VFC Index - Watershed (Plan)

Program: Watershed

IDEM Document Type: Plan

Document Date: 1/31/2012

Security Group: Public

Project Name: Brandywine Creek WMP

Plan Type: Watershed Management Plan

HUC Code: 05120204 Driftwood

Sponsor: Hancock County SWCD

Contract #:

County: Hancock

Cross Reference ID:

Comments: Shelby

Additional WMP Information

Checklist: 2009 Checklist

Grant type: LARE

Fiscal Year:

IDEM Approval Date: 1/31/2012

EPA Approval Date:

Project Manager: none

Watershed Management Plan

Brandywine Creek Watershed
Hancock and Shelby Counties, Indiana

February, 2012

DAVEY
RESOURCE GROUP
A Division of The Davey Tree Expert Company

Watershed Management Plan

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Hancock and Shelby Counties, Indiana

February, 2012

Prepared for:

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Executive Summary

Hancock County Soil and Water Conservation District (SWCD) retained Davey Resource Group (Davey) to conduct field data collection and write a Watershed Management Plan (WMP) for Brandywine Creek Watershed. The project was funded by an Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program (LARE) grant with a cash and in-kind services match provided by Hancock County SWCD.

The headwaters of Brandywine Creek originate in northeastern Hancock County, Indiana. Brandywine Creek generally flows southwest to a point where it debouches to Big Blue River in northwestern Shelby County, Indiana. Brandywine Creek is part of the Mississippi River Basin. Brandywine Creek Watershed is a 10-digit hydrologic unit code (HUC) watershed (0512020403) comprised of 27,615 hectares (65,238 acres). It is composed of four, 12-digit HUC subwatersheds including: Willow Branch-Brandywine Creek Subwatershed (051202040301), Richey Ditch-Brandywine Creek Subwatershed (051202040302), Andis Ditch-Brandywine Creek Subwatershed (051202040303), and Swamp Creek-Brandywine Creek Subwatershed (051202040304).

Cultivated cropland is the predominant land use type comprising just over 78% of the total watershed area. A total of 11.5% of the watershed is developed commercial, industrial, and residential areas as well as developed open space such as athletic fields and golf courses. Brandywine Creek Watershed is trending toward more rapid development due to its close proximity to Indianapolis, especially in the vicinity of Interstate (I)-70 and I-74 corridors which offer convenient access to Indianapolis.

A total of 14 sample sites were established within the watershed as part of this study. A reference site was also established on Sugar Creek. Data collected included temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, orthophosphate phosphorus, ammonia, nitrate + nitrite, total Kjeldahl nitrogen (TKN), total suspended solids (TSS), turbidity, discharge, *E. coli*, macroinvertebrate communities, and habitat data.

High nutrients are the biggest concern in Brandywine Creek Watershed. All samples tested for ammonia nitrogen exceeded the state water quality standards, and all TKN samples exceeded the United States Environmental Protection Agency (USEPA) recommended maximum target. In addition, 86% of nitrate + nitrite samples and 71% of total phosphorus samples exceeded USEPA recommended maximum targets. *E. coli* concentrations in the upper watershed are also a concern where numerous samples exceeded the state standard at the time of base flow conditions. All *E. coli* samples exceeded the state target at the time of storm flow sampling resulting in a combined base flow and storm flow sample standard exceedance rate of 67%. TSS and turbidity samples exceeded water quality targets at rates of 39% and 50%, respectively. Half of the sample sites lacked suitable habitat for aquatic life use, and macroinvertebrate communities at 29% of sites indicated aquatic life use impairment based on macroinvertebrate index of biotic integrity (mIBI) scores.

Stakeholder water quality concerns were collected at public and steering committee meetings and solicited by steering committee members. The steering committee determined whether each concern was supported by available data. The steering committee identified specific problems relating to each concern that was supported by data and on which the group wished to focus. Problems were defined as issues that exist due to a concern. Specific problems were consolidated into problem categories. Identified problem categories include: high stream nutrient levels, high stream TSS and turbidity levels, high stream *E. coli* levels, degraded aquatic habitat, flooding, trash, reduced aquatic recreation, and decreased aquatic biodiversity.

Goals were developed to address the identified problem categories and improve water quality in Brandywine Creek Watershed. Five primary goals selected include reducing *E. coli* concentrations to below the state standard, reducing sediment to below the water quality target, reducing nutrient loads to below water quality targets, increasing public awareness of water quality issues, and reducing flood damages. The steering committee determined sub-goals to work toward with timelines in order to achieve each primary goal as well as indicators that can be used to determine if progress is being made toward achieving the goal.

Critical areas were identified and described for implementation of best management practices (BMPs) to remediate nonpoint source pollution. Specific BMP's were selected to improve water quality or mitigate future pollutant sources to protect water quality. Critical areas were determined independently for urban and rural pollutant sources. Critical areas were also determined based on type including site-specific pollutant sources and watershed-wide pollutant sources. Site-specific critical areas identified include areas where livestock have access to streams, streambank erosion, areas lacking filter strips or riparian buffers, and areas suffering from gully erosion. The steering committee selected the top three subwatersheds as non-site specific, rural critical areas based on modeled pollutant load contributions. These subwatersheds were Richey Ditch Subwatershed, Andis Ditch Subwatershed, and Swamp Creek Subwatershed. Richey Ditch Subwatershed and Swamp Creek Subwatershed, which include Greenfield and Fairland, respectively, were selected as urban critical areas.

Recommended BMPs to address critical areas on agriculture and livestock land include no-till conservation tillage; cover crops; drainage water management; grass waterways; livestock fencing, stream crossings, alternative watering facilities, and rotational grazing; nutrient and pest management plans; and wetlands restoration. BMPs recommended to address critical areas in urban settings include nuisance waterfowl control; pervious pavement; pet waste receptacles; rain barrels; and stormwater management practices such as infiltration gardens, stormwater swales, and stormwater planters. BMPs such as riparian restoration and streambank stabilization including natural channel restoration and two-stage ditch designs are recommended for site-specific critical areas in both rural and urban areas. In addition to structural BMPs, multiple topics for educational programing and potential new ordinances as well as updates to existing local ordinances were also recommended.

An Action Register was developed to facilitate implementation of the WMP. It includes specific objectives to be carried out in the process of working toward accomplishing each water quality improvement goal for Brandywine Creek Watershed. Also included in the Action Register is the target audience for each water quality improvement objective, objective milestones, estimated costs for implementing each objective, and possible partners as well as technical assistance resources that may be beneficial for objective implementation. WMP implementation progress will be tracked using a combination of social indicators, administrative indicators, and environmental indicators.

Several well-known cost-share programs are offered by the USDA NRCS, ISDA, IDNR, IDEM and other less well-known programs that could be used to financially support the implementation of recommended BMPs. A large variety of established institutional resources and other potential institutional resources exist to aid in water quality improvement efforts. The Hancock County SWCD and steering committee will be seeking grants and assistance from institutional resources to move forward with implementation of the WMP.

Acknowledgements

This study was made possible by funding from the Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program and the Hancock County Soil and Water Conservation District (SWCD). Davey Resource Group (Davey) project team members conducted fieldwork, data collection, report writing and mapping, facilitated public meetings and outreach, and provided project oversight. The Davey project team consisted of Chad Appleman, Alicia Douglass, Kasey Krouse, Todd Gillian, Deb Sheeler, Holly Richards, and Karen Wise.

Individuals who provided project consultation or contributed data to this report via personal communication include:

- Brant Fisher, IDNR Nongame Aquatic Biologist
- Caleb Osborne, Morristown Wastewater Department
- Chuck Bell, IDEM Watershed Assessment and Planning Branch
- Cindy Newkirk, Hancock County Soil and Water Conservation District
- Cliff Chapman, Central Indiana Land Trust
- Dan Miller, City of Greenfield Stormwater Coordinator
- Derrick Byers, City of Shelbyville MS4 Director
- Jamie Dean, Indiana Downs Operations Manager
- Jeff Harmon, IDEM Office of Land Quality
- Joan Fitzwater, City of Greenfield Planning Director
- John Milburn, Hancock County GIS Coordinator
- Kathleen Hagan, IDEM Office of Water Quality
- Laura Fribley from the Indiana State Department of Agriculture
- Michael Fruth, City of Greenfield Engineer
- Rick Daily, Town of Fairland Board President
- Roger Hedge, IDNR Division of Nature Preserves
- Ron Hellmich, Division of Nature Preserves
- Taylor Sumerford, Shelby County Surveyor
- Todd Davis, IDEM Watershed Assessment and Planning Branch
- William Pursley, Shelby County Health Department

Special thanks are also due to numerous Brandywine Creek Watershed steering committee members and stakeholders who participated in steering committee and public meetings. These individuals are listed in the meeting notes in Appendix A.

Introduction

Hancock County Soil and Water Conservation District (SWCD) retained Davey Resource Group (Davey) to conduct field data collection and write a Watershed Management Plan (WMP) for Brandywine Creek Watershed (Photograph 1). The purpose of a WMP is to summarize available data that influence water quality in a watershed and develop a consensus driven plan for a community to achieve solutions to address water quality problems. This Brandywine Creek WMP was funded by an Indiana Department of Natural Resources (IDNR) Lake and River Enhancement Program (LARE) grant with a cash and in-kind services match provided by Hancock County SWCD.

The headwaters of Brandywine Creek originate in northeastern Hancock County, Indiana. Brandywine Creek generally flows southwest to a point where it debouches to Big Blue River in northwestern Shelby County, Indiana (Figure 1). Brandywine Creek is part of the Mississippi River Basin and eventually reaches the Mississippi River via the following flow sequence: Big Blue River to Driftwood River to East Fork White River to White River to Wabash River to Ohio River to Mississippi River.

A watershed is the total land area that drains to a particular waterbody. Watershed basin boundaries have been delineated and assigned hydrological-unit code (HUC) numbers based on the basin size. Brandywine Creek Watershed is a 10-digit HUC watershed (0512020403) comprised of 27,615 hectares (65,238 acres) (Indiana Geological Survey [IGS], 2010). It is composed of four, 12-digit HUC subwatersheds.

Photograph 1 (10-21-10). State Route 9 crosses over Brandywine Creek just south of the Hancock and Shelby County line.

Figure 1. Indiana State Map

Watershed Community Initiative

The Hancock County SWCD initiated development of the Brandywine Creek WMP project prior to formation of a steering committee by applying for an IDNR LARE grant. The Hancock County SWCD recently completed a WMP for the Sugar Creek Watershed, which was funded by Section 319 through the Indiana Department of Environmental Management (IDEM). The Hancock County SWCD chose to develop a WMP for Brandywine Creek, so they could apply for Section 319 best management practice (BMP) implementation funding for both watersheds jointly. In addition, funding the Brandywine Creek WMP using LARE funds enables the Hancock County and Shelby County SWCDs to apply for LARE BMP implementation funds in the Brandywine Creek Watershed in addition to Section 319 funding.

The Hancock County SWCD was especially interested in knowing the water quality in Brandywine Creek since the creek and a significant tributary flow through the City of Greenfield. The Hancock County SWCD expressed concern about *Escherichia coli* (*E. coli*) levels in Brandywine Creek particularly at Riley Park in Greenfield. There were no local groups beyond the Hancock County SWCD specifically focused on Brandywine Creek at the time the WMP project was initiated. Individuals were brought together to focus on Brandywine Creek as part of the steering committee formation process.

Steering Committee Members

Two public meetings were held in fall, 2010, with a three-fold purpose including introducing the project to the public, gathering stakeholder water quality concerns, and soliciting potential steering committee volunteers. Both meetings were advertised in local newspapers and by flyers posted in local libraries. The first public meeting was held on September 13, 2010, at the Hancock County Library in Greenfield, Indiana. The second public meeting was held on November 23, 2010, at the Shelby County Public Library in Shelbyville, Indiana.

The Hancock County SWCD and Davey also personally invited other key individuals and leaders in the community to participate in the steering committee. Steering committee members who attended or provided comments for three or more meetings or provided review and comment on a draft version of the report are listed in Table 1. Numerous individuals invited to be a part of the steering committee elected to stay informed and be included in steering committee correspondence. Kathleen Hagan, IDEM Watershed Specialist, and Rod Edgell, IDNR LARE Biologist, provided technical support to the steering committee.

Table 1. Steering Committee Members and Affiliations

Steering Committee Member	Affiliation
Alice Bogemann	Hancock County SWCD Supervisor
Angie Brown	Greenfield Resident, IDEM Watershed Specialist
Brian Gandy	Hancock County SWCD Associate Supervisor, Indiana Society of American Foresters Chair
Cindy Newkirk	Hancock County SWCD Administrator/Tech/Educator
Cliff Chapman	Central Indiana Land Trust Conservation Director
Dale Herthel	Shelby County Landowner
Dan Miller	City of Greenfield Storm Water Coordinator
Dave Huffman	Greenfield Resident
John Moran	Hancock County SWCD Associate Supervisor
Kent Kaster	Shelby County Landowner
Kevin Bump	Greenfield Resident
Mike Conner	Hancock County SWCD Associate Supervisor
Susan Bodkin	Hancock County Surveyor
Susan Kaster	Shelby County Landowner

Stakeholder Concerns

The majority of stakeholder concerns were collected at the two introductory public meetings and the first steering committee meeting, which was held on September 30, 2010. Other public concerns were solicited by a steering committee member at a church adjacent to Brandywine Creek. These concerns were submitted to Davey via e-mail and comment cards.

Log jams and streambank erosion were the two most common concerns expressed by watershed stakeholders at the initial public outreach meetings. Specific concerns and associated details expressed by stakeholders at public and steering committee meetings are included in the meeting notes for each meeting in Appendix A. Concerns received from stakeholders are summarized and categorized in Table 2 to aid in understanding watershed issues. Concerns identified through windshield and desktop surveys are discussed in the Watershed Inventory – Part 2, Subwatershed Discussions section of this report.

Table 2. Initial Stakeholder and Steering Committee Member Concerns

Agricultural/Rural Issues
Streambank erosion – field acreage loss
Gravel bars – influence on drainage and facilitating log jam establishment
Log jams and beaver dams – influence on drainage
Development/Urban Issues
Combined sewer overflows
Runoff from soils exposed by earthwork
Wetland protection
Impact of water quality from development around lakes
Flooding of mobile home residences
Nutrients leaching into stormwater from autumn leaves piled in city streets
Widespread Pollution Issues
Streambank erosion – sediment and nutrient loss
Waterfowl impact on water quality
Contamination from failing septic systems
Trash in creeks
Increase in water volume in Little Brandywine Creek as well as other streams
Fish kills
Recreation Issues
Safeness of full-body water contact
Fishing – fish populations, safeness of consumption
Sediment accumulation in lakes

A final public meeting was held on December 1, 2011 to summarize the findings of water quality data and the methods by which the steering committee proposes to address stakeholder concerns. A survey was also distributed to gather information on meeting participants interested in implementing BMPs and becoming Hoosier Riverwatch volunteers. Notes from this meeting are included in Appendix A. An educational handout developed for the public and to be distributed at this meeting is included in Appendix B.

Watershed Inventory –
Part 1: Watershed Characteristics

Data from multiple secondary sources were gathered and analyzed to provide an understanding of the physical setting and general characteristics of Brandywine Creek Watershed. Surface water quality is influenced by multiple factors relating to the setting and characteristics of the watershed. Surface water quality can also be influenced by local planning efforts. Local planning efforts as well as the presence of endangered, threatened, and rare (ETR) species are further discussed in this section. ETR species are noted to create awareness of how the watershed conditions and activities may influence these species and other life within the watershed. Fully understanding the watershed physical setting, local planning efforts that influence water quality, and other relevant existing conditions strengthens the watershed planning process.

Physical Setting

Hydrology

Subwatersheds

Brandywine Creek Watershed is a 10-digit HUC watershed (0512020403) comprised of 27,615 hectares (65,238 acres). It is composed of four, 12-digit HUC subwatersheds including: Willow Branch-Brandywine Creek (051202040301) (Willow Branch Subwatershed), Richey Ditch-Brandywine Creek (051202040302) (Richey Ditch Subwatershed), Andis Ditch-Brandywine Creek (051202040303) (Andis Ditch Subwatershed), and Swamp Creek-Brandywine Creek (051202040304) (Swamp Creek Subwatershed). The Willow Branch Subwatershed is 4,136 hectares (10,219 acres), the Richey Ditch Subwatershed is 9,747 hectares (24,085 acres), the Andis Ditch Subwatershed is 7,552 hectares (18,662 acres), and the Swamp Creek Subwatershed is 6,180 hectares (15,271 acres). Figure 2 depicts the watershed and subwatershed boundaries overlaid on an aerial photograph.

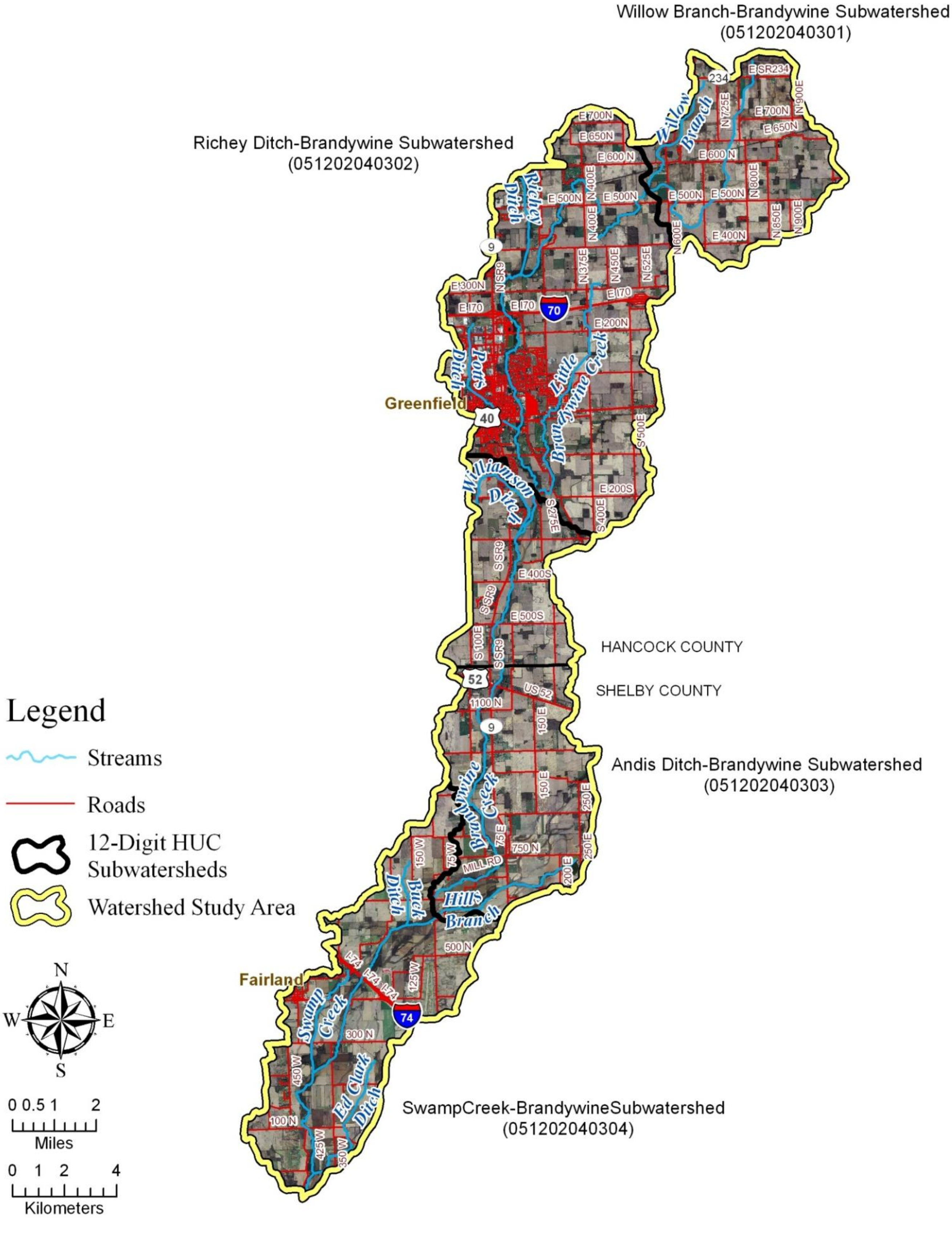

Figure 2. Aerial Photograph Map

Drainage

The headwaters of Brandywine Creek begin in southwestern Brown Township in Hancock County, Indiana. The creek generally meanders in a southwesterly direction for several miles prior to taking a more southerly direction and passing through Greenfield in Hancock County. Brandywine Creek continues to flow mostly southward into Shelby County and east of Fountaintown. The creek begins to flow in a southwesterly direction after crossing County Road (CR) 750 North in Shelby County. The creek flows to the east of Fairland. It debouches to Big Blue River east of CR 425 West and between CRs 50 South and 100 South in Hendricks Township, Shelby County.

Numerous tributaries feed Brandywine Creek including Willow Branch, Richey Ditch, Potts Ditch, and Little Brandywine Creek in Hancock County as well as Buck Ditch, Hills Branch, Swamp Creek, and Ed Clark Ditch in Shelby County. Potts Ditch flows through the middle of Greenfield. All other tributaries primarily drain agricultural land. There are approximately 117 kilometers (72.8 miles) of United States Geological Survey (USGS) National Hydrography Dataset (NHD) mapped streams in Brandywine Creek Watershed. Approximately 41.3 kilometers (25.7 miles) of NHD mapped streams in Hancock County are legal drains (Figure 3) (J. Milburn, personal communication, March 23, 2011). An additional 122.7 kilometers (76.2 miles) of smaller ditches in Brandywine Creek Watershed in Hancock County are also legal drains that have been digitally mapped, but not part of NHD. Approximately 19.3 kilometers (12 miles) of NHD mapped streams in Shelby County are considered legal drains (T. Summerford, personal communication, June 22, 2011). Many more miles of smaller ditches are legal drains in Shelby County; however, these ditches have not been digitally mapped.

The waters in Brandywine Creek Watershed serve many functions. Brandywine Creek receives water being discharged from Greenfield Waste Water Utility and storm sewer system. Legal drains and other streams facilitate drainage on nearly 22,300 hectares (55,000 acres) acres of agriculture row crop, hay, and pastureland.

A legal drain is a stream, ditch, or tile under the maintenance authority of a County Drainage Board. Indiana code establishes the right of a County Drainage Board for each county. County drainage boards consist of three to five people of which one must be a county commissioner. The County Surveyor serves as a technical advisor to the Drainage Board. A tax is assessed to lands that drain to legal drains to financially support maintenance activities. Maintenance activities can include dredging, tile repair, and removal of any obstructions. Maintenance has historically also involved substantial channelization, or straightening, of streams and altering of the streams' natural flow pathway in order to drain water more quickly from the landscape. Numerous streams in Brandywine Creek Watershed have at some point been dredged and channelized including portions of Brandywine Creek. A significant portion of Potts Ditch has been encapsulated through Greenfield. Dredging, channelization, and encapsulation can result in negative water quality impacts.

Brandywine Creek and its tributaries pass through numerous livestock pastures and the streams are used as water sources in numerous locations throughout the watershed. Recreational fishing is a reported use by watershed residents, and children have been observed swimming and playing in the water in Brandywine Creek in Riley Park in Greenfield. Healthy fish populations and the safeness for full-body water contact recreation in Brandywine Creek are concerns expressed by watershed stakeholders.

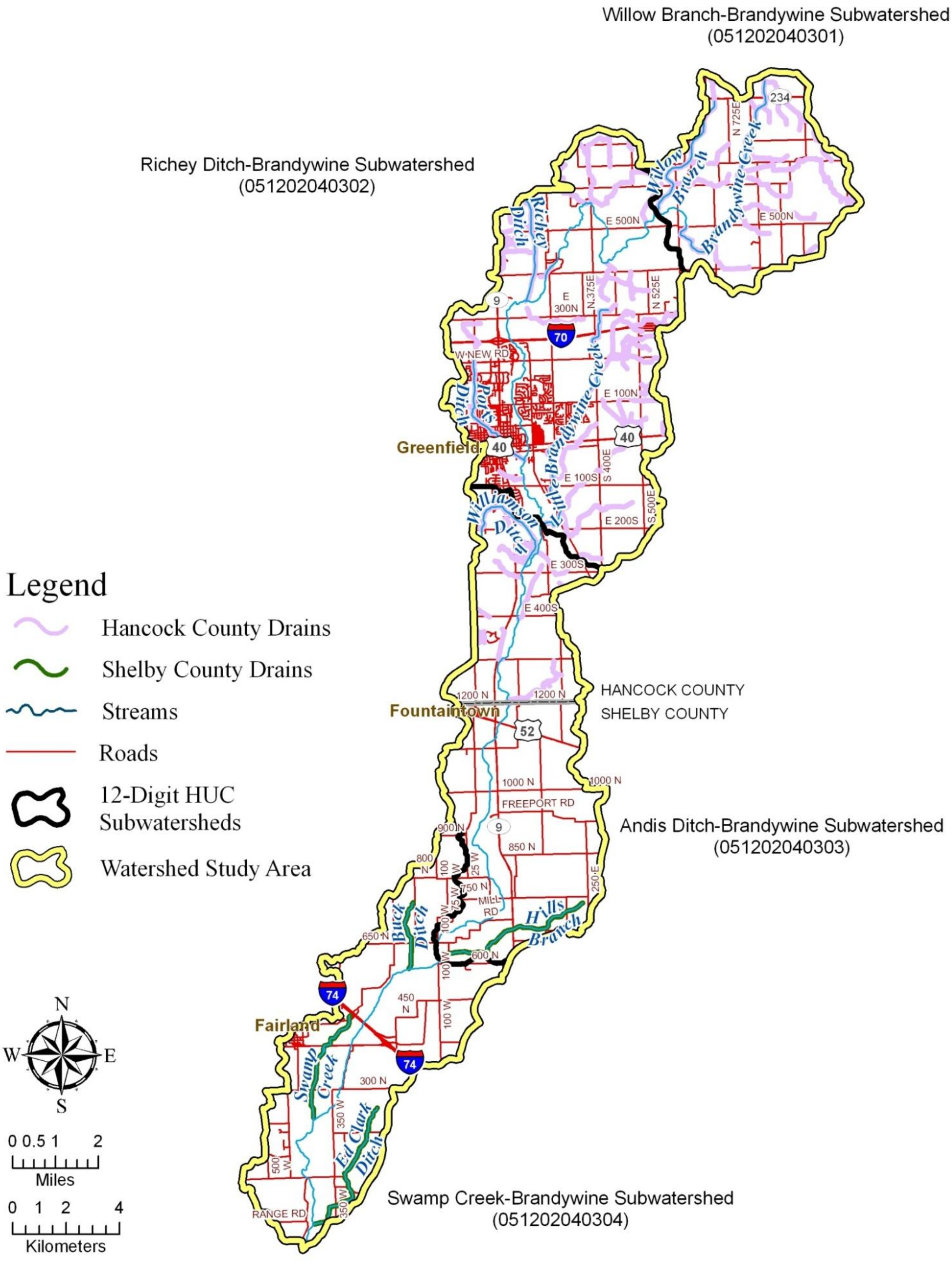

Figure 3. Legal Drains Map

Wetlands and Lakes

Wetlands are areas where soils are saturated at or near the surface at a frequency and duration long enough to support a dominance of wetlands plants and the development of hydric soils (Environmental Laboratory, 1987). Wetlands serve many functions upon which people and animals depend. Wetlands detain and retain stormwater, thereby attenuating downstream flooding, filter nutrients and sediments from water, help to keep surface water flowing during dry periods, and recharge groundwater aquifers. Many animal species depend on wetlands for food, shelter, and breeding. Plants that are a source of food and the raw materials for many medicines are found in wetlands. Wetlands clearly benefit the pharmaceutical, agriculture, tourism, and recreational industries, to name a few.

Approximately 30 years ago, the United States Fish and Wildlife Service (USFWS) began the National Wetlands Inventory (NWI) program to map the extent and status of wetlands. The process entailed examining aerial photographs and other available spatial information, and tracing the locations of wetlands on USGS topographic base maps. Today, the USFWS, in cooperation with the USGS, has converted most NWI paper maps to digital format.

Digital NWI data were downloaded from IndianaMap and overlaid on aerial imagery to produce Figure 4, in which the locations of wetlands in Brandywine Creek Watershed are displayed (IGS, 2010). NWI maps represent the locations where wetlands were likely to have occurred at the times maps were produced. Some wetlands depicted in the map may no longer exist and other wetlands may exist that do not appear on the map. Aerial photointerpretation suggests that there are few NWI mapped wetlands in the watershed that have been drained and/or filled since the NWI maps were developed.

According to NWI data, approximately 614 hectares (1,518 acres) of wetlands occur in the watershed. Hydric soils are a good indicator of where wetlands may currently occur or once existed. Approximately 9,734 hectares (24,053 acres) of hydric soils occur in the watershed. Hydric soils are fairly evenly distributed across the watershed with the exception of an area east of Brandywine Creek, south of United States (US) 52, and north of CR 850 North in Shelby County in which few hydric soils occur. Aerial photointerpretation in association with analysis of NWI and hydric soils maps indicate that vast acreages of historic wetlands have been drained for row-crop agriculture. Remaining wetlands may be used for wildlife viewing as well as hunting.

Geographic Information System (GIS) data identify 54 hectares (133 acres) of open water aquatic features including 14 lakes and ponds in the watershed in addition to wetlands (IGS, 2010). Open waterbodies are primarily used for recreational fishing, swimming, and small watercraft boating. Sediment draining to watershed lakes and its impact on recreational activities is a concern expressed by watershed stakeholders.

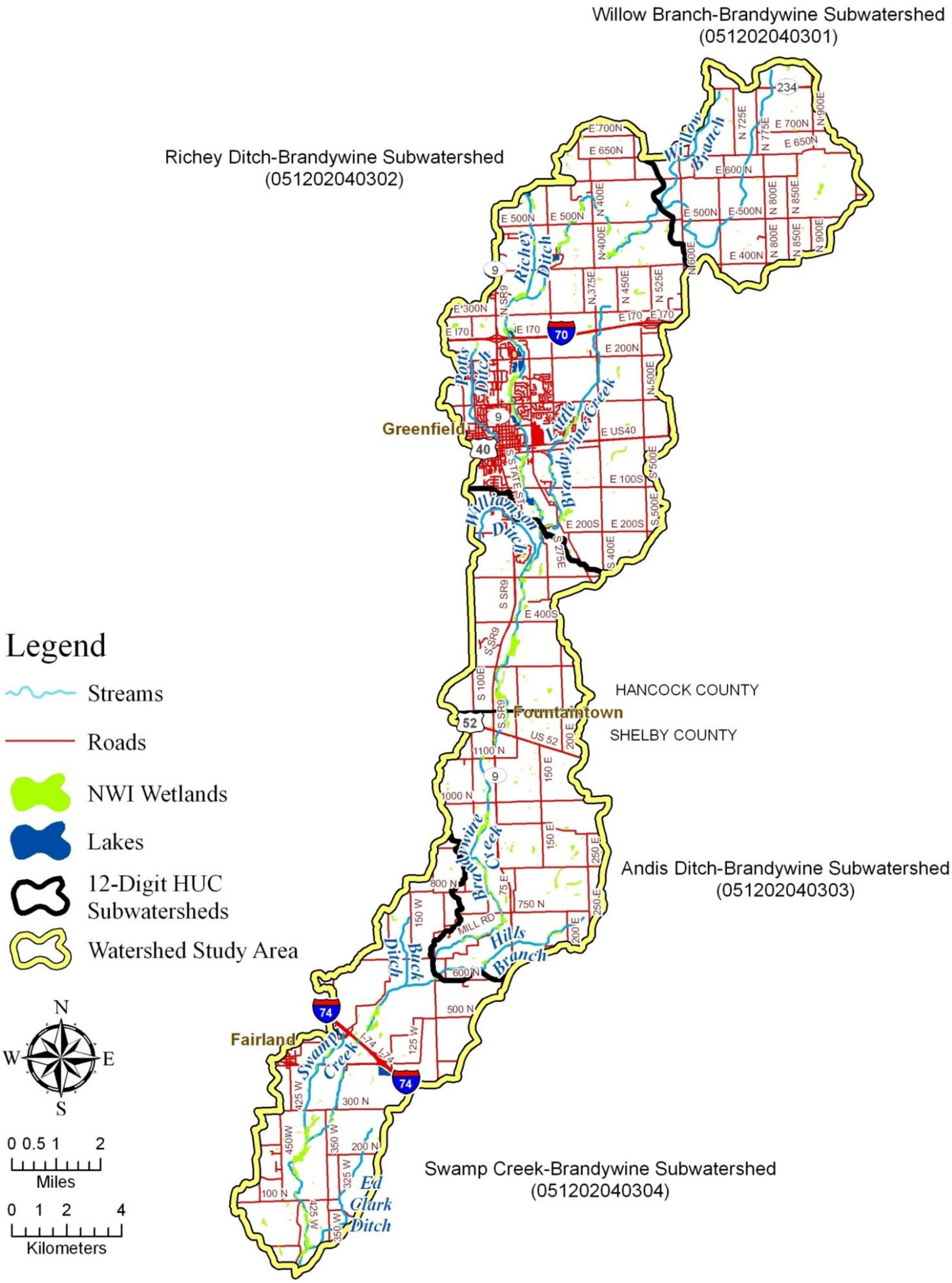

Figure 4. NWI Wetlands and Lakes Map

Floodplain Management Areas

Floodplains are low-lying areas adjacent to streams and rivers that are prone to recurring flooding. Figure 5 indicates the extent of the Federal Emergency Management Agency (FEMA) 100-year floodplain within the watershed. The floodplain encompasses 4,647 hectares (11,483 acres) (IGS, 2009). Most of the 100-year floodplain within the watershed occurs in Shelby County along the southern third of Brandywine Creek, which is the lowest topographic point in the watershed. A small amount of the 100-year floodplain does occur within Greenfield and is developed.

As defined by FEMA, floodplain management is the operation of a community program of corrective and preventative measures for reducing flood damage. These measures take a variety of forms and generally include ordinances governing land use development. Both the Hancock County and Shelby County Comprehensive Plans seek to limit future development of currently undeveloped areas within the Brandywine Creek floodplain. A significant portion of the floodplain is currently in agricultural production; however, significant riparian zones are intact along much of the length of Brandywine Creek.

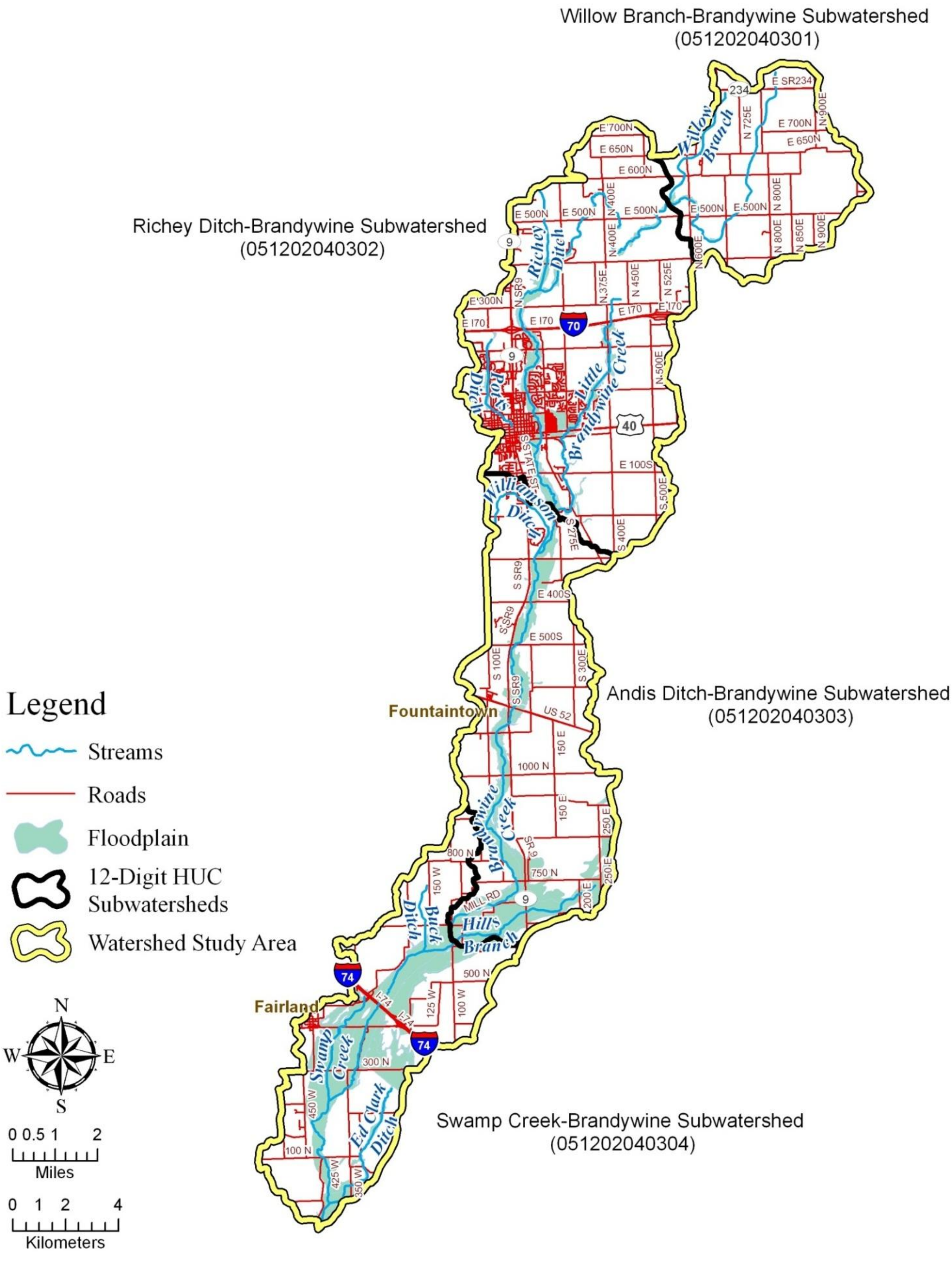

Figure 5. FEMA 100-Year Floodplain Map

Geology

The bedrock geology of Brandywine Creek Watershed consists of rock from the Muscatatuck Group and is composed of dolomite and limestone. The Muscatatuck Group is overlain by dark shales except where affected by post-Devonian erosion. The watershed was glaciated in the pre-Wisconsin and Wisconsin Stages and is part of the Tipton Till Plain. The Tipton Till Plain is characterized by flat to gently rolling terrain caused by deposition of till, an unsorted mixture of sand, silt, clay, and boulders, left by the retreating glaciers (Hill, 1998).

Topography

The topography of Brandywine Creek Watershed visually appears relatively flat resulting in fairly even drainage patterns across the land. It gradually and consistently decreases from the northern end of the watershed to the southern end of the watershed. Topography ranges from a high elevation of 1,014 meters (3,327 feet) in the northeastern portion of the watershed to a low of 721 meters (2,365 feet) in the southwestern part of the watershed based on 3-meter (10-foot) contour line topographical data (Figure 6). The elevation at the upstream-most point of Brandywine Creek is approximately 949 meters (3,114 feet), and the elevation at the downstream-most point is 724 meters (2,375 feet), resulting in a 3.3-meter/kilometer (17.5 feet/mile) overall grade change along the length of Brandywine Creek. Figure 7 depicts the watershed boundary overlaid on a 7.5-minute USGS topographical map with 6-meter (20-foot) contour lines.

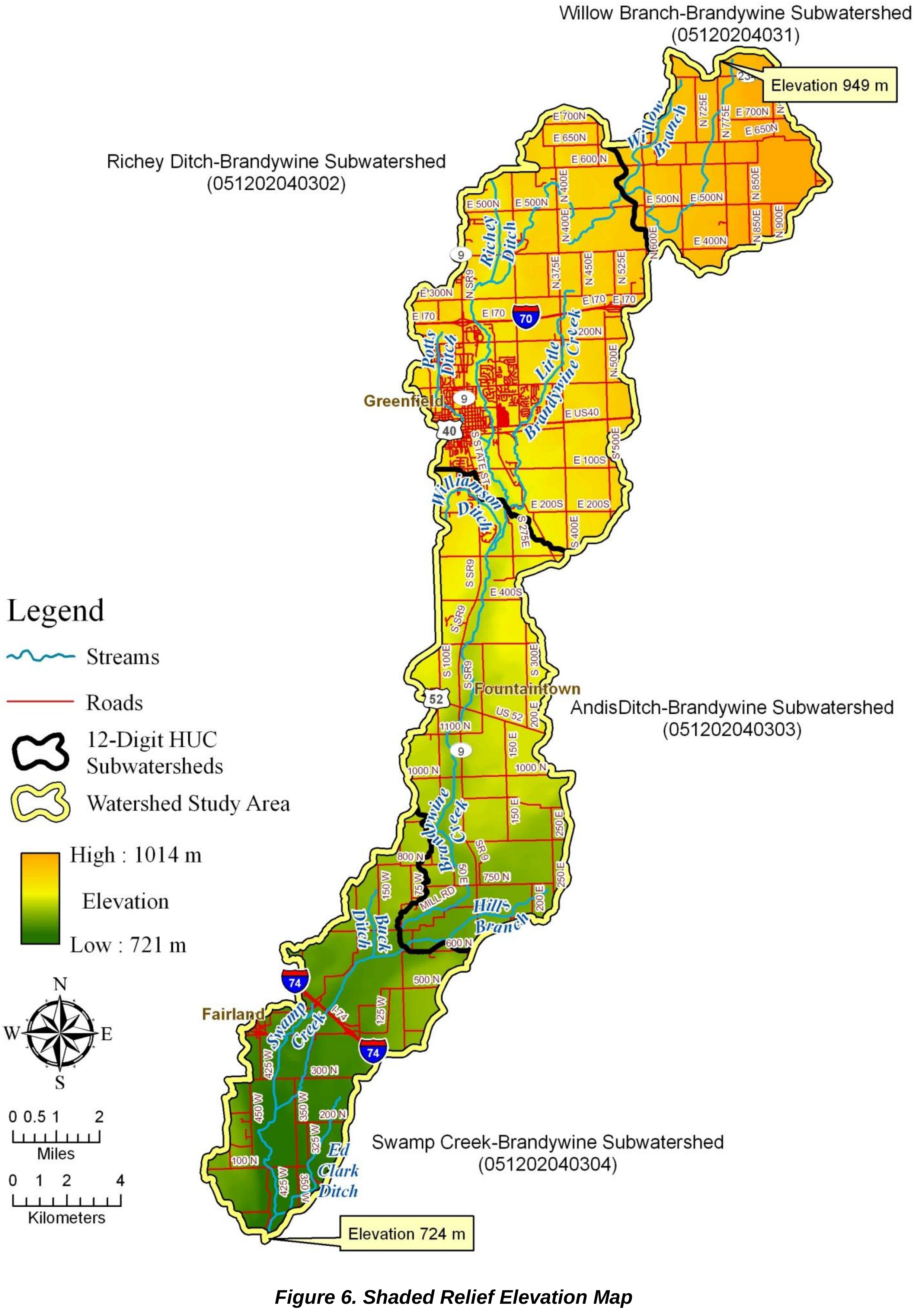

Figure 6. Shaded Relief Elevation Map

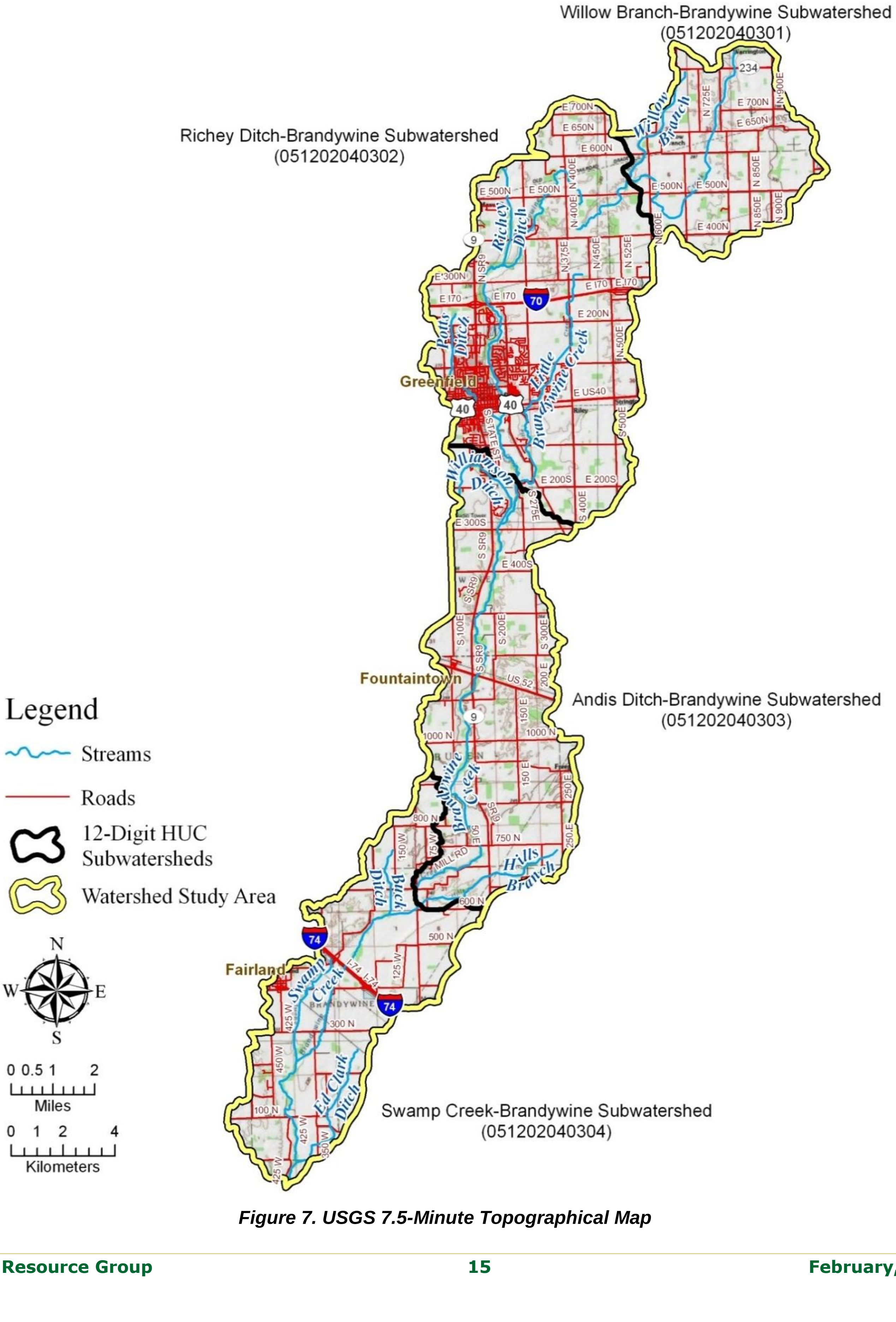

Figure 7. USGS 7.5-Minute Topographical Map

Soils

Highly Erodible and Hydric Soils

Different soil types vary in their susceptibility to erosion. Numerous factors influence soil erodibility including soil texture, erosive force of rainfall, as well as slope gradient and length. These factors in addition to a soil loss tolerance value that permits ongoing crop productivity are used to calculate a soil's erodibility index. Mapped soil units having a potential for erosion eight times or greater than the erosion tolerance value and an erodibility index value of eight or more are considered highly erodible (United States Department of Agriculture [USDA], 2008b).

Highly erodible soils in the watershed are comprised of 22 different soil series and total 17% of the watershed acreage. The most common erodible soil series in the watershed is Miami silt loam (MmB2, MmB3, MmC2, MmC3, MmD2, MmD3), which in conjunction with Miami complex soils (MpC3, MpD3) comprises nearly 12.5% of the watershed. Miami silt loam and Miami complex soils have slopes ranging from 2–18%.

Hydric soil series are soils that formed under conditions of saturation, flooding, or ponding for a duration long enough to develop anaerobic conditions in the upper part of the soil column during the growing season (Environmental Laboratory, 1987). Hydric soils make up a significant portion of the watershed consisting of over 35% of all soils. Brookston silty clay loam is the dominant hydric soil series present consisting of 19% of all watershed soils.

The topography of Brandywine Creek Watershed is relatively flat and consists of a matrix of highly erodible and hydric soils (Figure 8). Hydric soils are spread throughout the entire watershed and are found directly adjacent to Brandywine Creek along much of its length. Highly erodible soils are frequently found adjacent to the hydric soils that border Brandywine Creek and are also found directly adjacent to the creek north of CR 400 North in Hancock County.

Special caution should be taken to minimize disturbance to highly erodible soils for crop production and development as these soils have a higher probability of being washed into streams and other waterbodies. Sediment can also carry excess nutrients to streams that are bound to the soil particles. Watershed stakeholders have expressed concern relating to sediment being deposited in watershed lakes and ponds.

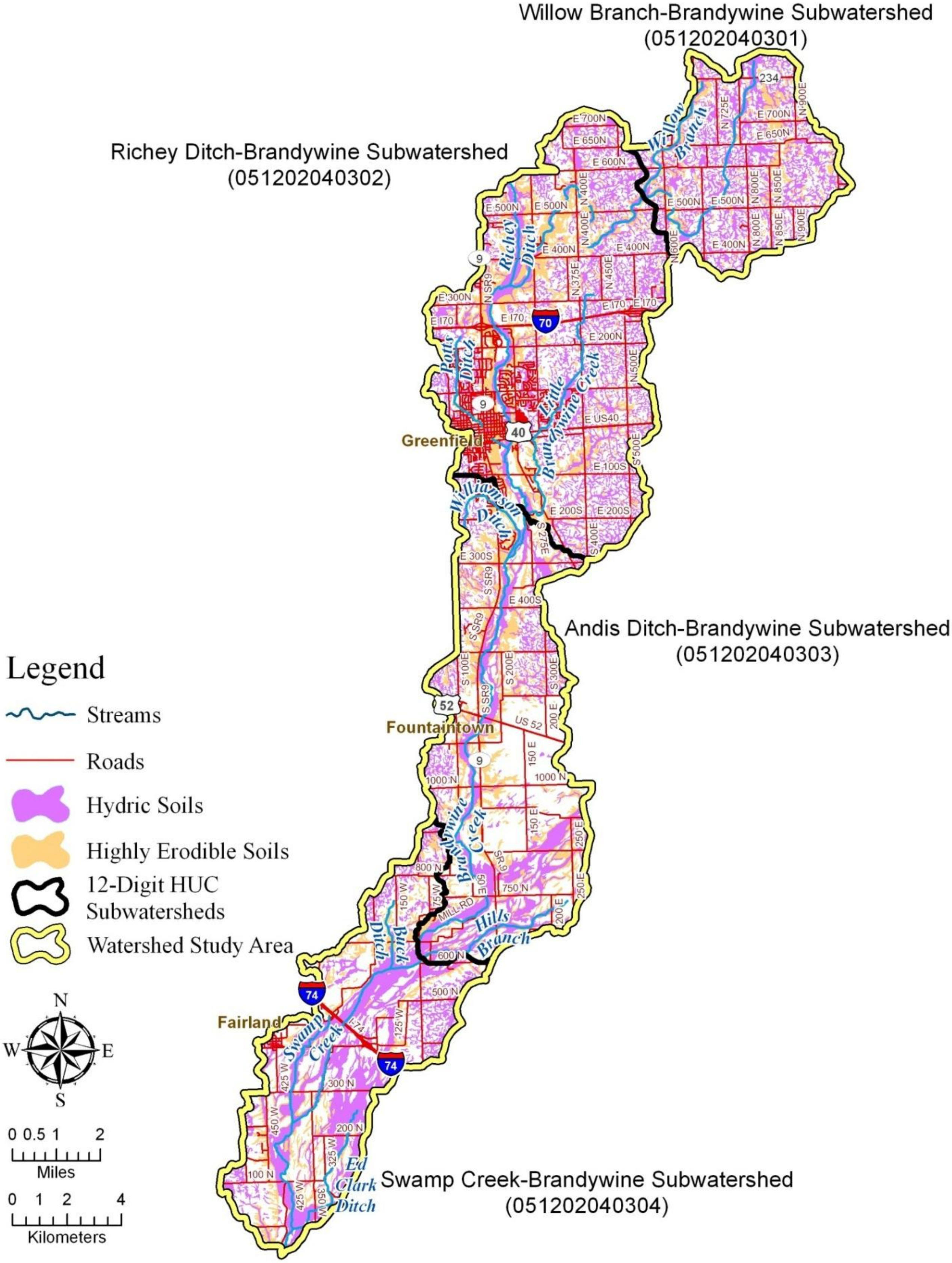

Figure 8. Hydric and Highly Erodible Soils Map

Septic System Suitability and Unsewered Communities

Septic systems are on-site sewage treatment systems that utilize absorption fields to distribute effluent into the soil below the surface. Septic systems include septic tanks, which are watertight containers below the soil surface that receive effluent from a house. Solids settle out of the effluent in the tank and wastewater is discharged from the tank into the drainfield. Wastewater effluent percolates into the soil from the drainfield where bacteria, viruses, and nutrients are removed.

Soils are rated based on properties that affect the absorption of effluent, such as hydraulic conductivity, depth to water table, ponding, depth to bedrock or a cemented pan, depth to loose stone and gravel, and flooding which may affect absorption of the effluent (Soil Survey Staff, 2010). A total of 90% of watershed soils are classified as very limited suitability for on-site septic systems, which means that the soil has one or more features that are unfavorable for properly functioning septic systems (Figure 9). Limitations in these soils generally cannot be overcome without special designs, expensive installation procedures, or major soil reclamation. Somewhat limited soils have features that are moderately favorable for septic systems, and have limitations that can typically be overcome or be minimized by special designs and installations. Soils that are not limited have features that are very favorable for on-site septic systems (Soil Survey Staff, 2010).

Soil types were rarely taken into consideration for homes built in Indiana prior to the 1980s (Lee and Jones, 2004). It is estimated that approximately 25% of on-site septic systems in Indiana are failing and annually discharging more than 289,800 liters (76,560 gallons) of untreated wastewater into the environment per failing system (Lee, *et al*, 2005).

Greenfield is serviced by a sanitary sewer system. The area around Interstate (I-) 74 Exit 109 Fairland Exit is serviced by the City of Shelbyville sanitary sewer system (Figure 9). Residences and businesses in the remainder of the watershed use septic systems. There are multiple areas in the watershed where failing septic systems are suspected. Three of these areas are directly adjacent to Brandywine Creek and near the Greenfield sanitary sewer system include the Hickory Hills subdivision, Hill Grove subdivision, and Walnut Ridge subdivision (D. Miller, personal communication, March 22, 2011). Hickory Hills is located along Hickory Boulevard south of I-70 and north of CR 200 North. Hill Grove subdivision is located south of Main Street and west of Morristown Pike. Walnut Ridge subdivision is located along Ridge Drive west of Apple Street. Combined, these subdivisions include over 50 residences. Other unsewered communities in the watershed with over 100 residences and not near existing sanitary sewers include portions of Fountaintown and Fairland (Figure 9). The Town of Fairland is exploring options for installing a sewage treatment system (W. Pursley, personal communication, March 31, 2011). Smaller, unsewered communities in the watershed include Willow Branch, a portion of Maxwell, and other scattered subdivisions.

Based on soil characteristics, it is anticipated that there are numerous, unidentified rural houses with failing septic systems throughout the watershed. Failing septic systems may contribute significant amounts of nutrients and pathogens to surface waters. Watershed stakeholders have expressed concern related to the safeness of recreation in Brandywine Creek, specifically at Riley Park, which is downstream of areas known to have failing septic systems.

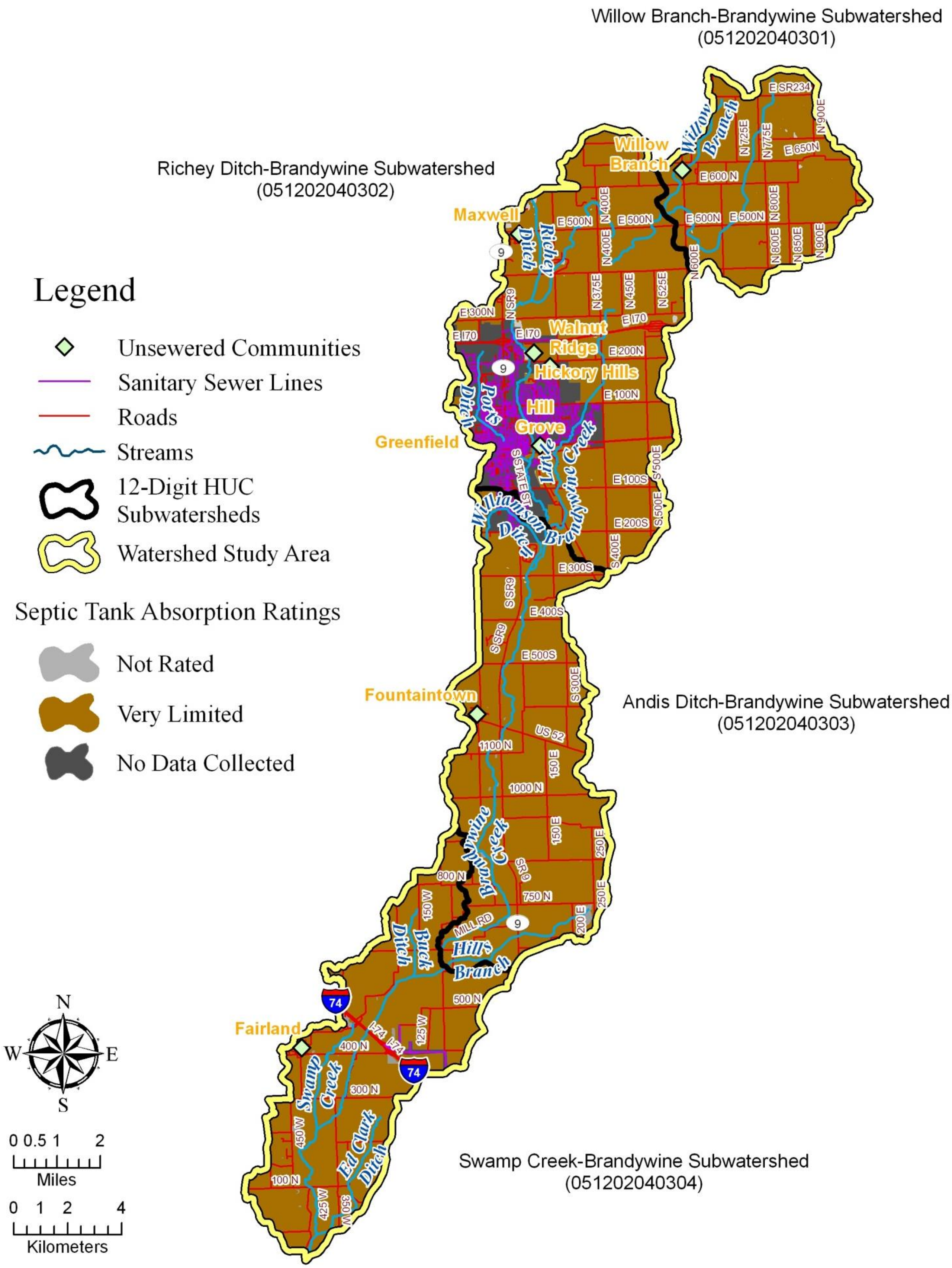

Figure 9. Septic System Suitability and Unsewered Communities Map

Tillage Transect Data

Indiana Conservation Partnership members regularly conduct surveys of randomly selected farm fields to determine what types of tillage systems are being used in Indiana. Evaluated fields are assigned to one of four primary tillage categories: conventional tillage, reduced tillage, mulch tillage, and no-till. The no-till category also includes strip-till and ridge-till tillage systems. Conventional tillage refers to a tillage system that leaves 0–15% residue cover after planting. Reduced tillage refers to a tillage system that leaves 16-30% residue cover. Mulch tillage refers to tillage systems excluding no-till that leave more than 30% residue cover. Any tillage system that leaves 30% or greater residue cover is considered conservation tillage (Photograph 2). No-till and mulch tillage are both conservation tillage systems (Evans, *et al.,* 2000). It is believed that conservation tillage has more potential than any other agricultural BMP to reduce soil erosion, improve water quality, and promote long-term productivity of soils in intensive cropping systems (USDA, 2008a). Table 3 depicts the correlation between percent residue cover and soil loss (Hill and Mannering, 2011).

Table 3. Percent Residue Cover and Soil Loss

Percent Residue Cover	Soil Loss (tons/ac)
0	12.4
41	3.2
71	1.4
93	0.3

Tillage transect data were obtained at the county and state level from the Indiana State Department of Agriculture (ISDA) for 2004, 2007, and 2009 (ISDA, 2010; L. Fribley, personal communication, October 12, 2010). The mulch-till and reduced-till categories were combined by ISDA in 2009 data.

In 2004, the percent of fields on which no-till was practiced where the present crop was soybeans in Hancock County was far below the state average. Hancock County far exceeded state averages for no-till in 2007 and 2009, and Shelby County far exceed state averages in 2004, 2007, and 2009 for the percent of fields where the present crop was soybeans (Figure 10). In 2009, Hancock and Shelby Counties ranked fifth and sixth in the state respectively for the greatest percent of no-till soybean fields.

Hancock County lagged behind the state average for no-till in fields where the present crop was corn in 2004 and 2009. Shelby County exceeded state no-till averages where the present crop was corn in 2004, 2007, and 2009 (Figure 11).

Photograph 2 (10-21-10). A field adjacent to Swamp Creek was photographed being tilled.

The decrease in percent no-till recorded in 2009 from 2007 may partially be contributed to field data interpretation. Crops had already germinated at the time tillage transect data were collected in 2009, thus obscuring the percentage of residue present. Consequently, field staff decided to conservatively estimate percent residue resulting in a potentially lower overall recorded percentage of fields in which no-till was practiced (C. Newkirk, personal communication, February 8, 2012).

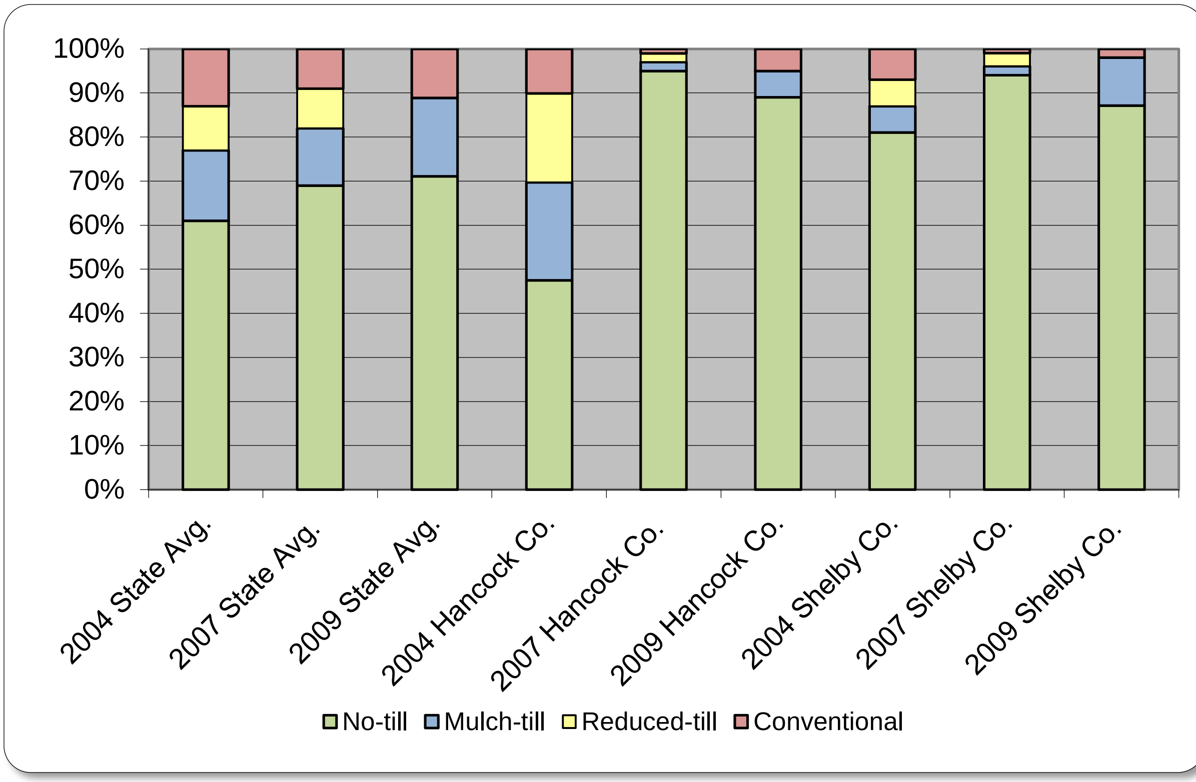

Figure 10. Tillage Systems in Fields Where Soybeans was the Present Crop

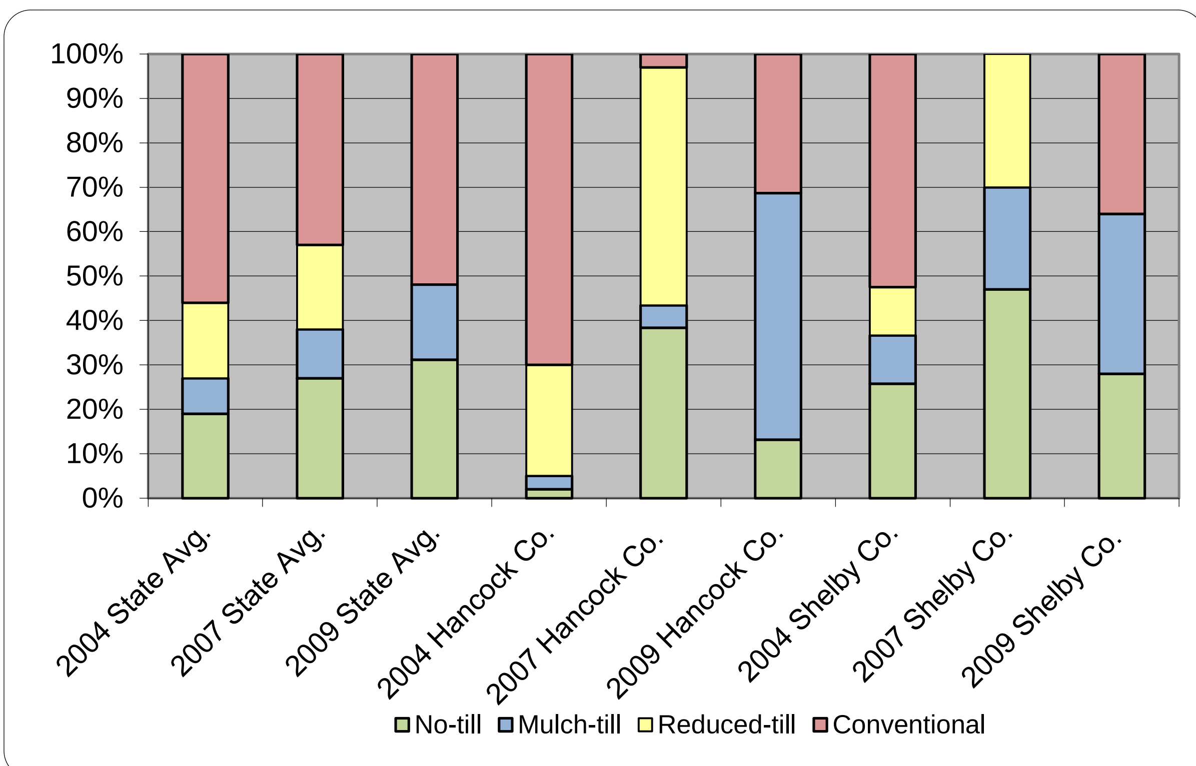

Figure 11. Tillage Systems in Fields Where Corn was the Present Crop

Land Use

Land use data were obtained from the 2001 National Land Cover Database (NLCD) available from IndianaMap (IGS, 2010). These data were originally produced using a combination of Landsat imagery and ancillary data. Figure 12 depicts the distribution of land use types throughout the watershed.

Cultivated cropland is the predominant land use type comprising just over 78% of the total watershed area (Figure 13 and Table 4). An additional 2.4% of the watershed is pasture or hay fields making the total agricultural land use percentage greater than 80% of the watershed. Agricultural practices significantly influence water quality. Factors such as the timing, quantities, and methods of fertilizer application on cropland influence nutrient loading in streams. Nutrients as well as pathogens and sediments from degraded banks enter surface water when livestock have direct access to streams. Sediment erodes from fields and enters streams when soils are disturbed for cultivation. High nutrient levels, sediment, and pathogens such as *E. coli* in streams in Brandywine Creek Watershed are all concerns expressed by stakeholders.

A total of 11.5% of the watershed is developed including commercial, industrial, and residential areas as well as developed open space such as athletic fields and golf courses. Brandywine Creek Watershed is trending toward more rapid development due to its close proximity to Indianapolis, especially in the vicinity of I-70 and I-74 corridors which offer convenient access to Indianapolis. Development increases impermeable surface in the watershed consequently resulting in greater runoff volumes and possible higher pollutant concentrations. Notable impacts to water quality occur with as little as 10% watershed impervious cover, which can be obtained with as little as one house per 2 acres. Watershed impervious cover greater than 25% indicates a high probability that streams will be impaired for aquatic life use (Center for Watershed Protection, 2003). It is anticipated that total impervious cover as a component of developed land will exceed 10% in Brandywine Creek Watershed in coming years.

Urban and suburban fertilizer application poses another threat to water quality. Public perception of the beauty of green, well-manicured lawns frequently results in significant quantities of fertilizer being applied by homeowners and managers of recreational facilities such as golf courses and athletic fields. These fertilizers often contain phosphorus and are likely applied by homeowners adjacent to stormwater retention ponds as well as recreational facilities directly adjacent to Brandywine Creek and its tributaries.

Increasing development also brings the potential for increased habitat for urban waterfowl using retention ponds and other developed areas adjacent to streams, as well as increasing numbers of hobby farms with small numbers of livestock such as horses that may be given direct access to streams. Such animals currently contribute to nutrient and *E. coli* loading in the watershed and may become more problematic as development increases.

Natural area including forest, scrub/shrub areas, and grassland comprise less than 8% of the total watershed area. Forested watersheds are frequently used for defining stream reference conditions and loss of forested cover in watersheds correlates with declining water quality (Center for Watershed Protection, 2003).

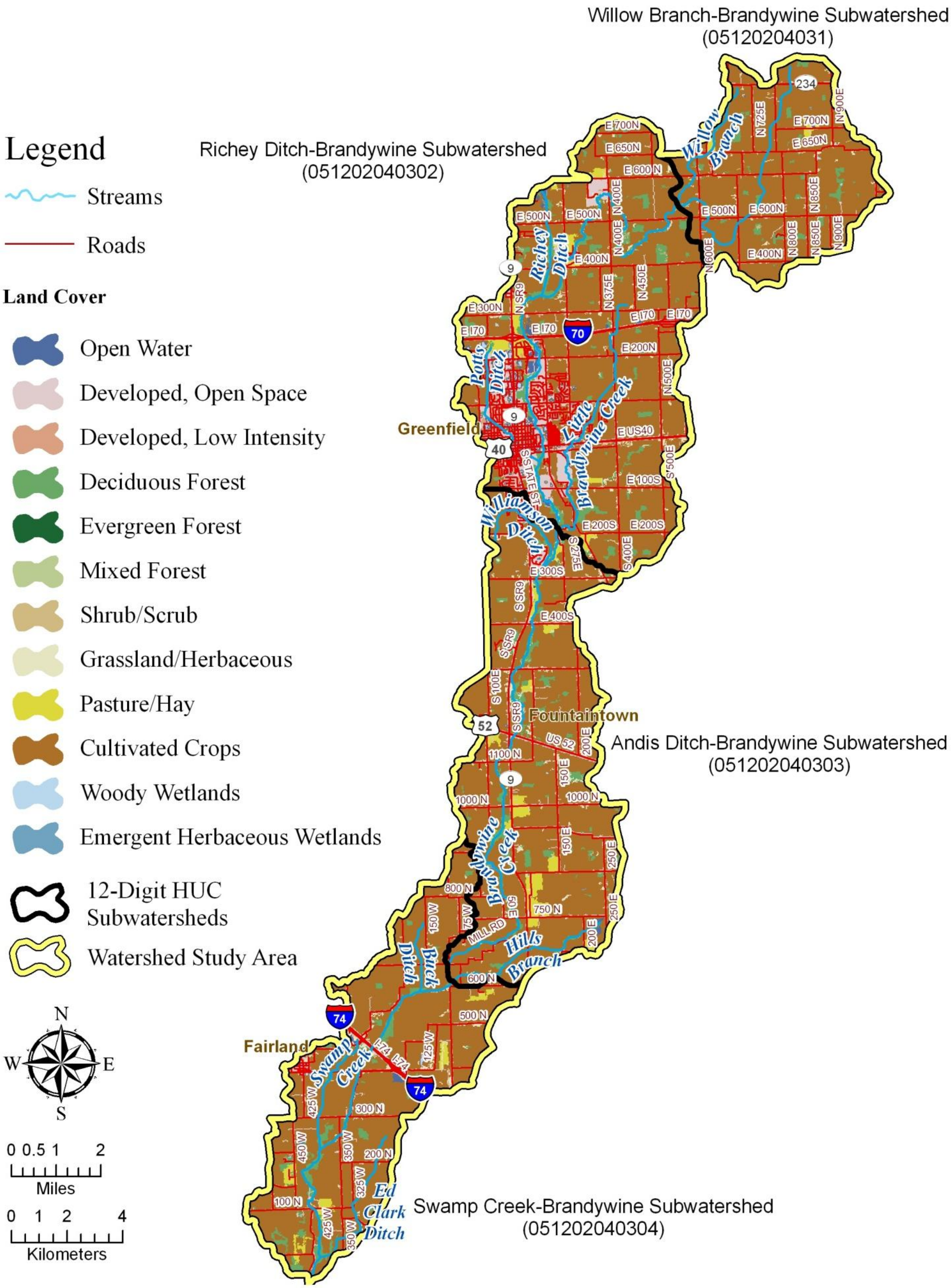

Figure 12. Land Use Map

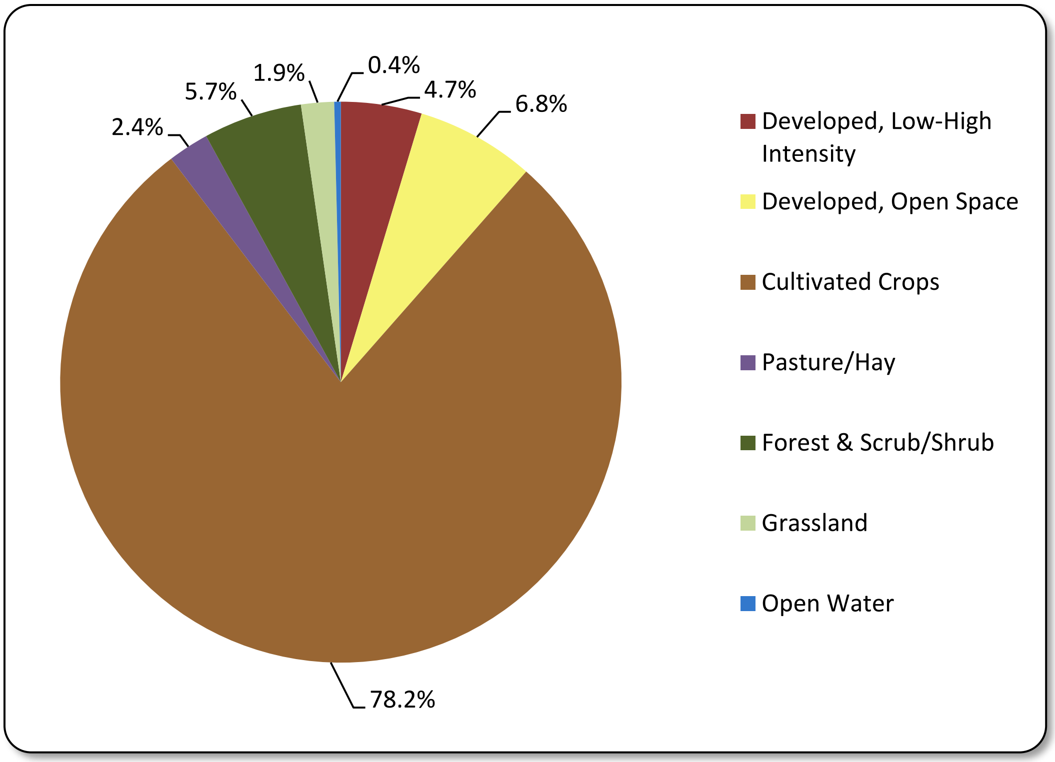

Figure 13. Brandywine Creek Watershed Land Use Percentage Graph

Table 4. Brandywine Creek Watershed Land Use Acreages

Land Use Classification	Percent of Watershed	Watershed Area (Hectares) ([Acres])
Developed, low-high intensity	4.7	1,284 (3,174)
Developed, open space	6.8	1,886 (4,661)
Cultivated crops	78.2	21,590 (53,351)
Pasture/hay	2.4	654 (1,615)
Forest and scrub/shrub	5.7	1,572 (3,884)
Grassland	1.9	524 (1,295)
Open water	0.4	104 (257)

Local Watershed Planning Efforts

There are multiple local planning documents whose jurisdictions overlap with Brandywine Creek Watershed that at least in part address water quality concerns or contain information that indicate potential water quality stressors. These documents include the Greenfield Comprehensive Plan, Greenfield MS4 Storm Water Quality Management Plan, Greenfield Wellhead Protection Plan, Hancock County Stormwater Management Ordinance, Hancock County Comprehensive Plan, Shelbyville Comprehensive Plan, and Fairland Exit Small Area Plan.

Greenfield Comprehensive Plan

Greenfield is the largest incorporated area in Brandywine Creek Watershed and Hancock County. The Greenfield Comprehensive Plan was developed to help direct future growth and development in the City by establishing a legislative policy document for decision making by the Plan Commission and City Council. The City of Greenfield last updated the Comprehensive Plan in 2006. It includes information relating to current developed conditions in the city as well as areas proposed for future development and growth. The comprehensive plan map is included in Appendix C.

The plan recognizes Potts Ditch and Brandywine Creek as the "backbone of the City's greenway system". It suggests that the City should protect and enhance environmentally sensitive areas including, but not limited to, Potts Ditch, Brandywine Creek, and Little Brandywine Creek. The plan also recommends that new developments along Potts Ditch include an easement for the ditch to preserve the integrity of the ditch and ensure it continues to serve as a natural greenway. However, it is not believed that this recommendation has been implemented in new developments to date (J. Fitzwater, personal communication, August 29, 2011).

Other recommendations specifically mentioned in the Greenfield Comprehensive Plan that would have positive benefits for water quality if implemented include:

- Increasing the use of native plantings and ecologically sound maintenance practices
- Creating a tree preservation ordinance and encouraging new plantings
- Requiring a certain percentage of green space in all new subdivisions
- Discouraging development sprawl away from the City center core and encouraging redevelopment of vacant properties within the core of the community and an established 15-year growth boundary
- Development of an annexation strategy

Annexation involves incorporating adjacent unincorporated areas into a political territory, such as a municipality. Annexation enables a municipality to increase its tax base and in turn offer services, such as water, sewer, fire, and police protection, to the previously unincorporated communities. Greenfield does not currently have a formal annexation strategy; however, it is the City's general policy not to actively seek areas to annex or to supply utilities to unincorporated areas as it becomes difficult to annex and tax these areas later. The City will consider annexing new areas when landowners request that the City provides them municipal services. Consequently, there are no plans to increase the extent of area serviced by city sewer at this time which would alleviate water quality impacts caused by neighborhoods adjacent to city sewer service that are known to failing septic systems. (M. Fruth, personal communication, August 29, 2011). Development of an annexation strategy should include consideration of surface water quality and target areas having a high density of failing septic systems.

Greenfield MS4: Storm Water Quality Management Plan

The Hancock County Comprehensive Plan does not specifically address stormwater concerns. However, Greenfield is required to implement a Storm Water Quality Management Plan as a result of its National Pollutant Discharge Elimination System (NPDES) permit for its Municipal Separate Storm Sewer System (MS4) required under 327 IAC 15-13. City of Greenfield MS4 District is depicted in Figure 14.

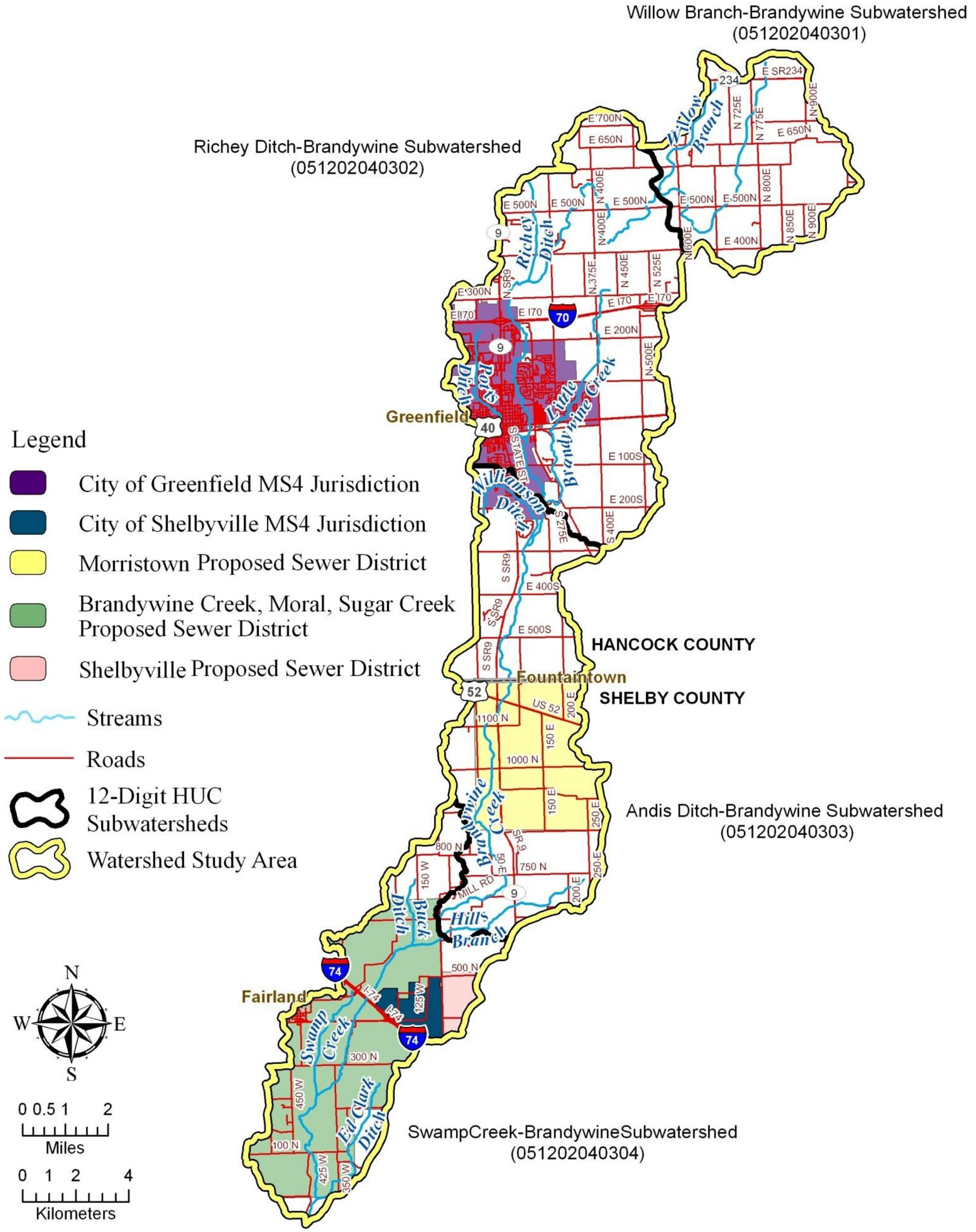

Figure 14. Local Planning Efforts Jurisdiction Map

The City of Greenfield MS4 includes approximately 137 kilometers (85 miles) of storm sewers and approximately 12.2 kilometers (7.6 miles) of open ditches having bottom widths 61 centimeters (24 inches) or greater (Wessler, 2010). The City has identified 108 outfalls greater than or equal to 30.5 centimeters (12 inches) in diameter within the MS4 district, and is currently working to detect and eliminate illicit discharges. Other measures the City has undertaken or is planning to undertake in the near future to improve water quality include:

- A stormwater hotline for citizens to report concerns
- An ordinance to prohibit illicit discharges
- Provide hazardous waste disposal opportunities (Photograph 3)
- An ordinance to enforce erosion and sediment control at construction sites consistent with requirements in Rule 5 and 13
- Compliance standards for BMPs implemented in accordance with Rule 5
- A formal system for performing technical reviews of Storm Water Pollution Prevention plans for proposed developments within Greenfield
- Erosion and sediment control inspections by trained inspectors on all construction sites issued Rule 5 permits
- Enforcement actions for violations of Rule 5 erosion and sediment control requirements
- An erosion and sediment control hotline for citizens to report concerns
- An ordinance for the MS4 to the extent of its authority to implement planning procedures for post-construction stormwater management including buffer strip and riparian zone preservation, filter strip creation, minimization of land disturbance, minimization of impervious surface, maximization of open space, and directing development away from sensitive areas for water quality
- Standards for operational and maintenance plans for all structural stormwater BMPs
- Inspections for structural stormwater BMPs
- Stormwater and pollution prevention training for all City employees whose job tasks have potential to influence water quality
- Daily removal of litter from parks and City properties
- Cleaning catch basins in the City as needed or a minimum of once per permit term
- Street sweeping
- Conduct heavy trash, Christmas tree, and leaf collection pick-up days
- Maintenance to minimize erosion from roadside shoulders and ditches

Photograph 3 (10-21-10). Hazardous waste disposal opportunities are available to Hancock County residents through the Hancock County Solid Waste Management District.

- Inspection of sewer outfalls for scouring once per permit term and repair as needed
- Conduct training on handling and application of road salt to reduce the amount of salt disbursed to stormwater
- Ensure plowed snow is not placed on impervious surfaces
- The City will ensure that municipal chemicals and petroleum products are properly managed and stored and that spill cleanup kits are readily available
- City vehicles will be washed in locations to minimize impacts to water quality
- A designated canine park
- Evaluation of flood management projects for water quality impacts

An informal survey was conducted by City of Greenfield MS4 in 2010 to gauge baseline public awareness of stormwater issues. Less than 0.5% of survey recipients (43 out of 9,700) returned the survey. Consequently, the results of the survey were not reliable. The low response rate may in part be attributed to the survey methodology; however, it also appears to indicate a lack of interest by Greenfield residents in communicating about stormwater issues. Specific public education measures to be implemented by City of Greenfield MS4 include distribution of rain garden educational information, distribution of stormwater educational information, educational outreach to commercial and industrial facilities, maintaining website containing information about the MS4 program and stormwater topics, and educational outreach to construction professionals. City of Greenfield will also require that storm drain inlets be stamped with a pollution prevention label.

Greenfield Wellhead Protection Plan

Groundwater is susceptible to contamination by pollutants permeating through soil. Wellhead protection involves identifying and protecting land where subsurface water flows to a public drinking supply water well within a given time frame. Greenfield maintains six public water supply groundwater wells (City of Greenfield, 2011b). Four of these wells and are located in Brandywine Creek Watershed. Two wells are located at Riley Park, and two wells are located north of I-70 and east of Brandywine Creek at a stone quarry owned by Irving Materials, Inc. Water from these wells is pumped to the Water Filtration Plant located one block west of Riley Park on Main Street. The Greenfield Well Head Protection Plan available through Greenfield Water Utility depicts designated wellhead protection areas where subsurface water flows to the public water supply wells within a period of five years. The plan lists potential contaminant sources within the wellhead protection areas including commercial/industrial properties and agricultural fields.

Hancock County and City of Greenfield Stormwater Management Ordinances

Hancock County and City of Greenfield have developed a stormwater management ordinance under the NPDES program authorized by the Clean Water Act as well as Rule 5 and Rule 13 administered by IDEM. The current version of the Hancock County ordinance was developed in 2005, and the City of Greenfield ordinance was developed in 2006. Both ordinances were developed by Christopher B. Burke Engineering. The ordinances regulate the following:

- Discharges of non-stormwater flows into a Greenfield MS4 conveyance or other waterbody excluding certain exemptions
- Stormwater drainage improvements related to development of land
- Drainage control systems and erosion control systems installed during new construction and grading of land
- Design, construction, and maintenance of stormwater drainage and stormwater quality facilities and systems
- Land-disturbing activities affecting wetlands in Greenfield

The ordinances specify that private property owners have an obligation to keep and maintain waterways passing though their property free of trash, debris, excessive vegetation, and other obstacles that would pollute or significantly slow the flow of water.

Rule 5 requires entities conducting land development activities to prepare and submit a Stormwater Pollution Prevention Plan (SWPPP) to the Hancock County Drainage Board, County Surveyor, or County Engineer when the development activity disturbs 1 acre or more in the County. A SWPPP is to be submitted to the City of Greenfield whenever 1 acre or more of land is disturbed within city limits. Rule 5 is strictly enforced through routine inspections in Hancock County and Greenfield by the entity reviewing the SWPPP. There are currently no known areas of unmanaged construction or sprawl within Brandywine Creek Watershed.

Hancock County Comprehensive Plan

The Hancock County Comprehensive Plan was adopted by the Hancock County Board of Commissioners in 2005 (Hancock County Area Plan Commission, 2005). Due to its close proximity to Indianapolis, significant growth has occurred in Hancock County in recent years. Based on growth rates at the time the Comprehensive Plan was developed, projections were made for additional residential land needs in Hancock County townships through 2014. The townships expected to need the greatest number of new dwelling units were Buck Creek and Vernon Townships located on the western edge of the county and west of Brandywine Creek Watershed. A portion of Brandywine Creek Watershed overlaps with six of nine Hancock County townships including Brown, Jackson, Green, Center, Blue River, and Brandywine Creek Townships. Greenfield is located in Center Township. Combined anticipated growth for all six of these townships is approximately 12% of the overall county projected growth through the year 2014, or 1,089 new dwellings out of a projected 9,040 new dwellings county wide. While residential development pressure will influence water quality in Brandywine Creek Watershed in the future, the residential development projections listed in the Comprehensive Plan indicate that the greatest threats to water quality resulting from residential development will be concentrated in watersheds west of Brandywine Creek.

Based on the county future land use plan map, the projected number of years until residential development is built out based on housing densities varying from 2.5 to 3.5 units per acre are following: Brown Township 640 years; Jackson Township 89 years; Center Township 336 years; and Brandywine Township 107 years.

The Hancock County Comprehensive Plan acknowledges that drainage is a significant concern in the county and lists an action step to make educational material available that provides information on BMPs for drainageways and proper techniques for keeping channels clear. The plan mentions the importance of protecting floodways and floodplains from development impacts, promoting the protection of wetlands, and supporting wellhead protection practices. Action steps listed to help address these goals include creating an inventory of significant environmental features, developing standards that create buffers around streams to be incorporated into the zoning ordinance, and implementing educational measures that promote the use of erosion control practices on development sites. Implementation of buffer requirements adjacent to streams as part of the zoning ordinance could have positive water quality implications for Brandywine Creek as development pressure increases in the future. At this time, there has been no action taken to implement such an amendment to the zoning ordinance. The county does have a GIS map that shows locations of lakes, streams, and NWI wetlands. Most of the Brandywine Creek corridor and floodplain is designated as Conservation on the county’s Future Land Use Map (Appendix D). Watershed stakeholders have expressed concern that the Conservation designation in the Comprehensive Plan is not taken into serious consideration when new development plans are presented in or near the designated conservation zones.

Fairland Exit Small Area Plan

I-74 crosses Brandywine Creek northeast of Fairland in Shelby County. I-74 Exit 109, known as the Fairland Exit, is located approximately 0.8 kilometer (0.5 mile) southeast of Brandywine Creek. Indiana Downs Horse Track and Live Casino as well as an airport, industrial area, commercial area, and National Guard property are located at this exit. The City of Shelbyville, Indiana has developed the Fairland Exit Small Area Plan as an amendment to the city's Comprehensive Plan (2008). The Fairland Exit Small Area Plan amendment was developed to guide planning activities for emerging development in this location. Indiana Downs Horse Track is located within the 100-year floodplain of Brandywine Creek. The City of Shelbyville seeks to discourage further development within the floodplain to the north and west of the horse track as well as areas within the floodplain south of I-74. Restricting development within the floodplain will help prevent future economic losses due to flooding as well as help safeguard water quality.

A portion of the land area near Exit 109 has been designated as suitable for industrial or distributional facilities. Industrial development will undoubtedly have a negative impact on water quality in Brandywine Creek; however, due to the geographic location of this area, it is desirable for development. The Fairland Exit Small Area Plan suggests a preference that this area becomes a sustainable industrial park through the incorporation of stormwater management practices such as green roofs, rain gardens, and bioswales. Implementing low impact development is the best way to safeguard water quality during and after the development process.

Shelbyville MS4: Storm Water Quality Management Plan

City of Shelbyville MS4 includes all land within City of Shelbyville incorporated limits (D. Byers, personal communication, September 20, 2011). This includes a small area north of I-74 and adjacent to the Fairland Exit that is not contiguous with the core of the City (Figure 14). City of Shelbyville adopted a Stormwater Erosion and Sediment Control Ordinance on October 18, 2004. The ordinance allows for the city to review SWPPPs for properties being developed, conduct site inspections, and take enforcement action. The City of Shelbyville published its Storm Water Quality Management Plan in January, 2005. In addition to regulating developing areas, other MS4 minimum control measures required by the City as discussed in the Storm Water Quality Management Plan include developing a public education and outreach program as well as a public participation program, illicit discharge detection and elimination, post-construction site stormwater runoff control measures, and pollution prevention by municipal operations.

Shelby County Comprehensive Plan

The most current Shelby County Comprehensive Plan was adopted in 2006 and recognizes the value and importance of preserving and enhancing water quality. It lists numerous objectives relating to water quality including: maintaining floodways and floodplains as natural spaces; promoting the protection of wetlands; eliminating failing septic systems; developing a drinking water wellhead protection program; promoting stormwater management including implementation of BMPs; adopting development standards for buffers to protect natural drainage and habitat of rivers and streams; preserving and enhancing existing riparian areas; enforcing erosion control measures; and promoting community awareness of water related issues. The plan also suggests creating an inventory of environmentally sensitive areas including water resources to use as a guide for new development and preservation as well as developing ordinances that give credit to developers for preserving natural resources and implementing progressive stormwater management techniques (Shelby County Plan Commission, 2006). If implemented especially where development is likely to occur around Fairland, these objectives would certainly have a positive effect on water quality.

The Comprehensive Plan includes a Future Land Use Map in which the entire Brandywine Creek corridor and floodplain with the exception of an area already developed near I-74 is encompassed by the Parks, Open Space, and Conservation land use designation (Appendix E).

The plan also contains a map that depicts proposed sewer district service expansion areas (Figure 14). The proposed Morristown sewer service area overlaps with Brandywine Creek Watershed. Morristown sewer service currently terminates on US 52 approximately 0.25 kilometer (0.15 mile) east of the Brandywine Creek Watershed boundary. Morristown sewer services will likely continue expanding westward along US 52 and serve Fountaintown on the west side of Brandywine Creek Watershed as funds become available (C. Osborne, personal communication, August 17, 2011). A sewer district that would encompass Brandywine Creek Township, Moral Township, and Sugar Creek Township is in the preliminary stages of being formed under the direction of the Town of Fairland Board. This sewer district will provide sewer service to Fairland in the future, and will connect to current sewer lines currently present near the I-74. However, an estimated timeline for sewer service installation in Fairland has not yet been identified (R. Daily, personal communication, August 22, 2011). Municipal sewer infrastructure and service made available in Fairland and Fountaintown will reduce nutrient and pathogen loading currently occurring in the lower portion of Brandywine Creek Watershed.

Greening the Crossroads

In 2009, Central Indiana Land Trust in cooperation with The Conservation Fund produced a report titled *Greening the Crossroads: A Green Infrastructure Vision for Central Indiana*. The report is based on an initiative to involve citizens in a nine county region of central Indiana in green infrastructure planning including protecting and connecting natural areas within the region in the future. Among many goals, the Greening the Crossroads vision seeks to address water quality issues by:

- Guiding development away from floodplains
- Focusing restoration of vegetated buffers along key rivers and streams
- Guiding the use of BMPs to improve water quality
- Promoting the upgrade of traditional ditches to two-stage ditches
- Promoting no-till farming

GIS was used as part of the Greening the Crossroads study to identify forests, wetlands, and aquatic systems, which were in turn used to identify core areas within the green infrastructure network. Core areas were defined as areas that provide essential habitat for sensitive wildlife. Compatible land cover types were added to core areas to form a hub around core areas. Hubs are the least fragmented contiguous areas of native landscape including forest, wetlands, and streams. Hubs should ideally be connected by corridors in order to create ecologically beneficial network of green infrastructure. Corridors are pathways that for animal movement and plant migration throughout a region and may provide human recreation opportunities as well. Figure 15 depicts the green infrastructure mapped in Brandywine Creek Watershed as part of this study. The Greening the Crossroads report specifically recommends that areas adjacent to Brandywine Creek be given high consideration when planning for future parks and greenspace. Parks adjacent to the creek can provide outdoor recreational opportunities while simultaneously helping to protect aquatic resources in the watershed.

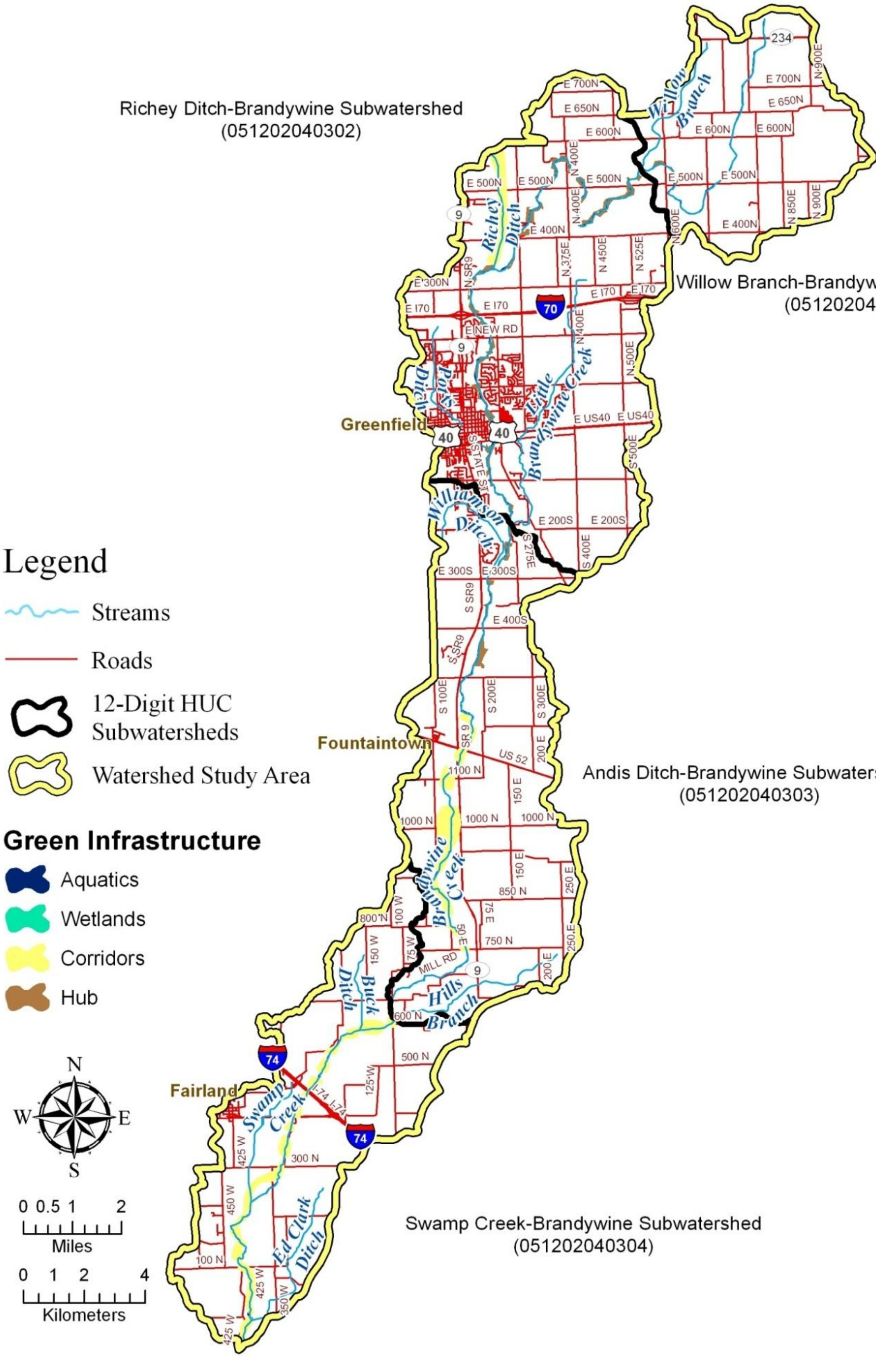

Figure 15. Greening the Crossroads Map

Endangered, Threatened, and Rare Species

It is important to note the presence of endangered, threatened, and rare (ETR) species in a watershed so as to have an understanding of how watershed management activities may influence these species. The IDNR Division of Nature Preserves manages the Indiana Natural Heritage Data Center that compiles information on the presence of ETR species, high-quality natural communities, and natural areas throughout the state. These data are a collection of observations from many individuals and not the result of comprehensive field surveys. A list of ETR species for all of Hancock and Shelby Counties from the Indiana Natural Heritage Data Center can be found in Appendix F. Table 5 lists the ETR species that have specifically been documented in Brandywine Creek Watershed (R. Hellmich, personal communication, October 12, 2010).

Table 5. Endangered, Threatened, and Rare Species

Common Name	Scientific Name	Federal Status	State Status	Date Observed	Observation Comments
Insect					
turquoise bluet	*Enallagma divagans*		rare	2004	
Mollusks					
little spectaclecase	*Villosa lienosa*		special concern	10-06-2008	live in Brandywine Creek and Little Brandywine Creek
purple lilliput	*Toxolasma lividus*		special concern	10-06-2008, 08-27-2008	weathered shells in Brandywine Creek
rabbitsfoot	*Quadrula cylindrica*	candidate species	endangered	1991	weathered shells in Brandywine Creek
kidneyshell	*Ptchobranchus fasciolaris*		special concern	08-27-2008	live in Brandywine Creek
clubshell	*Pleurobema clava*	endangered	endangered	08-27-2008	weathered dead in Brandywine Creek
wavyrayed lampmussel	*Lampsilis fasciola*		special concern	08-27-2008, 10-16-2008	live and fresh dead in Brandywine Creek
Birds					
great blue heron	*Ardea herodias*		status monitored	04-23-1990, 1993	Pendleton Colony, Willow Branch Colony
Mammals					
American badger	*Taxidea taxus*		special concern	04-25-1988, 05-02-1988	
High-Quality Natural Communities					
Hawk Woods Nature Preserve	Central till plain flat woods		significant	05-18-1982	

The turquoise bluet (*Enallagma divagans*) is listed as a rare damselfly in Indiana. It was recorded in Brandywine Creek Watershed in 2004. Turquoise bluet nymphs have been found in habitat types that include glacial lakes and pools as well as small swift streams, especially those that are spring-fed. The nymphs are often found clinging to debris and vegetation (Huggins, 1978).

In addition to providing habitat for the turquoise bluet, Brandywine Creek Watershed streams also provide habitat for three different Indiana freshwater mussel special concern species that have been recently identified to live in Brandywine Creek. These species include the little spectaclecase (*Villosa lienosa*), the kidneyshell (*Ptchobranchus fasciolaris*), and the wavyrayed lampmussel (*Lampsilis fasciola*). The purple lilliput (*Toxolasma lividus*) is another mussel special concern species that was recently identified in Brandywine Creek from a weathered shell. Habitat for all these species is gravel in medium streams to large rivers (Cummings and Mayer, 1992).

The clubshell mussel (*Pleurobema clava*), which is listed as federal and state endangered, was last identified as a weathered dead shell in Brandywine Creek in 2008. The rabbitsfoot mussel (*Quadrula cylindrica*), which is listed as a federally endangered candidate species and Indiana endangered species, was last identified in Brandywine Creek in 1991 as a weathered dead shell. Typical habitat for both mussel species includes gravel and mixed gravel, and sand substrate in medium to large rivers (Cummings and Mayer, 1992). Both species are believed to be extirpated from the watershed (B. Fisher, personal communication, March 3, 2011).

Watershed Inventory – Part 1: Relevant Relationships

Many watershed characteristics in Brandywine Creek Watershed are intertwined and cooperatively influence water quality. The location of soil types and corresponding land uses can play an especially significant role in quantities and types of pollutants reaching streams.

Approximately 17% of watershed soils are highly erodible. A significant portion of these highly erodible soils are adjacent to Brandywine Creek. An analysis of a land use map shows that a substantial portion of highly erodible soils adjacent to Brandywine Creek are cultivated cropland. Continual disturbance of highly erodible soils very near Brandywine Creek and its tributaries increases the probability of high sediment and nutrient loads entering surface waters.

Analysis of the floodplain map in conjunction with the soils and land use maps shows that most soils in the Brandywine Creek floodplain are hydric and that a significant portion of the floodplain is also cultivated cropland. The presence of hydric soils suggests these areas were once wetlands and are likely heavily tiled. Nitrogen applied as fertilizer on fields is often transported to streams through tile systems.

Soils data also indicate that nearly all of Brandywine Creek Watershed soils are very limited for septic system suitability. Sanitary sewer service is limited to Greenfield city limits and a small area around I-74. Local planning efforts to increase sewer service in the watershed will benefit water quality in the future. However, failing septic systems will continually contaminate watershed surface waters in the watershed until sewer service availability substantially increases.

Sensitive aquatic ecosystems such as wetlands and lakes may be especially susceptible to negative impacts when they are located in close proximity to developed areas. Multiple lakes and wetlands are located near Greenfield.

There are numerous local plans that acknowledge water quality influences including the Greenfield Comprehensive Plan, Greenfield MS4: Stormwater Quality Management Plan, Greenfield Wellhead Protection Plan, Hancock County Stormwater Management Ordinance, Greenfield Stormwater Management Ordinance, Hancock County Comprehensive Plan, Fairland Exit Small Area Plan, Shelbyville MS4: Stormwater Quality Management Plan, Shelby County Comprehensive Plan, and Greening the Crossroads. In addition, there are multiple sewer districts that have the capacity to further influence water quality.

Lastly, nearly all of the ETR species that have been documented in Brandywine Creek Watershed depend on high-quality aquatic habitat for all or a significant part of their life cycle. Pollution in Brandywine Creek and its tributaries has likely contributed to habitat degradation and negatively influenced the viability of these species of concern including possible extirpation of some endangered species from the watershed. Live specimens of several species of special concern have been recently documented indicating that habitat conditions have not been completely degraded and emphasizing the importance of maintaining and improving current conditions.

Watershed Inventory –
Part 2: Data and Subwatershed Discussions

This section summarizes water quality data that were collected as part of the *Watershed Management Plan* development process. It also includes other water quality data and influencing factors collected by various organizations from as early as 1967. Factors influencing water quality in the watershed observed via windshield and desktop surveys as part of the *Watershed Management Plan* development process as well as through regulated land use activities are also discussed. Data are first presented and discussed for the entire Brandywine Creek Watershed as a whole. Data analysis relevant to12-digit HUC subwatersheds ensues.

LARE WMP Field Data

A total of 14 sample sites were established within the watershed and one reference site (Site R) was selected on Sugar Creek as part of this study by IDNR LARE staff, Hancock County SWCD staff, and Davey staff during a field visit on July 29, 2011 (Figure 16). Table 6 includes information for each sample site location. A photograph of each sample site and the reference site is located in Appendix G.

Sample site locations were selected so as to be able to collect samples at the downstream most accessible point on tributaries to Brandywine Creek as well as periodically along the length of Brandywine Creek itself. The reference site was selected north of CR 200 South on Sugar Creek in Hancock County. Water quality data collected at this site and available in the Sugar Creek WMP reflect best known conditions in the region. Ideally, conditions at reference sites should closely resemble regional stream conditions if no significant impacts occurred. The central Indiana landscape has been significantly altered from pre-settlement conditions and nearly all streams in the region have suffered significant impacts.

Data were collected at each sample site location relating to the physical and chemical properties of surface water in Brandywine Creek Watershed. Water quality parameters evaluated included temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, orthophosphate phosphorus, ammonia, nitrate + nitrite, total Kjeldahl nitrogen, total suspended solids, turbidity, discharge, *E. coli*, macroinvertebrate communities, and habitat data (Photograph 4).

Photograph 4 (04-05-11). A Davey Resource Group field technician collecting flow velocity and depth measurements to determine stream discharge.

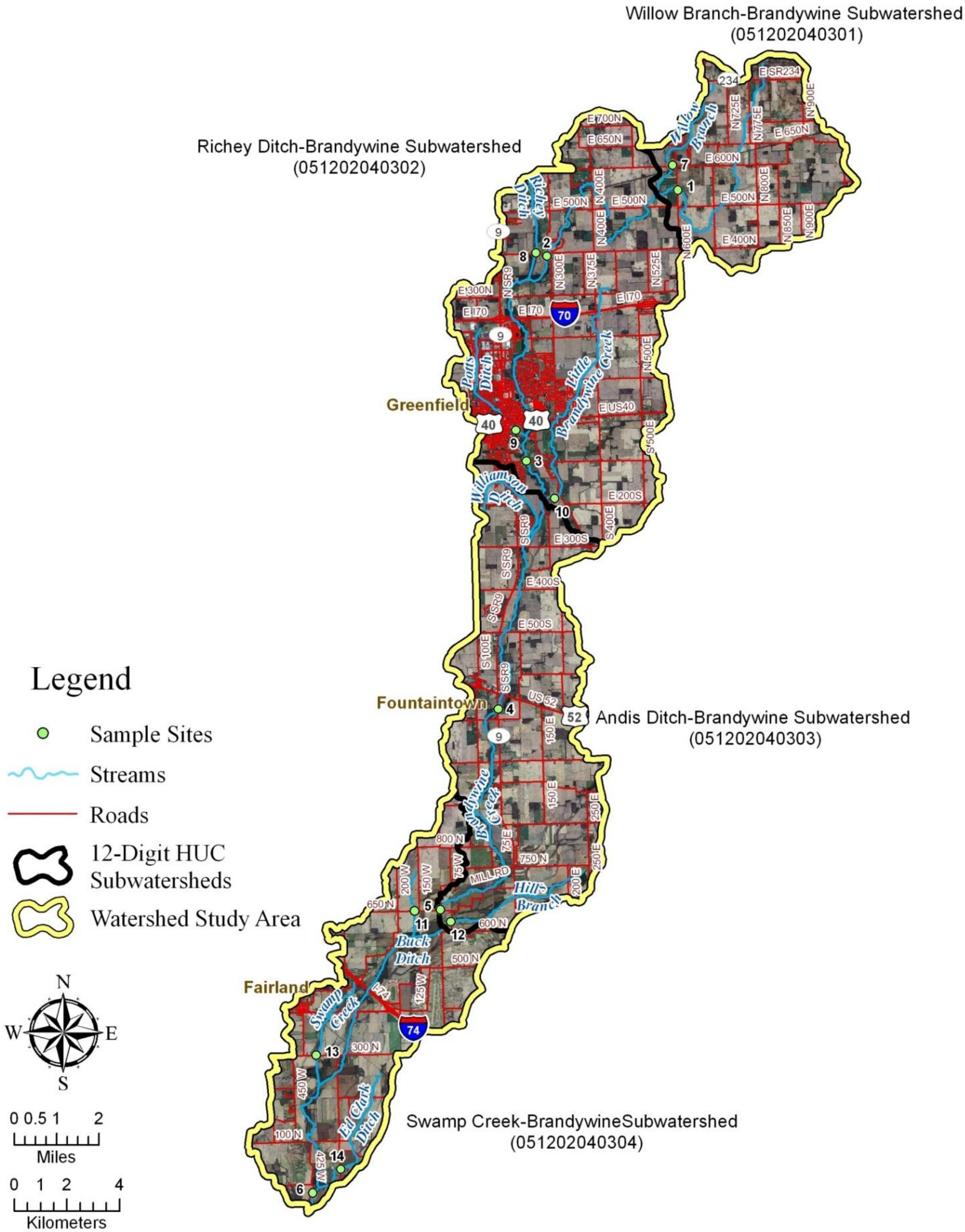

Figure 16. Sample Site Location Map

Table 6. Sample Site Location Information

Sample Site	Waterbody Name	Road Crossing	Coordinates	
			Latitude	Longitude
1	Brandywine Creek	CR 600 East (Hancock County)	39.864525	-85.690049
2	Brandywine Creek	CR 400 North (Hancock County)	39.842507	-85.748750
3	Brandywine Creek	CR 100 South (Hancock County)	39.772203	-85.759327
4	Brandywine Creek	SR 9 (Shelby County)	39.687178	-85.773490
5	Brandywine Creek	CR 650 North (Shelby County)	39.618685	-85.800296
6	Brandywine Creek	CR 425 West (Shelby County)	39.521971	-85.858661
7	Willow Branch	CR 600 North (Hancock County)	39.873081	-85.692239
8	Richey Ditch	CR 400 North (Hancock County)	39.843659	-85.753676
9	Potts Ditch	Osage Street (Greenfield)	39.782905	-85.763759
10	Little Brandywine Creek	Steele Ford Road (Hancock County)	39.759215	-85.746886
11	Buck Ditch	CR 650 North (Shelby County)	39.618344	-85.811769
12	Hills Branch	CR 75 West (Shelby County)	39.614487	-85.795953
13	Swamp Creek	CR 300 North (Shelby County)	39.569252	-85.856339
14	Ed Clark Ditch	CR 350 West (Shelby County)	39.529996	-85.845987
R	Sugar Creek	CR 200 South (Hancock County	39.758389	-85.870233

Physical and Chemical Water Quality Data

Davey biologists collected base flow samples on January 10, 12, and 13, 2011. No rain events occurred within the watershed in the three days prior to base flow sampling on January 10. A few snow flurries occurred within the watershed during the time base flow samples were collected. Davey collected storm flow samples on April 5, 2011. A rain storm occurred the previous evening and night. A total of 6.35 centimeters (2.85 inches) of rain was recorded in Greenfield (Community Collaborative Rain, Hail and Snow Network, 2011).

All samples were collected upstream of road crossings to avoid potential data interference by the road crossing structure with the exception of Sites 2 and 12 where data were collected downstream of the bridge due to accessibility issues or a structure impounding water upstream of the bridge. Measurement of pH, temperature, conductivity, dissolved oxygen, and discharge were conducted in the field by Davey staff. Data from analyses conducted in the field can be found in Appendix H. Total phosphorus, ammonia nitrogen, nitrate+nitrite nitrogen, total Kjeldahl nitrogen, total suspended solids, and turbidity were analyzed by ESG Laboratories. ESG Laboratories report sheets can be found in Appendix I.

Samples analyzed by ESG Laboratories were collected in sterile containers containing preservatives and provided by the lab. All samples were placed in a cooler immediately after collection and transported to the lab in Indianapolis, Indiana for analysis no later than eight hours after collection.

Temperature

Water temperature affects the maximum amount of dissolved oxygen that water can hold. Dissolved oxygen is a necessary component for most aquatic life. Many aquatic organisms also require specific temperature ranges for proper metabolic function (IDNR, 2008). Temperature of a stream is influenced by the presence or absence of riparian vegetation, runoff from impervious surfaces, and direct wastewater discharge.

Indiana water quality standards include temperatures that streams shall not exceed based upon the month of sampling. Base flow samples collected in January shall not exceed 10.0 degrees Celsius (°C) (50.0 degrees Fahrenheit [°F]). Storm flow samples collected in April shall not exceed 22.8°C (73.0°F) (327 IAC 2-1-6[1]).

Water temperature measurements were conducted in the field using the temperature function on a YSI® EcoSense pH100 instrument. No samples collected as part of this study were in violation of the monthly standard (Figure 17).

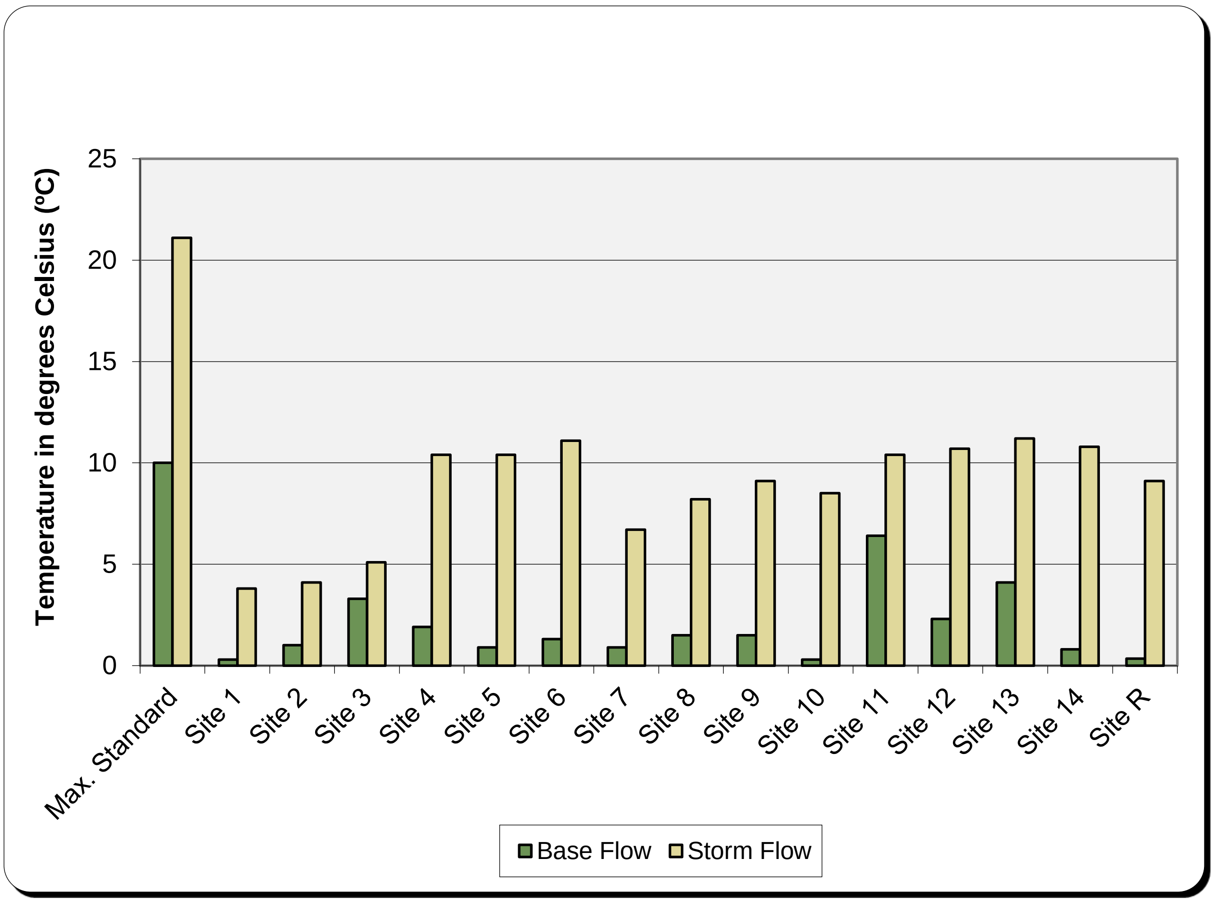

Figure 17. Temperature Values

[1] Indiana General Assembly. Indiana Administrative Code Database. Available online at <http://www.in.gov/legislative/iac/>. Accessed August 9, 2011.

pH

Determination of a pH value is a measure of the acidity or basicity of solution. Many aquatic organisms are sensitive to pH (IDNR, 2008). Indiana water quality standards for aquatic life specify that no pH values shall be below 6.0 or above 9.0 (327 IAC 2-1-6). Many factors influence pH including water temperature, algae blooms, acid rain input, watershed soils and geology, and runoff from mines.

A YSI® EcoSense pH100 instrument was used to collect pH readings in the field. No samples collected as part of this study were in violation of the standard (Figure 18).

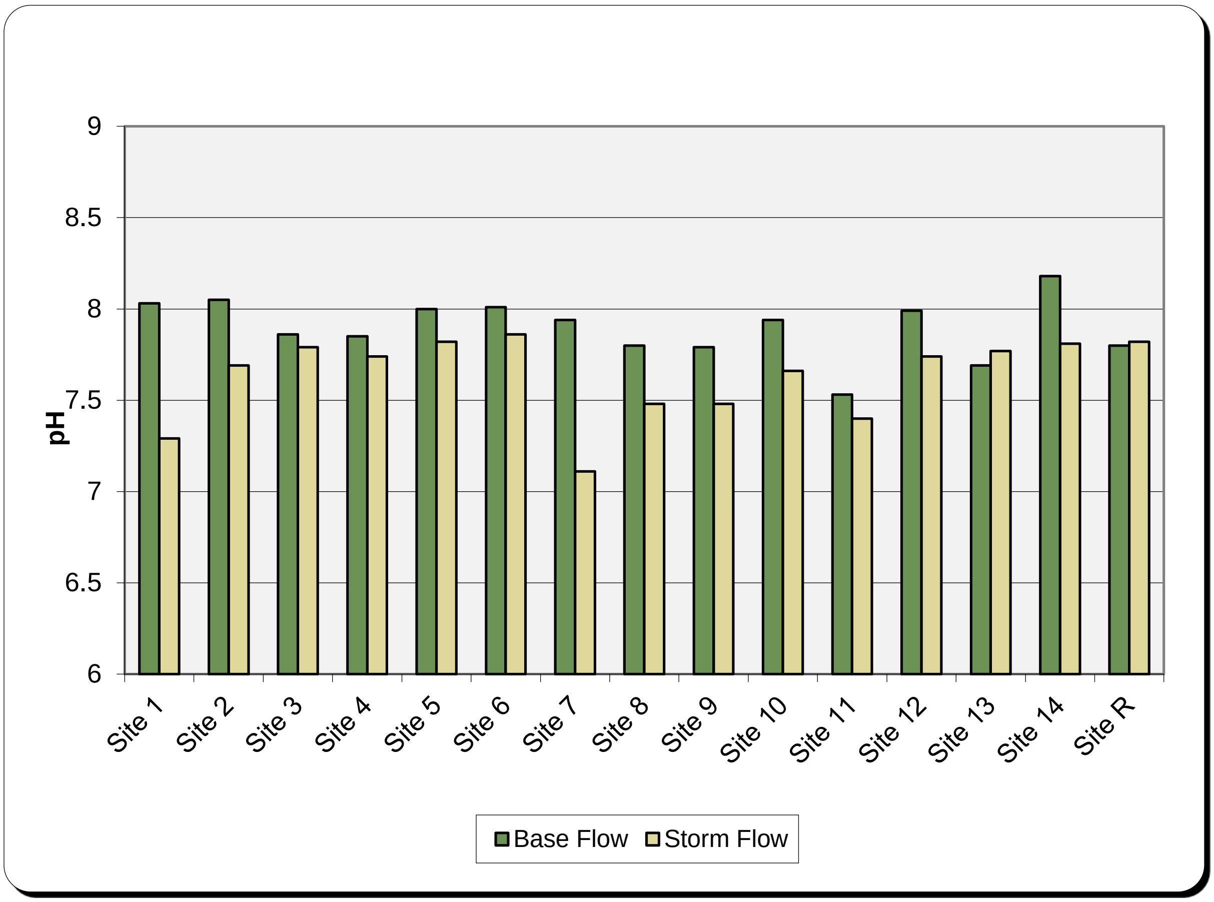

Figure 18. pH Values

Specific Conductivity

Indiana water quality standards regulate the concentration of dissolved solids for waters used as a public or industrial water supply. Specific conductivity may be used as a measurement to assess compliance with this standard. Specific conductivity measurements increase with ion concentration. Thus, specific conductivity is an indirect measure of dissolved solids including, but not limited to, chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron. Specific conductivity is influenced by watershed soils and geology, as well as runoff from mines, roads, and agricultural fields. Specific conductivity shall not exceed 1,200 microsiemens (µS) per centimeter at 25°C (327 IAC 2-1-6).

Specific conductivity was measured in the field using a YSI® EcoSense EC300 instrument that compensated measurements to 25°C. No samples collected as part of this study were in violation of the standard for waters used as a public or industrial water supply (Figure 19).

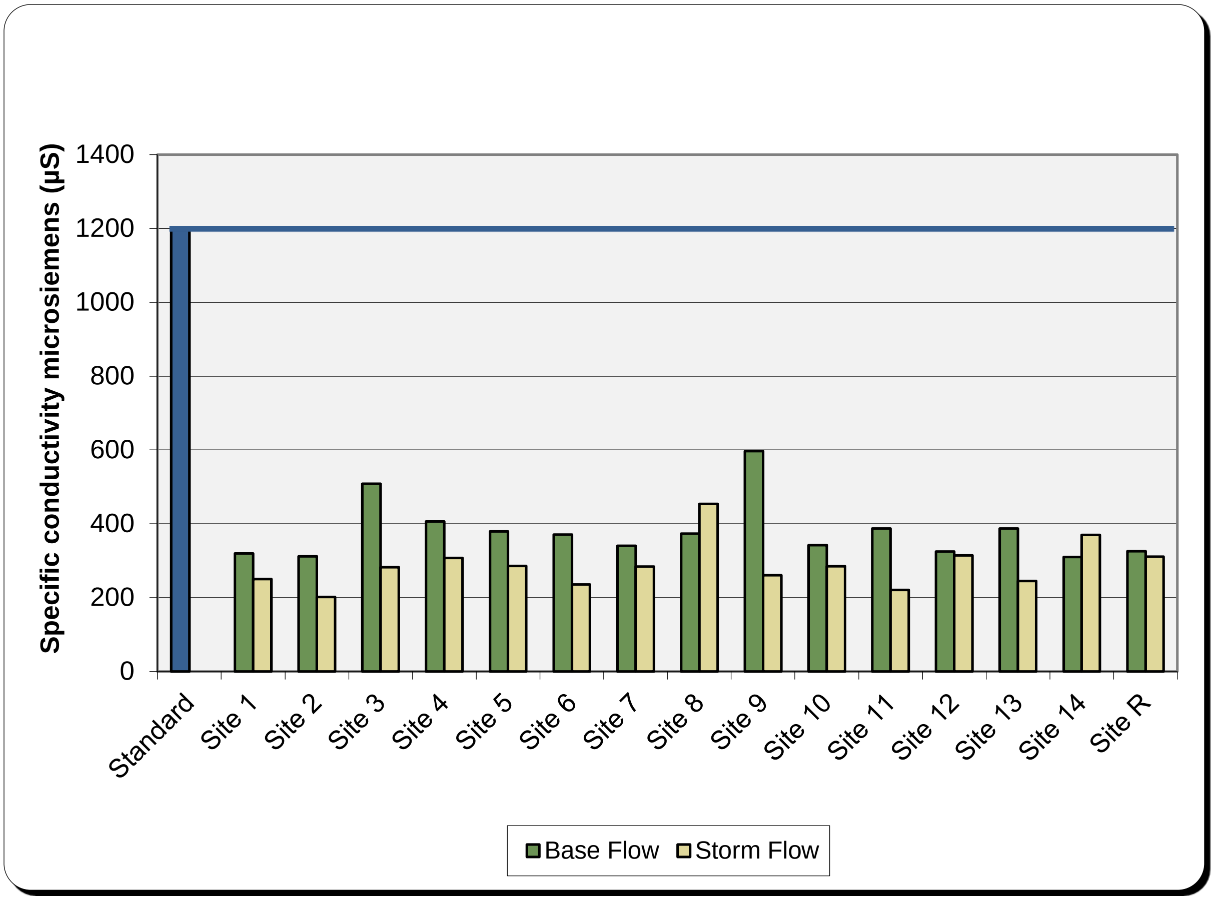

Figure 19. Specific Conductivity Values

Dissolved Oxygen

Most aquatic organisms require dissolved oxygen (DO) gas in the water for survival. Indiana water quality standards for aquatic life state that DO shall not be less than 4.0 milligrams per liter (mg/L) at any time and shall average at least 5.0 mg per calendar day (327 IAC 2-1-6). The Indiana average DO concentration is 9.8 mg/L (IDNR, 2008). DO is influenced by factors such as stream temperature and velocity, as well as by total suspended solids, nutrient, and organic waste concentrations.

DO measurements were collected in the field using a Milwaukee® SM600 Dissolved Oxygen Meter. No samples collected as part of this study were in violation of the standard, but all samples were less than the state average (Figure 20).

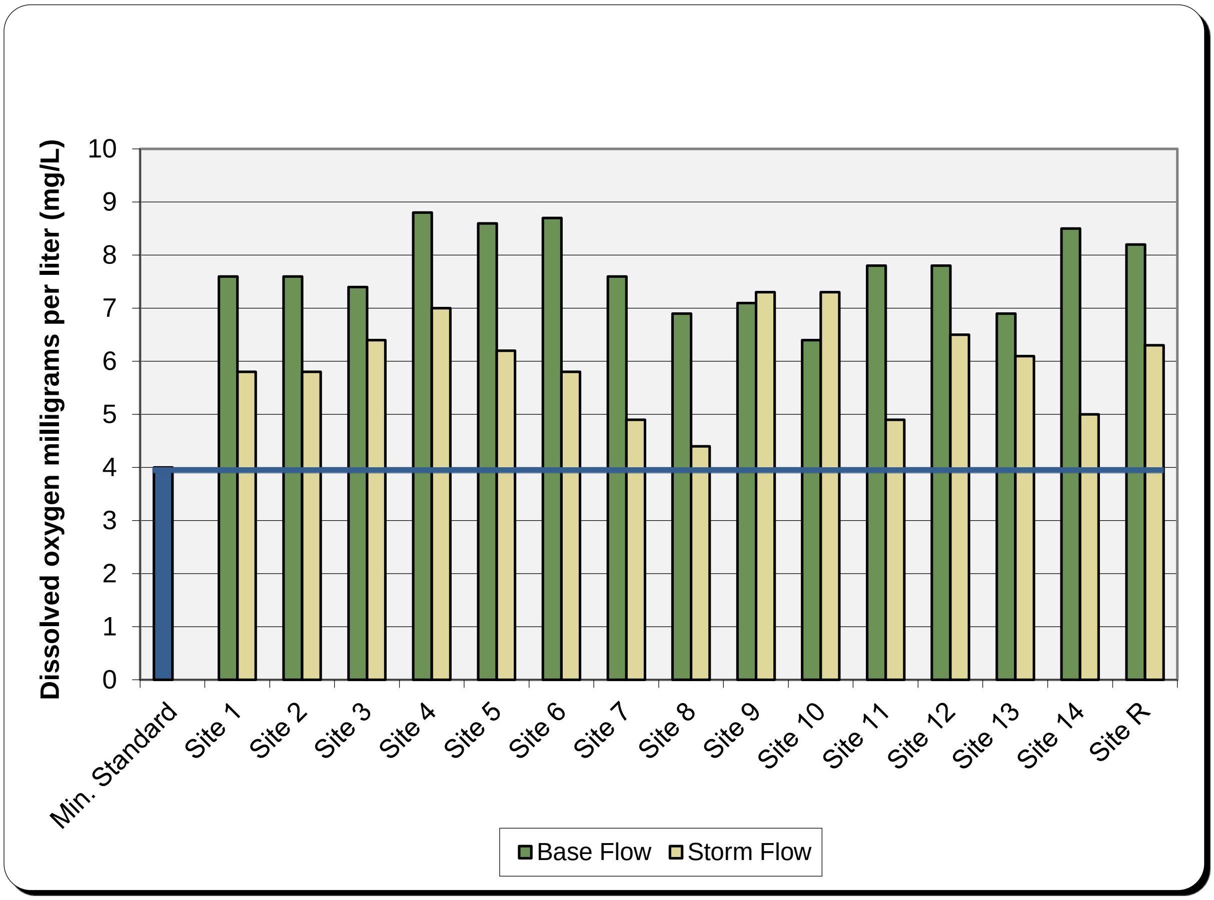

Figure 20. Dissolved Oxygen Concentrations

Total Phosphorous

Phosphorus is a naturally occurring nutrient in aquatic systems. Sources of additional phosphorus inputs include organic wastes such as human and animal wastes, fertilizers, detergents, and industrial wastes. Phosphorus is necessary for plant growth and is often the limiting growth factor in aquatic systems. Excessive amounts of phosphorus result in algae blooms and eutrophication. In an aquatic system, phosphorus cycles through different forms. Analysis of total phosphate levels indicates the potential for future algal blooms and eutrophication by indicating the amount of phosphate that can convert to orthophosphate and be utilized by plants.

There is not currently an Indiana water quality standard for total phosphorus. The average total phosphorus value for Indiana waterbodies is 0.05 mg/L (IDNR, 2008). A benchmark set by IDEM states that one or more measurements of total phosphorus greater than 0.3 mg/L coupled with another impairment on the same date allows the waterbody to be classified as impaired (IDEM, 2010c). Ohio Environmental Protection Agency (Ohio EPA) recommends a maximum total phosphorus concentration of 0.08 mg/L to protect aquatic biotic integrity in warm water habitat (IDEM, 2010e). The total phosphorus reference condition for United States Environmental Protection Agency (USEPA) Aggregate Ecoregion VI, Ecoregion 55 is 0.0625 mg/L that is based on median total phosphorus concentrations for the top 25th percentile of streams sampled (2000). The top 25th percentile consisted of streams with the lowest concentrations of total phosphorus.

Base flow samples collected at Sites 3–6, 9, and 12 exceeded both the state average and USEPA reference condition (Figure 21). All storm flow samples exceeded the state average and USEPA reference condition. The base flow sample collected at Site 3 and the storm flow samples collected at Sites 2–7, 9–10, and 12–13 exceeded the IDEM threshold to be classified as impaired if coupled with another impairment. A pronounced total phosphorus concentration spike was observed at Site 3 on the south side of Greenfield at the time of base flow sampling, and it became increasingly diluted at each downstream sampling point on Brandywine Creek (Sites 4–6). A large concentration spike was also observed at this site during the storm flow sampling event. Dye testing of car washes was conducted by Greenfield MS4 to ensure the spike was not due to illicit discharges. The Greenfield WWTP is the most likely source of the phosphorus causing the spike. The Greenfield WWTP is not required to monitor phosphorus as a condition of its NPDES permit.

ESG Laboratories used USEPA 365.2 methodology[2] for testing the samples.

[2] United States Environmental Protection Agency (USEPA), Office of Research and Development. 1983. *Methods for Chemical Analysis of Water and Wastes*. EPA/600/4-79/020. Washington, D.C. 491 pp.

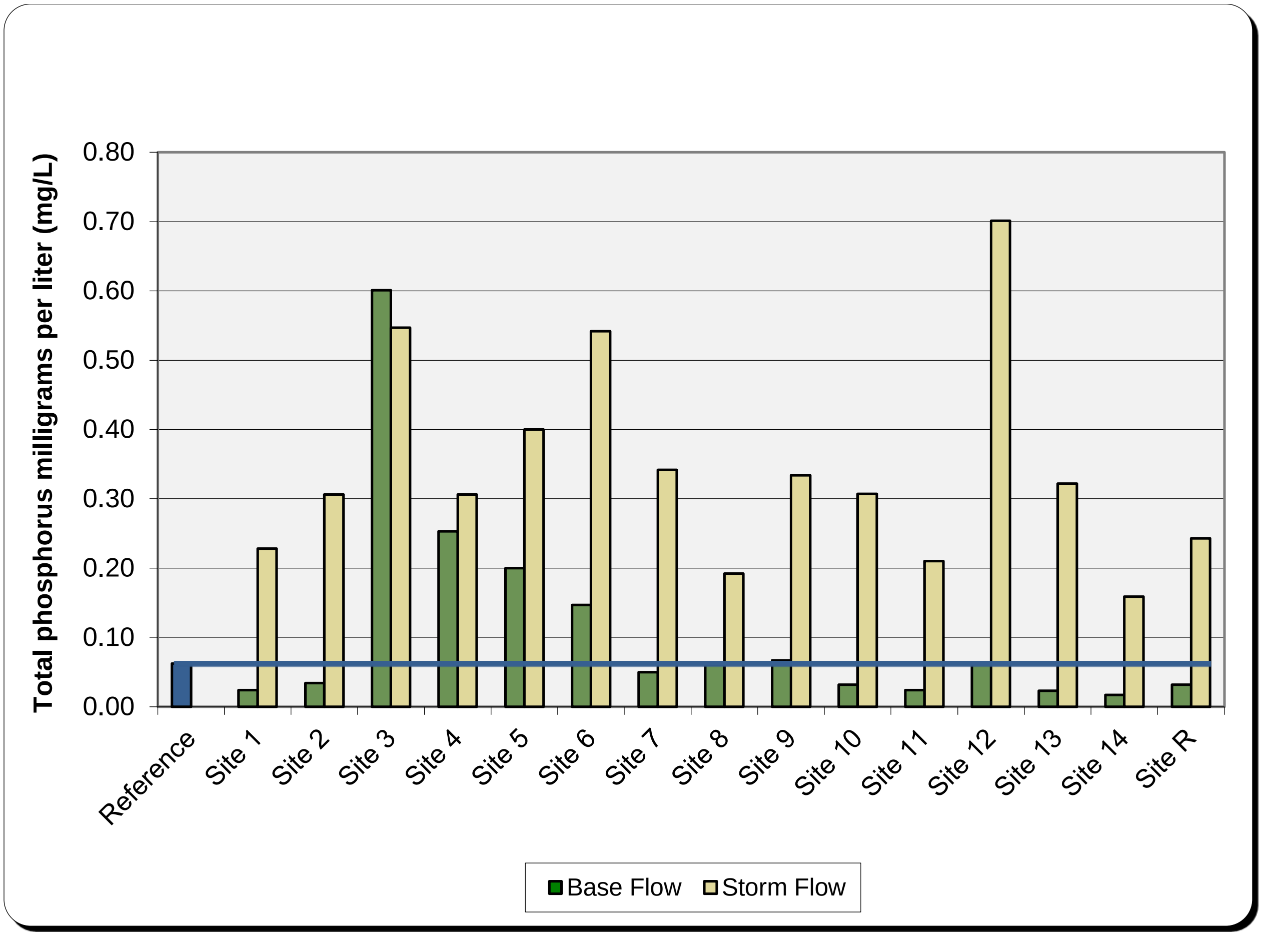

Figure 21. Total Phosphorus Concentrations

Orthophosphate Phosphorus

Orthophosphates are a form of phosphorus dissolved in water and immediately available for plant uptake. The orthophosphate level is an indicator of the current potential for algae blooms and eutrophication in a waterbody (IDNR, 2008). There is not a water quality standard for orthophosphate in Indiana at this time. The Wawasee Area Conservancy Foundation recommends a 0.005 mg/L maximum in lake systems (IDEM, 2010e). No samples were collected in lake systems as a part of this study, and Brandywine Creek does not drain directly to a lake system.

ESG Laboratories used USEPA 365.2 methodology for testing the samples. Orthophosphate concentrations reported on the laboratory data sheets have been divided by three to make the results comparable to reported total phosphate concentrations by compensating for difference in molecule weights (Figure 22). An average of 29% of the total phosphorus concentration was comprised of orthophosphate at the time base flow samples were collected in Brandywine Creek (Sites 1–6). The average percent of the total phosphorus concentration comprised of orthophosphate in tributaries to Brandywine Creek was 22%. Orthophosphate comprised only 16% of the total phosphorus concentration recorded at the reference site on Sugar Creek.

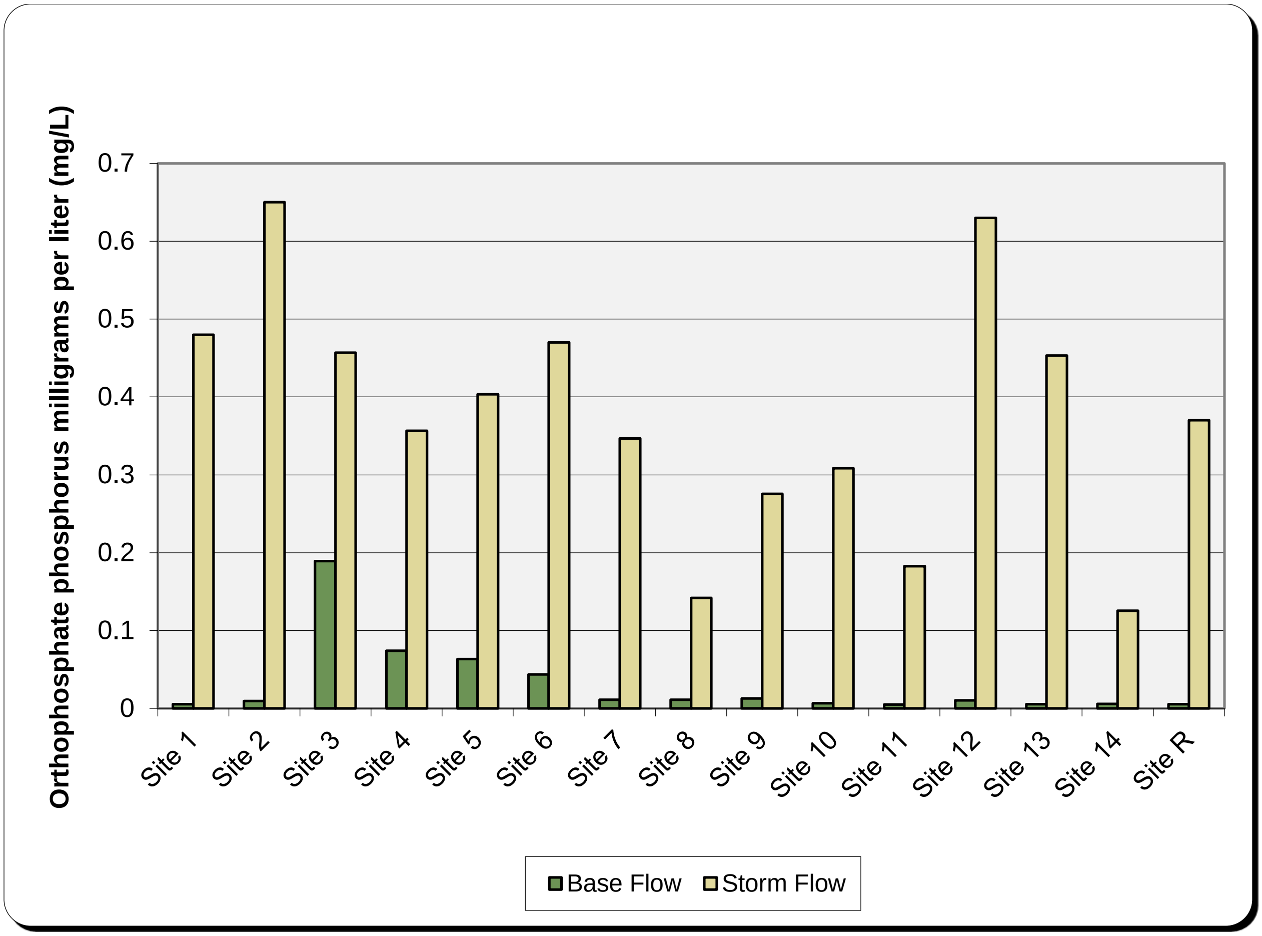

Figure 22. Orthophosphate Phosphorus Concentrations

Ammonia

Ammonia (NH_3) is a form of nitrogen soluble in water. Sources of ammonia found in water include decomposing organic matter, human and animal wastes, and fertilizers (IDNR, 2008). Ammonia is known to be toxic and/or carcinogenic, mutagenic, or teratogenic to aquatic organisms, humans, animals, and plants. Water quality standards for unionized ammonia concentrations are a function of water pH and temperature. As pH and temperature decrease, the standard becomes more stringent (327 IAC 2-1-6).

All sample sites exceeded ammonia-nitrogen concentration standards at the time of base flow and storm flow sampling (Figures 23 and 24). Ammonia-nitrogen concentrations during the storm flow sampling event were substantially higher than concentrations recorded during the base flow sampling event. The highest base flow concentrations were recorded on tributary Sites 7–9. The highest storm flow concentrations were recorded at Site 2 on Brandywine Creek as well as tributary Sites 7–9. Sites 2, 8, and 9 are located in the Richey Ditch Subwatershed. This subwatershed contains the highest overall percentage of cultivated cropland in Brandywine Creek Watershed as well as the largest percentage of urban development. ESG Laboratories used SM 4500-NH3 G methodology[3] for testing the samples.

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[3] Standard Methods Committee. 1997. *Standard Methods for the Examination of Water and Wastewater: 4500-NH3 Nitrogen (Ammonia)*. Available online at <www.standardmethods.org>. Accessed August 9, 2011.

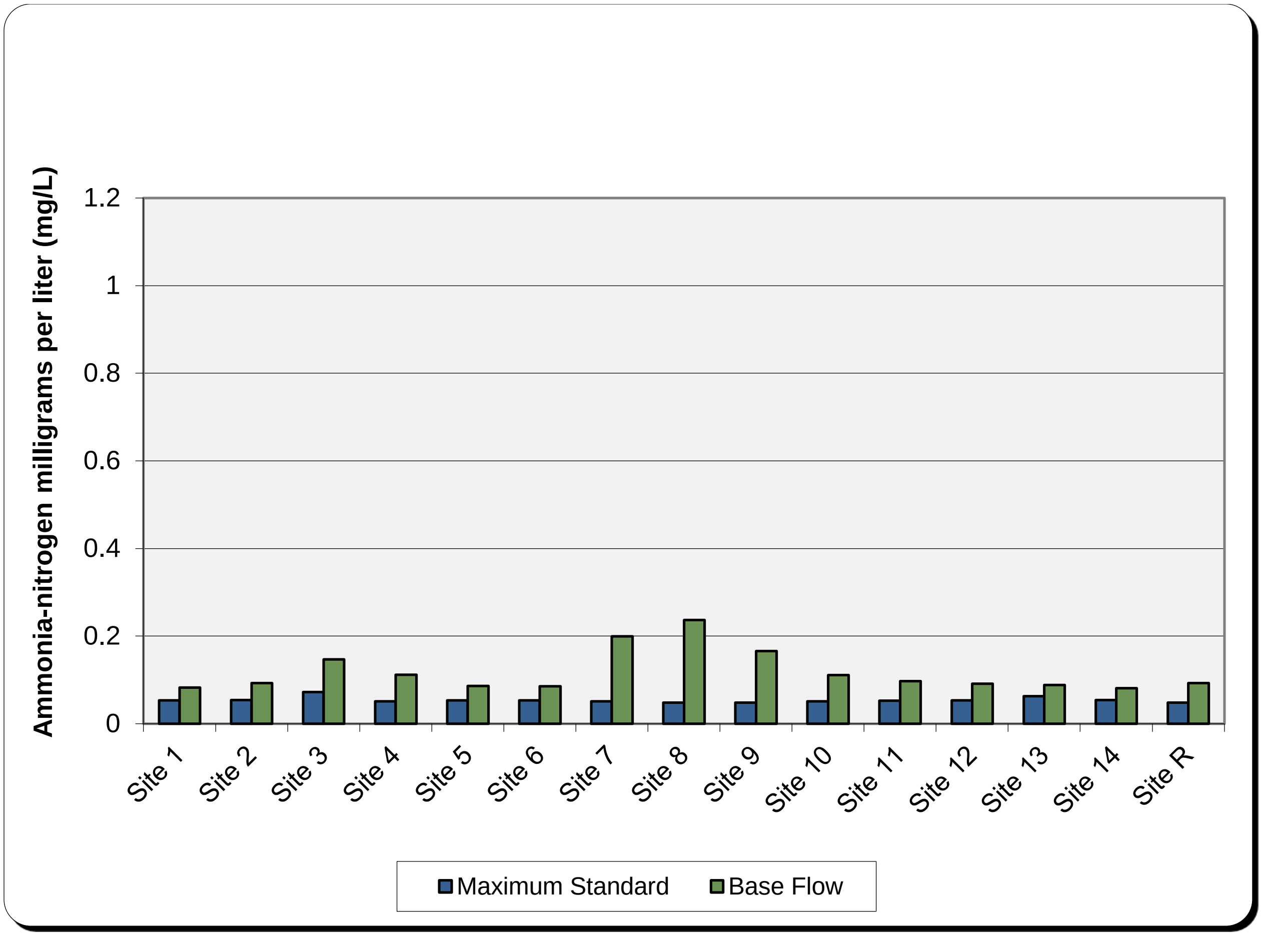

Figure 23. Base Flow Ammonia-Nitrogen Concentrations

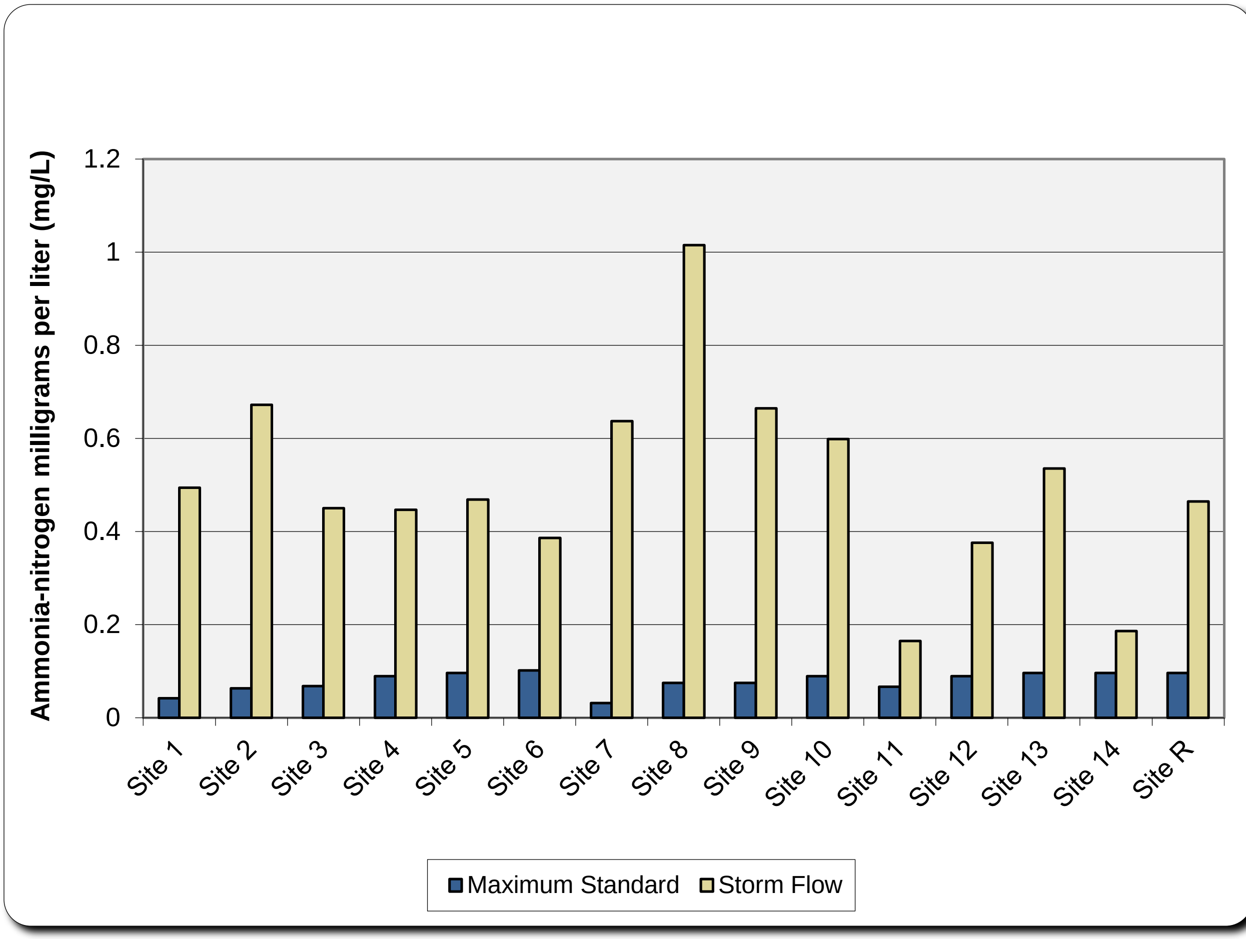

Figure 24. Storm Flow Ammonia-Nitrogen Concentrations

Nitrate+Nitrite

Nitrate (NO_3) and nitrite (NO_2) are oxidized inorganic forms of nitrogen that are readily converted between the two forms in nature. Common sources of excess nitrates are human and animal wastes and runoff containing lawn and agricultural fertilizers. Nitrates can lead to increased aquatic plant growth and eutrophication. Elevated levels of nitrates in drinking water can cause severe illness.

There is no current standard for nitrate+nitrite concentrations in surface water not used as a public water supply. Surface water in Brandywine Creek Watershed is not used as a public water supply. Indiana water quality standards state that nitrate+nitrite-nitrogen levels in surface water are not to exceed a 30-day average of 10 mg/L at a public water supply intake (327 IAC 2-1-6). The nitrate+nitrite reference condition for USEPA Aggregate Ecoregion VI, Ecoregion 55 is 1.60 mg/L and is based on median nitrate+nitrite concentrations for the top 25th percentile of streams sampled (2000). The top 25th percentile consisted of streams with the lowest concentrations of nitrate+nitrite.

Nitrate+nitrite concentrations at Sites 1–7, 10, 12, 14 and R were above reference conditions at the time of base flow sampling. The reference concentration was exceeded at all sites at the time of storm flow sampling (Figure 25). ESG Laboratories used EPA 353.3 methodology[4] for testing the samples.

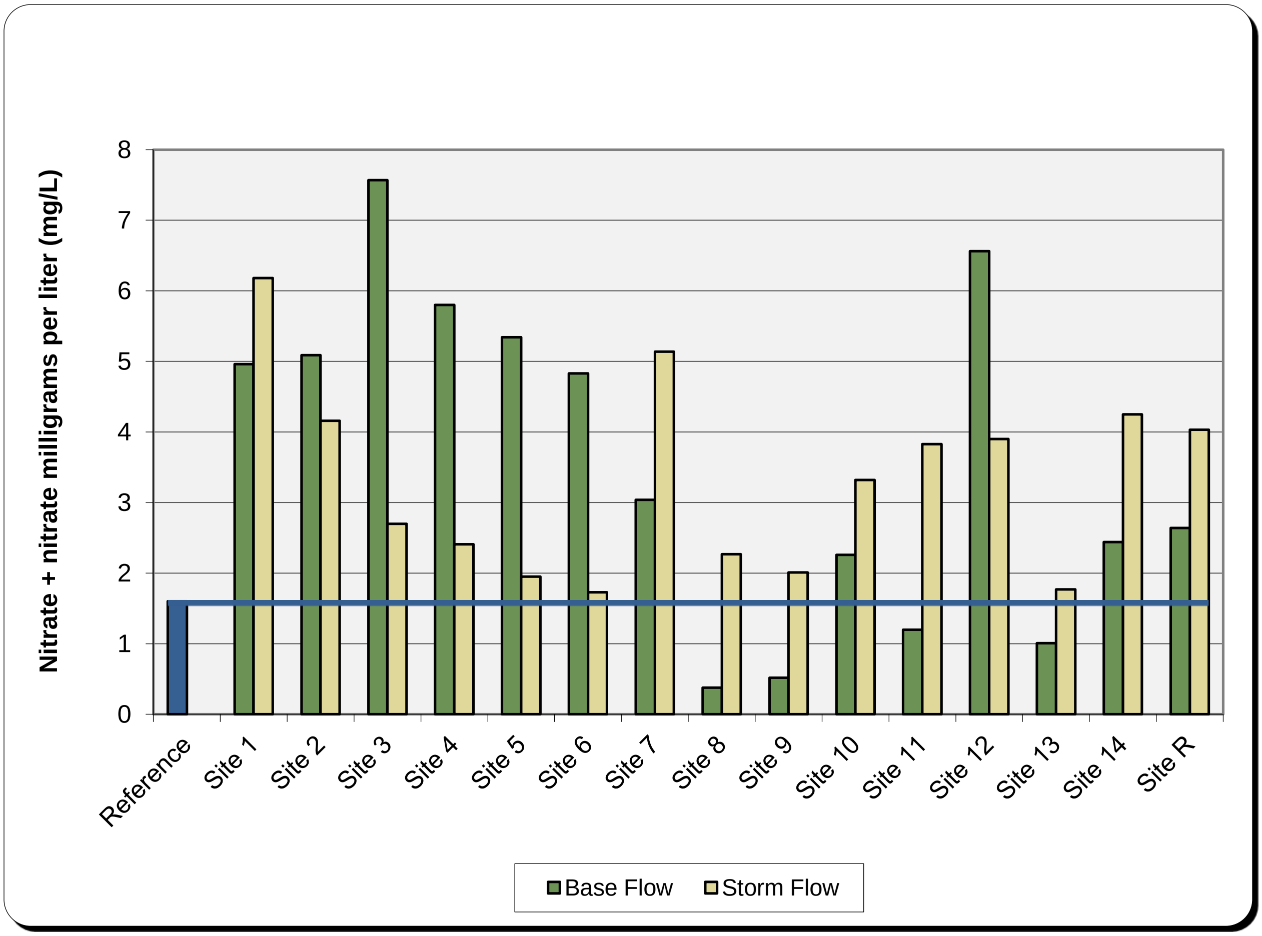

Figure 25. Nitrate+Nitrite Concentrations

Total Kjeldahl Nitrogen

Total Kjeldahl nitrogen (TKN) is the sum of all organic nitrogen and ammonia. Indiana does not have a water quality standard for TKN. The TKN reference condition for USEPA Aggregate Ecoregion VI, Ecoregion 55 is 0.4 mg/L and is based on median TKN concentrations for the top 25th percentile of streams sampled (2000). The top 25th percentile consisted of streams with the lowest concentrations of TKN.

All sample sites exceeded the reference condition at the time of base flow and storm flow sampling (Figure 26). ESG Laboratories used EPA 351.3 methodology[4] for testing the samples.

[4] United States Environmental Protection Agency (USEPA), Office of Research and Development. 1983. *Methods for Chemical Analysis of Water and Wastes*. EPA/600/4-79/020. Washington, D.C. 491 pp.

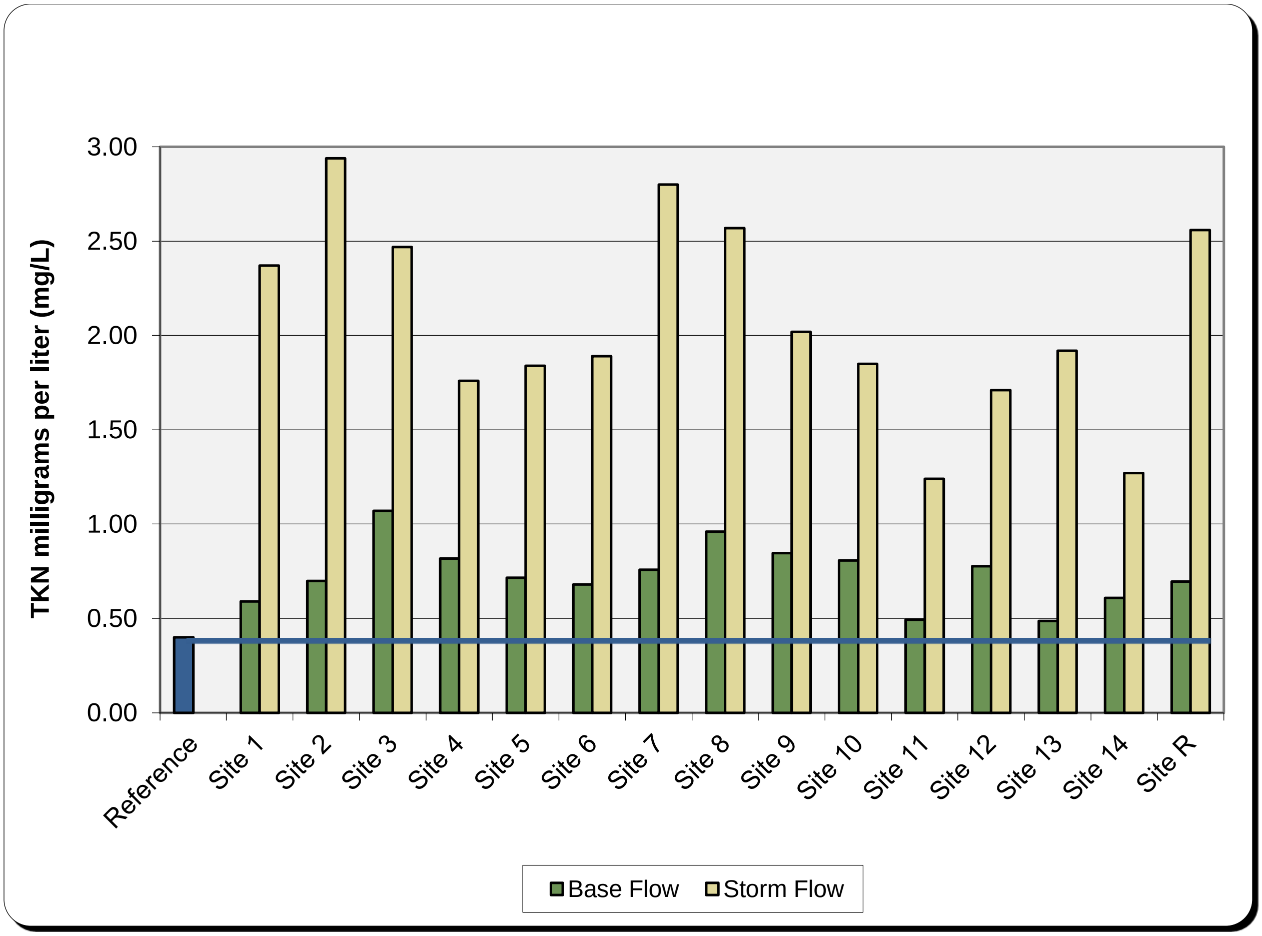

Figure 26. TKN Concentrations

<u>Total Suspended Solids</u>

The total suspended solids (TSS) measurement provides the weight of particulate material suspended in a water sample including sediment and other particles such as decaying organic matter. TSS concentrations are influenced by stream velocity. The higher the velocity, the larger and greater number of particles a stream can carry. Suspended particles absorb heat from the sun. A large quantity of suspended particles can result in elevated water temperatures and consequently lower levels of DO. Large quantities of suspended solids can also inhibit sunlight from reaching submerged plants and reduce photosynthesis resulting in less oxygen being released. As the velocity of water slows, TSS settle to the bottom of a stream where they can smother aquatic organisms. Solids suspended in the water column can originate from overland surface flow and streambank erosion. IDEM has established a maximum TSS concentration target of 30.0 mg/L; concentrations from 25.0-80.0 mg/L have been shown to reduce fish populations (IDEM, 2010e).

TSS concentrations were below the IDEM target value at all sites at the time of base flow sampling and above at all sites at the time of storm flow sampling (Figure 27). The highest recorded TSS value, which was greater than four times the target value, was at Site 3 on Brandywine Creek on the downstream side of Greenfield. Base flow concentrations at Sites 7 and 14 were below the detectable lab limit.

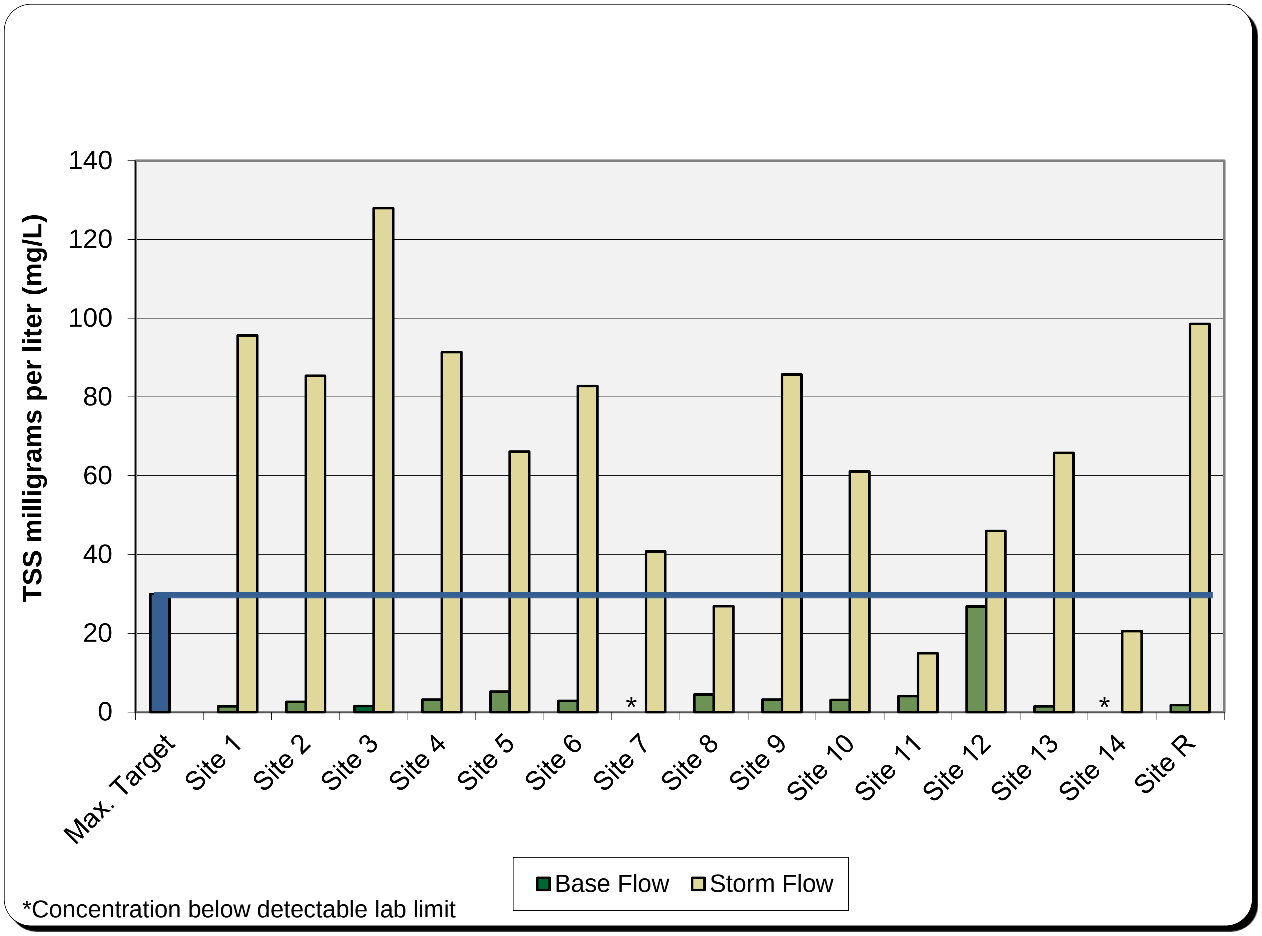

Figure 27. TSS Concentrations

Turbidity

Turbidity is a measure of water clarity. Suspended solids in the water column scatter and absorb light reducing the clarity of water and increasing the turbidly value. Unlike a measure of TSS, turbidity measurements do not often include heavier particles that settle out quickly. Turbidity is measured in Nephelometric Turbidity Units (NTU). The average turbidity value for Indiana surface water is 36 NTU (IDNR, 2008). The turbidity reference condition for USEPA Aggregate Ecoregion VI, Ecoregion 55 is 10.4 NTU, which is, based on turbidity concentrations for the top 25th percentile of streams sampled (2000). The top 25th percentile consisted of streams with the lowest turbidity levels.

No sample sites exceeded the USEPA recommended maximum for turbidity during base flow conditions. The recommended maximum was exceeded in storm flow samples at all sites (Figure 28). The highest recorded storm flow turbidity values were recorded at Sites 1 and 2 on Brandywine Creek.

ESG Laboratories used USEPA 180.1 methodology[5] for testing the samples.

[5] United States Environmental Protection Agency (USEPA), Office of Research and Development, Environmental Monitoring Systems Laboratory. 1993 *Method 180.1 Determination of Turbidity by Nephelometry*. Cincinnati, Ohio. 10 pp.

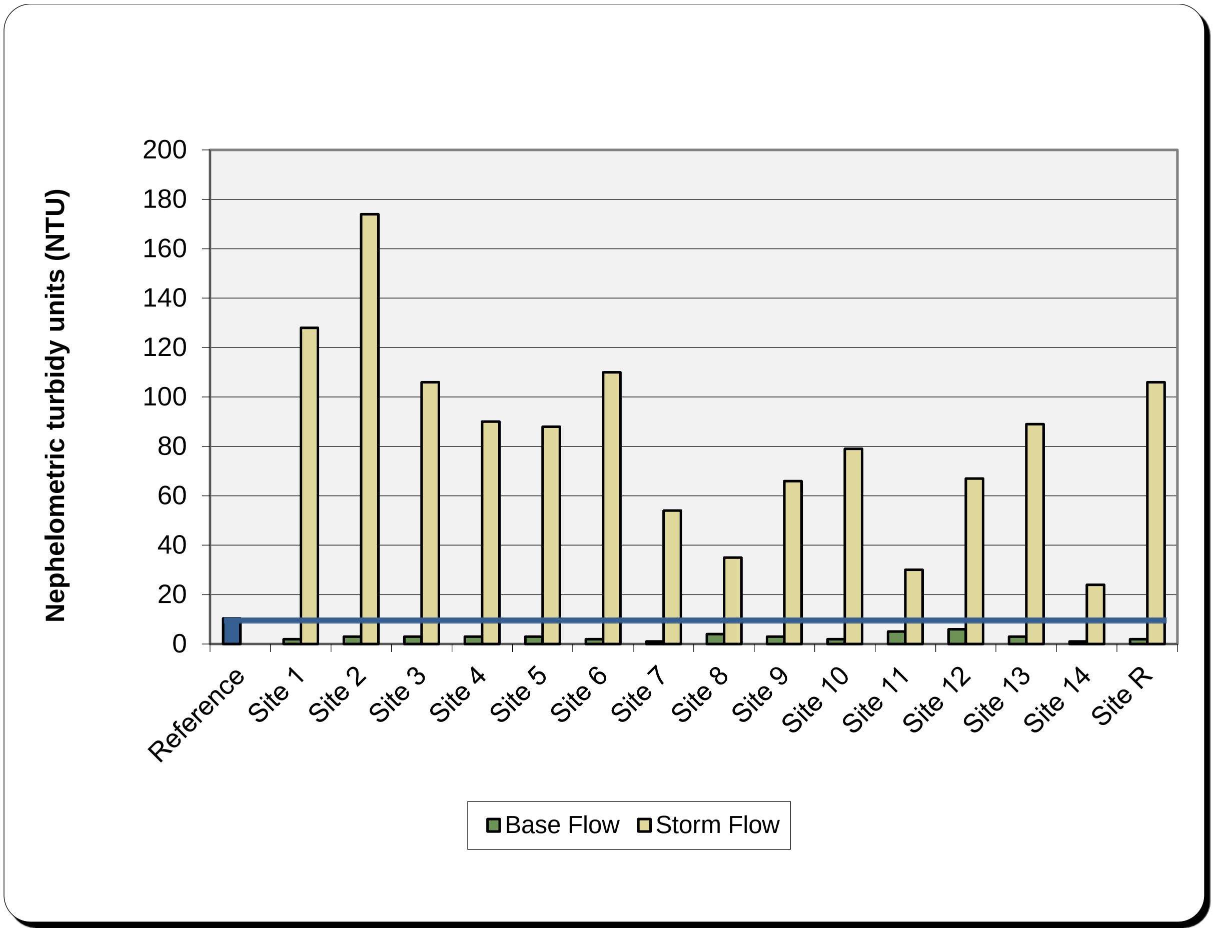

Figure 28. Turbidity Values

Discharge

Velocity measurements were taken along a transect across the stream channel at each sample site at the time water chemistry samples were collected. Velocity measurements were taken using a Marsh-McBirney Flow-Mate™ model 2000 portable velocity meter. The cross-sectional area of the stream at each sample site was estimated by measuring the stream width and depths of water in the stream channel. Velocity measurements were taken in 10% increments of the total stream width, but not closer together than 46 centimeters (18 inches). Velocity measurements were taken at 60% of the water column depth in locations where the depth was equal to or less than 46 centimeters (18 inches), and at 20% and 80% of the water column depth in areas of deeper water. The amount of discharge for each stream was determined by multiplying the cross-sectional area of the stream by the velocity of the water flowing through it.

Discharge for base flow and storm flow sampling events is included in Table 7 and Figure 29. Total discharge was estimated for the storm flow sampling event for Sites 2–6, 12, 13, and R due to high flows and safety concerns associated with wading across streams. Discharge estimates were derived from an analysis of discharge data increases between base flow and storm flow samples at sites where a complete data set was obtained.

Table 7. Discharge Rates

Site	Discharge (m^3/sec)		Discharge (ft^3/sec)	
	Base Flow	Storm Flow	Base Flow	Storm Flow
1	0.1	3.1	2.63	112.38
2	0.2	9.2	6.80	327.33[1]
3	0.5	24.9	18.47	888.67[1]
4	0.7	33.4	24.82	1,194.25[1]
5	0.9	43.5	32.27	1,552.58[1]
6	1.7	83.5	61.99	2,982.62[1]
7	0.0	1.1	0.75	40.54
8	0.0	0.4	1.36	15.61
9	0.0	0.7	0.35	23.54
10	0.1	3.7	2.82	130.96
11	0.0	0.3	0.28	12.41
12	0.1	4.1	3.03	145.86[1]
13	0.1	2.8	2.09	100.65[1]
14	0.1	0.8	2.41	30.26
R	1.0	46.5	34.49	1,659.34[1]

[1] Estimated discharge

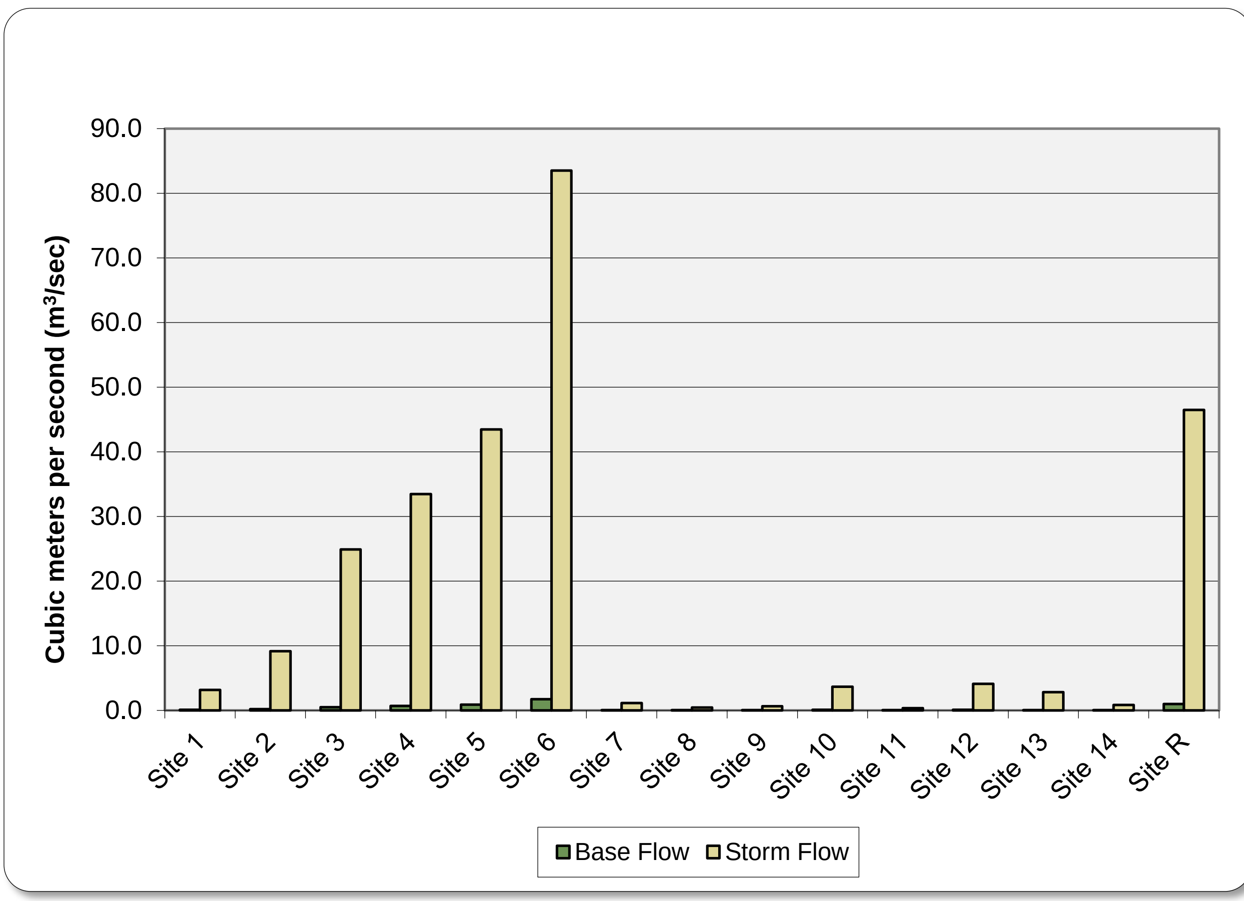

Figure 29. Discharge

Biological and Habitat Data

E. coli

Escherichia coli (*E. coli*) bacteria are found in the lower intestine and feces of warm-blooded animals. Some strains of *E. coli* can cause illness when they enter the body through the mouth, nose, eyes, ears, or cuts in the skin. The presence of *E. coli* in water is a good indicator of fecal contamination and the presence of other bacteria harmful to human health. Typical sources of *E. coli* in water are combined sewer overflows, malfunctioning septic systems, and livestock manure. Indiana water quality standards state that for full body contact recreational use, *E. coli* concentrations shall not exceed 235 colony-forming units (CFU) per 100 milliliters (mL) of water in any one sample in a 30-day period (327 IAC 2-1-6). The average *E. coli* concentration of surface water in Indiana is 645 CFU/100 mL (IDNR, 2008).

E. coli samples were collected at the same time and by the same Davey staff as the physical and chemical water quality parameters. ESG Laboratories used SM 9223B methodology to test the samples. Davey collected an *E. coli* sample at Riley Park (Site P) in Greenfield in addition to collecting a sample at each of the established sample sites.

Sites 1–3, 7, and 9 had *E. coli* concentrations greater than the state water quality standard at the time of the base flow sampling event (Figure 30). Base flow concentrations at Riley Park were slightly below the state standard. Samples at all sites exceeded the state water quality standard at the time of the storm flow sampling event. Cattle and other livestock with direct access to the stream as well as a large number of waterfowl were observed upstream of Site 2 at the time of base flow sampling. It is probable that high *E. coli* concentrations at other sites at the time of base flow and storm flow sampling can be attributed to failing septic systems.

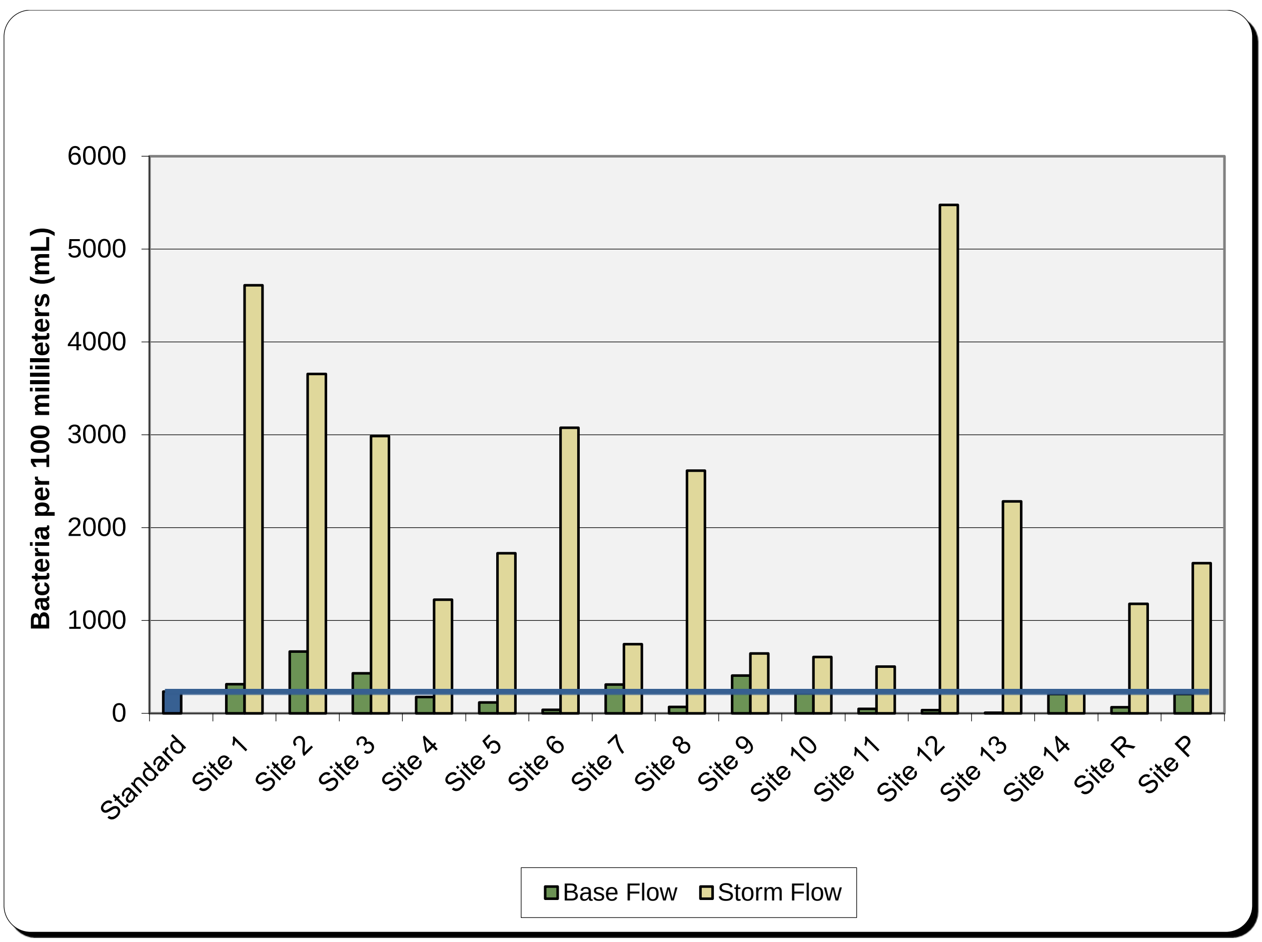

Figure 30. E. coli Concentrations

Macroinvertebrates

Benthic macroinvertebrates were sampled October 18-21, 2010 at all sites except Site 7 and 14 by Davey Biologist Alicia Douglass and Kasey Krouse (Photograph 5). Sites 7 and 14 lacked flowing water at the time of macroinvertebrate sampling. Macroinvertebrates were collected in riffles and leaf packs where riffles were not present using a kick net in accordance with the Rapid Bioassessment Protocol single-habitat approach (Barbour, *et al.,* 1999). A 100-organism subsample was taken in accordance with IDEM's subsampling protocol and the IDNR LARE Protocol for Macroinvertebrate Sample Collections and Index Calculation (IDNR, 2011; T. Davis, personal communication, December 10, 2008). All specimens in the sub-sample were identified to the family level. Identifications are based on Merritt and Cummins (1996) and Voshell (2002). A complete list of the families identified and the number of individuals at each site is included in Appendix J.

Photograph 5 (10-21-10). A crayfish was observed at Site 5 on Brandywine Creek.

HBI

Organic and nutrient stream pollution can be evaluated using a family level macroinvertebrate biotic index developed by Hilsenhoff (HBI). Macroinvertebrate families are assigned a number from 0 to 10 based on tolerance to organic pollution. A 0 is assigned to families most intolerant to organic pollution and a 10 to families most tolerant to organic pollution (Hilsenhoff, 1988). In accordance with IDEM and IDNR standard practices, in this study Hilsenhoff tolerance values were supplemented with values from Bode (1988). Families not assigned a tolerance value by either Hilsenhoff or Bode were excluded from the HBI (IDNR, 2011; T. Davis, personal communication, December 10, 2008). HBI scores are determined by multiplying the total number of individuals for each family by the family tolerance values. The sum of all products for a site is divided by the total number of individuals to determine the HBI score. Table 8 correlates the HBI score with water quality and the likely degree of organic pollution.

Table 8. Interpretation of HBI Scores

Family Biotic Index	Water Quality	Degree of Organic Pollution
0.00 – 3.75	Excellent	Organic pollution unlikely
3.76 – 4.25	Very good	Possible slight organic pollution
4.26 – 5.00	Good	Some organic pollution probable
5.01 – 5.75	Fair	Fairly substantial pollution likely
5.76 – 6.50	Fairly poor	Substantial pollution likely
6.51 – 7.25	Poor	Very substantial pollution likely
7.26 – 10.00	Very poor	Severe organic pollution likely

HBI scores for all sites ranged from a low of 3.93 to a high of 8.00 (Table 9). An analysis of HBI scores indicates that severe organic pollution is likely at Site 2, which is compatible with observed high concentrations of TKN. Sites 10 and 11 have very substantial pollution likely and poor water quality based on HBI scores, and Sites 1, 12, and 13 have substantial pollution likely and fairly poor water quality.

Table 9. HBI Data Summary

Site	Score	Water Quality	Organic Pollution
1	6.43	Fairly poor	Substantial pollution likely
2	8.00	Very poor	Severe organic pollution likely
3	4.27	Good	Some organic pollution
4	4.20	Very good	Possible slight organic pollution
5	5.07	Fair	Fairly substantial pollution likely
6	3.93	Very good	Possible slight organic pollution
7	n/a	n/a	n/a
8	5.17	Fair	Fairly substantial pollution likely
9	4.72	Good	Some organic pollution
10	6.73	Poor	Very substantial pollution likely
11	6.72	Poor	Very substantial pollution likely
12	6.19	Fairly poor	Substantial pollution likely
13	6.48	Fairly poor	Substantial pollution likely
14	n/a	n/a	n/a
R	4.59	Good	Some organic pollution

mIBI

IDEM has developed scoring criteria for a family level macroinvertebrate index of biotic integrity (mIBI) based on a single habitat (KICK) sampling technique. IDEM's mIBI for KICK samples was used to evaluate the macroinvertebrate community. Using mIBI, a score is determined for each site in 10 different metrics (T. Davis, personal communication, October 13, 2008). The average of all 10 metric scores is the mIBI score for a site. The 10 mIBI metrics include the family level HBI score, the number of taxa collected at the family level; the number of individual macroinvertebrates collected; the percent of the dominant macroinvertebrate family collected; the number of families from the orders *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT index); the number of individuals from the EPT orders to the total number of individuals; the number of individuals from the EPT orders to the total number of chironomids; the total number of chironomids; and the total number of individuals to the number of squares sorted when subsampling. The EPT index is a measure of taxa richness within the orders *Ephemeroptera*, *Plecoptera*, and *Trichoptera*. These orders typically contain families less tolerant of pollution (Mandaville, 2002). Chironomids are organisms belonging to the taxonomic family *Chironomidae*.

Ranges for each metric are assigned a score of 0, 2, 4, 6, and 8. Scores from each metric are averaged to obtain an overall mIBI score for each sampling site. A mIBI score between 0 and 2 indicates that the site is severely impaired. A score between 2 and 4 indicates moderate impairment. Scores between 4 and 6 and scores between 6 and 8 suggest that sites are slightly impaired and non-impaired, respectively. IDEM designates sites sampled using the KICK method and receiving a score less than 2.2 as impaired for aquatic life (IDEM, 2010c; T. Davis, personal communication, December 5, 2008). Table 10 depicts mIBI scoring criteria using the KICK method.

Table 10. Scoring Criteria for the Family Level mIBI – Riffle KICK Samples[1]

	Classification Score				
	0	**2**	**4**	**6**	**8**
Family Level HBI	≥ 5.63	5.06-5.62	4.55-5.05	4.09-4.54	< 4.08
Number of Taxa	< 7	8-10	11-14	15-17	> 18
Number of Individuals	< 79	80-129	130-212	213-349	> 350
Percent Dominant Taxon	> 61.6	43.9-61.5	31.2-43.8	22.2-31.1	< 22.1
EPT Index	< 2	3	4-5	6-7	> 8
EPT Count	< 19	20-42	43-91	92-194	> 195
EPT Count to Total Number of Individuals	< 0.13	0.14-0.29	0.30-0.46	0.47-0.68	> 0.69
EPT Count to Chironomid Count	< 0.88	0.89-2.55	2.56-5.70	5.71-11.65	> 11.66
Chironomid Count	> 147	55-146	20-54	7-19	< 6
Total Number of Individuals to Number of Squares Sorted	< 29	30-71	72-171	172-409	> 410

[1]Calibrated from transformed data distribution of the 1990–1995 100-organism subsamples.

All sites have mIBI scores indicating that they are moderately impaired to severely impaired (Table 11). Total mIBI scores for all sites range from a minimum of 0.60 to a maximum of 4.00. The mIBI scores obtained for Sites 2, 8, 10, and 11 are low enough to be classified as impaired for aquatic life use. Low scores at these sites may be due in part to insufficient habitat.

An even distribution among the EPT taxa and chironomids indicates a community in good biotic condition; whereas, a community disproportionately high in chironomids may indicate environmental stress. Chironomids are typically more tolerant of pollution (Mandaville, 2002). The EPT to the chironomid count was high for all sites and a disproportionate amount of chironomids was not present. Consequently, all sites received good scores for the chironomid count (Tables 12 and 13).

All sites had a relatively low number of overall taxa and received low scores for the number of taxa metric with the exception of Sites 8 and R, which had a moderate amount of taxa diversity. This metric coupled with the percent dominant taxa metric indicates that the macroinvertebrate community at Site R, the reference site on Sugar Creek, is the most diverse and balanced of all the macroinvertebrate communities sampled. The percent dominant taxon metric indicates the family level community balance. Communities dominated by few families indicated that the community is under environmental stress (Mandaville, 2002). Sites 4 and 9 also had balanced macroinvertebrate communities not dominated by any particular family.

All sites scored relatively low for the total number of individuals after subsampling.

Table 11. mIBI Data Summary

Site	mIBI Score	Impairment Classification
Site 1	3.20	Moderately impaired
Site 2	1.20	Severely impaired
Site 3	2.60	Moderately impaired
Site 4	3.20	Moderately impaired
Site 5	2.40	Moderately impaired
Site 6	4.00	Slightly impaired
Site 7	n/a	n/a
Site 8	2.00	Severely impaired
Site 9	2.20	Moderately impaired
Site 10	1.60	Severely impaired
Site 11	0.60	Severely impaired
Site 12	3.00	Moderately impaired
Site 13	2.60	Moderately impaired
Site 14	n/a	n/a
Site R	3.40	Moderately impaired

Table 12. Metric Scores for the Family Level mIBI – Riffle KICK Samples Sites 1-8

	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 8	
Metric	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**
Family Level HBI	6.43	0	8.00	0	4.27	6	4.20	6	5.07	2	3.93	8	5.17	2
Number of Taxa	8	2	8	2	9	2	11	4	9	2	8	2	12	4
Number of Individuals	102	2	107	2	103	2	111	2	99	2	113	2	110	2
Percent Dominant Taxon	59.8	2	43.9	2	50.5	2	29.7	6	38.4	4	33.6	4	31.8	4
EPT Index	2	0	2	0	2	0	3	2	3	2	6	4	1	0
EPT Count	63	4	10	0	29	2	37	2	35	2	67	6	1	0
EPT Count to Total Number of Individuals	0.62	6	0.09	0	0.28	2	0.33	4	0.35	4	0.59	6	0.01	0
EPT Count to Chironomid Count	31.50	8	0.67	0	4.14	4	1.12	2	0.92	2	0	0	0	0
Chironomid Count	2	8	15	6	7	6	33	4	38	4	0	8	0	8
Number of Individuals to Number of Squares Sorted	9.3	0	8.9	0	7.4	0	5.0	0	5.0	0	7.1	0	3.1	0
Site mIBI Score	**3.20**		**1.20**		**2.60**		**3.20**		**2.40**		**4.00**		**2.00**	

Table 13. Metric Scores for the Family Level mIBI – Riffle KICK Samples Sites 9-13 and R

	Site 9		Site 10		Site 11		Site 12		Site 13		Site R	
Metric	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**	**Data**	**Score**
Family Level HBI	4.72	4	6.73	0	6.72	0	6.19	0	6.48	0	4.59	4
Number of Taxa	10	2	7	0	8	2	10	2	9	2	11	4
Number of Individuals	96	2	111	2	102	2	105	2	128	2	108	2
Percent Dominant Taxon	25.0	6	42.3	4	79.4	0	49.5	2	43.0	4	24.1	6
EPT Index	3	2	1	0	2	0	3	2	2	0	4	4
EPT Count	11	0	38	2	5	0	61	4	73	4	49	4
EPT Count to Total Number of Individuals	0.11	0	0.34	4	0.05	0	0.58	6	0.57	6	0.45	4
EPT Count to Chironomid Count	0.79	0	0.81	0	0.06	0	8.71	6	0	0	2.33	2
Chironomid Count	14	6	47	4	81	2	7	6	0	8	21	4
Number of Individuals to Number of Squares Sorted	2.5	0	5.0	0	1.6	0	5.8	0	14.2	0	12.0	0
Site mIBI Score	**2.20**		**1.60**		**0.60**		**3.00**		**2.60**		**3.40**	

RBPII

Rapid Bioassessment Protocol (RBPII) II is one of multiple Rapid Bioassessment Techniques. RBPII involves identification of macroinvertebrates to the family level in a 100-organism subsample (USEPA, 1990). Standard LARE RBPII metrics include an analysis of the number of taxa, EPT Index, the percent of the dominant taxon, ratio of EPT individuals to Chironomidae individuals, HBI, ratio of scraper to filtering collector feeders, ratio of shredder to non-shredder feeders, and the Community Loss Index. A numeric score of 6, 3, or 0 is assigned to each metric with 6 indicating non-impaired and a 0 indicating severe impairment. The numeric scores for all metrics at each site are then totaled and divided into the score for a reference site. Each site is then assigned to a biological condition category based on its percent comparison to the reference site score (IDNR, 2011). Tables 14 and 15 include scoring classifications for RBPII (USEPA, 1989).

Table 14. RBPII Metric Scoring Criteria

RBPII Metric	Metric Scoring Criteria		
	6	3	0
Number of Taxa[1]	>80%	40-80%	<40%
Family Level HBI[2]	>85%	50-85%	<50%
Ratio of Scrapers to Filtering Collectors[1]	>50%	25-50%	<25%
Ratio of EPT to Chironomidae[1]	>75%	25-75%	<25%
Percent Dominant Taxon	<30%	30-50%	>50%
EPT Index[1]	>90%	70-90%	<70%
Community Loss Index	<0.5%	0.5-4.0%	>4%
Ratio of Shredders to Nonshredders[1]	>50%	25-50%	<25%

[1] Score is the percentage of the ratio of study site to reference site
[2] Score is the percentage of the ratio of the reference site to study site

Table 15. RBPII Biological Condition Categories

Percent of Study Site Score Compared to a Reference Score	Biological Condition Category	Attributes
>79	Non-impaired	Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.
29-72	Moderately impaired	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<21	Severely impaired	Few species present. If high densities of organisms, then dominated by one or two taxa. Only tolerant organisms present.
Percentage values between 22-28 and 73-78 require best professional judgment for placement in the most appropriate category and may take into consideration habitat and other water quality data.		

Macroinvertebrate data collected in Brandywine Creek Watershed were compared for the RBPII analysis to a site selected on Sugar Creek as a reference site (Site R). The reference site was selected based on data previously collected at the site available in the Sugar Creek Watershed Management Plan. The percentage of Brandywine Creek Watershed sample site scores to the reference score obtained on Sugar Creek placed all Brandywine Creek Watershed sites into the moderately impaired biological condition category with the exception of Sites 9 and 11. Site 9 on Potts Ditch downstream of Greenfield was determined to be non-impaired. The score for Site 11 on Buck Ditch in Shelby County fell between the moderately impaired and severely impaired biological condition categories. Biological condition category attributes at Site 11 most closely match the severely impaired category. Water chemistry at Site 11 was generally better than at the reference site; however, the site had very poor habitat. Table 16 contains a summary of RBPII data. Tables 17-21 contain RBPII data for each site.

Table 16. RBPII Data Summary

Site	RBPII Score	Impairment Category
Site 1	15	Moderately impaired
Site 2	24	Moderately impaired
Site 3	33	Moderately impaired
Site 4	36	Moderately impaired
Site 5	24	Moderately impaired
Site 6	33	Moderately impaired
Site 7	n/a	n/a
Site 8	24	Moderately impaired
Site 9	39	Non-impaired
Site 10	18	Moderately impaired
Site 11	12	Severely impaired
Site 12	27	Moderately impaired
Site 13	18	Moderately impaired
Site 14	n/a	n/a
Site R	48	n/a

•

Table 17. RBPII Analysis Site R Data

Metric	Site R		
	Data	RBP II	Score
Number of Taxa	11	100	6
Family Level HBI	4.59	100	6
Ratio of Scrapers to Filtering Collectors	2.64	100	6
Ratio of EPT to Chironomidae	2.33	100	6
Percent Dominant Taxon	24	100	6
EPT Index	4	100	6
Community Loss Index	0	0	6
Ratio of Shredders to Nonshredders	0.05	100	6
Total Score			48
Percent of Reference Site			100
Impairment Category			n/a

Table 18. RBPII Sites 1-3 Data

Metric	Site 1			Site 2			Site 3		
	Data	RBP II	Score	Data	RBP II	Score	Data	RBP II	Score
Number of Taxa	8	73	3	8	73	3	9	82	6
Family Level HBI	6.43	71	3	8.00	174	6	4.27	93	6
Ratio of Scrapers to Filtering Collectors	0	0	0	15.50	588	6	9.63	365	6
Ratio of EPT to Chironomidae	31.50	1,350	6	0.67	29	3	4.14	178	6
Percent Dominant Taxon	60	60	0	44	44	3	50	50	0
EPT Index	2	50	0	2	50	0	2	50	0
Community Loss Index	0.88	0.88	3	0.75	0.75	3	0.67	0.67	3
Ratio of Shredders to Nonshredders	0	0	0	0	0	0	0.03	63	6
Total Score			15			24			33
Percent of Reference Site			43.75			50			68.75
Impairment Category			MI			MI			MI

Table 19. RBPII Sites 4-6 Data

Metric	Site 4			Site 5			Site 6		
	Data	RBP II	Score	Data	RBP II	Score	Data	RBP II	Score
Number of Taxa	11	100	6	9	82	6	8	73	3
Family Level HBI	4.20	91	6	5.07	110	6	3.93	85	6
Ratio of Scrapers to Filtering Collectors	5.10	193	6	0	0	0	3.74	142	6
Ratio of EPT to Chironomidae	1.12	48	3	0.92	39	3	0	0	0
Percent Dominant Taxon	30	30	6	38	38	3	34	34	3
EPT Index	3	75	3	3	75	3	6	150	6
Community Loss Index	0.45	0.45	6	0.67	0.67	3	0.75	0.75	3
Ratio of Shredders to Nonshredders	0	0	0	0	0	0	0.04	76	6
Total Score			36			24			33
Percent of Reference Site			75			50			68.75
Impairment Category			MI			MI			MI

Table 20. RBPII Sites 8–10 Data

Metric	Site 8			Site 9			Site 10		
	Data	RBP II	Score	Data	RBP II	Score	Data	RBP II	Score
Number of Taxa	12	109	6	10	91	6	7	64	3
Family Level HBI	5.17	112	6	4.72	103	6	6.73	147	6
Ratio of Scrapers to Filtering Collectors	20.00	759	6	2.14	81	6	0.00	0	0
Ratio of EPT to Chironomidae	0.00	0	0	0.79	34	3	0.81	35	3
Percent Dominant Taxon	32	32	3	25	25	6	42	42	3
EPT Index	1	25	0	3	75	3	1	25	0
Community Loss Index	0.83	0.83	3	0.50	0.50	3	1.29	1.29	3
Ratio of Shredders to Nonshredders	0.00	0	0	0.07	137	6	0.00	0	0
Total Score			24			39			18
Percent of Reference Site			50			81.25			37.5
Impairment Category			MI			NI			MI

Table 21. RBPII Sites 11-13 Data

Metric	Site 11			Site 12			Site 13		
	Data	RBP II	Score	Data	RBP II	Score	Data	RBP II	Score
Number of Taxa	8	73	3	10	91	6	9	82	6
Family Level HBI	6.72	146	6	6.19	135	6	6.48	141	6
Ratio of Scrapers to Filtering Collectors	0	0	0	0	0	0	0	0	0
Ratio of EPT to Chironomidae	0.06	3	0	8.71	373	6	0	0	0
Percent Dominant Taxon	79	79	0	50	50	3	43	43	3
EPT Index	2	50	0	3	75	3	2	50	0
Community Loss Index	0.88	0.88	3	0.60	0.60	3	1.00	1.00	3
Ratio of Shredders to Nonshredders	0.01	20	0	0	0	0	0	0	0
Total Score			12			27			18
Percent of Reference Site			25			56.25			37.5
Impairment Category			SI			MI			MI

Macroinvertebrate Data Analyses Summary

The HBI and mIBI analyses both classified Site 2 as being the most impaired based on macroinvertebrate data. In addition, the mIBI and RBPII analyses jointly indicated that Site 11 is the most impaired. Site 6 was identified as the least impaired site by the HBI and mIBI analyses. Site 4 and Site 9 were independently categorized as least impaired by HBI and RBPII, respectively. Table 22 includes a summary of HBI, mIBI, and RBPII macroinvertebrate community analyses.

Table 22. Macroinvertebrate Data Analyses Summary

Site	HBI Score	HBI Water Quality	HBI Organic Pollution	mIBI Score	mIBI Impairment Classification	RBPII Score	RBPII Impairment Category
Site 1	6.43	Fairly poor	Substantial pollution likely	3.2	Moderately impaired	15	Moderately impaired
Site 2	8	Very poor	Severe organic pollution likely	1.2	Severely impaired	24	Moderately impaired
Site 3	4.27	Good	Some organic pollution	2.6	Moderately impaired	33	Moderately impaired
Site 4	4.2	Very good	Possible slight organic pollution	3.2	Moderately impaired	36	Moderately impaired
Site 5	5.07	Fair	Fairly substantial pollution likely	2.4	Moderately impaired	24	Moderately impaired
Site 6	3.93	Very good	Possible slight organic pollution	4	Slightly impaired	33	Moderately impaired
Site 7	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Site 8	5.17	Fair	Fairly substantial pollution likely	2	Severely impaired	24	Moderately impaired
Site 9	4.72	Good	Some organic pollution	2.2	Moderately impaired	39	Non-impaired
Site 10	6.73	Poor	Very substantial pollution likely	1.6	Severely impaired	18	Moderately impaired
Site 11	6.72	Poor	Very substantial pollution likely	0.6	Severely impaired	12	Severely impaired
Site 12	6.19	Fairly poor	Substantial pollution likely	3	Moderately impaired	27	Moderately impaired
Site 13	6.48	Fairly poor	Substantial pollution likely	2.6	Moderately impaired	18	Moderately impaired
Site 14	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Site R	4.59	Good	Some organic pollution	3.4	Moderately impaired	48	n/a

Habitat Evaluation

The Qualitative Habitat Evaluation Index (QHEI) is a six metric index used to evaluate the physical habitat of a waterway. A QHEI analysis was conducted by Alicia Douglass at each site at the same time that macroinvertebrate communities were sampled. QHEI takes into account substrate, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality, and the waterway gradient. The maximum QHEI score is 100 (Ohio EPA, 2006). IDEM has determined that a total QHEI score less than 51 indicates poor quality habitat. QHEI scores are evaluated to determine if poor quality habitat is a contributing stressor on aquatic biotic communities (IDEM, 2010c).

QHEI scores at Sites 1, 5, 7, 8, and 10-12 indicate the presence of poor quality habitat (Figure 31). Nearly all sites scored very low for the development of pools and riffles with the exception of Site 9. Sites 1, 8, and 11 had low channel morphology, and Sites 7-8 and 10-12 scored low in the substrate category primarily due to a significant quantity of silt in the streams. Table 23 lists QHEI scores for each sample site by metric. QHEI data sheets can be found in Appendix K.

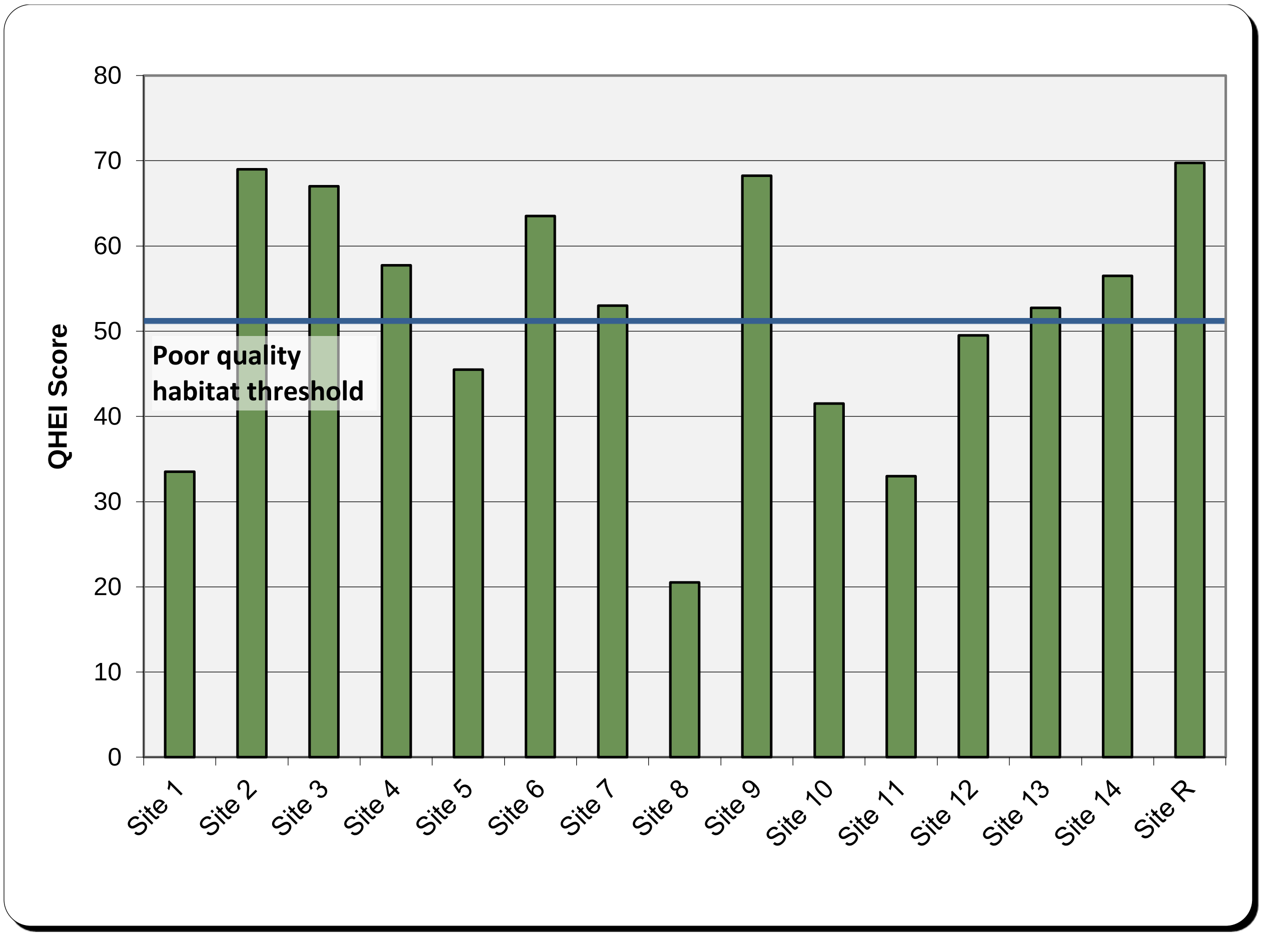

Figure 31. Sample Site QHEI Scores

Table 23. Sample Site QHEI Scores per Metric

Metric	Substrate	In-stream Cover	Channel Morphology	Bank Erosion & Riparian Zone	Pool/Glide & Riffle/Run Quality	Gradient	Total
Maximum Score	20	20	20	10	20	10	100.00
Site 1	6.5	9	4	2	4	8	33.50
Site 2	18	15	12	8	8	8	69.00
Site 3	13	15	14	7	8	10	67.00
Site 4	14	15	11	4.25	6.5	6	56.75
Site 5	13	10	7	4.5	3	8	45.50
Site 6	14.5	13	13.5	6	10	8	65.00
Site 7	6	16	10	5	6	6	49.00
Site 8	4	4	4	6.5	2	4	24.50
Site 9	16.5	16	12.5	6.75	9	8	68.75
Site 10	4.5	11	8	5	3	10	41.50
Site 11	6.5	7	4	3.5	3	10	34.00
Site 12	6.5	15	10	4	6	8	49.50
Site 13	11.5	14	9	6.25	2	10	52.75
Site 14	13	14	9.5	7	3	10	56.50
Site R	15	15	10	6.25	10.5	10	66.75

QHEI data is very useful in the interpretation of macroinvertebrate data. If habitat is high quality and macroinvertebrate community analyses indicate impairment, it can be assumed that poor water quality is influencing the degradation of the macroinvertebrate community. Conversely, it is possible in some circumstances that macroinvertebrate community analyses indicate water quality impairment when in fact the macroinvertebrate community has been negatively impacted by lack of sufficient habitat. If both the macroinvertebrate community and QHEI analysis indicate impairment there is a lack of certainty in the reason for the degradation of the macroinvertebrate community. For instance, QHEI does not indicate the presence of poor quality habitat at Site 2; however, macroinvertebrate community analyses indicate impairment at this site. It can be assumed that poor water quality is the primary factor influencing the macroinvertebrate community. Macroinvertebrate community analyses also indicate impairment at Site 11. QHEI indicates poor quality habitat at this site. Consequently, it is uncertain whether the macroinvertebrate community has been negatively influenced by poor water quality or poor habitat. Table 24 summarizes the findings of QHEI and macroinvertebrate analyses at each site.

Table 24. QHEI and Macroinvertebrate Data Analyses Summary

Site	QHEI Score	Habitat Classification	HBI Water Quality	mIBI Impairment Classification	RBPII Impairment Category
Site 1	33.5	Poor quality habitat	Fairly poor	Moderately impaired	Moderately impaired
Site 2	69	-	Very poor	Severely impaired	Moderately impaired
Site 3	67	-	Good	Moderately impaired	Moderately impaired
Site 4	56.75	-	Very good	Moderately impaired	Moderately impaired
Site 5	45.5	Poor quality habitat	Fair	Moderately impaired	Moderately impaired
Site 6	65	-	Very good	Slightly impaired	Moderately impaired
Site 7	49	Poor quality habitat	n/a	n/a	n/a
Site 8	24.5	Poor quality habitat	Fair	Severely impaired	Moderately impaired
Site 9	68.75	-	Good	Moderately impaired	Non-impaired
Site 10	41.5	Poor quality habitat	Poor	Severely impaired	Moderately impaired
Site 11	34	Poor quality habitat	Poor	Severely impaired	Severely impaired
Site 12	49.5	Poor quality habitat	Fairly poor	Moderately impaired	Moderately impaired
Site 13	52.75	-	Fairly poor	Moderately impaired	Moderately impaired
Site 14	56.5	-	n/a	n/a	n/a
Site R	66.75	-	Good	Moderately impaired	n/a

LARE WMP Field Data Summary

High nutrients in streams are the most notable concerns in Brandywine Creek Watershed. All samples tested for ammonia nitrogen exceeded the state water quality standards, and all TKN samples exceeded the USEPA recommended maximum target. In addition, 86% of nitrate+nitrite samples and 71% of total phosphorus samples exceeded USEPA recommended maximum targets. *E. coli* concentrations are also a concern in the upper part of the watershed where numerous samples exceeded the state standard at the time of base flow conditions. All *E. coli* samples exceeded the state target at the time of storm flow sampling resulting in a combined base flow and storm flow sample standard exceedance rate of 67%. TSS and turbidity samples exceeded water quality targets at rates of 39% and 50%, respectively. Half of the sample sites lacked suitable habitat for aquatic life use, and macroinvertebrate communities at 29% of sites indicated aquatic life use impairment based on mIBI scores. Table 25 summarizes water quality standards and targets.

Table 25. Water Quality Standards and Targets Summary

Water Quality Parameter	Standard	Target	Standard/Target	Standard/Target Source
Temperature	x		varies based on month of sample	327 IAC 2-1-6
pH	x		>6 and <9	327 IAC 2-1-6
Specific conductivity	x		1,200 µS/cm at 25 °C	327 IAC 2-1-6
Dissolved oxygen	x		<4.0 mg/L	327 IAC 2-1-6
Total phosphorus		x	≤0.0625 mg/L	USEPA, 2000
Ammonia nitrogen	x	x	varies based on water temperature and pH	327 IAC 2-1-6
Nitrate+nitrite		x	≤1.6 mg/L	USEPA, 2000
TKN		x	≤0.4 mg/L	USEPA, 2000
TSS		x	≤30.0 mg/L	IDEM, 2010e
Turbidity		x	≤10.4 NTU	USEPA, 2000
E. coli	x		≤235 CFU/100mL	327 IAC 2-1-6
mIBI		x	impaired for aquatic life use if <2.2	IDEM, 2010c
QHEI		x	impaired for aquatic life use if <51	IDEM, 2010c

Historic Watershed Studies

Brandywine Creek Watershed Investigation Report - 1967

A report was compiled on the status of Brandywine Creek Watershed by the USDA in November, 1967. The report indicated land use in the watershed at that time consisted of 85% cropland, 5% pasture, 6% forest, and 4% in idle land and other uses. This indicates an approximate loss of 7% in cropland, 2.5% in pasture, and 1% in forest land and in increase by roughly 10% in land that is idle or in other uses such as developed when compared with the 2001 NLCD data presented earlier in this report.

The study found that moderately serious sheet erosion had been reported on 33-50% of watershed land and that gully erosion was reported on 20%. Sediment deposition in ditches and culverts as well as channel filling was a reported problem. However, flooding was identified as the greatest concern in the watershed. It was reported that flooding damaged crops, interrupted farming operations, and prevented full use of the floodplain. Proposed solutions included construction of a flood control structure (lake) that would store 862 hectare-meters (6,995 acre-feet) in the upper part of the watershed and deepening Brandywine Creek by excavating 2,183,569 cubic meters (2,856,000 cubic yards) from 42.2 kilometers (26.2 miles) of the creek which was approximately 87% of its total length. Construction of the flood control structure was later determined infeasible due to insufficient storage north of I-70 and potential flooding of I-70, if the structure were to be constructed downstream (Bowling, 1968).

Other recommendations included protection of forest land from livestock grazing, minimum tillage, use of cover and green manure crops, pasture renovation, pasture planting, pasture management, grade control strucutres, surface and tile drainage systems, grass waterways, terraces and diversions, and water control structures. Specific locations for recommended practices were not identified.

IDEM Water Chemistry Data

IDEM collected water chemistry data in Brandywine Creek Watershed from August 25, 1993 to October 21, 2004 (C. Bell, personal communication, September 1, 2010). Data were collected at four established sampling sites; however, these sites are clustered in pairs in two locations along Brandywine Creek (Figure 32). Data collected included heavy metals as well as parameters also collected as part of this study. Parameters collected as part of this study are depicted in Table 26 and include dissolved oxygen, pH, specific conductivity, temperature, turbidity, nitrate+nitrite, total phosphorus, TKN, TSS, and *E. coli*. Data that exceeds state water quality standards and established water quality targets previously discussed in the LARE WMP Field Data section of this report are depicted in red font. A total of 78% of turbidity samples, 100% nitrate+nitrite samples, 92% of total phosphorus samples, 67% of TKN samples, and 71% of *E. coli* samples exceeded state water quality standards and targets.

IDEM sites WED040-0001 and WED040-0003 generally coincide with the location of Site 4 as established in this study. Base flow parameters collected during this study are expected to be most comparable to data collected by IDEM. All base flow parameters collected at Site 4 are within the range of data collected by IDEM from 1993 through 2004 with the exception of specific conductivity. Specific conductivity data collected as part of this study was significantly lower during base flow and storm flow conditions than data collected by IDEM.

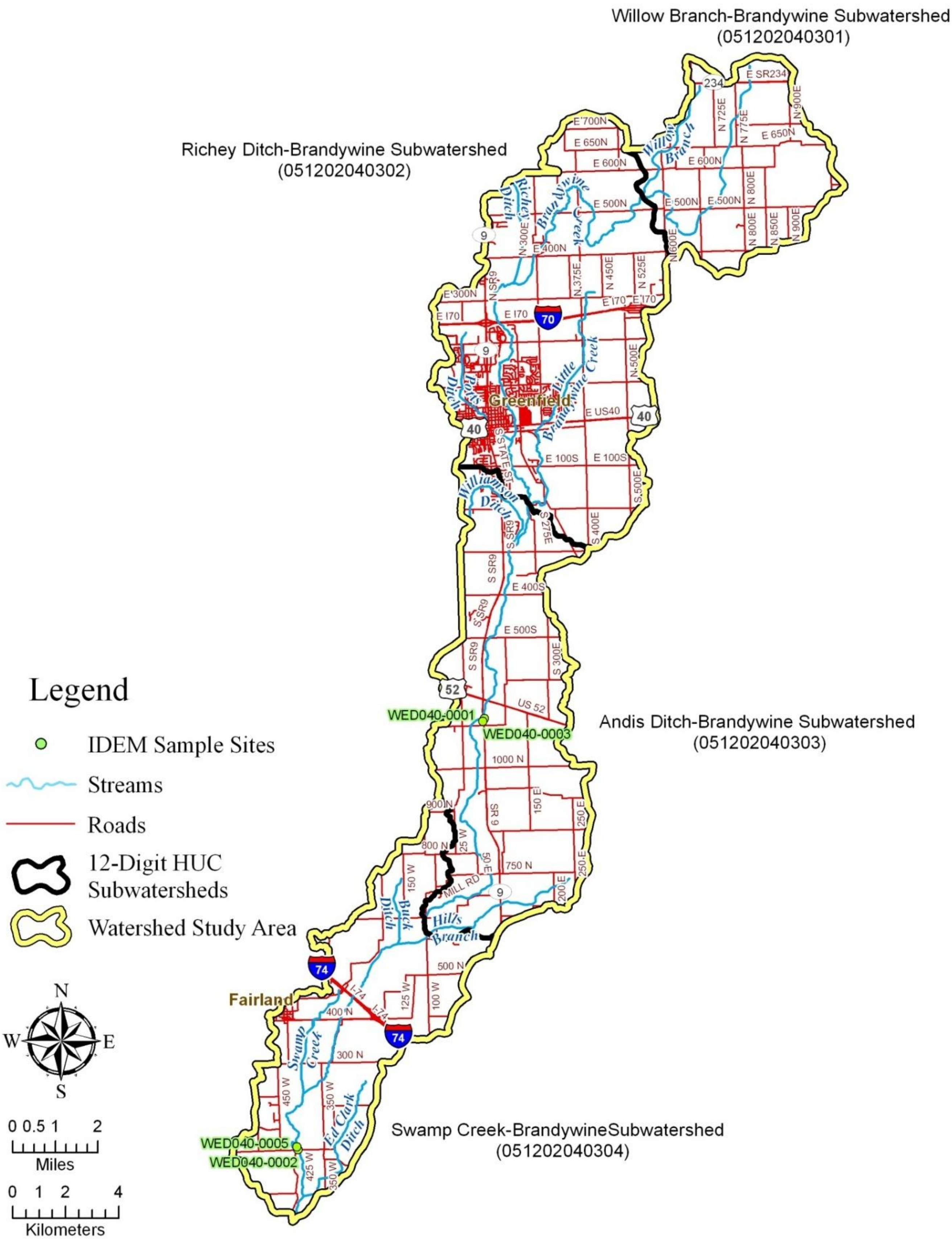

Figure 32. IDEM Sample Site Location Map

Table 26. IDEM Water Chemistry Data

Site	Date	DO (mg/L)	pH	Specific Conductivity (µS/cm)	Temperature (°C)	Turbidity (NTU)	Nitrate+Nitrite (mg/L)	Total Phosphorus (mg/L)	TKN (mg/L)	TSS (mg/L)	*E. coli* (MPN/100mL)
Water Quality Standard/Target[1]		**>4**	**>6, <9**	**1,200**	**varies**	**10.4**	**1.6**	**0.0625**	**0.4**	**30**	**235**
WED040-0001	17-Apr-97	13.12	8.38	614	7.61	**24.39**	**3.6**	**0.11**	**0.77**	9	-
WED040-0001	28-May-97	8.29	7.96	631	14.68	**11.1**	**3.1**	**0.14**	**1.3**	4	**250**
WED040-0001	17-Jul-97	7.73	8.06	732	24.64	**22.29**	**2.6**	**0.29**	**0.53**	15	**250**
WED040-0001	17-Sep-97	7.77	7.9	826	20.7	**18**	**3.8**	**0.35**	0.35	5	220
WED040-0001	13-Nov-97	12.64	8.22	1,022	4.59	5.09	**3.8**	**0.52**	**0.52**	1	-
WED040-0001	19-Nov-97	10.66	7.88	535	7.4	**63**	**4.2**	**0.15**	0.15	17	-
WED040-0002	17-Apr-97	13.75	8.55	599	8.14	**18**	**3.4**	0.043	**0.43**	4	-
WED040-0002	29-May-97	8.23	8.15	**2,299**	14.78	7.09	**3.4**	**0.1**	**1.1**	11	-
WED040-0002	18-Jul-97	6.92	8.13	651	23.46	**19.5**	**2.8**	**0.14**	0.23	12	-
WED040-0002	18-Sep-97	8.17	8.01	710	17.5	**14**	**7.4**	**0.17**	**0.76**	5	-
WED040-0002	14-Nov-97	11.04	8.5	814	4.69	7.8	**2.6**	**0.11**	0.32	< 4	-
WED040-0002	20-Nov-97	10.34	7.98	555	7.5	**75**	**4.1**	**0.11**	**1.2**	20	-
WED040-0003	25-Aug-93	6.3	7.61	635	23.09	n/a	-	-	-	-	-
WED040-0003	18-Sep-97	7.42	7.67	874	18.12	n/a	-	-	-	-	-
WED040-0003	21-Oct-04	8.51	7.89	920	12.95	8.5	-	-	-	-	-
WED040-0005	3-Jun-02	10.17	8.25	720	20.17	**14.6**	-	-	-	-	127.4
WED040-0005	10-Jun-02	8.68	8.02	703	21.05	**29.7**	-	-	-	-	204.6
WED040-0005	17-Jun-02	8.78	8.06	593	17.95	**79.19**	-	-	-	-	**488.4**
WED040-0005	24-Jun-02	8.2	8.09	732	22.45	**26.2**	-	-	-	-	**365.4**
WED040-0005	1-Jul-02	7.93	8.1	648	23.13	**38.5**	-	-	-	-	**726**

[1] Data in red font exceeds state water quality standards or established water quality targets

IDEM Macroinvertebrate and Habitat Data

IDEM has developed scoring criteria for mIBI based on multiple sampling techniques. These two techniques include the single habitat (KICK) and multi-habit (MHAB) methods. KICK methods data are evaluated using 10 metrics designed to assess macroinvertebrate communities' structural, compositional, and functional integrity. The MHAB approach evaluates the macroinvertebrate community using 12 metrics of which there are three metrics in common with the KICK method.

The mIBI allows IDEM to determine waterways that are impaired for aquatic life use based on the macroinvertebrate community present. Any site sampled using the KICK method and receiving a score less than 2.2 is designated as impaired for aquatic life use by IDEM (IDEM, 2010c). Any site sampled using the MHAB method and receiving a score less than 36 is designated as impaired for aquatic life use (T. Davis, personal communication, January 13, 2010).

Macroinvertebrate sampling was conducted in Brandywine Creek in the vicinity of Site 4 by IDEM using the KICK method in 1993 and 1997 and the MHAB method in 2004 (T. Davis, personal communication, September 1, 2010). QHEI data was collected concurrently. Both the macroinvertebrate community and habitat quality appear to have been on a steady decline from 1993 to 2010.

Table 27 depicts the sampling location, sampling dates, sampling methods, mIBI scores, whether or not the site is designated as impaired for aquatic life use based on its mIBI score, and QHEI scores.

Table 27. Historical Macroinvertebrate and Habitat Data

IDEM Sample Site	Stream Name	Coordinates		Sample Date	Method	mIBI Score	Integrity Class	QHEI Score
		Latitude	Longitude					
WED040-0003	Brandywine Creek	39.686944	-85.7738889	08-25-93	KICK	6.4	Not impaired	78
WED040-0003	Brandywine Creek	39.686944	-85.7738889	09-18-97	KICK	5.0	Not impaired	61
WED040-0003	Brandywine Creek	39.686944	-85.7738889	10-21-04	MHAB	44	Not impaired	60

IDNR Fish and Habitat Data

A fish survey was conducted in the Big Blue Watershed including Brandywine Creek in 1995 by IDNR (Carnahan, 1996). Samples were collected at 4 sites in Shelby County at river miles 2.3, 4.4, 5.1, and 5.9 as measured from the confluence of Brandywine Creek with Big Blue River. QHEI data were collected at each site and ranged from a low of 58.5 at river mile 5.9 to a high of 65 at river mile 4.4. QHEI scores at river miles 2.3 and 5.1 were 60 and 63, respectively. None of the sites at which fish data were collected coincide with sites at which data were collected as part of development of the Brandywine Creek WMP.

Fish were sampled in both spring and fall of 1995 using a DC barge electrofisher. All fish species were collected and identified in the spring. Only game fish were collected in the fall sampling. A total of 28 fish species were identified representing 5 families (Table 28). Cyprinidae, the carp and minnow family, comprised 59.9% of the number of fish identified and 35.1% of fish surveyed by weight making it the most abundant family based on fish numbers. Catostomidae, the sucker family, was the second most abundant family identified by number comprising 26.5% of the number of fish collected and first most abundant family based on a weight of 53.1% of total fish collected. Centrarchidae, the sunfish family, was the third most abundant family. This family includes smallmouth bass. Based on sizes and quantities of smallmouth bass collected during the different seasons, the study speculates that Brandywine Creek may be an important smallmouth bass rearing area for Big Blue River.

Table 28. Fish Species and Quantities Collected in Brandywine Creek in Spring 1995

Common Name	Scientific Name	Number of Fish
Central stoneroller	*Campostoma anomalum*	330
Golden redhorse	*Moxostoma erythrurum*	178
Steelcolor shiner	*Cyprinella whipplei*	137
Northern hog sucker	*Hypentelium nigricans*	115
Striped shiner	*Luxilus chrysocephalus*	81
Bluntnose minnow	*Pimephales notatus*	64
Smallmouth bass	*Micropterus dolomieu*	63
Longear sunfish	*Lepomis megalotis*	58
Emerald shiner	*Notropis atherinoides*	40
Rock bass	*Ambloplites rupestris*	23
Creek chub	*Semotilus atromaculatus*	13
Common carp	*Cyprinus carpio*	7
Redfin shiner	*Lythrurus umbratilis*	6
Sand shiner	*Notropis stramineus*	6
Bigeye chub	*Notropis amblops*	5
White sucker	*Catostomus commersoni*	5
Spotted sucker	*Minytrema melanops*	4
Gizzard shad	*Dorosoma cepedianum*	3
Johnny darter	*Etheostoma nigrum*	3
Silverjaw minnow	*Notropis buccatus*	3
Bluegill	*Lepomis macrochirus*	2
Green sunfish	*Lepomis cyanellus*	2
Greenside darter	*Etheostoma blenniodes*	2
Silver redhorse	*Moxostoma anisurum*	2
Logperch	*Percina caprodes*	1
Rainbow darter	*Etheostoma caeruleum*	1
River carpsucker	*Carpiodes carpio*	1
Shorthead redhorse	*Moxostoma macrolepidotum*	1
Total		**1,156**

305(b)/303(d) Data

Clean Water Act Sections 305(b) and 303(d) require states to conduct water quality assessments, identify waters that do not or are not expected to meet state water quality standards, and rank these waters based on the severity of pollution and the designated uses of the waters. In accordance with the Clean Water Act, IDEM develops a 303(d) List of Impaired Waters every two years from data collected during 305(b) water quality assessments (IDEM, 2008b).

A summary of Brandywine Creek Watershed 303(d) data is included in Table 29. There are five possible category ranks assigned to different use types for designated stream assessment units. Brandywine Creek Watershed stream resources support three use types including recreational use, fishable use, and aquatic life use. A stream assessment unit is assigned to Category 1 when water quality standards and other applicable criteria for all designated uses are being attained and no use is threatened. No Brandywine Creek Watershed stream assessment units were assigned Category 1. Category 2 stream assessment units are attaining some of the designated uses, no use is threatened, and insufficient data and information are available to determine if the remaining uses are attained or threatened. Stream assessment units with insufficient data and information to determine if any designated use is attained are assigned Category 3. Category 4 indicates that a stream assessment unit is impaired or threatened for one or more designated uses, but does not require development of a total maximum daily load (TMDL). A stream assessment unit is assigned Category 5 when water quality standards or other applicable criteria are not attained (IDEM, 2010b). Two sections of Brandywine Creek in Shelby County totaling 4.8 kilometers (3 miles) are listed as impaired for *E. coli* on the 2008 303(d) List (Figure 33).

Table 29. 2008 303(d) List Data

Assessment Unit Name	Assessment Unit ID	12-Digit HUC	County	Category Rank			*E. coli* Impairment
				Recreational Use	Fishable Use	Aquatic Life Use	
Brandywine Creek-Willow Branch tributaries	INW0441_00	51202040301	Hancock	2	3	2	
Brandywine Creek	INW0441_T1021	51202040301	Hancock	2	3	2	
Richey Ditch tributaries	INW0442_00	51202040302	Hancock	2	3	2	
Brandywine Creek	INW0442_T1022	51202040302	Hancock	2	3	2	
Potts Ditch tributaries	INW0443_00	51202040302	Hancock	2	3	2	
Brandywine Creek	INW0443_T1023	51202040302	Hancock	2	3	2	
Little Brandywine Creek	INW0444_00	51202040302	Hancock	2	3	2	
Andis Ditch tributaries	INW0445_00	51202040303	Shelby	4A	3	2	
Brandywine Creek	INW0445_T1024	51202040303	Hancock	2	3	2	
Hills Branch	INW0446_00	51202040303	Shelby	2	3	2	
Brandywine Creek	INW0446_T1025	51202040303	Shelby	2	3	2	
Brandywine Creek (upstream of Swamp Creek)	INW0447_00	51202040304	Shelby	2	3	2	
Brandywine Creek (downstream of Swamp Creek)	INW0447_01	51202040304	Shelby	5A	3	2	x
Buck Ditch	INW0447_T1001	51202040304	Shelby	2	3	2	
Swamp Creek	INW0447_T1002	51202040304	Shelby	2	3	2	
Brandywine Creek	INW0448_00	51202040304	Shelby	5A	3	2	x
Clark Ditch	INW0448_T1001	51202040304	Shelby	2	3	2	

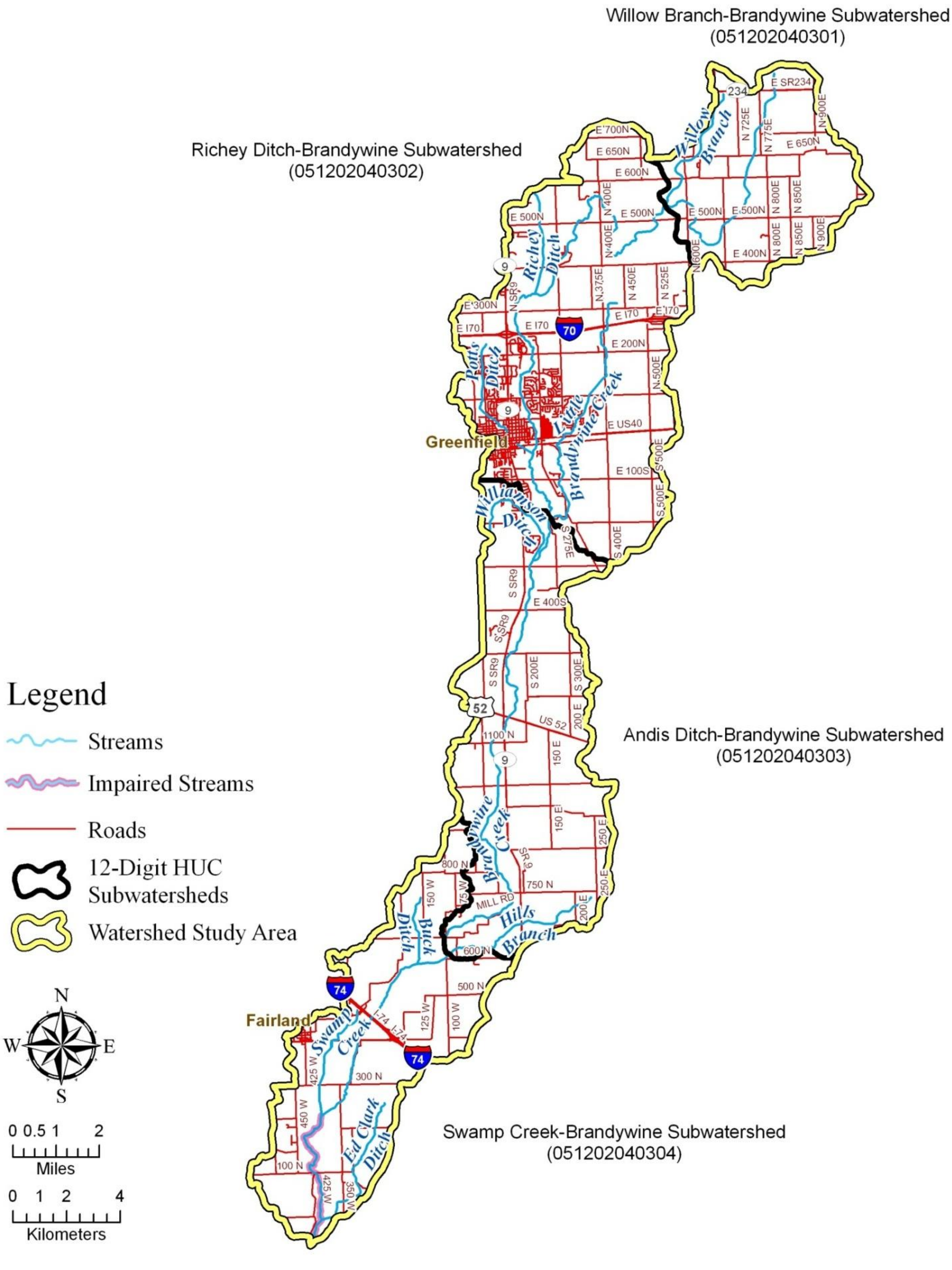

Figure 33. 303(d) List Impaired Streams

Watershed Regulated Land Uses Data

NPDES Facilities

The National Pollutant Discharge Elimination System (NPDES) permit program administered by IDEM regulates pollutants discharged to waters of the State from point sources. Effluent samples are collected on a daily basis for analysis and reports containing the data are sent to IDEM monthly. The Greenfield Municipal Waste Water Treatment Plant (WWTP) maintains an active NPDES permit (permit #IN0020109). It is located at 809 South State Street in Greenfield, Indiana. The Indiana National Guard Armory WWTP located at 3356 North Michigan Road near I-74 in Shelby County also maintains an active NPDES permit (permit #IN0109479).

There are no combined sewer overflows (CSOs) in the Greenfield wastewater collection system. A sanitary sewer overflow NPDES pipe draining to Brandywine Creek is located east of the Greenfield WWTP (Figure 34). Sanitary sewer overflows to Brandywine Creek have rarely occurred. The last overflow occurred on June 21, 2010, as a result of excessive rainfall and amounted to an estimated 700,000 gallons of raw sewage being released to Brandywine Creek (IDEM, 2010d - Virtual File Cabinet [VFC] #63067640). Greenfield WWTP was last inspected on May 17, 2011 and no violations were recorded. Daily and monthly monitoring data were reviewed from May, 2010 to April, 2011, as part of the inspection and found satisfactory (IDEM, 2010d - VFC #63067640).

Tables 30 and 31 depict Greenfield WWTP monitoring requirements as expressed in the NPDES permit. The Greenfield WWTP is not currently required to monitor total phosphorus. A large spike in total phosphorus was observed at the time of base and storm flow monitoring immediately downstream of the Greenfield WWTP sanitary sewer overflow. The WWTP is suspected to contribute significantly to total phosphorus loading in Brandywine Creek Watershed. Total phosphorus will be added to the Greenfield WWTP NPDES permit as a monitoring requirement when the permit comes up for renewal as it is now required by USEPA (K. Hagan, personal communication, October 31, 2011). The current permit expires September 30, 2014.

Table 30. Greenfield WWTP Effluent Monitoring Requirements - 1

Parameter	Maximum Load (lb./day)		Maximum Concentration (mg/L)		Measurement Frequency	Sample Type
	Monthly Average	Weekly Average	Monthly	Weekly		
$CBOD_5$[1] – summer[2]	835	1,252	10	15	5 times weekly	24-hour composite
$CBOD_5$ – winter[3]	2,086	3,338	25	40	5 times weekly	24-hour composite
TSS – summer[2]	1,001	1,502	12	18	5 times weekly	24-hour composite
TSS – winter[3]	2,504	3,755	30	45	5 times weekly	24-hour composite
Ammonia nitrogen – summer[2]	108	159	1.3	1.9	5 times weekly	24-hour composite
Ammonia nitrogen – winter[3]	159	242	1.9	2.9	5 times weekly	24-hour composite

[1] Carbonaceous biochemical oxygen demand ($CBOD_{5)}$ is a method used to determine the concentration of biodegradable carbonaceous materials in effluent by measuring the depletion of dissolved oxygen by biological organisms in a water sample over a five day period

[2] Winter is defined as December 1 through April 30

[3] Summer is defined as May 1 through November 30

Table 31. Greenfield WWTP Effluent Monitoring Requirements - 2

Parameter	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
Dissolved oxygen - summer[1]	6.0 mg/L	n/a	n/a	5 times weekly	4 grabs/24 hours
Dissolved oxygen - winter[2]	5.0 mg/L	n/a	n/a	5 times weekly	4 grabs/24 hours
pH	6.0	n/a	9.0	5 times weekly	grab
E. coli	n/a	125 CFU/100 mL	235 CFU/100 mL	5 times weekly	grab

[1] Winter is defined as December 1 through April 30

[2] Summer is defined as May 1 through November 30

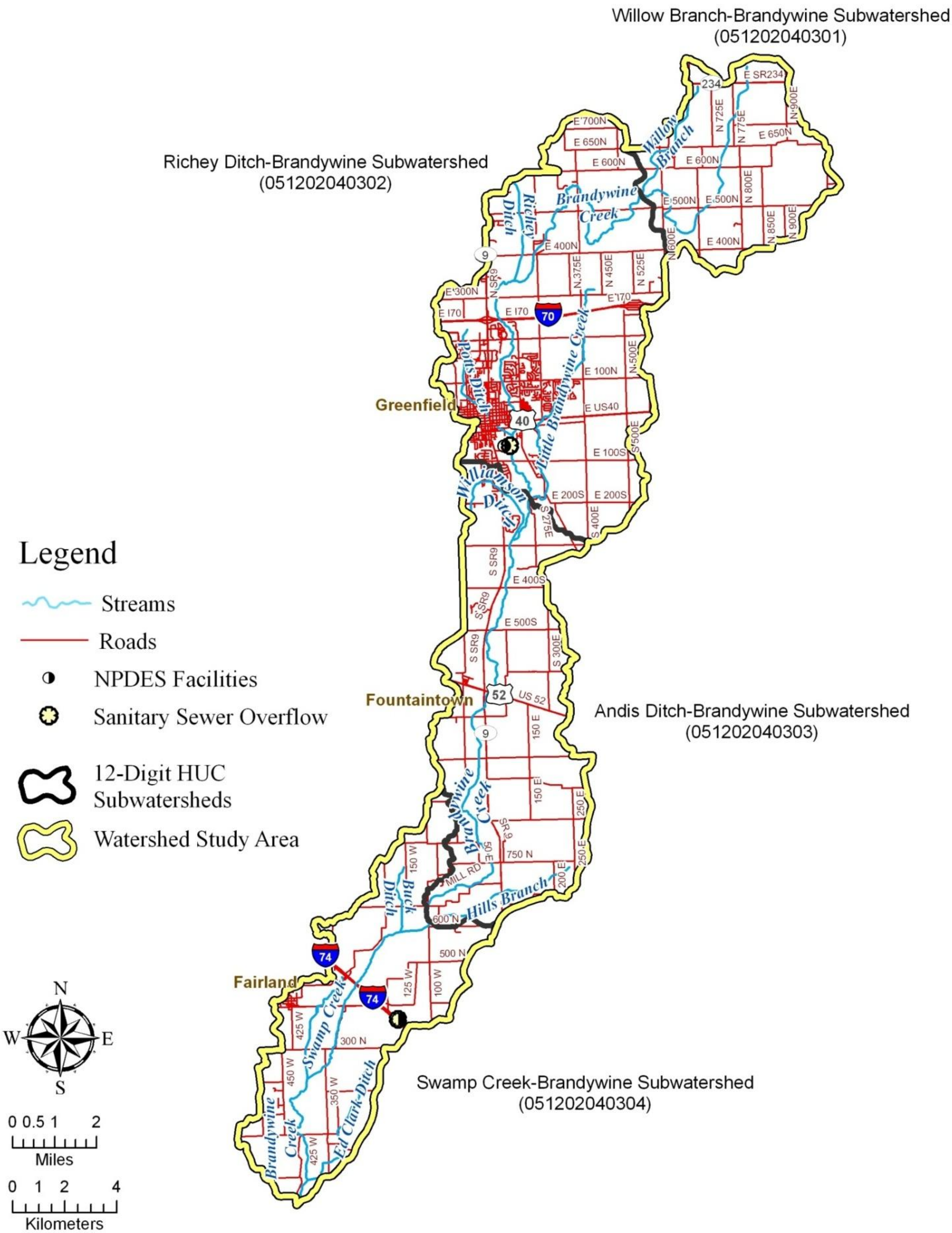

Figure 34. Sanitary Sewer Overflows Map

Indiana National Guard Armory WWTP has a NPDES sanitary sewer overflow pipe that drains to the headwaters of Ed Clark Ditch, a tributary to Brandywine Creek (Figure 34). There are no CSOs in the Indiana National Guard Armory sewer system. The Indiana National Guard Armory WWTP was last inspected by IDEM on December 17, 2008. No violations were observed at the time of the inspection (IDEM, 2010d - VFC #59980121).

Tables 32 and 33 depict Indiana National Guard Armory WWTP monitoring requirements as expressed in the NPDES permit.

Table 32. Indiana National Guard Armory WWTP Effluent Monitoring Requirements - 1

Parameter	Maximum Load (lb./day)		Maximum Concentration (mg/L)		Measurement Frequency	Sample Type
	Monthly Average	Weekly Average	Monthly	Weekly		
$CBOD_5$ – summer[1]	0.5	0.8	15	23	1 time weekly	24-hour composite
$CBOD_5$ – winter[2]	0.8	1.3	25	40	1 time weekly	24-hour composite
TSS - summer[1]	0.6	0.9	18	27	1 time weekly	24-hour composite
TSS - winter[2]	1.0	1.5	30	45	1 time weekly	24-hour composite
Ammonia nitrogen - summer[1]	0.04	0.05	1.1	1.6	1 time weekly	24-hour composite
Ammonia nitrogen - winter[2]	0.05	0.08	1.6	2.4	1 time weekly	24-hour composite

[1] Winter is defined as December 1 through April 30

[2] Summer is defined as May 1 through November 30

Table 33. Indiana National Guard Armory WWTP Effluent Monitoring Requirements - 2

Parameter	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency	Sample Type
Dissolved oxygen - summer[1]	6.0 mg/L	n/a	n/a	2 times weekly	2 grabs/24 hours
Dissolved oxygen - winter[2]	5.0 mg/L	n/a	n/a	2 times weekly	2 grabs/24 hours
pH	6.0	n/a	9.0	2 times weekly	grab
E. coli	n/a	125 CFU/100 mL	235 CFU/100 mL	1 times weekly	grab
Total Residual Chlorine		0.01 mg/L	0.02 mg/L	2 times weekly	grab

[1] Winter is defined as December 1 through April 30

[2] Summer is defined as May 1 through November 30

NPDES Facilities Biosolids Application Sites

The Greenfield WWTP and Shelbyville WWTP produce biosolids as a byproduct of sewage treatment. Biosolids are primarily organic matter and may contain nutrients such as nitrogen, phosphorus, potassium, zinc, calcium, magnesium, and iron as well as water, bacteria, and various pollutants (IDEM, 2011a). Biosolids are usually spread on land or injected below the land surface as a soil amendment.

IDEM issues two types of permits for land application of biosolids. One permit is for site-specific application locations and lists approved sites on which a permittee may apply the biosolids. The second type of permit authorizes biosolids to be used on any agricultural land within the specified counties. A hybrid permit combining the two other types may also be issued. As of 2009, Greenfield upgraded the class of treated biosolids that it produces to contain lower bacteria counts than the biosolids it previously produced. Consequently, land application sites for biosolids from the Greenfield WWTP are no longer tracked and biosolids are available to the general public. All biosolids users are recorded and given an information sheet with recommended application rates based upon nutrient content and a notice that the application of the biosolids except as indicated with the instructions is prohibited (IDEM, 2010d - VFC #59728442). Greenfield WWTP historic land application sites encompassing 22 hectares (55 acres) are depicted in Figure 35. Shelbyville WWTP produces biosolids for site-specific and non-site specific land application sites. Figure 35 includes both historic and current site-specific land application sites encompassing 13 hectares (32 acres) in Brandywine Creek Watershed for biosolids from the Shelbyville WWTP (J. Harmon, personal communication, August 25, 2011).

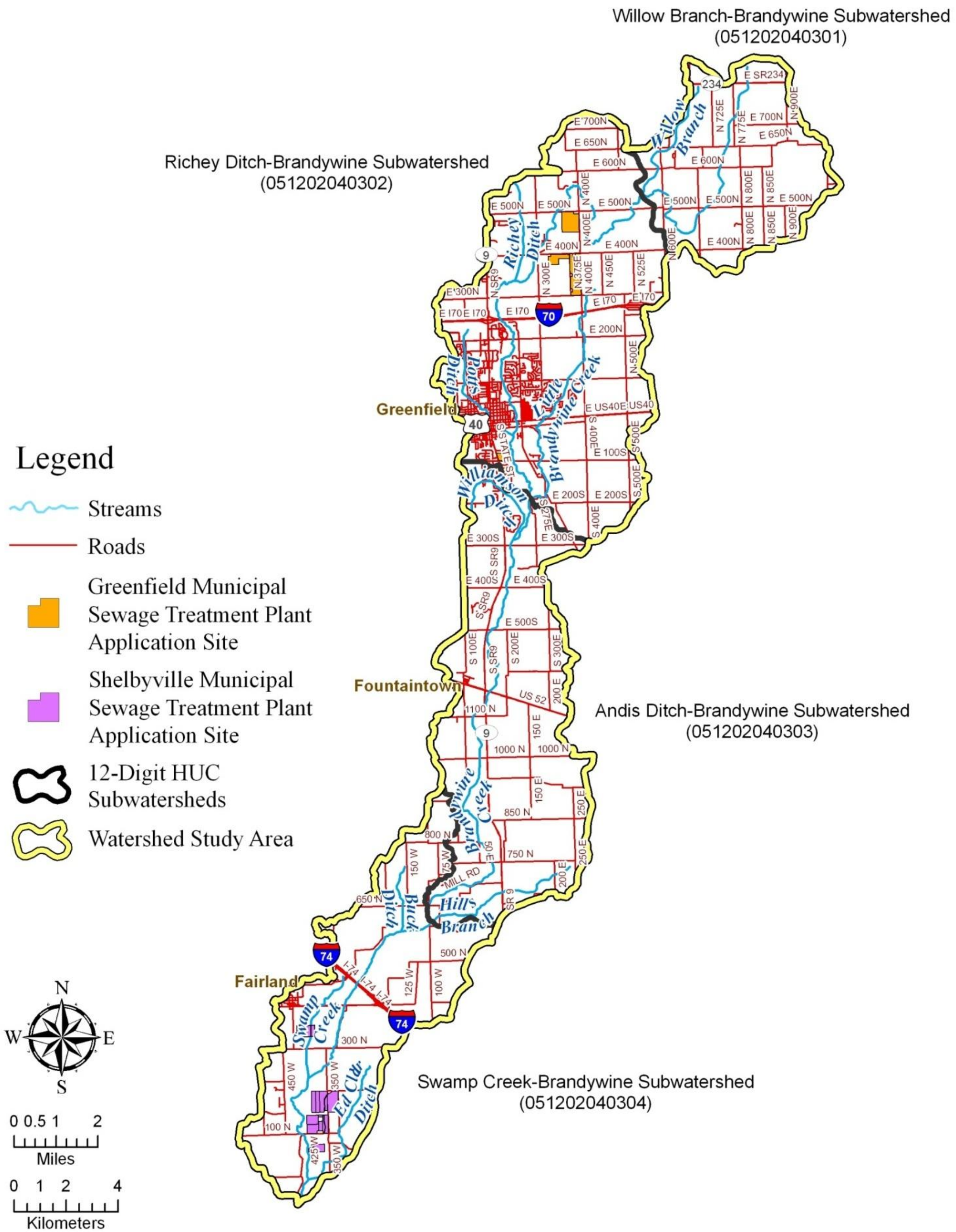

Figure 35. Municipal Sludge Application Sites

Brownfields, LUSTs, and Other Remediation Sites

A brownfield is defined by the State of Indiana as a parcel that is abandoned or inactive or may not be operated at its appropriate use and on which expansion, redevelopment or reuse is complicated because of the presences or potential presence of a hazardous substance, a contaminant, petroleum, or a petroleum product that poses a risk to human health and the environment (IDEM, 2011b). One brownfield located in Fairland was identified in the watershed (Figure 36). The site was designated as a brownfield due to soil and groundwater contamination from petroleum (IDEM, 2010d; Document # 41403976).

There are two Voluntary Remediation Program (VRP) sites in the watershed and four other environmental cleanup sites, and 11 industrial waste sites (Figure 36).

IDEM regulates underground storage tanks (USTs). Most USTs store petroleum products, but some may hold other hazardous materials such as industrial chemicals and pesticides (IDEM, 2011c). These tanks are placed underground to lessen the risk of explosion. Tanks were historically made of unprotected steel and would rust and leak. Leaking underground storage tanks (LUSTs) can easily contaminate groundwater. Surface water is also impacted in some instances. A total of 24 LUSTs were identified in the watershed (Figure 37). The largest concentration of LUSTs is located in Greenfield and several are located in Fairland. One LUST affecting groundwater is located approximately 55 meters (60 yards) west of Brandywine Creek on Main Street in Greenfield. However, it does not appear to have affected Brandywine Creek (IDEM, 2010d - VFC #51806781). No other LUSTS near streams were reported to affect surface or ground water.

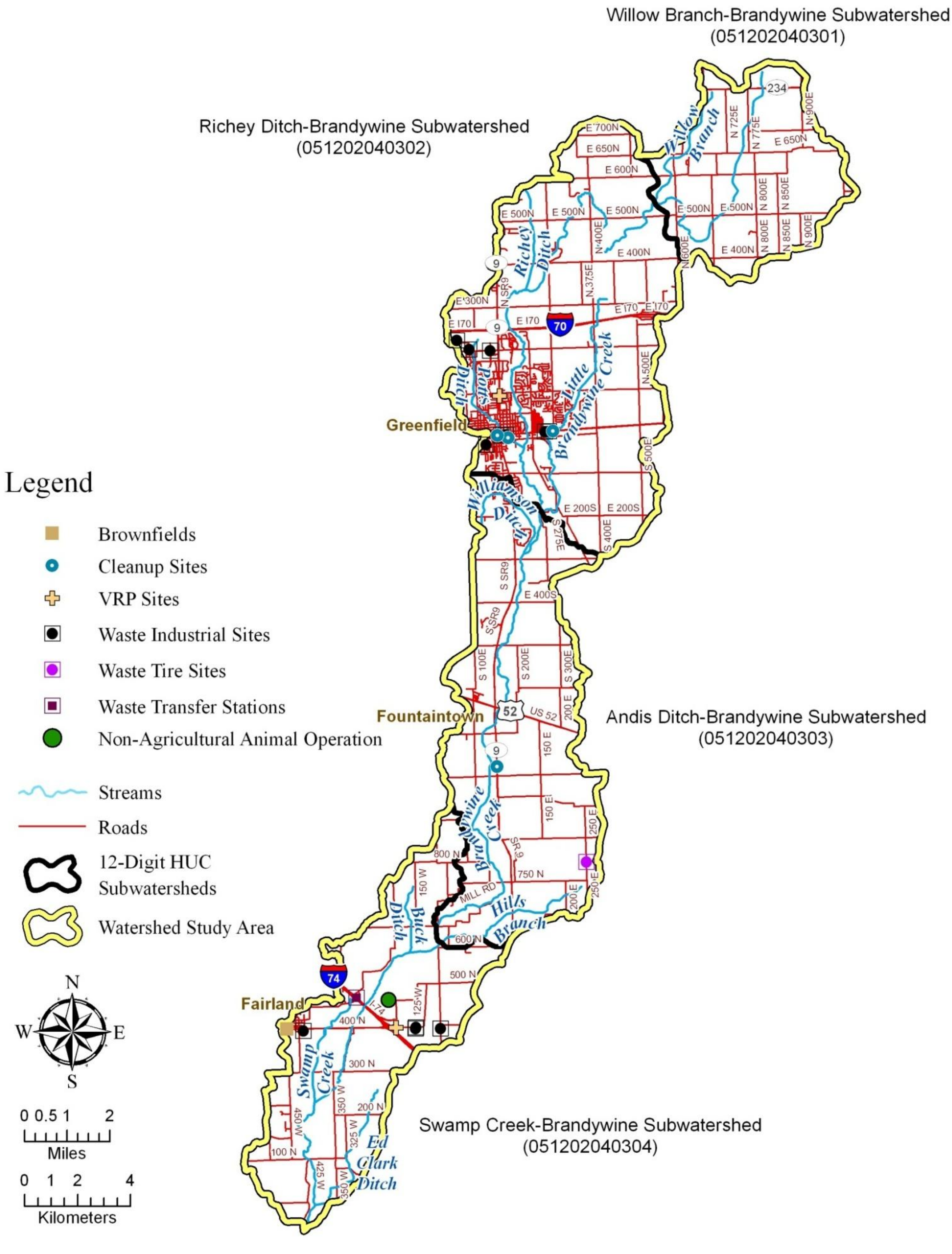

Figure 36. Environmental Sites Map

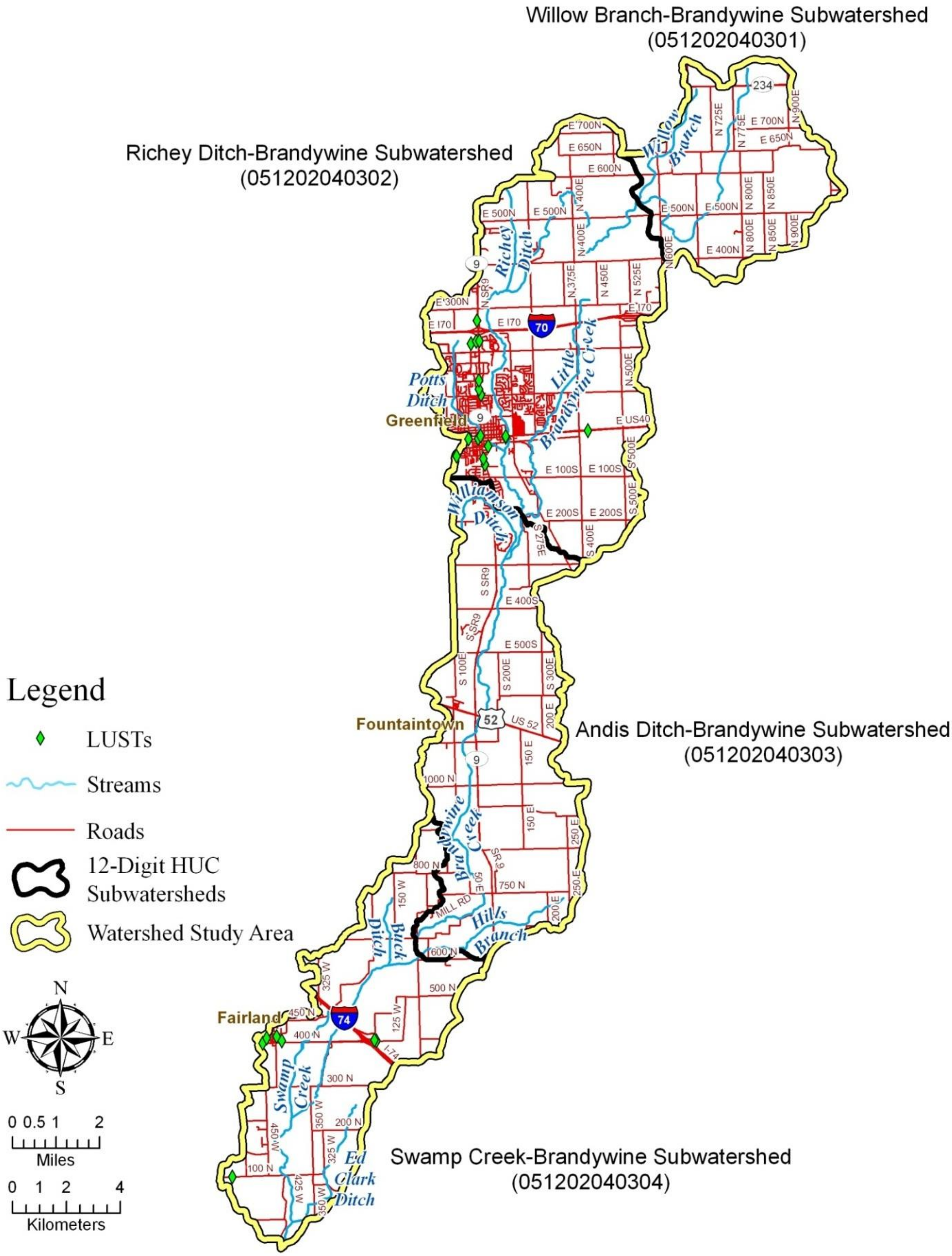

Figure 37. Leaking Underground Storage Tanks Map

Confined Feeding Operations

Confined feeding operations (CFOs) are livestock facilities regulated by the Indiana Department of Environmental Management. To be classified as a confined feeding operation, the operation must confine a minimum of 300 cattle, 600 swine or sheep, or 30,000 fowl for at least 45 days during the year in an area where there is no ground cover present over a minimum of half of the confinement area. CFOs typically collect and store manure and wastewater in pits, tanks, or lagoons on site. Collected manure is later applied to fields as fertilizer. The Indiana Department of Environmental Management (IDEM) regulates CFOs to assure that waste storage structures are properly designed and functioning and that manure is applied to land in an environmentally acceptable manner (IDEM, 2010a). CFOs can provide notable threats to water quality when manure storage devices fail or when manure is not applied to fields in accordance with permit conditions.

CFOs having exceptionally large numbers of animals or that have had historical compliance issues are defined as concentrated animal feeding operations (CAFOs). CAFOs are regulated by IDEM under the NPDES program. Animal number thresholds to meet the CAFO designation include 700 mature dairy cows, 1,000 veal calves, 1,000 cattle other than mature dairy cows, 2,500 swine greater than 55 pounds, 10,000 swine less than 55 pounds, 500 horses, 10,000 sheep, 55,000 turkeys, 30,000 laying hens or broilers with a liquid manure handling system, 125,000 broilers with a solid manure handling system, 82,000 laying hens with a solid manure handling system, 30,000 ducks with a solid manure handling system, and 5,000 ducks with a liquid manure handling system.

There are eight CFOs in Brandywine Creek Watershed with active permits (Figure 38). There are an additional four facilities in the watershed that have historically held a CFO permit, but the permits are currently void due to the facilities being empty or having animal numbers below the threshold requiring a permit. Manure from active CFOs is spread throughout the watershed and outside of the watershed boundary. No records available through IDEM Virtual File Cabinet indicate permit violations due to improper handling of manure or other concerns that would influence water quality. No CFOs had animal quantities exceeding CAFO thresholds (IDEM, 2010d).

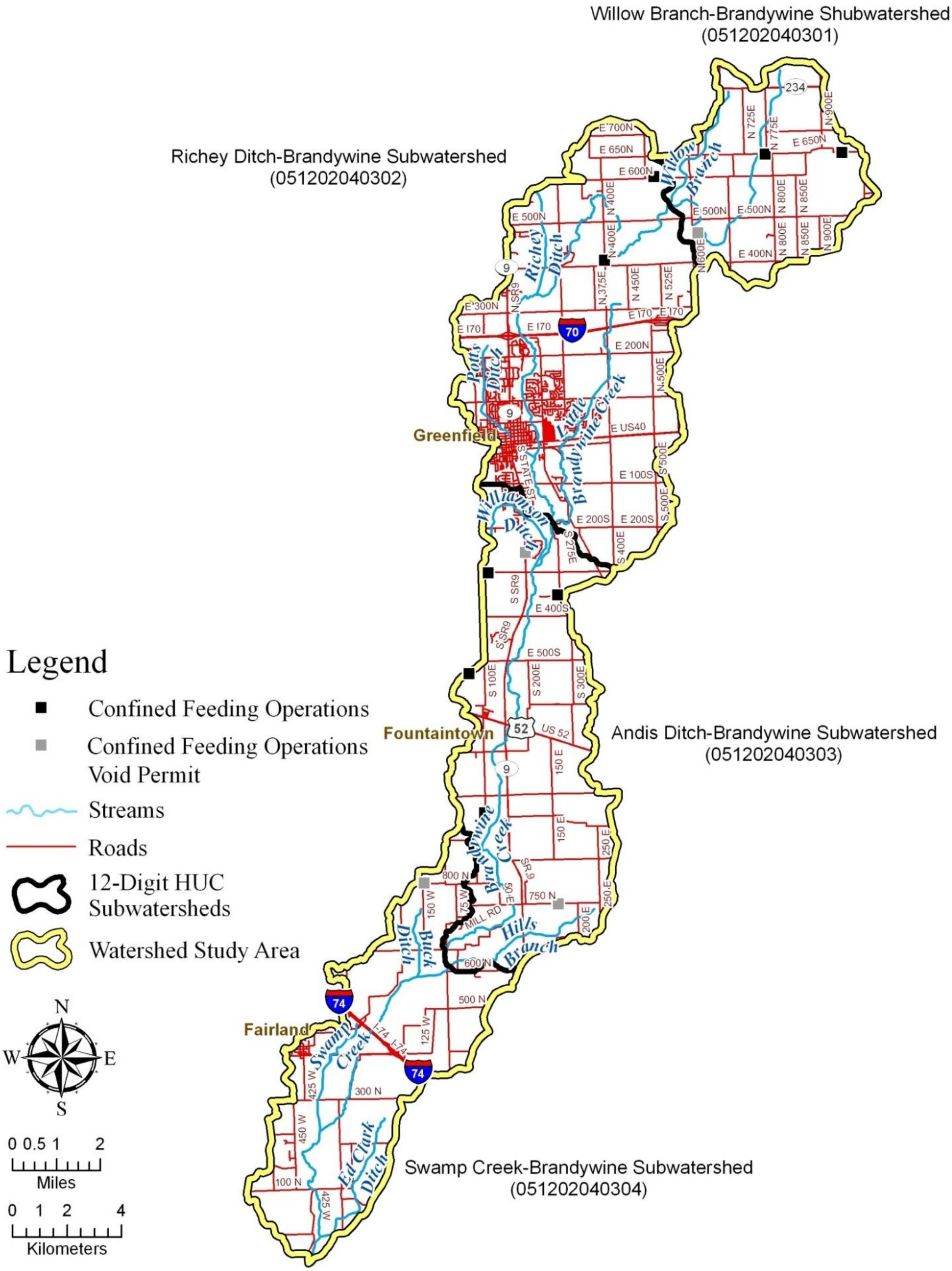

Figure 38. Confined Feeding Operations Map

Subwatershed Discussions

The 10-digit HUC Brandywine Creek Watershed (0512020403) is further subdivided into four, 12-digit HUC subwatersheds. These subwatersheds include: Willow Branch Subwatershed (051202040301); Richey Ditch Subwatershed (051202040302); Andis Ditch Subwatershed (051202040303); Swamp Creek Subwatershed (051202040304). Further discussion of water quality and land use data specific to each subwatershed ensues.

A desktop survey of the entire watershed was conducted by reviewing the most recent high-resolution, digital aerial photographs available for the watershed. Aerial images dated February 28, 2005 were reviewed for Willow Branch Subwatershed. Aerial images dated May 5, 2010 were available for all but the eastern most edge of Richey Ditch Subwatershed where 2005 aerials were the most current. Aerial images from 2010 were available for the entire Andis Ditch and Swamp Creek Subwatersheds. Aerial photographs were inspected for width of riparian areas adjacent to streams and evidence of gully erosion in fields. Areas having less than 6 meters (20 feet) of natural vegetation on either side of a stream are depicted in Figure 39 as being most critical in need of filter strip or riparian buffer installation.

Approximately one-third of watershed county roads were driven by Davey as part of a windshield survey to ground truth the desktop survey and look for evidence of additional factors that may influence water quality. Notes were taken on a map of the watershed to document observations. Other observations were supplied by steering committee members. Areas identified where streambank stabilization measures could be implemented, log jam locations, areas of gully erosion, locations where livestock have access to streams, and a potential wetlands restoration site are also depicted on Figure 39.

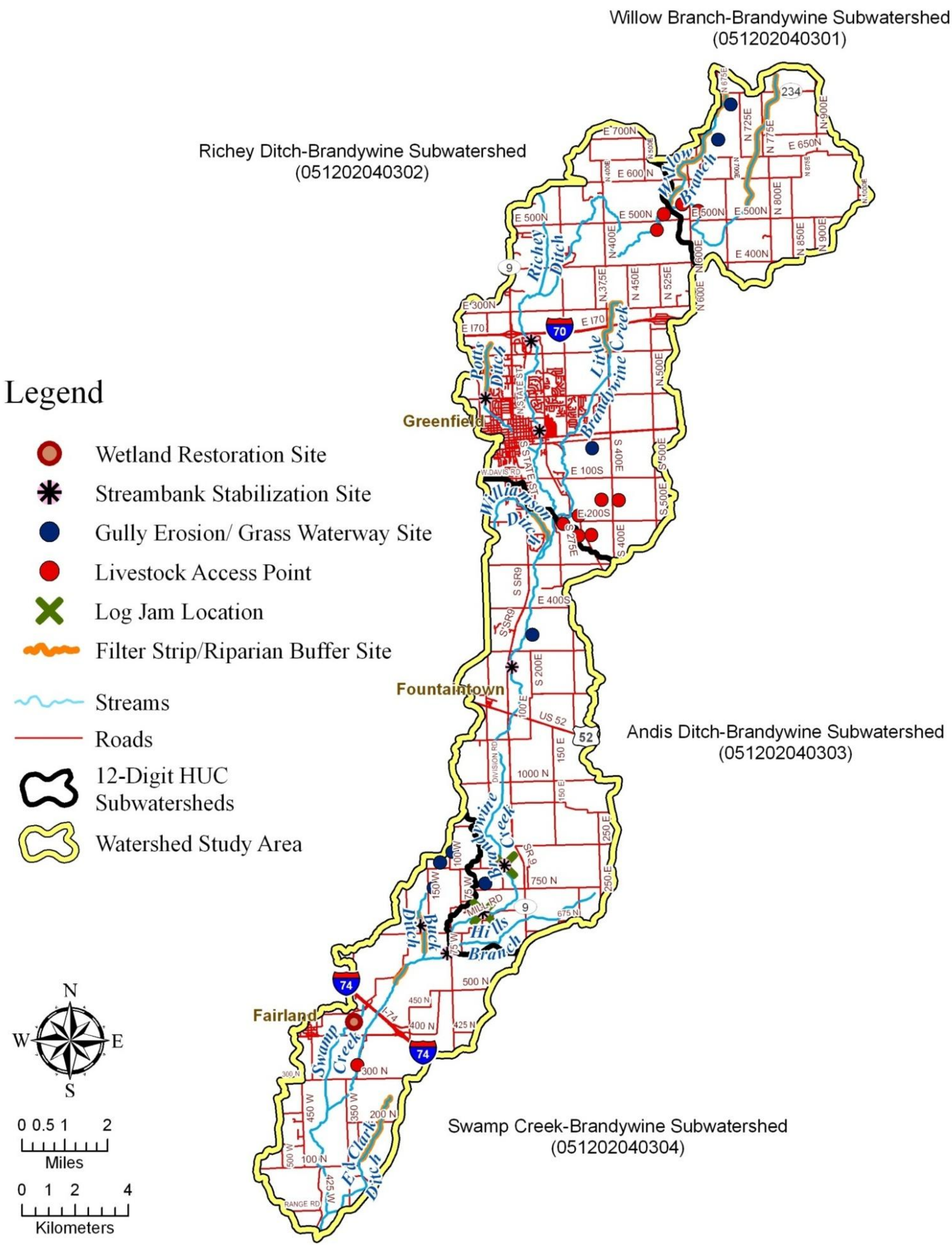

Figure 39. BMP Potential Implementation Sites

Willow Branch-Brandywine Creek Subwatershed (051202040301)

The Willow Branch Subwatershed is the upstream most 12-digit HUC subwatershed in Brandywine Creek Watershed. It is the smallest subwatershed encompassing 4,136 hectares (10,220 acres). Brandywine Creek and Willow Branch as well as numerous unmapped ditches are located in this subwatershed. Brandywine Creek and Willow Branch headwaters begin just north of State Route (SR) 234 and continue southwest to the point where Willow Branch drains to Brandywine Creek just west of CR 600 East and south of CR 600 North in Hancock County. The entire Willow Branch Subwatershed is in Hancock County.

Water Quality and Habitat Data Summary

Two sample sites were established in the Willow Branch Subwatershed as part of this study. Table 34 depicts the tested parameters exceeding water quality standards or targets. *E. coli*, nitrate+nitrite, ammonia nitrogen, and TKN samples exceeded standards and targets at both sample sites at the time of base flow and storm flow sampling. Total phosphorus, TSS, and turbidity exceeded targets at the time of storm flow sampling only. QHEI indicated that the habitat at both sites was impaired for aquatic life use; however, analyses of macroinvertebrate communities did not indicate the presence of severe pollution and aquatic life impairment.

Table 34. Willow Branch Subwatershed Data Exceeding Water Quality Standards/Targets

Sample Site	*E. coli*		Total Phosphorus		Nitrate+ Nitrite		Ammonia Nitrogen		TKN		TSS		Turbidity		Habitat	Macro-invertebrates		
																mIBI	HBI	RBPII
	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Base Flow		
Site 1	x	x		x	x	x	x	x	x	x		x		x	x			
Site 7	x	x		x	x	x	x	x	x	x		x		x	x			

Land Use Summary

The Willow Branch Subwatershed has the greatest percentage of cultivated cropland and least amount of developed land of the four subwatersheds in Brandywine Creek Watershed according to 2001 NLCD data. This subwatershed also has the lowest percentage of pasture/hay, grassland, and forest and scrub/shrub habitats (Figure 40).

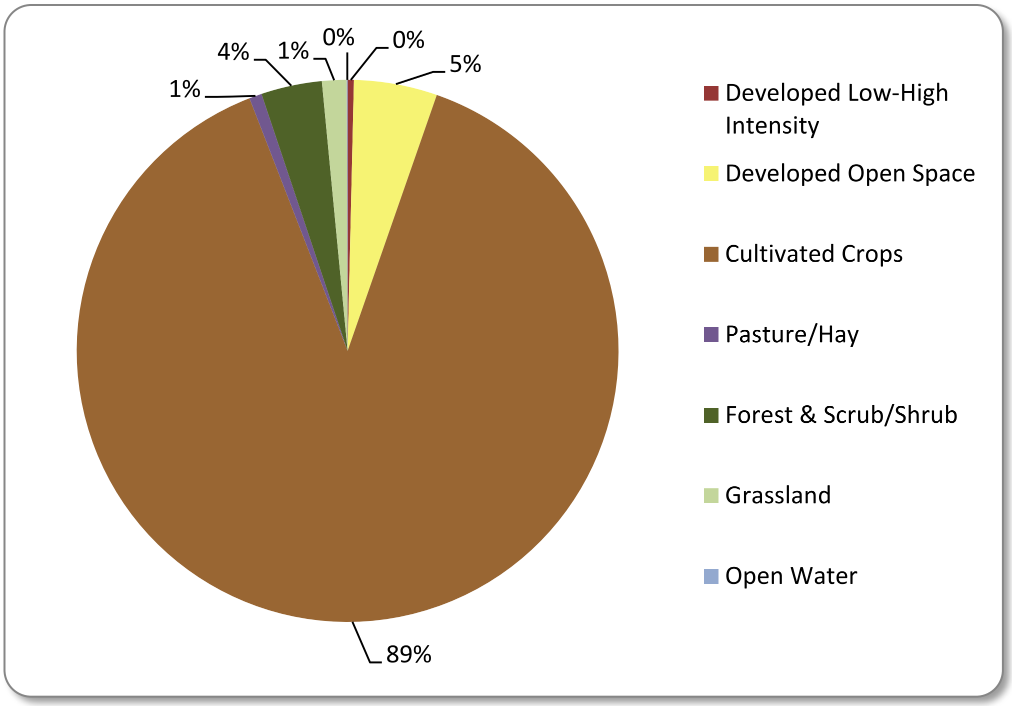

Figure 40. Willow Branch Subwatershed Land Use Percentage Graph

Windshield and Desktop Survey

The Willow Branch Subwatershed is predominantly rural consisting of cultivated land with scattered rural residences and farmsteads. Davey traveled numerous roads crisscrossing the subwatershed as part of a windshield survey conducted to document factors in the subwatershed influencing water quality. There were neither hobby farms nor non-agricultural animal feeding operations observed in this subwatershed. Inadequate riparian buffers and filter strips for pollutant filtering were observed in many locations adjacent to NHD mapped streams and unmapped ditches in the subwatershed. Locations adjacent to NHD mapped streams where filter strips or riparian buffers would be beneficial for water quality that were observed via the windshield and/or a desktop survey analysis of 2005 aerial photography are depicted on Figure 39. A summary of all issues observed in the subwatershed is included in Table 35.

Table 35. Willow Branch Subwatershed Windshield/Desktop Survey Data

Potential Negative Water Quality Influence	BMP Needed	Location	Survey Type	Observer
Gully erosion	Grass waterway	Fields adjacent to Willow Branch south of SR 234	Desktop	Davey
Livestock with direct access to stream (historic evidence; cattle not observed)	Fencing/alternative water source	Brandywine Creek east and west of CR 600 East approximately 0.9 km (0.55 mi.) south of CR 600 North	Windshield	Davey
Livestock with direct access to stream	Fencing/alternative water source	Brandywine Creek south and north of CR 500 North approximately 0.4 km (0.25 mi.) east of CR 500 East	Windshield	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Brandywine Creek headwaters to approximately 0.7 km (0.45 mi.) south of CR 600 North	Desktop	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Unmapped tributary to Brandywine Creek west of CR 800 E and south of CR 600 North	Desktop	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Unmapped tributaries to Brandywine Creek north of the intersection of CR 900 East and CR 500 North	Desktop	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Willow Branch north and south of SR 234	Desktop	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Willow Branch north of CR 600 North	Windshield	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Willow Branch south of CR 600 North	Desktop	Davey

Regulated Land Use

Two CFOs known as D & P Swine Farms and Condo Farms are located on CR 650 North in the subwatershed. The Condo Farms permit authorizes the farm to have 250 nursery pigs and 950 grow-to-finish hogs in four production buildings (IDEM, 2010d - VFC #51758943). No additional data were found for D & P Swine Farms.

Industry

There is not a significant industry component present in the subwatershed at this time.

Future Development and Open Space

There are no known plans for future development in the subwatershed at this time. Nor are there currently any properties preserved as open space in the subwatershed.

Fertilizer Application

The Willow Branch-Brandywine Creek Subwatershed is predominantly rural consisting of scattered rural residences and farmsteads; consequently, the vast majority of fertilizer applied in the subwatershed is applied to cropland cultivated for commodity crops. The amount of fertilizer applied to corn and soybean fields in the subwatershed in 2009 is estimated to have included approximately 397,000 kilograms (882,000 pounds) of nitrogen and 121,359 kilograms (270,000 pounds) of phosphorus based on statewide fertilizer sales and corn and soybean acreages in 2009 (USDA, 2011b).

Richey Ditch-Brandywine Creek Subwatershed (051202040302)

The Richey Ditch Subwatershed begins downstream of the point where Willow Branch drains to Brandywine Creek to downstream of the point where Little Brandywine Creek drains to Brandywine Creek south of Greenfield. This subwatershed is the largest of the four subwatersheds and encompasses a total of 9,747 hectares (24,085 acres). NHD mapped tributaries to Brandywine Creek in this subwatershed include Richey Ditch, which drains primarily agricultural and rural residential land north of Greenfield; Potts Ditch, which drains urban land in Greenfield; and Little Brandywine Creek, which drains both agricultural and suburban land east of Greenfield. The entire Richey Ditch Subwatershed is in Hancock County.

Water Quality and Habitat Data Summary

Multiple water quality parameters were tested at five sites in the Richey Ditch Subwatershed (Table 36). In addition, *E. coli* was sampled at Riley Park due to the fact that children play in the creek at the park. *E. coli* only exceeded water quality standards at Riley Park at the time of storm flow sampling along with all other sample sites in the subwatershed. Sites 2 and 3 on Brandywine Creek as well as Site 9 on Potts Ditch exceeded *E. coli* standards at the time of base flow sampling as well as storm flow sampling. Nitrogen was consistently high at sample points throughout the subwatershed. Ammonia nitrogen and TKN exceeded standards and targets in 100% of the subwatershed samples. Nitrate+nitrite exceeded the target in 80% of the samples.

Total phosphorus exceeded the water quality target in 70% of subwatershed samples. A large spike in total phosphorus was observed at Site 3 on Brandywine Creek at the time of base flow sampling. Site 3 is located just downstream of the Greenfield WWTP sanitary sewer overflow. It is suspected that the large spike in total phosphorus at this sample site can be attributed to effluent from the Greenfield WWTP. The NPDES permit does not include a condition requiring total phosphorus concentrations in the effluent to be monitored. The Greenfield MS4 District conducted dye testing of car washes in the City to ensure that there were no illicit discharges to the storm sewer system contributing to total phosphorus load.

High TSS and turbidity values were only recorded at the time of storm flow sampling and were to be expected given the significant rain event. Habitat was impaired for aquatic life use as determined by the QHEI analysis at Site 8 on Richey Ditch and Site 10 on Little Brandywine Creek. Both streams were historically channelized and had significant quantities of silt in the substrate. The macroinvertebrate community was severely impaired at Site 10 per mIBI, and had very substantial organic pollution likely per HBI.

QHEI assessments indicated that Site 2 has the highest quality habitat in Brandywine Creek Watershed. The macroinvertebrate community was severely impaired per mIBI, and HBI indicated severe organic pollution likely. Poor water quality is suspected to be the primary factor negatively affecting the macroinvertebrate community in this location due to the presence of high-quality habitat.

Table 36. Richey Ditch Subwatershed Data Exceeding Water Quality Standards/Targets

Sample Site	*E. coli*		Total Phosphorus		Nitrate+ Nitrite		Ammonia Nitrogen		Total Kjeldahl Nitrogen		TSS		Turbidity		Habitat	Macro-invertebrates		
																mIBI	HBI	RBPII
	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Base Flow		
Site 2	x	x		x	x	x	x	x	x	x		x		x		x	x	
Site 3	x	x	x	x	x	x	x	x	x	x		x		x				
Site 8		x		x		x	x	x	x	x				x	x	x		
Site 9	x	x	x	x		x	x	x	x	x		x		x				
Site 10		x		x	x	x	x	x	x	x		x		x	x	x	x	
Riley Park		x	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

Land Use Summary

The Richey Ditch Subwatershed contains a mixture of agricultural land as well as highly developed industrial, commercial, and urban and suburban residential properties. This subwatershed has the greatest percentage of developed land in Brandywine Creek Watershed with 20% of the subwatershed developed as open space or in low- to high-intensity development (Figure 41). Consequently, this subwatershed also has the least percentage of cultivated cropland.

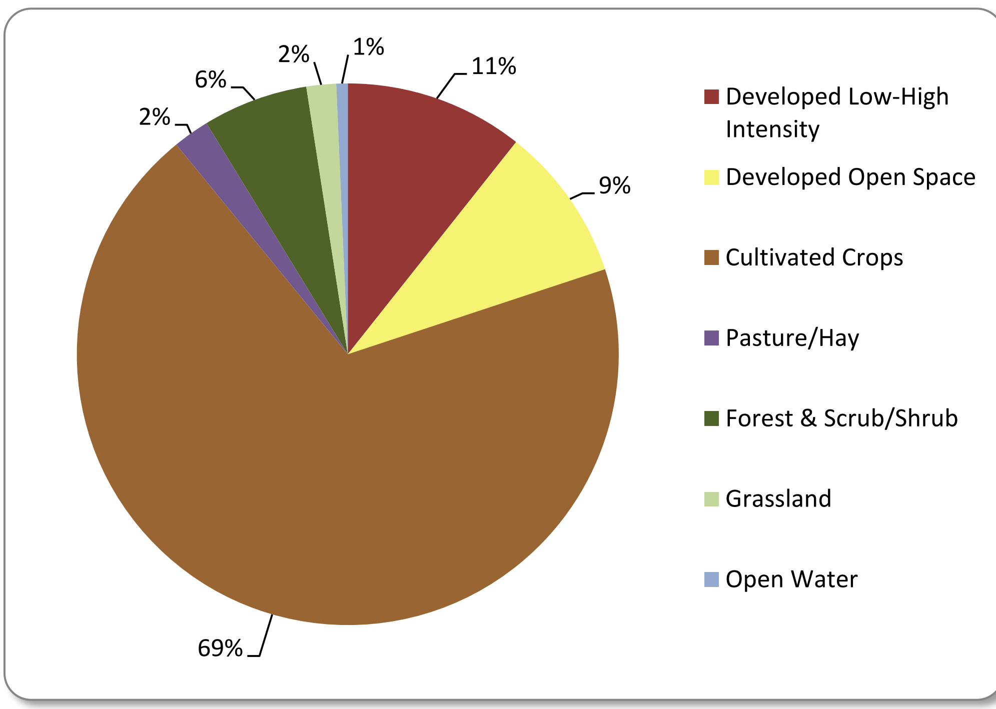

Figure 41. Richey Ditch Subwatershed Land Use Percentage Graph

Windshield and Desktop Survey

Numerous factors capable of influencing water quality were observed during desktop and windshield surveys of the Richey Ditch Subwatershed. These factors included golf courses and pastures directly adjacent to streams as well as areas of streambank erosion. A desktop analysis of 2005 and 2010 aerial photographs further revealed areas where a grass waterway and filter strips may be beneficial. Areas in need of filter strips or riparian buffers and streambank stabilization are depicted on Figure 39. A junk yard containing hundreds of automobiles was identified north of Greenfield near 5400 East CR 600 North during a windshield survey. This junk yard was not identified in digital mapping data of regulated sites. A summary of issues observed in the subwatershed is included in Table 37.

Table 37. Richey Ditch Subwatershed Windshield/Desktop Survey Data

Potential Negative Water Quality Influence	BMP needed	Location	Survey Type	Observer
Athletic fields having high-intensity lawn management	Phosphorus-free fertilizer	Potts Ditch south of McKenzie Road	Windshield	Davey
Athletic fields having high-intensity lawn management	Phosphorus-free fertilizer	Brandywine Creek north of CR 100 South	Windshield	Davey
Athletic fields having high-intensity lawn management	Phosphorus-free fertilizer	Brandywine Creek north of Main Street	Desktop	Davey
Golf course having high-intensity lawn management	Phosphorus-free fertilizer	Adjacent to Brandywine Creek on CR 400 East south of CR 600 North	Windshield	Davey
Golf course having high-intensity lawn management and lacking riparian buffer	Phosphorus-free fertilizer; riparian buffer	Adjacent to Little Brandywine Creek east of Morristown Pike and south of Pennsy Trail	Desktop	Davey
Gully erosion	Grass waterway	Field south of Pennsy Trail and west of CR 400 East	Desktop	Davey
Livestock with direct access to stream	Fencing/alternative water source	Unmapped tributary to Little Brandywine Creek on the east and west sides of CR 400 East approximately 0.8km (0.5 mi.) south of CR 100 South	Windshield	Davey
Livestock with direct access to stream	Fencing/alternative water source	Unmapped tributary to Little Brandywine Creek on the east and west sides of Morristown Pike south of CR 200 South and north of CR 200 South west of Morristown Pike	Windshield	Davey
Livestock with direct access to stream	Fencing/alternative water source	Little Brandywine Creek south of Steele Ford Road	Windshield	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Little Brandywine Creek north and south of CR 300 North	Desktop	Davey
Row crops within 30 feet of top of bank	Filter strip/riparian planting	Little Brandywine Creek between I-70 and CR 200 North	Desktop	Davey
Streambank erosion	Two-stage ditch	Potts Ditch south of McKenzie Road	Windshield	Davey
Streambank erosion	Riparian vegetation planting or two-stage ditch	Unmapped tributary to Little Brandywine Creek on the east and west sides of Morristown Pike south of CR 200 South	Windshield	Davey
Streambank erosion	More information needed	Brandywine Creek in Riley Park	Windshield	Steering Committee
Streambank erosion	More information needed	Brandywine Creek in Henry B. Wilson Park	Windshield	Steering Committee
Automobile junk yard	n/a	Near 5400 East CR 600 North	Windshield	Davey
Automobile junk yard	n/a	Adjacent to Little Brandywine Creek south of CR 100 North	Desktop	Davey

Regulated Land Use

There are multiple sites in the Richey Ditch Subwatershed regulated by IDEM. These sites include a sanitary sewer overflow from the Greenfield WWTP, one VRP cleanup site, three other environmental cleanup sites, eight industrial waste sites, 17 LUSTs, and two CFOs. Biosolids from the Greenfield WWTP were historically applied to specific IDEM approved fields in the Richey Ditch Subwatershed. Biosolids can now be applied anywhere within Hancock County.

The sanitary sewer overflow directly contributes to pollutant loads in Brandywine Creek. The most recent inspection of the Greenfield WWTP revealed satisfactory conditions within the parameters required by the NPDES permit. The NPDES permit does not require Greenfield WWTP to monitor total phosphorus levels. Water chemistry data collected as part of this study suggest that the Greenfield WWTP may contribute significant total phosphorus loads on some occasions.

Industry

Industry in the Richey Ditch subwatershed is concentrated southwest of the intersection of I-70 and SR 9 in Greenfield. Businesses in this location include Modernfold, Inc., Hanger Bold and Stud Company, Sam's Club Distribution Center, Cabot II, Indiana Automotive Fasteners, and Avery Dennison Corporation.

Future Development

Future development in the Richey Ditch Subwatershed is anticipated to occur in and around Greenfield. The Greenfield Comprehensive Plan proposes the area northwest of the intersection of I-70 and SR 9 be developed as a commerce park and research campus. The plan recommends that an outdoor shopping center or mixed-use commercial development be built northeast of the intersection of I-70 and SR 9. Brandywine Creek is located in this location as well as open water lakes associated with a gravel quarry and a wellhead protection area for Greenfield's source water. Development in this location has potential to create negative impact on the public water supply as well as the water quality of Brandywine Creek.

Open Space

There are three Greenfield parks in the watershed having extensive open space. These parks include Riley Park, Brandywine Park, and Henry B. Wilson Park. All three parks are located directly adjacent to Brandywine Creek. Riley Park consists of 40 acres located at the intersection of Apple Street and US 40 in Greenfield. The park has numerous amenities including basketball courts, tennis courts, baseball fields, and playground equipment. Children were observed swimming and playing in Brandywine Creek Park during a windshield survey.

Brandywine Park is located at 900 East Davis Road in Greenfield and across the creek from the Greenfield WWTP. Intensively managed facilities are also present at this 60-acre park including 20 soccer fields, softball fields, and a playground. A trail is also available adjacent to Brandywine Creek.

Henry B. Wilson Park is a 14-acre natural park with nature trails adjacent to Brandywine Creek located east of Greenfield Village subdivision at the end of Martindale Drive. Martindale Drive is 0.2 mile southeast of the intersection of SR 9 and I-70. Future development at the park is proposed to include fishing piers (City of Greenfield, 2011a).

A natural area having high conservation potential, but not currently officially preserved, is located southwest of the intersection of CRs 400 East and 200 South. It is adjacent to a tributary of Little Brandywine Creek and may potentially be set aside as a preserve in the future (C. Chapman, personal communication, June 20, 2011).

Fertilizer Application

It is expected that a large quantity of fertilizer is applied on residential properties in the Richey Ditch Subwatershed. Intensive turf management practices are also expected to occur on numerous athletic fields and golf courses adjacent to Brandywine Creek, Potts Ditch, and Little Brandywine Creek. The amount of fertilizer applied to corn and soybean fields in the subwatershed in 2009 is estimated to have included approximately 729,000 kilograms (1,620,000 pounds) of nitrogen and 223,000 kilograms (495,000 pounds) of phosphorus based on statewide fertilizer sales and corn and soybean acreages in 2009 (USDA, 2011b).

Hobby Farms and Non-Agricultural Animal Feeding Operations

Numerous hobby farms having small quantities of animals were observed in the Richey Ditch Subwatershed during windshield surveys. Animals observed included horses, goats, llamas, and zebras.

Andis Ditch-Brandywine Creek Subwatershed (05120204030З)

The Andis Ditch Subwatershed begins south of Greenfield in Hancock County and extends southward to just north of CR 600 North in Shelby County. NHD mapped tributaries to Brandywine Creek in this subwatershed include Williamson Ditch and Hills Branch. Williamson Ditch is located south of Greenfield and drains a combination of agricultural land and subdivisions. Hills Branch drains to Brandywine Creek just north of CR 600 North in Shelby County. It primarily drains cultivated land, but also drains a stone quarry located in its headwaters. There are multiple smaller, unmapped tributaries in the subwatershed. One of these tributaries includes Andis Ditch. Andis Ditch is a channelized stream located east of Brandywine Creek and directly adjacent to the south side of CR 400 South in Hancock County. Andis Ditch drains cultivated cropland and is approximately 1 kilometer (0.7 mile) in length. The Andis Ditch Subwatershed encompasses 7,552 hectares (18,662 acres).

Water Quality and Habitat Data Summary

Stream water samples were collected at four sites in the Andis Ditch Subwatershed including Sites 4 and 5 on Brandywine Creek and Site 12 on Hills Branch as part of this study. Nutrients were high and exceeded targets and standards in 100% of samples collected in the subwatershed for total phosphorus, nitrate+nitrite, ammonia nitrogen, and TKN. *E. coli*, TSS, and turbidity samples exceeded standards and targets at all sites at the time of storm flow sampling. QHEI scores indicated that habitat is impaired for aquatic life use at Sites 5 and 12; however, poor habitat does not appear to have significantly negatively influenced macroinvertebrate communities.

The location of Site 4 corresponds with the same location of IDEM sites WED040-0001 and WED040-0003. A total of six water samples were collected in this location in 1997. Tested parameters included dissolved oxygen, pH, specific conductivity, temperature, turbidity, nitrate+nitrite, total phosphorus, TKN, and TSS (Table 38). TKN targets were exceeded in 67% of the samples. Total phosphorus and nitrate+nitrite exceeded targets in 100% of samples collected. Three *E. coli* samples were also collected at the site in 1997, and concentrations exceeded water quality standards in two of the samples.

Turbidity was above the recommended maximum target in 83% of the samples collected in 1997. An additional turbidity sample was collected in 2004 and was below the recommended maximum target. Dissolved oxygen, pH, specific conductivity, and temperature were measured at this site on one occasion in 1993, 1997, and 2004. No samples exceeded water quality standards for these parameters at the time of these monitoring events.

IDEM conducted mIBI and QHEI analyses at Site WED040-0003 in 1993, 1997, and 2004. Macroinvertebrate communities and habitat were determined not to be impaired; however, QHEI habitat scores appear to be steadily decreasing since 1993.

Table 38. Andis Ditch Subwatershed Data Exceeding Water Quality Standards/Targets

Sample Site	*E. coli*		Total Phosphorus		Nitrate+ Nitrite		Ammonia Nitrogen		Total Kjeldahl Nitrogen		TSS		Turbidity		Habitat	Macro-invertebrates		
																mIBI	HBI	RBPII
	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Base Flow		
Site 4		x	x	x	x	x	x	x	x	x		x		x				
Site 5		x	x	x	x	x	x	x	x	x		x		x	x			
Site 12		x	x	x	x	x	x	x	x	x		x		x	x			

Land Use Summary

The Andis Ditch Subwatershed primarily consists of cultivated cropland with only 1% of the subwatershed developed. Development is concentrated in the northwestern portion of the watershed, and consists of subdivisions on the south side of Greenfield as well as in Fountaintown located along US 52 west of SR 9. This subwatershed has the greatest amount of pasture/hay compared to the other subwatersheds according to 2001 NLCD data; however, few livestock were observed during the windshield survey (Figure 42).

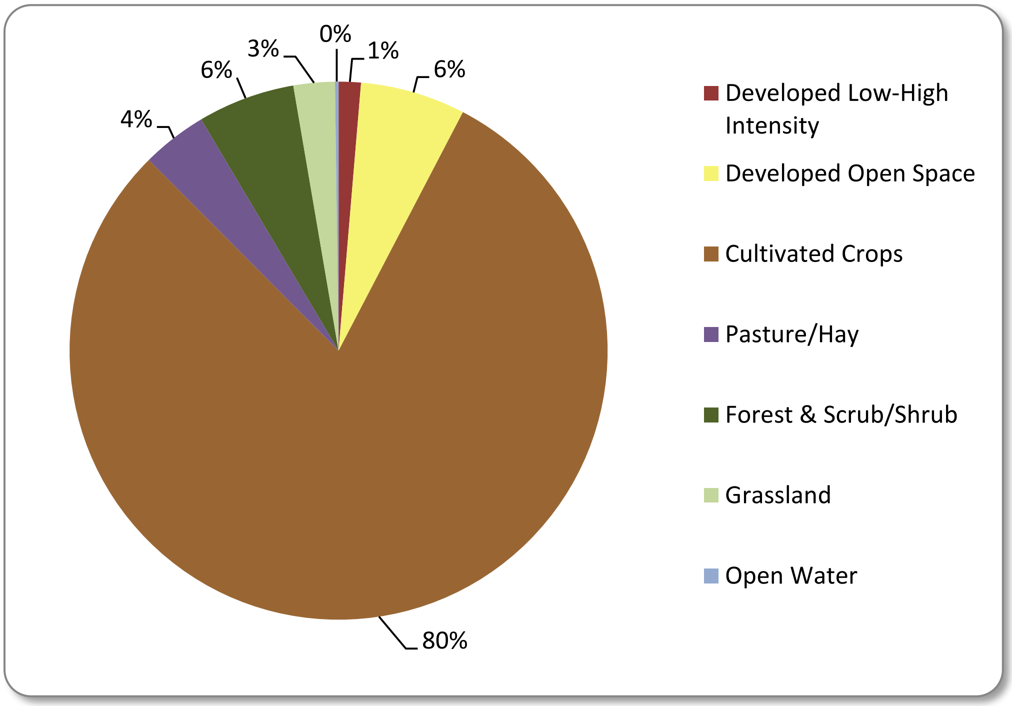

Figure 42. Andis Ditch Subwatershed Land Use Percentage Graph

<u>Windshield and Desktop Survey</u>

The Andis Ditch Subwatershed spans both Hancock and Shelby Counties. Windshield surveys and a desktop survey analysis of 2010 aerial photographs revealed areas where grass waterways, filter strips, and streambank erosion control may be beneficial. Streambank erosion was a primary concern observed and reported by steering committee members. Areas in need of filter strips or riparian buffers and streambank stabilization are depicted on Figure 39. A summary of issues observed in the subwatershed is included in Table 39.

Table 39. Andis Ditch Subwatershed Windshield/Desktop Survey Data

Potential Negative Water Quality Influence	BMP needed	Location	Survey Type	Observer
Gully erosion	Grass waterway	Fields east of Brandywine Creek and between CRs 400 and 500 South in Hancock County	Desktop	Davey
Gully erosion	Grass waterway	Field northwest of the intersection of CR 750 North and 50 East	Desktop	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Hills Branch west of SR 9	Windshield	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Williamson Ditch east of SR 9 as well as 0.6km (0.35 mi.) north of CR 300 South in Hancock County	Desktop	Davey
Streambank erosion	More information needed	Brandywine Creek approximately 0.8km (0.5 mi.) south of CR 500 South in Hancock County	Windshield	Steering Committee
Streambank erosion	More information needed	Brandywine Creek 1km (0.6 mi.) west of the intersection of Mill Road and SR 9 Shelby County	Windshield	Steering Committee
Streambank erosion	More information needed	Brandywine Creek at the intersection of CR 800 North and 50 East in Shelby County	Windshield	Steering Committee
Streambank erosion/log jam	More information needed	Brandywine Creek west of the intersection of Freeport Road and SR 9 in Shelby County	Windshield	Steering Committee
Streambank erosion/log jam	More information needed	Brandywine Creek approximately 0.3km (0.2 mi.) south CR 750 North and west of SR 9	Windshield	Steering Committee

Regulated Land Use

There are four CFOs with active permits in the Andis Ditch Subwatershed. Three of these CFOs are in Hancock County including Arthurs, Inc. located northeast of the intersection of CR 300 South and Franklin, Arthur Guilt Farm located on Franklin Street south of CR 500 South, and Hill Farms located southwest of the intersection of CR 275 East and CR 350 South in Hancock County. Conner Farm is located on Division Road south of CR 1000 North in Shelby County.

A waste tire site is recorded as Terry's Tire Recovery at 7948 North 250 East in Shelbyville. No further records were available in reference to the site in the IDEM VFC. No tires were observed at the site during the windshield or desktop survey.

One cleanup site is located at 8870 North SR 9 in Morristown. An incident in March, 2007 when a triaxle dump truck crashed into a residential home caused a water well, soil, and concrete at the site to become contaminated with diesel fuel. Remediation was completed at the site in July, 2007 (IDEM, 2010d - VFC #49311165).

Industry

A minimal amount of industry is present in the Andis Ditch Subwatershed in Shelby County. This includes a few industrial/commercial properties located adjacent to SR 9 north of the intersection of US 52 as well as scattered properties in Fountaintown. A stone quarry is located southwest of the intersection CR 750 North and 250 East in Shelby County. A body of open water at the stone quarry drains directly to Hills Branch.

Future Development

There are currently no known plans for developments in this subwatershed in the near future. Future development is anticipated to primarily consist of single-family residences scattered across the subwatershed.

Open Space

Hawk Woods Nature Preserve is an approximately 60-acre woodland owned by The Nature Conservancy and located in the Andis Ditch Subwatershed (Figure 43). The public has limited access to the area. The site is also dedicated as an Indiana state nature preserve. Hawk Woods is located in Shelby County east of CR 150 East, south of US 52, and north of CR 1000 North (R. Hedge, personal communication, September 1, 2011).

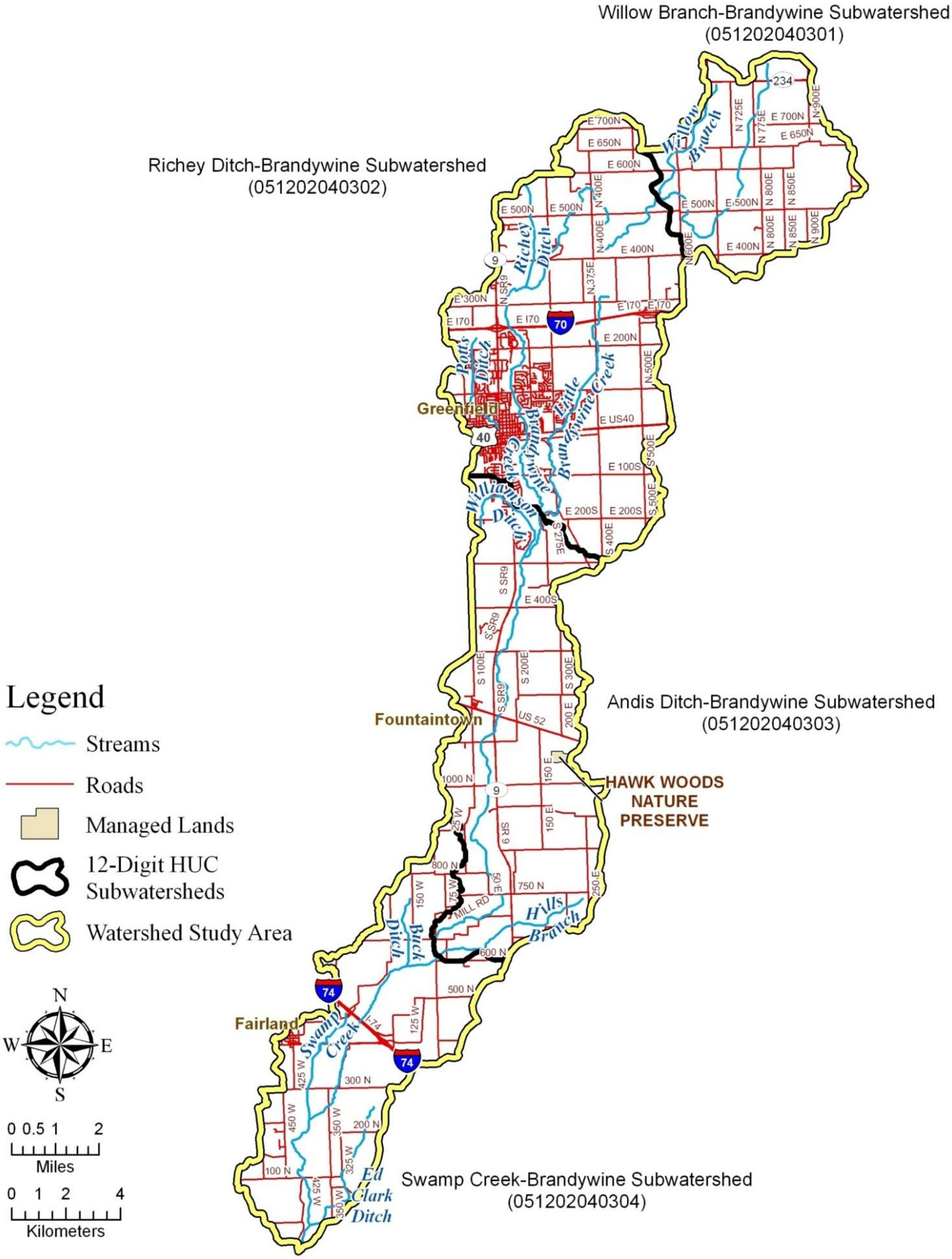

Figure 43. Significant Natural Areas Map

Fertilizer Application

The amount of fertilizer applied to corn and soybean fields in the subwatershed in 2009 is estimated to have included approximately 652,000 kilograms (1,450,000 pounds) of nitrogen and 199,000 kilograms (443,000 pounds) of phosphorus based on statewide fertilizer sales and corn and soybean acreages in 2009 (USDA, 2011b). There are multiple housing subdivisions in the subwatershed at which intensive turf management practices are expected to occur.

Hobby Farms and Non-Agricultural Animal Feeding Operations

There were no observed hobby farms or non-agricultural animal feeding operations observed in the subwatershed at the time of this study.

Swamp Creek-Brandywine Creek Subwatershed (051202040304)

The Swamp Creek Subwatershed begins along Brandywine Creek just north of CR 600 North and continues south to the confluence of Brandywine Creek with Big Blue River southeast of the intersection of CR 50 South and CR 425 West in Shelby County. The Swamp Creek Subwatershed encompasses 6,180 hectares (15,271 acres). NHD mapped tributaries to Brandywine Creek in this subwatershed include Buck Ditch, Swamp Creek, and Ed Clark Ditch. Buck Ditch and Ed Clark Ditch primarily drain cultivated cropland with the exception of a commercial/industrial area that drains to the headwaters of Ed Clark Ditch adjacent to I-74. Swamp Creek drains cultivated cropland as well as a subdivision adjacent to I-74 and Fairland. The entire Swamp Creek Subwatershed is in Shelby County.

Water Quality and Habitat Data Summary

Stream water samples were collected at four sites in the Swamp Creek Subwatershed including Site 6 on Brandywine Creek, Site 11 on Buck Ditch, Site 13 on Swamp Creek, and Site 14 on Ed Clark Ditch as part of this study. Nutrients were high and exceeded targets and standards in 100% of samples collected in the subwatershed for nitrate+nitrite, ammonia nitrogen, and TKN. Total phosphorus exceeded the water quality target at all sites at the time of storm flow sampling and at Site 6 at the time of base flow sampling. High base flow total phosphorus concentrations from inputs upstream of Site 3 on Brandywine Creek were carried downstream to Site 6. *E. coli* and turbidity samples exceeded standards and targets at all sites at the time of storm flow sampling. TSS only exceeded targets at two sites, Sites 6 and 13, at the time of storm flow sampling. QHEI scores revealed habitat impaired for aquatic life use at Site 11. Macroinvertebrate communities were also impaired at this site in all three of the macroinvertebrate analyses conducted. Site 11 is a channelized ditch lacking any riparian buffer or significant habitat substrate.

IDEM sites WED040-0002 and WED040-0005 are located in the same general location on Brandywine Creek north of CR 100 North and approximately 2 kilometers (1.2 miles) north of Site 6 (Figure 32). IDEM collected data for dissolved oxygen, pH, specific conductivity, temperature, turbidity, nitrate+nitrite, total phosphorus, TKN, and TSS on six occasions in 1997 (Table 40). Dissolved oxygen, pH, specific conductivity, temperature, turbidity, and *E. coli* were monitored on five occasions in 2002. No dissolved oxygen or pH samples exceeded water quality standards. Specific conductivity exceeded the water quality standard on one occasion in 1997. A total of 82% of turbidity samples exceeded target levels including 1997 and 2002 data. However, none of the TSS samples collected in 1997 exceeded targets. Nutrients levels were high throughout the 1997 sampling program with 100% of nitrate+nitrite samples, 83% of total phosphorus samples, and 67% of TKN samples exceeding water quality targets. *E. coli* samples were only collected in 2002 at which time 60% exceeded water quality standards.

Table 40. Swamp Creek Subwatershed Data Exceeding Water Quality Standards/Targets

Sample Site	*E. coli*		Total Phosphorus		Nitrate+ Nitrite		Ammonia Nitrogen		Total Kjeldahl Nitrogen		TSS		Turbidity		Habitat	Macro-invertebrates		
																mIBI	HBI	RBPII
	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Base Flow		
Site 6		x	x	x	x	x	x	x	x	x		x		x				
Site 11		x		x		x	x	x	x	x				x	x	x	x	x
Site 13		x		x		x	x	x	x	x		x		x				
Site 14		x		x	x	x	x	x	x	x				x				

Land Use Summary

Swamp Creek Subwatershed consists of 83% cultivated cropland and 2% is developed (Figure 44). The developed area consists of residential properties in Fairland as well as a subdivision and commerical/industrial properties adjacent to I-74.

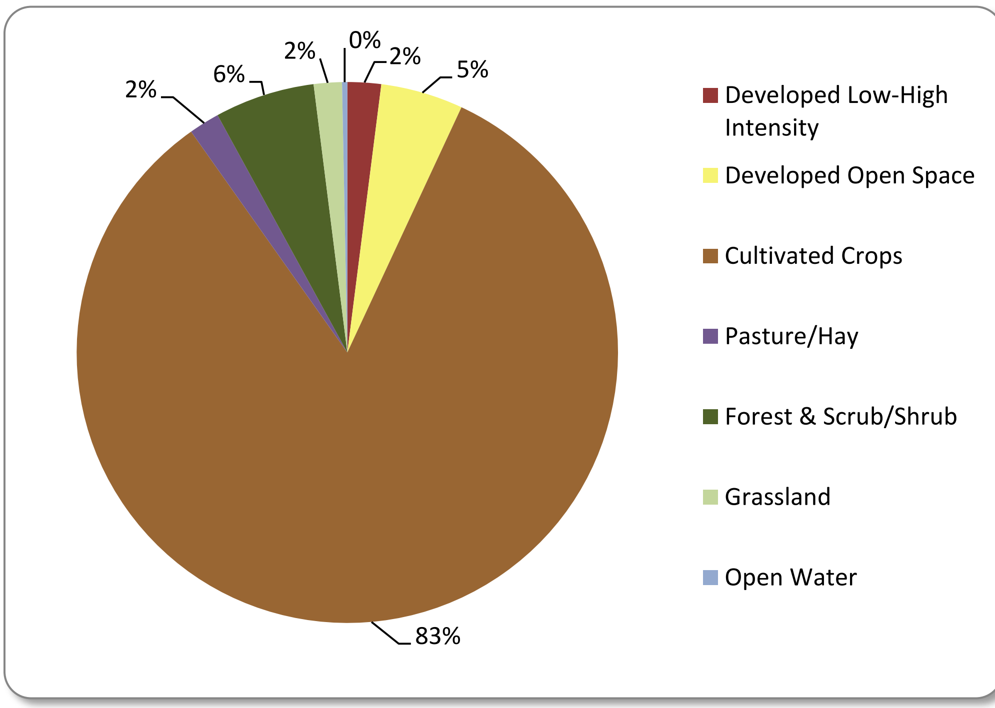

Figure 44. Swamp Creek Subwatershed Land Use Percentage Graph

Windshield and Desktop Survey

A windshield survey in the Swamp Creek Watershed revealed one location where horses have direct access to Brandywine Creek as well as ditches without adequate filter strips. A desktop survey analysis of 2010 aerial photographs further revealed areas where a grass waterway and filter strips may be beneficial. Areas in need of filter strips or riparian buffers and streambank stabilization are depicted on Figure 39. A summary of issues observed in the subwatershed is included in Table 41.

Table 41. Swamp Creek Subwatershed Windshield/Desktop Survey Data

Potential Negative Water Quality Influence	BMP Needed	Location	Survey Type	Observer
Gully erosion	Grass waterway	Field southeast of the intersection of CR 800 North and 150 West	Desktop	Davey
Gully erosion	Grass waterway	Fields northeast and northwest of the intersection of CR 800 North and 100 West	Desktop	Davey
Livestock with direct access to stream	Fencing/alternative water source	Brandywine Creek 0.6 km (0.35 mi.) north of the intersection of Brandywine Road and CR 300 North	Windshield	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Buck Ditch north and south of CR 650 North	Desktop	Davey
Row crops within 30 feet of top-of-bank	Filter strip/riparian planting	Unmapped headwaters of Ed Clark Ditch northwest of the intersection of CRs 150 West and 450 North to south of CR 300 North	Windshield /desktop	Davey
Row crops within 30 feet of top of bank	Filter strip/riparian planting	Ed Clark Ditch north and south of CR 200 N	Desktop	Davey
Row crops within 30 feet of top of bank	Filter strip/riparian planting	Unmapped tributary to Brandywine Creek northwest of the intersection of CRs 100 North and 350 West	Desktop	Davey
Row crops within 30 feet of top of bank	Filter strip/riparian planting	Brandywine Creek where it runs parallel to Brandywine Road	Desktop	Davey
Streambank erosion	Two-stage ditch	Buck Ditch north and south of CR 650 North	Windshield	Davey
Streambank erosion	More information needed	Brandywine Creek west of the intersection of CR 600 North and 100 West	Windshield	Steering Committee

Regulated Land Use

There are multiple sites in the Swamp Creek Subwatershed regulated by IDEM. These sites are primarily concentrated in Fairland and along the I-74 corridor. These sites include one VRP site, three industrial waste sites, one brownfield, seven LUSTs, and one NPDES facility with a sanitary sewer overflow.

Field application sites for biosolids produced by the Shelbyville WWTP are concentrated northwest of the intersection of CRs 350 West and 100 North near an unmapped ditch to Brandywine Creek.

The sanitary sewer overflow directly contributes a minimal pollutant load to the headwaters of Ed Clark Ditch when operating in accordance with the NPDES requirements. IDEM last inspected the Indiana National Guard Armory WWTP on December 17, 2008, and no violations were recorded.

Industry

Industry and commercial properties in the Swamp Creek Subwatershed are concentrated around I-74. Properties in this area include Indiana Live Casino and Indiana Downs racetrack, Shelbyville Municipal Airport, Indiana National Guard Armory, a travel center, and a distribution center.

Future Development

Future development in the Swamp Creek Subwatershed is anticipated to occur near I-74. The Fairland Exit Small Area Plan amendment to the City of Shelbyville's comprehensive plan was developed to guide planning activities for emerging development in this location. The Plan seeks to discourage future development within the floodplain directly adjacent to Brandywine Creek and designates areas outside of the Brandywine Creek floodplain and near I-74 as suitable for an industrial park.

Fertilizer Application

The amount of fertilizer applied to corn and soybean fields in the subwatershed in 2009 is estimated to have included approximately 556,000 kilograms (1,237,000 pounds) of nitrogen and 170,000 kilograms (378,000 pounds) of phosphorus based on statewide fertilizer sales and corn and soybean acreages in 2009 (USDA, 2011b). Fertilizer is also likely applied at residential and commercial properties around Fairland.

Hobby Farms and Non-Agricultural Animal Feeding Operations

Indiana Downs horse race track is located at 4200 North Michigan Road adjacent to I-74 in Shelby County (Figure 36). Animals are typically present on site from the first part of March to the first part of November each year. The facility has the capacity to house over 500 hundred racehorses at any given time, but actual numbers continually fluctuate based on events being held at the track. Manure is removed from the horse stalls each day and hauled out of the watershed (J. Dean, personal communication, September 12, 2011). One other hobby farm with a small quantity of horses having access to Brandywine Creek was observed along Brandywine Road between Fairland Road and CR 300 North.

Watershed Inventory –
Part 3: Watershed Inventory Summary

Water Quality Data Summary

Review of historic and recently collected water chemistry data reveals numerous consistent impairments in Brandywine Creek Watershed from 1997 to the present. Parameters consistently exceeding water quality standards and targets included ammonia nitrogen, TKN, nitrate+nitrite, total phosphorus, turbidity, and *E. coli*. Habitat and macroinvertebrate communities were sampled only one time in most locations with the exception of Site 4. Habitat and macroinvertebrate communities were assessed in 1993, 1997, 2004, and 2010 at Site 4. Habitat and macroinvertebrate community qualities appear to be steadily declining in this location. Figures 45 and 46 depict sampling locations where specific parameters exceeded the water quality standard or target in 51% or greater of the samples collected including current and historic data.

The percentage of water quality standard and target exceedances for all parameters and sampling events collected by Davey were determined per subwatershed. The percent of samples exceeding standards and targets provides a better understanding of the most impaired subwatersheds (Table 42). Willow Branch Subwatershed, which forms the headwaters of Brandywine Creek Subwatershed, had the greatest percentage of samples exceeding a water quality standard or target. Andis Ditch Subwatershed and Richey Ditch Subwatershed closely followed Willow Branch Subwatershed in water quality standard and target exceedance rates. Swamp Creek Subwatershed had the lowest percentage of samples exceeding water quality standards and targets.

Table 42. Sample Percentages Exceeding Standards/Targets per Subwatershed

Subwatershed	Percent of Samples Exceeding a Water Quality Standard/Target
Willow Branch	50
Richey Ditch	48
Andis Ditch	49
Swamp Creek	41

The number of hotspots that contribute to poor water quality identified through windshield and desktop surveys per subwatershed was determined to help further prioritize subwatersheds in need of concentrated water quality improvement efforts (Table 43).

Table 43. Hotspots Identified per Subwatershed

Subwatershed	Number of Hotspots Identified During Windshield/Desktop Survey
Willow Branch	8
Richey Ditch	15
Andis Ditch	7
Swamp Creek	9

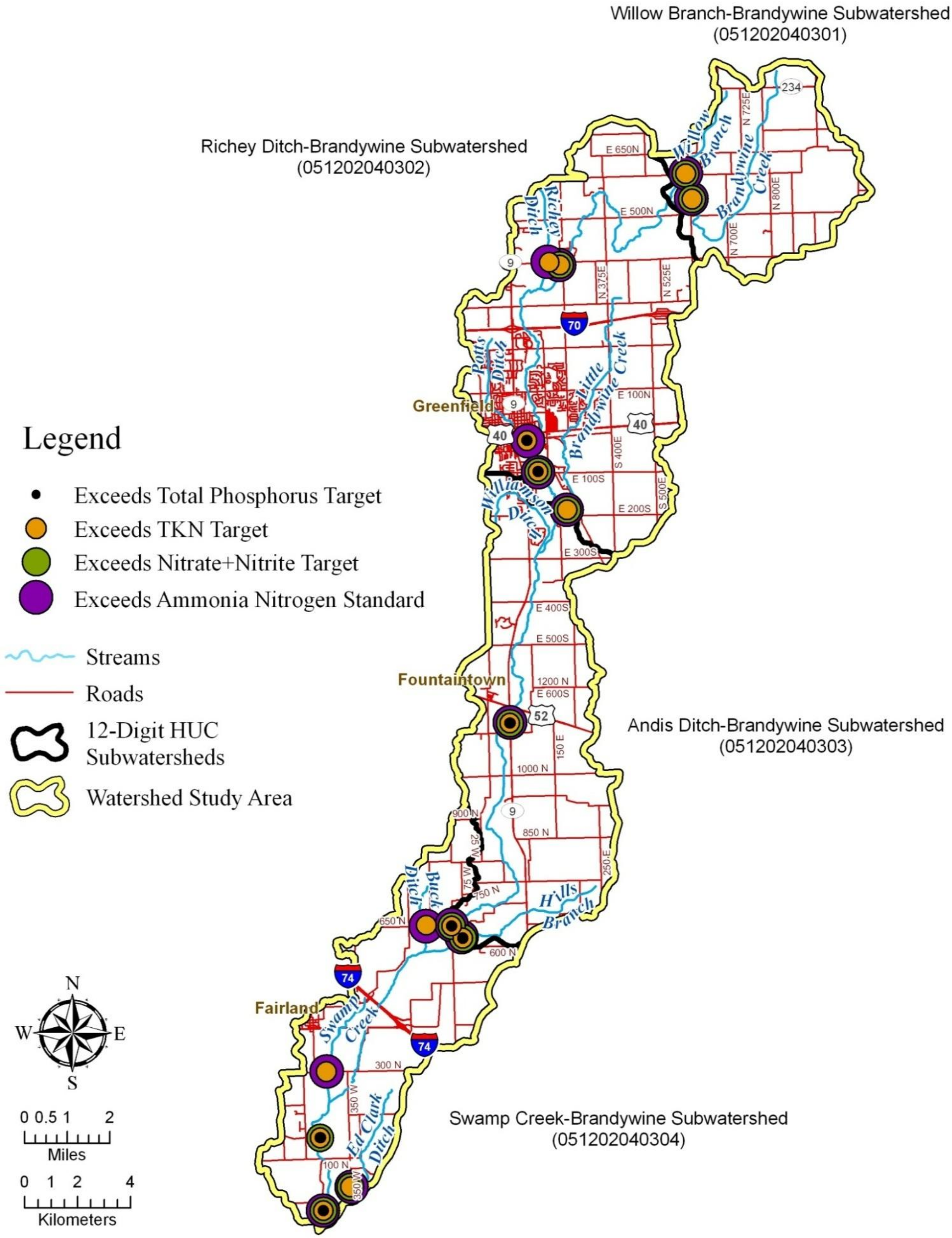

Figure 45. Sites Exceeding Water Quality Standards and Targets - 1

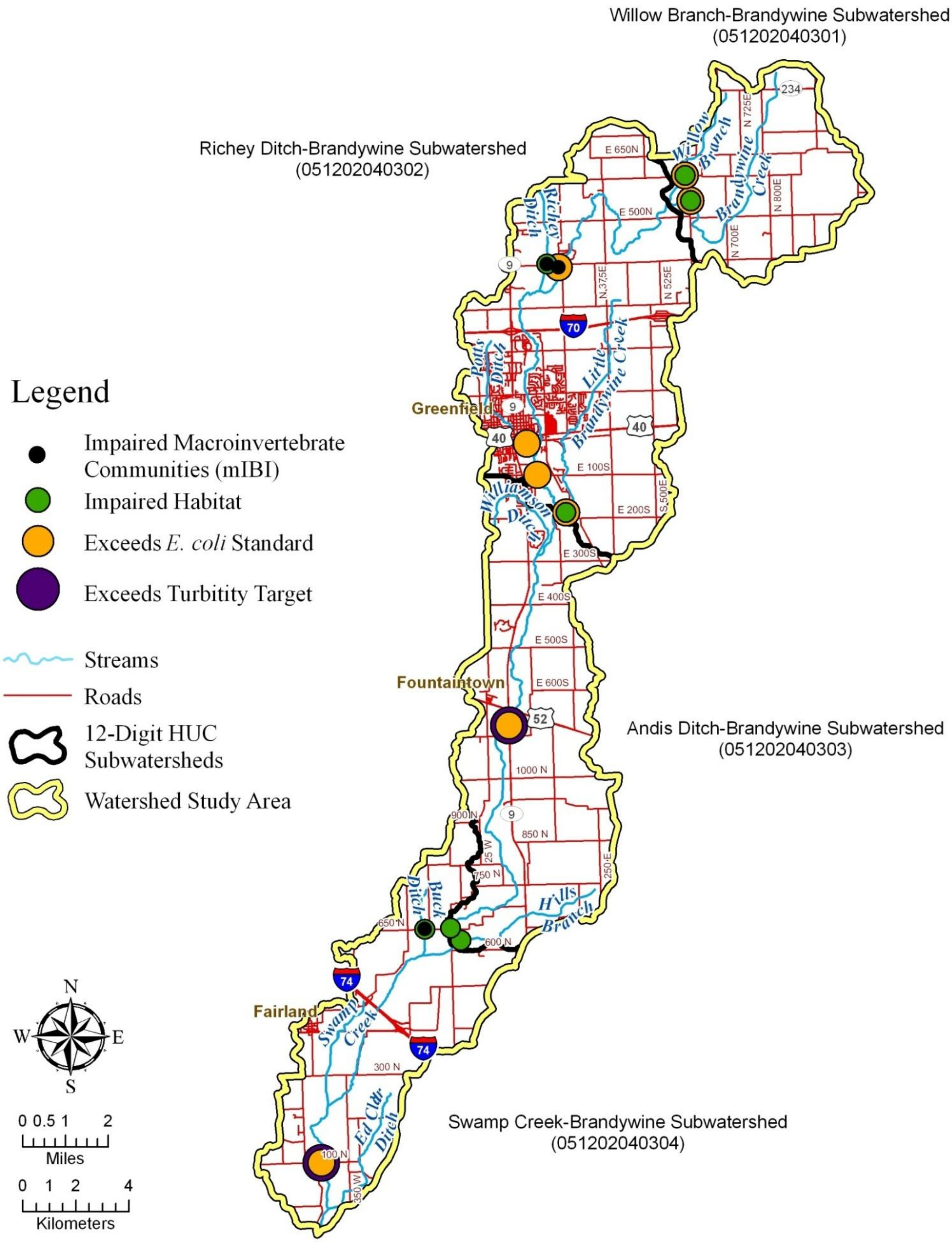

Figure 46. Sites Exceeding Water Quality Standards and Targets - 2

Analysis of Stakeholder Concerns

All stakeholder concerns generated through public outreach meetings and steering committee meetings are listed in Table 44. The steering committee determined whether each concern was supported by available data and the evidence supporting each concern. The steering committee also determined whether or not each concern was within their scope of consideration and whether or not it was a concern on which they wished to focus. Build-up of sediment and gravel bars in Brandywine Creek was an expressed concern on which the steering committee ultimately decided not to focus on, because sand and gravel bar formation is a natural process in a healthy stream system. These features supply valuable habitat for aquatic organisms. It is believed that removal of these features would provide negligible drainage benefits and would be detrimental to the health of Brandywine Creek.

Table 44. Stakeholder Concerns Analysis

Concern	Supported by our Data?	Evidence	Quantifiable?	Outside the Scope?	Group Wants to Focus On?
Streambank erosion	Yes	Photographs and location descriptions supplied by landowners. Turbidity/TSS data in some locations Sandbar formation/sedimentation	Yes	No	Yes
Combined sewer overflow frequency in Greenfield	No	No CSOs have occurred due to rainfall since Greenfield made recent updates to the sewer system (Dan Miller)	n/a	n/a	No
Protection of wetlands	Yes	Historical aerials and percent hydric soil in watershed suggest substantial wetlands acreage loss	Yes	No	Yes
Safeness of full-body contact in Brandywine Creek	Yes	303d list, historic IDEM *E. coli* levels, current *E. coli* levels	Yes	No	Yes
Safety of fish consumption	No	Not on 303d list	No	Yes	No
E. coli contamination from septic systems	Yes	Exceptionally high *E. coli* levels at some sites recorded during storm flows suggest septic system sources	No (Not without costly analyses on additional samples)	No	Yes
Flooding trailer park north of Riley Park in Greenfield	Yes	Observation of steering committee members	No	No	Yes
Housing developments on lakes	Yes	Aerial photographs	Yes	No	Yes
Sediment accumulation in lake south of New Road in Greenfield	Yes	Anecdotal evidence	No	No	Yes
Trash in Brandywine Creek	Yes	Anecdotal evidence	No	No	Yes
Apparent increase in water volume in Little Brandywine Creek and Brandywine Creek (suspected increase in stormwater discharge from increasing impervious surface and tile system improvements)	Yes	Anecdotal evidence that Little Brandywine Creek is not drying out as frequently as in the past	No	No	Yes
Pollutants associated with apparent increases in water volume in Little Brandywine Creek and Brandywine Creek	Yes	Increase in pollutant levels immediately downstream of heavily developed areas along Brandywine Creek	Yes	No	Yes

Table 44. Stakeholder Concerns Analysis (Continued)

Concern	Supported by our Data?	Evidence	Quantifiable?	Outside the Scope?	Group Wants to Focus On?
Build-up of sediment/gravel bars	Yes	Photographs, anecdotal evidence	No	No	No
Log jams/beaver dams	Yes	Photographs, anecdotal evidence	Yes	No	Yes
Fish kills	Yes	IDEM/DNR records	Yes	No	Yes
Livestock with access to streams	Yes	Windshield survey observations	Yes	No	Yes
Golf courses and athletic fields directly adjacent to waterbodies – fertilizer, pesticides, irrigation	Yes	Two golf courses, three athletic field locations – windshield/desktop survey observations	Yes	No	Yes
Waterbodies without filter strips or riparian buffers	Yes	Windshield/desktop survey	Yes	No	Yes
Nutrients leaching into stormwater from autumn leaves piled in city streets	Yes	Anecdotal evidence and high urban nutrient loads	Yes	No	Yes
Waterfowl impact on water quality	Yes	E. coli levels and large quantities of observed waterfowl	Yes	No	Yes
Runoff from soils exposed by earthwork	No	Rule 5 is strictly enforced	Yes	No	No

Water Quality Problems and Causes

The steering committee identified specific problems relating to each concern on which the group wished to focus. Problems were defined as issues that exist due to a concern. Identified problems build upon concerns by identifying a condition or actions that need to be changed, improved, or investigated in greater depth. Specific problems were then consolidated into problem categories. Table 45 links stakeholder concerns to specific water quality problems and generalized water quality problem categories.

Table 45. Stakeholder Concerns and Related Problems

Concerns	Specific Problem	Problem Category
Livestock with access to streams	Erosion from trampled banks; degraded stream habitat; nutrient and *E. coli* inputs	High nutrient levels High *E. coli* levels High TSS and turbidity levels Degraded habitat
Log jams and beaver dams (and gravel bars facilitating log jams)	Streambank erosion; poor drainage from underwater tiles and resulting flooding	High TSS and turbidity levels High nutrient levels Flooding
Golf courses and athletic fields directly adjacent to waterbodies (fertilizer, pesticides, irrigation)	High nutrient inputs	High nutrient levels
Wetlands protection	Filled wetlands and wetland degradation associated with development resulting in loss of natural wetlands functions	High nutrient levels High TSS and turbidity levels Degraded habitat
Impact of water quality from development around lakes	Potential septic system failures; nutrients from lawn care; trash washed into lakes	High nutrient levels High *E. coli* levels Trash
Flooding of mobile home residences	Potential septic failures; floating household debris and hazardous household waste	High nutrient levels High *E. coli* levels Trash
Waterfowl impact on water quality	*E. coli* and nutrient inputs	High nutrient levels High *E. coli* levels
Nutrients leaching into stormwater from autumn leaves piled in city streets	Nutrient inputs	High nutrient levels
Waterbodies without filter strips or riparian buffers	Nutrient and TSS inputs; poor aquatic habitat	High nutrient levels High *E. coli* levels High TSS and turbidity levels Degraded habitat
Streambank erosion – sediment and nutrient loss	TSS inputs and associated nutrient inputs	High nutrient levels High TSS and turbidity levels
Contamination from failing septic systems	*E. coli* and nutrient inputs	High nutrient levels High *E. coli* levels
Trash in creeks	Contributes to damming issues; may contain hazardous materials; reinforces public perception that trash in natural areas is okay	Trash
Increase in water volume in Little Brandywine Creek as well as other streams	Flooding; streambank erosion	High nutrient levels High TSS and turbidity levels Flooding
Fish kills	Decrease in biodiversity	Decrease in biodiversity
Safeness of full-body water contact	Reduced recreation due to health concerns (especially at Riley Park)	Reduced recreation
Fishing – fish populations	Reduced recreation due to low fish populations	Reduced recreation
Sediment accumulation in lakes	Reduced recreation potential; increased flooding potential	Reduced recreation Flooding

Potential causes for each problem category were also identified. Table 46 links stakeholder concerns to water quality problems and potential causes of those problems. A cause is an event, agent, or series of actions that produce a problem. For the purpose of watershed management planning, causes of water quality problems are defined as specific pollutant parameters.

Table 46. Problem Categories and Potential Causes

Problem Category	Potential Causes
High stream nutrient levels	Nutrient levels exceed water quality targets; insufficient public understanding of nutrient sources
High stream TSS and turbidity levels	TSS and turbidity levels exceed water quality targets
High stream *E. coli* levels	*E. coli* levels exceed water quality standards; insufficient public understanding of *E. coli* sources
Degraded aquatic habitat	High nutrient and TSS levels, insufficient cover
Flooding	Increased peak flows; development in floodplain
Trash	Insufficient public understanding of pollution consequences and negligence
Reduced aquatic recreation	Streams are impaired for recreational contact by IDEM; thick sediment deposits; aesthetics; low biodiversity
Decrease in aquatic biodiversity	High pollutant loads resulting from insufficient public understanding of pollution sources and storm sewer drain connections to streams as well as negligence

Pollutant Sources and Loads

Potential Pollution Sources

The steering committee linked identified water quality problems and causes of those problems to sources based on windshield survey data and other observations made in the watershed (Table 47). Sources can be an activity, material, or structure that result in a cause of nonpoint source pollution.

Table 47. Potential Pollutant Sources per Problem Category

Problem Category	Potential Causes	Potential Sources
High stream nutrient levels	Nutrient levels exceed water quality targets; insufficient public understanding of nutrient sources	• Livestock access to streams (four pastures in Willow Branch Subwatershed; six pastures in Richey Ditch Subwatershed) • Fertilizer application to farm fields (all subwatersheds) and commercial and residential properties (Richey Ditch & Swamp Creek Subwatersheds) • Eroded sediments from streambanks (seven identified locations), fields (approximately 3,900 hectares [9,650 acres] conventionally tilled cropland across all subwatersheds, seven identified gully erosion sites), and development sites (Richey Ditch and Swamp Creek Subwatersheds) • Failing septic systems (all subwatersheds; specific neighborhoods identified in Richey Ditch Subwatershed)
High stream TSS and turbidity levels	TSS and turbidity levels exceed water quality targets	• Livestock access to streams (4 pastures in Willow Branch Subwatershed; six pastures in Richey Ditch Subwatershed) • Eroded sediments from streambanks, fields (all subwatersheds), and development sites (Richey Ditch & Swamp Creek Subwatersheds)
High stream *E. coli* levels	*E. coli* levels exceed water quality standards; Insufficient public understanding of *E. coli* sources	• Failing septic systems(all subwatersheds; specific neighborhoods identified in Richey Ditch Subwatershed) • Livestock access to streams (four pastures in Willow Branch Subwatershed; six pastures in Richey Ditch Subwatershed) • Pet and wildlife waste including significant resident waterfowl populations (2 specific locations in Richey Ditch Subwatershed)
Degraded aquatic habitat	High nutrient and TSS levels, insufficient cover	• Streams lacking riparian buffers (9,776 meters in Willow Branch Subwatershed; 4,521 meters in Richey Ditch Subwatershed; 1,112 meters in Andis Ditch Subwatershed 4,932 meters in Swamp Creek Subwatershed) • Livestock access to streams (4 pastures in Willow Branch Subwatershed; six pastures in Richey Ditch Subwatershed) • Filled wetlands (historically all subwatersheds; greatest future threat in Richey Ditch and Swamp Creek Subwatersheds)
Flooding	Increased peak flows; development in floodplain	• Increasing impervious surface (Richey Ditch and Swamp Creek Subwatersheds) • Agricultural drainage improvements (all subwatersheds)
Trash	Insufficient public understanding of pollution consequences and negligence	n/a

Problem Category	Potential Causes	Potential Sources
Reduced aquatic recreation	Streams are impaired for recreational contact by IDEM; thick sediment deposits in streams and lakes; poor aesthetics; low biodiversity	• Livestock access to streams (four pastures in Willow Branch Subwatershed; six pastures in Richey Ditch Subwatershed) • Fertilizer application to farm fields (all subwatersheds) and commercial and residential properties (Richey Ditch & Swamp Creek Subwatersheds) • Eroded sediments from streambanks, fields (all subwatersheds), and development sites (Richey Ditch & Swamp Creek Subwatersheds) • Failing septic systems (all subwatersheds; specific neighborhoods identified in Richey Ditch Subwatershed)
Decrease in aquatic biodiversity	High pollutant loads resulting from insufficient public understanding of pollution sources and storm sewer drain connections to streams as well as negligence	• Livestock access to streams (four pastures in Willow Branch Subwatershed; six pastures in Richey Ditch Subwatershed) • Fertilizer application to farm fields (all subwatersheds) and commercial and residential properties (Richey Ditch & Swamp Creek Subwatersheds) • Eroded sediments from streambanks, fields (all subwatersheds), and development sites (Richey Ditch & Swamp Creek Subwatersheds) • Failing septic systems (all subwatersheds; specific neighborhoods identified in Richey Ditch Subwatershed) • Chemical spills (historically in Richey Ditch and Swamp Creek Subwatersheds)

Modeled Pollutant Loads

The Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) Region 5 Load Estimation Model Version 4.0 was selected to model sediment and nutrient loads from predicted sources of nonpoint source pollution from different land use types in each 12-digit HUC subwatershed in Brandywine Creek Watershed. STEPL was designed for the Grants Reporting and Tracking System of the USEPA by Tetra Tech, Inc. STEPL uses algorithms to calculate relative nutrient and sediment loads and resulting load reductions associated with implementation of certain BMPs (Tetra Tech, 2006).

Load reductions are determined by first estimating gross erosion within the watershed, and then the amount of sediment and associated nutrients that reach surface water. Gross erosion is determined through the Revised Universal Soil Loss Equation (RUSLE), the Gully Erosion Equation (GEE), and the Channel Erosion Equation. Estimated sediment delivery to surface waters and the associated nutrient contents are estimated using equations and values derived from scientific literature. Pollutant and sediment load reductions are computed using known BMP efficiencies for certain practices. Nutrient reductions are assumed to come from reduction in sediment-borne nutrients. Dissolved nutrients are not included.

The program considers acreages of urban, cropland, pasture, feedlot, and forest land use types. The urban land use category includes all developed areas such as commercial areas, homes, barns, lawns, and roads. For this particular watershed model, the STEPL program also took into consideration the numbers and types of registered farm animals in the watershed, septic system numbers and failure rate data, national weather service rainfall data, and observed streambank and gully erosion instances.

Watershed baseline conditions were established for the model by taking into consideration BMPs known to currently exist in the watershed that are factored into the STEPL program including filter strips and reduced tillage (including reduced tillage, mulch tillage, and no-till). Reduced tillage or a more conservative tillage practice, was utilized on 82% of fields in Hancock County and Shelby County in 2009. It was assumed that the percentage of the number of fields on which reduced tillage or a more conservative tillage form is practiced is equivalent to the percentage of acres on which these same practices occur. Data from Hancock County as a whole was assumed representative of Willow Branch and Richey Ditch Subwatersheds. Data from Shelby County was assumed representative of Swamp Creek Subwatersheds. Hancock and Shelby Counties tillage data were averaged to determine estimates for Andis Ditch Subwatershed. Overland flow from an estimated 5% of cultivated land in Brandywine Creek Watershed was assumed through a filter strip prior to entering surface water. It was also assumed that conservation tillage is practiced on fields having filter strips. An estimated 2% of urban land was modeled as draining to dry detention basins and another 2% was modeled draining to wet ponds in Richey Ditch Subwatershed. Based on these data and assumptions, STEPL calculated baseline annual nutrient and sediment loads for all subwatersheds.

Figures 47–49 display the percentage of contributions to total nitrogen, phosphorus, and sediment loads per pollutant source analyzed by STEPL under baseline conditions. Pollutant sources analyzed included urban areas, cropland, pastureland, forest, feedlots, septic systems, gully erosion, streambank erosion, and groundwater. Approximately 78% of the watershed is cultivated cropland. STEPL estimates that cultivated cropland contributes 69% of the total nitrogen load, 79% of the total phosphorus load, and 70% of the sediment load in Brandywine Creek Watershed. Land use data indicate that 11.5% of Brandywine Creek Watershed is developed. Developed land is estimated to contribute 19% of the total nitrogen load, 11% of the total phosphorus load, and 29% of the sediment load. This indicates that on a per acre basis, urban land is contributing more nitrogen and phosphorus than cultivated cropland in the watershed. Animal feeding operations are estimated to contribute 9% of the total nitrogen and 7% of the total phosphorus loads. Pastureland contributes 3% of total nitrogen and 1% of both total phosphorus and sediment loads. An estimated 1% of the total phosphorus load is derived from forestland, which also contributes less than 1% to the total nitrogen and sediment loads. Septic systems are the source of an estimated 1% of the total phosphorus load and less than 1% of the total nitrogen load.

Total baseline modeled loads per parameter per subwatershed are included in Table 48. STEPL model data sheets can be found in Appendix L.

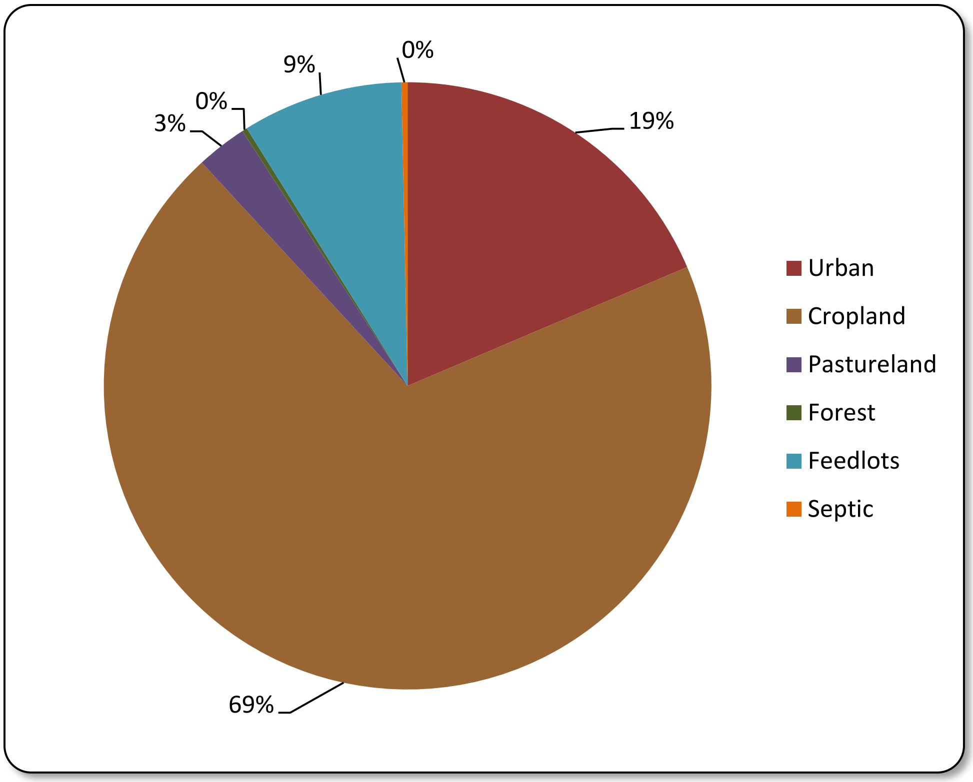

Figure 47. Modeled Total Nitrogen Load per Source

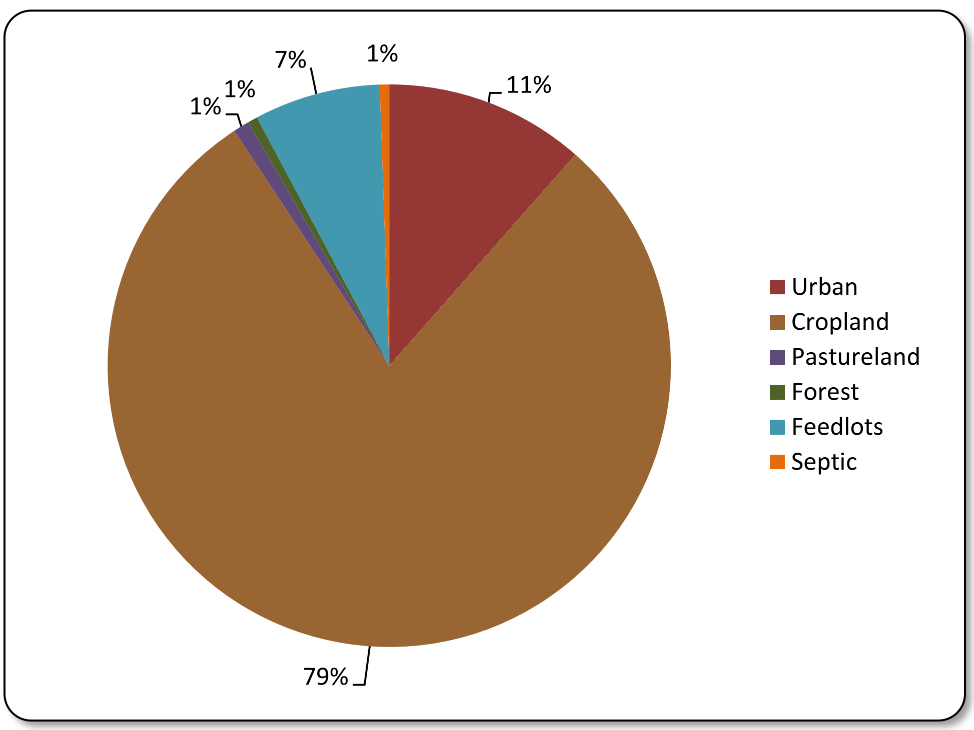

Figure 48. Modeled Total Phosphorus Load per Source

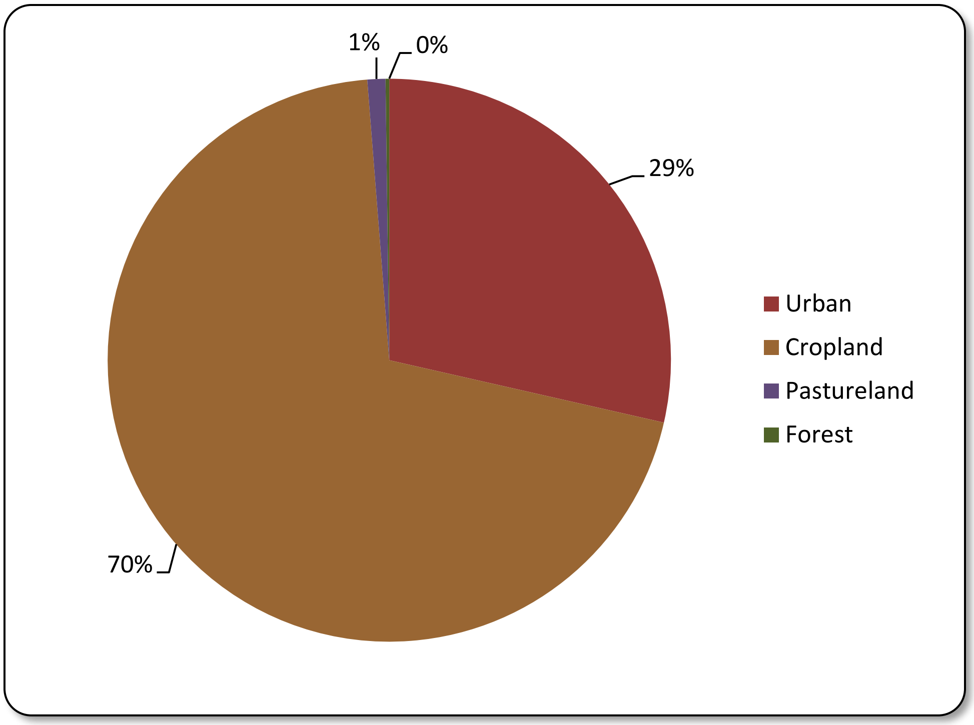

Figure 49. Modeled Total Sediment Load per Source

Table 48. Modeled Pollutant Loads per Subwatershed

Subwatershed	Total Sediment (kg/yr.) ([lb./yr.])	Total Phosphorus (kg/yr.) ([lb./yr.])	Total Nitrogen (kg/yr.) ([lb./yr.])
Willow Branch Subwatershed	836,511 (1,858,914)	6,557 (14,571)	26,845 (59,655)
Richey Ditch Subwatershed	2,212,909 (4,917,577)	14,831 (32,958)	66,759 (148,353)
Andis Ditch Subwatershed	1,239,698 (2,754,883)	9,315 (20,700)	39,656 (88,125)
Swamp Creek Subwatershed	1,072,829 (2,384,065)	7,902 (17,561)	32,646 (72,546)
Brandywine Creek Watershed	5,361,948 (11,915,439)	38,605 (85,790)	165,906 (368,679)

Calculated Pollutant Loads

To obtain a statistically significant and more accurate estimate of pollutant loads based on field data, substantially more than two pollutant concentration samples and corresponding flow measurements as are currently available are needed. Consequently, modeled pollutant loads are expected to be more accurate than available field data for estimating total annual loads. A comparison of calculated loads under base flow and storm flow conditions versus modeled loads for the entire Brandywine Creek Watershed are included in Table 49. Calculated loads for each sample site at the time of base flow and storm flow sampling are included in Appendix M.

Table 49. Calculated Loads Versus Modeled Loads

	Pollutant Loads (kg/yr.) ([lb./yr.])				
	TSS	**Total Phosphorus**	**Total Nitrogen**	**Nitrate+ Nitrite**	**TKN**
Calculated load using base flow data	154,000 (339,512)	8,143 (17,952)	n/a	267,561 (589,871)	37,669 (83,046)
Calculated load using storm flow data	220,688,581 (486,535,038)	1,444,604 (3,184,807)	n/a	4,611,005 (10,165,526)	5,037,457 (11,105,692)
Modeled annual load	5,361,948 (11,915,439)	38,605 (85,790)	165,906 (368,679)	n/a	n/a

Pollutant loads calculated on a per acre basis using field data can be useful in determining relative load contribution rates from various locations in the watershed. Table 50 depicts average pollutant loads during base flow and storm flow monitoring events at each sample site per acre of watershed. The highest pollutant load on a per acre basis for each pollutant in a subwatershed is highlighted in red, the second highest pollutant load is highlighted in orange, and the third highest pollutant load is highlighted in blue. Field data suggests that subwatersheds draining to Sites 3 and 6 on Brandywine Creek are receiving the highest pollutant loads on a per acre basis. Highly developed areas in Greenfield drain to Brandywine Creek upstream of Site 3. The developed area around I-74 drains to Brandywine Creek upstream of Site 6. TSS levels were consistently higher at Site 12 on Hills Branch. A gravel quarry that drains directly to the Hills Branch headwaters along with cultivated cropland draining to this tributary are likely sources of TSS.

Table 50. Pollutant Loads per Acre Calculated from Field Data

Site	Subwatershed	Base Flow Load per Acre (kg/yr.) ([lb./yr.])				Storm Flow per Acre (kg/yr.) ([lb./yr.])			
		TSS	Total Phosphorus	Nitrate+ Nitrite	TKN	TSS	Total Phosphorus	Nitrate+ Nitrite	TKN
1	Willow Branch	0.4 (0.9)	0.01 (0.02)	1.5 (3.3)	0.2 (0.4)	1,227 (2,700)	3 (6)	79 (175)	30 (67)
2	Richey Ditch	1.0 (2.1)	0.01 (0.03)	1.9 (4.2)	0.3 (0.6)	1,549 (3,407)	6 (12)	75 (166)	53 (117)
3	Richey Ditch	1.0 (2.2)	**0.40 (0.88)**	**5.0 (11.1)**	**0.7 (1.6)**	**4,097 (9,013)**	**18 (39)**	**86 (190)**	**79 (174)**
4	Andis Ditch	1.6 (3.6)	**0.13 (0.29)**	3.0 (6.7)	0.4 (0.9)	2,304 (5,070)	8 (17)	61 (134)	44 (98)
5	Andis Ditch	**3.1 (6.8)**	**0.12 (0.26)**	3.2 (7.0)	0.4 (0.9)	1,898 (4,177)	11 (25)	56 (123)	**53 (116)**
6	Swamp Creek	2.4 (5.3)	**0.13 (0.28)**	**4.2 (9.2)**	**0.6 (1.3)**	**3,460 (7,611)**	**23 (50)**	72 (159)	**79 (174)**
7	Willow Branch	<0.0	0.02 (0.04)	1.0 (2.2)	0.3 (0.6)	730 (1,606)	6 (13)	**92 (202)**	50 (110)
8	Richey Ditch	**3.8 (8.3)**	0.05 (0.12)	0.3 (0.7)	**0.8 (1.8)**	265 (582)	2 (4)	22 (49)	25 (56)
9	Richey Ditch	0.5 (1.1)	0.01 (0.02)	0.1 (0.2)	0.1 (0.3)	873 (1,921)	3 (7)	20 (45)	21 (45)
10	Richey Ditch	0.8 (1.9)	0.01 (0.02)	0.6 (1.4)	0.2 (0.5)	792 (1,742)	4 (9)	43 (95)	24 (45)
11	Swamp Creek	0.6 (1.3)	<0.00 (0.01)	0.2 (0.5)	0.1 (0.2)	97 (213)	1 (3)	25 (55)	8 (18)
12	Andis Ditch	**16.3 (35.9)**	0.04 (0.09)	**4.0 (8.8)**	0.5 (1.0)	1,347 (2,964)	**21 (45)**	**114 (251)**	50 (110)
13	Swamp Creek	1.4 (1.3)	0.02 (0.05)	1.0 (2.2)	0.5 (1.1)	**3,125 (6,876)**	15 (34)	84 (185)	**91 (201)**
14	Swamp Creek	<0.0	0.01 (0.03)	1.7 (3.7)	0.4 (0.9)	176 (387)	1 (3)	36 (80)	11 (24)

Target Pollutant Loads

Target pollutant loads for Brandywine Creek Watershed were calculated based on water quality standards and base flow discharge data collected at Site 6 on Brandywine Creek on January 10, 2011 (Table 51). The total nitrogen target load includes a nitrate+nitrite target load and a TKN target load.

E. coli concentrations should remain less than or equal to 235 CFU/100 mL at any given time based on water quality standards. Consequently, calculation of an *E. coli* annual load reduction is not appropriate.

Table 51. Pollutant Load Reductions Needed

	Total Nitrogen[1] (kg/yr.) ([lb./yr.])	Total Phosphorus (kg/yr. ([lb./yr.])	Total Sediment (kg/yr.) ([lb./yr.])
Current Modeled Pollutant Load	165,906 (368,679)	38,605 (85,790)	5,361,948 (11,915,439)
Target Pollutant Load	107,222 (235,889)	3,351 (7,372)	1,608,366 (3,538,339)
Reduction Needed	58,684 (132,790)	35,254 (78,418)	3,753,582 (8,377,100)

[1] Total nitrogen target loads include a nitrate+nitrite target load (85,778 kg/yr.), a TKN target load (21,444 kg/yr.)

Watershed Goals and Critical Areas

Goals and Indicators

Goals were developed to address the eight identified problem categories and improve water quality in Brandywine Creek Watershed. Identified problem categories include high stream nutrient levels, high stream TSS and turbidity levels, high stream *E. coli* levels, degraded aquatic habitat, flooding, trash, reduced aquatic recreation, and a decrease in aquatic biodiversity.

The five primary goals selected include a reduction in *E. coli* concentrations to below the state standard, a reduction in sediment to below the water quality target, a reduction in nutrient loads to below water quality targets, an increase in public awareness of water quality issues, and a reduction in flood damages. The steering committee determined sub-goals to work toward with timelines in order to achieve each primary goal as well as indicators that can be used to determine if progress is being made toward achieving the goal.

Some of the primary goals address more than one problem category. For instance, achieving the goal to reduce sediment will not only address the problem of high stream TSS and turbidity levels, it will also improve degraded aquatic habitat, reduce flooding risks, improve aesthetics for aquatic recreation value, reduce stream nutrient levels, and create potential for an increase in aquatic biodiversity. Reducing nutrient loads will also create potential for increased aquatic biodiversity by making habitat more suitable for sensitive species. Reducing *E. coli* levels will make the streams safer for citizens to participate in aquatic recreation. Trash reaching Brandywine Creek is expected to diminish as citizens become more knowledgeable about water quality and the factors that influence it through the efforts undertaken as part of an educational campaign to increase public awareness.

Reduction in *E. coli* Concentrations to Below the State Standard

A total of 75% of samples tested for *E. coli* as part of this study exceeded the 235 CFU/100 mL water quality standard. The goal is to reduce *E. coli* concentrations throughout the watershed so that in 20 years concentrations in all samples collected in the watershed do not routinely exceed water quality standards. Table 52 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 52. E. coli Reduction Goals and Indicators

<table>
<tr><th>Sub-goals</th><th>Indicators</th></tr>
<tr><td>Short-term (1-5 years)</td><td rowspan="15">
Increased septic system awareness and changing attitudes measured by survey data
Number of residences connected to municipal sewer
Number of residences upgrading on-site septic systems indicated by county permit trends
Residences participating in group discount maintenance programs if such a program is offered
Number of landowners installing fence, etc. who apply for funding
Number of pet waste receptacles
Number of riparian areas installed
Implementation of pet waste and livestock ordinances and enforcement
Measured reduction in E. coli concentrations
</td></tr>
<tr><td>Educate homeowners so that they understand how failing septic systems impact water quality, they believe changes are important, and they become willing to take action by conducting regularly scheduled maintenance and necessary upgrades</td></tr>
<tr><td>Educate livestock owners so that they understand how livestock wastes impact water quality, they believe changes are important, and they become willing to take action by implementing BMPs to exclude livestock access from streams</td></tr>
<tr><td>Educate pet owners so that they understand how pet wastes impact water quality, and install pet waste receptacles in public areas</td></tr>
<tr><td>Implement local legislation allowing for fines for not properly disposing of pet waste on public properties</td></tr>
<tr><td>Reduce nuisance waterfowl populations</td></tr>
<tr><td>Medium-term (6-12 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Voluntary maintenance and upgrades are made to suitable on-site septic systems</td></tr>
<tr><td>Develop a local ordinance requiring upgrades to failing systems at the time of real estate transactions</td></tr>
<tr><td>City annexation of neighborhoods that are not suitable for on-site septic systems</td></tr>
<tr><td>Long-term (13-20 years)</td></tr>
<tr><td>Continued education and BMP implementation</td></tr>
<tr><td>Brandywine Creek is removed from the 303d list for E. coli impairment and is safe for recreation</td></tr>
<tr><td>Implement local legislation regulating livestock access to waterbodies (“Waters of the U.S.”)</td></tr>
</table>

Reduction in Sediment Loads to Below Water Quality Targets

Sediment levels in samples collected under storm flow conditions exceeded the IDEM water quality target. Sediment levels modeled for Brandywine Creek Watershed using STEPL estimated an annual load of 5,361,948 kg/yr. (11,915,439 lb./yr.). The maximum annual pollutant load that would still meet the water quality target for TSS is 1,608,366 kg/yr. (3,538,339 lb./yr.). To meet the water quality target, an annual load reduction of 3,753,582 kg/yr. (8,377,100 lb./yr.) is needed. In theory, it would be possible to meet this goal by converting less than 142 hectares (350 acres) of conventionally tilled agricultural land to a no-till system. However, decreasing sediment loads will also address other problems including improving degraded aquatic habitat, reducing potential for flooding, improving aesthetics for aquatic recreation, and creating potential for an increase in aquatic biodiversity. Therefore, sediment levels should be reduced substantially below the minimum required to achieve the maximum water quality target. Table 53 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 53. Sediment Reduction Goals and Indicators

Sub-goals	Indicators
Short-term (1-5 years)	• Number of urban and agricultural BMPs implemented using cost-shares • Survey data on public perception of BMPs and water quality • Measured reduction in TSS concentrations • Number of problematic log jams removed and number of log jam removal educational workshops
Educate agricultural producers and livestock owners so that they believe/understand BMPs are beneficial practices for crop production and water quality, and they become willing to implement them	
Educate homeowners so that they believe BMP implementation is important and becoming willing to take action	
Increase utilization of native plants/wildlife habitat for erosion control	
Identify/map small ditches for the primary purpose of identifying areas needing riparian buffers	
Remove large log jams if public infrastructure and safety are at risk and continuing log jam removal education workshops	
Medium-term (6-12 years)	
Continued education and BMP implementation	
Retrofit/upgrade existing stormwater basins designed primarily to treat water quantity and not water quality	
Increase utilization of native plants/wildlife habitat for erosion control	
Long-term (13-20 years)	
Continued education and BMP implementation	
Increase utilization of native plants/wildlife habitat for erosion control	
Increased recreational value and wildlife habitat quality	
Implement local legislation regulating livestock access to waterbodies (“Waters of the U.S.”)	

Reduction in Nutrient Loads to Below Water Quality Targets

Nutrient levels in tested samples frequently exceeded USEPA water quality targets. Nutrient levels modeled for Brandywine Creek Watershed using STEPL estimated a total nitrogen load of 165,906 kg/yr. (368,679 lb./yr.) and a total phosphorus load of 38,605 kg/yr. (85,790 lb./yr.). The maximum annual pollutant load that would still meet the water quality target for total nitrogen is 107,222 kg/yr. (235,889 lb./yr.) and 3,351 kg/yr. (7,372 lb./yr.) for total phosphorus. To meet water quality targets, an annual load reduction of 58,684 kg (132,790 lb./yr.) is needed for total nitrogen and 35,254 kg/yr. (78,418 lb./yr.) is needed for total phosphorus. Table 54 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal. Numerous sub-goals for nutrient load reduction overlap with sub-goals for sediment load and *E. coli* concentration reduction.

Table 54. Nutrient Reduction Goals and Indicators

Sub-goals	Indicators
Short-term (1-5 years)	• Number of urban and agricultural BMPs implemented using cost-shares • Ditch mapping GIS data • Measured reduction nitrogen and phosphorus concentrations • Survey data on perception of BMPs by agricultural producers, livestock owners, pet owners, land managers, and homeowners • Number of people taking the phosphorus-free pledge through Clear Choices Clean Water • Implementation and enforcement of an ordinance preserving riparian zones in new developments and stricter on-site stormwater pre-treatment requirements • Implementation and enforcement of new local ordinances that will positively influence water quality
Educate homeowners and land managers so that they understand how their actions impact water quality, they believe changes are important, and they become willing to take action by implementing BMPs and supporting clean water initiatives	
Educate agricultural producers and livestock owners so that they believe/understand BMPs are beneficial practices for crop production and water quality, and they become willing to implement them	
Promote development in accordance with the county comprehensive plan with a specific emphasis on preserving riparian areas as depicted in the plan	
Identify/map small ditches for the primary purpose of identifying areas needing riparian buffers	
Educate pet owners so that they understand how pet wastes impact water quality, and install pet waste receptacles in public areas	
Implement a local ordinance allowing for fines for not properly disposing of pet waste on public properties	
Reduce nuisance waterfowl populations	
Medium-term (6-12 years)	
Continued education and BMP implementation	
Implement local legislation requiring preservation of riparian zones, incorporation of green infrastructure in new developments, and stricter on-site stormwater pre-treatment requirements	
Retrofit/upgrade existing stormwater basins designed primarily to treat water quantity and not water quality	
Voluntary maintenance and upgrades are made to suitable on-site septic systems	
Develop a local ordinance requiring upgrades to failing systems at the time of real estate transactions	
City annexation of neighborhoods that are not suitable for on-site septic systems	
Long-term (13-20 years)	
Continued education and BMP implementation	
Incorporation of green infrastructure in new developments and retrofitted to older developments	
Implement local legislation regulating livestock access to waterbodies ("Waters of the U.S.")	

Reduction in Flood Damages

Flooding is a concern of many stakeholders in Brandywine Creek Watershed (Photograph 6). The steering committee wishes to, at a minimum, not see an increase in the extent of flood damages to structures and, at best, gradually decrease the extent of flood damages over the next 20 years. Table 55 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 55. Reduction in Flood Damages

Sub-goals	Indicators
Short-term (1-5 years)	• Reduction in flood damage insurance claims • No permits authorized for development in the floodplain • Number of green infrastructure stormwater BMPs installed
Educate watershed residents on the function and value of floodplains	
Implement stormwater BMPs	
Implement local legislation requiring incorporation of green infrastructure in new developments that decreases the quantity and/or delays the speed at which stormwater reaches streams	
Medium-term (6-12 years)	
Continued education and BMP implementation	
Long-term (13-20 years)	
Continued education and BMP implementation	
Increase stormwater retention requirements for new developments	

Photograph 6 (04-05-11). Multiple structures in Brandywine Creek Watershed are subject to flooding.

Increasing Public Awareness of Water Quality Issues

The steering committee believes that many problems in Brandywine Creek Watershed stem from the fact that the general public has an insufficient understanding of water quality issues and how their actions can make a difference as well as general apathy. For example, only 43 of 9,700 surveys distributed by the Greenfield MS4 Program were returned in a 2010 survey (Wessler Engineering, 2010). The steering committee wishes to gradually increase the general knowledge and understanding of water quality issues held by the general public over the next 20 years. Table 56 lists sub-goals to accomplish the primary goal and potential indicators for measuring progression toward the primary goal.

Table 56. Increasing Public Awareness Goals and Indicators

Sub-goals	Indicators
Short-term (1-5 years)	• Survey data on public perception of water quality issues • Reduced quantity of waste removed in stream clean-ups • Increased participation in hazardous waste collection • Number of school programs implemented
Implement an intense educational and outreach campaign including billboards, newspaper articles, and educational materials included with utility bills, school programs, etc.	
Establish obvious plastic bag collection programs in local grocery stores	
Continue hazardous waste removal days on a more frequent basis and have free disposal of household hazard waste	
Regularly scheduled stream and side ditch clean-up days	
Install additional stream drain markers	
Establish a turn in a litterer local phone number	
Medium-term (6-12 years)	
Continue general education and outreach programs as well as the second through sixth short-term sub-goals	
Long-term (13-20 years)	
Continue general education and outreach programs as well as the second through sixth short-term sub-goals	

Critical Areas

A critical area as defined for watershed management planning is a place where implementation of watershed management plan guidance can remediate nonpoint source pollution in order to improve water quality or mitigate future pollutant sources to protect water quality. Critical areas were determined separately for urban and rural pollutant sources. Critical areas were assigned in one of two ways. Critical areas were assigned as priority subwatersheds in instances where particular BMPs would benefit water quality across the entire watershed (Figure 50). Site-specific critical areas were assigned for specific pollutant sources scattered in various locations throughout the watershed, such as locations where livestock have access to streams (Photograph 7). Known locations of site-specific critical areas are depicted on Figure 39; however, it is anticipated that additional unidentified critical areas are present in Brandywine Creek Watershed.

Photograph 7 (10-19-10). Cattle have severely trampled the streambanks on this tributary to Little Brandywine Creek.

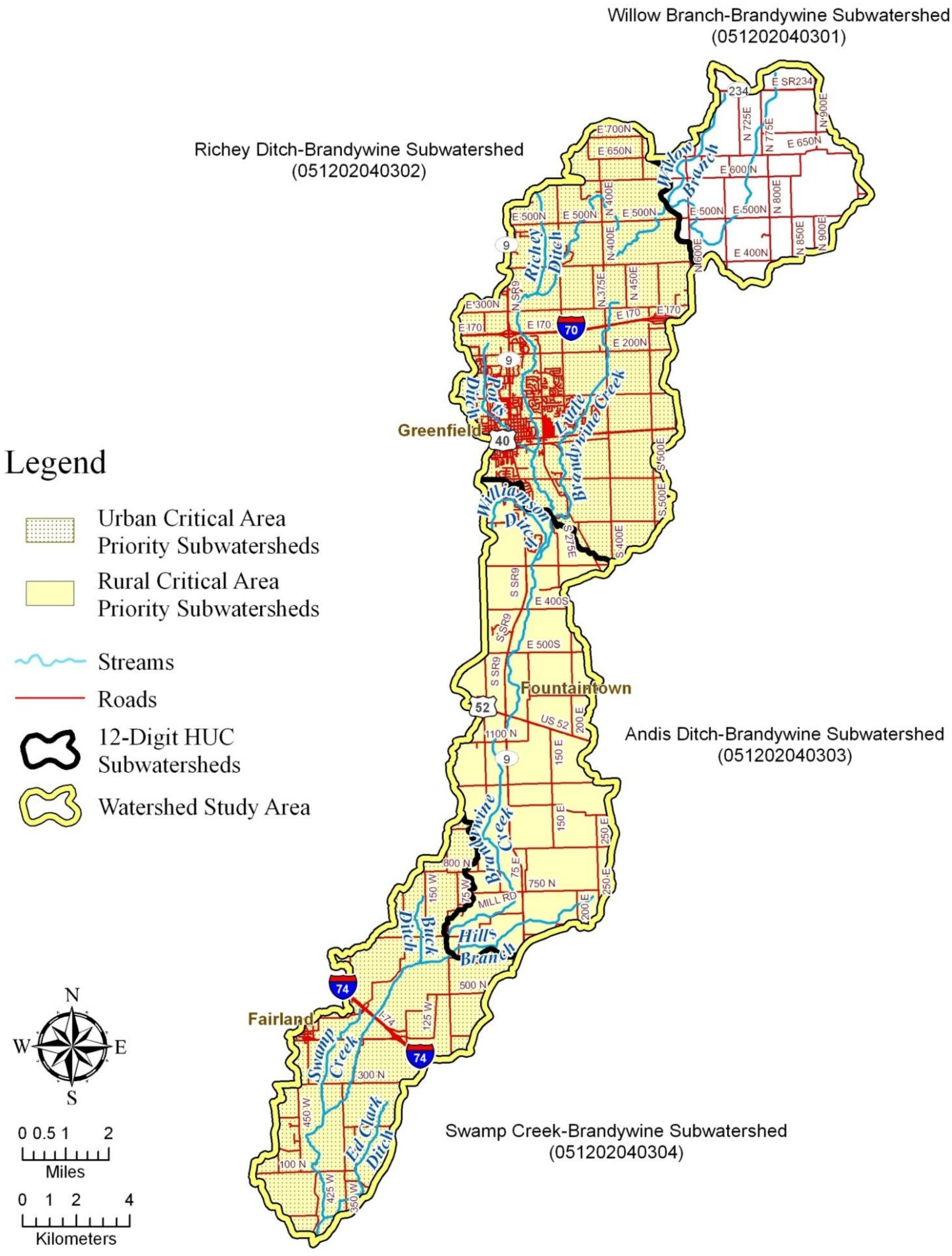

Figure 50. Urban and Rural Critical Areas Priority Subwatersheds

Urban Critical Areas

STEPL watershed modeling indicates a substantial pollutant load is originating from urban areas (Figures 47-49). Reduction in quantity and treatment of stormwater prior to reaching streams can significantly reduce the amount of pollutants being carried to streams from city streets, parking lots, and lawns. Richey Ditch Subwatershed contains the largest urban component. Swamp Creek Subwatershed also contains a substantial urban component near I-74 and in Fairland. Consequently, these subwatersheds were chosen by the steering committee as areas where implementation of the recommended BMPs listed in Table 57 could remediate current urban nonpoint source pollution and help mitigate future sources as well.

Table 57. Urban Critical Areas and Suggested BMPs

Critical Area	Reason for Being Critical	Suggested BMPs
Richey Ditch Subwatershed; Swamp Creek Subwatershed	*E. coli*, nutrients	Riparian restoration; nuisance waterfowl control; pet waste receptacles; streambank stabilization; stormwater BMPs; rain barrels; weekly/monthly street sweeping; pervious pavement

Rural Critical Areas

Many specific pollutant sources such as areas where livestock have access to streams, streambank erosion, areas lacking filter strips or riparian buffers, and areas suffering from gully erosion are scattered throughout the entire Brandywine Creek Watershed. These areas were identified as site-specific critical areas by the steering committee (Table 58).

Significant quantities of rural and agricultural land are present in all subwatersheds of Brandywine Creek Watershed. Numerous BMPs such as cover crops, drainage water management, nutrient and pest management plans (NPMPs), and no-till would improve water quality when implemented on cropland throughout the entire Brandywine Creek Watershed. Since the entire watershed cannot be designated as a critical area for watershed management plan implementation of practices, the steering committee selected the three top priority subwatersheds as critical areas based on modeled pollutant load contributions for implementation of the aforementioned practices.

Table 58. Rural Critical Areas and Suggested BMPs

Critical Area	Reason for Being Critical	Suggested BMPs
Areas where livestock have access to streams	Nutrients, *E. coli*, TSS	Livestock fencing, alternative water sources, stream crossings, rotational grazing
Severely eroding streambanks	Sediment; phosphorus; log jams	Streambank stabilization techniques including two-stage ditches
Log jams	Streambank erosion; flooding issues	Removal education or physical removal if public infrastructure and safety is at risk
Areas lacking filter strips/riparian buffers	Nutrients, *E. coli*; habitat	Filter strips; riparian restoration
Gully erosion	Sediment, nutrients	Grass waterway
Richey Ditch Subwatershed; Andis Ditch Subwatershed; Swamp Creek Subwatershed	Nutrients, TSS; *E. coli*	Cover crops, drainage water management; nutrient and pest management plans; no-till

Recommended BMPs and Other Measures

Numerous BMPs were selected by the steering committee for implementation in Brandywine Creek Watershed to address the key issues identified as a result of this study. Recommended BMPs for agricultural land include no-till conservation tillage; cover crops; drainage water management; grass waterways; livestock fencing, stream crossings, alternative watering facilities, and rotational grazing; nutrient and pest management plans; and wetlands restoration. BMPs recommended for urban land include nuisance waterfowl control; pervious pavement; pet waste receptacles; rain barrels; and stormwater management practices such as infiltration gardens, stormwater swales, and stormwater planters. BMPs such as riparian restoration and streambank stabilization including natural channel restoration and two-stage ditch designs are applicable in both agricultural and urban areas. In addition to structural BMPs, multiple topics for educational programing and potential local ordinances were recommended. Implementation of these recommendations should result in a demonstrable improvement in water quality and habitat conditions in the watershed. It is important to note that no single recommendation will address all principle issues; rather, it will be necessary to implement a combination of most, if not all, in order to achieve the highest level of results.

BMPs

The appropriateness of implementing any one BMP will be affected by landowner participation, implementation costs, and the overall expected water quality benefits given specific site conditions on which the BMP is implemented. General estimates of water quality benefits associated with recommended BMPs are listed in Table 59. Voluntary landowner and homeowner participation will likely increase as they are further educated about watershed and water quality issues as well as cost-share programs and incentive payments that are available to offset costs associated with BMP implementation. Demonstrations and presentations by those who have successfully implemented BMPs in the watershed may also further encourage additional people to participate. Explanation of each recommended BMP ensues.

Estimated implementation costs associated with each BMP are listed in Table 59. Cost estimates are approximations only and may vary significantly from actual costs depending on many potential variables associated with implementation of each practice. Many complicating factors influence total BMP cost, and in many instances the extra cost to implement a BMP may be offset by other attributes of the BMP. Implementing BMPs frequently cost less in the long term than many traditional practices through reducing long-term maintenance costs.

Table 59. Summary of Recommended BMPs

BMP	Annual Estimated Load Reduction[1]			Estimated Implementation Cost
	Nitrogen	Phosphorous	Sediment	
Conservation tillage				
Reduced tillage (~40% residue)	55%	45%	75%	variable
No-till	>55%	>45%	97%	$22.50 per acre[6]
Cover crops[2]	64-70%	7-15%	10-20%	$35-40 per acre[7]
Drainage water management	15-70%	n/a	n/a	$20-110 per acre[1]
Filter strips	70%	75%	65%	$80 per acre[8]
Grass waterways[3]	70%	75%	65%	$7.50 per linear foot[9]
Livestock fencing[4], stream crossings, alternative watering facilities, and rotational grazing	75%	75%	75%	fencing $3.13 per linear foot; watering facility: $1,875
Log jam removal	n/a	n/a	n/a	varies based on size and accessibility of log jam
Nuisance waterfowl control	n/a	n/a	n/a	varies based on particular techniques utilized and waterfowl numbers
Nutrient and pest management plans	n/a	n/a	n/a	$18.75 per acre[6]
Pervious pavement	85%	65%	90%	varies based on pavement type and other associated stormwater infrastructure
Pet waste receptacles	n/a	n/a	n/a	$250[7]
Rain barrels	0%	0%	0%	$75[7]
Riparian restoration and preservation	75%	75%	75%	$563 per acre for tree planting[9]
Stormwater BMPs				
Infiltration gardens	60%	65%	75%	$4-25 per square foot[7]
Stormwater planters	n/a	83%	94%	varies based on size and materials used
Stormwater swales	8%	18%	48%	$25 per square foot[7]
Stormwater basin retrofit	n/a	n/a	n/a	varies based on basin size and particular retrofit practices necessary
Streambank stabilization				
Natural channel	75%	75%	75%	$63 per linear foot[9]
Two-stage ditches	27%[5]	65%	74%	$10-15 per linear foot[7]
Street sweeping	n/a	6%	16%	$5,000 per event[10]
Wetlands restoration	20%	44%	78%	$1,250 per acre[9]

[1] (Frankenberger,*et al.*, 2006; Tetra Tech, Inc., 2006; Tank, 2010; Hill and Mannering, 2011; Simpson and Weammert, 2011)
[2] Nutrient removal efficiencies vary with cover crop species and season planted
[3] Pollutant reductions include filtering capacity after installation only. Vegetating an eroded gully may reduce nearly 100% of potential further sediment loss.
[4] Load reductions listed are associated with livestock fencing
[5] Nitrate only, not total nitrogen
[6] Based on the assumption that the LARE incentive or flat-rate payment is approximately 80% of cost
[7] Based on general industry standard costs
[8] (Megumi, *et al.*, 2012) Estimate includes, seed, equipment, and labor, but actual costs will vary based on vegetation species selected. Estimate does not include the cost to take land out of production.
[9] Based on the 80% maximum cost share amount from LARE
[10] Cost for actual sweeping; does not include equipment depreciation

Conservation Tillage

Conservation tillage includes tillage practices that leave 30% or more of crop residue on the soil surface following planting. Any tillage system that leaves 30% or greater residue cover is considered conservation tillage. No-till is the conservation tillage type that allows for the least amount of soil erosion. A residue cover of 93% versus 0% can result in preventing 12.1 tons per acre of sediment loss; however, actual results will vary based on factors such as soil type and slope (Hill and Mannering, 2011). No-till has other benefits including improving soil quality and reducing labor and fuel costs associated with tillage. Long-term benefits of improved soil quality can take many years to materialize. Some farmers may become discouraged from using no-till as a result of the need for increased weed control and costs associated with equipment modifications. No-till is often not practiced on poorly drained soils planted to corn because no-till fields dry out slower in the spring resulting in slower growth and increased potential.

Cover Crops

Cover crops are applicable for all cropland in the watershed where natural resource protection and/or soil improvement is the goal. Cover crops may consist of grasses, legumes, and forbs that are established for seasonal cover when soil would otherwise be exposed in an agricultural field. Cover crops serve many functions, including reducing erosion from wind and water, increasing soil organic matter content, adding to and redistributing nutrients in the soil profile, weed suppression, providing forage, soil moisture management, reducing soil compaction, reducing particulate emissions into the atmosphere, and increasing biodiversity (Natural Resources Conservation Service [NRCS], 2008a). Agricultural producers should be encouraged to begin implementing cover crops.

Drainage Water Management

Drainage water management is the practice of using a water level control structure installed on a field tile outlet to vary the depth of possible drainage during different seasons of the year and draining only what is needed for crop production. The outlet on the structure is raised to increase the water level in the soil column after harvest. This reduces the level of nitrate lost through the tile system to streams and ditches during fall and winter from between 15-75%. The outlet is then lowered a few weeks prior to planting to allow the field to drain more effectively. After planting, the structure outlet is raised once again to retain more moisture in the field during the summer months. Limited data suggest yield increases up to 5% can be expected by increasing the water table above the tile depth during summer months. The outlet structure is lowered once again to allow increased drainage prior to harvest (Figure 51) (Frankenberger, *et al.*, 2006).

Drainage water management is most suitable on fields that are relatively flat (less than 0.5% slope), and where a pattern drainage system is installed or feasible to install.

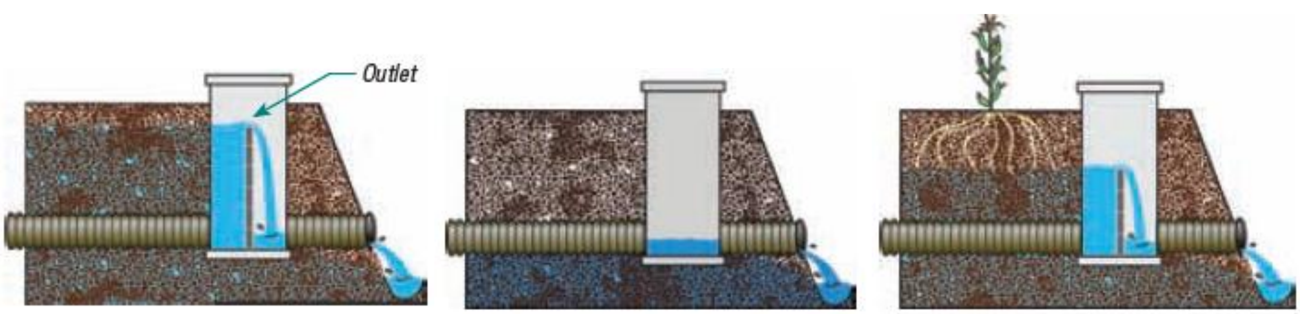

Figure 51. Drainage Water Management Diagram

Filter Strips

Filter strips are narrow bands of sod-forming grasses, legumes, and forbs planted adjacent to waterway edges that retard the transport of sediment, nutrients, and pesticides to a waterbody (Photograph 8) (NRCS, 2008b). Filter strips are relatively inexpensive to install and maintain and offer substantial water quality benefits. There are locations in the watershed where filter strips have been installed; however, there are numerous areas remaining where filter strips or riparian buffer installation would be advantageous. These areas are shown in Figure 39 and total approximately 20.4 kilometers (12.6 miles) of stream length. Filter strips or riparian buffers may be advantageous on one or both sides of the stream in these locations.

Photograph 8 (06-23-11). Filter strips are located adjacent to a small tributary in the Willow Branch-Brandywine Creek Subwatershed.

Grass Waterways

Grass waterways are drainage swales in farm fields constructed where gully erosion is a recurring problem. Generally, construction involves minor grading to form a trapezoidal or parabolic channel followed by seeding with a sod-forming grass (USDA, 2011a). Stream headwaters are the most practicable places for grass waterway installation.

Livestock Fencing, Stream Crossings, Alternative Watering Facilities, and Rotational Grazing

Livestock with direct access to streams can trample riparian vegetation resulting in bare streambanks that lack the ability to filter surface flow draining to the streams and to resist streambank erosion, which can contribute to significant nutrient and sediment loads. Manure deposited in streams may also minimally contribute to nutrient and *E. coli* loads in waterways (Schwarte, *et al*, 2011). Exclusionary fencing installed in conjunction with filter strips adjacent to streams is the most effective method to help safeguard water quality. Installation of stream crossings may be necessary to allow livestock access to pastures divided by waterways. An alternative watering facility should be provided where livestock rely on streams for water. Types of alternative watering facilities may include nose-operated pumps, pumps powered by alternative energy sources, and ponds.

Rotational grazing in conjunction with installation of alternative watering facilities can also be an effective and less costly means of reducing pollutant loads induced by livestock. Rotational grazing is a system in which a high density of livestock is rotated frequently through a series of paddocks. Rotational grazing has many benefits beyond water quality improvement including maximization of forage yield and quality, improved livestock growth, reduced soil compaction, fewer weeds, and improved distribution of manure across a paddock. Allowing grazing as part of a rotational grazing system is effective when the riparian area has suitable species to graze, livestock are allowed to graze the riparian zone for less than a week and when conditions are dry, and when the riparian vegetation is allowed to fully recover before grazing is reinstituted. Grazing riparian areas is not recommended when streambanks are eroding, conditions are wet, when forage is not grass or legumes, and during peak reproductive periods of aquatic organisms (Hoorman and McCutcheon, 2011).

Log Jam Removal

Log jams are naturally occurring phenomena. They influence natural channel morphology and provide valuable habitat for aquatic organisms. Consequently, not every log jam should be removed. Occasionally, very large log jams occur that create a significant threat to public infrastructure and public safety as well as potential for severe economic loss through flooding and catastrophic streambank failure. Large log jams should be evaluated on a case-by-case basis for removal consideration using public funds.

Private landowners may take precaution to prevent potential for catastrophic log jams by using log jam removal practices that minimize damage to streams. Private landowners may also prevent log jams by discouraging beavers (*Castor canadensis*) from felling trees and building dams in streams. Beavers may be trapped during a designated trapping season typically running from autumn through early spring. A landowner or tenant may take a beaver without a permit outside of trapping season if the beaver is discovered in the act of damaging property. A beaver taken under these circumstances must be reported to a conservation officer within 72 hours (IDNR, 2012).

Nuisance Waterfowl Control

Large quantities of nuisance waterfowl can contribute significant amounts of *E. coli* and nutrients to streams. One way to reduce populations of resident Canada geese congregating adjacent to streams on public properties and around ponds and lakes is to restore woody or herbaceous riparian buffer vegetation adjacent to water edges. Various harassment techniques can also be employed to keep geese from congregating adjacent to waterbodies, including use of noise-making devices, visual devices such as motion sensor lights and predator decoys, high-pressure water spraying devices such as a motion activated sprayer, chemical repellents that make the grass unpalatable, and nest destruction. It is legal to conduct nest destruction at any time when eggs are not present in a nest. However, once an egg is laid, a person can register online with the United States Fish and Wildlife Service and adhere to established protocols for nest destruction and oiling of eggs to render them incapable of hatching. It is also recommended that waterfowl hunting season be promoted for population control in areas where safety issues would not be a concern.

Nutrient and Pest Management Plans

A Nutrient and Pest Management Plan (NPMP) is a tool that helps agricultural producers identify the best timing and adequate amounts of fertilizers to apply for a particular crop in order to maximize yields and minimize nutrient runoff. NPMPs should take into consideration all sources of potential nutrients for a field such as commercial fertilizers, animal manure and other organic by-products, irrigation water, and naturally occurring soil nutrients. NPMPs can help minimize costs that would be incurred by agricultural producers by preventing an overapplication of fertilizer. Application of insecticides and herbicides should also be evaluated as part of a pest management plan.

Development of NPMPs should be prioritized for fields directly adjacent to waterways on cropland that may be prone to flooding as well as cropland in and near wellhead protection areas.

Pervious Pavement

Pervious pavement reduces stormwater runoff by allowing rain and melted snow to drain through pores in the pavement and infiltrate into the ground below. Pervious pavement can be made of specialized asphalt and concrete. Interlocking pavers having joints filled with sand or gravel, gravel paving systems reinforced with a structure that provides support to gravel without the fines, and reinforced grass paving are also types of pervious pavement systems.

Pet Waste Receptacles

Installing signs and receptacles specifically for pet waste in Greenfield parks is a great way to simultaneously educate local residents about watersheds and water quality and help cut down on the amount of *E. coli* and nutrients reaching streams.

Rain Barrels

Stormwater runoff from rooftops can be captured by disconnecting downspouts and directing the water to a rain barrel. Capturing stormwater from residential roofs slows runoff to local drainageways and increases the potential for filtering. Residents can then use the water for non-potable purposes such as irrigation. Promotion of rain barrels can also be a good opportunity to educate local residents about watersheds. Rain barrels are only effective at slowing stormwater peak flows from a site when emptied between rain events.

Riparian Restoration and Preservation

Riparian buffers are naturally vegetated, often forested, areas adjacent to waterways. Riparian buffers keep banks stabilized, provide aquatic and wildlife habitat, enhance infiltration, slow water running to streams from the adjacent landscape, and filter and capture sediment and pollutants. Numerous studies have analyzed optimum riparian buffer widths for protecting water quality. Ideal riparian buffer width is influenced by multiple factors including slope, soil type, and vegetation cover type. Over 140 articles and books have been reviewed to determine a legally defensible, established riparian buffer width for local ordinance development in Georgia. It was concluded that 30-meter (100 feet)-wide riparian buffers are sufficient for good pollutant reduction over a long period of time in most instances; however, buffer widths as narrow as 4.6 meters (15 feet) can provide water quality benefits over a short term (Wenger, 1999). There is extensive opportunity for riparian buffer preservation and width expansion throughout the entire Brandywine Creek Watershed. Streams with riparian buffers and/or filter strips less than 6 meters (20 feet) wide are highlighted in Figure 39. Creation of riparian zones involving woodlands should include a long-term plan to manage log jams so as to ensure confidence among some landowners that their concerns are addressed.

Stormwater BMPs: Infiltration Gardens, Stormwater Swales, Stormwater Planters, and Stormwater Basin Retrofits

There are numerous site specific BMPs that can be used to improve stormwater quality. These BMPs are designed to slow the flow of stormwater, and in many cases allow plants and soils to absorb water and nutrients, thereby reducing the volume of water and pollutant concentrations reaching streams. A few such practices include infiltration gardens, also known as rain gardens, stormwater swales, and stormwater planters. These practices can be easily incorporated into new developments, or existing developed areas can be retrofitted to include these practices. Many older, existing stormwater basins designed primarily for treating water quantity with little emphasis on water quality can also be retrofitted, so as to have the capacity to filter more pollutants from stormwater.

Infiltration Gardens

Infiltration gardens are shallow, vegetated depressions in the landscape used to pond and infiltrate stormwater. Infiltration gardens have the capacity to absorb 30% more stormwater than an area of lawn of equivalent size. They are commonly used to capture stormwater draining from residential rooftops. Properly constructed infiltration gardens should not pond water for much longer than 24 hours.

Stormwater Planters

Stormwater planters can be described as landscaped containers set within a hardscape. They have vertical walls and flat bottoms. There are two types of stormwater planters: infiltration planters that function like infiltration gardens and flow-through planters that absorb only as much water as they are designed to contain within their walls.

Stormwater Swales

Stormwater swales are often long, linear features that intercept and convey stormwater from one location to another. They are gently sloping vegetated channels that slow the flow of water allowing more sediment and pollutants to filter out of stormwater than pipes or concrete channels.

Stormwater Basin Retrofits

Existing stormwater basins, especially dry detention basins, can be retrofitted to provide water quality improvement benefits in addition to merely addressing water quantity. Stormwater basin retrofits can vary widely based on site conditions. A few examples of potential retrofit tasks include creating pools of permanent water within a dry detention basin and replacing concrete channels within basins with vegetated stormwater swales. Wetland vegetation may reduce nutrients leaving the stormwater basin by as much as 90% and provides filtration allowing sediment and other solids to settle out of water (Tetra Tech, 2006). One location where it may be possible to conduct a stormwater basin retrofit project in Brandywine Creek Watershed is northwest of the intersection of McKenzie Road and Broadway Street in Greenfield.

Streambank Stabilization

Natural Channel Restoration

Unstable, severely eroding streambanks contribute sediment and nutrients bound to the sediment to pollutant loads in watershed streams. Areas of streambank erosion identified by watershed stakeholders and during the windshield survey are identified on Figure 39. Figure 52 illustrates a typical cross-sectional drawing for bioengineered streambank stabilization measures using live stakes and facines that could be implemented in some locations in the watershed. Other streambank stabilization practices including use of root wads, boulders, and riprap revetments as well as cribwalls and coir fiber logs for armoring streambanks; rock vanes for deflecting flow; and rock weirs and step pools for grade control may be useful in some instances (Photograph 9). More information on varying streambank stabilization techniques can found in Urban Stream Repair Practices (Schueler and Brown, 2004).

Photograph 9 (10-21-11). A rock vane diverts the flow of Brandywine Creek away from the bank adjacent to CR 425 West in Shelby County.

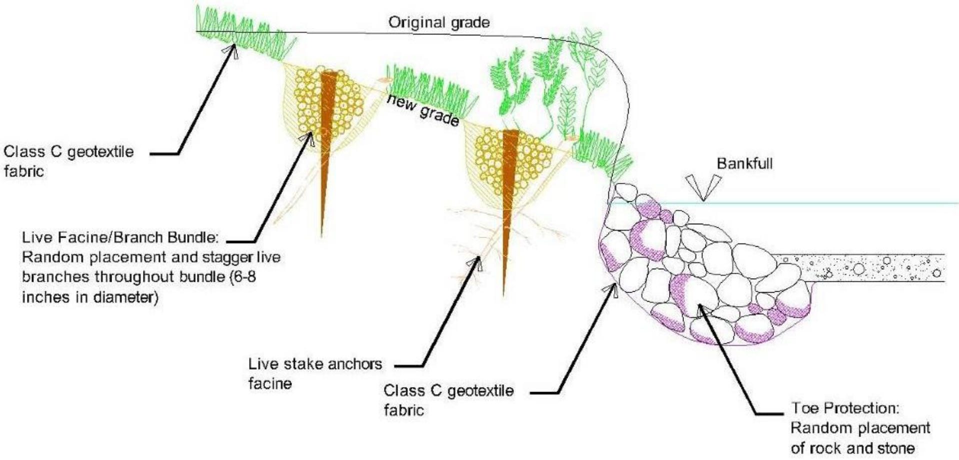

Figure 52. Typical Streambank Stabilization Cross-Section

Two-Stage Ditches

The majority of headwater streams in Indiana have been converted to ditches having incised, trapezoidal channels. These channels have historically been maintained in a fashion to straighten the flow pathway and eliminate a stream's natural floodplain. This results in a high-energy system and high rates of shear stress on the channelized ditch banks. Consequently, ditch bank erosion and instability is a common result. In a two-stage ditch design, the ditch banks are excavated outward above the ordinary high watermark to restore a floodplain to the stream. During storm flow events, energy is dissipated as water flows across the floodplain, reducing bank shear stress and subsequent sediment loading to the stream. Sediment and associated nutrients carried by the stream is also decreased because it has a greater opportunity to filter out of the water column as it flows across the floodplain. Consequently, construction of two-stage ditches has shown to reduce nitrate loads and improve water quality (Tank, 2010). Greater stability of two-stage ditches than traditional ditches also results in lower long-term maintenance costs.

Street Sweeping

Street sweeping removes trash, sediment, and associated nutrients, as well as salts and other pollutants from roadways and parking lots that would otherwise be washed into storms drains. The effectiveness of street sweeping as a BMP varies with the type of street sweeper used and sweeping frequency. Some municipalities conduct street sweeping on a weekly basis. Greenfield currently conducts street sweeping once per year in October (Wessler Engineering, 2010). The City estimated that 192,323kg (424,000 lb.) of debris was removed from city streets in 2008 and 293,928 (648,000 lb.) were removed in 2009 (City of Greenfield, 2010). More frequent street sweeping, especially of high traffic areas can result in further pollutant reduction. Increasing street sweeping frequency to include spring snowmelt can significantly reduce pollutants in stormwater from road salt and sand (USEPA, 2011).

Wetlands Restoration

Wetlands restoration involves returning wetlands hydrology and vegetation to an area that was historically wetlands, but was drained or tiled for agricultural purposes. A few natural wetlands functions include nutrient and sediment filtration, nutrient uptake, floodwater retention, and wildlife habitat. Wetlands restoration can likely be implemented in many areas of the watershed having hydric soil (Figure 8). Wetlands restoration appears to be especially suitable in the headwaters of Swamp Creek south of I-74 based on analysis of multiyear aerial photographs (Figure 39).

Educational Recommendations

The steering committee believes there is extensive need for the public to be educated about water quality in Brandywine Creek Watershed. Topics for which further education is needed in no particular order include:

- Log jam functions and removal procedures to minimize damage to aquatic habitats
- Stormwater pollutant sources
- Septic system care and maintenance
- Proper disposal for hazardous waste, organic yard waste, etc.
- Influence of lawn maintenance practices on water quality and benefits of phosphorus free fertilizer
- Wetlands functions and values
- Riparian buffer functions and values

Legislative Recommendations

Local ordinances can have substantial impacts on water quality. The steering committee believes that education and cost-share incentives should be the first step in persuading behavioral changes to benefit water quality. However, some measures may prove to be more effectively addressed through local legislative action after a period of educational initiatives. Multiple types of local ordinances were discussed and suggested by the steering committee that would have potential to change behaviors in a way that would result in reducing pollutant sources. Some of the potential ordinances discussed have been implemented in other communities in Indiana. Possible local ordinances that would have a positive impact on water quality in Brandywine Creek Watershed include:

- Requiring upgrades to failing septic systems at the time of real estate transactions
- Restricting livestock access to waterways
- Riparian buffer preservation requirements for new developments

Watershed Objectives Action Register and Schedule

The Action Register is a tool to facilitate implementation of the WMP. It includes specific objectives to be carried out in the process of working toward accomplishing each water quality improvement goal statement for Brandywine Creek Watershed. Also included in the Action Register is the target audience for each water quality improvement objective, objective milestones, estimated costs for implementing each objective, and possible partners as well as technical assistance resources that may be beneficial for objective implementation. Cost estimates are approximations only and may vary significantly from actual costs depending on many potential variables associated with each objective.

An Action Register was compiled by the steering committee for each water quality improvement goal statement and is included as Tables 60-64. Many Action Register objectives are applicable to more than one goal statement. Similar objectives may be listed under multiple goal statements; however, identical objectives are only referenced in each applicable table and not repeated.

Table 60. Action Register for Reduction in E. coli Concentrations to Below the State Standard

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
Residential Sources						
E.1	Develop an educational program for homeowners including information on water quality, public health, and septic system site suitability	Homeowners not connected to city utilities; Greenfield City Council	Develop and implement a survey (6 months, Year 3, Year 5)	$18,000	Electric utilities (NineStar Connect)	Steering committee; Social Indicators Data Management & Analysis Tool (SIDMA) (Linda Prokopy, Purdue University); Indiana State Department of Health (ISDA)
			Develop an educational workshop (Year 1)	$1,800	Health departments; SWCDs, SWMDs	Health departments, Purdue University; ISDA
			Develop and distribute educational brochures (Year 1)	$1,000	Health departments; SWCDs, SWMDs; electric utilities (NineStar Connect)	Health departments; Water Words that Work
			Write a minimum of four educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$8,400	Local newspapers	
			Conduct two educational workshops (Year 2, Year 3)	$2,400	Health departments; SWCDs	Health departments
			Adapt educational program accordingly based on survey results (Year 5)	$3,600		ISDA
			Continue on a five-year cycle	-		
E.2	Set up a possible annexation mechanism for subdivisions near Greenfield	Greenfield City Council; homeowners associations of neighborhoods near current Greenfield sanitary sewer infrastructure	Conduct testing to identify neighborhoods with a high proportion of septic system failures near current Greenfield sanitary sewer infrastructure (Year 5)	$8,700	Health departments	Health departments
			Annexation of neighborhoods not suitable for on-site septic systems by the end of Year 12	$10,000	Greenfield Water Utility	Greenfield Engineering Department; Greenfield Water Utility; Greenfield City Council
E.3	Set up an elective program for wide-scale rural septic system upgrades/maintenance potentially at a discount if septic system sites are suitable	Homeowners not connected to city utilities	Coordinate with septic system contractors to develop a discount program (Year 4)	$4,800	Health departments; septic system contractors	Septic system contractors; unidentified funding source
			Advertise discount program (Year 5)	$3,000	Health departments; septic system contractors; electric utilities (NineStar Connect); Shelby Co. SWCD	
			75 residences conducting maintenance during 1st special maintenance discount program	$7,500	Septic system contractors; SWCDs	Septic system contractors
			Repeat discount program every five years	-		Septic system contractors
			Six voluntary upgrades made by the end of Year 12	$0	Health departments; septic system contractors	Health departments

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
E.4	Develop an ordinance requiring upgrades to failing systems at the time of real estate transactions	All parties involved in real estate transactions	Begin planning (Year 5) and continue development through Year 12	$28,800	Health departments, ISDA, septic contractors	County commissioners
			Ordinance passed and enforced (Year 12)	$3,600	Real estate agents	County Commissioners
E.5	Seek federal grants for extending sewer service as well as grants for septic upgrades based on income and information on low interest loans	n/a	Look for and apply for grants (ongoing)	$6,000		USDA Rural Development; ISDA; usa.gov
Animal Sources						
E.6	Develop an educational program for watershed residents about animal waste and water quality issues	Livestock producers; pet owners; city officials; homeowners and homeowners associations with lakeshores, pond shores, and streambanks (waterfowl)	Develop and implement survey (6 months, Year 3, Year 5)	see E.1	Electric utilities (NineStar Connect)	Steering committee; SIDMA (Linda Prokopy, Purdue University);
			Develop and distribute educational brochures (Year 1)	$1,000	Pet stores; veterinary clinics; Greenfield Parks and Recreation; Greenfield MS4; NRCS	Water Words that Work
			Write educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$3,600	Local newspapers; SWCDs	
			Adapt educational program accordingly based on survey results (Year 5)	$3,600	SWCDs	
			Develop educational signs - minimum three, maximum six (Years 1-5)	$16,200	Greenfield Parks and Recreation, local residences;	Cartoon artist; Water Words that Work
			Continue on a five-year cycle	-		
E.7	Implementation of livestock and other agricultural BMPs including but not limited to livestock fencing, stream crossings, alternative watering facilities, rotational grazing, nutrient and pest management plans	Livestock producers	Contact critical area landowners regarding available cost-shares and benefits of BMP implementation (Year 1)	$7,200	Steering committee, NRCS	NRCS
			Prioritize and implement feasible projects; continue to identify potential projects (Year 1 and ongoing)	$90,000	NRCS, LARE, Farm Bureau, Purdue Extension, steering committee	NRCS, LARE
E.8	Installation of pet waste receptacles at parks	Greenfield Parks and Recreation	Identify parks that would benefit from receptacles (Year 1)	$900	Greenfield Parks and Recreation	Greenfield Parks and Recreation
			Install receptacles at designated parks (Year 2)	$15,000	Greenfield Parks and Recreation	Greenfield Parks and Recreation

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
Animal Sources (Continued)						
E.9	Reduce nuisance waterfowl numbers	Hunters; landowners; homeowners associations	Promote waterfowl hunting season (Year 2 and ongoing)	$500	DNR	DNR
			Obtain permit for nuisance waterfowl egg removal (Year 2)	$10,800	Nuisance animal removal contractors	DNR
			Assist landowners/homeowners with seeking habitat improvement grants (Year 1, ongoing; eight projects target completion by Year 10)	$9,000	National Wildlife Federation	DNR, NRCS
E.10	Implement legislation regarding pet waste at parks	Greenfield City Council	Legislation passed and enforced by end of Year 5	$3,600	Greenfield Parks and Recreation, park patrons	Greenfield City Council; Greenfield Parks and Recreation
E.11	Implement legislation regulating livestock access to waterbodies	County commissioners; watershed stakeholders	Develop support for legislation (Years 5-10)	$10,000	Steering committee; Hoosier Environmental Council, Indiana Conservation Alliance	
			Legislation passed and enforced by end of Year 20	$3,600	NRCS; Hoosier Environmental Council, Indiana Conservation Alliance	County commissioners

Table 61. Action Register for Reduction in Nutrient Loads Below Water Quality Targets

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
Urban Land Sources						
N.1	Develop an educational program for homeowners including information on water quality and the factors that influence it including information on phosphorus.- free fertilizers and other structural, residential BMPs.	Homeowners	Develop and implement a survey (6 months, Year 3, Year 5)	see E.1	Electric utilities (NineStar Connect)	Steering committee; SIDMA (Linda Prokopy, Purdue University)
			Develop and distribute educational brochures (Year 1-2)	$1,000	Fertilizer sales facilities; Greenfield MS4	Water Words that Work
			Write a minimum of eight educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$16,800	Local newspapers; Shelby Co. SWCD	
			Develop educational signs - minimum three, maximum six (Years 1-5)	see E.6	Beckenholt Park – Greenfield Parks and Recreation	Cartoon artist; Water Words that Work
			Conduct a field day at a demonstration site near the Hancock County Courthouse, City Hall, and McCleerey's Sporting Goods (Year 2)	$1,200	Greenfield MS4	
			Adapt educational program accordingly based on survey results (Year 5)	$3,600	SWCDs	
			Continue on a five-year cycle	-		
N.2	Implement residential BMPs including but not limited to infiltration gardens and rain barrels	Master Gardeners	Work with local Master Gardner volunteers to promote infiltration gardens within their program and develop a means through which they can provide technical assistance to homeowners interested in infiltration garden installation (Year 2)	$3,000	Steering committee, Purdue Extension	
		Homeowners	Promote cost-share program; make rain barrels available through SWCDs; identify homeowners interested in infiltration gardens and connect them with the appropriate resources (Years 2-5)	$29,500	Greenfield MS4; Master Gardeners	Master Gardeners

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
Urban Land Sources (Continued)						
N.3	Promote development in accordance with the county/city comprehensive plans with a specific emphasis on preserving riparian areas as depicted in the plan. Create an ordinance requiring preservation and restoration of riparian zones in new developments as well as incorporation of green infrastructure including, but not limited to, pervious pavement, infiltration gardens, stormwater planters, and stormwater swales.	County commissioners; county plan commissions; developers	Actively engage in dialogue with planning officials to stress the importance of riparian buffer preservation (Year 2 and ongoing)	$1,200	CILTI; steering committee	
			Develop ordinance committee (Year 3)	$1,200	County Planners	
			Ordinance passed (Year 5)	$3,600		Greenfield City Council; Hancock and Shelby County Plan Commissions
N.4	Improve requirements associated with retention pond specifications for pre-treatment in the existing stormwater ordinances to improve water quality further	County commissioners: county plan commissions; Greenfield City Council	Provide educational materials and examples of other local stormwater ordinances that further protect water quality above and beyond the scope of the existing ordinances (Year 3 and ongoing)	$1,800	Steering committee; county planners	
			Work with committee revising the local ordinances whenever they are subject to review	$2,000	Steering committee	
N.5	Seek grants to implement urban stormwater BMPs at the municipal level	Entities owning properties with antiquated stormwater treatment practices	Identify locations that would benefit from stormwater BMP implementation (Year 5)	$3,600	Greenfield MS4	Greenfield Engineering Department

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
Rural Land Sources						
N.6	Develop an educational program about agricultural BMPs and reduced fertilizer use	Agricultural producers; hobby livestock farms; rural landowners, county commissioners, and county surveyors (two-stage ditches)	Develop and implement a survey (6 months, Year 3, Year 5)	see E.1	Farm Bureau; co-ops; electric utilities (NineStar Connect)	Steering committee; SIDMA (Linda Prokopy, Purdue University)
			Develop and distribute educational brochures (Year 1)	$1,000	Fertilizer sales facilities; Farm Bureau; co-ops	Water Words that Work
			Write a minimum of 10 educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$21,000	Local newspapers; SWCDs	
			Conduct field days at a demonstration site for less abundant practices in the watershed such as drainage water management or cover crops (Year 2, Year 3, Year 4)	$9,000	Steve Stohry, Shelby County landowner who has installed drainage water management; ISDA; Purdue Extension	Indiana Conservation Cropping Systems (Hans Kok); NRCS; Purdue Extension
			Have field day with USGS to discuss what is coming out of tiles (Year 2, 5)	$1,200	SWCDs	USGS
			Adapt educational program accordingly based on survey results (Year 5)	$3,600		
			Continue on a five-year cycle	-		
N.7	Implement agricultural BMPs including but not limited to no-till, cover crops, drainage water management, filter strips, grass waterways, livestock fencing, stream crossings, alternative watering facilities, rotational grazing, nutrient and pest management plans, riparian restoration and preservation, two-stage ditches, and wetlands restoration	Agricultural producers; hobby livestock farms; rural landowners	Identify landowners with potential interest in BMP implementation, inform them about available cost-shares and benefits of BMP implementation, prioritize potential projects, provide necessary resources for implementation (Year 1 and ongoing)	Varies based on types and sizes of selected BMPs (Table 55)	Farm Bureau; co-ops; SWCDs	NRCS; LARE
Previously Listed Action Register Objectives						
Please see Action Register Objectives: E.1-11						

Table 62. Action Register for Reduction in Sediment Loads Below Water Quality Targets

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
Urban and Rural Land						
S.1	Develop an educational program on natural stream functions; values of fence rows and riparian areas for wildlife and erosion control; and maintenance of riparian areas to prevent problematic log jams	Landowners; agricultural producers	Develop and implement a survey (6 months, Year 3, Year 5)	see E.1	Farm Bureau; co-ops; electric utilities (NineStar Connect)	Steering committee; SIDMA (Linda Prokopy, Purdue University)
			Write a minimum of three educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$6,300	Local newspapers; SWCDs; The Nature Conservancy; DNR; Pheasants Forever (root pruning fence rows)	NRCS; DNR
			Provide support and participate in an edition of Indiana Expeditions (PBS show) (express interest in Year 1)	$9,000 contribution	Indiana Association of SWCDs; DNR Division of Forestry; DNR Natural Resources Education Center	Indiana Expeditions
			Adapt educational program accordingly based on survey results (Year 5)	$3,600		
			Continue on a five-year cycle	-		
S.2	Identify and map small ditches and retention ponds (esp. in reference to identifying areas in need of riparian buffers)	County GIS departments	Have accurate watershed boundaries depicted on county GIS websites (Year 1)	$1,500	Hancock County and Shelby County GIS departments; Greenfield MS4	
			Seek funding (Years 1-4)	$6,000		
			Complete mapping by end of Year 5	$18,000		Watershed coordinator; intern
S.3	Removal of large, problematic log jams especially when public infrastructure is at risk	n/a	Conduct as needed	variable depending on specific site conditions	County surveyors; LARE	County surveyors; DNR
S.4	Promote more frequent street sweeping in Greenfield	Greenfield City Council; Greenfield Street Department	Discuss the benefits of and possible options for increasing the frequency of routine street sweeping with the appropriate authorities (Year 1)	$500	Greenfield MS4	Greenfield Street Department
Previously Listed Action Register Objectives						
Please see Action Register Objectives: E.9, N.1, and N.3-7						

Table 63. Action Register for Reduction in Flood Damages

Action Register ID#	Outputs/Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
F.1	Develop an educational program for watershed residents on the function and value of floodplains and stormwater reduction BMPs	All watershed residents, county commissioners; county plan commissions; developers	Develop and implement a survey (6 months, Year 3, Year 5)	see E.1	Electric utilities (NineStar Connect)	Steering committee; SIDMA (Linda Prokopy, Purdue University)
			Develop and distribute educational brochures (Year 1-2)	$1,000	Greenfield MS4	Water Words that Work
			Write a minimum of three educational articles for inclusion in SWCD newsletters or local newspapers (Years 1-5)	$6,300	Local newspapers; Shelby Co. SWCD	
			Conduct a field day at a BMP demonstration site near the Hancock County Courthouse, City Hall, and McCleerey's Sporting Goods (Year 2)	$3,000	Greenfield MS4	
			Adapt educational program accordingly based on survey results (Year 5)	$3,600	SWCDs	
			Continue on a 5 year cycle	-		
F.2	Create an ordinance requiring incorporation of green infrastructure in new developments including but not limited to pervious pavement, infiltration gardens, stormwater planters, and stormwater swales	County commissioners; county plan commissions; developers	Actively engage in dialogue with planning officials to stress the importance of green infrastructure (Year 2 and ongoing)	$1,200	Steering committee	
			Develop ordinance committee (Year 3)	$1,200	County Planners	
			Ordinance passed (Year 5)	$3,600		Greenfield City Council; Hancock and Shelby County Plan Commissions
F.3	Improve requirements associated with retention pond specifications in the existing stormwater ordinances to further protect watershed streams from stormwater surges	County commissioners: county plan commissions; Greenfield City Council	Provide educational materials and examples of other local stormwater ordinances that further reduce flood potential above and beyond the scope of the existing ordinances (Year 3 and ongoing)	$4,800	Steering committee; county planners	

Table 64. Action Register for Increasing Public Awareness of Water Quality Issues

Action Register ID#	Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
P.1	Develop an intense educational and community outreach campaign that includes Action Register Objectives: E.1, E.6, N.1, N.6, S.1, and F.1	All watershed stakeholders	Develop and install three billboard layouts (end of Year 3)	$15,000	Indiana Expeditions	IDEM
			Develop a movie theater/video advertisement in conjunction with an episode of Indiana Expeditions (express interest Year 1)	see S.1	Indiana Expeditions; Indiana Association of SWCDs; DNR Division of Forestry; DNR Natural Resources Education Center	Indiana Expeditions
			Establish a turn in a litterer local phone number (end of Year 5)	$180	Greenfield MS4	Greenfield MS4
			Deliver a minimum of two presentations and develop an appropriate brochure for homeowners associations (end of Year 4)	$5,200	Steering committee; utilities	
			Install approximately 25 markers annually on storm drains indicating they drain to streams (Years 1-5)	$3,600	Greenfield MS4; Shelbyville MS4	Greenfield MS4; Shelbyville MS4
			Increase number of household hazardous waste collection days in Hancock County to a minimum of four times annually by Year 2, six times annually by Year 4, and monthly by Year 6. Have free disposal of household hazard waste by Year 3.	$5,100	Greenfield MS4; Shelby County SWMD	Hancock County SWMD
			One trash removal/stream clean-up day per year (Year 1-5)	$7,500	Adopt-a-highway volunteer groups; Lions Club, 4-H clubs, scout groups	
P.2	Seek opportunities to participate in school programs	Students	Develop contacts within watershed schools (within 6 months)	$1,200	Rich McGown a Triton Central teacher	
			Develop and conduct a minimum of 1 teacher workshop per year (Years 1-5)	$7,800	Shelby County SWCD	
			Develop and conduct a minimum of three student workshops per year (Years 1-5)	$19,800	Shelby County SWCD	
P.3	Create a digital database of all educational materials produced	SWCD staff; steering committee	Create a digital resource of all educational materials produced promoting water quality improvement in Brandywine Creek Watershed (Year 1 and ongoing)	$4,800	SWCDs; steering committee; Greenfield MS4	Watershed coordinator

Action Register ID#	Objectives	Target Audience	Milestone	Cost	Possible Partners	Technical Assistance Needed
P.4	Develop partnerships with retail stores to improve plastic bag collections and provide space for other hazardous waste collection such as household batteries	Retail facilities including but not limited to Walmart, Kroger, Marsh, and Home Depot	Obvious plastic bag collection programs in local retail stores by end of Year 5	$4,000	Steering committee	Retail stores
			Small household waste collection bins in retail stores by end of Year 5	$5,400	Hancock County SWMD; steering committee	Retail stores; Hancock County SWMD
P.5	Promote Hoosier Riverwatch and host training events	All watershed stakeholders	Advertise Hoosier Riverwatch as a way local residents can make a difference as a part of all outreach activities. Attempt to host four training workshops by Year 5. Continue to host workshops as relevant in future years.	$6,600	all local SWCDs	Hoosier Riverwatch program
Previously Listed Action Register Objectives						
Please see Action Register Objectives: E.1, E.6, N.1, N.6, S.1, and F.1						

Tracking Watershed Management Effectiveness

Goal Indicators

The success of the WMP can be measured by the progress made toward achieving each stated water quality improvement goal. Progression indicators include social indicators, administrative indicators, and environmental indicators. A watershed coordinator or steering committee members will be responsible for tracking all indicators. Administrate indicators will be tracked on a quarterly basis and reported to the steering committee and other appropriate entities quarterly. Social indicators and environmental indicators will be included in quarterly reports, as new data are available.

Social Indicators

Water quality is significantly influenced by the behaviors and attitudes of the people living and working in a watershed. Education about water quality issues is a substantial component in improving and maintaining water quality over the long term, and multiple educational initiatives are proposed as part of WMP implementation. Measuring social indicators is one way to gauge changing attitudes and awareness of water quality issues over time and gauge the progress and success of educational initiatives. Specifically, social indicators are designed to measure awareness of pollutants, consequences of pollutants, and practices that are used to improve water quality as well as attitudes linked to behavioral change. In addition to the benefit of gauging the long-term sustainability of water quality improvement, measuring social indicators also provides a means to demonstrate WMP success sooner than measuring environmental indicators, which may take numerous years to see fruition.

Social Indicators Data Management and Analysis tool (SIDMA) has been developed to help watershed managers manage, analyze, and monitor social indicators associated with water quality improvement attributed nonpoint source pollution in USEPA Region 5. A key feature of SIDMA is a survey builder, which includes survey questions worded to reduce ambiguity by respondents that can be used as a template (Institute of Water Research, 2011).

A survey is proposed to be developed and given to a random sample of people in the watershed within six months of implementation of the WMP to provide baseline social indicator data. The survey is planned to be repeated after three and five years of WMP implementation to gauge progress being made, and to adjust the educational initiatives as appropriate to attain maximum results. The same survey or an adapted version will also be given to those participating in educational programming.

Administrative Indicators

Administrate indicators amount to keeping tally of activities associated with WMP implementation and are best tracked in spreadsheets. They are used to track public participation as well as attainment of basic BMP implementation goals. Administrate indicators that will be tracked as part of WMP may include, but are not limited to:

- Number of each type or acreage of BMP installed
- Modeled pollutant load reductions associated with BMP implementation
- Number of people attending workshops and field days
- Number of hits on the watershed website, newspaper articles published, etc.
- Number of specific educational materials distributed
- Number of permits for septic system upgrades

Environmental Indicators

Water quality parameters analyzed during development of the WMP provide minimal water quality baseline condition data for Brandywine Creek Watershed. Continued monitoring will track trends and the progression of actual water quality. Although, it should be expected for there to be lag time between implementation of the WMP and BMPs and detecting consistent, measurable improvements in water quality. Parameters analyzed as part of this study included temperature, pH, specific conductivity, dissolved oxygen, total phosphorus, ammonia nitrogen, nitrate+nitrite nitrogen, TKN, TSS, turbidity, discharge, *E. coli*, macroinvertebrate, and habitat data. At a minimum, Davey recommends two sampling events per year analyzing total phosphorus, total nitrogen, TSS, and *E. coli* concentrations as well as collecting discharge for as long of duration as feasible. Davey recommends sampling macroinvertebrates a minimum of once every other year. Davey recommends that samples be consistently collected at the same sites with a minimum of one location per 12-digit HUC subwatershed. Samples may be collected either professionally and analyzed by a laboratory or using Hoosier Riverwatch methods.

If funding allows, the steering committee proposes three water chemistry monitoring events per year at 10 sites in Brandywine Creek Watershed, and sampling macroinvertebrates during two seasons in the first and third years of WMP implementation. Parameters proposed for testing include total phosphorus, total nitrogen, TSS, pH, temperature, dissolved oxygen, salinity, conductivity, *E. coli*, and discharge.

Hoosier Riverwatch volunteer monitoring will be encouraged in the watershed. It is proposed that Hoosier Riverwatch volunteers collect data from the same locations from which samples will be collected for laboratory analyses; thus, providing a long-term, cost-effective means of tracking water quality in Brandywine Creek Watershed.

Future Watershed Management Plan Activity

As watershed conditions and public opinions change over time, the priority for recommended BMPs will change. Further, implementation of some BMPs may no longer be as important or may no longer be needed at all. As policies change and technologies improve, new BMPs may be identified that should be implemented. An annual steering committee meeting led by the Hancock County SWCD or watershed coordinator should be held to evaluate the progress made in implementing WMP recommendations. The WMP is a flexible guidance document and necessary accommodations can be made by the steering committee annually. It is recommended that the plan be thoroughly reevaluated by the steering committee after five years and be adjusted and updated as appropriate to incorporate future unforeseen circumstances. It is recommended that the plan continue to be thoroughly reevaluated and updated on a five-year rotation. As the WMP development sponsor, Hancock County SWCD will be the primary contact for implementation of the WMP and can be reached at the following contact information:

Hancock County SWCD
Cindy Newkirk, District Administrator
1101 West Main Street, Suite N
Greenfield, Indiana 46140
317-462-2283

Watershed Management Resources

BMP Funding Sources

Several well-known cost-share programs are offered by the USDA NRCS, ISDA, IDNR, IDEM, and other less well-known programs that could be used to financially support the implementation of common BMPs recommended in this report.

The NRCS offers its Conservation Reserve Program (CRP), which provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program assists farmers and ranchers in complying with Federal, State, and tribal environmental laws, and encourages environmental enhancement. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning, and practice implementation. The CRP reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost-sharing is provided to establish the vegetative cover practices.

The NRCS Environmental Quality Incentives Program (EQIP) is a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. Other NRCS programs such as the Wildlife Habitat Incentive Program (WHIP) and Wetland Reserve Program (WRP) also provide funding for ecological restoration projects.

The ISDA Division of Soil Conservation administers the Clean Water Indiana (CWI) fund under direction of the State Soil Conservation Board. CWI provides financial assistance to SWCDs, conservation groups, and land occupiers to implement conservation practices for reducing nonpoint source water pollution. Funds are available for education, technical assistance, training, and cost-share programs. Cost-share programs can provide funds to encourage land occupiers to implement conservation practices to reduce nutrient, pesticide, and sediment runoff as well as implementing nutrient management programs including fencing for rotational grazing systems, purchasing nutrient management equipment, voluntary environmental audits, and similar expenditures (IC 14-32-8). SWCDs must apply for funds, and priority will be given to applications with at least a 50% match.

The IDNR LARE program provides cost-share funds or incentive payments to implement many of the recommended structural BMPs. Organizations interested in sponsoring a Watershed Land Treatment project for landowners must contact LARE project managers by November 1st of each year to discuss potential projects. Grant applications are due January 15th of each year. The LARE program also provides funding for engineering feasibility, design, and construction projects.

The Federal Clean Water Act Section 319(h) provides funding for various types of projects that work to reduce nonpoint source water pollution. Application for Section 319 funds is made through the Indiana Department of Environmental Management. Funds may be used to conduct assessments, develop and implement watershed management plans and Total Maximum Daily Limits (TMDL), provide technical assistance, demonstrate new technology, and provide education and outreach. Organizations eligible for funding include nonprofit organizations and universities as well as local, state, and federal government agencies. A 40% (non-federal) in-kind or cash match of the total project cost must be provided. Section 319 funds can be used to demonstrate new technology that could potentially address principle issues discussed in this report. A Section 319 approved Watershed Management Plan must exist in order to obtain funds for project implementation.

A summary of sources that provide funds supporting recommended BMPs is provided in Table 65. Many of the programs listed also fund numerous other BMPs that would be beneficial for water quality, but are not discussed in this report.

Table 65. BMP Funding Sources Summary

BMP	Funding Source					
	LARE	Sect. 319	CRP	EQIP	CWI	Other
Conservation tillage (no-till)	x	x		x		
Cover crops	x	x		x	x	
Drainage water management		x		x		
Filter Strips	x[1]	x	x	x		CREP[2]
Grass waterways	x	x	x	x		
Livestock fencing, stream crossings, alternative watering facilities, and rotational grazing	x	x		x	x	
Log jam removal	x					County Drainage Boards
Nuisance waterfowl control		x				
Nutrient and pest management plans	x	x		x	x	
Pervious pavement		x				
Pet waste receptacles						Misc. stormwater grants
Rain barrels		x				
Riparian restoration and preservation	x	x	x	x		IDNR Division of Forestry, CREP
Stormwater BMPs						
Infiltration gardens		x				
Stormwater planters		x				
Stormwater swales		x				
Stormwater basin retrofit		x				
Streambank stabilization						
Natural channel	x	x		x		
Two-stage ditches	x	x		x		
Street sweeping						Greenfield MS4
Wetlands restoration/construction	x	x	x	x		WRP, WHIP, CREP
Educational initiatives		x			x	SWCDs, Community Foundation Grants

[1] LARE incentive payments can be combined with funds from other non-state sources.
[2] Conservation Reserve Enhancement Program

Institutional Resources

A large variety of established institutional resources and other potential institutional resources exist in the watershed to aid in water quality improvement efforts. Davey recommends that potential institutional resources such as local 4-H clubs, the Greenfield Lions Club, Boy Scout and Girl Scout troops, potential science clubs at local high schools, and landowners who attended the public meetings be made aware of the opportunity to serve as Hoosier Riverwatch volunteers. A class at Triton Central High School taught by Rich McGown visits Brandywine Creek on annual basis to collect data using Hoosier Riverwatch methods, although no one submits official data to Hoosier Riverwatch at this time. Mr. McGown can be contacted at the following information:

Rich McGown
Triton Central High School
4774 West 600 North
Fairland, Indiana 46126
317-902-9445
rmcgown@nwshelby.k12.in.us

Established institutional resources range from local government offices, state and federal agency personnel/programs, and non-profit conservation organizations. The following sub-sections outline some of the various roles, resources, and contact information for established institutional resources.

Local and County Government Offices and Resources

Soil and Water Conservation Districts

The Indiana Conservation Act (IC 14-32) established Indiana's Soil and Water Conservation Districts (SWCDs). SWCDs are chartered, legal subdivisions of State Government whose territories are aligned with county boundaries. SWCDs develop and implement conservation programs based on a set of resource priorities, and channel resources from all levels of government into action at the local/county level. Indiana's 92 SWCDs are each governed by a board of supervisors, consisting of three elected supervisors, who own or rent more than 10 acres of land in the district, and two appointed supervisors who maintain their permanent residence in the district.

Hancock County SWCD
Cindy Newkirk, District Administrator
1101 West Main Street, Suite N
Greenfield, Indiana 46140
317-462-2283
cindy.newkirk@in.nacdnet.net

Shelby County SWCD
Jill Williams, District Administrator
2779 South 840 West
Manilla, Indiana 46150
765-544-2051
jill.williams@in.nacdnet.net

Ashley Carlton, District Technician
2779 South 840 West
Manilla, Indiana 46150
765-544-2051
ashley.carlton@in.nacdnet.net

Surveyors and Drainage Boards

County surveyors and drainage boards play a critical role in the implementation of streamside BMPs, as well as potential restoration efforts that may involve the manipulation of current above- or below-ground drainage infrastructure.

The Indiana Drainage Code of 1965 sets forth the authority to create a Drainage Board in each County. The Drainage Board consists of either the County Commissioners or a citizen board with one Commissioner as a member. The County Surveyor serves the Board as an Ex-Officio Member. This position is a non-voting position, and the County Surveyor serves as a technical advisor to the Board. The Drainage Board has the authority to construct, maintain, reconstruct, or vacate a regulated drain. They may also create new regulated drains if so petitioned by landowners. There are numerous regulated drains in the watershed.

Hancock County Surveyor
Susan Bodkin
111 South American Legion Place, Suite 171
Greenfield, Indiana 46140
317-477-1150
sbodkin@hancockingov.org

Shelby County Surveyor
Taylor Sumerford
25 West Polk Street, Room B-20
Shelbyville, Indiana 46176
317-392-6481

Purdue University Cooperative Extension Service

The Purdue University Cooperative Extension Service provides educational programs and information relating to agricultural and natural resources based on scientific research to the general public among other topics. Each county maintains an extension service office and many employ an Agriculture and Natural Resources Educator.

Hancock County Agriculture and Natural Resources Educator
Roy Ballard
Purdue University Cooperative Extension Service
Hancock County Office
802 Apple Street
Greenfield, Indiana 46140
317-462-1113
rballard@purdue.edu

Shelby County Agriculture and Natural Resources Educator
Daniel Gabbard
Purdue University Cooperative Extension Service
Shelby County Office
1110 Amos Road
Shelbyville, Indiana 46176
317-392-6460
gabbardd@purdue.edu

Purdue University maintains a website that contains multiple fact sheets related to septic systems as well as a page to answer frequently asked questions about septic systems. The website can be accessed at www.extension.purdue.edu/henv/index.html.

Solid Waste Management Districts

Hancock and Shelby Counties each have a Solid Waste Management District (SWMD). Many SWMDs have collection locations for waste oil, paints, solvents, household chemicals, and other residential chemicals.

Hancock County SWMD
Katherine Wampler
802 North Apple Street
Greenfield, Indiana 46140
317-462-7605

Shelby County SWMD
Katherine Wampler
1600 East State Road 44, Suite A
Shelbyville, Indiana 46176
317-392-8904

Health Departments

Local health departments issue permits for and inspect new septic systems as well as septic system repairs under the administrative authority of the State of Indiana Residential Onsite Sewage Systems Rule 410 IAC 6-8.2. Health departments also investigate sewage complaints and license local septic installers. Neither the Hancock County nor Shelby County Health Department conducts regular surface water quality monitoring.

Hancock County Health Department
111 South American Legion Place, Suite 150
Greenfield, Indiana 46140
317-477-1127

Shelby County Health Department
Robert Lewis
1600 East State Road 44, Suite B
Shelbyville, Indiana 46176
317-392-6470
rlewis@localhealth.in.gov

State Government Offices and Programs

Indiana Department of Natural Resources and Indiana Department of Environmental Management

The Indiana Department of Natural Resources (IDNR) and the Indiana Department of Environmental Management (IDEM) have a variety of programs and staff dedicated to water quality assessments and watershed planning initiatives. The most relevant contacts at these agencies to assist local leaders in water quality planning efforts are listed below. While there are countless specialists at these agencies, the staff listed below should be able to guide local questions to appropriate personnel.

Indiana Department of Natural Resources
Division of Fish & Wildlife – Lake and River Enhancement Program (LARE)
Rod Edgell, Biologist
1353 South Governors Drive
Columbia City, Indiana 46725
260-244-6805 ext. 230
redgell@dnr.in.gov

Indiana Department of Environmental Management
Office of Water Quality
Kathleen Hagan, Watershed Specialist
100 North Senate Avenue
MC 65-44 Shadeland
Indianapolis, IN 46204-2251
317-308-3197
khagan@idem.in.gov

IDNR Division of Forestry provides training and technical assistance to private forest landowners and forest industries. The Division of Forestry also administers state and federal programs that provide property tax incentives and cost-share incentives for implementing practices that promote sustainable management including wildlife habitat, watershed and water quality protection, and forest products.

Indiana Department of Natural Resources
District 14 Forester
Donna Rogler
Ft. Harrison State Park – NREC
5785 Glenn Road
Indianapolis, Indiana 46216
317-549-0354
drogler@dnr.in.gov

IDNR Division of Fish and Wildlife maintains a list of nuisance waterfowl control operators as well as provides technical assistance relating to reducing nuisance resident waterfowl populations.

Indiana Department of Natural Resources
District 11 Wildlife Biologist (Hancock County)
Nate Yazel
2239 North State Road 103
New Castle, Indiana 47362
765-529-6319
nyazel@dnr.in.gov

District 8 Wildlife Biologist (Shelby County)
Josh Griffin
7920 South Rowe Street
PO Box 3000
812-526-4891
jgriffin@dnr.in.gov

District 4 Fisheries Biologist
Rhett Wisener
Cikana State Fish Hatchery
2650 State Road 44
Martinsville, Indiana 46151
765-342-5527
rwisener@dnr.IN.gov

Indiana State Department of Agriculture

The Division of Soil Conservation belongs to the Indiana Conservation Partnership; however, it is situated in the Indiana State Department of Agriculture (ISDA). As part of the Partnership, ISDA provides technical, educational, and financial assistance to citizens to solve erosion and sediment-related problems occurring on the land or impacting public waters. The Division of Soil Conservation is divided into Conservation Implementation Teams (CIT) each covering specific counties. These teams can deliver advice to landowners regarding BMPs, assist with engineering design, and secure/coordinate associated project permits and cost-share amounts.

Hancock and Shelby Counties CIT Resource Specialists
Brenda Gettinger
823 South Round Barn Road, Suite 1
Richmond, Indiana 47674
765-966-0191, ext. 3
bgettinger@isda.in.gov

Mark Thomas
1981 South Industrial Park Road, Suite 2
Versailles, Indiana 47042
812-689-6410 ext. 3
mthomas@isda.in.gov

Clean Water Indiana (CWI) is administered through ISDA. CWI provides funds to implement conservation practices that reduce nonpoint source water pollution. Information regarding CWI fund applications can be directed to the ISDA Grants Coordinator:

Jennifer Pinkston
jpinkston@isda.in.gov

Indiana State Department of Health

The mission of the Indiana State Department of Health (ISDH) is to protect and provide for the health of citizens in their communities. ISDH administers the Onsite Sewage Systems Program. ISDH provides educational programs and technical assistance regarding septic systems for the general public and different organizations. ISDH can also conduct surveys for local government organizations to determine the extent of septic system problems in a given area.

Environmental Public Health Division
Mike Mettler, Division Director
2 North Meridian Street, 5-E
Indianapolis, Indiana 46204
317-233-7183
mmettler@isdh.in.gov

Federal Government Offices and Programs

Natural Resources Conservation Service

The NRCS is a Federal agency that works with landowners and managers to conserve their soil, water, and other natural resources. NRCS employees provide technical assistance based on a customer's specific needs in such areas as animal husbandry and clean water, ecological sciences, engineering, resource economics, and social sciences. They also provide financial assistance for many conservation activities. The NRCS programs are all voluntary participation programs.

Hancock County District Conservationist
Wes Slain
1101 West Main Street, Suite N
Greenfield, Indiana 46140
317-462-2283, ext. 3

Shelby County District Conservationist
Bill Harting
2779 South 840 West
Manilla, Indiana 46150
765-544-2051

Non-Profit Organizations

Rural Community Assistance Program

The Rural Community Assistance Program (RCAP) is a nationwide nonprofit organization that works with low-income individuals and communities to improve rural quality of life by providing free technical assistance for drinking water, wastewater, and community development needs. Indiana RCAP conducts numerous specific tasks including needs assessments, community meetings, public education, community surveys, and income surveys. Indiana RCAP also procures engineering and professional services, completes grant applications, and assists with environmental reviews. Indiana RCAP receives funding from the following programs: United States Department of Health and Human Services, Office of Community Services; USDA Rural Utility Service; and the USEPA Safe Drinking Water Program.

IN-RCAP
Vicki Perry, Director
1845 West 18th Street
Indianapolis, Indiana 46202
800-382-9895
vperry@incap.org

The Nature Conservancy

The Nature Conservancy is a non-profit conservation organization that works to protect ecologically sensitive land and water quality for the benefit of both humans and other organisms. The Nature Conservancy works using sound science and ecological principles in all 50 states in the United States and more than 30 other countries. The Nature Conservancy manages Hawk Woods Nature Preserve in the watershed.

Efroymson Conservation Center
620 East Ohio Street
Indianapolis, Indiana 46202
317 951-8818

Central Indiana Land Trust

Central Indiana Land Trust is a non-profit conservation organization that seeks to preserve natural areas through legal land protection, stewardship activities, and education. Central Indiana Land Trust is specifically seeking to expand awareness on the value of natural area corridors, which includes the natural areas flanking Brandywine Creek.

Central Indiana Land Trust
Cliff Chapman, Conservation Director
1500 North Delaware Street
Indianapolis, Indiana 46202
317-631-5263, ext. 113
cchapman@conservingindiana.org

Hoosier Heartland RC&D Council

The Hoosier Heartland Resource Conservation and Development Council is a nonprofit organization dedicated to improving the quality of life in central Indiana. The Hoosier Heartland RC&D serves Boone, Hamilton, Hendricks, Marion, Hancock, Morgan, Johnson, Selby, Monroe, and Brown Counties. The RC&D works to provide opportunities for citizens, businesses, organizations, and governments to profitably develop and use natural resources, while conserving and improving them for future generations. The primary tasks of the RC&D are to assess local resource needs and develop plans of action to address concerns and problems, act as a liaison between communities or citizens and government to secure needed services and assistance, and to promote the wise use and management of resources through educational activities. Specifically, the RC&D sponsors the Plant a Million Project, which strives to educate people about the importance of trees and tree care as well as to plant more than one million trees in Central Indiana. The Hoosier Heartland RC&D Council can be contacted at:

Hoosier Heartland RC&D Council, Inc.
6960 South Gray Road, Suite C
Indianapolis, Indiana 46237
317-290-3250
hhrcd@hhrcd.org

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Abbreviation Index

µS –	microsiemens
BMP –	best management practice
C –	Celsius
CAFO –	concentrated animal feeding operation
CFO –	confined feeding operation
CFU –	colony-forming units
CIT –	Conservation Implementation Teams
cm –	centimeter
CR –	county road
CRP –	Conservation Reserve Program
CWI –	Clean Water Indiana
DO –	dissolved oxygen
EPT –	Ephemeroptera, Plecoptera, and Trichoptera macroinvertebrate orders
EQIP –	Environmental Quality Incentives Program
ETR species –	endangered, threatened, and rare species
FEMA –	Federal Emergency Management Agency
ft. –	foot/feet
GIS –	Geographic Information Systems
HBI –	Hilsenhoff Biotic Index
HUC –	hydrological-unit code
IAC –	Indiana Administrative Code
IDEM –	Indiana Department of Environmental Management
IDNR –	Indiana Department of Natural Resources
I	Interstate
IGS –	Indiana Geological Survey
ISDA –	Indiana State Department of Agriculture
KICK –	single habitat macroinvertebrate collection method
L -	liter
lb. –	pound/pounds
LARE –	Lake and River Enhancement Program
LUST –	leaking underground storage tank
mg –	milligrams

MHAB –	multi-habitat macroinvertebrate collection method
mi. –	mile/miles
mIBI –	macroinvertebrate index of biotic integrity
mL –	milliliter
MS4 –	Municipal Separate Storm Sewer System
NHD –	National Hydrography Dataset
NLCD –	National Land Cover Database
NPDES –	National Pollutant Discharge Elimination System
NPMP –	nutrient and pest management plan
NRCS –	Natural Resources Conservation Service
NTU –	Nephelometric Turbidity Units
NWI –	National Wetlands Inventory
MS4 –	Municipal Separate Storm Sewer System
Ohio EPA –	Ohio Environmental Protection Agency
QHEI –	Qualitative Habitat Evaluation Index
RBPII –	Rapid Bioassessment Protocol II
sec –	second
SIDMA –	Social Indicators Data Management and Analysis Tool
STEPL –	Spreadsheet Tool for the Estimation of Pollutant Load program
SWCD –	Soil and Water Conservation District
SWPPP –	Stormwater Pollution Prevention Plan
TKN –	total Kjeldahl nitrogen
TP –	total phosphorus
TSS –	total suspended solids
US –	United States highway
USDA –	United States Department of Agriculture
USEPA –	Untied States Environmental Protection Agency
USGS –	United States Geological Survey
USFWS –	United States Fish and Wildlife Service
WHIP –	Wildlife Habitat Incentives Program
WRP –	Wetland Reserve Program
WWTP –	Waste Water Treatment Plant
yr. –	year

Appendix A
Meeting Notes

Brandywine Creek Watershed

Public Meeting Notes

Monday, September 13, 2010
6:00-8:30 p.m.
Hancock County Public Library
Greenfield, Indiana

Meeting Schedule and Attendance Summary

A total of 9 people attended the first introductory public meeting at the Hancock County Library in Greenfield, Indiana including Alicia Douglass and Chad Appleman from Davey, Cindy Newkirk with the Hancock County Soil and Water Conservation District (SWCD), and Rod Edgell with the Indiana Department of Natural Resources Lake and River Enhancement Program (LARE). The meeting began with introductions followed by an educational presentation was delivered by Alicia Douglass via PowerPoint. The presentation included information explaining watersheds, the components of a Watershed Management Plan, general reasons for interest in water quality, the process of eutrophication, sources of sediment and nutrients, the benefits of having a watershed management plan, graphical representations of historical water quality data collected by IDEM in the watershed study area, and an appeal for the need of steering committee volunteers. The presentation was followed by time a time of discussion for questions, comments, and a survey. A map was available for stakeholders on which stakeholders could mark areas of concern. A total of 6 people signed the steering committee interest sheet including: Alice Bogemann, Cindy Newkirk, John Neeby, Dave Huffman, Rodger Neeb, and Angie Brown.

Discussion Summary

- A question was raised asking about BMPs implemented (J. Neeb). It was explained that different resources will be consulted as part of the study to help identify BMPs that have been implemented.
- Concern was expressed about beavers girdling trees adjacent to the creek which later fall into the creek damaging and destabilizing the streambank in the process. This has resulted in log jams and instances where streambanks have eroded as water cuts a pathway around the obstructions (J. Neeb).
- A question was raised regarding the status of sewage overflows from the waste water treatment plant to Brandywine Creek (J. Neeb). It was reported that the frequency of these events were not known at this time, but would be identified later as part of the study.
- One resident commented that a couple of years ago the City of Greenfield conducted inspections in his subdivision to make sure that sump pumps did not discharge to the sewer system (D. Huffman).
- One attendee continued to encourage others to inform their friends about the project and to get involved (A. Bogemann).
- One attendee fishes in Brandywine Creek and reported that he is certain that carp, bluegill, catfish, and sucker fish are present in the creek. He stated that other people have told him there are bass and trout in Brandywine Creek in Shelby County, but he is skeptical (R. Neeb).
- It was mentioned that Canada geese are abundant in the watershed (R. Neeb).
- Streambank erosion was mentioned at Riley Park (A. Brown), and a question was raised if the park can be used for anything other than flood storage (C. Newkirk).
- It was mentioned that there is also streambank erosion occurring at Wilson Park (A. Brown).

- It was discussed that earthwork is occurring directly north of McKenzie Road and west of Brandywine Creek in Greenfield (A. Bogemann, A. Brown). No erosion control plan has been submitted to the SWCD (C. Newkirk). Work may be within in the floodplain (A. Brown). One attendee volunteered to ask local officials about the development plan (A. Bogeman).
- A question was raised about a possible need of future protection of a large wetland in Greenfield (A. Brown). The wetland may be owned by the city.
- It was reported that there are no known local conservation clubs.
- One resident will notify members of her church about the study. The church is located adjacent to Brandywine Creek (A. Brown).

Survey Summary

The survey was developed to allow for written questions, comments, and identification of potential areas of water quality concern. Summarized comments/concerns obtained from the survey include:

- Goose and duck population at Riley Park & the 4-H fairgrounds
- Erosion at Riley Park and Wilson Park.
- There are several housing developments on lakes on the Brandywine
- E. coli levels and the safeness of full-body contact recreation
- Multiple people have been observed fishing at various points along the river
- There is a trailer park on the river in Greenfield which the river may flood
- City of Greenfield encourages leaf piles in the streets in the fall which causes concern about nutrients leaching into stormwater.
- If the Watershed Management Plan will be written to the IDEM checklist.

Map Notations Summary

An area of streambank erosion was noted south of CR 500 South in Hancock County.

Attendees List

Alice M. Bogemann
Cindy Newkirk
Rodger Neeb
John C. Neeb
Rod Edgell
Dave Huffman
Angie Brown
Chad Appleman
Alicia Douglass

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Brandywine Creek Watershed

Public Meeting Notes

Tuesday, November 23, 2010
6:30-8:30 p.m.
Shelby County Public Library
Shelbyville, Indiana

Meeting Schedule and Attendance Summary

A total of 15 people attended the second introductory public meeting at the Shelby County Library in Shelbyville, Indiana including Alicia Douglass and Kasey Krouse from Davey Resource Group (Davey) and Jill Williams and Ashley Carlton with the Shelby County Soil and Water Conservation District (SWCD). The meeting began with introductions followed by an educational presentation delivered by Alicia Douglass via PowerPoint. The presentation included information explaining watersheds, the components of a Watershed Management Plan, general reasons for interest in water quality, the process of eutrophication, sources of sediment and nutrients, the benefits of having a watershed management plan, graphical representations of historical water quality data collected by IDEM in the watershed study area, and an invitation to become a steering committee volunteer. The presentation was followed by time a time of discussion for questions, comments, and a survey. A map was available for stakeholders on which they could mark areas of concern. Public meeting attendees Dale Herthel and Kent and Susan Kaster have attended past steering committee meetings. No other public meeting attendees expressed interest in joining the steering committee.

Discussion Summary

- A question was asked about what BMPs often result from doing a watershed study. (M. Nigh, B. Harting). Several different BMPs were discussed including conservation tillage, stream bank stabilization, two-stage ditch conversion, sediment control basins, exclusionary fencing, alternative water sources, livestock crossings, cover crops, and tree plantings (riparian improvements).
- Concern was expressed about the City of Greenfield's water treatment plant (M. Nigh) discharging into Brandywine Creek. It was discussed that the city has updated the plant in recent years and that no combined sewer overflows (CSOs) have occurred as a result of significant rainfall events since the upgrade. A minimal number of CSOs have occurred due to other system failures.
- A question was raised whether the Department of Natural Resources (DNR) has taken recent data at the groundwater test well located on the Kaster property south of Brandywine Creek and west of County Road (CR) 100 West in Shelby County (K. Kaster). It was explained that Davey has not yet obtained a copy of any groundwater data to determine if data has been collected recently.
- One resident asked what causes/constitutes streambank erosion and what is involved in streambank stabilization (M. Nigh). Streambank erosion causes were mentioned including log jams and destabilization of banks through vegetation removal. Several methods of streambank stabilization were also mentioned including armoring the bank with rock, installing in-stream rock structures to divert water away from the bank, and planting vegetation such as willow stakes to stabilize streambank soils.
- One resident would like to stabilize an area on his property where the streambank has eroded approximately 5 feet into his field (D. Herthel). He inquired if putting rock along the

streambank was all that he needed to do. It was explained that permits would be necessary. He requested contact information for the Indiana Department of Environmental Management and United States Army Corps of Engineers (USACE). The landowner stated that he had the United USACE look at the site in the past, but nothing subsequently developed.

- There was concern that a log jam in Swamp Creek is causing the creek to back-up and overflow across the road and then into Brandywine Lake after large rain events. It was mentioned that Brandywine Lake Homeowners Association should be contacted about the problem and the study. The problem area is between CR 400 North and Brandywine Lake. Brandywine Lake is spring fed (R. Meyer).
- There were several concerns about log jams in other parts of the watershed. This included beaver dams in Brandywine Creek about a mile south of CR 1000 North and in Brandywine Creek south of CR 750 North. These areas were marked on the map (R. Meyer, B. Gillon).
- Jill Williams mentioned that she would like to get a representative from the DNR to come to a meeting and discuss ways in which log jam can be removed and the permitting process. She will plan on organizing a public meeting on the subject.
- Another log jam in Hughes Ditch was mentioned (R. Myer). The location of Hughes Ditch is uncertain.
- An issue was raised about streambank erosion adjacent to the road at the corner of CR 800 North and CR 50 East. A log jam was previously removed and the stream was dredged in this location. The streambank is now eroding. There is an approximate 20 to 25 foot drop from the road to the creek. The County has placed riprap along the bank for stabilization, but the problem has continued to increase. It was stated that an old oak tree is the only thing holding the bank in this location. There is concern that the road may possibly erode away if the problem in not solved (B. Gillon).

Survey Summary

The survey was developed to allow for written questions, comments, and identification of potential areas of water quality concern. Summarized comments/concerns obtained from the survey include:

- Streambank erosion
- Build-up of gravel bars
- Log jams
- E. coli contamination from home septic systems
- Nutrients causing fish kills
- Steve Woolman expressed an interest in possibly becoming a Hoosier Riverwatch volunteer.

Map Notations Summary

- A log jam was noted south of CR 750 North in Shelby County.
- A log jam was noted north of Freeport Road in Shelby County.
- An area of streambank erosion was identified at the corner of CR 800 North and CR 50 East in Shelby County.
- The location of Brandywine Lake was identified south of Interstate 74 near the western watershed boundary.

Attendees List

Jill Williams
Ashley Carlton
Bill Harting
Dale Herthel
Steve Woolman
Ben Gillon
Mark R. Nigh
Rob Myer
Pam Meyer
Loretta Bruning
Joe Bruning
Kent Kaster
Susan Kaster
Alicia Douglass
Kasey Krouse

Brandywine Creek Watershed

Public Meeting Notes

Thursday, December 1, 2011
6:00-8:30 p.m.
Hancock County Public Library
Greenfield, Indiana

Meeting Schedule and Attendance Summary

A total of 8 people attended the final public meeting at the Hancock County Library in Greenfield, Indiana. The purpose of the meeting was to recap the process of developing the Watershed Management Plan and the outcomes of the work. The meeting began with a presentation delivered via PowerPoint by Alicia Douglass. The presentation included a summary of public concerns that were collected, water quality parameters collected and analyzed by Davey as well as discussion of parameters of concern, a discussion of pollutant sources as indicated by watershed modeling, problem categories defined by the steering committee, goals for water quality improvement, assignment of critical areas, recommended BMPs, and next steps for implantation of the Watershed Management Plan.

Discussion Summary

- A question was raised asking about a database available to the public to see water quality test results in state parks and other properties (D. Huffman). It was mentioned that Hoosier Riverwatch data is collected in various places across the state and that the database is available online (A. Douglass). It was also mentioned that agency collected data can be obtained from IDEM watershed specialists (C. Newkirk).
- A question was raised as to if the steering committee was working with the sewer district because they have had a history of releasing raw sewage in Brandywine Creek (J. Neeb). It was explained that Greenfield no longer had combined sewers and consequently has not released raw sewage into the creek in a very long time (A. Douglass).
- It was mentioned that a couple of years ago the City of Greenfield conducted inspections in his subdivision to make sure that sump pumps did not discharge to the sewer system (D. Huffman).
- A question was raised as to if the steering committee has been working with zoning board in regard to new developments channeling stormwater to Brandywine Creek (J. Neeb). It was explained that the steering committee has not had interaction with the zoning board to date, but that it is an action step recommended in the Watershed Management Plan for the steering committee to take in the future (A. Douglass).
- Concern was expressed over a log jam causing severe streambank erosion in Hancock County (J. Neeb). It was expressed that the Hancock County SWCD will be applying for LARE funds to remove problematic log jams in the next grant funding cycle (C. Newkirk).

Survey Summary

The survey was developed to allow for meeting participants to express interest in becoming a Hoosier Riverwatch volunteer and to express interest in implementing BMPs. Summarized comments obtained from the survey include:

- John Neeb expressed interest in becoming a Hoosier Riverwatch volunteer and in having a log jam on his property removed.
- Dave Huffman expressed interest in becoming a Hoosier Riverwatch volunteer and implementing residential BMPs.

Attendees List

Alicia Douglass
Chad Appleman
Cindy Newkirk
Dave Huffman
Delores Basey
James Newkirk
John Neeb
Richard Basey

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, September 30, 2010
Hancock County Public Library
Greenfield, Indiana

Attendees List

Alice Bogemann – Hancock County SWCD Supervisor
Alicia Douglass – Davey Resource Group
Amy Hodge – Master Naturalist
Angie Brown – Hancock County watershed resident, IDEM Watershed Specialist
Chadwick Appleman – Davey Resource Group
Cindy Newkirk – Hancock County SWCD District Administrator
Dale Herthel – Shelby County watershed resident
Dan Miller – City of Greenfield MS4 Coordinator
Dave Huffman – Hancock County watershed resident
Kathleen Hagan – IDEM Watershed Specialist
Kent Kaster – Shelby County watershed resident
Kevin Bump – Hancock County watershed resident
Rod Edgell – IDNR LARE Project Manager
Susan Kaster – Shelby County watershed resident

Discussion Summary

- The meeting began at 6:00 pm with introductions of the 14 meeting attendees.
- A review of the project purpose to develop a consensus driven watershed management plan was provided by Alicia Douglass.
- Cindy Newkirk provided an overview of why the Hancock County SWCD chose to undertake a watershed management plan (WMP) for the Brandywine Creek Watershed.
  - The Hancock County SWCD recently completed a WMP for Sugar Creek. A watershed study for Sugar Creek was completed first due to involvement of the USGS. Brandywine Creek was next on Hancock County SWCD's priority list due the fact that Brandywine Creek runs through the City of Greenfield.
  - The Hancock County SWCD plans to apply for BMP implementation funding in the future for both the Brandywine Creek and Sugar Creek Watersheds jointly.
- Committee goals were reviewed by Alicia Douglass.
- Alicia Douglass provided an overview of concerns regarding water quality that were derived from the first public meeting held in Greenfield on September 13, 2010. Additional concerns received by Alicia Douglass via email on September 29, 2010 as follows were also presented:
  - A dramatic increase in sediment accumulation over the last 10 years has occurred in a lake on the south side of New Road in Greenfield.
  - Sewage seeps from a hillside into Brandywine Creek from the Hickory Hills addition.
  - Plastic bags from Wal-Mart frequently blow into Brandywine Creek
- The committee was asked to present additional concerns and to provide clarification on previously documented concerns.
- Kent Kaster mentioned knowledge of log jams resulting in streambank erosion in Shelby County and stated that sandbars currently allow places for log jams to establish.

- Angie Brown stated that a fish kill recently occurred in Potts Ditch. Coolant leaking from the high school is the suspected cause of the fish kill. More information can be obtained from David Cage or Max Michaels at IDEM. Rod Edgell volunteered to look for more information.
- Kevin Bump mentioned that there is streambank erosion occurring on Potts Ditch in Greenfield.
- Dan Miller stated that Greenfield has been removed from the combined sewer overflow (CSO) list.
  - A new waste water treatment facility was installed resulting in a treatment capacity increase from 4.3 million gallons per day to 16 million gallons per day in 2006.
  - CSO discharges no longer occur as a result of rainfall; however blockages in sewer lines have resulted in overflows since the treatment facility upgrade.
- Dale Herthel expressed concern over bubbles and foam observed in Brandywine Creek.
- Dale Herthel expressed concern over 20 feet of field lost in a meander bend due to streambank erosion. He stated that 3 people from the USACE looked at the site and stated that a rock structure placed in the stream could be used to divert water from the eroding bank. Nothing was ever implemented.
- Dan Miller presented clarification on earth moving activities occurring north of McKenzie Road and adjacent to Brandywine Creek in Greenfield.
  - The activity was initiated by the City to clear a 20-foot wide easement for the purpose of conducting ditch reconstruction where the ditch has undercut a sanitary sewer line.
  - Dan Miller assumes that additional clearing has occurred by the earthwork contractor at the landowner's request.
- Dale Herthel mentioned that he has removed falling trees from the Creek to prevent log jams and wanted to know if riprap could be placed on the streambank to limit erosion. Rod Edgell mentioned that the riprap would have to be sized appropriately and the permits may be necessary.
- Cindy Newkirk stated that you can get on a waiting list to have log jams removed in Hancock County, and that may also be a possibility in Shelby County.
- Alicia Douglass asked if anyone was aware of any water quality data being collected such as Hoosier Riverwatch data which is not being reported. She mentioned that a class from Triton Central High School has collected Hoosier Riverwatch data on Brandywine Creek twice in the past two years, but has not reported it. The class is taught by Rich McGown. He is not currently a certified Hoosier Riverwatch data collector.
- Kent and Susan Kaster mentioned that they have a groundwater sampling well located on their property. And, that a very large log jam was removed on the Big Blue River last year by the Shelby County Surveyor.
- It was asked why Shelby County agency representatives were not at the meeting. It was stated that the Shelby County Commissioner and SWCD personnel were invited to attend the meeting.
- Kent Kaster commented that Brandywine Creek flow used to be faster.
- Cindy Newkirk mentioned that Cliff Chapman with the Central Indiana Land Trust was interested in participating in the steering committee and that he has a wealth of information to share about what the land trust has been doing. She also stated that she heard that Brandywine Creek ranked first in either the state or central Indiana for mussel habitat.
- Cindy Newkirk mentioned that there will be river clean-up days in the near future.

Map Notations Summary

- An area of streambank erosion was documented on the Herthel property using Google Earth.
- An area of streambank erosion was documented on the Kaster property using Google Earth.
- Streambank erosion on Potts Ditch was mentioned but the location was not documented on a map.

DAVEY RESOURCE GROUP
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Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, October 28, 2010
Greenfield City Hall Building
10 W. State St., Greenfield, Indiana

Attendees List

Alicia Douglass – Davey Resource Group
Dale Herthel – Shelby County watershed resident
Dan Miller – City of Greenfield MS4 Coordinator
Dave Huffman – Hancock County watershed resident
David Mohr – Shelby County resident
John Moran – Hancock County SWCD Supervisor
Kathleen Hagan – IDEM Watershed Specialist
Kent Kaster – Shelby County watershed resident
Kevin Bump – Hancock County watershed resident
Susan Kaster – Shelby County watershed resident

Discussion Summary

- The meeting began at 6:00 pm with introductions of the 10 meeting attendees.
- Follow-up items from the September 30, 2010 meeting were reviewed by Alicia Douglass including:
    - Log jam removal language from Indiana Code
    - Brandywine Creek Watershed fish kill data
    - IDEM foam fact sheet
    - Potts Ditch antifreeze release and fish kill in September, 2010
- A review of the October, 2010 field data collection was provided by Alicia Douglass.
    - Macroinvertebrate data and habitat data were collected. Data has not been analyzed. Site 13 initially appears very good and Site 11 appears to be the poorest.
    - Asian clam was observed to be abundant in Brandywine Creek
    - Water chemistry data was not collected at any of the sites due to lack of flowing water at two sites.
- Secondary source data maps were presented via PowerPoint by Alicia Douglass. Maps presented included topography, soils, wetlands (discussion of the acreage of hydric soil vs. wetlands), land cover, floodplains, impaired streams (discussion that shapefile data does not appear to be current), CFOs, environmental hot spots, NPDES land application site (discussion of uncertainty of NPDES source) . IDEM water chemistry data was also presented.
- The Green Infrastructure Vision for Central Indiana booklet was shown to the meeting attendees by Alicia Douglass, and its recommendations were presented including 2-stage ditch conversions, planting riparian corridors adjacent to streams, and protecting lands adjacent to the creek as suburban growth continues.
- Data needed to complete the watershed management plan were listed:
    - Areas in need of Rule 5 enforcement or unmanaged construction: none known
    - MS4 Plans: Greenfield only MS4 in watershed, plan provided by Dan Miller

- City/County master plans: Shelby County plan is online at www.shelbyplancommission.com
- Regional sewer district plans: none in Hancock County; Fountaintown is unincorporated and has no sewer (Dan Miller); Fairland has no sewer, Swamp Creek is the closest tributary, city sewer is 10-12 years out (Dale Herthel, John Moran)
- Groundwater/source water protection plans: public well head protection plan should be on IDEM Virtual Filing Cabinet (Kathleen Hagan)
- Areas slated for development: a few things are slated for development in March in Greenfield (Dan Miller); there aren't really any areas in Greenfield with high potential for development (Dan Miller); the area for highest development potential in Shelby County is around the horse track (John Moran)
- Description of industry in the watershed: Greenfield industry is described in Part C of the MS4 plan (Dan Miller)
- Fertilizer use on urban/suburban land: there is a co-op in Fountaintown that sells fertilizer (John Moran), they may have more information
- Describe hobby farms: not much to speak of in Shelby County, a few alpacas (Kent Kaster); Irving property with zebras, etc. having direct access to Brandywine Creek in Hancock County, there are significantly fewer animals there now than there used to be; one thing to look for are over-grazed pastures and compacted soil (Kathleen Hagan)
- Other:
  - Gravel pit in Shelby County pumps water into Hills Branch (Dale Herthel, Kent Kaster)
  - Dave Huffman has water quality sample data from a 31 acre lake south of New Road
  - There appears to be more water coming down Little Brandywine Creek by the Greenfield country club/Hawks Tail since there are more subdivisions upstream, a large influx of water came down the creek a couple of weeks ago before rain, there is water in the creek when it is suspected it should be dry (Dave Huffman)
  - Dale Herthel and the Kasters shared photos of log jams, streambank erosion, and sand bars in Brandywine Creek
  - Kevin Bump suggested we share the Nature Conservancy 2-stage ditch video clip

- It was announced that the next steering committee meeting will be held on December 2 at 6:00 PM

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, December 2, 2010
Hancock County Public Library
Greenfield, Indiana

Attendees List
Alice Bogemann – Hancock County SWCD Supervisor
Alicia Douglass – Davey Resource Group
Angie Brown – Hancock County watershed resident, IDEM Watershed Specialist
Brian Gandy – Hancock County SWCD Associate Supervisor, ISAF Chair
Chadwick Appleman – Davey Resource Group
Cindy Newkirk – Hancock County SWCD District Administrator
Cliff Chapman – Central Indiana Land Trust
Dave Huffman – Hancock County watershed resident
John Moran – Hancock County SWCD Supervisor
Kevin Bump – Hancock County watershed resident
Linda Conner – Hancock County watershed resident
Mike Conner – Hancock County watershed resident
Rod Edgell – IDNR LARE Project Manager
Steve Woolman – Shelby County watershed resident
Sue Woolman – Shelby County watershed resident
Tara Conner – Hancock County watershed resident

Discussion Summary

- The meeting began at 6:00 pm with introductions of the 16 meeting attendees.
- It was asked if there were any needed modifications to the October 28, 2010 steering committee meeting minutes. No modifications were proposed.
- The meeting proceeded with an explanation of the task for the evening of organizing watershed concerns and problems to fit the example chart provided in the 2009 Watershed Management Plan Checklist Instructions.
- A comprehensive list of problems and concerns identified in the watershed to date were included with the meeting agenda. The steering committee looked at each concern and determined whether or not it was valid. Evidence was listed for the concerns where applicable. The steering committee also determined whether or not each concern was something on which the group wants to focus.
- A copy of the completed chart is included in the meeting minutes.
- A summary of discussion associated with the concerns is following:
    - When discussing high waterfowl populations at Riley Park and the 4-H fairgrounds it was mentioned that tall vegetation next to the creek can help reduce the quantity of geese accessing Brandywine Creek in these locations.
    - There was discussion about whether the concern regarding "fishing in Brandywine Creek" was regarding a decline in fish populations or the safety of fish consumption.
        - It was mentioned that Jim Stahl may have fish tissue data.

    - It was stated that Hoosier Riverwatch volunteer monitoring for *E. coli* could be conducted to better understand the extent of contamination from home septic systems in the watershed.
    - It was asked if the Hancock County Health Department has a list of septic system problem locations in the watershed and if it includes the Hickory Hills addition.
    - Housing developments on lakes in the watershed were determined to be a concern due to the potential of phosphorus runoff from fertilizers and high waterfowl populations.
    - A trailer park that floods adjacent to Brandywine Creek and north of Riley Park was determined to be a concern due to potential water contamination from household hazardous wastes and septic systems.
    - Sediment accumulation in a lake on the south side of New Road in Greenfield was determined to be a concern associated with the problem of total suspended solids.
    - The stated concern of Wal-Mart bags blowing in Brandywine Creek was expanded to encompass trash in Brandywine Creek in general.
    - It was clarified that the concern involving an apparent increase in water flowing down Brandywine Creek was based on what kind of water was resulting in the increase and whether or not it was clean. Discussion progressed to include that an increase in water quantity can also be an issue due to the fact that higher volumes can further erode streambanks which in turn results in deposition of sediment/gravel bars in other locations.
        - It was mentioned that Brandywine Creek overflows its banks much more readily with the ever increasing amount of blacktop in Greenfield.
    - It was mentioned that the Shelby and Hancock County SWCDs will hold a workshop in January or February with the assistance state employees to help educate landowners about log jams.
    - It was determined that there is no known evidence for nutrients causing fish kills in the watershed, but fish kills resulting from other contamination have occurred and may be a concern that can be addressed with education.
    - It was asked if grant money for exclusionary fencing could be applied on top of EQIP money.
        - LARE funds can be used in conjunction with EQIP, but 319 funds cannot since both are from federal funding sources.
    - In association with the concern of golf courses and athletic fields directly adjacent to creeks, it was mentioned that water in Potts Ditch adjacent to the school athletic practice fields gets scummy in the summer months. This may in part be a result of application of fertilizers and irrigation on the fields.
    - Cliff Chapman brought copies of the Central Indiana Land Trust, Inc. (CILTI) booklet titled Greening the Crossroads and briefly spoke about their study. CILTI may have funding for water quality education.
- It was announced that the next steering committee meeting will be held on January 27, 2011 at 6:00 PM at the Hancock County Public Library.

Concern	Supported by our data?	Evidence	Quantifiable?	Outside the scope?	Group wants to focus on?
Streambank erosion	Yes	Photographs and location descriptions supplied by landowners. In the future, maybe turbidity or TSS data. Sandbar formation/sedimentation.	Yes. Photographs depicting the severity erosion (depth). Seven known sites.	No	Yes
Combined sewer overflow frequency in Greenfield	No	No CSOs have occurred due to rainfall since Greenfield made recent updates to the sewer system. (Dan Miller)	Yes		No
Protection of wetlands	Yes	Historical aerials; percent hydric soil	Yes. Acreages of wetland loss could be calculated	No	Yes
Safeness of full-body contact in Brandywine Creek	Yes	303d list, IDEM water quality data	Yes		
Safety of fish consumption	No	Not on 303d list ***double check		Yes	No
E. coli contamination from septic systems	TBD			No	Yes
Flooding trailer park north of Riley Park in Greenfield	Yes	Observation of steering committee members	TBD	No	Yes/TBD
Housing developments on lakes	Yes	Aerial photographs	Yes	No	Yes
Sediment accumulation in lake south of New Road in Greenfield	Yes	Anecdotal evidence		No	Yes
Trash in Brandywine Creek	Yes	Anecdotal evidence		No	Yes
Apparent increase in water volume in Little Brandywine Creek and Brandywine Creek	Yes	Anecdotal. Little Brandywine Creek not drying out as frequently as in the past.		No	Yes
Apparent increase in water volume in Little Brandywine Creek and Brandywine Creek – what kind of water is it clean or not?	No/TBD	TBD	TBD	TBD	TBD
Build-up of sediment/gravel bars	Yes	Photographs, anecdotal evidence	TBD	TBD	TBD
Log jams/beaver dams	Yes	Photographs	Yes	No	Yes

Concern	Supported by our data?	Evidence	Quantifiable?	Outside the scope?	Group wants to focus on?
Fish kills	Yes	IDEM/DNR records	Yes	No	Yes
Livestock with access to streams	Yes	Windshield survey observations	Yes	No	Yes
Golf courses and athletic fields directly adjacent to waterbodies – fertilizer, pesticides, irrigation	Yes	Two golf courses, two athletic field locations – windshield survey observations	Yes	No	Yes
Waterbodies without filter strips or riparian buffers	Yes	Aerial photos, windshield survey	Yes	No	Yes

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, January, 27, 2010
Hancock County Public Library
Greenfield, Indiana

Attendees List

Alice Bogemann – Hancock County SWCD Supervisor
Alicia Douglass – Davey Resource Group
Cindy Newkirk – Hancock County SWCD District Administrator
Cliff Chapman – Central Indiana Land Trust
Dave Huffman – Hancock County watershed resident
Kevin Bump – Hancock County watershed resident
Kent Kaster – Shelby County watershed resident
Susan Kaster – Shelby County watershed resident
Dale Herthel – Shelby County watershed resident
Susan Bodkin – Hancock County Surveyor
Mike Conner – Hancock County watershed resident
Kathleen Hagan – IDEM Watershed Specialist
Mark R. Nigh – Shelby County SWCD Associate Supervisor, Hoosier Heartland RC&D

Discussion Summary

- The meeting began at 6:00 pm with the meeting attendees divided into three groups for a round of watershed trivia won by Kathleen Hagan and Susan Bodkin.
- Introductions of the 13 meeting attendees ensued.
- A brief overview of the content of the three previous steering committee meetings was delivered by Alicia Douglass.
- Alicia Douglass then showed photographs of each sample site via PowerPoint. The photos were taken in fall, 2010 at the time of macroinvertebrate sampling. The location of each sample site was pointed out on the large watershed map as its photograph was shown.
- PowerPoint slides were shown depicting graphs of water quality data obtained during the base flow sampling event the week of January 10, 2011. Water quality parameters presented included *E. coli*, ammonia nitrogen, nitrate+nitrite, total phosphorus, total suspended solids, turbidity, temperature, dissolved oxygen, and pH. Potential sources for each type of pollutant were also briefly mentioned. Preliminary macroinvertebrate mIBI and HBI analyses were also presented.
- It was noted that *E. coli* levels were above the state water quality standard at 5 sites. Levels were the highest at Site 2. Numerous waterfowl were observed at Site 2 just prior to sample collection (A. Douglass). It was asked if there was a way to distinguish animal from human *E. coli* sources in the sample, and whether or not IDEM distinguishes E. coli sources in their samples. There was concern about how people automatically assume that high *E. coli* levels are from human sources when they see reports showing elevated levels and that natural wildlife sources are not taken into account (S. Bodkin). It was reported that the LARE program does not require for the samples analyzed to distinguish between sources, and that those tests are much more costly (A. Douglass). It was reported that IDEM does not distinguish sources in their samples (K. Hagan). It was reported that there is currently water

sampling being conducted on Sugar Creek which is distinguishing different sources including swine, cattle, human, and wildlife (C. Newkirk).

- It was shown that ammonia nitrogen results came back as above the standard at all sites, and that nitrate+nitrate was above average at 8 sites. It was mentioned that there appears to be no pattern in the high results, and that they do seem unusually high for the time of year. It was questioned whether or not the cold temperatures may have had an effect on the ammonia nitrogen results in relation to the standards (S.Bodkin). And, it was reported that the standard takes temperature into consideration. It was also noted that more inquiry will be done to determine analytical methods used by the laboratory and if they may have influenced the apparent results.
- Total phosphorus results showed a large spike above the water quality standard at Site 3 on Brandywine Creek directly south of Greenfield, and then steadily decreased between Site 3 to Site 6. It was later mentioned that carwashes in Greenfield may be a potential source of phosphorus (C. Chapman).
- Total suspended solids concentrations were low at all sites except for Site 12, but it was still below the maximum target. It was mentioned that a gravel quarry discharges to the creek upstream of Site 12 (K. Kaster).
- All turbidity levels were below the target.
- All temperature measurements were below the maximum standard. Sites 11 and 13 were notably higher. Bubbles have been seen emerging from the gravel substrate at the time of fall and winter visits to Site 13 and may be an indication of a spring which could influence water temperature (A. Douglass). It was suggested that a geothermal system outlet could influence water temperature at Site 11 (S. Bodkin). M. Nigh and K. Kaster indicated they did not know of anyone in the vicinity who has a geothermal system.
- All sites were above the minimum standard for dissolved oxygen (A. Douglass).
- All sites were between the pH minimum and maximum standard (A. Douglass).
- Brief explanation of mIBI and HBI macroinvertebrate analysis was given. There is one more analyses left to complete. Site 2 appears to have the most degraded macroinvertebrate community followed by Sites 10 and 11 and then Sites 12 and 13. Site 2 had the most overall water chemistry impairments. No correlation between degraded macroinvertebrate communities and water chemistry impairments at other sites (A. Douglass).
- The next meeting will be held on February 24 at 6:00 pm. The location is to be determined, but will most likely be at the library. We can begin the thought process of recommending BMPs in light of the current data (C. Newkirk). Pictures of areas needing BMPs or pictures of installed BMPs and their locations in the watershed would be helpful. They can be emailed to Alicia Douglass or brought to the next meeting (A. Douglass).

Brandywine Creek Watershed

Open Stream Management Workshop

Steering Committee Meeting Notes

Wednesday, March 16, 2011
Bluebird Restaurant
Morristown, Indiana

Attendees List

Alice Bogemann – Hancock County SWCD Supervisor
Chadwick Appleman – Davey Resource Group
Ashley Carlton – Shelby County SWCD
Jill Williams – Shelby County SWCD
George Bowman – Assistant Director, IDNR Division of Water
Brad Baldwin – Project Manager, IDEM Office of Water Quality
Greg Biberdorf – IDNR, LARE Program
Steve LeMasters
Matt LeMasters
John L. Martin
Burl Carmichael – Hancock County SWCD Supervisor
Georgia Carmichael
Bill Garriott
Barbara Garriott
David Brown
Josh West
Phyllis Miller
Ronald Myers
Alma Myers
Jonathan Everhart
Chris Everhart
Steve Zike
Harold Weaver
Steve Musgrave
Ray Dooley
Susie Dooley
Mike Conner – Hancock County SWCD Supervisor
John Neeb – Hancock County watershed resident
Rodger Neeb – Hancock County watershed resident
Dale Herthel – Shelby County watershed resident
Larry Smith
Susan Bodkin – Hancock County Surveyor
Kent Kaster – Shelby County watershed resident
Jon Dolan
Jeff Fuchs – Hancock County watershed resident
David Kissitt
David McDaniel
Maryann Wietbrock
Daniel Miller – City of Greenfield MS4 Coordinator

Discussion Summary

- The Open Stream Management Workshop organized by Brandywine Creek Watershed steering committee members from the Hancock and Shelby Counties SWCDs began at 7:00 pm following dinner at the Bluebird Restaurant.
- Brief introductions of 3 speakers were given.
- George Bowman delivered a presentation on IDNR's authority over the removal of log jams. House Bill 1232 passed the Indiana General Assembly in 2010 which drastically relaxed regulatory control over the removal of log jams. In many cases, landowners, contractors, and other parties can remove log jams without having to notify IDNR or acquiring a permit from IDNR, with the following conditions:
    - Work must not be within a salmonid stream designated under 327 IAC 2-1.5-5 without the prior written approval of the IDNR's Division of Fish and Wildlife.
    - Work must not be within a natural, scenic, or recreational river or stream designated under 312 IAC 7-2.
    - Except as otherwise provided in Indiana law, free logs or affixed logs that are crossways in the channel must be cut, relocated, and removed from the floodplain. Logs may be maintained in the floodplain if properly anchored or otherwise secured so as to resist flotation or dislodging by the flow of water and placement in an area that is not a wetland. Logs must be removed and secured with a minimum damage to vegetation.
    - Isolated or single logs that are embedded, lodged, or rooted in the channel, and that do not span the channel or cause flow problems, must not be removed unless the logs are either of the following:
        - Associated with or in close proximity to larger obstructions.
        - Posing a hazard to navigation.
    - A leaning or severely damaged tree that is in immediate danger of falling into the waterway may be cut and removed if the tree is associated with or in close proximity to an obstruction. The root system and stump of the tree must be left in place.
    - To the extent practicable, the construction of access roads must be minimized, and should not result in the elevation of the floodplain.
    - To the extent practicable, work should be performed exclusively from one (1) side of a waterway. Crossing the bed of a waterway is prohibited.
    - To prevent the flow of sediment laden water back into the waterway, appropriate sediment control measures must be installed.
    - Within fifteen days, all bare and disturbed areas must be revegetated with a mixture of grasses and legumes. Tall fescue must not be used under this subdivision, except that low endophyte tall fescue may be used in the bottom of the waterway and on side slopes.
- Mr. Bowman mentioned that the Flood Control Act gives IDNR regulatory authority from the center of a stream to the outer limits of the "floodway fridge". Local drainage boards have authority up to the limits of the "floodway".
- Brad Baldwin provided an informative presentation about IDEM's Section 401 Water Quality Certification and Isolated Wetlands programs. So long as log jam removal activities do not result in the placement or repositioning of material in wetlands or streams below the ordinary high water mark, IDEM does not need to be contacted. Mr. Baldwin stressed the

importance of preserving as many live trees adjacent to streams as possible, as trees help keep stream water cool and keep habitat values high. Mr. Baldwin provided an overview of what wetlands are and how to identify them; and, he informed the audience that IDEM regulates the smallest of water channels that have a defined bed and bank, such as ephemeral streams through which water only flows during a rain event. People were encouraged to call the IDEM project manager for their area for help in determining if wetlands are present in their project area.

- Chad Appleman provided an overview of the Brandywine Creek Watershed Management Plan project. Almost a third of the audience was aware that the project existed. Chad explained how the project is funded, who applied for the funding, what work is being done to produce the watershed management plan, and the value of a watershed management plan when it is completed. The plan will be used by the community to tackle identified watershed challenges and meet stated improvement goals. The plan can be used to apply for EPA and LARE funds for implementation of best management practices. The plan will give credibility to organizations that apply for funds from various organizations, be they corporations, not-for-profit organizations, etc.
- One landowner in the upper part of the watershed brought up concern to Chad Appleman associated with increasing water discharge to Brandywine Creek from agricultural drainage improvements. He has noted an apparent increase in water depth in the creek over the years, and increasing instances of flooding after minor storm events.
- The meeting adjourned at approximately 9:00 p.m.

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, April, 21, 2011
Hancock County Public Library
Greenfield, Indiana

Attendees List
Alice Bogemann – Hancock County SWCD Supervisor
Alicia Douglass – Davey Resource Group
Burl Carmichael – Hancock County SWCD Supervisor
Cindy Newkirk – Hancock County SWCD District Administrator
Kent Kaster – Shelby County watershed resident
Rod Edgell – IDNR LARE Project Manager

Discussion Summary

- The meeting began at 6:00 pm with six meeting attendees and brief introductions
- A brief overview of the content of the five previous steering committee meetings/workshop was delivered by Alicia Douglass.
- Alicia Douglass then showed photographs of each sample site via PowerPoint. The photos were taken in fall 2010 at the time of macroinvertebrate sampling. Meeting attendees were given maps that showed the location of each sample site.
- PowerPoint slides were shown depicting graphs of water quality data obtained during the base flow sampling event the week of January 10, 2011 and the storm flow sampling event on April 5, 2011. Water quality parameters presented included *E. coli*, ammonia nitrogen, nitrate+nitrite, total Kjeldahl nitrogen, total phosphorus, total suspended solids, turbidity, temperature, dissolved oxygen, specific conductivity, and pH. Stream habitat QHEI data was presented, and preliminary macroinvertebrate mIBI, HBI, and RBPII analyses were also very briefly discussed as a refresher.
- It was noted that *E. coli* levels were above the state water quality standard at all sites during the storm flow sampling event. It was mentioned that there is a little bit of livestock upstream Site 12 on Hills Branch. Historically there was 500-600 head of cattle, but numbers have been substantially reduced. There was also discussion as to whether or not the Greenfield sewer system has been separated and it was concluded that it has been. It was mentioned that the origination of Swamp Creek is at Brandywine Lake, and that there are numerous homes on septic systems around the lake.
- The spike in total phosphorus levels south of Greenfield in the base flow samples, and subsequent dye testing of car washes in the City to verify if a car wash was the source was discussed. The City did not find any car washes to be draining to the storm sewer.
- In relation to TSS data and the spike south of Greenfield, it was discussed that Rule 5 inspections do routinely occur in the City.
- The steering committee proceeded to identify problems based on water quality data and initial public concerns, link the identified problems to potential causes, and link potential causes to potential sources. The results of this work will be incorporated into the final report.
- The next meeting will be held on May 26 at 6:00 pm at the Hancock County Library.

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, June 23, 2011
Hancock County Public Library
Greenfield, Indiana

Attendees List

Alice Bogemann – Hancock County SWCD Supervisor
Alicia Douglass – Davey Resource Group
Angie Brown - Hancock County watershed resident
Cindy Newkirk – Hancock County SWCD District Administrator
Dave Huffman – Hancock County watershed resident
Kathleen Hagan – IDEM Watershed Specialist
Kevin Bump – Hancock County watershed resident
Jill Williams – Shelby County SWCD District Administrator

Discussion Summary

- The meeting began at 6:00 pm with eight meeting attendees and brief introductions
- An overview of the field data was presented by Alicia Douglass.
- An overview of problems as well as educational recommendations identified in the April, 2011 steering committee meeting was presented. Educational topic recommendations include: stormwater pollutant sources, septic system maintenance, trash disposal, lawn maintenance, wetland values, and riparian area values
- A map was shown depicting the location of known problems in the area. A comment was made that there are likely many more log jams in the watershed than have been identified on the map (C. Newkirk). It was stated that future LARE funding may include log jam removal (A. Brown)
- An explanation of BMPs recommended for rural and urban areas in the Brandywine Creek Watershed by Davey was presented. Recommended structural agricultural BMPs discussed include drainage water management, livestock fencing and alternative watering sources, filter strips/riparian restoration, cover crops, and nutrient/pest management plans. Recommended structural urban BMPs discussed include infiltration/rain gardens, rain barrels, stormwater swales, stormwater planters, stormwater basin retrofits, street sweeping, and pervious pavement. Two-stage ditches and streambank stabilization were recommended in both urban and rural areas.
- Continued implementation on no-till was recommended as an additional BMP (C. Newkirk).
- A video clip produced by The Nature Conservancy about two-stage ditches was shown
- It was discussed that there are currently no known two-stage ditches in either Hancock or Shelby County (C. Newkirk, J. Williams). The Hancock County Surveyor was on board to install a two-stage ditch in the past, but the extra expense was not supported by the county commissioners and the project did not move forward (C. Newkirk).
- It was stated that there has been interest by numerous landowners/producers to install filter strips, but are not willing to commit to the 10-15 year FSA contract. It was mentioned that Section 319 funding requires a 5 year contract that may be more suitable to these landowners/producers (C. Newkirk).

- It was also mentioned that EQIP ranking procedures have not worked in the favor of some landowners to help fund alternative water sources for livestock and that Section 319 may help fund these for some of these landowners (C. Newkirk).
- The term critical area was defined and it was explained that Section 319 funds can only be used to implement BMPs in areas that have been identified as critical areas.
- A summary of the breakdown of the types and numbers of recommended BMPs per subwatershed was presented.
- The steering committee proceeded to identify critical areas.
    - Richey Ditch and Swamp Creek Subwatersheds in which Greenfield and Fairland are located were selected as critical areas for implementation of recommended urban BMPs.
    - Willow Branch, Richey Ditch, and Andis Ditch Subwatersheds were identified as critical areas for implementation of cover crops, drainage water management, nutrient/pest management plans, and no-till
    - Other critical areas identified as site specific critical areas across the entire watershed include areas where livestock have access to streams, severely eroding streambanks, log jams, streambanks lacking buffer, and gully erosion.
- The next meeting will be held on July 28 at 6:00 pm at the Hancock County Library.

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, July 28, 2011
Hancock County Public Library
Greenfield, Indiana

Attendees List

Alicia Douglass – Davey Resource Group
Brian Gandy – Hancock County SWCD Associate Supervisor, ISAF Chair
Cindy Newkirk – Hancock County SWCD District Administrator
Dave Huffman – Hancock County watershed resident
John Moran – Hancock County SWCD Supervisor
Kathleen Hagan – IDEM Watershed Specialist

Discussion Summary

- The meeting began at 6:00 pm with six meeting attendees and brief introductions
- The steering committee proceeded to examine an example worksheet filled out addressing the goal of reducing *E. coli* loads from failing septic systems and add supplemental information. The worksheet includes short, medium, and long term objectives as well as resources needed to accomplish the objectives, particular outputs required by the steering committee, and measureable indicators of the outcomes.
- It was decided by the steering committee that short-term objectives would be defined as those to be completed within 1-5 years of implementation of the plan, medium-term objectives will be targeted for completion 6-12 years, and long-term objectives will be target for completion in 13-20 years.
- The steering committee proceeded to fill out worksheets for the following goals (all worksheets are attached):
    - Reducing *E. coli* loads resulting from livestock, wildlife, and pets
    - Reduction in nutrient loads received from urban land
    - Reduction in nutrient loads received from rural land
    - Reduction in TSS loads and turbidity values during storm events
    - Increasing public awareness of water quality issues
- A program named Canines for Clean Water was mentioned as a resource for modeling an educational program about clean water for pet owners (K. Hagan).
- It was mentioned that Clear Choices Clean Water will have information on pet waste in the near future (K. Hagan).
- It was mentioned that America's Great Outdoors Initiative lists water quality as a concern, and it was questioned wither or not it may be a potential grant source (B. Gandy).
- The importance of riparian zones was stressed as a concern. It was mentioned that Hoosier Environmental Council has an upcoming field trip to look at riparian zones (B. Gandy). CILTI previously expressed preservation and restoration of riparian zones as top priority (A. Douglass).
- Discussion of increasing standards for stormwater treatment was discussed. One example mentioned was an observation of stormwater passing through vegetated swales around stormwater ponds prior to water draining to the pond (B. Gandy).

- It was discussed that Indiana should follow suit of Michigan in raising revenue through bottle returns (B. Gandy).
- It was commented that a significant number of industries in Marion County were not in compliance with established maximum pollutant concentration discharges (B. Gandy).
- The next meeting will be held on August 25 at 6:00 pm at the Hancock County Library.

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, September 1, 2011
Hancock County Public Library
Greenfield, Indiana

Attendees List

Alicia Douglass – Davey Resource Group
Brian Gandy – Hancock County SWCD Associate Supervisor, ISAF Chair
Cindy Newkirk – Hancock County SWCD District Administrator

Discussion Summary

- The meeting began at 6:00 pm with three meeting attendees
- The steering committee proceeded to further refine long term objectives, milestones, and timelines initially brainstormed at the last steering committee meetings. Information was compiled into an Action Register that will be directly incorporated into the watershed management plan report.
- Additional work to further refine cost estimates for long term objectives listed in the action register will be discussed via teleconference between Davey and Hancock SWCD and any other steering committee members interested in participating prior to the next on-site steering committee meeting. Other topics of discussion will include determining criteria for updating the watershed management plan in the future.
- The Hancock County SWCD has applied for Section 319 implementation funds from IDEM for Brandywine and Sugar Creek watersheds jointly. Cindy Newkirk will supply cost estimates for implementation included in the application for inclusion in the Action Register.
- An initial draft of the watershed management plan will be made available to the steering committee for review and comment at a steering committee meeting to be held and 6:00 pm on September 29 at the Hancock County Public Library.
- Comments on the initial draft will be collected from steering committee members at a steering committee meeting to be held on October 27 at 6:00 pm at the Hancock County Public Library. Comments will be incorporated into the final draft report submitted to the DNR for agency review and comment.
- A final public meeting discussing the findings of the study and introducing the watershed management plan to the public will be scheduled in November.
    - The public meeting will be advertised via direct mailings, an article in the Hancock County Public Library newsletter, an article in the Hancock County SWCD newsletter, an article in the Greenfield paper, and flyers hung at public places. Coordination will be conducted with the Shelby County SWCD to advertise in Shelby County as well.

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, September 29, 2011
Hancock County Public Library
Greenfield, Indiana

Attendees List

Adam Rickert – Hancock County resident
Alicia Douglass – Davey Resource Group
Dave Huffman – Greenfield resident
John Moran – Hancock County SWCD Associate Supervisor
Rod Edgell – LARE project manager

Discussion Summary

- The meeting began at 6:00 pm with four meeting attendees
- Hard copies of the preliminary draft report were given to meeting attendees. Alicia Douglass provided a status update on the preliminary draft report including sections still needing more work, and the need for a review of the overall content of the report.
- A digital copy of the draft report was posted on the Davey ftp-site for download by steering committee members who could not physically attend the meeting.
- Alicia Douglass presented the fact that subwatersheds selected as rural critical areas were previously determined based on water quality data. Subwatersheds previously selected included Willow Branch, Richey Ditch, and Andis Ditch Subwatersheds. Load calculations showed that Swamp Creek Subwatershed contributes a higher pollutant load to Brandywine Creek than Willow Branch Subwatershed. Pros and cons of listing Swamp Creek Subwatershed as a critical area over Willow Branch Subwatershed were discussed including benefits of starting in the headwaters versus the lower portion of Brandywine Creek Watershed as well as the subwatershed with the greatest potential for implementation of BMPs. It was determined not to change the listing of critical areas at the time of the meeting, but to consult further with Cindy Newkirk regarding the possibility.
- It was requested that questions and/or comments relating to the preliminary draft report be submitted to Alicia Douglass via email prior to the next steering committee meeting or be brought to the meeting to be held on October 27 at 6:00 pm at the Hancock County Public Library. Comments will be incorporated into the final draft report submitted to the DNR for agency review and comment.
- A date of November 17 was proposed for the final public meeting to present the findings of the study and introduce the watershed management plan to the public.

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

Brandywine Creek Watershed

Steering Committee Meeting Notes

Thursday, October 27, 2011
Hancock County Public Library
Greenfield, Indiana

Attendees List

Alicia Douglass – Davey Resource Group
Cindy Newkirk - Hancock County SWCD District Administrator

Discussion Summary

- The meeting began at 6:00 pm with two meeting attendees.
- Cindy Newkirk and Alicia Douglass discussed the current status of the draft report and the intention to submit a final draft to the DNR by the end of November.
- Comments on the preliminary draft report submitted by steering committee members via email were discussed. Items of discussion included:
  - The likelihood of failing septic systems in Willow Branch and the manner in which to present information in the report
  - Citation of a source and mention of other methods of streambank stabilization not discussed in the report
  - Insertion of more information stressing the benefits of two-stage ditches
  - Insertion of information further explaining potential need for local legistlation
  - Identification of a wetlands area on a map recommended for conservation. It was determined that Alicia Douglass would visit the wetlands after the meeting to assess potential for it to be dedicated as a preserve. Observation from the road suggests the wetlands is dominated by *Typha angustifolia* or its hybrid, which is an invasive cattail. Likelihood of securing funding for preserving the site was determined to be low, and that it will not be recommended for further protection beyond existing wetlands laws in the report.
- No additional steering committee meetings were scheduled.
- Additional comments on the preliminary draft report are expected to be forthcoming.
- The meeting room was not available on November 17 for the final public meeting to present the findings of the study and introduce the watershed management plan to the public. December 1 was selected as an alternative date.

Brandywine Creek Watershed

Steering Committee Meeting Notes

Tuesday, December 26, 2011
Conference Call

Attendees List
Alicia Douglass – Davey Resource Group
Cindy Newkirk - Hancock County SWCD District Administrator

Discussion Summary

- A brief conference call was held between Cindy Newkirk and Alicia Douglass to discuss the sections of the report revised in accordance to feedback on the preliminary draft version of the Brandywine Creek Watershed Management Plan (WMP) submitted to the steering committee for review. Sections receiving substantial updates included the addition of flood reduction as a WMP goal and additional detail incorporated into the action register.
- It was determined that no further modifications were necessary, and that the draft report is now finalized per steering committee recommendations and suitable for submission to IDNR for a technical review by agency personnel.
- A current United States Environmental Protection Agency request for proposals for projects designed to improve urban waters was also discussed. Projects recommended in the WMP Action Register may qualify for funding.
- No additional steering committee meetings or conference calls are planned.

Appendix B
Public Education Handout

What are some examples of environmentally friendly practices?

Rain gardens with native vegetation filter pollutants from stormwater before they reach streams.

Preventing livestock from entering streams helps maintain stable streambanks and reduces *E. coli* and other pollutants entering streams.

For more information on protecting Brandywine Creek and available best management practices implementation cost-shares please contact:

Hancock County Soil & Water Conservation District

1101 W Main Street, Suite N

Greenfield, Indiana 46140

Phone: 317-462-2283 ext. 3

Shelby County Soil and Water Conservation District

2279 South 840 West

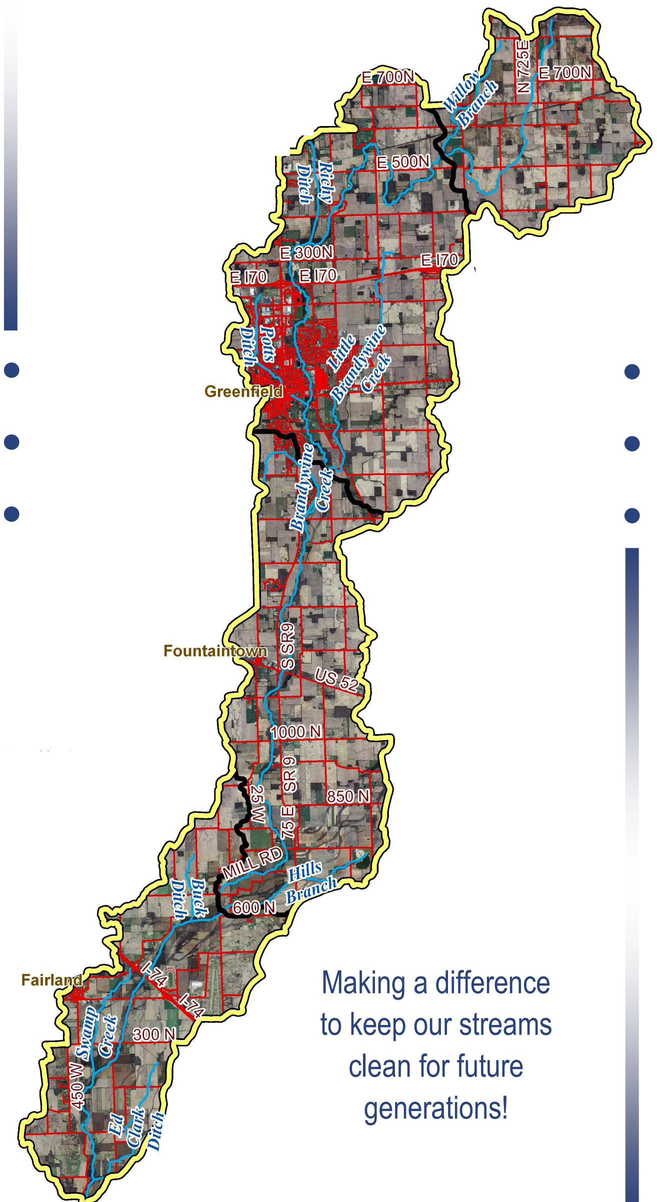
Manilla, Indiana 46150

Phone: 765-544-2051 ext. 7

The *Brandywine Creek Watershed Management Plan* was made possible by funding from the Indiana Department of Natural Resources Lake and River Enhancement Program and the Hancock SWCD. Davey Resource Group managed the study.

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company
DNR

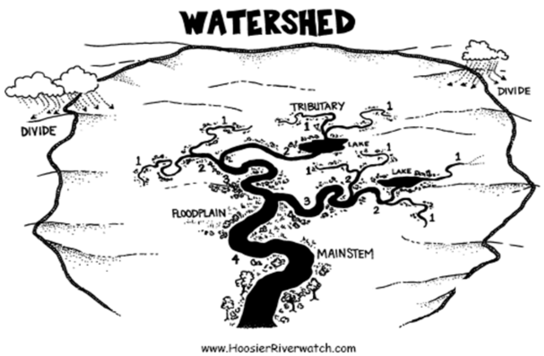
Brandywine Creek Watershed



Making a difference to keep our streams clean for future generations!

What is a Watershed?

- An area of land at a higher elevation that drains water, sediment, and dissolved materials to a common area of water at a lower elevation



Clean, healthy streams are important because they:

- Provide a place for fun and safe water recreation activities
- Support healthy fish and aquatic life populations
- Preserve areas for wildlife habitat
- Reduce the possibility of ground water contamination
- Influence economic activities
- Regulate flooding

Common pollutants in the Brandywine Creek watershed include:

- *E. coli*
- Phosphorus
- Nitrogen
- Sediment

Sources of non-point source pollutants in our streams include:

- Urban stormwater from parking lots and developed areas
- Failing and inadequate septic systems
- Improper disposal of trash and hazardous waste
- Excessive use of lawn and agricultural fertilizers
- Livestock, wildlife, and pet waste deposited in or adjacent to waterways or storm drains
- Clearing vegetation in natural areas
- Soils disturbed for new development and agricultural production

What can **homeowners** do to make our streams healthier?

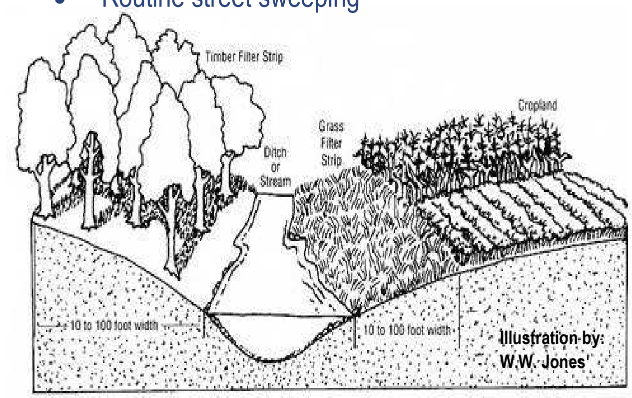
- Install rain gardens
- Use phosphorus free fertilizers
- Maintain septic systems
- Properly dispose of household waste
- Use rain barrels

What can **agricultural producers** do to make streams healthier?

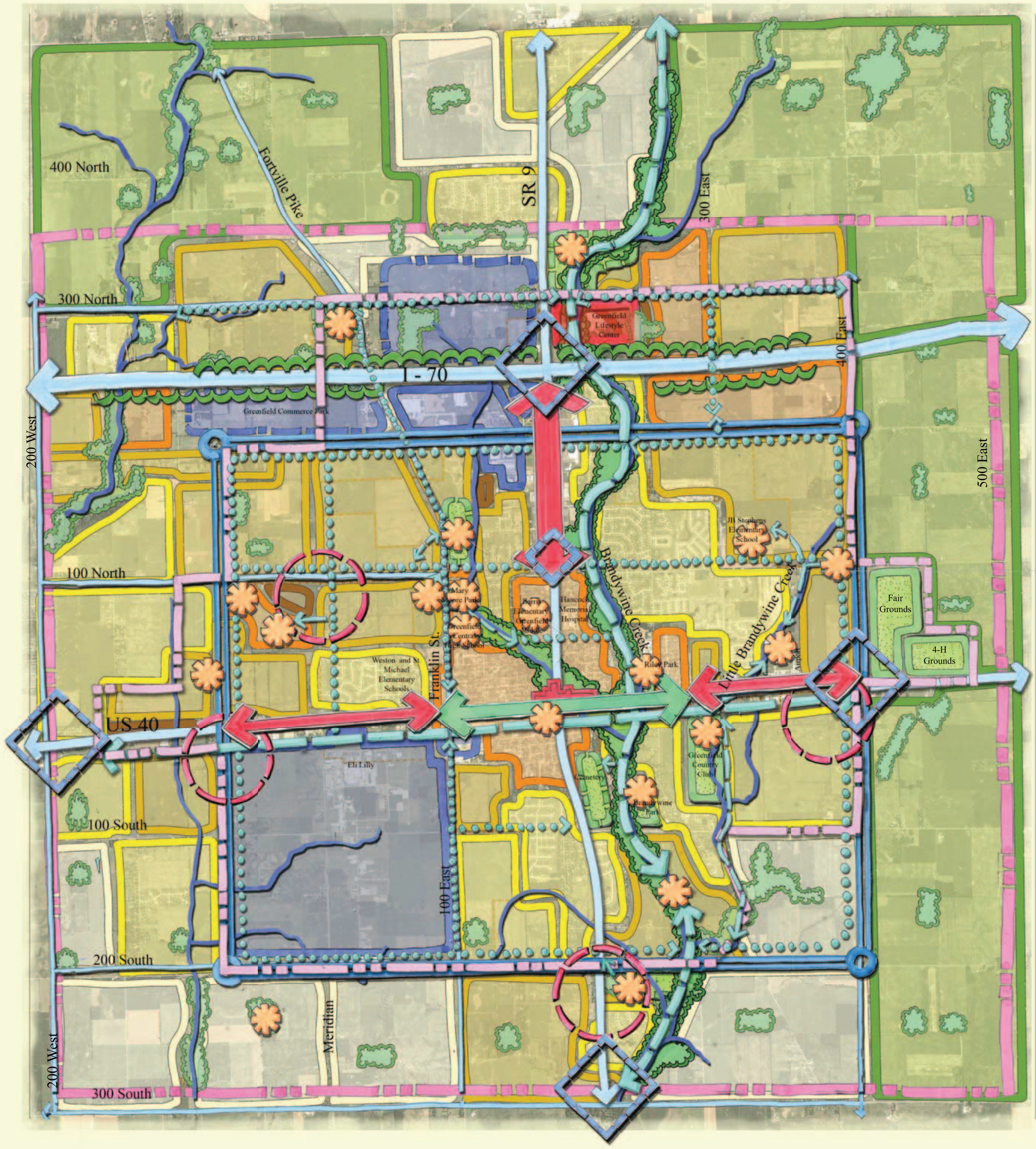
- Prevent livestock access to waterbodies
- Install filter strips and preserve natural riparian areas adjacent to streams
- Install water control structures on tile system outlets
- Plant cover crops
- Implement no-till practices
- Develop nutrient and pest management plans

How can **my community** work together to make our streams healthier?

- Ensure environmentally friendly practices are incorporated in new developments
- Develop areas of native vegetation adjacent to streambanks and shorelines
- Routine street sweeping



Appendix C
Greenfield Comprehensive Plan Map



LEGEND:

- Stream Corridors
- Natural Areas
- Community Connectors
- Major Collectors
- Agricultural
- Very Low Density Residential (Less than 1 DU per acre)
- Low Density Residential (1 to 3 DU per acre)
- Low to Medium Density Residential (3 to 5 DU per acre)
- Medium to High Density Residential (5 to 7 DU per acre)
- High Density Residential (More than 7 DU per acre)
- Neighborhood Commercial Node
- Greenfield Lifestyle Center
- Existing Industrial/ Research Park
- Proposed Commerce Park and Research Campus
- Commercial Corridor
- Historic Corridor Enhancements
- Existing Park
- Proposed Park
- Parkway
- Neighborhood/Civic Hub
- Gateways
- Greenway Spine
- Regional Greenways
- On-Street Trails
- I-70 Overlay District
- 10 - 15 Year Growth
- 30 Year Growth Boundary

COMMUNITY DEVELOPMENT PLAN

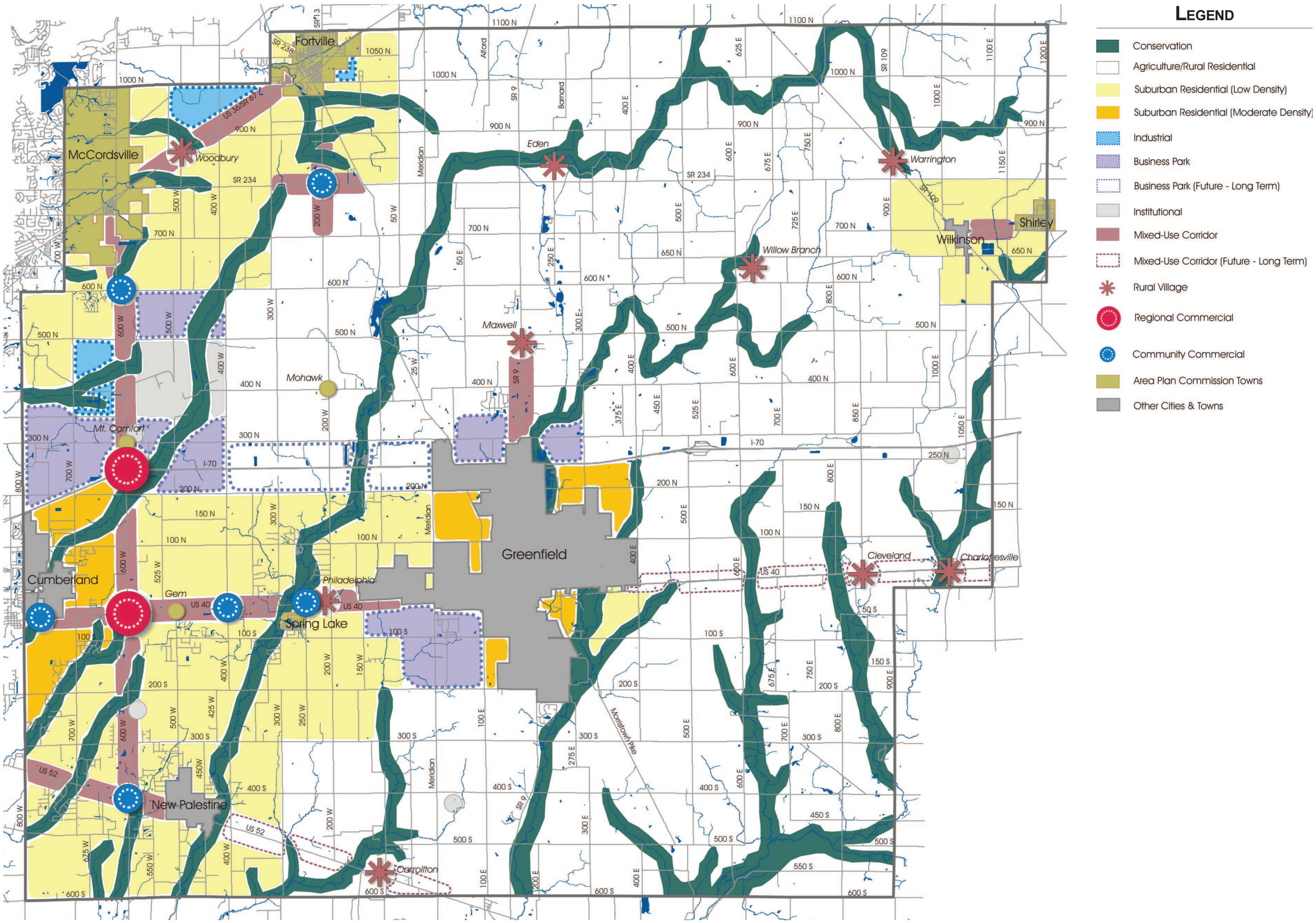
A TRADITIONAL AMERICAN CITY

Greenfield Comprehensive Plan – Adopted May 11, 2006

HNTB

Appendix D
Hancock County Comprehensive Plan Map

Future Land Use Map

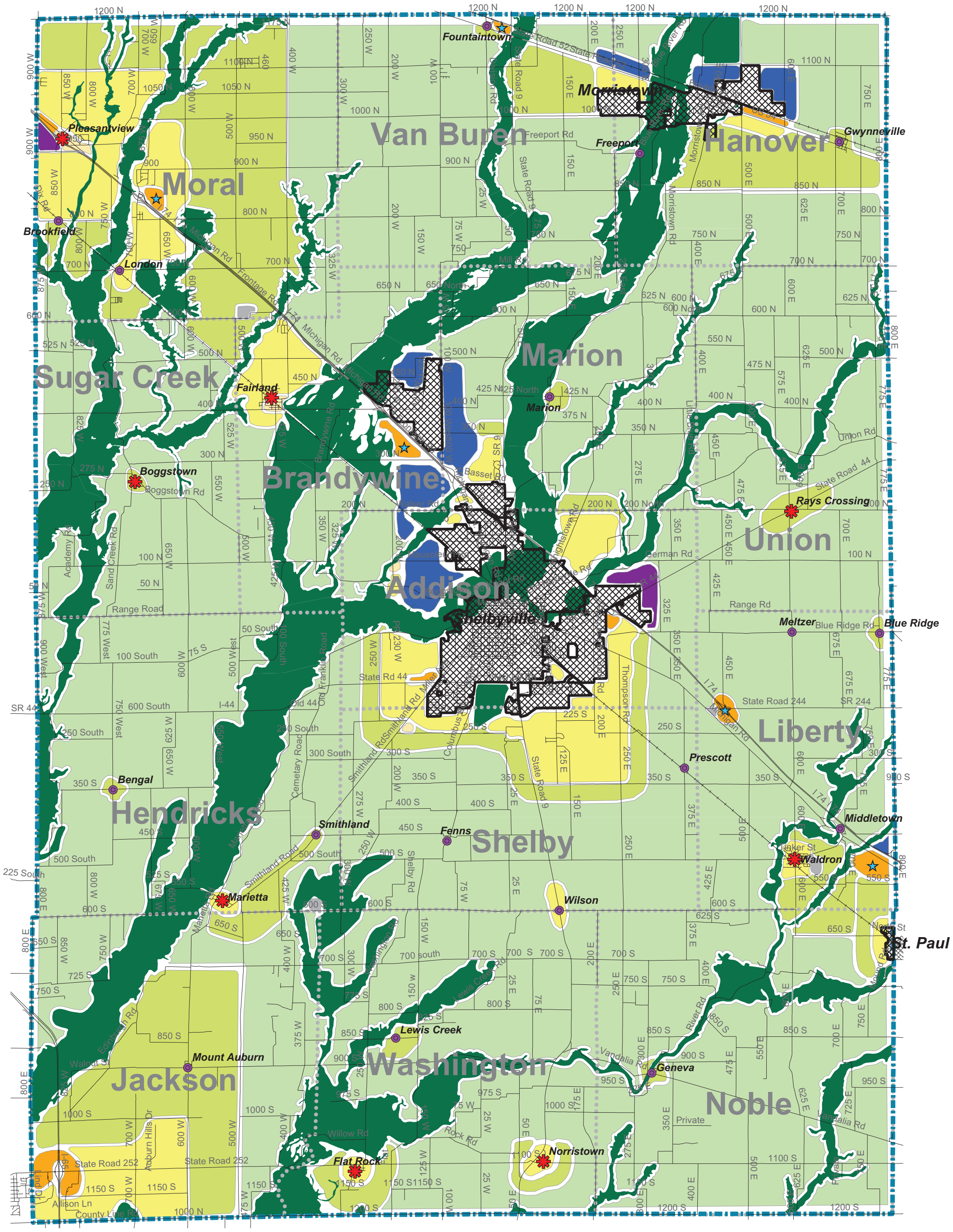


Updating The Map

It is important that a thorough review of this Future Land Use Map occur on a regular basis. Not only should issues of appropriate land use patterns be evaluated, but changes to town boundaries and the construction of new roads should be reflected. In this way, the map will always reflect the most current information available. To update this map, the County should take advantage of the Geographic Information System tools at its disposal. This powerful technology is key to maintaining the accuracy of the information on the Future Land Use Map as well as helping the county to evaluate land based on the location criteria for development listed in this plan.

Appendix E
Shelby County Comprehensive Plan Map

Future Land Use Map



Legend

- Roads
- Railroad
- Unincorporated Towns
- Incorporated Cities & Towns
- Parks, Open Space, & Conservation
- Agriculture
- Agricultural Residential
- Suburban Residential
- Neighborhood Commercial
- General Commercial
- Institutional
- Business Park
- Industrial
- Rural Town Center
- Highway Corridor Commercial
- Township Borders
- County Limits

Miles: 0 1 2
Feet: 0 5,000 10,000

Appendix F
Hancock and Shelby Counties Endangered, Threatened, and Rare Species

Indiana County Endangered, Threatened and Rare Species List

County: Hancock

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Toxolasma lividus	Purple Lilliput		SSC	G3	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Bird					
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Mammal					
Mustela nivalis	Least Weasel		SSC	G5	S2?
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger		SSC	G5	S2
Vascular Plant					
Magnolia acuminata	Cucumber Magnolia		SE	G5	S1

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

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; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

Indiana County Endangered, Threatened and Rare Species List

County: Shelby

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	SX
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G5	S3
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot	C	SE	G3G4T3	S1
Simpsonaias ambigua	Salamander Mussel		SSC	G3	S2
Toxolasma lividus	Purple Lilliput		SSC	G3	S2
Villosa fabalis	Rayed Bean	C	SSC	G2	S1
Villosa lienosa	Little Spectaclecase		SSC	G5	S3
Insect: Odonata (Dragonflies & Damselflies)					
Enallagma divagans	Turquoise Bluet		SR	G5	S3
Bird					
Haliaeetus leucocephalus	Bald Eagle	LT,PDL	SE	G5	S2
Mammal					
Lutra canadensis	Northern River Otter		SSC	G5	S2
Taxidea taxus	American Badger		SSC	G5	S2
High Quality Natural Community					
Forest - flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2
Other					
Geomorphic - Nonglacial Erosional Feature - Water Fall and Cascade	Water Fall and Cascade			GNR	SNR

Indiana Natural Heritage Data Center
Division of Nature Preserves
Indiana Department of Natural Resources
This data is not the result of comprehensive county surveys.

Fed: LE = Endangered; LT = Threatened; C = candidate; PDL = proposed for delisting

State: SE = state endangered; ST = state threatened; SR = state rare; SSC = state species of special concern; SX = state extirpated; SG = state significant; WL = watch list

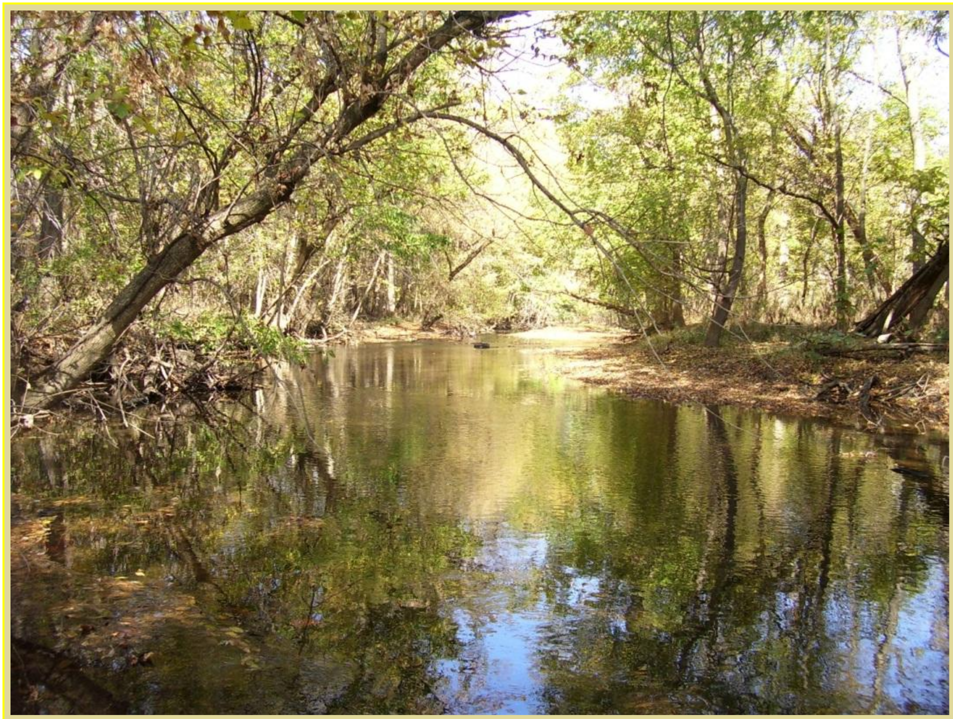
GRANK: Global Heritage Rank: G1 = critically imperiled globally; G2 = imperiled globally; G3 = rare or uncommon globally; G4 = widespread and abundant globally but with long term concerns; G5 = widespread and abundant globally; G? = unranked; GX = extinct; Q = uncertain rank; T = taxonomic subunit rank

SRANK: State Heritage Rank: S1 = critically imperiled in state; S2 = imperiled in state; S3 = rare or uncommon in state; G4 = widespread and abundant in state but with long term concern; SG = state significant; SH = historical in state; SX = state extirpated; B = breeding status; S? = unranked; SNR = unranked; SNA = nonbreeding status unranked

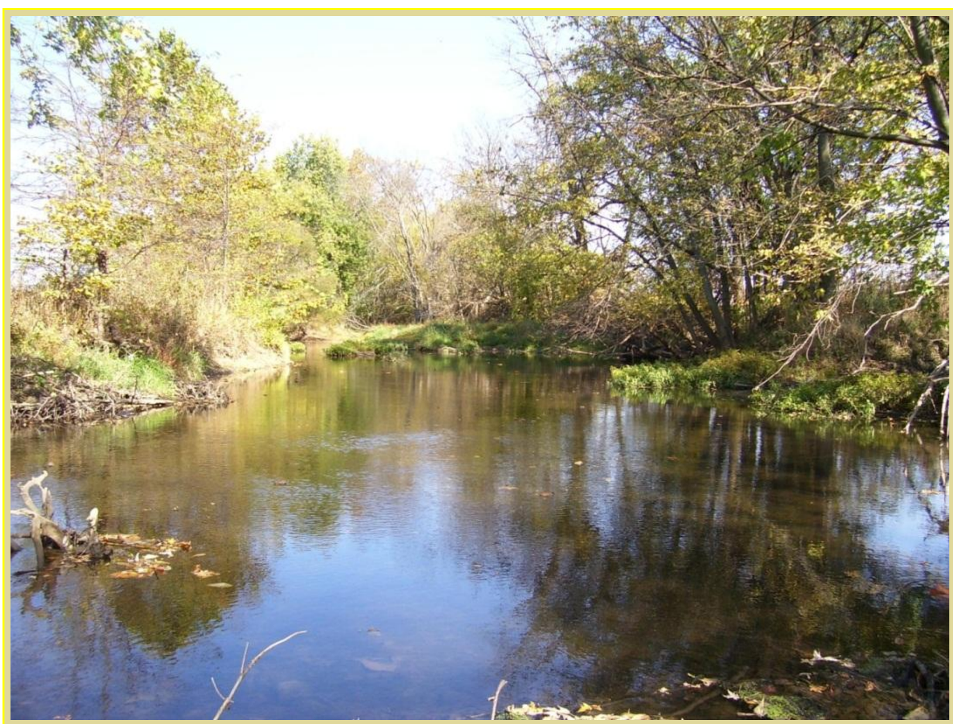
Appendix G
Sample Site Photographs

Photograph 1 (10-18-11). Site 1 Brandywine Creek

Photograph 2 (10-18-11). Site 2 Brandywine Creek

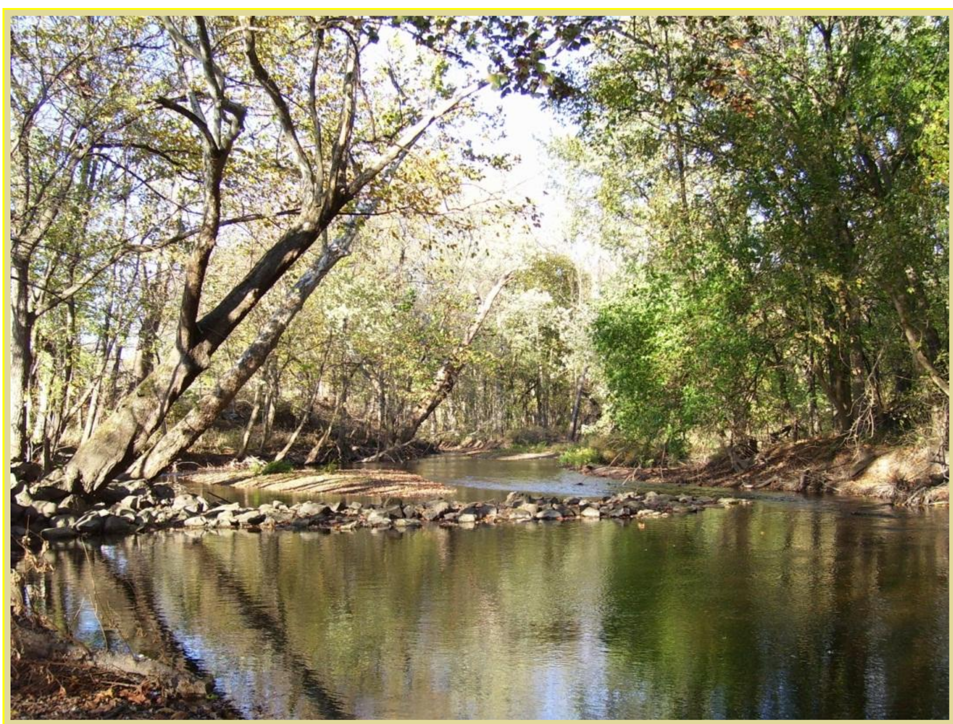


Photograph 3 (10-19-11). Site 3 Brandywine Creek



Photograph 4 (10-19-11). Site 4 Brandywine Creek

Photograph 5 (10-21-11). Site 5 Brandywine Creek



Photograph 6 (10-21-11). Site 6 Brandywine Creek

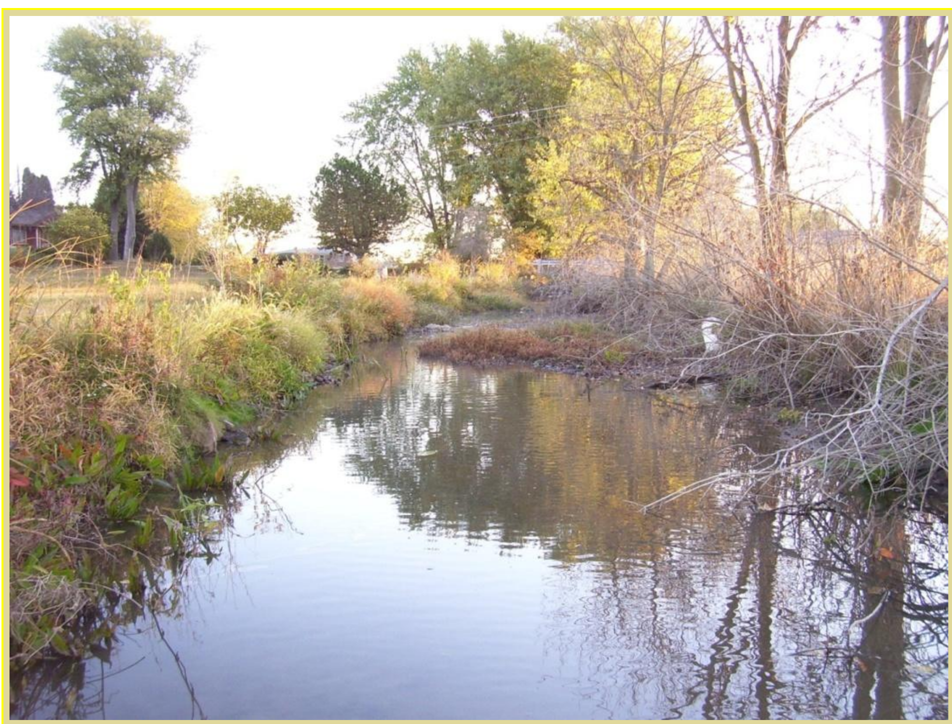
Photograph 7 (10-18-11). Site 7 Willow Branch

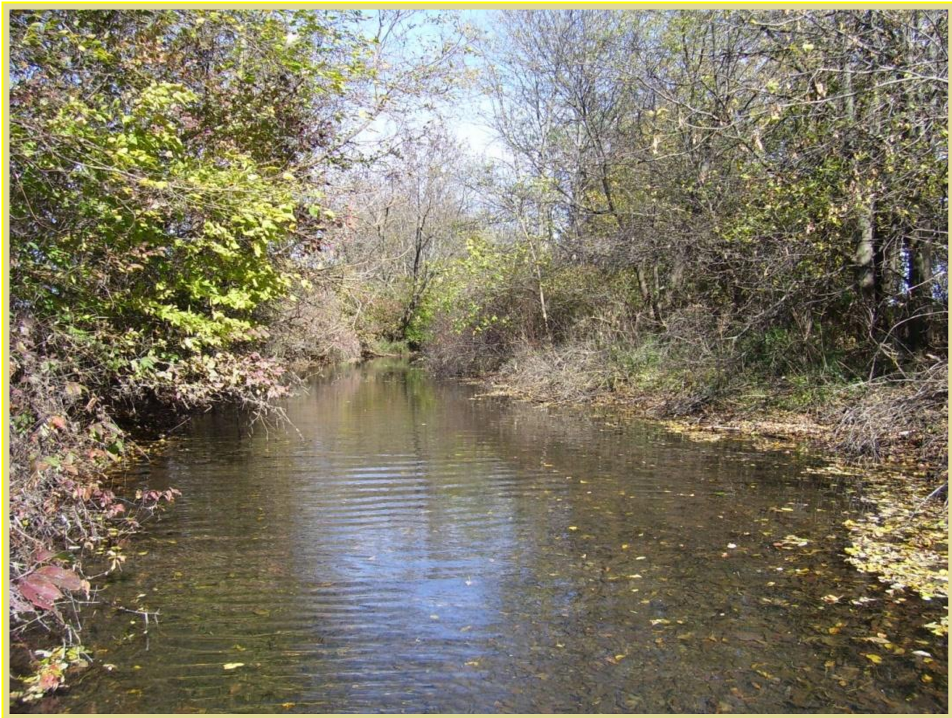
Photograph 8 (10-19-11). Site 8 Richey Ditch

Photograph 9 (10-19-11). Site 9 Potts Ditch

Photograph 10 (10-19-11). Site 10 Little Brandywine Creek


Photograph 11 (10-19-11). Site 11 Buck Ditch


Photograph 12 (10-19-11). Site 12 Hills Branch



Photograph 13 (10-21-11). Site 13 Swamp Creek

Photograph 14 (10-20-10). Site 14 Ed Clark Ditch

Photograph 15 (10-20-11). Site R Sugar Creek

Appendix H
Field Analyzed Data

Site	Sample Type	Date	Time	Air Temp. (ºC)	Water Temp. (ºC)	pH	Specific Conductivity (µS)	Dissolved Oxygen (mg/L)	Data Collectors[1]	Weather
1	base flow	1/11/2001	9:20 am	-1.7	0.3	8.03	319.9	7.6	AD, TG	sunny
1	storm flow	4/5/2011	8:00 am	3.8	3.8	7.29	250.4	5.8	AD, KK, TG	overcast
2	base flow	1/11/2011	10:30 am	-2.8	1.0	8.05	312	7.6	AD, TG	sunny
2	storm flow	4/5/2011	9:50 am	4.1	4.1	7.69	201.6	5.8	AD, KK, TG	sunny
3	base flow	1/10/2011	11:45 am	-0.6	3.3	7.86	509.0	7.4	AD, TG	sunny
3	storm flow	4/5/2011	11:55 am	5.1	5.1	7.79	282.1	6.4	AD, KK, TG	overcast
4	base flow	1/10/2011	12:30 pm	1.5	1.9	7.85	406	8.8	AD, TG	overcast
4	storm flow	4/5/2011	2:20 pm	8.3	10.4	7.74	308	7.0	AD, KK, TG	sunny
5	base flow	1/10/2011	1:45 pm	1.2	0.9	8.00	379.2	8.6	AD, TG	overcast
5	storm flow	4/5/2011	3:15 pm	6.4	10.4	7.82	286.3	6.2	AD, KK, TG	overcast
6	base flow	1/10/2011	3:15 pm	1.2	1.3	8.01	371.0	8.7	AD, TG	overcast
6	storm flow	4/5/2011	4:45 pm	8.5	11.1	7.86	235.7	5.8	AD, KK, TG	overcast
7	base flow	1/12/2011	9:30 am	-0.7	0.9	7.94	340.4	7.6	AD, TG	snow
7	storm flow	4/5/2011	9:00 am	5.3	6.7	7.11	284.1	4.9	AD, KK, TG	overcast
8	base flow	1/12/2011	10:15 am	-0.7	1.5	7.80	373.5	6.9	AD, TG	snow
8	storm flow	4/5/2011	10:30 am	6.3	8.2	7.48	453.8	4.4	AD, KK, TG	sunny
9	base flow	1/12/2011	11:00 am	-1.2	1.5	7.79	597.0	7.1	AD, TG	snow
9	storm flow	4/5/2011	11:25 am	12.3	9.1	7.48	260.8	7.3	AD, KK, TG	sunny

Site	Sample Type	Date	Time	Air Temp. (ºC)	Water Temp. (ºC)	pH	Specific Conductivity (µS)	Dissolved Oxygen (mg/L)	Data Collectors[1]	Weather
10	base flow	1/12/2011	11:45 am	-0.4	0.3	7.94	342.5	6.4	AD, TG	snow
10	storm flow	4/5/2011	1:15 pm	7.1	8.5	7.66	285.4	7.3	AD, KK, TG	overcast
11	base flow	1/12/2011	2:30 pm	1.0	6.4	7.53	387.1	7.8	AD, TG	snow
11	storm flow	4/5/2011	3:30 pm	6.7	10.4	7.40	221.1	4.9	AD, KK, TG	overcast
12	base flow	1/13/2011	10:55 am	-3.0	2.3	7.99	325.2	7.8	AD, TG	sunny
12	storm flow	4/5/2011	2:45 pm	5.8	10.7	7.74	314.2	6.5	AD, KK, TG	overcast
13	base flow	1/13/2011	11:45 am	-4.7	4.1	7.69	387.2	6.9	AD, TG	sunny
13	storm flow	4/5/2011	4:00 pm	8.9	11.2	7.77	245.0	6.1	AD, KK, TG	sunny
14	base flow	1/13/2011	1:00 pm	-1.8	0.8	8.18	309.8	8.5	AD, TG	overcast
14	storm flow	4/5/2011	5:15 pm	9.2	10.8	7.81	369.6	5.0	AD, KK, TG	sunny
R	base flow	1/12/2011	12:45 pm	-1.5	0.4	7.80	325.5	8.2	AD, TG	snow
R	storm flow	4/5/2011	12:55 pm	5.2	9.1	7.82	311.4	6.3	AD, KK, TG	overcast

[1] Alicia Douglass (AD), Kasey Krouse (KK); Todd Gillian (TG)

Appendix I
Laboratory Analyzed Data

- CERTIFICATE OF ANALYSIS -

Report Date: *18-Jan-11*

Client ID: DAVEY_RESOURCE

Davey Resource Group
3846 New Vision Drive
Fort Wayne, Indiana 46845

Attn: Alicia Douglass

Phone: (260) 969-5990
FAX: (260) 969-5992

Our Lab # 11000337-001
Your Sample ID: Sample #1
Your Project #
Collection Date: 01/10/11 09:20
Your Project Name: **Brandywine Creek**
Collected By: Client
Sample Type: Water
Receipt Date: 01/10/11 16:30

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.016	mg/L as P		0.010		1/11/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	1.43	mg/L		1.00		1/13/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	2	NTU		1		1/11/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/11/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.024	mg/L		0.010	7723-14-0	1/11/2011	amyers

ESG Laboratories

5927 WEST 71ST STREET
INDIANAPOLIS, INDIANA 46278

PHONE (317) 290-1471
FAX (317) 290-1670

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.107	mg/L		0.100	7664-41-7	1/13/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	4.96	mg/L		1.25		1/14/2011	dgoode

Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.590	mg/L		0.100		1/14/2011	nmason

ESG Laboratories

5927 WEST 71ST STREET
INDIANAPOLIS, INDIANA 46278

PHONE (317) 290-1471
FAX (317) 290-1670

Our Lab #	11000337-002	**Your Sample ID:**	Sample #2
Your Project #		**Collection Date:**	01/10/11 10:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/10/11 16:30

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.029	mg/L as P		0.010		1/11/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	2.56	mg/L		1.00		1/13/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	3	NTU		1		1/11/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/11/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.034	mg/L		0.010	7723-14-0	1/11/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.121	mg/L		0.100	7664-41-7	1/13/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	5.09	mg/L		1.25		1/14/2011	dgoode

ESG Laboratories

5927 WEST 71ST STREET
INDIANAPOLIS, INDIANA 46278

PHONE (317) 290-1471
FAX (317) 290-1670

Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.699	mg/L		0.100		1/14/2011	nmason

ESG Laboratories

5927 WEST 71ST STREET
INDIANAPOLIS, INDIANA 46278

PHONE (317) 290-1471
FAX (317) 290-1670

Our Lab #	11000337-003	**Your Sample ID:**	Sample #3
Your Project #		**Collection Date:**	01/10/11 11:45
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/10/11 16:30

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.568	mg/L as P		0.010		1/11/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	1.49	mg/L		1.00		1/13/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	3	NTU		1		1/11/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/11/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.601	mg/L		0.010	7723-14-0	1/11/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.191	mg/L		0.100	7664-41-7	1/13/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	7.57	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.07	mg/L		0.100		1/14/2011	nmason

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Our Lab #	11000337-004	**Your Sample ID:**	Sample #4
Your Project #		**Collection Date:**	01/10/11 12:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/10/11 16:30

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.222	mg/L as P		0.010		1/11/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	3.12	mg/L		1.00		1/13/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	3	NTU		1		1/11/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/11/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.253	mg/L		0.010	7723-14-0	1/11/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.145	mg/L		0.100	7664-41-7	1/13/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	5.80	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.817	mg/L		0.100		1/14/2011	nmason

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Our Lab #	11000337-005	**Your Sample ID:**	Sample #5
Your Project #		**Collection Date:**	01/10/11 13:45
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/10/11 16:30

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.190	mg/L as P		0.010		1/11/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	5.19	mg/L		1.00		1/13/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	3	NTU		1		1/11/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/11/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.200	mg/L		0.010	7723-14-0	1/11/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.112	mg/L		0.100	7664-41-7	1/13/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	5.34	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.715	mg/L		0.100		1/14/2011	nmason

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Our Lab #	11000337-006	**Your Sample ID:**	Sample #6
Your Project #		**Collection Date:**	01/10/11 15:15
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/10/11 16:30

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.131	mg/L as P		0.010		1/11/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	2.78	mg/L		1.00		1/13/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	2	NTU		1		1/11/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/11/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.147	mg/L		0.010	7723-14-0	1/11/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.111	mg/L		0.100	7664-41-7	1/13/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	4.83	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/13/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.680	mg/L		0.100		1/14/2011	nmason

Lab Manager	Date
	1/18/2011

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- CERTIFICATE OF ANALYSIS -

Report Date: *19-Jan-11*

Client ID: DAVEY_RESOURCE

Davey Resource Group
3846 New Vision Drive
Fort Wayne, Indiana 46845

Attn: Alicia Douglass

Phone: (260) 969-5990
FAX: (260) 969-5992

Our Lab # 11000445-001
Your Sample ID: Sample #7
Your Project #
Collection Date: 01/12/11 09:30
Your Project Name: **Brandywine Creek**
Collected By: Client
Sample Type: Water
Receipt Date: 01/12/11 16:36

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.034	mg/L as P		0.010		1/13/2011	bruhl

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	< 1.00	mg/L		1.00		1/17/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	1	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/13/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.050	mg/L		0.010	7723-14-0	1/13/2011	amyers

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Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.259	mg/L		0.100	7664-41-7	1/17/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	3.04	mg/L		1.25		1/14/2011	dgoode

Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.758	mg/L		0.100		1/18/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	310	MPN/100 mL		1		1/12/2011	cgarner

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Our Lab #	11000445-002	**Your Sample ID:**	Sample #8
Your Project #		**Collection Date:**	01/12/11 10:15
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/12/11 16:36

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.034	mg/L as P		0.010		1/13/2011	bruhl

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	4.41	mg/L		1.00		1/17/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	4	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/13/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.061	mg/L		0.010	7723-14-0	1/13/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.308	mg/L		0.100	7664-41-7	1/17/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	0.376	mg/L		0.200		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

	Analytical Method	Prep Method	Prep Date	By
	EPA 351.3	EPA 351.3	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.960	mg/L		0.100		1/18/2011	nmason

Escherichia coli, Colilert method

	Analytical Method	Prep Method	Prep Date	By
	SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	68	MPN/100 mL		1		1/12/2011	cgarner

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Our Lab #	11000445-003	**Your Sample ID:**	Sample #9
Your Project #		**Collection Date:**	01/12/11 11:00
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/12/11 16:36

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.039	mg/L as P		0.010		1/13/2011	bruhl

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	3.17	mg/L		1.00		1/17/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	3	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/13/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.067	mg/L		0.010	7723-14-0	1/13/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.216	mg/L		0.100	7664-41-7	1/17/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	0.519	mg/L		0.200		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.847	mg/L		0.100		1/18/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	407	MPN/100 mL		1		1/12/2011	cgarner

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Our Lab #	11000445-004	**Your Sample ID:**	Sample #10
Your Project #		**Collection Date:**	01/12/11 11:45
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/12/11 16:36

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.020	mg/L as P		0.010		1/13/2011	bruhl

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	3.03	mg/L		1.00		1/17/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	2	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/13/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.032	mg/L		0.010	7723-14-0	1/13/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.144	mg/L		0.100	7664-41-7	1/17/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.26	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.808	mg/L		0.100		1/18/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	218	MPN/100 mL		1		1/12/2011	cgarner

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Our Lab #	11000445-005	**Your Sample ID:**	Sample #11
Your Project #		**Collection Date:**	01/12/11 14:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/12/11 16:36

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.015	mg/L as P		0.010		1/13/2011	bruhl

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	4.00	mg/L		1.00		1/17/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	5	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/13/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.024	mg/L		0.010	7723-14-0	1/13/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.126	mg/L		0.100	7664-41-7	1/17/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	1.20	mg/L		0.500		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.493	mg/L		0.100		1/18/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	48	MPN/100 mL		1		1/12/2011	cgarner

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Our Lab #	11000514-007	**Your Sample ID:**	Sample #12
Your Project #		**Collection Date:**	01/13/11 10:55
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.031	mg/L as P		0.010		1/14/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	26.8	mg/L		1.00		1/18/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	6	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/17/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.064	mg/L		0.010	7723-14-0	1/17/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/18/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.119	mg/L		0.100	7664-41-7	1/18/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	6.56	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/18/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.776	mg/L		0.100		1/19/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	34	MPN/100 mL		1		1/13/2011	cgarner

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Our Lab #	11000514-008	**Your Sample ID:**	Sample #13
Your Project #		**Collection Date:**	01/13/11 11:45
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.016	mg/L as P		0.010		1/14/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	1.43	mg/L		1.00		1/18/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	3	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/17/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.023	mg/L		0.010	7723-14-0	1/17/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/18/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.115	mg/L		0.100	7664-41-7	1/18/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	1.01	mg/L		0.500		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/18/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.487	mg/L		0.100		1/19/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	8	MPN/100 mL		1		1/13/2011	cgarner

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Our Lab #	11000514-009	**Your Sample ID:**	Sample #14
Your Project #		**Collection Date:**	01/13/11 13:00
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.018	mg/L as P		0.010		1/14/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	< 1.00	mg/L		1.00		1/18/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	1	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/17/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.017	mg/L		0.010	7723-14-0	1/17/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/18/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.105	mg/L		0.100	7664-41-7	1/18/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.44	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/18/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.609	mg/L		0.100		1/19/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	< 4	MPN/100 mL		4		1/13/2011	cgarner

Our Lab # 11000514-010

Your Sample ID: Park

Your Project #

Collection Date: 01/13/11 09:45

Your Project Name: **Brandywine Creek**

Collected By: Client

Sample Type: Water

Receipt Date: 01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	208	MPN/100 mL		1		1/13/2011	cgarner

1/19/2011

Lab Manager **Date**

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Our Lab #	11000445-006	**Your Sample ID:**	Sample #R
Your Project #		**Collection Date:**	01/12/11 14:45
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/12/11 16:36

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.016	mg/L as P		0.010		1/13/2011	bruhl

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	1.79	mg/L		1.00		1/17/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	2	NTU		1		1/13/2011	bruhl

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	1/13/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.032	mg/L		0.010	7723-14-0	1/13/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.121	mg/L		0.100	7664-41-7	1/17/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.64	mg/L		1.25		1/14/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	1/17/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	0.696	mg/L		0.100		1/18/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	64	MPN/100 mL		1		1/12/2011	cgarner

1/19/2011

Lab Manager **Date**

Lab # 11000445-006 **Sample ID:** Sample #R

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- CERTIFICATE OF ANALYSIS -

Report Date: *19-Jan-11*

Client ID: DAVEY_RESOURCE

Davey Resource Group
3846 New Vision Drive
Fort Wayne, Indiana 46845

Attn: Alicia Douglass

Phone: (260) 969-5990
FAX: (260) 969-5992

Our Lab # 11000514-001
Your Sample ID: Sample #1
Your Project #
Collection Date: 01/13/11 09:00
Your Project Name: **Brandywine Creek**
Collected By: Client
Sample Type: Water
Receipt Date: 01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	314	MPN/100 mL		1		1/13/2011	cgarner

Our Lab # 11000514-002
Your Sample ID: Sample #2
Your Project #
Collection Date: 01/13/11 09:30
Your Project Name: **Brandywine Creek**
Collected By: Client
Sample Type: Water
Receipt Date: 01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	666	MPN/100 mL		1		1/13/2011	cgarner

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Our Lab #	11000514-003	**Your Sample ID:**	Sample #3
Your Project #		**Collection Date:**	01/13/11 10:00
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	432	MPN/100 mL		1		1/13/2011	cgarner

Our Lab #	11000514-004	**Your Sample ID:**	Sample #4
Your Project #		**Collection Date:**	01/13/11 10:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	175	MPN/100 mL		1		1/13/2011	cgarner

Our Lab #	11000514-005	**Your Sample ID:**	Sample #5
Your Project #		**Collection Date:**	01/13/11 11:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	115	MPN/100 mL		1		1/13/2011	cgarner

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Our Lab #	11000514-006	**Your Sample ID:**	Sample #6
Your Project #		**Collection Date:**	01/13/11 12:45
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	01/13/11 15:20

Escherichia coli, Colilert method

Analytical Method	**Prep Method**	**Prep Date**	**By**
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	39	MPN/100 mL		1		1/13/2011	cgarner

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- CERTIFICATE OF ANALYSIS -

Report Date: *12-Apr-11*

Client ID: DAVEY_RESOURCE

Davey Resource Group
3846 New Vision Drive
Fort Wayne, Indiana 46845

Attn: Alicia Douglass

Phone: (260) 969-5990
FAX: (260) 969-5992

Our Lab #	11003945-001	**Your Sample ID:**	Sample #1
Your Project #		**Collection Date:**	04/05/11 08:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.44	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	95.6	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	128	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.228	mg/L		0.010	7723-14-0	4/6/2011	amyers

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Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.642	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	6.18	mg/L		1.25		4/6/2011	dgoode

Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.37	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	4611	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-002	**Your Sample ID:**	Sample #2
Your Project #		**Collection Date:**	04/05/11
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.95	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	85.4	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	174	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.306	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.874	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	4.16	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.94	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	3654	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-003	**Your Sample ID:**	Sample #3
Your Project #		**Collection Date:**	04/05/11 12:00
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.37	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	128	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	106	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.547	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.585	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.70	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.47	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	2987	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-004	**Your Sample ID:**	Sample #4
Your Project #		**Collection Date:**	04/05/11 13:35
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.07	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	91.4	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	90	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.306	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.581	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.41	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.76	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	1223	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-005	**Your Sample ID:**	Sample #5
Your Project #		**Collection Date:**	04/05/11 13:55
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.21	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	66.1	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	88	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.400	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.609	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	1.95	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.84	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	1725	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-006	**Your Sample ID:**	Sample #6
Your Project #		**Collection Date:**	04/05/11 13:50
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.41	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	82.8	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	110	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.542	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.502	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	1.73	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.89	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	3076	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-007	**Your Sample ID:**	Sample #7
Your Project #		**Collection Date:**	04/05/11 09:00
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.04	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	40.8	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	54	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.342	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.828	mg/L		0.100	7664-41-7	4/6/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	5.14	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/6/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.80	mg/L		0.100		4/7/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	743	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-008	**Your Sample ID:**	Sample #8
Your Project #		**Collection Date:**	04/05/11 10:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.426	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	26.9	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	35	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.192	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	1.32	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.27	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.57	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	2613	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-009	**Your Sample ID:**	Sample #9
Your Project #		**Collection Date:**	04/05/11 11:30
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.827	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	85.7	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	66	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.334	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.864	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	2.01	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.02	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	644	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-010	**Your Sample ID:**	Sample #10
Your Project #		**Collection Date:**	04/05/11 13:15
Your Project Name:	Brandywine Creek	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.925	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	61.1	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	79	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.307	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.778	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	3.32	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.85	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	605	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-011	**Your Sample ID:**	Sample #11
Your Project #		**Collection Date:**	04/05/11 14:00
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.548	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	14.9	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	30	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.210	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.214	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	3.83	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.24	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	504	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-012	**Your Sample ID:**	Sample #12
Your Project #		**Collection Date:**	04/05/11 14:15
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.89	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	46.0	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	67	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.701	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.489	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	3.90	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.71	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	5475	MPN/100 mL		1		4/5/2011	cgarner

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Our Lab #	11003945-013	**Your Sample ID:**	Sample #13
Your Project #		**Collection Date:**	04/05/11 14:25
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.36	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	65.8	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	89	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.322	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.696	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	1.77	mg/L		1.25		4/6/2011	dgoode

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.92	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	2282	MPN/100 mL		1		4/5/2011	cgarner

ESG Laboratories

5927 WEST 71ST STREET
INDIANAPOLIS, INDIANA 46278

PHONE (317) 290-1471
FAX (317) 290-1670

Our Lab #	11003945-014	**Your Sample ID:**	Sample #14
Your Project #		**Collection Date:**	04/05/11 14:35
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	0.377	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	20.5	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	24	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.159	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.242	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	4.25	mg/L		1.25		4/6/2011	dgoode

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INDIANAPOLIS, INDIANA 46278
PHONE (317) 290-1471
FAX (317) 290-1670

Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	1.27	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	246	MPN/100 mL		1		4/5/2011	cgarner

ESG Laboratories

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PHONE (317) 290-1471
FAX (317) 290-1670

Our Lab #	11003945-015	**Your Sample ID:**	Sample #R
Your Project #		**Collection Date:**	04/05/11 12:55
Your Project Name:	**Brandywine Creek**	**Collected By:**	Client
Sample Type:	Water	**Receipt Date:**	04/05/11 15:53

ortho-Phosphate

Analytical Method	Prep Method	Prep Date	By
EPA 365.2			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
ortho-Phosphate	1.11	mg/L as P		0.010		4/6/2011	amyers

Total Suspended Solids

Analytical Method	Prep Method	Prep Date	By
SM 2540D			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Suspended Solids	98.6	mg/L		1.00		4/7/2011	cgarner

Turbidity

Analytical Method	Prep Method	Prep Date	By
EPA 180.1			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Turbidity	106	NTU		1		4/6/2011	spotts

Total Phosphorus, as P

Analytical Method	Prep Method	Prep Date	By
EPA 365.2	EPA 365.2	4/6/2011	amyers

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Phosphorus, as P	0.243	mg/L		0.010	7723-14-0	4/6/2011	amyers

Ammonia

Analytical Method	Prep Method	Prep Date	By
SM4500-NH3 D	SM4500-NH3 B	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Ammonia	0.604	mg/L		0.100	7664-41-7	4/7/2011	nmason

Nitrate-Nitrite, Manual Cadmium Column

Analytical Method	Prep Method	Prep Date	By
EPA 353.3			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Nitrate-Nitrite, Manual Cadmium Column	4.03	mg/L		1.25		4/6/2011	dgoode

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INDIANAPOLIS, INDIANA 46278

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Total Kjeldahl Nitrogen

Analytical Method	Prep Method	Prep Date	By
EPA 351.3	EPA 351.3	4/7/2011	nmason

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Total Kjeldahl Nitrogen	2.56	mg/L		0.100		4/8/2011	nmason

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	1178	MPN/100 mL		1		4/5/2011	cgarner

Our Lab # 11003945-016

Your Sample ID: Park

Your Project #

Collection Date: 04/05/11 11:00

Your Project Name: **Brandywine Creek**

Collected By: Client

Sample Type: Water

Receipt Date: 04/05/11 15:53

Escherichia coli, Colilert method

Analytical Method	Prep Method	Prep Date	By
SM 9223B			

Parameter	Result	Units	Qual	Quant. Limit	CAS #	Analysis Date	By
Escherichia coli	1616	MPN/100 mL		1		4/5/2011	cgarner

4/12/2011

Lab Manager **Date**

ESG Laboratories

5927 WEST 71ST STREET
INDIANAPOLIS, INDIANA 46278

PHONE (317) 290-1471
FAX (317) 290-1670

Appendix J
Macroinvertebrate Subsample Data

Site 1 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Caenidae	61
Chironomidae	2
Coenagrionidae	7
Elmidae	20
Ephemeridae	2
Hyalellidae	6
Oligochaeta	2
Planorbidae	2
Total	**102**
Squares Sorted	**11**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 2 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Ceratopogonidae	1
Chironomidae	15
Elmidae	31
Gomphidae	1
Hydrophilidae	2
Leptohyphidae	8
Philopotamidae	2
Turbellaria	47
Total	**107**
Squares Sorted	**12**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 3 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Baetidae	25
Chironomidae	7
Elmidae	52
Hirudinidae	1
Hydropsychidae	4
Isotomidae	2
Polycentropodidae	1
Simuliidae	3
Total	**103**
Squares Sorted	**14**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 4 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Asellidae	9
Calopterygidae	1
Chironomidae	33
Coenagrionidae	2
Elmidae	15
Gomphidae	2
Gordius	1
Heptageniidae	25
Hydropsychidae	10
Leptophlebiidae	2
Total	**111**
Squares Sorted	**22**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 5 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Caenidae	3
Calopterygidae	4
Chironomidae	38
Coenagrionidae	1
Elmidae	14
Heptageniidae	30
Leptophlebiidae	2
Lymnaeidae	1
Psephenidae	6
Total	**99**
Squares Sorted	**20**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 6 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Baetidae	36
Elmidae	38
Elmidae	2
Hydropsychidae	18
Hydroptilidae	2
Isonychiidae	5
Psephenidae	8
Taeniopterygidae	4
Total	**113**
Squares Sorted	**16**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 8 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Baetide	1
Chironomidae	1
Coenagrionidae	2
Elmidae	11
Ephydridae	1
Hirudinidae	26
Hyalellidae	8
Libellulidae	8
Oligochaeta	35
Physidae	8
Tabanidae	1
Turbellaria	8
Total	**110**
Squares Sorted	**35**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 9 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Caenidae	2
Calopterygidae	8
Chironomidae	14
Elmidae	11
Heptageniidae	2
Hydropsychidae	7
Oligochaeta	24
Tabanidae	1
Tipulidae	6
Turbellaria	21
Total	**96**
Squares Sorted	**38**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 10 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Caenidae	38
Chironomidae	47
Elmidae	8
Ephydridae	1
Gerridae	1
Oligochaeta	13
Physidae	3
Total	**111**
Squares Sorted	**22**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 11 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Asellidae	4
Caenidae	4
Cambaridae	1
Chironomidae	81
Coenagrionidae	1
Elmidae	9
Heptageniidae	1
Tipulidae	1
Total	**102**
Squares Sorted	**64**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 12 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Asellidae	5
Baetidae	9
Caenidae	52
Chironomidae	7
Elmidae	5
Hirudinidae	1
Hydrobiidae	3
Oligochaeta	11
Pleuroceridae	4
Total	**105**
Squares Sorted	**18**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site 13 Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Caenidae	55
Calopterygidae	2
Chironomidae	2
Coenagrionidae	7
Corixidae	3
Heptageniidae	18
Hirudinidae	1
Hyalellidae	31
Oligochaeta	3
Tabanidae	6
Total	**128**
Squares Sorted	**9**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Site R Macroinvertebrate Data	
Date Sampled	
Data Collectors[1]	AD, KK
Family	**Quantity**
Calopterygidae	1
Chironomidae	21
Elmidae	23
Heptageniidae	26
Hydropsychidae	17
Isonychiidae	5
Limnephilidae	1
Pleuroceridae	1
Psephenidae	8
Tipulidae	4
Veliidae	1
Total	**108**
Squares Sorted	**9**

[1] Alicia Douglass (AD), Kasey Krouse (KK)

Appendix K
QHEI Data Sheets

IDEM **OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)**

Sample #	bioSample #	Stream Name	Location
		Brandywine Creek	County Road N 600 E (Site 1)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/18/10	Hancock	KICC		33.5

1] *SUBSTRATE* Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

Check ONE (Or 2 & average)

BEST TYPES

PREDOMINANT P R		PRESENT P R	TOTAL %
☐☐	BLDR/SLABS [10]	☐☐	
☐☐	BOULDER [9]	☐☐	
☐☐	COBBLE [8]	☒☐	5
☒☐	GRAVEL [7]	☐☒	40
☐☐	SAND [6]	☐☒	15
☐☐	BEDROCK [5]	☐☐	

OTHER TYPES

PREDOMINANT P R		PRESENT P R	TOTAL %
☐☐	HARDPAN [4]	☐☐	
☐☐	DETRITUS [3]	☐☐	
☐☐	MUCK [2]	☐☐	
☒☐	SILT [2]	☐☐	40
☐☐	ARTIFICIAL [0]	☐☐	

(Score natural substrates; ignore sludge from point-sources)

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

ORIGIN
- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT
- ☒ HEAVY [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS
- ☒ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 6.5 Maximum 20

Comments

2] *INSTREAM COVER* Indicate presence 0 to 3 and estimate percent: 0–Absent; 1–Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
		UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
20	1	OVERHANGING VEGETATION [1]			ROOTWADS [1]	15	2	AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]			LOGS OR WOODY DEBRIS [1]
		ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☐ EXTENSIVE > 75% [11]
- ☒ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover Maximum 20: 9

Comments

3] *CHANNEL MORPHOLOGY* Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☐ MODERATE [2]
☐ LOW [2]	☐ FAIR [3]	☐ RECOVERING [3]	☒ LOW [1]
☒ NONE [1]	☒ POOR [1]	☒ RECENT OR NO RECOVERY [1]	

Channel Maximum 20: 4

Comments

4] *BANK EROSION AND RIPARIAN ZONE* Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

L R	EROSION	L R	RIPARIAN WIDTH	L R	FLOOD PLAIN QUALITY	L R	
☐☐	NONE/LITTLE [3]	☐☐	WIDE > 50m [4]	☐☐	FOREST, SWAMP [3]	☐☐	CONSERVATION TILLAGE [1]
☒☒	MODERATE [2]	☐☐	MODERATE 10-50m [3]	☐☐	SHRUB OR OLD FIELD [2]	☐☐	URBAN OR INDUSTRIAL [0]
☐☐	HEAVY/SEVERE [1]	☐☐	NARROW 5-10m [2]	☐☐	RESIDENTIAL, PARK, NEW FIELD [1]	☐☐	MINING /CONSTRUCTION [0]
		☐☐	VERY NARROW [1]	☐☐	FENCED PASTURE [1]		
		☒☐	NONE [0]	☒☒	OPEN PASTURE, ROWCROP [0]		

Indicate predominant land use(s) past 100m riparian.

Riparian Maximum 10: 2

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current Maximum 12: 3

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average)

☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☒ BEST AREAS < 5cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☒ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☒ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run Maximum 8: 1

Comments

6] *GRADIENT* (21.74 ft/mi)

DRAINAGE AREA (10.223 mi²)

- ☐ VERY LOW - LOW [2-4]
- ☐ MODERATE [6-10]
- ☒ HIGH - VERY HIGH [10-6] 8

%POOL: 15 %GLIDE: 75

%RUN: 5 %RIFFLE: 5

Gradient Maximum 10: 8

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY

- ☒ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Public ☒ Private
☐ Active ☐ Historic
Succession: ☒ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

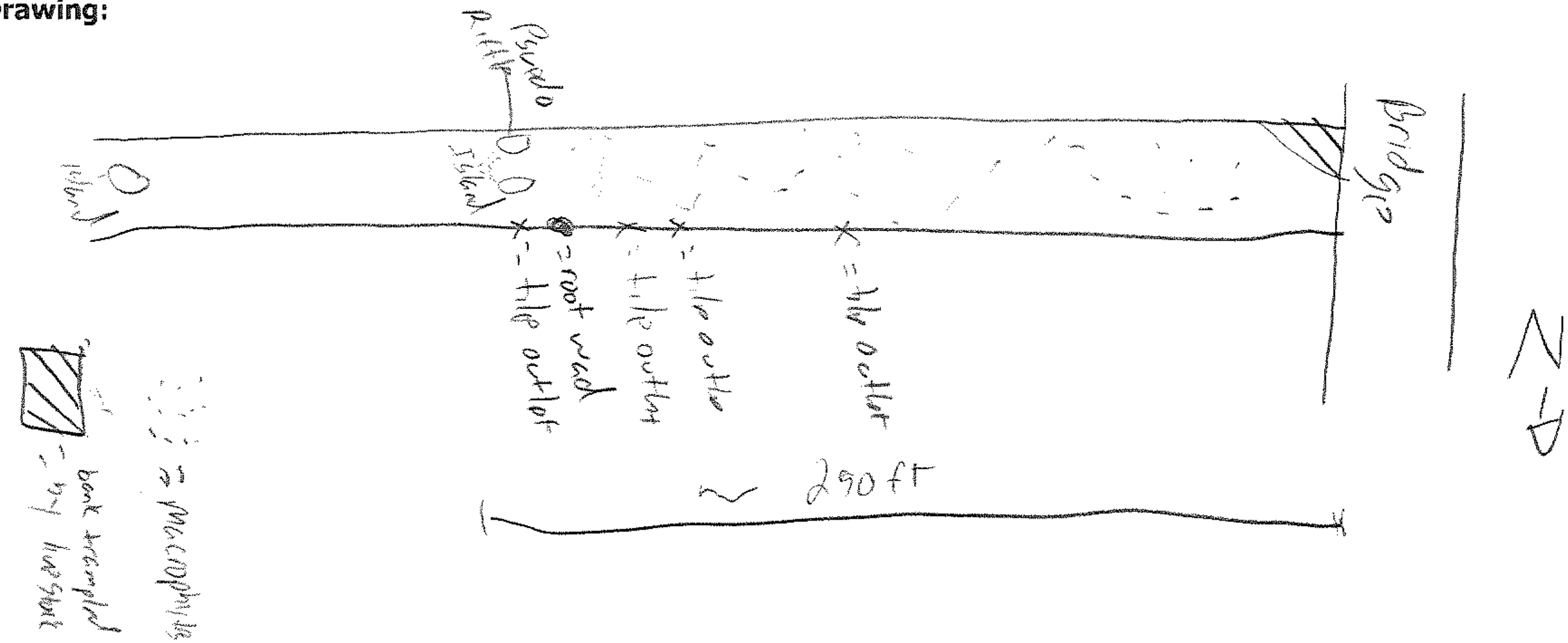
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☒ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Blandywine Creek	County Road W 300 E (site 2)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/18/10	Hancock	Kick		69

1] *SUBSTRATE* Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

Check ONE (Or 2 & average)

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐
- ☐☐ BOULDER [9] ☒☐ 2
- ☐☒ COBBLE [8] ☒☐ 30
- ☒☒ GRAVEL [7] ☐☐ 48
- ☐☐ SAND [6] ☒☐ 10
- ☐☐ BEDROCK [5] ☐☐

NUMBER OF BEST TYPES: ☒ 4 or more [2] ☐ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐
- ☐☐ DETRITUS [3] ☐☐
- ☐☐ MUCK [2] ☐☐
- ☐☐ SILT [2] ☒☒ 10
- ☐☐ ARTIFICIAL [0] ☐☐

(Score natural substrates; ignore sludge from point-sources)

ORIGIN

- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ NONE [1]

Substrate: 18 (Maximum 20)

Comments

2] *INSTREAM COVER* Indicate presence 0 to 3 and estimate percent: 0–Absent; 1–Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
5	1	UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
		OVERHANGING VEGETATION [1]	15	3	ROOTWADS [1]			AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	1	1	LOGS OR WOODY DEBRIS [1]
10	2	ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)

- ☒ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 15 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY* Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☒ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☒ GOOD [5]
- ☒ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 12 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE* Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☒ WIDE > 50m [4]
- ☒☐ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☒☒ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☒☐ OPEN PASTURE, ROWCROP [0]

(L R)
- ☐☐ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 8 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☒ POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 4 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average)

☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☒ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☒ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☒ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 4 (Maximum 8)

Comments

6] *GRADIENT* (25 ft/mi)

DRAINAGE AREA (25.087 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☐ MODERATE [6 - 10]
- ☒ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 8 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY

- ☐ >85% - Open
- ☐ 55% - <85%
- ☐ 30% - <55%
- ☒ 10% - <30%
- ☐ <10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

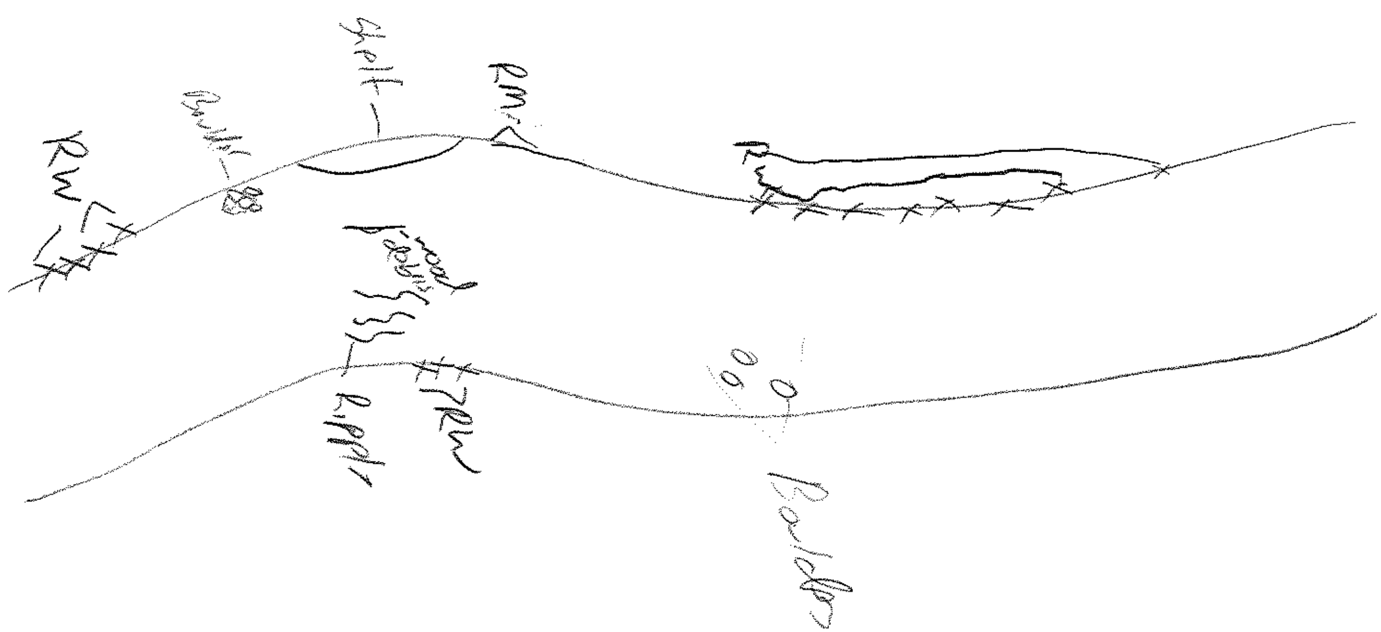
E-ISSUES

- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %
	X	X	X	

Stream Drawing:



IDEM 05/06/10

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Brandywine Creek	County Road 100 S (Site 3)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AO	10/19/10	Hancock	Kick		67

1] *SUBSTRATE* Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ___
- ☐☐ BOULDER [9] ☐☐ ___
- ☐☐ COBBLE [8] ☐☐ 2
- ☒☒ GRAVEL [7] ☐☐ 23
- ☒☒ SAND [6] ☐☐ 65
- ☐☐ BEDROCK [5] ☐☐ ___

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ___
- ☐☐ DETRITUS [3] ☐☐ ___
- ☐☐ MUCK [2] ☐☐ ___
- ☐☐ SILT [2] ☐☐ 10
- ☐☐ ARTIFICIAL [0] ☐☐ ___

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)

- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ NONE [1]

Substrate: 13 (Maximum 20)

Comments

2] *INSTREAM COVER* Indicate presence 0 to 3 and estimate percent: 0–Absent; 1–Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
1	1	UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
5	1	OVERHANGING VEGETATION [1]	15	2	ROOTWADS [1]			AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	5	2	LOGS OR WOODY DEBRIS [1]
		ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☒ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 15 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY* Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☒ MODERATE [3]
- ☐ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☒ GOOD [5]
- ☐ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 14 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE* Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☐ NONE/LITTLE [3]
- ☐☒ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☒☐ WIDE > 50m [4]
- ☒☒ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☒☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☒ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]

(L R)
- ☐☐ CONSERVATION TILLAGE [1]
- ☒☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 7 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☒ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 4 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average) ☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☒ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☒ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☒ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 4 (Maximum 8)

Comments

6] *GRADIENT* (8.45 ft/mi)

DRAINAGE AREA (38.4 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☒ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ___ %GLIDE: ___

%RUN: ___ %RIFFLE: ___

Gradient: 10 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT ____________________

A-CANOPY
- ☐ >85% - Open
- ☐ 55% - <85%
- ☐ 30% - <55%
- ☒ 10% - <30%
- ☐ <10% - Closed

B-AESTHETICS
- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

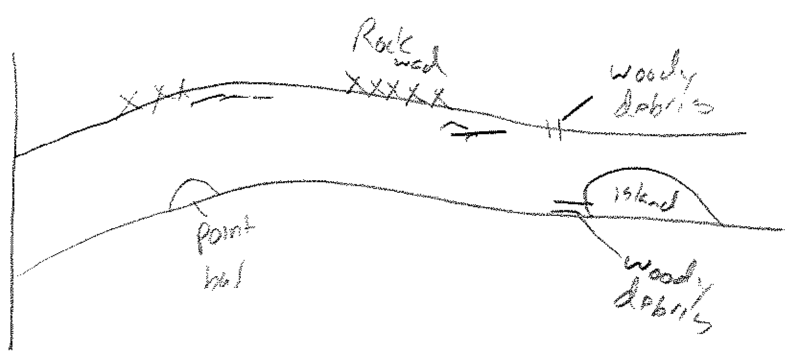
D-MAINTENANCE
- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

E-ISSUES
- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Brandywine Creek	County Road 400N (SH 9)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AW	10/19/10	Shelby County	Kick		56.75

1] *SUBSTRATE*
Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ___
- ☐☐ BOULDER [9] ☒☐ 1
- ☐☐ COBBLE [8] ☒☒ 15
- ☒☒ GRAVEL [7] ☐☐ 40
- ☒☒ SAND [6] ☐☐ 30
- ☐☐ BEDROCK [5] ☐☐ ___

NUMBER OF BEST TYPES: ☒ 4 or more [2] ☐ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ___
- ☐☐ DETRITUS [3] ☐☐ ___
- ☐☐ MUCK [2] ☐☐ ___
- ☐☐ SILT [2] ☒☒ 14
- ☐☐ ARTIFICIAL [0] ☐☐ ___

(Score natural substrates; ignore sludge from point-sources)

ORIGIN (Check ONE (Or 2 & average))

- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 14 (Maximum 20)

Comments

2] *INSTREAM COVER*
Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
		UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
35	2	OVERHANGING VEGETATION [1]	3	1	ROOTWADS [1]	25	2	AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	5	1	LOGS OR WOODY DEBRIS [1]
		ROOTMATS [1]						

AMOUNT (Check ONE (Or 2 & average))
- ☒ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 15 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY*
Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☒ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☒ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 11 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE*
Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☒ NARROW 5-10m [2]
- ☐☒ VERY NARROW [1]
- ☒☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]

(L R)
- ☐☒ CONSERVATION TILLAGE [1]
- ☒☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 4.25 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH (Check ONE (ONLY!))
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☒ 0.4 - < 0.7m [2]
- ☐ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH (Check ONE (Or 2 & average))
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY (Check ALL that apply)
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 4 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☒ BEST AREAS < 5cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE (Check ONE (Or 2 & average))
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☒ MOD. STABLE (e.g., Large Gravel) [1]
- ☒ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☒ LOW [1]
- ☒ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 2.5 (Maximum 8)

Comments

6] *GRADIENT* (4.9 ft/mi)

DRAINAGE AREA (66.14 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☒ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ___ %GLIDE: ___

%RUN: ___ %RIFFLE: ___

Gradient: 6 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY
- ☐ >85% - Open
- ☒ 55% - <85%
- ☐ 30% - <55%
- ☐ 10% - <30%
- ☐ <10% - Closed

B-AESTHETICS
- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft² ☐ > 3 ft

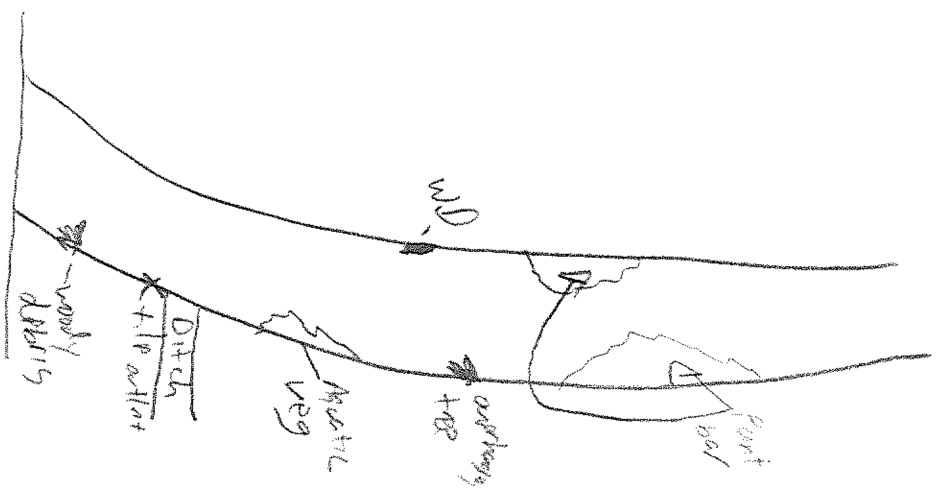
D-MAINTENANCE
- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

E-ISSUES
- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle) ; Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Brandywine Creek	County Road 650N (SHP 5)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/21/10	Shelby County	Kick		45.5

1] *SUBSTRATE*
Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

Type	Predominant P R	Present P R	Total %
BLDR/SLABS [10]	☐☐	☐☐	
BOULDER [9]	☐☐	☐☐	
COBBLE [8]	☐☐	☒☐	5
GRAVEL [7]	☒☒	☐☐	75
SAND [6]	☒☐	☒☒	15
BEDROCK [5]	☐☐	☐☐	

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES

Type	Predominant P R	Present P R	Total %
HARDPAN [4]	☐☐	☐☐	
DETRITUS [3]	☐☐	☒☐	2
MUCK [2]	☐☐	☐☐	
SILT [2]	☐☐	☒☐	13
ARTIFICIAL [0]	☐☐	☐☐	

(Score natural substrates; ignore sludge from point-sources)

ORIGIN (Check ONE (Or 2 & average))
- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 13 (Maximum 20)

Comments

2] *INSTREAM COVER*
Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount	Type	%	Amount	Type	%	Amount	Type
		UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
10	1	OVERHANGING VEGETATION [1]			ROOTWADS [1]	10	1	AQUATIC MACROPHYTES [1]
1	1	SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]			LOGS OR WOODY DEBRIS [1]
		ROOTMATS [1]						

AMOUNT (Check ONE (Or 2 & average))
- ☐ EXTENSIVE > 75% [11]
- ☒ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 10 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY*
Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☒ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☐ FAIR [3]
- ☒ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☐ RECOVERED [4]
- ☒ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- ☒ LOW [1]

Channel: 7 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE*
Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☒ VERY NARROW [1]
- ☒☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☒☒ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 4.5 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH (Check ONE (ONLY!))
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH (Check ONE (Or 2 & average))
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY (Check ALL that apply)
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 3 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

☒ NO RIFFLE [metric = 0]

Check ONE (Or 2 & average)

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 0 (Maximum 8)

Comments

6] *GRADIENT* (6.13 ft/mi)

DRAINAGE AREA (75.47 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☒ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 8 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT ______

A-CANOPY

- ☒ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Public ☐ Private
☐ Active ☐ Historic
Succession: ☐ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

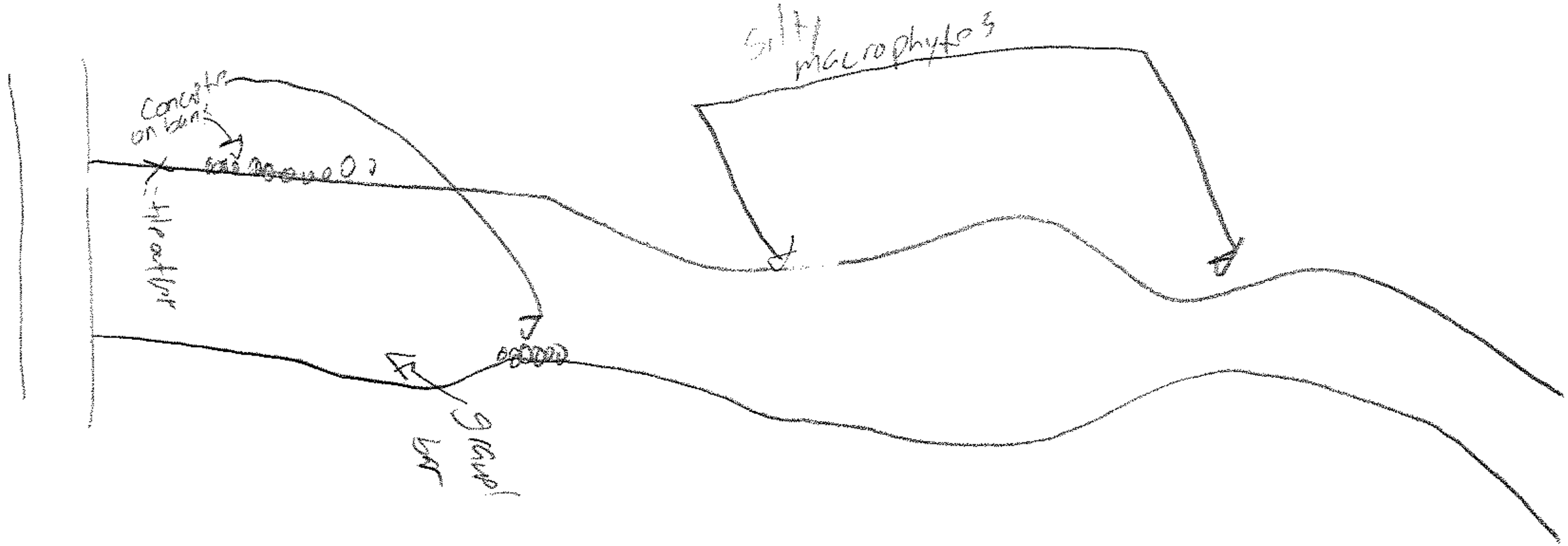
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☐ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM

OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Brandywine Creek	County Road 425W (Site 6)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/21/10	Shelby			65

1] SUBSTRATE
Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ___
- ☐☐ BOULDER [9] ☐☐ ___
- ☐☐ COBBLE [8] ☒☒ 25
- ☒☒ GRAVEL [7] ☐☐ 40
- ☒☒ SAND [6] ☐☐ 38
- ☐☐ BEDROCK [5] ☐☐ ___

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ___
- ☐☐ DETRITUS [3] ☒☐ 2
- ☐☐ MUCK [2] ☐☐ ___
- ☐☐ SILT [2] ☒☒ 5
- ☐☐ ARTIFICIAL [0] ☐☐ ___

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)

- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☒ NONE [1]

Substrate: 14.5 (Maximum 20)

Comments

2] INSTREAM COVER
Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
5	1	UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
		OVERHANGING VEGETATION [1]	10	2	ROOTWADS [1]			AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	1	1	LOGS OR WOODY DEBRIS [1]
1	1	ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☒ EXTENSIVE > 75% [11]
- ☒ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 13 (Maximum 20)

Comments

3] CHANNEL MORPHOLOGY
Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☒ MODERATE [3]
- ☒ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☒ GOOD [5]
- ☐ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 13.5 (Maximum 20)

Comments

4] BANK EROSION AND RIPARIAN ZONE
Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☐☐ NONE/LITTLE [3]
- ☒☒ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☒ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☒☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]

(L R)
- ☒☒ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 6 (Maximum 10)

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☒ POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☒ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 5 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average) ☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☒ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☒ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☒ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 5 (Maximum 8)

Comments

6] GRADIENT (16.15 ft/mi)

DRAINAGE AREA (105.24 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☐ MODERATE [6 - 10]
- ☒ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 8 (Maximum 10)

IDEM **OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)**

Circle some & COMMENT

A-CANOPY

- ☐ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☒ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft² ☐ > 3 ft

D-MAINTENANCE

☐ Public ☐ Private
☐ Active ☐ Historic
Succession: ☐ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

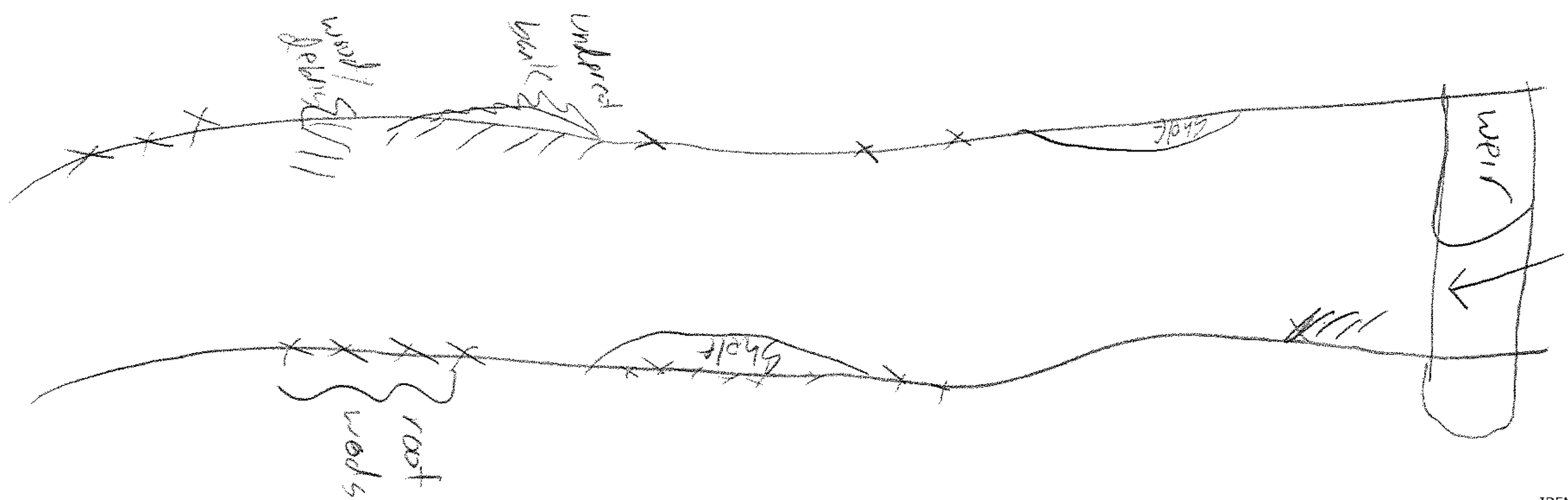
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☐ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM 05/06/10

Stream Dry / small stagnant pools

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Willow Branch	County Road 600N (Site 7)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/18/16	Hancock	Kick		49

1] SUBSTRATE
Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ BLDR/SLABS [10] ☐☐ ____
- ☐☐ BOULDER [9] ☐☐ ____
- ☐☐ COBBLE [8] ☐☐ ____
- ☐☐ GRAVEL [7] ☐☒ 5
- ☒☒ SAND [6] ☐☐ 45
- ☐☐ BEDROCK [5] ☐☐ ____

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ HARDPAN [4] ☐☐ ____
- ☐☐ DETRITUS [3] ☐☐ ____
- ☐☐ MUCK [2] ☐☐ ____
- ☒☒ SILT [2] ☐☒ 50
- ☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)
- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY
SILT:
- ☒ HEAVY [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 6 (Maximum 20)

Comments

2] INSTREAM COVER
Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

(% Amount)
- 1 1 UNDERCUT BANKS [1]
- 1 1 OVERHANGING VEGETATION [1]
- ___ ___ SHALLOWS (IN SLOW WATER) [1]
- 10 2 ROOTMATS [1]
- ___ ___ POOLS > 70cm [2]
- 1 1 ROOTWADS [1]
- ___ ___ BOULDERS [1]
- ___ ___ OXBOWS, BACKWATERS [1]
- ___ ___ AQUATIC MACROPHYTES [1]
- 15 1 LOGS OR WOODY DEBRIS [1]

AMOUNT Check ONE (Or 2 & average)
- ☒ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 16 (Maximum 20)

Comments

3] CHANNEL MORPHOLOGY
Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☐ LOW [2]
- ☒ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☒ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 10 (Maximum 20)

Comments

4] BANK EROSION AND RIPARIAN ZONE
Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☒☒ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☒☒ OPEN PASTURE, ROWCROP [0]
- ☐☐ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 5 (Maximum 10)

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☒ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 5 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average)

☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☒ BEST AREAS < 5cm [metric = 0] 0

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☒ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☒ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 1 (Maximum 8)

Comments

6] GRADIENT (7.5 ft/mi)

DRAINAGE AREA (2.65 mi^2)

- ☐ VERY LOW - LOW [2–4]
- ☒ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 6 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY

- ☐ > 85% - Open
- ☐ 55% - < 85%
- ☒ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Public ☐ Private
☐ Active ☐ Historic
Succession: ☐ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

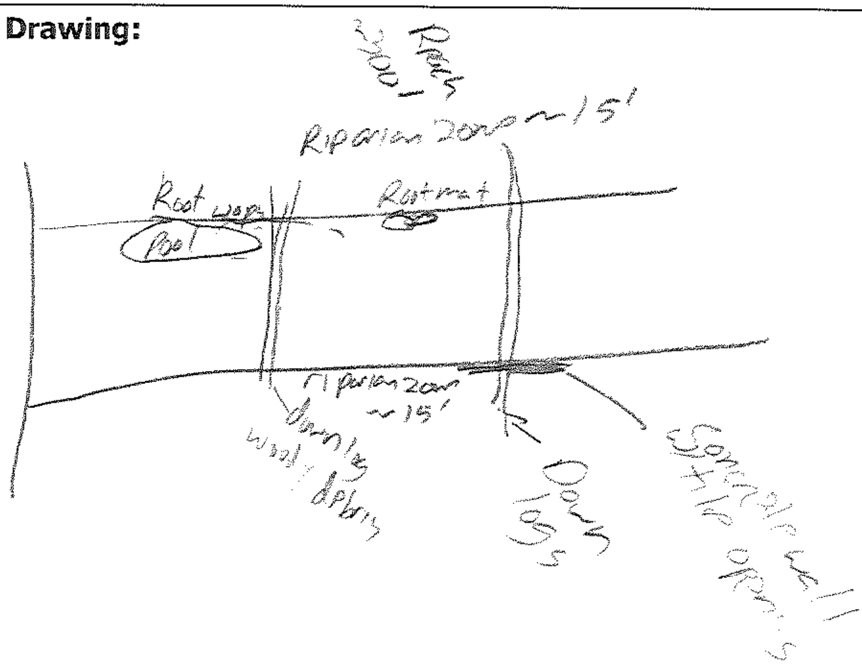
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☐ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Richey Ditch	County Road 400N (SHP8)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AP	10/19/10	Hancock	Kick		24.50

1] *SUBSTRATE*
Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ BLDR/SLABS [10] ☐☐ ____
- ☐☐ BOULDER [9] ☐☐ ____
- ☐☐ COBBLE [8] ☐☐ ____
- ☐☐ GRAVEL [7] ☐☐ ____
- ☒☒ SAND [6] ☒☒ 5
- ☐☐ BEDROCK [5] ☐☐ ____

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ HARDPAN [4] ☐☐ ____
- ☐☐ DETRITUS [3] ☒☒ 20
- ☐☐ MUCK [2] ☐☐ ____
- ☒☒ SILT [2] ☐☐ 75
- ☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

ORIGIN (Check ONE (Or 2 & average))
- ☐ LIMESTONE [1]
- ☐ TILLS [1]
- ☒ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☒ HEAVY [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☒ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 4 (Maximum 20)

Comments

2] *INSTREAM COVER*
Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

% Amount		% Amount		% Amount	
___ ___	UNDERCUT BANKS [1]	___ ___	POOLS > 70cm [2]	___ ___	OXBOWS, BACKWATERS [1]
___ ___	OVERHANGING VEGETATION [1]	___ ___	ROOTWADS [1]	3 1	AQUATIC MACROPHYTES [1]
___ ___	SHALLOWS (IN SLOW WATER) [1]	___ ___	BOULDERS [1]	___ ___	LOGS OR WOODY DEBRIS [1]
___ ___	ROOTMATS [1]				

AMOUNT (Check ONE (Or 2 & average))
- ☐ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☒ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

3

Cover: 4 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY*
Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☐ LOW [2]
- ☒ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☐ FAIR [3]
- ☒ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☐ RECOVERED [4]
- ☐ RECOVERING [3]
- ☒ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- ☒ LOW [1]

Channel: 4 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE*
Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☒☒ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☒☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☒ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☒☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☐☒ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 6.5 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH (Check ONE (ONLY!))
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH (Check ONE (Or 2 & average))
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY (Check ALL that apply)
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☐ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 2 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average)

☒ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 0 (Maximum 8)

Comments

6] *GRADIENT* (4.86 ft/mi)

DRAINAGE AREA (2.1 mi²)

- ☒ VERY LOW - LOW [2–4]
- ☐ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 4 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY

- ☒ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

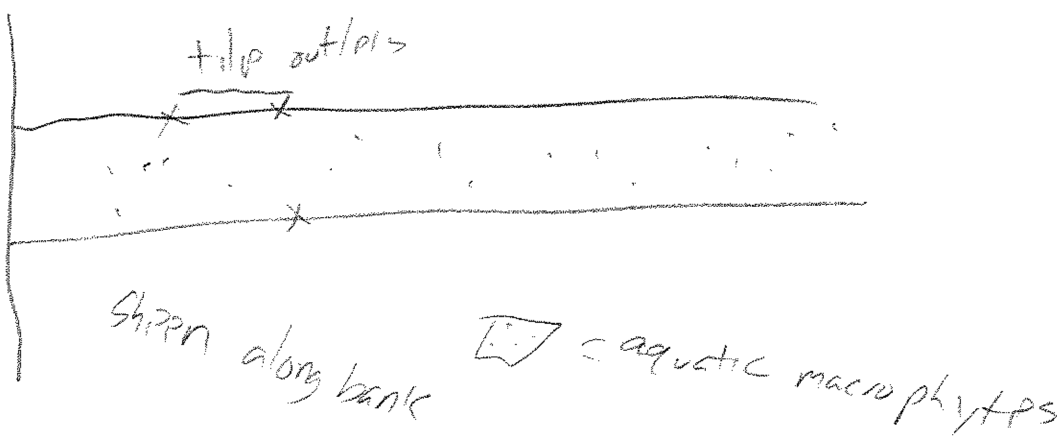
E-ISSUES

- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %
	X	X	X	

Stream Drawing:



IDEM **OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)**

Sample #	bioSample #	Stream Name	Location
		Potts Ditch	Osage Street site (9)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/19/10	Hancock			68.75

1] SUBSTRATE Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ____
- ☐☐ BOULDER [9] ☒☒ 8
- ☐☐ COBBLE [8] ☐☒ 10
- ☒☒ GRAVEL [7] ☐☐ 25
- ☒☐ SAND [6] ☐☒ 65
- ☐☐ BEDROCK [5] ☐☐ ____

NUMBER OF BEST TYPES: ☒ 4 or more [2] ☐ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ____
- ☐☐ DETRITUS [3] ☐☐ ____
- ☐☐ MUCK [2] ☐☐ ____
- ☐☐ SILT [2] ☒☐ 2
- ☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

ORIGIN (Check ONE (Or 2 & average))

- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☒ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ NONE [1]

Substrate: 16.5 (Maximum 20)

Comments

2] INSTREAM COVER Indicate presence 0 to 3 and estimate percent: 0–Absent; 1–Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
5	1	UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
		OVERHANGING VEGETATION [1]			ROOTWADS [1]	1	1	AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]	5	1	BOULDERS [1]	1	1	LOGS OR WOODY DEBRIS [1]
80	3	ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☒ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 16 (Maximum 20)

Comments

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☒ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☒ GOOD [5]
- ☐ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☒ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 12.5 (Maximum 20)

Comments

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☒ MODERATE 10-50m [3]
- ☐☒ NARROW 5-10m [2]
- ☒☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☒ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☒☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☐☐ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 6.75 (Maximum 10)

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☒ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 5 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average) ☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☒ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☒ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☒ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 4 (Maximum 8)

Comments

6] GRADIENT (31.34 ft/mi)

DRAINAGE AREA (3.25 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☐ MODERATE [6 - 10]
- ☒ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 8 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY

- ☐ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☒ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Public ☐ Private
☐ Active ☐ Historic
Succession: ☐ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

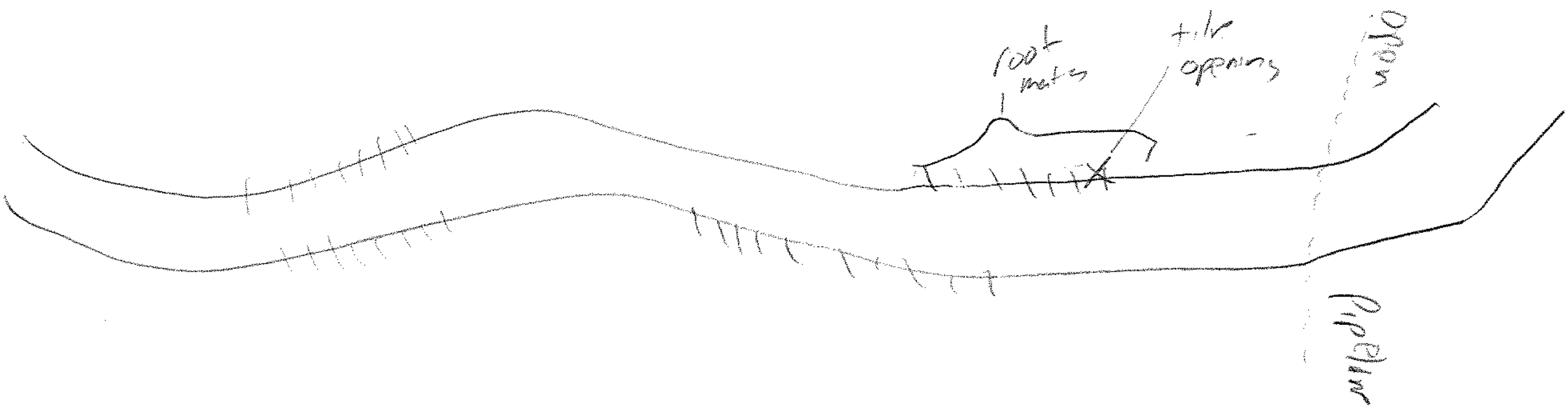
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☐ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %
	X	X	X	

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Little Brandywine Creek	E Steele Ford Road (Site 10)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/19/10	Hancock	Kick		41.50

1] *SUBSTRATE* Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ BLDR/SLABS [10] ☐☐
- ☐☐ BOULDER [9] ☐☐
- ☐☐ COBBLE [8] ☐☐
- ☐☐ GRAVEL [7] [x][x] 7
- [x][x] SAND [6] ☐☐ 33
- ☐☐ BEDROCK [5] ☐☐

NUMBER OF BEST TYPES: ☐ 4 or more [2] [x] 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ HARDPAN [4] ☐☐
- ☐☐ DETRITUS [3] ☐☐
- ☐☐ MUCK [2] ☐☐
- [x][x] SILT [2] ☐☐ 60
- ☐☐ ARTIFICIAL [0] ☐☐

2 (Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)
- ☐ LIMESTONE [1]
- [x] TILLS [1]
- [x] WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- [x] HEAVY [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- [x] EXTENSIVE [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 4.5 (Maximum 20)

Comments

2] *INSTREAM COVER* Indicate presence 0 to 3 and estimate percent: 0–Absent; 1–Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
		UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
		OVERHANGING VEGETATION [1]	15	2	ROOTWADS [1]	2	1	AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	10	2	LOGS OR WOODY DEBRIS [1]
2	1	ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☐ EXTENSIVE > 75% [11]
- [x] MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 11 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY* Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- [x] LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☐ FAIR [3]
- [x] POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- [x] RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- [x] LOW [1]

Channel: 8 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE* Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☐☐ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- [x][x] HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- [x][x] WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- [x][x] OPEN PASTURE, ROWCROP [0]
- ☐☐ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 5 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- [x] 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- [x] POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☐ MODERATE [1]
- [x] SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 3 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

[x] NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE Check ONE (Or 2 & average)
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 0 (Maximum 8)

Comments

6] *GRADIENT* (10.65 ft/mi)

DRAINAGE AREA (14.1 mi²)

- ☐ VERY LOW - LOW [2–4]
- [x] MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ______ %GLIDE: ______

%RUN: ______ %RIFFLE: ______

Gradient: 10 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY
- ☐ > 85% - Open
- ☐ 55% - < 85%
- ☒ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS
- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☒ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☒ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area Depth

Pool: ☐ > 100 ft² ☐ > 3 ft

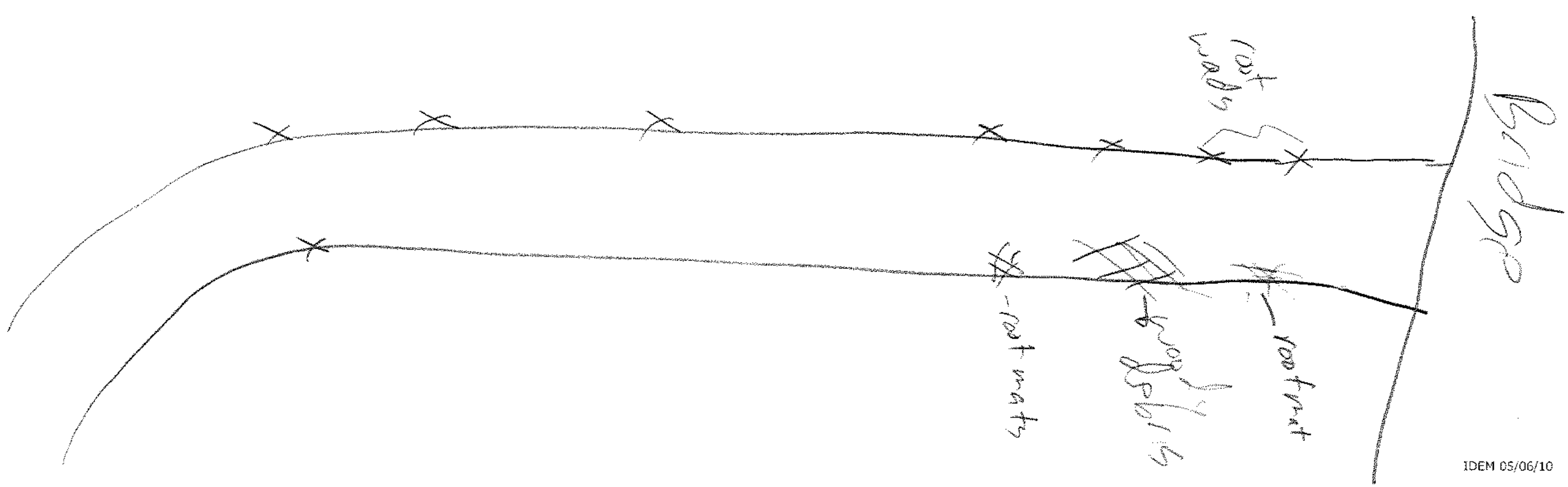
D-MAINTENANCE
- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

E-ISSUES
- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Buck Ditch	County Road 650N (Sitell)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/19/10	Shelby	Kick		34

1] *SUBSTRATE*
Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ BLDR/SLABS [10] ☐☐ ____
- ☐☐ BOULDER [9] ☐☐ ____
- ☐☐ COBBLE [8] ☐☐ ____
- ☐☐ GRAVEL [7] ☐☐ ____
- ☒☒ SAND [6] ☐☐ 25
- ☐☐ BEDROCK [5] ☐☐ ____

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☒☒ HARDPAN [4] ☐☐ 55
- ☐☐ DETRITUS [3] ☐☐ ____
- ☐☐ MUCK [2] ☐☐ ____
- ☐☐ SILT [2] ☒☒ 20
- ☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

ORIGIN (Check ONE (Or 2 & average))
- ☐ LIMESTONE [1]
- ☐ TILLS [1]
- ☐ WETLANDS [0]
- ☒ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY
SILT:
- ☒ HEAVY [-2]
- ☐ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☒ EXTENSIVE [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 6.5 — Maximum 20

Comments

2] *INSTREAM COVER*
Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
95	3	UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
95	3	OVERHANGING VEGETATION [1]			ROOTWADS [1]	1	1	AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]			LOGS OR WOODY DEBRIS [1]
20	2	ROOTMATS [1]						

AMOUNT (Check ONE (Or 2 & average))
- ☐ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☒ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 7 — Maximum 20

Comments

3] *CHANNEL MORPHOLOGY*
Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☐ LOW [2]
- ☒ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☐ FAIR [3]
- ☒ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☐ RECOVERED [4]
- ☐ RECOVERING [3]
- ☒ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- ☒ LOW [1]

Channel: 4 — Maximum 20

Comments

4] *BANK EROSION AND RIPARIAN ZONE*
Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☒☒ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☒☒ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☒☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☐☒ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 3.5 — Maximum 10

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH (Check ONE (ONLY!))
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☒ 0.4 - < 0.7m [2]
- ☐ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH (Check ONE (Or 2 & average))
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY (Check ALL that apply)
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☐ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 3 — Maximum 12

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average)

☒ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 0 — Maximum 8

Comments

6] *GRADIENT* 21.4 ft/mi)
DRAINAGE AREA 2.67 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☐ MODERATE [6 - 10]
- ☒ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____
%RUN: ____ %RIFFLE: ____

Gradient: 10 — Maximum 10

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

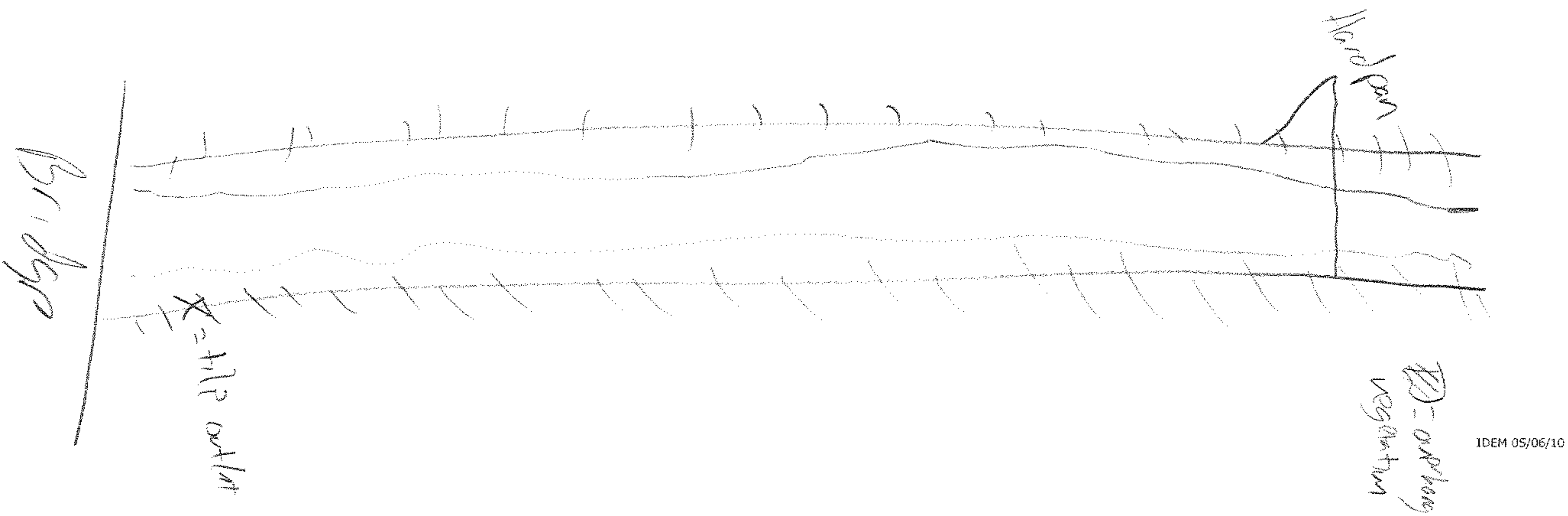
Circle some & COMMENT

A-CANOPY	B-AESTHETICS		C-RECREATION	D-MAINTENANCE	E-ISSUES
☒ >85% - Open	☐ Nuisance algae	☐ Oil sheen	Area / Depth	☐ Public ☐ Private	☐ WWTP ☐ CSO ☐ NPDES
☐ 55% - <85%	☐ Invasive macrophytes	☐ Trash/Litter	Pool: ☐ > 100 ft² ☐ > 3 ft	☐ Active ☐ Historic	☐ Industry ☐ Urban
☐ 30% - <55%	☐ Excess turbidity	☐ Nuisance odor		Succession: ☐ Young ☐ Old	☐ Hardened ☐ Dirt & Grime
☐ 10% - <30%	☐ Discoloration	☐ Sludge deposits		☐ Spray ☐ Islands ☐ Scoured	☐ Contaminated ☐ Landfill
☐ <10% - Closed	☐ Foam/Scum	☐ CSOs/SSOs/Outfalls		Snag: ☐ Removed ☐ Modified	BMPs: ☐ Construction ☐ Sediment
				Leveed: ☐ One sided ☐ Both banks	☐ Logging ☐ Irrigation ☐ Cooling
				☐ Relocated ☐ Cutoffs	Erosion: ☐ Bank ☐ Surface
				Bedload: ☐ Moving ☐ Stable	☐ False bank ☐ Manure ☐ Lagoon
				☐ Armoured ☐ Slumps	☐ Wash H_2O ☐ Tile ☐ H_2O Table
				☐ Impounded ☐ Desiccated	Mine: ☐ Acid ☐ Quarry
				☐ Flood control ☐ Drainage	Flow: ☐ Natural ☐ Stagnant
					☐ Wetland ☐ Park ☐ Golf
					☐ Lawn ☐ Home
					☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %
	X	X	X	

Stream Drawing:



IDEM **OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)**

Sample #	bioSample #	Stream Name	Location
		Hills Branch	County Road 75W (site D)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/19/10	Shelby	Kick		49.5

1] SUBSTRATE Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ___
- ☐☐ BOULDER [9] ☐☐ ___
- ☐☐ COBBLE [8] ☐☐ ___
- ☐☐ GRAVEL [7] ☒☒ 20
- ☒☒ SAND [6] ☐☐ 30
- ☐☐ BEDROCK [5] ☐☐ ___

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ___
- ☐☐ DETRITUS [3] ☒☒ 3
- ☐☐ MUCK [2] ☐☐ ___
- ☒☐ SILT [2] ☐☒ 45
- ☐☐ ARTIFICIAL [0] ☒☒ 2

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)

- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☒ HEAVY [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☒ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 6.5 — Maximum 20

Comments

2] INSTREAM COVER Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

(% Amount)

- 5 1 UNDERCUT BANKS [1]
- 40 3 OVERHANGING VEGETATION [1]
- ___ ___ SHALLOWS (IN SLOW WATER) [1]
- ___ ___ ROOTMATS [1]
- ___ ___ POOLS > 70cm [2]
- ___ ___ ROOTWADS [1]
- ___ ___ BOULDERS [1]
- ___ ___ OXBOWS, BACKWATERS [1]
- 20 2 AQUATIC MACROPHYTES [1]
- 5 1 LOGS OR WOODY DEBRIS [1]

AMOUNT Check ONE (Or 2 & average)

- ☒ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 15 — Maximum 20

Comments

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☒ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☒ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- ☒ LOW [1]

Channel: 10 — Maximum 20

Comments

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☒ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☒☒ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☒☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☐☒ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 4 — Maximum 10

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☒ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 3 — Maximum 12

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average) ☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☒ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☒ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☒ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 3 — Maximum 8

Comments

6] GRADIENT (11.39 ft/mi)

DRAINAGE AREA (6.95 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☒ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ___ %GLIDE: ___

%RUN: ___ %RIFFLE: ___

Gradient: 8 — Maximum 10

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY

- ☐ >85% - Open
- ☐ 55% - <85%
- ☒ 30% - <55%
- ☐ 10% - <30%
- ☐ <10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Public ☐ Private
☐ Active ☐ Historic
Succession: ☐ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

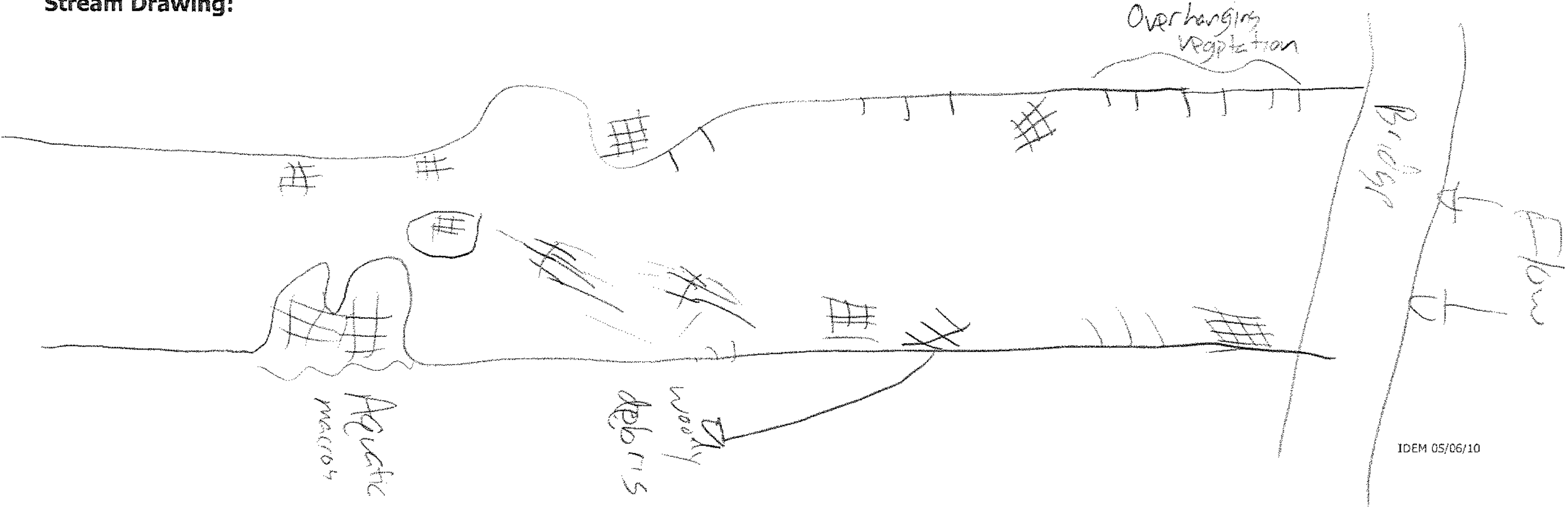
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☐ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM

OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Swamp Creek	County Road W 300N (site B)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/21/16	Shelby	Kick		52.75

1] SUBSTRATE

Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ____
- ☐☐ BOULDER [9] ☐☐ ____
- ☐☐ COBBLE [8] ☑☐ 5
- ☑☑ GRAVEL [7] ☐☐ 30
- ☑☑ SAND [6] ☐☐ 50
- ☐☐ BEDROCK [5] ☐☐ ____

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ____
- ☐☐ DETRITUS [3] ☑☐ 5
- ☐☐ MUCK [2] ☐☐ ____
- ☐☐ SILT [2] ☑☐ 10
- ☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☑ 3 or less [0]

ORIGIN Check ONE (Or 2 & average)

- ☐ LIMESTONE [1]
- ☐ TILLS [1]
- ☑ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☑ MODERATE [-1]
- ☑ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☑ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 11.5 (Maximum 20)

Comments

2] INSTREAM COVER

Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
		UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
80	3	OVERHANGING VEGETATION [1]			ROOTWADS [1]	20	2	AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	2	1	LOGS OR WOODY DEBRIS [1]
		ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)

- ☑ EXTENSIVE > 75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 14 (Maximum 20)

Comments

3] CHANNEL MORPHOLOGY

Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☑ LOW [2]
- ☐ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☐ FAIR [3]
- ☑ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☑ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☑ MODERATE [2]
- ☐ LOW [1]

Channel: 9 (Maximum 20)

Comments

4] BANK EROSION AND RIPARIAN ZONE

Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☑☑ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☑ MODERATE 10-50m [3]
- ☑☑ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☑☑ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 6.25 (Maximum 10)

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☑ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☑ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☐ MODERATE [1]
- ☑ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 2 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

☑ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE Check ONE (Or 2 & average)
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 0 (Maximum 8)

Comments

6] GRADIENT (15.83 ft/mi)

DRAINAGE AREA (2.96 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☑ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 10 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT

A-CANOPY
- ☐ >85% - Open
- ☒ 55% - <85%
- ☐ 30% - <55%
- ☐ 10% - <30%
- ☐ <10% - Closed

B-AESTHETICS
- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft² ☐ > 3 ft

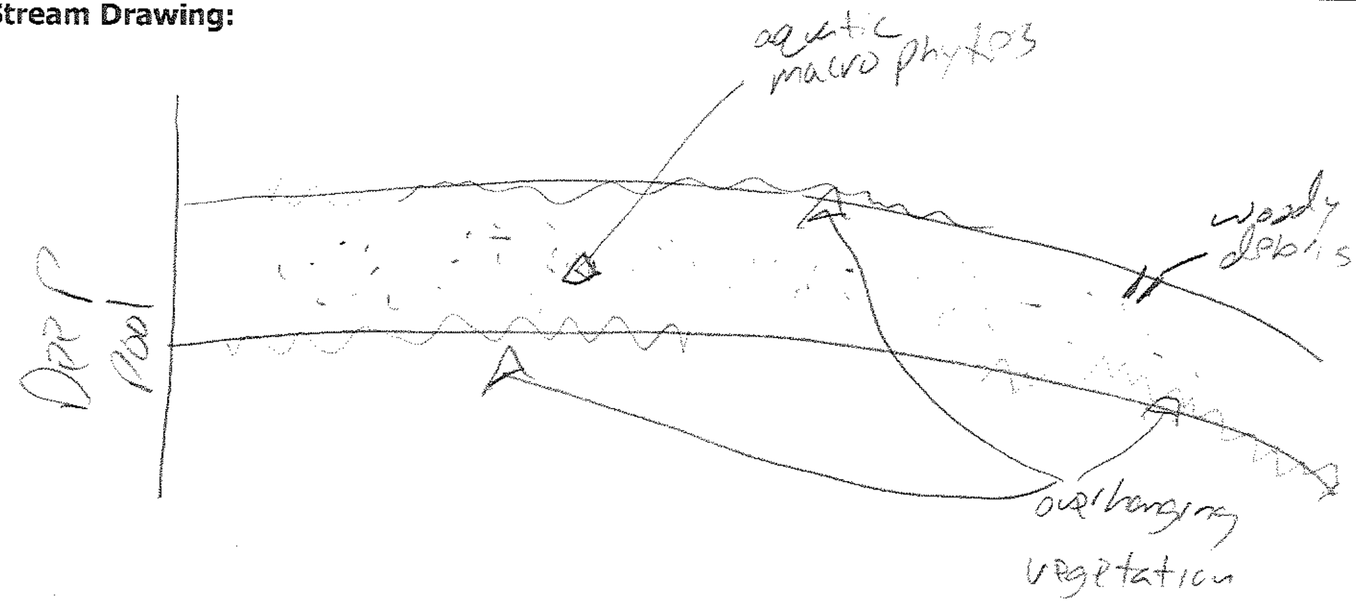
D-MAINTENANCE
- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

E-ISSUES
- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Ed Clark Ditch	County Road W 350W (Shelby)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete
AD	10/20/10	Shelby	Kick	

QHEI Score: 56.5

1] *SUBSTRATE* Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ BLDR/SLABS [10] ☐☐ ____
- ☐☐ BOULDER [9] ☐☐ ____
- ☐☐ COBBLE [8] ☐☐ ____
- ☑☑ GRAVEL [7] ☐☐ 35
- ☑☑ SAND [6] ☐☐ 65
- ☐☐ BEDROCK [5] ☐☐ ____

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☑ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)

- ☐☐ HARDPAN [4] ☐☐ ____
- ☐☐ DETRITUS [3] ☐☐ ____
- ☐☐ MUCK [2] ☐☐ ____
- ☐☐ SILT [2] ☐☐ ____
- ☐☐ ARTIFICIAL [0] ☐☐ ____

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)

- ☐ LIMESTONE [1]
- ☑ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY

SILT:
- ☐ HEAVY [-2]
- ☐ MODERATE [-1]
- ☑ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☑ MODERATE [-1]
- ☐ NORMAL [0]
- ☐ NONE [1]

Substrate: 13 (Maximum 20)

Comments

2] *INSTREAM COVER* Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
45	2	UNDERCUT BANKS [1]			POOLS > 70cm [2]			OXBOWS, BACKWATERS [1]
35	1	OVERHANGING VEGETATION [1]	2	1	ROOTWADS [1]			AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]			BOULDERS [1]	5	1	LOGS OR WOODY DEBRIS [1]
2	1	ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☑ EXTENSIVE > 75% [11]
- ☑ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 14 (Maximum 20)

Comments

3] *CHANNEL MORPHOLOGY* Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☑ LOW [2]
- ☑ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☑ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☐ RECOVERED [4]
- ☑ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☐ MODERATE [2]
- ☐ LOW [1]

Channel: 9.5 (Maximum 20)

Comments

4] *BANK EROSION AND RIPARIAN ZONE* Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☑☑ NONE/LITTLE [3]
- ☐☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☑☐ WIDE > 50m [4]
- ☐☐ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☐☐ VERY NARROW [1]
- ☐☑ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☑☐ FOREST, SWAMP [3]
- ☐☐ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☐☑ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING / CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 7 (Maximum 10)

Comments

5] *POOL/GLIDE AND RIFFLE/RUN QUALITY*

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☑ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☑ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☐ FAST [1]
- ☑ MODERATE [1]
- ☑ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 3 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average) ☑ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☐ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☐ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder) [2]
- ☐ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☐ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 0 (Maximum 8)

Comments

6] *GRADIENT* (7.1) ft/mi)

DRAINAGE AREA (4.93 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☐ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ____ %GLIDE: ____

%RUN: ____ %RIFFLE: ____

Gradient: 10 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT ______________________________

A-CANOPY

- ☐ > 85% - Open
- ☒ 55% - < 85%
- ☐ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS

- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE

☐ Public ☐ Private
☐ Active ☐ Historic
Succession: ☐ Young ☐ Old
☐ Spray ☐ Islands ☐ Scoured
Snag: ☐ Removed ☐ Modified
Leveed: ☐ One sided ☐ Both banks
☐ Relocated ☐ Cutoffs
Bedload: ☐ Moving ☐ Stable
☐ Armoured ☐ Slumps
☐ Impounded ☐ Desiccated
☐ Flood control ☐ Drainage

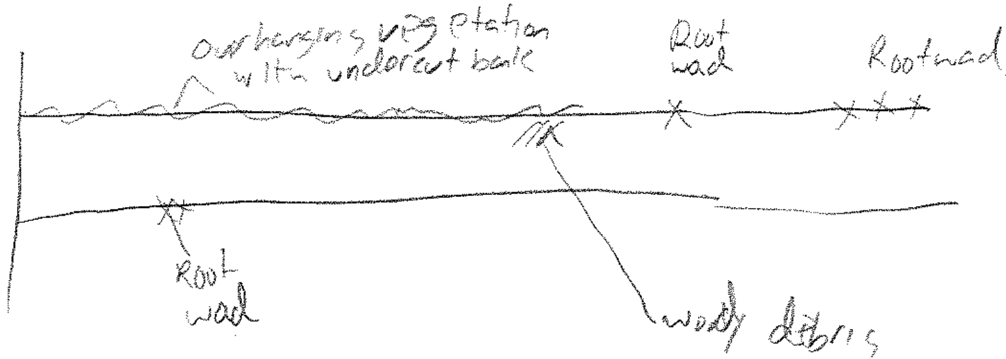
E-ISSUES

☐ WWTP ☐ CSO ☐ NPDES
☐ Industry ☐ Urban
☐ Hardened ☐ Dirt & Grime
☐ Contaminated ☐ Landfill
BMPs: ☐ Construction ☐ Sediment
☐ Logging ☐ Irrigation ☐ Cooling
Erosion: ☐ Bank ☐ Surface
☐ False bank ☐ Manure ☐ Lagoon
☐ Wash H_2O ☐ Tile ☐ H_2O Table
Mine: ☐ Acid ☐ Quarry
Flow: ☐ Natural ☐ Stagnant
☐ Wetland ☐ Park ☐ Golf
☐ Lawn ☐ Home
☐ Atmospheric deposition

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %
	X	X	X	

Stream Drawing:



IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Sugar Creek	County Road 200 S (SHP R)

Surveyor	Sample Date	County	Macro Sample Type	☐ Habitat Complete	QHEI Score:
AD	10/20/10	Shelby	Kick		66.75

1] SUBSTRATE Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ BLDR/SLABS [10] ☐☐ ___
- ☐☐ BOULDER [9] ☒☐ 2
- ☐☐ COBBLE [8] ☒☒ 13
- ☒☒ GRAVEL [7] ☐☐ 55
- ☒☒ SAND [6] ☐☐ 25
- ☐☐ BEDROCK [5] ☐☐ ___

NUMBER OF BEST TYPES: ☒ 4 or more [2] ☐ 3 or less [0]

OTHER TYPES (PREDOMINANT P R / PRESENT P R / TOTAL %)
- ☐☐ HARDPAN [4] ☐☐ ___
- ☐☐ DETRITUS [3] ☐☐ ___
- ☐☐ MUCK [2] ☐☐ ___
- ☐☐ SILT [2] ☒☒ 5
- ☐☐ ARTIFICIAL [0] ☐☐ ___

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)
- ☐ LIMESTONE [1]
- ☒ TILLS [1]
- ☐ WETLANDS [0]
- ☐ HARDPAN [0]
- ☐ SANDSTONE [0]
- ☐ RIP/RAP [0]
- ☐ LACUSTRINE [0]
- ☐ SHALE [-1]
- ☐ COAL FINES [-2]

QUALITY
SILT:
- ☐ HEAVY [-2]
- ☒ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ FREE [1]

EMBEDDEDNESS:
- ☐ EXTENSIVE [-2]
- ☒ MODERATE [-1]
- ☒ NORMAL [0]
- ☐ NONE [1]

Substrate: 15 (Maximum 20)

Comments

2] INSTREAM COVER Indicate presence 0 to 3 and estimate percent: **0**–Absent; **1**–Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.

%	Amount		%	Amount		%	Amount	
2	1	UNDERCUT BANKS [1]			POOLS > 70cm [2]	2	1	OXBOWS, BACKWATERS [1]
2	1	OVERHANGING VEGETATION [1]	5	1	ROOTWADS [1]			AQUATIC MACROPHYTES [1]
		SHALLOWS (IN SLOW WATER) [1]	2	1	BOULDERS [1]	2	1	LOGS OR WOODY DEBRIS [1]
		ROOTMATS [1]						

AMOUNT Check ONE (Or 2 & average)
- ☒ EXTENSIVE > 75% [11]
- ☒ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Cover: 15 (Maximum 20)

Comments

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH [4]
- ☐ MODERATE [3]
- ☐ LOW [2]
- ☒ NONE [1]

DEVELOPMENT
- ☐ EXCELLENT [7]
- ☐ GOOD [5]
- ☒ FAIR [3]
- ☐ POOR [1]

CHANNELIZATION
- ☐ NONE [6]
- ☒ RECOVERED [4]
- ☐ RECOVERING [3]
- ☐ RECENT OR NO RECOVERY [1]

STABILITY
- ☐ HIGH [3]
- ☒ MODERATE [2]
- ☐ LOW [1]

Channel: 10 (Maximum 20)

Comments

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☐☒ NONE/LITTLE [3]
- ☒☐ MODERATE [2]
- ☐☐ HEAVY/SEVERE [1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m [4]
- ☐☒ MODERATE 10-50m [3]
- ☐☐ NARROW 5-10m [2]
- ☒☐ VERY NARROW [1]
- ☐☐ NONE [0]

FLOOD PLAIN QUALITY (L R)
- ☐☒ FOREST, SWAMP [3]
- ☐☒ SHRUB OR OLD FIELD [2]
- ☐☐ RESIDENTIAL, PARK, NEW FIELD [1]
- ☐☐ FENCED PASTURE [1]
- ☐☐ OPEN PASTURE, ROWCROP [0]
- ☒☐ CONSERVATION TILLAGE [1]
- ☐☐ URBAN OR INDUSTRIAL [0]
- ☐☐ MINING /CONSTRUCTION [0]

Indicate predominant land use(s) past 100m riparian.

Riparian: 6.25 (Maximum 10)

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☐ > 1m [6]
- ☐ 0.7 - < 1m [4]
- ☐ 0.4 - < 0.7m [2]
- ☒ 0.2 - < 0.4m [1]
- ☐ < 0.2m [0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☒ POOL WIDTH > RIFFLE WIDTH [2]
- ☐ POOL WIDTH = RIFFLE WIDTH [1]
- ☐ POOL WIDTH < RIFFLE WIDTH [0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL [-1]
- ☐ VERY FAST [1]
- ☒ FAST [1]
- ☒ MODERATE [1]
- ☒ SLOW [1]
- ☐ INTERSTITIAL [-1]
- ☐ INTERMITTENT [-2]
- ☐ EDDIES [1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☐ Primary Contact
- ☐ Secondary Contact

Pool/Current: 6 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

☐ NO RIFFLE [metric = 0]

RIFFLE DEPTH
- ☐ BEST AREAS > 10cm [2]
- ☒ BEST AREAS 5 - 10cm [1]
- ☐ BEST AREAS < 5 cm [metric = 0]

RUN DEPTH
- ☐ MAXIMUM > 50cm [2]
- ☒ MAXIMUM < 50cm [1]

RIFFLE/RUN SUBSTRATE Check ONE (Or 2 & average)
- ☒ STABLE (e.g., Cobble, Boulder) [2]
- ☒ MOD. STABLE (e.g., Large Gravel) [1]
- ☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ NONE [2]
- ☒ LOW [1]
- ☐ MODERATE [0]
- ☐ EXTENSIVE [-1]

Riffle/Run: 4.5 (Maximum 8)

Comments

6] GRADIENT (10.86 ft/mi)

DRAINAGE AREA (90.9 mi²)

- ☐ VERY LOW - LOW [2–4]
- ☒ MODERATE [6 - 10]
- ☐ HIGH - VERY HIGH [10 - 6]

%POOL: ___ %GLIDE: ___

%RUN: ___ %RIFFLE: ___

Gradient: 10 (Maximum 10)

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Circle some & COMMENT ______________________________

A-CANOPY
- ☐ > 85% - Open
- ☐ 55% - < 85%
- ☐ 30% - < 55%
- ☒ 10% - < 30%
- ☐ < 10% - Closed

Looking upstream (> 10m, 3 readings; < 10m, 1 reading in middle); Round to the nearest whole percent

	Left	Middle	Right	Total Average
% open	___ %	___ %	___ %	___ %

B-AESTHETICS
- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

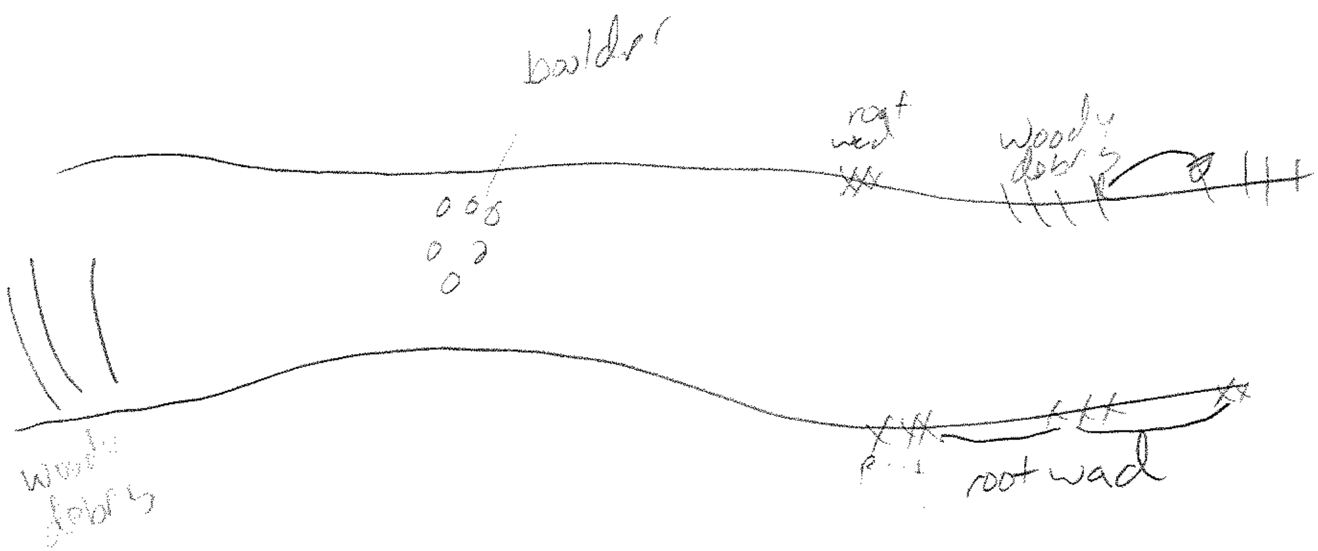
Area / Depth

Pool: ☐ > 100 ft^2 ☐ > 3 ft

D-MAINTENANCE
- ☐ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☐ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☐ Drainage

E-ISSUES
- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☐ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☐ Natural ☐ Stagnant
- ☐ Wetland ☐ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition

Stream Drawing:



Appendix L
STEPL Model Loads Data

Input:

1. Urban pollutant concentration in runoff (mg/l)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
TN	2	2.5	1.8	3	2.2	2.2	1.9	1.5	1.5
TP	0.2	0.4	0.3	0.5	0.4	0.4	0.3	0.15	0.15
BOD	9.3	9	7.8	9.3	10	10	4	4	4
TSS	75	120	67	150	100	100	150	70	70

2. Urban landuse distribution

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	81.7	54.5	54.5	54.5	54.5	163.4	27.2	27.2	27.2
W2	738.4	492.3	492.3	492.3	492.3	1476.9	246.1	246.1	246.1
W3	172.7	115.1	115.1	115.1	115.1	345.4	57.6	57.6	57.6
W4	141.6	94.4	94.4	94.4	94.4	283.3	47.2	47.2	47.2

2a. Effective BMP application area (ac)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	81.7	54.5	54.5	54.5	54.5	163.4	27.2	27.2	27.2
W2	14.8	492.3	492.3	492.3	492.3	1,476.9	246.1	246.1	4.9
W3	172.7	115.1	115.1	115.1	115.1	345.4	57.6	57.6	57.6
W4	141.6	94.4	94.4	94.4	94.4	283.3	47.2	47.2	47.2

3. Selected urban BMPs

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP
W2	Dry Detention	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	Wet Pond
W3	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP
W4	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP	0 No BMP

3a. Percentage of BMP effective area (%)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	100	100	100	100	100	100	100	100	100
W2	2.000163046	100	100	100	100	100	100	100	2.000027626
W3	100	100	100	100	100	100	100	100	100
W4	100	100	100	100	100	100	100	100	100

3.1. Urban runoff (ac-ft)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	142.4	75.3	75.3	146.1	64.5	109.9	23.4	32.3	16.3
W2	1,286.9	680.8	680.8	1,320.9	583.0	993.6	211.6	291.5	147.5
W3	301.0	159.2	159.2	308.9	136.4	232.4	49.5	68.2	34.5
W4	246.8	130.6	130.6	253.4	111.8	190.6	40.6	55.9	28.3

3.2. Total urban N load (kg)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	351.2	232.3	167.2	540.8	175.0	298.3	54.9	59.7	30.2
W2	3,174.8	2,099.4	1,511.5	4,888.2	1,582.2	2,696.4	495.8	539.4	272.9
W3	742.5	491.0	353.5	1,143.3	370.0	630.6	116.0	126.2	63.8
W4	609.0	402.7	289.9	937.6	303.5	517.2	95.1	103.5	52.3

3.2a. Selected urban N reduction efficiency

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	0	0	0	0	0	0	0	0	0
W2	0.3	0	0	0	0	0	0	0	0.35
W3	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0

3.3. Total urban P load (kg)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	35.1	37.2	27.9	90.1	31.8	54.2	8.7	6.0	3.0
W2	317.5	335.9	251.9	814.7	287.7	490.3	78.3	53.9	27.3
W3	74.3	78.6	58.9	190.5	67.3	114.7	18.3	12.6	6.4
W4	60.9	64.4	48.3	156.3	55.2	94.0	15.0	10.3	5.2

3.3a. Selected urban P reduction efficiency

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	0	0	0	0	0	0	0	0	0
W2	0.26	0	0	0	0	0	0	0	0.45
W3	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0

3.4. Total urban BOD load (kg)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	1,633.3	836.1	724.7	1,676.5	795.7	1,356.0	115.5	159.1	80.5
W2	14,762.8	7,557.7	6,550.0	15,153.4	7,191.9	12,256.5	1,043.9	1,438.4	727.7
W3	3,452.8	1,767.6	1,531.9	3,544.1	1,682.0	2,866.6	244.1	336.4	170.2
W4	2,831.7	1,449.7	1,256.4	2,906.6	1,379.5	2,351.0	200.2	275.9	139.6

3.4a. Selected urban BOD reduction efficiency

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	0	0	0	0	0	0	0	0	0
W2	0.27	0	0	0	0	0	0	0	ND
W3	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0

3.5. Total urban TSS load (kg)

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	13,171.6	11,148.5	6,224.6	27,040.1	7,956.7	13,559.8	4,330.8	2,784.8	1,409.0
W2	119,055.2	100,768.9	56,262.6	244,410.2	71,918.7	122,564.8	39,145.2	25,171.5	12,735.4
W3	27,844.8	23,567.9	13,158.8	57,162.9	16,820.4	28,665.6	9,155.3	5,887.1	2,978.6
W4	22,836.5	19,328.9	10,792.0	46,881.3	13,795.0	23,509.7	7,508.6	4,828.3	2,442.8

3.5a. Selected urban TSS reduction efficiency

Landuse	Commercial	Industrial	Institutional	Transportation	Multi-Family	Single-Family	Urban-Cultivated	Vacant (developed)	Open Space
W1	0	0	0	0	0	0	0	0	0
W2	0.575	0	0	0	0	0	0	0	0.6
W3	0	0	0	0	0	0	0	0	0
W4	0	0	0	0	0	0	0	0	0

4. Pollutant loads from urban in lb/year

Watershed	Pre-BMP Load				Load Reduction				After BMP Load			
	N	P	BOD	TSS	N	P	BOD	TSS	N	P	BOD	TSS
W1	4,206.9	647.7	16,252.3	193,039.6	0	0	0	0	4,206.9	647.7	16,252.3	193,039.6
W2	38,025.2	5,854.4	146,901.0	1,744,847.6	46.2	4.2	175.6	3,353.1	37,979.1	5,850.2	146,725.4	1,741,494.4
W3	8,893.4	1,369.2	34,357.4	408,087.0	0	0	0	0	8,893.4	1,369.2	34,357.4	408,087.0
W4	7,293.8	1,123.0	28,177.7	334,686.4	0	0	0	0	7,293.8	1,123.0	28,177.7	334,686.4

Output:

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	104,419.7	23,594.7	188,619.0	2,293.7	44,764.2	9,023.6	8,731.3	1,364.3	59,655.4	14,571.1	179,887.7	929.5	42.9	38.2	4.6	59.5
W2	232,761.6	49,968.5	485,909.7	5,031.6	84,409.0	17,010.0	16,630.6	2,572.8	148,352.6	32,958.4	469,279.1	2,458.8	36.3	34.0	3.4	51.1
W3	150,027.5	33,177.9	283,569.6	3,264.0	61,902.8	12,478.4	12,074.2	1,886.6	88,124.7	20,699.6	271,495.4	1,377.4	41.3	37.6	4.3	57.8
W4	127,343.1	28,606.8	237,109.4	2,862.1	54,796.8	11,045.9	10,688.1	1,670.0	72,546.3	17,560.8	226,421.3	1,192.0	43.0	38.6	4.5	58.4
Total	614,551.8	135,347.9	1,195,207.7	13,451.4	245,872.8	49,557.9	48,124.2	7,493.6	368,679.1	85,790.0	1,147,083.5	5,957.7	40.0	36.6	4.0	55.7

c. Nutrient and sediment load by land uses with BMP (lb/year)

Watershed	Urban				Cropland				Pastureland				Forest			
	N	P	BOD	Sediment	N	P	BOD	Sediment	N	P	BOD	Sediment	N	P	BOD	Sediment
W1	4,206.9	647.7	16,252.3	193,039.6	49,320.4	12,701.4	153,830.3	1,658,172.2	543.6	43.6	1,755.2	5,752.3	89.8	44.5	222.9	1,950.2
W2	37,979.1	5,850.2	146,725.4	1,741,494.4	92,949.4	23,937.2	289,909.2	3,124,997.2	4,138.3	332.1	13,361.8	43,789.4	335.9	166.6	833.9	7,295.6
W3	8,893.4	1,369.2	34,357.4	408,087.0	68,203.3	17,564.3	212,726.2	2,293,024.8	4,623.2	371.0	14,927.5	48,920.7	223.3	110.8	554.5	4,850.9
W4	7,293.8	1,123.0	28,177.7	334,686.4	60,374.1	15,548.1	188,306.8	2,029,802.4	1,455.5	116.8	4,699.7	15,401.9	192.2	95.3	477.1	4,173.9
Total	58,373.1	8,990.1	225,512.7	2,677,307.4	270,847.2	69,751.0	844,772.5	9,105,996.6	10,760.6	863.5	34,744.3	113,864.2	841.2	417.2	2,088.3	18,270.7

d. Load from groundwater by land uses with BMP (lb/year)

Watershed	Urban				Cropland				Pastureland				Forest			
	N	P	BOD	Sediment	N	P	BOD	Sediment	N	P	BOD	Sediment	N	P	BOD	Sediment
W1	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
W2	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
W3	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
W4	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2. Total load by land uses (with BMP)

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	58,373.1	8,990.1	225,512.7	1,338.7
Cropland	270,847.2	69,751.0	844,772.5	4,553.0
Pastureland	10,760.6	863.5	34,744.3	56.9
Forest	841.2	417.2	2,088.3	9.1
Feedlots	26,830.4	5,366.1	35,773.8	-
User Defined	-	-	-	-
Septic	1,026.6	402.1	4,191.8	-
Gully	-	-	-	-
Streambank	-	-	-	-
Groundwater	-	-	-	-
Total	368,679.1	85,790.0	1,147,083.5	5,957.7

Appendix M
Calculated Pollutant Loads

Calculated Base Flow Loads per Sample Site

Site	Subwatershed Hectares	Discharge (m^3/sec)	TSS Load (kg/yr.)	Total Phosphorus Load (kg/yr.)	Nitrate+Nitrite Nitrogen Load (kg/yr.)	TKN Load (kg/yr.)
1	3,129	0.07	3,361	56	11,658	1,387
2	6,452	0.19	15,563	207	30,944	4,249
3	9,924	0.52	24,593	9,920	124,944	17,660
4	16,932	0.69	69,203	5,612	128,647	18,122
5	19,323	0.90	149,658	5,767	153,983	20,618
6	25,516	1.74	154,000	8,143	267,561	37,669
7	810	0.02	n/a	34	2,044	510
8	567	0.04	5,373	74	458	1,170
9	826	0.01	1,003	21	164	268
10	3,612	0.08	7,646	81	5,703	2,039
11	684	0.01	1,003	6	301	124
12	1,780	0.08	72,601	173	17,771	2,102
13	758	0.06	2,673	43	1,888	910
14	1,262	0.07	n/a	37	5,245	1,309
Site	**Subwatershed Acres**	**Discharge (ft^3/sec)**	**TSS Load (lb./yr.)**	**Total Phosphorus Load (lb./yr.)**	**Nitrate+Nitrite Nitrogen Load (lb./yr.)**	**TKN Load (lb./yr.)**
1	640	2.63	7,394	124	25,648	3,051
2	1,280	6.80	34,239	455	68,077	9,349
3	1,920	18.47	54,104	21,823	274,876	38,853
4	2,560	24.82	152,247	12,346	283,024	39,867
5	3,200	32.27	329,247	12,688	338,762	45,359
6	3,840	61.99	338,800	17,915	588,635	82,872
7	4,480	0.75	n/a	74	4,496	1,121
8	5,120	1.36	11,821	164	1,008	2,573
9	5,760	0.35	2,206	47	361	589
10	6,400	2.82	16,820	178	12,546	4,485
11	1,711	0.28	2,206	13	662	272
12	7,680	3.03	159,723	381	39,096	4,625
13	8,320	2.09	5,881	95	4,154	2,003
14	8,960	2.41	n/a	80	11,539	2,880

Calculated Storm Flow Loads per Sample Site

Site	Subwatershed Hectares	Discharge (m^3/sec)	TSS Load (kg/yr.)	Total Phosphorus Load (kg/yr.)	Nitrate+Nitrite Nitrogen Load (kg/yr.)	TKN Load (kg/yr.)
1	3,129	3.15	9,600,620	22,897	620,626	238,007
2	6,452	9.17	24,979,809	89,506	1,216,815	859,961
3	9,924	24.88	101,648,565	434,389	2,144,149	1,961,500
4	16,932	33.44	97,541,989	326,563	2,571,950	1,878,270
5	19,323	43.47	91,707,736	554,964	2,705,448	2,552,833
6	25,516	83.51	220,688,581	1,444,604	4,611,005	5,037,457
7	810	1.14	1,478,242	12,391	186,229	101,448
8	567	0.44	375,341	2,679	31,674	35,860
9	826	0.66	1,802,732	7,026	42,281	42,491
10	3,612	3.67	7,150,522	35,928	388,539	216,505
11	684	0.35	165,251	2,329	42,477	13,752
12	1,780	4.08	5,995,699	91,369	508,331	222,884
13	758	2.82	5,918,504	28,963	159,206	172,698
14	1,262	0.85	554,275	4,299	114,911	34,338
Site	**Subwatershed Acres**	**Discharge (ft^3/sec)**	**TSS Load (lb./yr.)**	**Total Phosphorus Load (lb./yr.)**	**Nitrate+Nitrite Nitrogen Load (lb./yr.)**	**TKN Load (lb./yr.)**
1	640	112.38	21,165,527	50,478	1,368,232	524,710
2	1,280	327.33	55,070,487	197,325	2,682,590	1,895,869
3	1,920	888.67	224,094,426	957,654	4,726,992	4,324,322
4	2,560	1,194.25	215,041,069	719,941	5,670,120	4,140,835
5	3,200	1,552.58	202,178,874	1,223,473	5,964,430	5,627,975
6	3,840	2,982.62	486,530,046	3,184,774	10,165,422	11,105,577
7	4,480	40.54	3,258,932	27,318	410,561	223,652
8	5,120	15.61	827,477	5,906	69,828	79,056
9	5,760	23.54	3,974,302	15,489	93,213	93,677
10	6,400	130.96	15,764,040	79,207	856,573	477,307
11	1,711	12.41	364,312	5,135	93,645	30,319
12	7,680	145.86	13,218,117	201,433	1,120,666	491,369
13	8,320	100.65	13,047,934	63,852	350,985	380,730
14	8,960	30.26	1,221,954	9,478	253,332	75,702