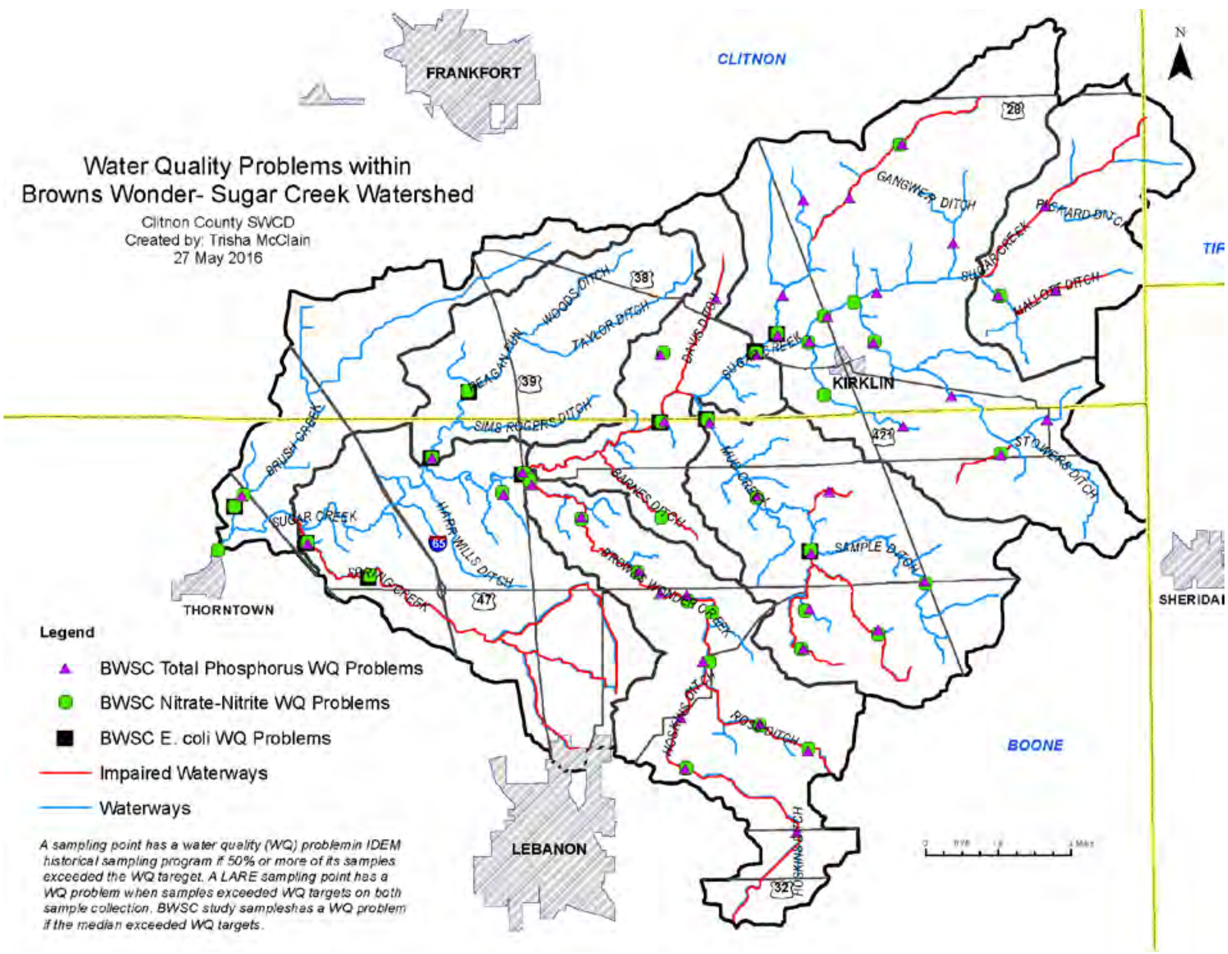

Figure 75. Identified water quality problems within BWSC

Habitat & Biology

The habitat and biological water quality problems were conducted in a different manner than chemical water quality problems, previously discussed. Habitat and biological assessments from the LARE Diagnostic Study (2012), IDEM Historical Sampling (1999-2015) and Browns Wonder-Sugar Creek Planning Project (2015) were used; however, different methods which can make it difficult to form an accurate analysis. The LARE Diagnostic study conducted Qualitative Habitat Evaluation Index Assessments (habitat) and Biotic Value (macroinvertebrates). The IDEM Historical Sampling conducted Qualitative Habitat Evaluation Index Assessments, Index of Biotic Integrity and Macroinvertebrate Indices of Biotic Integrity. While the Browns Wonder- Sugar Creek Watershed conducted a Hoosier Riverwatch Citizens Qualitative Habitat Evaluation Index Assessment. The steering committee determined that that biological and habitat watershed impairments would be sites that did not meet target values, for its specific method, and if target values were not met at least twice (using IDEM data, LARE data and BWSC data), indicating a continual trend then the site was designated as a water quality problem.

The Qualitative Habitat Evaluation Index (QHEI) is a physical habitat index that was developed by the Ohio Environmental Protection Agency in 1989 to evaluate major stream and river habitat characteristics important to biological communities. The QHEI is composed of six metrics, each designed to evaluate a different portion of the stream, and when added together, a total QHEI score is produced ranging from 0-100. A higher score is indicative of better stream habitat for aquatic biological communities. The target value for QHEI is >51.

The Citizens Qualitative Habitat Evaluation Index (CQHEI) is a modified version of the Qualitative Habitat Evaluation Index (QHEI) to allow volunteer stream monitors to easily assess stream habitat and riparian health in wadeable streams. The index consists of six metrics to evaluate different habitat attributes of a stream. The individual scores are summed to produce an overall CQHEI score, ranging from 0 to 114. Similar to QHEI higher scores indicate better stream health. The target value for CQHEI is >60.

The Index of Biotic Integrity (IBI) was developed by Dr. James Karr (1981) to assess fish community health in small warm water streams in central Illinois and Indiana. The IBI is composed of 12 metrics, which looks at characteristics of the fish community including the number of fish species and/or individuals as well as their feeding and reproductive behavior and sensitivity to pollution. These 12 metrics vary depending on ecoregion, watershed, type of waterbody (i.e., lake or stream/river), and size of waterbody (i.e., headwater, wadeable, great river, etc.). The target value for IBI is >36.

Finally, Macroinvertebrate Indices of Biotic Integrity (mIBI) are scoring systems generally specific to geographic areas or ecoregions. This method is similar to the IBI. Due to the limited amount of data and documented sample sites it did not receive a target value. IDEM conducted one mIBI survey in Rose Ditch- Browns Wonder subwatershed in August 1999 the sample site received a 9.2.

Habitat and biological water quality problems are noted below (Figure 76). Subwatersheds that indicate poor habitat & should be prioritized are Brush Creek- Sugar Creek, Barnes Ditch- Sugar Creek, Mud Creek, Mallott Ditch, Scott Wincoup Ditch- Sugar Creek & Rose Ditch- Browns Wonder. Subwatersheds that indicated poor biotic communities & should be prioritized are: Barnes Ditch-Sugar Creek, Mud Creek, Scott Wincoup Ditch- Sugar Creek and Mallott Ditch subwatersheds. Among these subwatersheds, higher priority should be given to Mallott Ditch-Sugar Creek & Mud Creek because IBI score were below 12; indicating no biotic communities reside at the sample site.

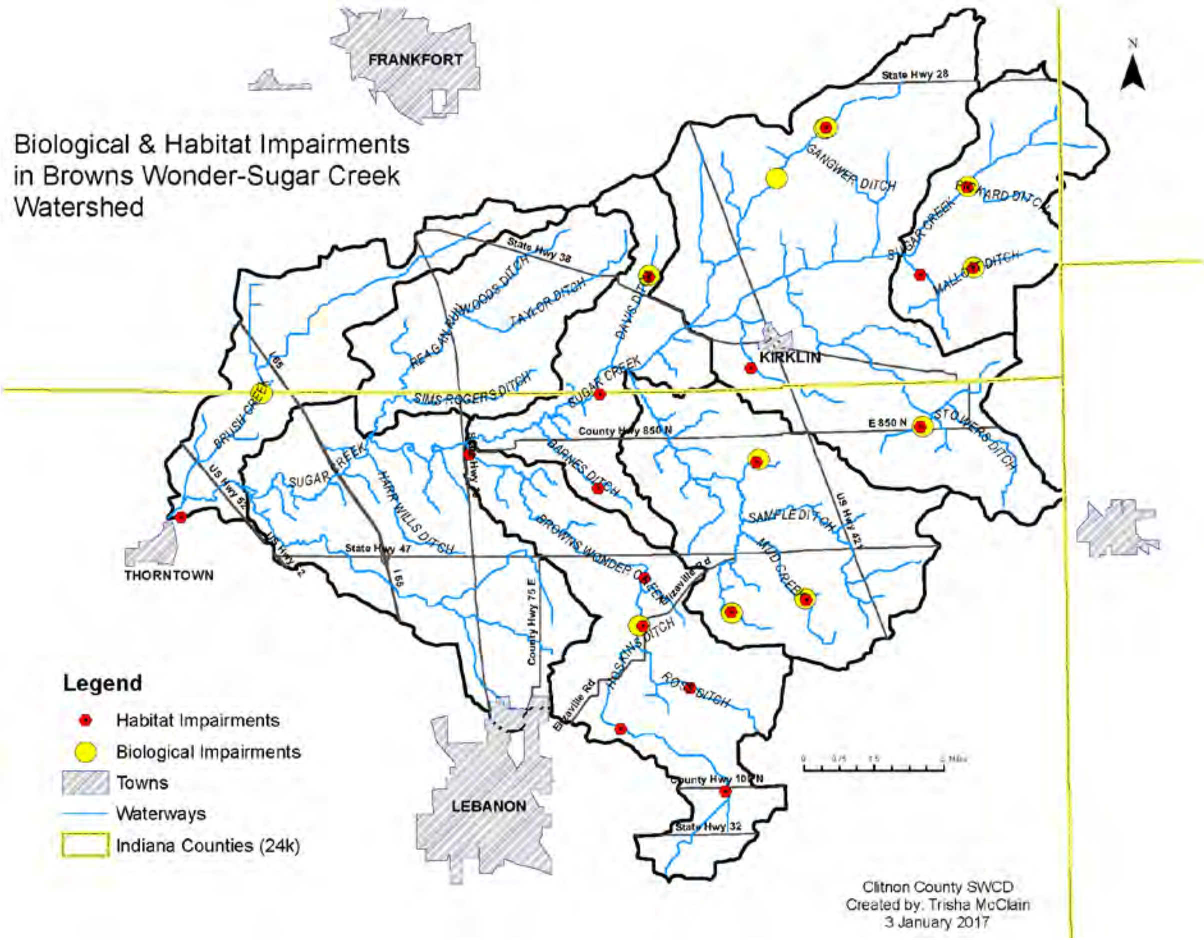

Figure 76. BWSC Biological & Habitat Impairment

5.2 Analysis of Stakeholder Concerns

Following the characterization and the inventory of the Brown's Wonder-Sugar Creek Watershed, stakeholders and steering committee concerns were analyzed to determine its priority within the watershed and whether the concern fit within the scope of the project. Please note, all stakeholder concerns were considered throughout the planning process, even if it fell out of the scope of the project. Through analysis each concern was evaluated in order to determine if there was supportive data with evidence available, which aided the steering committee to dictate if each concern identified was quantifiable data and if the concern was within the scope of this project. Concerns that were supported by data and fall within the scope of the project received a high priority ratings those that of less concern that fell within the scope of the project received a medium priority. While stakeholder concerns that fell outside of the scope of the project and had a low feasibility were designated as a low priority. Further analysis from the community [watershed residents & landowners] allowed the steering committee members to effectively prioritize concerns within the Brown's Wonder-Sugar Creek Watershed (Table 44). Planning efforts will be targeting stakeholder concerns that have been designated as a high priority.

Table 44. Analysis of Stakeholder Concerns

Stakeholder Concerns	Supported by Data (Y/N)	Evidence And/or Comments	Quantifiable (Y/N)	Outside WMP Scope (Y/N)	Priority
Lack of buffer strips allows for nutrient and sediment loss	Y	Windshield Survey	Y	N	High
Bare fields leave cropland susceptible to sediment and nutrient loss; especially in significant rain events	Y	Tillage Transects Windshield Survey	Y	N	High
Occurrence of surface drains lead to sediment runoff	Y	Windshield survey	Y	Y	Low
Logjams/beaver dams lead to sediment runoff	Y	Land user complaints	Y	Y	Low
Livestock have open access to streams leading to erosion and increase in nutrients	Y	Windshield survey	Y	N	Medium
Lack of knowledge on environmental regulation	Y	Social Surveys	Y	N	Medium
Lack of awareness and knowledge of natural resource problems	Y	Social Surveys	Y	N	High
Lack of conservation assistance	Y	Social Surveys	Y	N/Y Can be limited	High
Improper management/ or lack of septic systems	Y	Septic Study, Purdue University Health Department	Y	Y Can Provide Education	High
Excess Sediment	Y	IDEM & Purdue water quality sampling	Y	N	High
Excess nutrients	Y	IDEM & Purdue water quality sampling	Y	N	Medium
Streambank erosion	Y	Windshield Survey	Y	N	High
Open stream dumping	N	Lack of need for stream cleanups, lack of observation	N	Y	Low
Agriculture and stormwater runoff enter local waterways	Y	Windshield Survey Water Quality Data	Y	N	High
Loss of wetlands and forested woodlots	Y	GIS Land Use Layer, NWI, NASS, Windshield Survey	Y	Y	Medium
Decrease in soil organic matter and increased compaction	Y	Tillage Transects	Y	N	High
Stream recreation cannot be appreciated or increased due to polluted / eroded streams	Y	Purdue & IDEM Data, Public Access *E. Coli* above swimmable standards, Fish consumption advisories**	Y	Y/N	Low
Flooding of local towns & country roads	Y	USGS Gauge Station Landowner Complaints	Y	Y	Low
Loss of farmland	Y	CRP Enrollments, Tillage Transect, GIS Land Use Layer	Y	Y	Low
Nutrient and sediment movement travels through installed tile; direct conduit into local waterways	Y	Purdue & Notre Dame Research	Y	Y	High

5.3 Potential Sources for Resources Concerns in BWSC

The concerns addressed by the steering committee & watershed stakeholders were used to identify specific problems that can be seen throughout the watershed (Table 45). The established definition for problem used within this project is a certain condition within the watershed that occurs due to a particular resource concern; there may be multiple concerns associated with a single specific problem (Table 45). Potential cause and sources for each problem addressed were identified by the steering committee & watershed stakeholders with each associated problem identified. In order to provide accurate assessments about each potential cause addressed both recent and historic water quality data was used by the group, where applicable. Potential sources were developed for the entire Brown's Wonder-Sugar Creek Watershed using GIS data and the watershed inventory.

Table 45. Identification of Potential Problems within BWSC & Associated Causes

Problem	Concern (s)	Cause (s)
Surface waters throughout the watershed are often turbid and muddy, especially after significant rain events	-Streambank erosion -Lack of buffer strips -Excess sediment -Bare cropland	-Total Suspended Sediment (TSS) levels have exceeded the target set by the project during high flow -Cropland is left exposed after harvest, leaving the area susceptible to erosion during significant ran events
Many surface waters throughout the watershed may be unsafe for recreational use or contact use	-Stream recreation cannot be appreciated due to pollution -Open stream dumping -Improper management/ lack of septic systems	-Improper management or installation of septic systems -*E.coli* and TSS high flow concentrations have exceeded the target values set by the project and water quality standards -Improper disposal of waste [trash & debris] -Improper wastewater treatment -Livestock have open-access to local waterways -Hobby Farms are prevalent throughout the watershed [monitoring and management is minimal]
Unnatural nutrient concentrations can be found in surface waters throughout the watershed disrupting aquatic ecosystems as well as making surface water unsafe for consumption or use	-Agriculture &stormwater runoff -Excess nutrients -Nutrient & sediment transported by tile [direct conduit to local waterway] -Loss of wetlands & forested woodlots	- Nutrient levels [*E.coli* & Nitrate] have exceeded the target set by the project and water quality standards -Lack of nutrient and pest management plans integrated in farming operations -Removal of wetlands and woodlots -Installation & improper management of subsurface tile drains –Minimal to no riparian buffer along waterways
A significant disconnect among watershed residents, in regards to natural resources and environmental policy	-Lack of conservation assistance -Lack of knowledge/ awareness of natural resource problems - Lack of knowledge on environmental regulation	-Lack of public awareness about natural resources and the how certain actions/ behaviors effect their overall quality - Minimal education targeting the importance of watershed protection -Difficult to reach residents and landowners within the entire watershed -Difficult to persuade all residents and landowners to attend educational events
A majority of IDEM 303 (d) impaired streams within the Browns Wonder-Sugar Creek Watershed are documented as inadequate biotic communities	-Streambank erosion -Lack of buffer strips -Flooding of local towns & country roads	- Inadequate riparian buffers along waterways; exposed water increases temperatures and decrease the availability of dissolved oxygen to aquatic communities -A significant portion of waterways need stabilization and/or buffers –Low habitat and biotic integrity assessments

Identified problems, concerns and causes addressed in Table 45, along with: historical data, input from watershed stakeholders, 2015 water quality monitoring, and 2015 windshield survey, the steering committee developed five problem statements that summarizes all of the identified resource concerns and which subwatersheds are likely impacted by those concerns within the Browns Wonder-Sugar Creek Watershed (Table 46). The evidenced used to further confirm each developed problem statement is presented in the table below.

Table 46. Evidence for each identified problem within BWSC

Problem	Subwatershed (s)	Evidence (s)/ Potential Sources
Surface waters throughout the watershed are often turbid and muddy, especially after significant rain events	Rose Ditch Spring Creek Regan Run Brush Creek	- **5** out of the 8 subwatersheds had TSS concentrations above 90 mg/L after rain events - Approximately **107** points [6/ 8 subwatersheds] were documented within the windshield survey as areas with significant erosion issues (Brush Creek, Spring Creek, Reagan Run and Rose Ditch-Browns Wonder subwatersheds) - **5** out of the 8 subwatersheds had TSS concentrations above 90 mg/L after rain events - **26** stream miles require streambank stabilization (primarily along headwater streams and tributaries) –Rose Ditch- Browns Wonder Creek subwatershed had **3** sites documented as heavily used livestock areas (open access to stream or tributary) –Rose Ditch- Browns Wonder Creek & Spring Creek-Sugar Creek subwatersheds exceeded 100 mg/L after significant rain events
Many surface waters throughout the watershed may be unsafe for recreational use or contact use	Scott Wincoup Ditch Mud Creek Barnes Ditch Reagan Run Spring Creek Brush Creek	-**6** out of 8 sample sites on average exceeded *E.coli* target values – *E.coli* target values exceeded target values at base flow (indicates septic system failure) –Rose Ditch- Browns Wonder Creek subwatershed had **3** sites documented as heavily used livestock areas *(open access to stream or tributary)* - **8** active Confined Feeding Operations have been documented -**64** stream miles have been documented with Escherichia Coli (*E.coli*) impairments on IDEM's 303 (d) list
Unnatural nutrient concentrations can be found in surface waters throughout the watershed disrupting aquatic ecosystems as well as making surface water unsafe for consumption or use	Mallott Ditch Scott Wincoup Ditch Mud Creek Barnes Ditch Rose Ditch Spring Creek Reagan Run Brush Creek	-**4** out of 8 sample sites on average exceeded Total Phosphorus target values [annual average of 0.007 mg/L] -**All 8** sample sites on average exceeded Nitrate target values [annual average of 4.5 mg/L] -**8** NPDES pipes *(direct conduits for nutrients to enter waterways)* along Sugar Creek and McClamorck ditch - Approximately **135** miles of subsurface tile installed *(direct conduits for nutrients to enter waterways)* [5/8 subwatersheds] -**64** tile risers were documented in the BWSC windshield survey
A significant disconnect among watershed residents, in regards to natural resources and environmental policy	All subwatersheds	- **21%** of stakeholders indicated that education & awareness of natural resources & environmental policy are a concern -**20%** identified as habitat loss as a resource concern, yet 10 out of the 17 impaired stream have been identified as biotic impairment
A majority of IDEM 303 (d) impaired streams within the Browns Wonder-Sugar Creek Watershed are documented as inadequate biotic communities	Mallott Ditch Scott Wincoup Ditch Barnes Ditch Mud Creek Rose Ditch Brush Creek	-**77** points were documented as being inadequate riparian buffers in the 2015 windshield survey - **26** stream miles require streambank stabilization *(primarily along headwater streams and tributaries)* - **136** stream miles require buffers *(buffers are considered areas showcasing minor or major erosion)* -**5** out 8 subwatersheds did not meet D.O target values when water temperatures were high [annual average of 4.6 mg/L] -**47** stream miles have been documented with Biotic Community Impairments on IDEM's 303 (d) list

Section 6. Review of Pollutant Loads & Target Load Reductions within Browns Wonder-Sugar Creek Watershed

6.1 Current Pollutant Loads in BWSC

The monitoring data gathered by Purdue University in 2015 for the Browns Wonder-Sugar Creek were used to develop current nutrient loads within the watershed. Purdue University developed nutrient loads through a conversion factor [Nutrients: **5.39 =**(28.3L/ft3)*(1lb/453592mg)*(86400sec/day); *E.coli*: **24,465,758=**(28316.85mL/ft3)*(86400sec/day)], daily averages of discharge (cubic feet per second) from data collected from the USGS gage station in Thorntown, IN and collected nutrient concentration levels (mg/L or cfu/100mL) (Table 47). In addition, to establish specific pollutant loads for each subwatershed, drainage area (mi^2) (Table 15) was incorporated into the equation. Current loads per subwatershed are displayed in the table below as well as the total loads of each pollutant for the entire Browns Wonder-Sugar Creek Watershed for 2015. Loads have been converted from mg/L or cfu/ 100 mL to either lbs/day, cfu/day or tons/day because the Region 5 Model that will be used to track ongoing efforts display load reduction in these particular units. Potential sources for current loads are described in Table 45 & 46.

Table 47. Comparison of current and target nutrients loads within BWSC from water quality data collected in 2015

Sample Sites	*E. coli* (cfu/day)		Sediment (tons/day)		Phosphorus (lbs./day)		Nitrate-Nitrite (lbs./day)	
	Current	Target	Current	Target	Current	Target	Current	Target
SCU	**4.31E+13**	1.18E+13	**165**	106	**2,971**	747	**65,714**	15,617
MuC	**1.93E+13**	4.10E+12	**72**	44	**721**	308	**24,007**	6,160
SCM	**7.84E+13**	1.53E+13	**314**	163	**3,575**	1,148	**99,640**	22,984
BrW	**1.35E+13**	4.14E+12	**221**	42	**1,127**	308	**24,112**	6,161
ReR	**1.24E+13**	2.64E+12	**44**	28	**1,310**	195	**20,628**	3,911
SpC	**2.77E+13**	2.10E+12	**47**	22	**465**	155	**9,949**	3,081
BrC	**8.19E+12**	2.37E+12	**38**	25	**762**	175	**16,588**	3,554
SCD	**1.66E+14**	3.00E+13	**1,906**	317	**10,192**	2,239	**158,208**	44,783
TOTAL	**3.69E+14**	**7.30E+13**	**2,807**	**747**	**21,123**	**5,275**	**418,846**	**106,251**

6.2 Pollutant Load Reductions Needed to Achieve Established Targets in BWSC

Estimated load reductions for the Browns Wonder-Sugar Creek Watershed were established with the use of estimated pollutant loads, generated by Purdue University (Table 47) and established target pollutant loads. Target pollutant loads were developed similar to current pollutant loads, but nutrient concentration levels were altered. Instead of using actual nutrient values, targeted nutrient values were inserted into the calculations that were provided by Purdue University, which were established by the

BWSC steering committee (Table 15). Target values established are as follows: *E. coli* [<235 cfu/100ml (single sample)], Sediment (TSS) [< 25 mg/L], Phosphorus [< 0.08 mg/L] & Nitrogen [≤ 1.6 mg/L]. Estimated load reductions were established by subtracting current pollutant loads by target pollutant loads. Estimated load reductions have been established by subwatershed per evaluated pollutant and then totaled to showcase the total amount of load reductions required to reach established target values for the entire BWSC (Table 48).

Table 48. Load Reductions Needed to Meet Target Loads

Sample Sites	*E. coli* (cfu/day)	Sediment (tons/day)	Phosphorus (lbs./day)	Nitrate-Nitrite (lbs./day)
SCU	3.13E+13	59	2,224	50,097
MuC	1.52E+13	29	413	17,847
SCM	6.31E+13	151	2,427	76,656
BrW	9.36E+12	179	819	17,951
ReR	9.76E+12	17	1,115	16,717
SpC	2.56E+13	25	310	6,868
BrC	5.82E+12	13	587	13,034
SCD	1.36E+14	1,589	7,953	113,425
TOTAL	**2.96E+14** 80% reduction	**2,062** 73% reduction	**15,848** 75% reduction	**312,595** 74% reduction

Load reductions will be accomplished through the Action & Register Schedule (Sections 7.4 & Tables 49-52) as well as through the distribution of best management practices such as: filter strips, blind inlets, conservation cover, cover crops, grass waterways, etc. in critical land areas and priority protection areas; which is discussed in Section 7.2-7.3. Implementation efforts will be managed by the Clinton County Soil & Water Conservation District, but financial & technical assistance will be provided by project partners (NRCS, ISDA, & SWCD).

Section 7. Solutions to Obtain Water Quality Improvement within the Browns Wonder-Sugar Creek Watershed

7.1 Goals Statements for Water Quality Improvements in the Browns Wonder-Sugar Creek Watershed

Conservation assessments that were conducted through IDEM Historical Sampling (1999-2015), 2012 LARE Diagnostic Study and recent BWSC monitoring (2015) have established a resource baseline for the Browns Wonder-Sugar Creek Watershed. After a comprehensive assessment of the overall condition, the steering committee developed a series of broad goals and indicators to address local concerns such as: sedimentation (TSS) during high flows, turbidity, nutrients *(*nitrogen, phosphorus *& E. coli*) and degraded biotic communities. These goal statements listed below serve as a baseline for selecting the type and extent of conservation efforts needed to improve current conditions as well as showcase progress within the watershed. To provide additional direction, goal statements are accompanied by an achievable objective within a 5, 10 and 20 year timeframe. By establishing a set of community driven goals and objectives within a long and short-term timeframe, planning efforts can effectively address local priorities and carry out local needs to improve current conditions, which have been showcased for each statement below in an action register table. Also, it is important to note that the established goals, indicators, objectives and action register are addressing/ protecting the current needs and interests of watershed resident. To better serve the BWSC community and to ensure continual progress within the watershed this section should be re-evaluated each time an implementation grant is received and should be completely reconstructed no less than every 5 years and should not exceed 10 years, with the completion of the new BWSC watershed management plan.

PROBLEM STATEMENT: *Surface waters throughout the watershed experience high levels of sedimentation after significant rain events*

GOAL STATEMENT: *Sediment and other residue (i.e. Total Suspended Solids [TSS] & Turbidity) are closely related to stream flow and velocity. Significant concern arises during a storm event because high volumes of sediment and other particles have negative impacts on our local environments and biotic communities as well as shelter and feed pathogens. TSS values in BWSC exceed target values by about 21%. To address high sedimentation during significant rain events (≥ ½ inch) the steering committee would like TSS values to go from 2,807 tons/day to 747 tons/day [74% reduction]. In addition, stabilizing and maintaining soil structure throughout the landscape and along streambanks will help minimize sedimentation. CCSWCD Staff will compare collected TSS values with documented precipitation from local weather reports on an annual basis to monitor potential changes in TSS values during high flow. Along with sedimentation, Turbidity has a significant impact on water quality and biotic communities. Turbidity exceeds target values by approximately 74%. Due to a high occurrence of exceedance, the steering committee would like to see the annual average of turbidity of 10.4 NTU (EPA recommended value) instead of an annual average of 16.3 NTU [36 % difference] or reduce % of exceedance to 45% .*

INDICATOR (S): *Water quality data collected during Hoosier Riverwatch annual monitoring events will be used as the primary indicator to show progress. As per IDEM's requirement to analyze physical, chemical, and biological parameters within a watershed basin every 5 years will also be used as a secondary indicator. Data stored in the Assessment Information Management System (AIMS) will showcase TSS & turbidity trends and changes that occur over time. Also, TSS and NTU trends will be monitored through hosted Hoosier Riverwatch training workshops and/or volunteer monitoring events, which will document physical and chemical parameters. By the end of each implementation year CCSWCD staff will compare collected & historical TSS and NTU values to monitor any changes in TSS & NTU values. In addition, staff will compare historical and ongoing TSS values with recorded rain events in each subwatershed to determine if values have exceed target values during high flow. By year 5 (2024), targeted TSS load reductions will be 2,105 tons/day & by 2039 TSS load reduction will be at targeted values.*

SCALED GOALS: *The presented scaled goals are based off of standard grant procedure. Standard procedure would indicate that an implementation grant was immediately applied for at the completion of the watershed management plan (May 2017). Since implementation grants do not get approved until the following year (2018), ideally funds would be received in the fall of 2018. Conservation efforts would not be implemented until 2018 and effects would not begin until 2019. The scaled goals below would be from the anticipated year conservation would begin to have an effect on the watershed (2019).*

5 YEAR GOAL: *Reduce TSS loads by 25% [2,105 tons/day]*
Reduce turbidity annual average concentrations to 14.7 NTU [15% difference]
10 YEAR GOAL: *Reduce TSS loads by an additional 35% [1,368 tons/day]*
Reduce turbidity annual average concentrations to 12.5 NTU [15% difference]
20 YEAR GOAL: *Reduce TSS loads by an additional 46% [739 tons/day]*
Reduce turbidity annual average concentrations to 10.4 NTU [16% difference

Action Register:

Table 49. Action register for sedimentation goal statement

	Objective	Target Audience	Milestone	*Cost	Possible Partner [PP] & needed Technical Assistance [TA]
Tier 1 CLA: Scott Wincoup, Mud Creek, Barnes Ditch & Spring Creek	Implement at least 8,500 Cubic Yards (approx. 4 acres) of Bank Stabilizing Practices *Practices such as: 2-stage ditch, streambank protection, or grass waterways*	Landowners & Operators; Contractors & Developers	Recruit potential producers to implement practice & develop conservation plans	150 hrs. of a full-time staff ($22.86/hr.)= $3,429	PP=Willing Landowners PP=Local Contractors & Developers to implement and promote practice TA=Steering Committee to help discuss & promote program with landowners; write conservation plans; write engineer plans TA=Hoosier Riverwatch for monitoring data TA=IDEM for monitoring data PP=County Surveyor, Engineer & Government Officials
			Total on the ground implementation will be 8,500 yards³ (4 ac.) of bank stabilization practice (s), by the end of yr. 8	$60,000 *(total cost)*	
			Once implementation is complete, monitor TSS to measure possible TSS & NTU reduction	$200/ sample	
	Implement 500 acres of No-Till each year & at least 1% of Agricultural Cropland (corn & soybean) has Year-Round Vegetation Coverage Critical Area Acres- 74,729 Watershed Acres- 115,922	Agricultural Landowners & Operators	By the 1st quarter of each new implementation grant develop or update cost-share program	50 hrs. of a full-time staff ($22.86/hr.)= $1,143	PP=Willing Landowners PP= Local Agribusinesses to help promote and discuss the program with watershed stakeholders PP=County Surveyor, Engineer & Government Officials TA=Steering Committee to help discuss & promote program with landowners; write conservation plans TA=Hoosier Riverwatch for monitoring data TA=IDEM for monitoring data
			As long as funding is available, implement 500 acres of No-Till & at least 700 acres of cover crops each year	$35/ac for CC [$26,145/yr for Critical Acres; $40,600/yr for Watershed Acres] $20/ac for No-Till [$20,000]	
			Once implementation is complete, monitor TSS & NTU to measure possible reduction	$200/ sample	
	Implement at least 3 Urban Practices that Addresses Sedimentation & Drainage *Practices such as: rain gardens, permeable/pervious pavement or bioswales*	Landowners & Operators; Contractors & Developers	Recruit potential producers to implement practice & develop conservation plans	80 hrs. of a full-time staff ($22.86/hr.)= $1,828	PP=Willing Landowners PP=Local Contractors & Developers to implement and promote practice TA=Steering Committee to help discuss & promote program with landowners; write conservation plans; write engineer plans TA=Hoosier Riverwatch for monitoring data TA=IDEM for monitoring data PP=County Surveyor, Engineer & Government Officials
			By the end of year 5, implement 3 urban practices that addresses sedimentation & drainage	$45,000 *(total cost)*	
			Once implementation is complete, monitor TSS & NTU to measure possible reduction	$200/ sample	

**Costs are determined by standard cost-share incentives determined by IDEM, NRCS or LARE. Staff hours are based on the current coordinators salary. Water quality sample costs are based on Hoosier Riverwatch and standard associated costs when purchasing kits.*

PROBLEM STATEMENT: *Many surface waters throughout the watershed may be unsafe for recreational use or contact use*

GOAL STATEMENT: *E. coli found in water can cause illnesses to wildlife, livestock, domestic pets, and humans. In high concentrations, the water use is restricted and cannot be used for recreational purposes such as fishing, swimming and boating activities which will directly impact stakeholders downstream of this watershed. The steering committee would like to reduce average annual concentration levels of E. coli from 373 cfu/100mL to 235 cfu/100mL [37 % reduction]; which is the maximum level allowed for swimmable water according to the EPA. In addition, the steering committee would like to see a 50% exceedance or less in E. coli samples collected within a given year of monitoring.*

INDICATOR (S): *Water quality data collected during Hoosier Riverwatch monitoring events, E. coli will be sampled every 3 years, will be used as the primary indicator to show progress. As per IDEM's requirement to analyze pathogens within a watershed basin, this data will be used as a secondary indicator. Data stored in the Assessment Information Management System (AIMS) will showcase trends* & changes that occur over time. *E. coli* reductions are not easily modeled. *Targeting practices that minimizes TSS and filters surface water run-off as well as hosting educational workshops about septic systems installation &*

maintenance; can indirectly impact E. coli concentrations. In addition, specific practices can be implemented to address E. coli by targeting livestock producers and small farms. CCSWDC Staff will continually review Hoosier Riverwatch & IDEM sampling data to monitor trends and measure potential reductions.

SCALED GOAL: *The presented scaled goals are based off of standard grant procedure. Standard procedure would indicate that an implementation grant was immediately applied for at the completion of the watershed management plan (May 2017). Since implementation grants do not get approved until the following year (2018), ideally funds would be received in the fall of 2018. Conservation efforts would not be implemented until 2018 and effects would not begin until 2019. The scaled goals below would be from the anticipated year conservation would begin to have an effect on the watershed (2019).*

5 YEAR GOAL: *The Steering Committee would like to reduce current average annual E. coli concentrations from 373 cfu/100 mL to 309 CFU/100 mL (a 17% reduction)*

10 YEAR GOAL: *The Steering Committee would like to reduce average annual E. coli concentrations by an additional 10%. Values should go from 373 cfu/100 mL to 272 CFU/100 mL (a total 27% reduction)*

20 YEAR GOAL: *The Steering Committee would like to reduce current average annual E. coli concentrations by an additional 10%. Values should go from 373 cfu/100 mL to 235 cfu/100 mL (a 37% reduction) by 2039*

Action Register:

Table 50. Action register for unsafe surface water goal statement

	Objective	Target Audience	Milestone	*Cost	Possible Partner [PP] & needed Technical Assistance [TA]
TIER 1: Mud Creek, Barnes Ditch & Spring Creek	Host Septic System Maintenance & Installation Educational Program	Landowners and Operators; Contractors & Developers	Develop an educational program in year 1. Roll out to stakeholders by the end of year 1, 3 & 5.	$1,500/yr	TA=Steering Committee to help coordinate & promote event PP=County Health Department
	Livestock Exclusion *Practices such as: fencing or stream crossings	Livestock Producers & Small Farms	Every grant cycle, implement at least 1 project that excludes cattle from waterways	$5,000/ project	TA=Steering Committee to help discuss & promote program with landowners; write conservation plans PP=Willing Landowners PP=Local Contractors & Developers
	Livestock Waste Management *Practices such as: waste utilization, fencing or livestock facility closure	Livestock Producers & Small Farms	By the end of year 3, 5, & 7, implement at least 2 project within a 2 year cycle (a total of 6 by year 7) that addresses waste management	$15,000/ project	TA=Steering Committee to help discuss & promote program with landowners; write conservation plans PP=Willing Landowners PP=Local Contractors & Developers

**Costs are determined by standard cost-share incentives determined by IDEM, NRCS or LARE. Staff hours are based on the current coordinators salary. Water quality sample costs are based on Hoosier Riverwatch and standard associated costs when purchasing kits.*

PROBLEM STATEMENT: *Excessive nutrient concentrations can be found in surface waters throughout the watershed disrupting aquatic ecosystems as well as making surface water unsafe for consumption or use*

GOAL STATEMENT: *Nutrients such as phosphorus and nitrogen impact our local environments and wildlife. Nitrogen is critical for plant growth, but high concentrations lead to eutrophication of streams and lakes. While Phosphorus is a nutrient required for the basic process of life and is often considered the* *limiting factor in the growth and biomass of algae. The steering committee would like to reduce total phosphorus (TP) concentrations from 21,123 lbs. /day to 5,275 lbs. /day (a 76% reduction) and nitrate-nitrite concentrations from 418,846 lbs. /day to 106,251 lbs. /day (a 75% reduction).*

INDICATOR (S): *Water quality data collected during Hoosier Riverwatch annual monitoring events will be used as the primary indicator to show progress. As per IDEM's requirement to analyze physical, chemical, and biological parameters within a watershed basin every 5 years will also be used as a secondary indicator. Data stored in the Assessment Information Management System (AIMS) will showcase trends and changes that occur over time. Trends will be monitored through Hoosier Riverwatch data, which will document physical and chemical parameters. CCSWCD Staff will continually review sampling data from Hoosier Riverwatch & IDEM to monitor trends and measure potential reductions.*

SCALED GOALS: *The presented scaled goals are based off of standard grant procedure. Standard procedure would indicate that an implementation grant was immediately applied for at the completion of the watershed management plan (May 2017). Since implementation grants do not get approved until the following year (2018), ideally funds would be received in the fall of 2018. Conservation efforts would not be implemented until 2018 and effects would not begin until 2019. The scaled goals below would be from the anticipated year conservation would begin to have an effect on the watershed (2019).*

5 YEAR GOAL: *Reduce Nitrate-nitrite & Total phosphorus loads by 25%*
(Nitrate-nitrite 314,135 lbs. /day; Total phosphorus 15,842lbs. /day)

10 YEAR GOAL: *Reduce Nitrate-nitrite & Total phosphorus loads by 35%*
(Nitrate-nitrite 204,188 lbs. /day; Total phosphorus 10,297 lbs. /day)

20 YEAR GOAL: *Reduce Nitrate-nitrite & Total phosphorus loads by 50%*
(Nitrate-nitrite 102,094 lbs. /day; Total phosphorus 5,149 lbs. /day)

Action Register:

Table 51. Action register for unnatural nutrient concentrations' goal statement

	Objective	Target Audience	Milestone	Cost	Possible Partner [PP] & needed Technical Assistance [TA]
Tier 1 CLA Scott Wincoup, Mud Creek, Barnes Ditch & Spring Creek	Implement at least 8,500 Cubic Yards (approx. 4 acres) of Bank Stabilizing Practices	Landowners and Operators; Contractors & Developers	Please reference Table 49; this objective has previously been discussed		
	Implement 30 acres of Riparian Buffer/ Cover *Practices such as: conservation cover, riparian buffers/ cover or filter strips	Landowners and Operators; Contractors & Developers	Implement at least 15 ac. of Riparian Buffers/Cover by the end of yr. 5 & implement the remaining 15 ac. by end of year 8	$3,000/ac [$45,000]	PP=Willing Landowners TA=Steering Committee to help discuss & promote program with landowners; write conservation plans PP=County Surveyor, Engineer & Government Officials
	Implement at least 3 Urban Practices that Addresses Sedimentation & Drainage	Landowners and Operators	Please reference Table 49; this objective has previously been discussed		
	Host Nutrient Educational Programs	Landowners and Operator	Host annual field days/ workshop that focuses on nutrient management	$1,500/yr	PP=Farm Service Agency; Local Seed Dealerships TA=Steering Committee to help coordinate & promote event

**Costs are determined by standard cost-share incentives determined by IDEM, NRCS or LARE. Staff hours are based on the current coordinators salary. Water quality sample costs are based on Hoosier Riverwatch and standard associated costs when purchasing kits.*

PROBLEM STATEMENT: *A majority of IDEM 303 (d) impaired streams & tributaries within the Browns Wonder-Sugar Creek Watershed are documented as inadequate biotic communities.*

GOAL STATEMENT: *Biotic communities require specific parameters in order to maintain a healthy population. Minor or major changes to: habitat, dissolved oxygen (D.O.), temperature and turbidity will result in significant impacts on the integrity of biotic communities and water quality. Currently, 47 stream miles have a biotic impairment, according to IDEM standards. Turbidity will already be monitored through our sedimentation goal, but it will be reviewed to monitor biotic health. Though temperature and dissolved oxygen do impact biotic communities the steering committee believes indicator scores such as cQHEI (Citizen Qualitative Habitat Evaluation Index), QHEI (Qualitative Habitat Evaluation Index), IBI (Index of Biotic Integrity) and mIBI (Macroinvertebrates Indices of Biotic Integrity) will provide a better assessment of the ongoing changes occurring in the biotic communities within the watershed. Habitat scores at each subwatershed should receive at least a score of 60 (cQHEI) or 51 (QHEI) while biotic integrity scores should at least be 36 (IBI) and/ or 36 mIBI score. Currently, evaluated sites have fallen under indicator target scores 55% of the time in QHEI Scores [n=29], 52% in of the time in IBI scores [n=29] & 13% of the time in cQHEI scores [n=8].*

INDICATOR (S): *Indicator scores for both habitat and biotic communities will be used as the primary indicator to showcase progress. IDEM is required to analyze the physical and biological parameters within a watershed basin every 5 years; which results in a QHEI & IBI evaluation. Data documented in IDEM'S Assessment Information Management System (AIMS) will showcase trends and changes that occur over time. In addition to IDEM data, trends will be monitored through hosted Hoosier Riverwatch training workshops and/or volunteer monitoring events, which will document cQHEI & mIBI scores. CCSWCD Staff will continually review data to monitor trends. By 2039, 3 waterways listed with impaired biotic communities will be removed from IDEM's 303 (d) list.*

SCALED GOAL: *The presented scaled goals are based off of standard grant procedure. Standard procedure would indicate that an implementation grant was immediately applied for at the completion of the watershed management plan (May 2017). Since implementation grants do not get approved until the following year (2018), ideally funds would be received in the fall of 2018. Conservation efforts would not be implemented until 2018 and effects would not begin until 2019. Due to standard procedure the scaled goals presented would be from the anticipated year conservation would begin to have an effect on the watershed (2019).*

5 YEAR GOAL: *IDEM QHEI & IBI scores fall under indicator target scores 50% of the total amount of evaluated sites or each site evaluated should receive a QHEI score of 40-45 & an IBI score of 25-30. Hoosier Riverwatch mIBI & cQHEI scores are at least under the indicator target values 10% of the total evaluated sites; each site evaluated should receive a mIBI score of 25-30 & a cQHEI score of 55-60*

10 YEAR GOAL: *IDEM QHEI & IBI scores fall under indicator target scores 20-30% of the total amount of evaluated sites or each site evaluated should receive a QHEI score of 50-55 & an IBI score of 32-36. Hoosier Riverwatch mIBI & cQHEI scores are at least under the indicator target values 5% of the total evaluated sites; each site evaluated should receive a mIBI score of 32-36 & a cQHEI score of 65-70*

20 YEAR GOAL: *The Steering Committee would like to remove at least 3 stream segments from the 303(d) IDEM Biotic Impairment list.*

Action Register:

Table 52. Action register for impaired biotic communities' goal statement

	Objective	Target Audience	Milestone	Cost	Possible Partner [PP] & needed Technical Assistance [TA]
Tier 1 CLA: Mud Creek, Barnes Ditch & Spring Creek	Implement 5 acres Riparian Forest Buffer	Landowners and Operators; Contractors & Developers	Recruit potential producers to implement practice & develop conservation plans	150 hrs. of a full-time staff ($22.86/hr.)= $3,429	PP=Willing Landowners PP=Local Contractors & Developers to implement and promote practice TA=Steering Committee to help discuss & promote program with landowners; write conservation plans; write engineer plans TA=Hoosier Riverwatch for monitoring data TA=IDEM for monitoring data PP=County Surveyor, Engineer & Government Officials
			Implement 5 acres of Riparian Forest Buffer by the end of year 8	$800/acre [$4,000]	
			After each implementation year, conduct or habitat & biotic assessments	$500/ both assessments	
	Develop Habitat & Biotic Educational Program	Landowners and Operators; Contractors & Developers	Host Hoosier Riverwatch Trainings & Workshops each grant cycle to promote stakeholder involvement & educate the public about biotic communities & the importance of habitat	$2,000/ event	TA=Steering Committee to help discuss & promote program with watershed stakeholders TA=Hoosier Riverwatch PP=Local Stakeholders [volunteers]

**Costs are determined by standard cost-share incentives determined by IDEM, NRCS or LARE. Staff hours are based on the current coordinators salary. Water quality sample costs are based on Hoosier Riverwatch and standard associated costs when purchasing kits.*

7.2 Establishing Critical Land Areas & Priority Protection Areas

In order to prioritize future implementation and funding efforts, the steering committee worked to develop Critical Land Areas (CLA) and Priority Protection Areas (PPA). CLA's are areas which have a high likelihood of contributing pollutant loads to the watershed, but have a high recovery potential. The steering committee also recognized that the Browns Wonder-Sugar Creek Watershed has land areas where riparian and in-stream habitats exist in a relatively natural condition. These areas have been designated as PPA's and will be prioritized for future protection measures to preserve the existing natural conditions. Though PPA's will be targeted during implementation, CLA's will take higher priority. Implementation distributed across CLA's will introduce new land use & management strategies into the watershed which will combat water quality concerns more effectively than already established land use (i.e. PPA's).

CLA's were calculated at the subwatershed level using a numeric ranking system that was developed by the Environmental Protection Agency (EPA), the Recovery Potential Screening (RPS) Tool, which would take into account all stakeholder concerns by addressing the ecological, stress and social indicators at a subwatershed-level. In addition to the RPS Tool, the steering committee evaluated other criteria such as stakeholder willingness, upstream land management to downstream water quality, and self-sustaining as well as long-term impacts. CLA's were finalized through steering meeting discussions, historical data, monitoring data, STEPL data and RPS Tool results [Appendix A1-A3].

PPA's are specifically targeting land areas where riparian and in-stream habitats exist in a relatively natural condition. PPA's were designated by the steering committee based on pre-existing conditions [i.e. forested landscape], which were identified using GIS 2011 NLCD land use data, 2015 windshield survey data, habitat assessments and stakeholder concerns. Since the landscape has a robust agricultural industry, producers tend to eliminate woodlots and wetlands to increase crop productivity. It is essential to maintain the remaining natural landscape, because it filters and/or buffers pollutants from local waterbodies; maintaining healthy water quality. In addition, it provides essential habitat and food for wildlife residing in the watershed.

The Recovery Potential Screening (RPS) is a systematic method for comparing watersheds based on characteristics that may influence the relative likelihood of successful watershed restoration or protection. RPS was developed to provide a flexible screening tool to guide prioritization of watersheds according to differences in key environmental and social factors affecting prospects for restoration and protection success.

Indicators of recovery potential are evaluated in three categories (Ecological, Stressor, and Social); indicators within each of these categories were selected based on current resource concerns established by the steering committee and stakeholders of the Browns Wonder-Sugar Creek Watershed [Appendix A3] RPS definitions for these indicators are defined in Figure 77. Resource concerns were formulated through community surveys, historical data and recent water quality assessment.

Ecological Indicators

Measures the capacity to maintain or reestablish natural structure and processes

Stress Indicators

Measure the extent of anthropogenic sources of impaired water quality

Social Indicators

Measure relevant community, regulatory, economic, or behavioral

Figure 77. Definitions of the ecological, stress and social indicators, defined by the RPS Tool

Even though the Recovery Potential Screening Tool prioritizes subwatersheds, the steering committee wanted to further build upon the predetermined RPS ranking. The RPS Tool does not accurately reflect personal relationships or willingness of stakeholders to participate in conservation efforts. In addition, the RPS Tool does not have access to ongoing conservation efforts, current monitoring data, windshield survey data or recent social indicator data. Lastly, most of the higher ranking subwatersheds are near the outlet of the watershed while lower ranking subwatersheds tended to be in the upper regions of BWSC. To better recognize and evaluate downstream water quality and upstream land management, the steering committee prioritized subwatersheds in the upper reaches & will move downward in the watershed as efforts progress. This type of approach will be more self-sustaining & ensure long-term success.

All subwatersheds were grouped as Tier 1, Tier 2, Tier 3 or Non Priority CLA's (Figure 78). Tier 1 subwatersheds represent the highest priority and is the area that will have the largest impact on the watershed. Also, Tier 1 areas will receive the greatest amount of technical and financial assistance. Tier 2 & 3 are subwatersheds are areas of concern but aren't a high priority compared to Tier 1 CLA's. Conservation efforts are needed within these areas but implementation will not occur until all conservation opportunities have been fulfilled in Tier 1. Further detail about the implementation strategy is presented in Section 7.3.

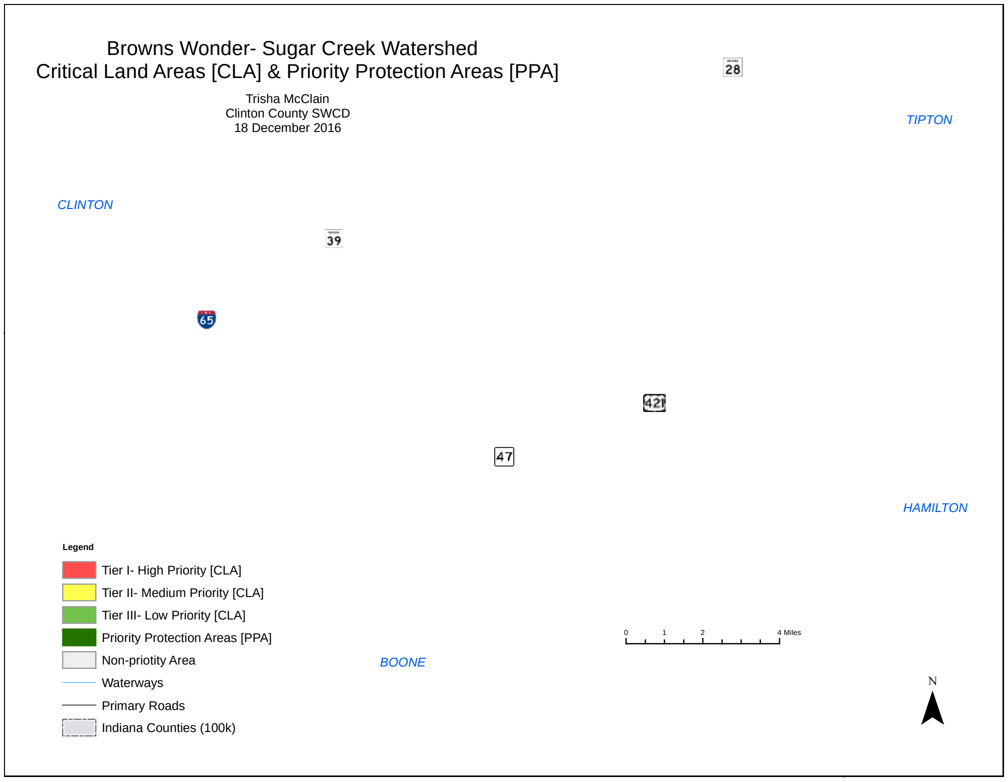

Figure 78. Browns Wonder-Sugar Creek Watershed Critical Land Areas

7.3 Implementation Strategy

The following best management practices have been identified from the NRCS Field Office Technical Guide (FOTG) as practices that would adequately control drainage, pathogens, sediment, nutrients, provide streambank stabilization, and provide riparian zones. The selection of which BMPs are most appropriate for producers to use will be based off of a field visit and the development of a Conservation Plan. Field visits & Conservation plans will be managed by CCSWCD & conducted by approved technical staff from NRCS, ISDA or SCWD. The purpose of a Conservation Plan is for a NRCS District Conservationist/ approved staff member and a landowner to identify resource concerns within the area of interest and provide a menu of conservation practices that would adequately address those concerns. The landowner then can decide which practice fits within their budget and operation. A Conservation Plan must be in place before an applicant is considered eligible for cost-share.

Implementation funds will target, in numeric, order the established Critical Land Areas (CLA's) Tier system. During the initial phase of implementation Tier 1 CLA's [the most critical areas] and Priority Protection Areas (PPA's) will receive available cost-share funds; Tier 1 CLA's will have a higher prioritization than PPA's. Filter strips, blind inlets, cover crops, no-till, integrated crop management, conservation cover, riparian cover, hayland/pasture planting, fencing, livestock facility closures, heavy use protection areas, & grass waterways will be prioritized best management practices (BMPs) in Tier 1 CLA's (Scott Wincoup Ditch-Sugar Creek, Barnes Ditch-Sugar Creek, Mud Creek & Spring Creek). Other BMPs listed within Table 53 will be considered during implementation; however, prioritized BMPs will receive a higher ranking, especially if the applicant is a first-time adaptor or implementing a system of practices. Implementation efforts (cost-share funds) will be limited to Tier 1 CLA's & PPA's until opportunities for water quality improvement have been exhausted, which will be identified by the steering committee & approved by IDEM. Once Tier 1 has exhausted opportunities for water quality improvement then Tier 1 CLA's, Tier 2 CLA's & PPA's will be targeted (Phase 2). Similar to phase 1, once conservation opportunities have been exhausted in Tier 1 & 2, implementation will transition into Phase 3; which targets all CLA's & PPA's. Education & outreach activities will target the entire watershed, no matter the phase in the implementation schedule.

Implementation Schedule

Phase 1: Target only Tier 1 and Priority Protection Areas (PPA's)
Phase 2: Target only Tier 1, Tier 2 and PPA's
Phase 3-Beyond: All Critical Areas and PPA's will be addressed

Urban Best Management Practices

Urban land use (i.e. developed areas) make up about 6% of the landscape. The town of Kirklin & the northern reaches of Lebanon are the two largest urban communities that reside within the watershed. However, there are numerous small rural communities such as: Mechanicsburg, Cyclone, Pickard, Reagan, Terhune, Elizaville, Pike & Stringtown. Though agricultural areas will be the primary focus, urban communities will still be eligible for cost-share.

Urban BMPs (NRCS FOTG)	
Critical Area Planting (342)	Conservation Cover (327)
*Grass Swale (Bioswale) (635)	*Pervious/Permeable Pavement
Riparian Forested Buffer (391)	2-Stage Ditch (Open Channel) (582)
Riparian Herbaceous Cover (390)	*Rain Barrel (587)
*Streambank Stabilization (580)	*Rain Garden (570)

**Practices will require special IDEM approval or will be implemented using funds outside of 319*

Agricultural Best Management Practices

Agriculture is the predominant land use within the watershed, accounting for 83% of the total BWSC acres. Cropland is typically designated to corn or soybean production, but there are some producers that plant tomatoes, sorghum, watermelon and popcorn. Due to the prevalence of agricultural production, technical and financial assistance will primarily target concerns that are associated with that practice. Agriculture is not limited to farming operations, but also refers to livestock operations. There are approximately eight active confined feeding operations scattered throughout the landscape. Approximately, 7,106 acres are designated as pasture/grass; indicating that there are a few small livestock operations present within the area. Agricultural areas will be the primary focus during implementation.

Agricultural BMPs (NRCS FOTG)	
Permanent Fencing (382)	Residue and Tillage Management, Reduced Tillage (345)
Stream Crossing (578)	Conservation Cover (327)
*Streambank Stabilization (580)	Grassed Waterway (412)
*Livestock Facility Closure (360)	Filter Strip (393)
Heavy Use Protection Area (561)	Cover Crops (340)

*Pasture/Hayland Planting (512)	*Grass Swale (Bioswale) (635)
Sediment Basin (350)	Underground Inlet (Blind Inlet) (620)
*Denitrification Bioreactor (605)	*Saturated Buffer (604)
2-Stage Ditch (Open Channel) (582)	Nutrient Management Plan (590)
*Forage & Biomass Planting (512)	Pest Management Plan (595)
Critical Area Planting (342)	Detention-Constructed Wetland (656)
Detention- Dry/ Wet Pond (378)	Wetland Restoration (657)
Grade Stabilization Structure (410)	Riparian Forested Buffer (391)
Riparian Herbaceous Cover (390)	Residue and Tillage Management, No-Till (329)

**Practices will require special IDEM approval or will be implemented using funds outside of 319*

7.4 Action Register and Schedule

In an effort to bring together identified strategies for both on-the-ground land use management practices as well as education and outreach priorities, the steering committee compiled an Action Register to help guide future efforts (Table 49-52). The Action Register identifies strategies, estimated costs, milestones, and potential project partners & technical assistance for each goal identified above in Section 7.1. Project partners will be extremely valuable during implementation efforts through leveraging of funds and by providing technical support.

The steering committee members identified a general list of Best Management Practices (Table 53) which could be implemented in the Browns Wonder-Sugar Creek Watershed to achieve water quality goals. Please note neither the Action Register & Schedule or the list of BMPS in Table 53 are all-inclusive, other objectives and practices may come into play in future implementation programs as there are improvements in technology and land management strategies. The Action Register & Schedule tables and list of practices are items that will be heavily focused on by the steering committee and are believed to be effective strategies to address current resource concerns within the watershed.

Best Management Practices Recommendations for Critical Land Areas

The following table includes both agricultural and urban best management practices with their associated load reduction, according to the Region 5 Model. Best management practices along with measures have been categorized by pollutant and Critical Land Areas (Table 53). Pollutants/ concern are categorized by Critical Land Areas. While best management practices or measure are tied to a pollutant/ concern. For example, practices that will be implemented in Spring Creek, Mud Creek, & Barnes Ditch (Tier 1 CLA's), targeting *E. coli* are Livestock Facility Closures, Fencing, & Heavy Use Area Protection. Practices that have been highlighted in green will receive higher prioritization during implementation, but all listed practices will be considered.

Practices will be installed through cost-share funds. CCSWCD will seek funding for technical and financial assistance within the BWSC through cost-share funds provided by IDEM through 319, ISDA through Clean Water Indiana (CWI) & IDNR Lake & River Enhancement (LARE). Additional funding sources will be targeted, but 319, CWI & LARE will be the primary funding source for cost-share. Landowners & operators have the opportunity to seek federal funds such as Environmental Quality Incentive Program (EQUIP), Conservation Stewardship Program (CSP) or Conservation Reserve Program (CRP). However, records for these programs are only available to approved federal or state staff. Only funding sources acquired by local SWCD (Boone & Clinton County) will be used as a reference for this watershed management plan.

Table 53. Load reductions expected for each BMP implemented in the CLA's

Critical Land Areas	Pollutant/ Concern	BMP or Measure [FOTG]	Estimated Load Reduction for a Single BMP		
			Sediment	Phosphorus	Nitrogen
Tier I Spring Creek Mud Creek Barnes Ditch	*E. coli**	Septic System Maintenance Workshops	N/A	N/A	N/A
		Fencing [382] *Modeled on 0.3 acres; 1 Bank*	57.4 tons/yr	57.4 lbs./yr	114.8 lbs./yr
		Stream Crossing [578] [modeled at 0.3; Height 10ft & length 100ft]	23 tons/yr	23 lbs./yr	46 lbs./yr
Tier II Reagan Run Rose Ditch		Waste Utilization [624/629]	N/A	N/A	N/A
		Livestock Facility Closure [360]	N/A	N/A	N/A
		Heavy Use Area Protection [561] *Modeled on 10 acres*	89 tons/yr	80 lbs./yr	160 lbs./yr
		Manure Management Plan	N/A	N/A	N/A
		Nutrient Management Field Day/ Workshop	N/A	N/A	N/A
Tier I Spring Creek Mud Creek Scott Wincoup Ditch Barnes Ditch	*Nutrients* *[i.e. nitrogen, sediment & phosphorus]*	No-Till/Strip Till [329] *Modeled on 100 acres*	218 tons/yr	253 lbs./yr	506 lbs./yr
		Cover Crops [340] *Modeled on 100 acres*	176 tons/yr	222 lbs./yr	444 lbs./yr
		Conservation Cover [327] *Modeled on 10 acres*	25 tons/yr	35 lbs./yr	69 lbs./yr
		Grass Swale/ Bioswale [Urban]	86 tons/yr	75 lbs./ yr	371 lbs./yr
		Blind Inlet [620]	106 tons/yr	Unavailable	1,300 lbs./yr
		Denitrification Bioreactor [747]	99 tons/yr	196 lbs./yr	2,228 lbs./yr
Tier II Rose Ditch Reagan Run Barnes Ditch		2-Stage Ditch [582] *Modeled at 0.3; Height 10ft & length 500ft*	114.8 tons/yr	114.8 lbs. /yr	229.5 lbs./yr
		Saturated Buffer [604]	N/A	N/A	N/A
		Sediment Basin [350] *Top W 40ft; Bottom W 20ft; Depth 5ft & Length 200 ft*	43 tons/yr	43 lbs./yr	86 lbs./yr
		Pasture/Hayland Planting [512] *Modeled on 10 acres*	27 tons/yr	35 lbs./yr	69 lbs./yr
		Forage & Biomass Planting [512] *Modeled on 10 acres*	27 tons/yr	35 lbs./yr	69 lbs./yr
		Grassed Waterway [412] *Modeled on Top Width 40ft; Bottom Width 20ft; Depth 5ft & Length 400 ft*	229.5 tons/yr	229.5 lbs./yr	459 lbs./yr
		Integrated Crop Management Plan [Nutrient [590]/ Pest Management[595]]	N/A	N/A	N/A
		Rain Garden [570]	109 tons/yr	181 lbs./yr	2,042 lbs./yr
		Rain Barrel [587]	137 tons/yr	250 lbs./yr	N/A
		Pervious/Permeable Pavement [Urban]	761 tons/yr	66 lbs./yr	36 lbs./yr
Tier III Mallott Ditch Brush Creek		Detention- Dry Pond [378] *Modeled on 100 acres*	84 tons/yr	78 lbs./yr	1,114 lbs./yr
		Detention- Wet Pond [378]	87 tons/yr	135 lbs./yr	1,300 lbs./yr
		Detention-Constructed Wetland (656)	23 tons/yr	28 lbs./yr	56 lbs./yr

		Wetland Restoration [657]	113 tons/yr	132 lbs./yr	743 lbs./yr
		Vegetated Filter Strip [393] *Modeled on 10 acres*	28 tons/yr	36 lbs./yr	72 lbs./yr
		Drainage Water Management [554]	N/A	N/A	N/A
Tier I Spring Creek Barnes Ditch Mud Creek	*Impaired Biotic Communities*	Riparian Forested Buffer [391] *Modeled on 20 acres*	31 tons/yr	35 lbs./yr	70 lbs./yr
		Riparian Herbaceous Cover [390]	37 tons/yr	65 lbs./yr	130 lbs./yr
Tier II Barnes Ditch Rose Ditch		Streambank Stabilization [580] [modeled at 0.3; Height 10ft & length 500ft]	114.8 tons/yr	114.8 lbs./yr	229.5 lbs./yr
		Critical Area Planting [342] *Modeled on 10 acres*	27 tons/yr	35 lbs./yr	69 lbs./yr
Tier III Mallott Ditch		Grade Stabilization Structure [410]	14.5 tons/yr	14.5 lbs./yr	29.1 lbs./yr

7.5 Adaptive Management Strategy

Adaptive management links policy with implementation. Since conservation efforts & watershed management planning has an underlying uncertainty, regarding both cause and effect it is important to incorporate adaptive management into the Action Register & Schedule. Adaptive management utilizes the concept “learning by experience.” As new information presents itself such as shifts in community attitude/behavior, changes in resource concerns or as project goals are accomplished; established policies and implementation strategies within a watershed management plan is modified to ensure conservation efforts are as effective as possible. To ensure project success, a four step adaptive management strategy, based on Figure 79, has been established for the Browns Wonder-Sugar Creek Watershed Management Plan (BWSC-WMP). Those steps are presented below.

Figure 79. Adaptive Management Strategy Flow Chart

STEP 1: PLANNING- Planning process followed the IDEM’s 2009 Watershed Management Checklist. Existing knowledge, goals, objectives technology & historical data was used during the development of the BWSC-WMP. The BWSC-WMP is a community-based & led, fluid document that will be revised or amended as new information becomes available; as shifts, goals & objectives change among local stakeholders (i.e. landowners, government officials, producers, natural resource agencies & residents); or as established milestones are accomplished.

STEP 2: IMPLEMENTATION (DO) - Implement action register & schedule established within the BWSC-WMP to achieve project objectives and goals (Section 7.3-7.4; Tables 49-52). Implementation will be conducted by local natural resource agencies (i.e. NRCS, SWCD, IDNR, IDEM or ISDA). Implementation will be based on community needs & distributing conservation efforts that will effectively combat resource concerns within the watershed. Practices implemented will follow NRCS Field Office Technical Guide (FOTG) Practice Standards. Filter strips, blind inlets, cover crops, no-till, integrated crop management, conservation cover, riparian cover, hayland/pasture planting, fencing, livestock facility closures, heavy use protection areas, & grass waterways will be prioritized best management practices (BMP's) in Tier 1 CLA's (Scott Wincoup Ditch-Sugar Creek, Barnes Ditch-Sugar Creek, Mud Creek & Spring Creek). Other BMPs listed within Table 53 & designated Priority Protection Areas (PPA's) will be considered; however, prioritized BMP's will receive a higher ranking on submitted applications, especially if the applicant is a first-time adaptor or implementing a system of practices (ex. No-Till-Cover Crops- Integrated Crop Management). Long-term, self-sustaining practices such as blind inlets, conservation cover, & riparian cover will be periodically (half-life of a practice) checked by approved technical staff (SWCD, NRCS or ISDA) to ensure the practice is being properly maintained & is fully functional.

STEP 3: EVALUATE & LEARN- Evaluate the BWSC-WMP periodically (5 yrs.) to review water quality results; social trends & behaviors; and goals & objectives to determine project effectiveness. Evaluations will be conducted by the established steering committee (i.e. local stakeholders, government officials & natural resource agencies). Steering committee members will provide recommendations that will improve project success.

STEP 4: ADJUST (ALTER STRATEGY) - Adjust management & implementation strategy to improve project success using new knowledge, goals, objectives, technology & data. Adjustments will be dictated by the established steering committee (i.e. local stakeholders, government officials & natural resource agencies) & will be based off of recommendations made during the Evaluate & Learn Step. Once adjustments are finalized the project will revert back to the Implementation Step and continue with the adaptive management process (Step 2-4) until project scaled goals & objectives have been fully achieved or all conservation opportunities have been exhausted.

Section 8. Schedule of Operations to Address Water Quality Concerns in the Browns Wonder-Sugar Creek Watershed

8.1 Strategy to Measure Success

Indicators and goals that have been outlined in Section 7.1, are just a starting point to address local resource concerns. Based on the Action & Register Schedule (Table 49-52) & implementation strategy (Section 7.3) by 2024 (5-year goal), load reductions should be as follows: TSS 2,105 tons/day, Nitrate-Nitrite 314,135 lbs./day & Total Phosphorus 15,842lbs./day. *E. coli* will be difficult to monitor, but through educational programs and targeting *E. coli* indirectly by minimizing surface water run-off & implementing practices on livestock operations, concentrations should go from 373 cfu/100 mL to 309 cfu/100 mL by 2024. For more detailed information please refer back to Section 7.1.

Water quality data will be provided through Hoosier Riverwatch annual monitoring & IDEM Office of Water Quality Assessment Branch's rotating basin monitoring strategy (5 year rotation). Hoosier Riverwatch data & IDEM'S Assessment Information Management System (AIMS) will showcase trends, %

exceedance and changes that occur over time. Chemical, physical & biological parameters will be monitored through these events. Hoosier Riverwatch will be considered to be the primary source for water quality data. Hoosier Riverwatch Workshops will occur at least once a year & will monitor , as funding permits, temperature, dissolved oxygen, pH, conductivity, orthophosphates, nitrate-nitrite, turbidity, total suspended solids & habitat (i.e. cQHEI) using either standard IDEM/ EPA monitoring standards or Hoosier Riverwatch methods. *E. coli* will be monitored at least once per implementation cycle (3 years). Sampling sites will be based on BWSC 2015 monitoring, additional sample sites may be added. Hoosier Riverwatch will promote community involvement & increase awareness as well as appreciation among local stakeholders. Events will be hosted by Clinton County SWCD & monitoring efforts will be completed by project partners such as Boone County SWCD, USDA-NRCS, Purdue Cooperative Extension, Friends of Sugar Creek, ISDA, or qualified volunteers. Streamflow data will be collected during each sampling visit using a velocity meter and channel dimensions. In addition to cQHEI, habitat (i.e. QHEI) and biological communities (i.e. IBI) will be evaluated through IDEM historical sampling. All water quality data will be maintained in the Hoosier Riverwatch database, AIMs & Clinton County SWCD (CCSWCD) database.

By the end of each implementation year (3 years) CCSWCD staff will compare collected & historical chemical, physical & biological data to monitor changes & evaluate trends occurring in the watershed. In addition, CCSWCD staff will compare historical and ongoing TSS values with recorded rain events in each subwatershed to determine if project target values are still being exceeded during high flow. Unfortunately, *E. coli* reductions are not easily modeled, but can be indirectly addressed when minimizing pollutants in surface water run-off. CCSWCD staff plan on hosting educational workshops about septic systems installation & maintenance as well as targeting specific livestock practices in order to minimize *E.coli* values. Data collected during Hoosier Riverwatch monitoring should provide some additional insight about whether conservation efforts are addressing *E. coli* & other resource concerns occurring within the watershed. **The total estimated costs for sample collection (10 sites x $200/site x 5yrs.), travel (400 mi x $0.44/mi) and database management (i.e. staff time) (350 hrs. x $23.07/hr.) for 5 years of data collection would be $18,880.5**.

To further evaluate & monitor implementation efforts.Any implemented best management practices will be mapped and modeled with their respective load reductions according to the Region 5 model. We will also evaluate the potential for developing an online mapping application where community members can place a “push pin” where best management practices have been completed. These “push pins” would then be field verified by Clinton County SWCD & project partners such as Boone County SWCD, USDA-NRCS, Purdue Cooperative Extension, ISDA or qualified volunteers on a quarterly basis. In addition, CCSWCD will conduct a Conservation Tour at the end of each implementation grant (3 years), which will promote implemented practices to local stakeholders, contractors, government officials & natural resource agencies. In addition, CCSWCD staff & project partners (USDA-NRCS, ISDA, SWCD & Purdue) will conduct windshield surveys (every 5 yrs.), as funding permits, to gather first-hand knowledge about watershed progress & determine whether resource concerns are being met. Windshield survey data will be collected & stored on the CCSWCD database. **The total estimated cost**

for travel (250 mi. x $0.44/mi) & staff time (350 hrs. x $23.07/hr.) for 5 years of data collection would be $8,184.50.

Social data will also be used to help track progress towards our goals and objectives. Occasionally, attendees of field days, workshops, or informational meetings will be given a questionnaire to evaluate any immediate changes in knowledge and awareness. Annual follow-up questionnaires will also be distributed through a direct mailing to get a more accurate estimate of how/if individuals apply information that they received at our events. Personal interviews will be completed with any landowners taking advantage of financial assistance programs to evaluate usefulness and effectiveness as well as to identify improvements for future programs. Website statistics (e.g. Google Analytics or Facebook) will be used to collect data on our online presence such as visits to specific pages and document downloads. Social Survey results will be stored on CCSWCD's database & will be monitored by CCSWCD staff. **Annual cost estimates for social indicator tracking & evaluation, including materials (i.e. printing, ink, stamps, envelopes, & cardstock/paper) ($2,500/yr x 5 yrs.) and staff time (250hrs/ $23.07/hr.) for 5 years of data collection would be $18,267.50.**

Conservation efforts will continually be monitored by CCSWCD staff. Collected data from water quality monitoring, windshield survey, tillage transect, social indicator data, etc. will be reviewed & discussed at a steering committee or stakeholder meeting on an annual basis (Adaptive Management Strategy Step 3). During this time steering committee members will determine if goals, objectives and/or milestones are being met as well as determine if current strategies dictated within the watershed management plan are effective. If items have been accomplished, priorities have changed or deemed deficient then the watershed management plan will be adjusted accordingly, prior to the next implementation phase, to ensure project success (Adaptive Management Strategy Step 4). This process will continue until project scaled goals & objectives have been fully achieved or all conservation opportunities have been exhausted.

8.2 Schedule of Events for Future Implementation and Watershed Activities

The Browns Wonder-Sugar Creek Watershed Management Plan (BWSC WMP) is intended to be a fluid document that will be revised or amended as new information becomes available (Adaptive Management Strategy, Section 7.5). Clinton and Boone County SWCD will be jointly responsible for holding and revising the BWSC WMP, revisions will be based on stakeholder feedback/ recommendations. The steering committee will meet annually to review the WMP and discuss project efforts. To account for changes in local land use and regulations; document associated changes in water quality; and ensure the plan addresses stakeholder needs, the steering committee will review project goals, objectives and strategies no less than every 5 years. Revisions and updates to the plan will be necessary as the project progresses and as stakeholders begin to implement the plan. This plan may be incorporated with other watershed plans to effectively create living documents that cover large-scale projects and capitalize on shared resources.

Clinton County SWCD will remain the project leader for the Browns Wonder-Sugar Creek Watershed, but will be working collaboratively with Boone County SWCD to ensure all stakeholder needs are being met. In addition, it is imperative for this project to develop and maintain strong stakeholder involvement and support from groups such as the Friends of Sugar Creek, Inc., USDA-Natural Resources Conservation Service, Purdue Cooperative Extension, Indiana Department of Agriculture and local governmental agencies. By maintaining strong partnerships, the project can effectively address project goals, objectives and strategies within the watershed management plan; to ensure project success in current and future conservation efforts.

The Clinton and Boone County Soil & Water Conservation Districts are dedicated to maintaining a long-term watershed management effort within the BWSC Watershed. Both counties have recently been awarded an Indiana Clean Water Act Grant (2016-2019) and IDNR Lake & River Enhancement Grant (2017-2020), to assist stakeholders in implementing BMPs in the Browns Wonder Sugar-Creek Watershed. Boone and Clinton County SWCD's are making continual efforts through education & outreach as well as seeking additional funding to ensure our goals and expectations are met.

In order to achieve improvement in water quality there needs to be a universal understanding about the actions that affect it. Both Boone and Clinton County believe this can be achieved through a balance of educational programs, BMP implementation programs, public participation and monitoring local waterways. Each component is essential in maintaining a successful watershed program. In addition, the local Soil & Water Conservation Districts must maintain positive and effective relationships with stakeholders and partners to receive public and financial support in order to perform the appropriate tasks for watershed management. Clinton and Boone County look forward to maintaining close relationships among local stakeholders and continue conservation efforts that benefit water quality as well as establish healthy ecosystems.

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Appendix

A1. Subwatershed Water Quality Data & Ecological Assessment

A1 Table 1. Subwatershed Water Quality Data

HUC 12 Name	Impaired Stream Miles [% impaired]	Percent of Watershed [acres]	*E.coli* *Avg. cfu/ 100 mL* [%Exceedance]	TSS *Avg. mg/L* [%Exceedance]	N *Avg. mg/L* [%Exceedance]	TP *Avg. mg/L* [%Exceedance]	D.O *Avg. mg/L* [%Exceedance]	Turbidity *Avg. NTU* [%Exceedance]
Mallott Ditch	**8**/16mi [50%]	8% *[10,077ac]*	-	-	-	-	-	-
Scott Wincoup Ditch	**6.4**/47mi [14%]	25% *[30,339ac]*	291 [78%]	7 [26%]	3.9[86%]	0.08[50%]	4.3[29%]	15.9 [71%]
Mud Creek	**9**/34mi [26%]	14% *[16,820ac]*	407[82%]	9[27%]	4.2[82%]	0.09[59%]	4.2[58%]	20.8[88%]
Rose Ditch	**18**/28mi [64%]	14% *[16,382ac]*	194[46%]	4[18%]	4.5[68%]	0.08[77%]	5.2[47%]	14[68%]
Barnes Ditch	**11**/17mi [65%]	8% *[9,212ac]*	434[90%]	9[19%]	5.3[79%]	0.06[54%]	4.4[53%]	18.1[82%]
Reagan Run	**0**/ 18mi	9% *[10,818ac]*	772[79%]	7[25%]	5.6[76%]	0.07[60%]	4.1[59%]	14 [71%]
Spring Creek	**26**/37mi [70%]	14% *[16,920ac]*	276[66%]	5[13%]	3.5[68%]	0.04[59%]	4.4[59%]	11.7[59%]
Brush Creek	**0**/17mi	8% *[10,391ac]*	443[64%]	4[16%]	4.8[87%]	0.05[52%]	3.9[35%]	16.6[82%]

**Target Values: E.coli 235 cfu/ 100 mL; TSS (Total Suspended Sediment) 25 mg/L; N (Nitrogen) 1.6 mg/L; TP (Total Phosphorus) 0.05 mg/L; DO (Dissolved Oxygen) 4 mg/L-9 mg/L; Turbidity 10.4 NTU*

A1 Table 2. Subwatershed Habitat & Biotic Assessment Scores

HUC 12 NAME	QHEI scores	IBI scores	cQHEI scores	QHEI SCORES >64: Habitat is capable of supporting a balanced warmwater community 51-64: Habitat is only partially supportive <51: Poor Habitat
	IDEM Historical Sampling		BWSC Monitoring	
Mallott Ditch	32	20	-	
Scott Wincoup Ditch	51	33	74	cQHEI SCORES 70-100: Excellent, "least impacted" 61-69: Good, not enough positive habitat features 50-60: Fair, habitat is lacking 0-49: Very Poor Habitat
Mud Creek	37	28	76	
Rose Ditch	39	31	44	
Barnes Ditch	35	26	79	IBI SCORES 53-60: Excellent, "least impacted" 45-52: Good, decreased species richness 35-44: Fair, skewed trophic structure 12-22: Very Poor, Few species present
Reagan Run	-	-	70	
Spring Creek	64.5	39	78	
Brush Creek	65	38	89	

**Target Values: QHEI (Qualitative Habitat Evaluation Index) >51; IBI (Index of Biotic Integrity) >36; cQHEI (Citizen Qualitative Habitat Evaluation Index) >60*

A2. Steering Committee Ranking System

A2 Table 1. Subwatershed Recovery Potential Tool (RPI) Rankings Based on Each Evaluated Indicator

Watershed	Ecological Rank	Stressor Rank	Social Rank	Recovery Potential Index [RPI] Rank
Mallott Ditch-Sugar Creek	8	8	7	8
Scott Wincoup Ditch- Sugar Creek	7	7	4	7
Mud Creek	6	4	6	6
Rose Ditch- Browns Wonder Creek	5	5	3	5
Barnes Ditch- Sugar Creek	1	3	2	1
Reagan Run	3	2	8	4
Spring Creek- Sugar Creek	2	6	1	2
Brush Creek- Sugar Creek	4	1	5	3

A2 Table 2. Evaluated Categories with their Associated Ranks, Determined by the Steering Committee & RPI Tool

SUBWATERSHED	Impaired Streams Rank	Watershed Coverage Rank	RPI Rank	Water Quality Rank	Biological Rank	Watershed Health	Social Rank	Stress Rank	Overall Rank
Mallott Ditch	4	7	8	8	1	8	7	6	8
Scott Wincoup Ditch	6	1	7	4	5	4	5	8	4
Mud Creek	5	3	6	1	3	3	6	4	2
Rose Ditch	3	4	5	5	4	2	3	5	3
Barnes Ditch	2	8	1	2	2	1	1	1	1
Reagan Run	7	5	4	3	8	5	8	3	6
Spring Creek	1	2	2	7	6	6	2	7	5
Brush Creek	8	6	3	6	7	7	4	2	7

**Ranks are color coordinated*

A3. STEPL Subwatershed Data

A3 Table 1. Subwatershed Landscape STEPL Data

Watershed	HUC 12	Watershed Acres	Urban Acres	Cropland Acres	Pasture Acres	Forested Acres	Feedlots Acres	Water Acres	Others Acres
Barnes Ditch	51201100105	9,212	446	7,706	309	554	3	8	189
Brush Creek	51201100108	10,391	745	9,112	48	247	0.6	15	224
Mallott Ditch	51201100101	10,077	518	9,411	0	72	0	2	74
Mud Creek	51201100103	16,820	1,030	14,936	248	370	0.4	1	235
Reagan Run	51201100106	10,818	581	0	36	170	0.6	0	0
Scott Wincoup	51201100102	30,339	1,909	27,627	52	440	1	9	304
Rose Ditch	51201100104	16,382	9,78	14,345	401	402	0.6	12	244
Spring Creek	51201100107	16,920	1,433	1,331	551	1,076	1	127	403
Source: NRCS-USDA & US Federal Agencies; County boundary- US Census Bureau			*Feedlot areas are estimated from minimum space required by animals. Source: NLCD, 2006*						

A3 Table 2. Subwatershed Livestock STEPL Data

Watershed	Number of Beef Cattle	Number of Dairy Cattle	Number of Swine	Number of Sheep	Number of Horses	Number of Chickens	Number of Ducks
Barnes Ditch	88	8	9,090	74	39	8	10
Brush Creek	15	1	1,662	13	6	1	2
Mallott Ditch	0	0	0	0	0	0	0
Mud Creek	43	11	1,097	15	24	15	4
Reagan Run	13	1	1,550	12	5	0	1
Scott Wincoup	17	1	1,978	16	7	1	2
Rose Ditch	68	17	1,535	23	38	24	6
Spring Creek	93	24	2,107	31	52	33	8
Source: USDA Census of Agriculture, 2007							

A3 Table 3. Subwatershed Septic System STEPL Data

Watershed	Number of Septic Systems	Population per Septic Systems	% Septic Failure Rate
Barnes Ditch	9	3	1.09
Brush Creek	138	3	1.09
Mallott Ditch	5	3	1.09
Mud Creek	33	3	1.09
Reagan Run	15	3	1.09
Scott Wincoup	198	3	1.09
Rose Ditch	27	3	1.09
Spring Creek	338	3	1.09
Source: Environmental Service Center 1992-1998 summary of the status of onsite wastewater treatment systems in the United States			

A4. RPS Selected Indicators

A3 Table 1. RPS Selected Social, Ecological & Stress Indicators

Ecological Indicators	Stress Indicators	Social Indicators
% Forest in WS (2011)	% Developed, High Intensity in WS (2011)	Drinking Water Source Protection Area, Total
% Forest Change in WS (2001-11)	% Developed, Medium Intensity in WS (2011)	Nonpoint Control Projects Count
% Canopy Cover, Mean Value in WS (2011)	% Developed, Low Intensity in WS (2011)	Nutrients Nonpoint Control Projects Presence
% Grassland/Herbaceous in WS (2011)	% Agriculture in WS (2011)	Sediment Nonpoint Control Projects Presence
% Wetlands in WS (2011)	% Agriculture Change in WS (2001-11)	Pathogens Nonpoint Control Projects Presence
% Wetlands Change in WS (2001-11)	% Agriculture on Hydric Soil in WS	NPDES Permit Count
% Wetlands Remaining in WS	% Pasture/Hay in WS (2011)	% Stream length Assessed (2015)
% Perennial Ice/Snow in WS (2011)	% Human Use, U-Index1 in WS (2011)	% Waterbody Area Assessed (2015)
% Barren Land in WS (2011)	% Human Use, U-index2 in WS (2011)	
% N-Index1 in WS (2011)	% High Intensity Land Cover in RZ (2011)	
% N-Index2 in WS (2011)	Soil Erodibility, Mean in WS	
% N-Index2 Change in WS (2001-11)	Population Density in WS	
Habitat Condition Index WS (2015)	% Tile or Ditch Drained in WS	
Habitat Condition Index, Local Buffer WS (2015)	Domestic Water Demand in WS	
% National Ecological Framework (NEF) in WS (2001)	Agricultural Water Demand in WS	
% Rare Ecosystem in WS	Industrial Water Demand in WS	
Soil Stability, Mean in WS	Manure Application in WS	
% Draining to 1st, 2nd, or 3rd Order Streams in WS	% Stream length 303d-Listed (2015)	