VFC Index - Watershed (Plan)

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Project Manager: Sky Schelle

Duck Creek Watershed Management Plan

Final Report

Prepared for:
Hamilton County Soil & Water Conservation District

February 2008

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Executive Summary

The Duck Creek Watershed Management Plan is the result of the combined efforts of the Hamilton, Tipton, and Madison County Soil and Water Conservation District offices, the Hamilton County Surveyor's Office, the IN Farm Bureau, IDEM, Local Farmers, Residents, and Landowners. This group met throughout the planning phase to discuss social issues, identify public outreach topics, define water quality issues and their potential sources, and prioritize and develop management goals.

The Duck Creek Watershed collects runoff from approximately 105 square miles of north-central Indiana. It is a *sub-watershed* of the Upper White River Watershed, and drains predominantly agricultural areas within Hamilton, Madison, and Tipton Counties.

Based on *E. Coli* and biotic community studies, the Indiana Department of Environmental Management (IDEM) has listed Duck Creek and all of its major tributaries on their list of impaired water bodies. In response, the Hamilton County Soil and Water Conservation District (HCSWCD) applied for and received a federal grant through the state to create this Watershed Management Plan.

With this grant, the HCSWCD formed a steering committee made up of government personnel, professional consultants, local farmers, residents, and landowners with the mission to *provide leadership, education, and coordination to identify water quality needs and concerns within the watershed, and to develop a comprehensive and feasible management plan to address those needs and promote an improved watershed health.* Based on steering committee input and IDEM watershed management plan guidance, this plan addresses nonpoint sources of pollution by summarizing readily available water quality data, collecting supplemental data where provided for by the grant, identifying and prioritizing critical areas, and proposing possible locations for Best Management Practices (BMPs) capable of improving water quality.

Through these efforts, the Duck Creek Watershed steering committee hopes to achieve the vision of a *healthy watershed in which all land uses are both economically feasible and ecologically responsible to ensure improved and sustainable water quality for present and future generations.* In order to achieve this vision, the following goals have been developed by the steering committee.

Goal 1: Reduce TSS loads in the Duck Creek Watershed

Goal 2: Reduce *E. coli* loads in the Duck Creek.

Goal 3: Reduce Nitrogen loads in the Duck Creek Watershed.

Goal 4: Reduce Phosphorus loads in the Duck Creek Watershed.

Goal 5: Create and implement water quality educational programs in the Duck Creek Watershed.

This Watershed Management Plan should not only serve as a reference for the implementation phase, but also as a reference for future water quality efforts in this area.

SECTION 1.0 INTRODUCTION

In 2005, the Hamilton County Soil and Water Conservation District (HCSWCD) submitted a Section 319 project grant application to the Indiana Department of Environmental Management (IDEM) for the development of a Watershed Management Plan. A grant was awarded in 2006 from the U.S. Environmental Protection Agency (EPA) through the IDEM. The grant performance period is from July 26, 2006 through March 31, 2009. HCSWCD Board of Supervisors reviewed several proposals for the Duck Creek Watershed Management Plan and selected Williams Creek Consulting, Inc. (WCC) from Indianapolis as the contractor for the development of the Watershed Management Plan (WMP).

Both the planning process and the implementation phase are non-regulatory in nature. No landowners will be forced to participate or change any current land use practices if they are not interested.

Steering Committee

In developing the plan, the HCSWCD formed a steering committee with the mission to *provide leadership, education, and coordination to identify water quality needs and concerns within the watershed, and to develop a comprehensive and feasible management plan to address those needs and promote an improved watershed health.*

The Duck Creek Watershed Management Plan was developed by integrating the following previous and ongoing studies: Duck Creek, Pipe Creek, Killbuck Creek, and Stony Creek TMDLs for *E. coli* Bacteria (Draft) Report, the IDEM 305b and 303d analyses, Little Duck and Lilly Creek Watershed Management Plan (Draft), and a US Fish and Wildlife 2002 White River fishery study.

Many community partners were invited to become members of the Duck Creek Steering Committee. These members included the following groups from Hamilton, Madison, and Tipton Counties: local landowners; livestock producers; Soil and Water Conservation District (SWCD) representatives; Purdue Cooperative Extension Service; County Surveyors Offices; County Health Departments; County Plan Commissions; US Department of Agriculture (USDA), Farm Service Agency (FSA), and Natural Resource Conservation Service (NRCS); County Parks Departments; Upper White River Watershed Alliance; White River Watchers; and Indiana Farm Bureau.

The steering committee was composed of local landowners and livestock producers from all three counties, Madison, Tipton, and Hamilton County SWCD representatives; Hamilton County Surveyors Office; Hamilton County Parks and Recreation; and Indiana Farm Bureau.

Through these efforts, the Duck Creek Watershed steering committee hopes to achieve the vision of a *healthy watershed in which all land uses are both economically feasible and ecologically responsible to ensure improved and sustainable water quality for present and future generations*

Watershed management plans such as this document can help communities:

- Define and prioritize water quality issues within their watershed
- Increase public understanding and awareness about water quality issues
- Plan best management practices capable of improving water quality

1.1 LOCATION

Watersheds are defined as a region or area draining to a particular watercourse or body of water. Hydrologic Unit Codes (HUC) are a system devised to classify these drainage areas throughout the United States. These drainage areas are divided and sub-divided into successively smaller areas, 6-digit, 8-digit, 11-digit, and 14-digit, with 6-digit HUCs having the largest area and 14-digit HUCs having the smallest area. The Duck Creek Watershed is an 11-digit HUC sub-watershed (HUC 05120201060) within the 8-digit HUC Upper White River Watershed (HUC 05120201). **Figure 1** shows the location and size of the 105-square mile Duck Creek Watershed relative to Indiana and the Upper White River Watershed within which it is located. The Duck Creek Watershed is shown in **Figure 2** and is typical of the Midwest Plains landscape. It is relatively flat and land use is dominated by crop production.

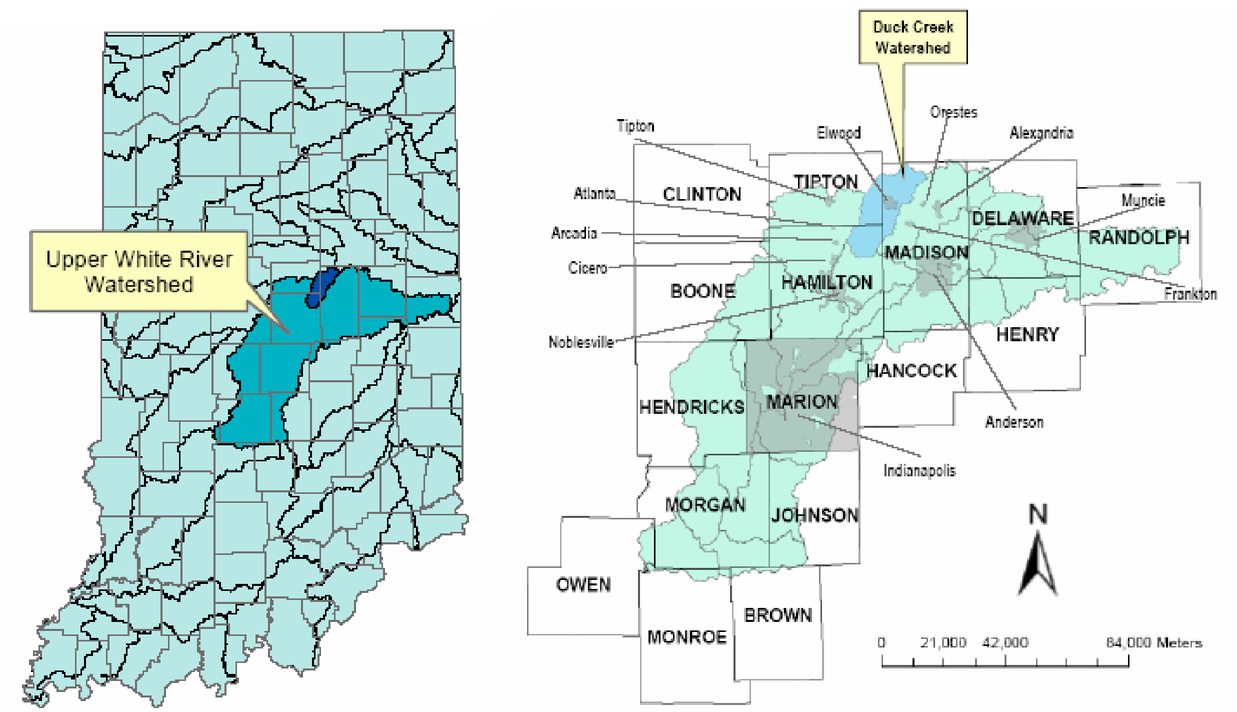

Figure 1. Duck Creek Watershed Location Map

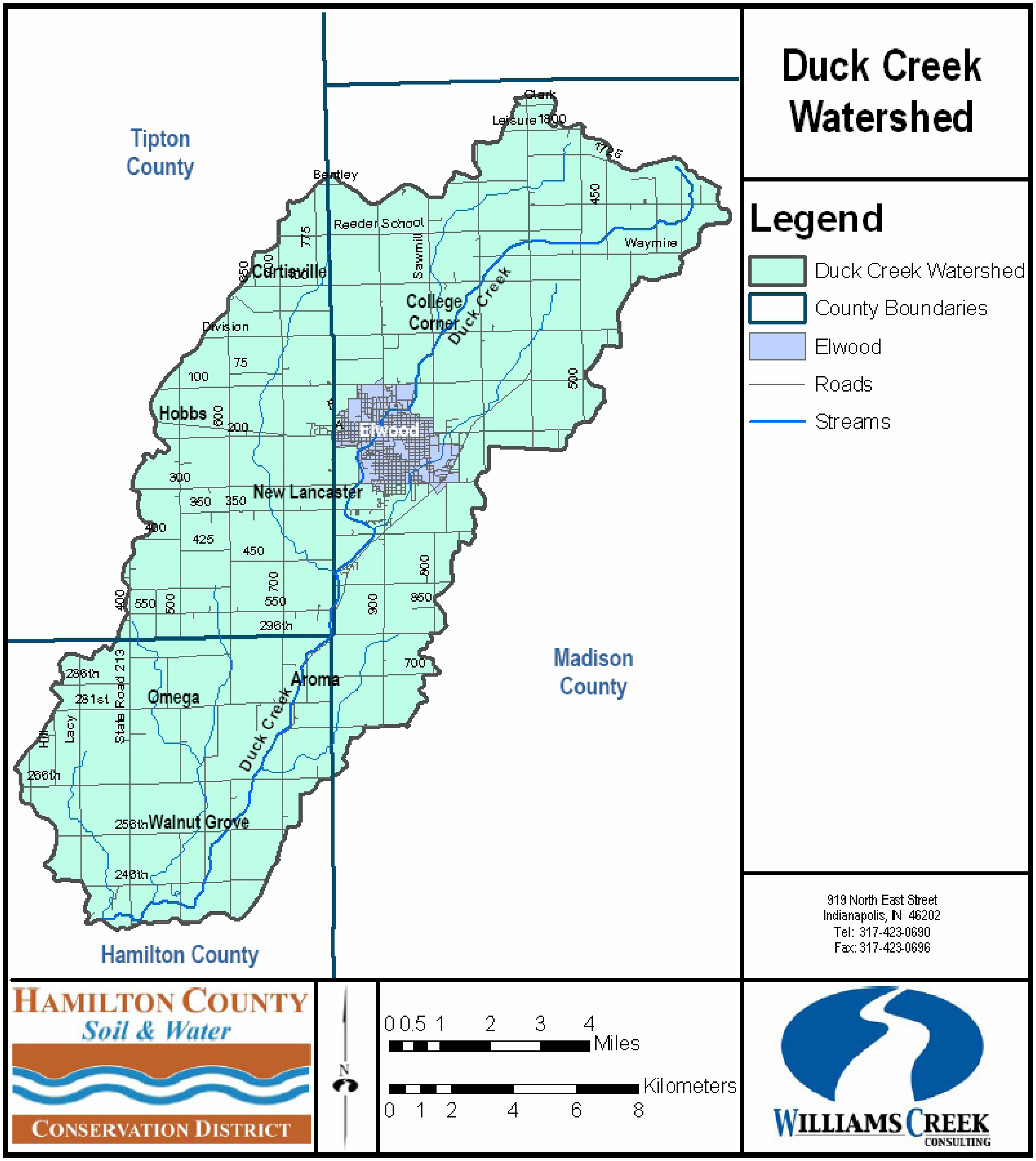

Figure 2. Duck Creek Watershed

SECTION 2.0 PHYSICAL SETTING

2.1 NATURAL HISTORY

The current landscape of the Duck Creek Watershed is the product of continental glaciation during the Wisconsinan glacial Ice Age. As the ice sheet retreated approximately 10,000 to 12,000 years ago, accumulations of glacial till were deposited, and the Duck Creek Watershed was superimposed on the glacial till from the melting of the glacier. The resulting landscape is therefore flat to gently rolling.

Prior to settlement in the early 1800's, the Duck Creek Watershed was primarily composed of hardwood forests, wetlands, and streams. During settlement, most of the forested land was cleared and drained to prepare it for agricultural production. Since settlement the watershed has had active and successful agricultural production with limited urban development primarily in the City of Elwood.

2.2 SOILS

According to the NRCS STATSGO 2005 Soils Data, the soil associations present in the Duck Creek Watershed are Pewamo-Glynwood-Blount, Starks-Mahalasville, Treaty-Crosby, Patton-Del Rey-Crosby, Miami-Crosby, and Sawmill-Lawson-Genesee. The NRCS SSURGO descriptions of these associations can be found in **Table 1**. Of these soil associations, the Pewamo-Glynwood-Blount and Miami-Crosby are the only associations that contain moderately well drained soils as well as poorly drained soils. The remaining associations contain somewhat poorly to very poorly drained soils.

As seen in **Figure 3**, the NRCS STATSGO soil associations map, the primary soil types in the Duck Creek Watershed are Treaty and Crosby. The NRCS SSURGO descriptions of these soils are as follows, Treaty soils are dark in color, are silty or clayey, and drain very poorly. In Indiana Treaty soils are classified as hydric soils, which according to the NRCS, is defined as a soil that formed under saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. The Crosby soils are lighter in color, are clayey or loamy, and drain somewhat poorly. Both soils have severe limitations for septic tank absorption fields due to slow permeability and flooding resultant of high water tables. Artificial drainage is usually required for agricultural production for both soil types.

The Duck Creek Watershed is composed of Hydrologic Soil Groups (HSG) B and C. HSG B soils are silt loam or loam. They are characterized by moderate infiltration rates when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. HSG C soils are sandy clay loam. They are characterized by low infiltration rates when thoroughly wetted, and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure (Purdue Research Foundation, 2004). As seen in **Figure 4**, the HSG B, moderately well to well drained soils, are located in the stream corridor and the majority of the Polywog Creek Watershed, while the HSG C, poorly drained soils make up the large remainder of the Duck Creek Watershed.

Figure 5 shows how the soils of the Crosby-Brookston association are related to one another. The Crosby-Brookston association is depicted because with Treaty being a newly classified soil type, this figure was not found for the Treaty-Crosby association. The Crosby-Brookston association shares the same characteristics as the Treaty-Crosby association, and in **Figure 5**, Treaty soils replace the Brookston soils.

Table 1. Soil Associations in the Duck Creek Watershed (NRCS SSURGO 2005 Soils Data)

Soil Association	Characteristics
Pewamo-Glynwood-Blount	Deep, nearly level and gently sloping, poorly drained, moderately well drained and somewhat poorly drained, moderately fine textured soils that formed in glacial till on uplands.
Starks-Mahalasville	Deep, nearly level, somewhat poorly drained and poorly drained, medium textured soils that formed in silty material and the underlying stratified loamy and sandy outwash, or in silty material and the underlying loamy and sandy outwash on outwash plains.
Treaty-Crosby	Deep, nearly level, very poorly and somewhat poorly drained, medium textured and moderately fine textured soils that formed in a thin mantle of loess and the underlying glacial till on uplands.
Patton-Del Rey-Crosby	Deep, nearly level, poorly drained and somewhat poorly drained soils that formed in silty sediments, in silty and sandy sediments, or in a thin mantle of silty material and the underlying loamy and clayey glacial till on lake plains and till plains.
Miami-Crosby	Deep, nearly level to strongly sloping, moderately well drained and somewhat poorly drained, medium textured soils that formed in a thin mantle of loess and the underlying glacial till on uplands.
Sawmill-Lawson-Genesee	Deep, nearly level, poorly drained, somewhat poorly drained and well drained, medium textured soils that formed in silty alluvium or in loamy alluvium on flood plains.

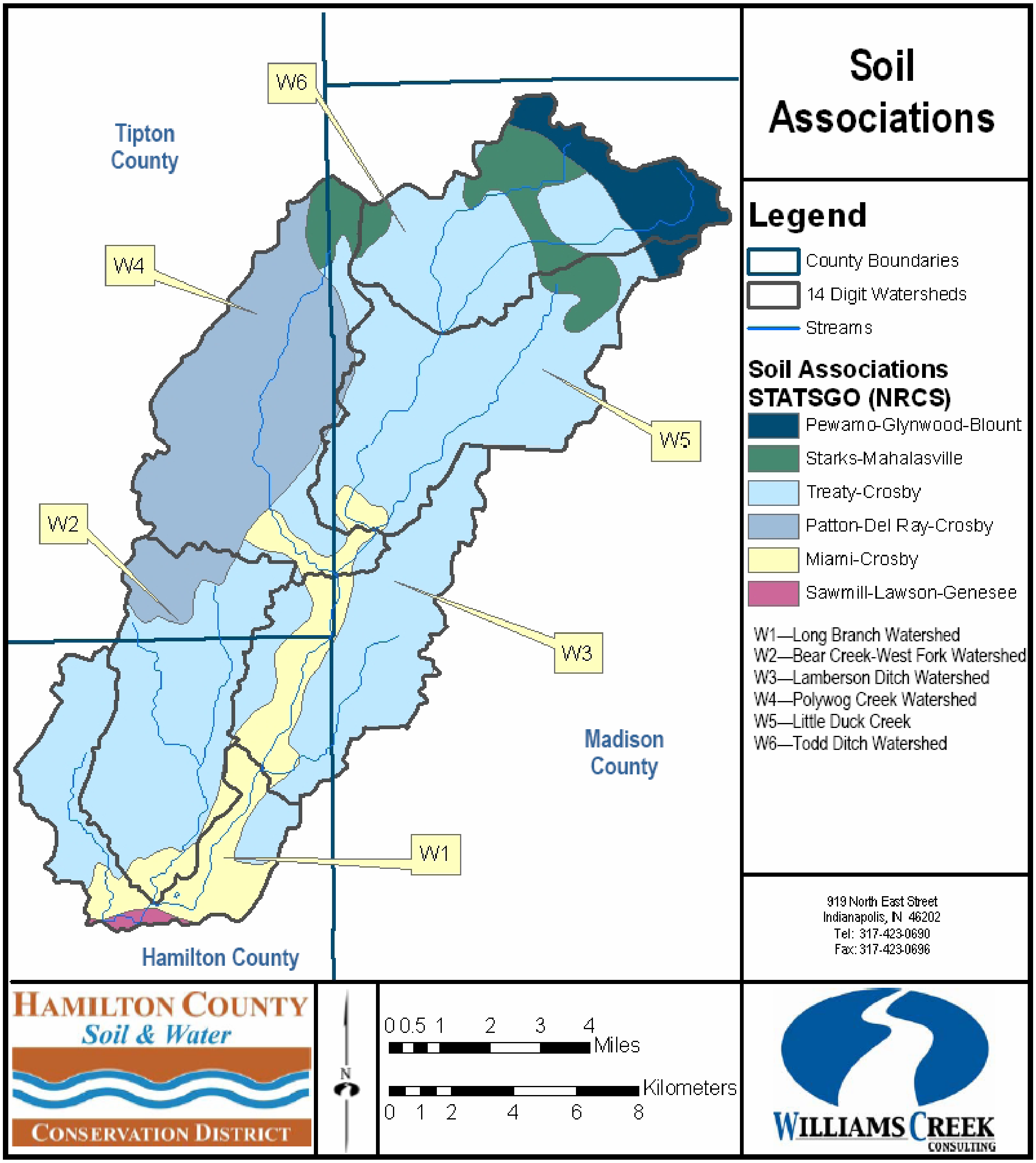

Figure 3. Soil Associations of the Duck Creek Watershed (NRCS STATSGO 2005 Soils Data)

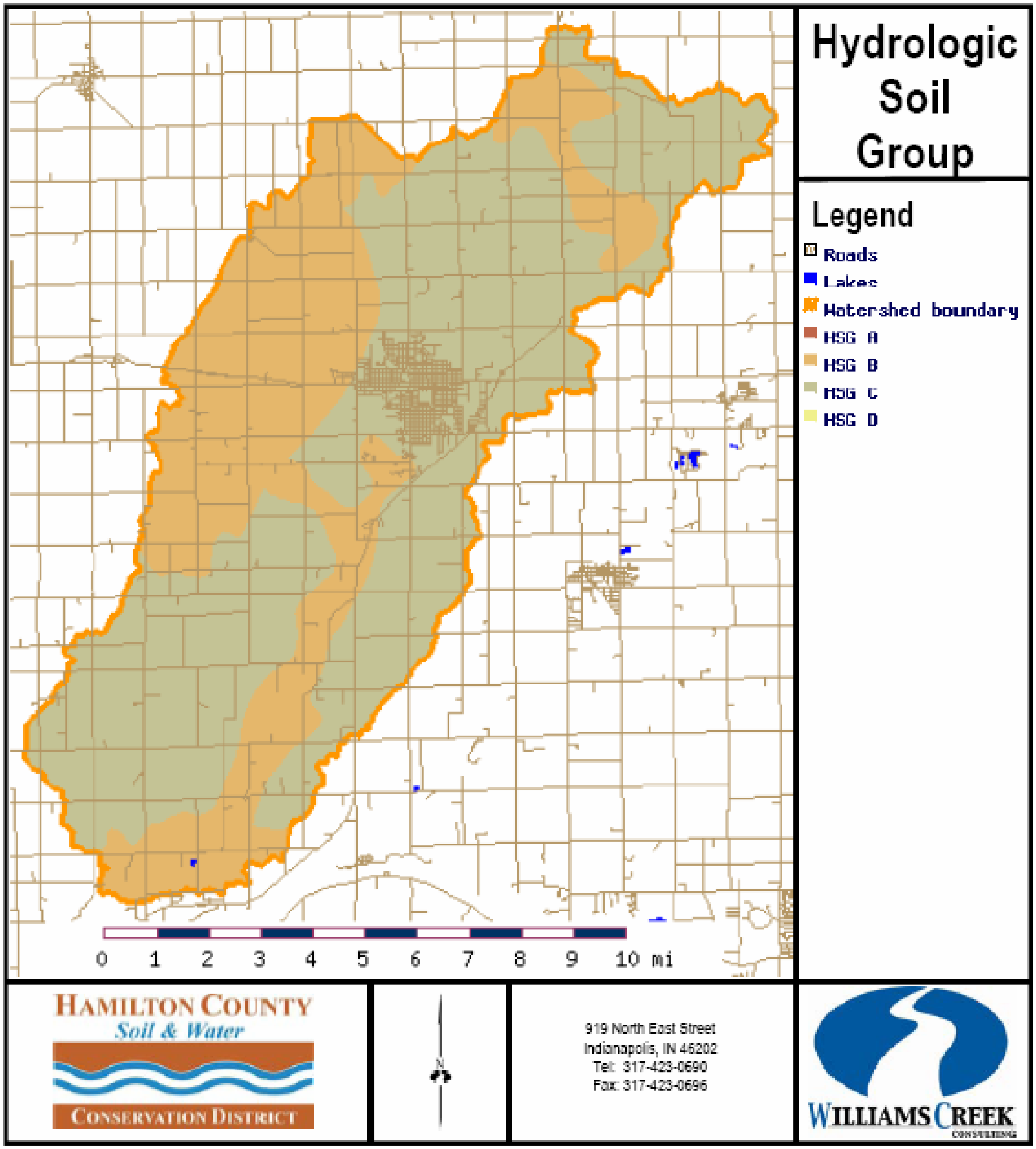

Figure 4. Hydrologic Soil Groups Map (HYMAPS-OWL)

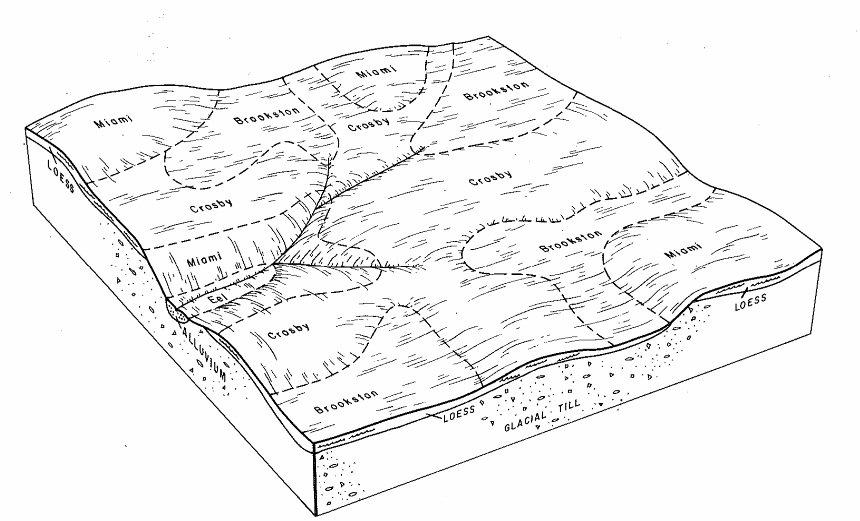

Figure 5. **Pattern of soils and underlying material in Crosby-Brookston association (USDA Soil Survey)**

As shown in **Figure 6**, the entire Duck Creek Watershed except for a portion of the stream corridor is somewhat poorly to very poorly drained, meaning the majority of the soils in this watershed are unsuitable for septic systems and are artificially drained for agricultural production. This is indicative of the presence of tile drains and malfunctioning septic systems, and the BMPs recommended later in this plan should be reflective of these issues.

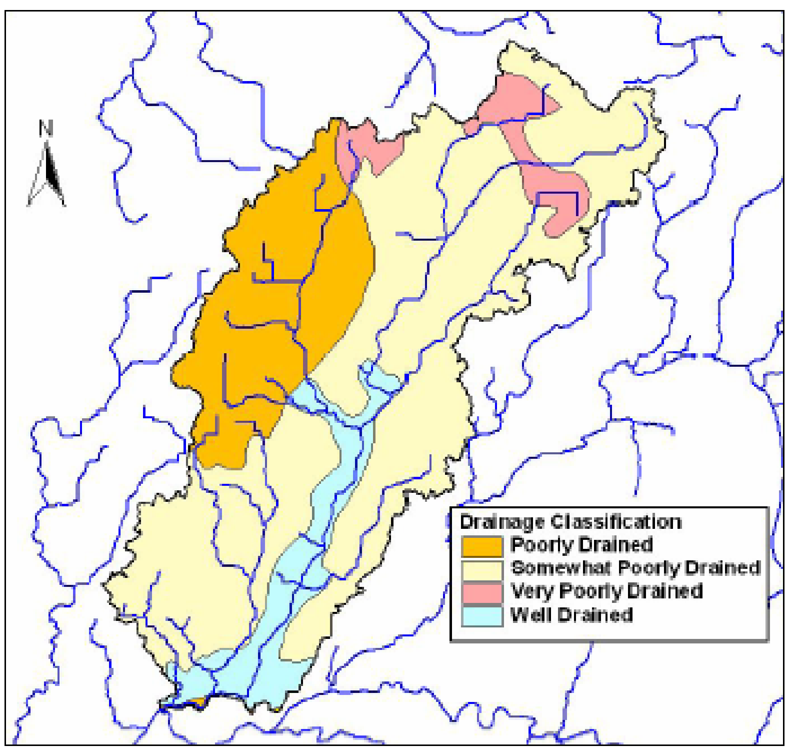

Figure 6. State Soil Geographic (STATSGO) Drainage Classification Categories (IDEM, 2005)

2.3 TOPOGRAPHY

The topography of the Duck Creek Watershed is relatively flat and typical of the Tipton Till Plain of Central Indiana. The confluence with the West Fork White River is the lowest point in the watershed at 790 ft., while the highest elevation, 936 ft., is in the headwaters. The average slope of the watershed is 2.9 percent. **Figure 7** shows watershed topography and **Figure 8** shows the typical landscape of the watershed.

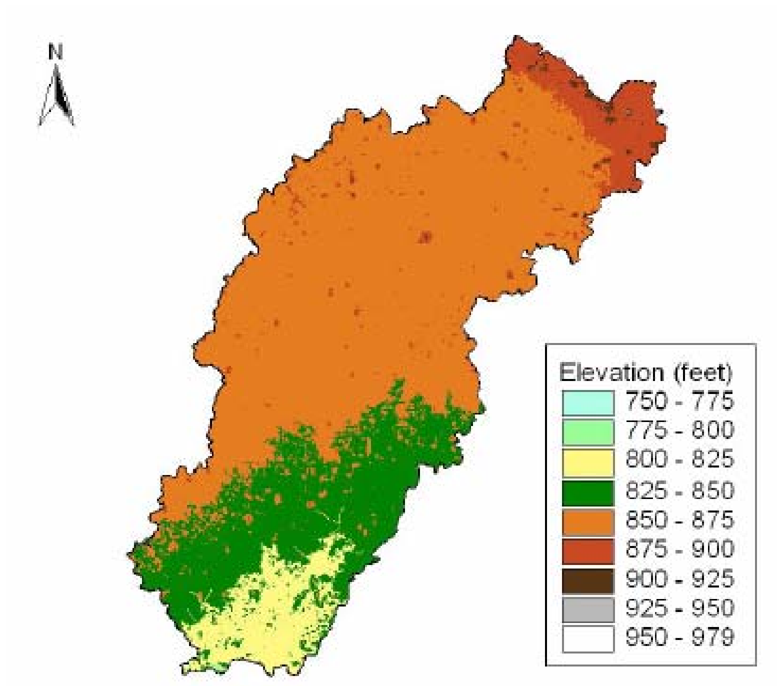

Figure 7. Shuttle Radar Topography Mission (SRTM) (IDEM, 2005)

Figure 8. Typical Landscape of the Duck Creek Watershed

2.4 DUCK CREEK SUBWATERSHEDS

The Duck Creek Watershed (HUC 05120201060) is located within the Upper White River Watershed (HUC 05120201). **Table 2** lists the six, 14-digit HUC watersheds within the Duck Creek Watershed shown on **Figure 9**. In this table the watersheds are numbered W-1 through W-6; the numbering designations are used throughout the watershed management plan.

Figures 10 through 15 depict typical drainage ditches, streams, and landscapes found in each of the subwatersheds. They have been included to paint a picture of the subwatersheds of the larger Duck Creek Watershed.

Table 2. 14-digit HUC Subwatersheds in the Duck Creek Watershed

Subwatershed #	Subwatershed Name	HUC Number	Area (Acres)
W1	Long Branch	05120201060060	7,230
W2	Bear Creek	05120201060050	11,024
W3	Lamberson Ditch	05120201060040	10,332
W4	Polywog Creek	05120201060030	14,405
W5	Little Duck Creek	05120201060020	12,928
W6	Todd Ditch	05120201060010	11,267

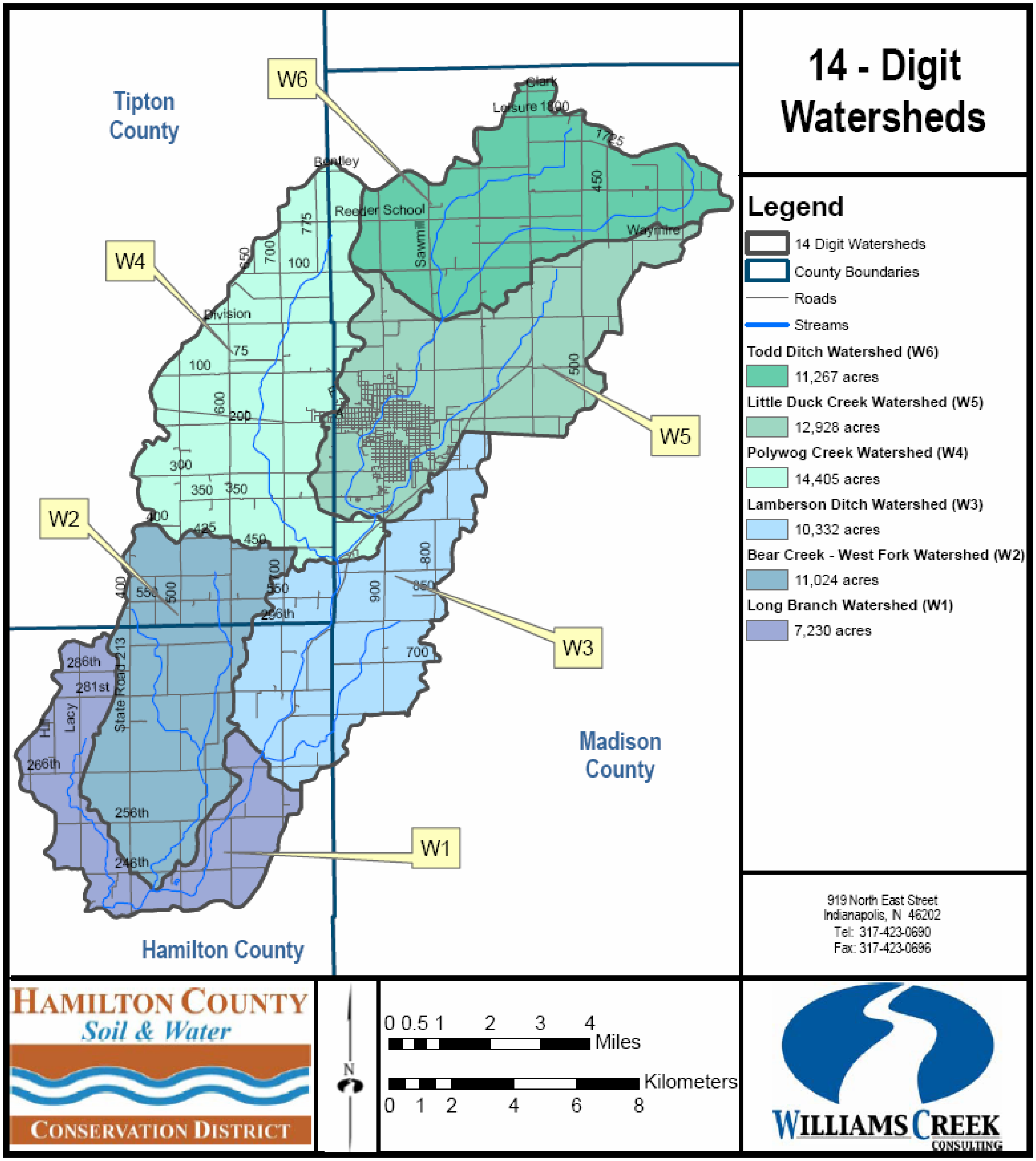

Figure 9. 14-digit Watersheds within the Duck Creek Watershed

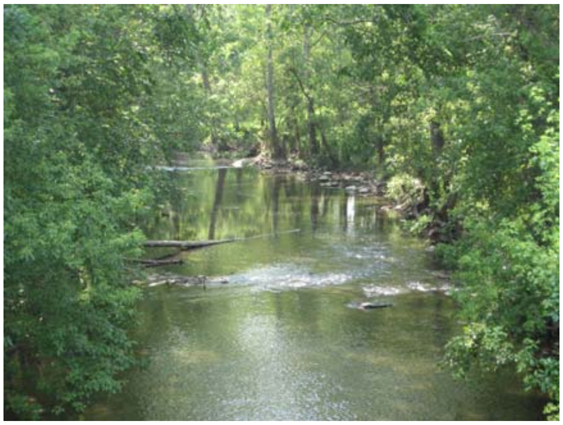

Fig. 10 Long Branch Watershed (W1)

Fig. 11 Bear Creek Watershed (W2)

Fig. 12   Lamberson Ditch Watershed (W3)

Fig. 13 Polywog Creek Watershed (W4)

Fig. 14 Little Duck Creek Watershed (W5)

Fig. 15 Todd Ditch Watershed (W6)

2.5 HYDROLOGY OF THE DUCK CREEK WATERSHED

There are approximately 65.4 miles of streams and major drainage ditches (**Table 3 and Figure 16**) and 1,290 acres of wetlands (**Table 4 and Figure 17**) within the Duck Creek Watershed. Wetlands have a natural ability to filter pollutants out of water before it enters a ditch or stream. Streams and ditches range from 1st order to 4th order based on USGS 1:24,000 scale topographic maps (**Table 3**). According to the Indiana Geological Survey, the area heavily relies on groundwater as the drinking water source; most utilizing private wells.

Table 3. Stream Lengths and Orders

Stream or Ditch	Length (miles)	Stream Order
Duck Creek	23.9	4th
Long Branch	4.7	2nd
Bear Creek	7.4	3rd
West Fork-Bear Creek	3.9	1st
Lamberson Ditch	4.8	1st
Polywog Creek	8.1	3rd
Little Duck Creek	6.8	2nd
Todd Ditch	5.8	2nd
Total	**65.4**	

Table 4. Wetland Types and Acreages Within the Duck Creek Watershed (National Wetlands Inventory)

Wetland Type	Description	Acres
PEM/FO1A	Palustrine, Emergent/Forested, Hyperhaline, Temporarily Flooded	3
PEM/SS1A	Palustrine, Emergent/Scrub Shrub, Hyperhaline, Temporarily Flooded	2
PEM/SS1C	Palustrine, Emergent/Scrub Shrub, Hyperhaline, Seasonally Flooded	2
PEMA	Palustrine, Emergent, Temporarily Flooded	27
PEMC	Palustrine, Emergent, Seasonally Flooded	14
PEMCx	Palustrine, Emergent, Seasonally Flooded, Excavated	1
PEMF	Palustrine, Emergent, Semipermanently Flooded	0.5
PFO/SS1A	Palustrine, Forested/Scrub Shrub, Hyperhaline, Temporarily Flooded	15
PFO1A	Palustrine, Forested, Hyperhaline, Temporarily Flooded	1,163
PFO1Ax	Palustrine, Forested, Hyperhaline, Temporarily Flooded, Excavated	3
PFO1C	Palustrine, Forested, Hyperhaline, Seasonally Flooded	16
PSS1A	Palustrine, Scrub Shrub, Hyperhaline, Temporarily Flooded	4
PSS1C	Palustrine, Scrub Shrub, Hyperhaline, Seasonally Flooded	0.5
PUBGH	Palustrine, Unconsolidated Bottom, Intermittently Exposed, Permanently Flooded	11
PUBGx	Palustrine, Unconsolidated Bottom, Intermittently Exposed, Excavated	27
PUBKH	Palustrine, Unconsolidated Bottom, Artificially Flooded, Permanently Flooded	1

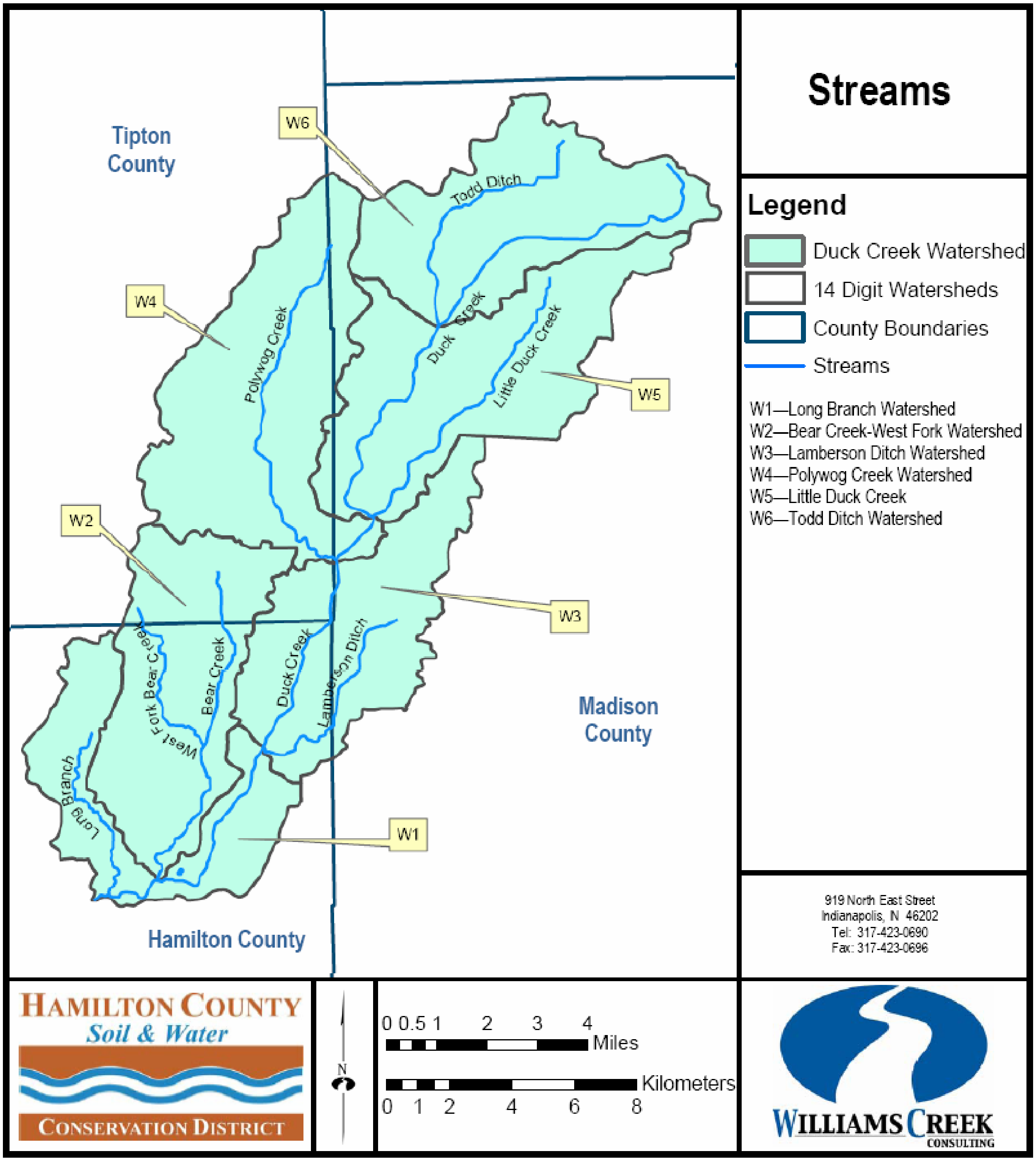

Figure 16. Duck Creek and Major Tributaries

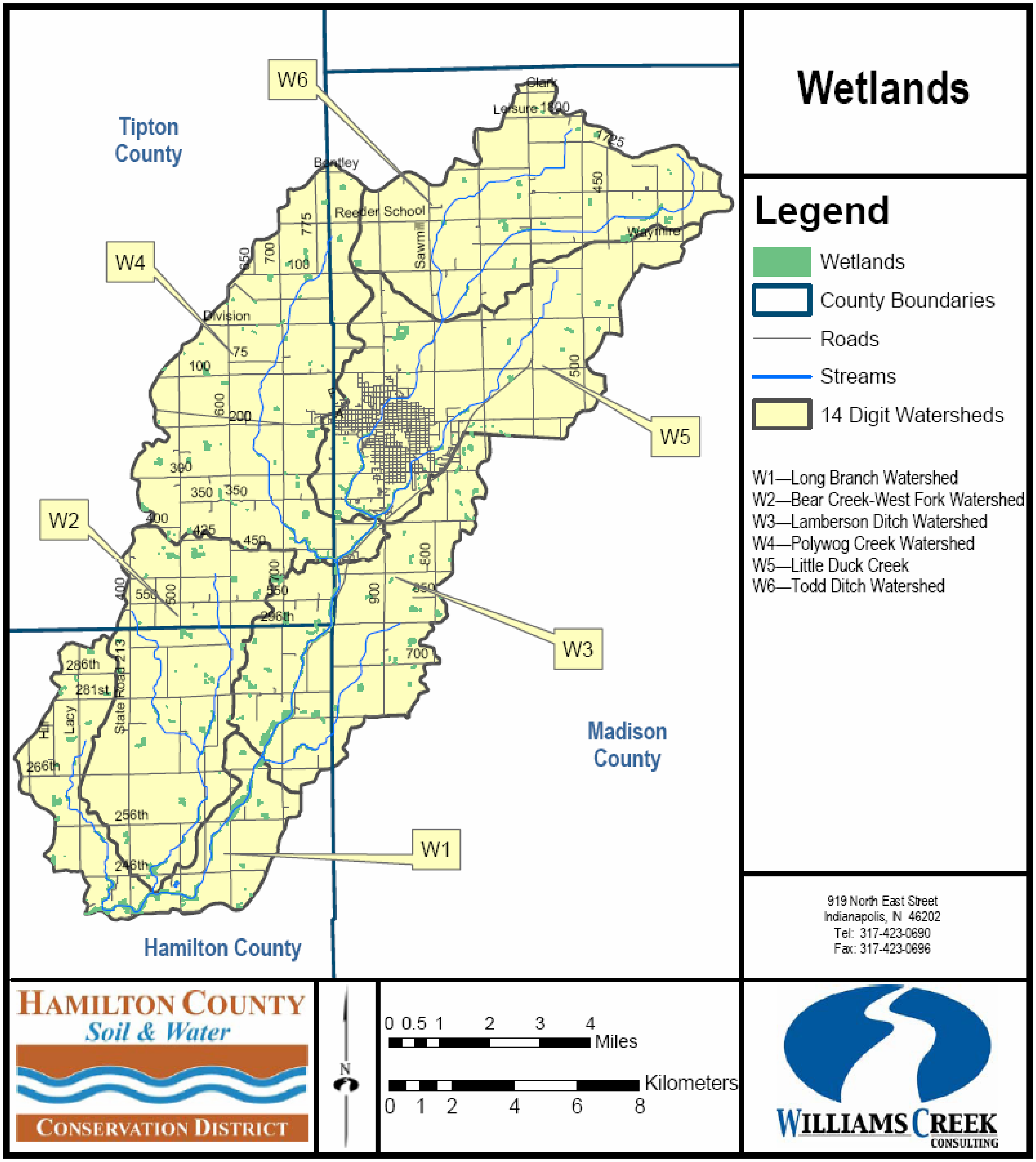

Figure 17. Wetlands in the Duck Creek Watershed (National Wetlands Inventory)

Waterbodies in the Duck Creek Watershed may be considered "waters of the US". Therefore, permits will be required for crossing, outletting or working within the easement of the waterbody. The required permits include US Army Corps of Engineers, Section 404; and Indiana Department of Environmental Management, Water Quality Certification. If the action involves the floodway of a waterbody a Construction in a Floodway permit from the Indiana Department of Natural Resources, Division of Water will be required. Furthermore, the waterbody may be classified on the county level as regulated or legal drains. Permits from individual county surveyor's offices will be needed for any actions on a county regulated drain. The approximate locations of the regulated drains of the Duck Creek Watershed are illustrated on **Figure 18**, based on information obtained from the County Surveyors' Offices and/or websites.

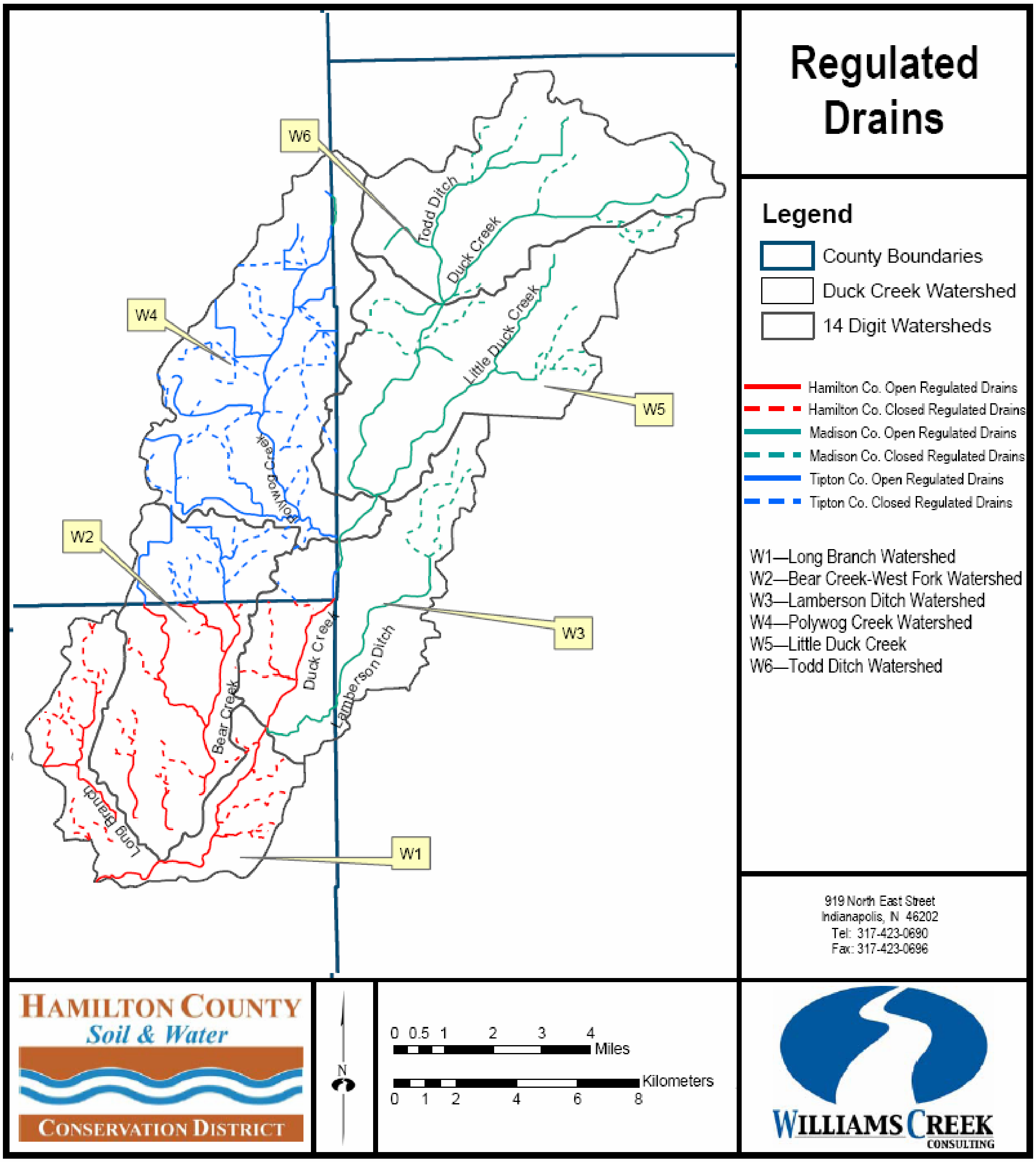

Figure 18. Approximate Locations of the Regulated Drains in the Duck Creek Watershed

2.6 CLIMATE

Hamilton, Madison, and Tipton Counties all have typical Midwest North American climates. The watershed receives an average of 38 inches of rainfall a year. The Average high temperature for the watershed is 84°F, while the average low temperature is 18°F (**Figure 19**).

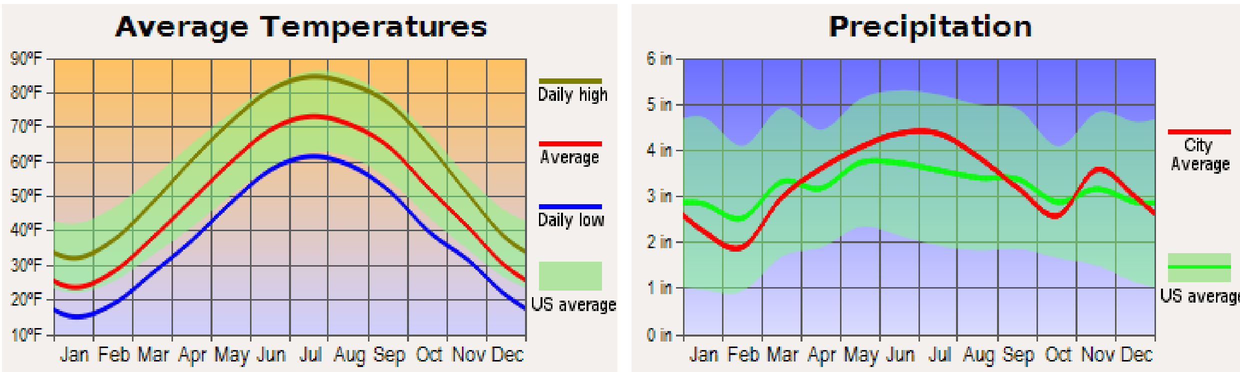

Figure 19. Average Temperatures and Precipitation for the City of Elwood (City Data, 2007)

2.7 HISTORY OF THE DUCK CREEK WATERSHED

Since settlement in the late 1800s, the Duck Creek Watershed has been dominated by agricultural production. The City of Elwood, however, has been a small urban area since the establishment of the Pennsylvania Railroad (PRR) through central Indiana. A Block Station was built in Elwood in 1945, but was abandoned in 1976. Occurring during this active period, the Gas Boom allowed industry to take a stronghold in Elwood. Elwood became the home of several glass companies and canning and tin companies. Being located in the heart of an agricultural area and with the local PRR, Elwood was a natural location for canning companies. Elwood continues to have a strong glass heritage, and Red Giant Foods is an active canning factory (Hensley, 1997)

2.8 ENDANGERED SPECIES

There are a number of endangered or threatened species in Hamilton, Madison, and Tipton Counties (**Tables 5 through 7**). However, a detailed study to determine if these species are present in the Duck Creek Watershed was not performed.

Table 5. Tipton County Endangered, Threatened, and Rare Species (IDNR)

Page 1 of 1
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Indiana County Endangered, Threatened and Rare Species List

County: Tipton

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Bird					
Laterallus jamaicensis	Black Rail		SE	G4	SHB
Vascular Plant					
Carex atherodes	Awned Sedge		SE	G5	S1
Panicum leibergii	Leiberg's Witchgrass		ST	G5	S2

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

Table 6. Hamilton County Endangered, Threatened, and Rare Species (IDNR)

Page 1 of 1
11/22/2005

Indiana County Endangered, Threatened and Rare Species List

County: Hamilton

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Epioblasma triquetra	Snuffbox		SE	G3	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Ligumia recta	Black Sandshell			G5	S2
Obovaria subrotunda	Round Hickorynut		SSC	G4	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Toxolasma parvum	Lilliput			G5	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Fish					
Ammocrypta pellucida	Eastern Sand Darter			G3	S2
Amphibian					
Necturus maculosus	Common mudpuppy		SSC	G5	S2
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4T3T4	S2
Bird					
Bartramia longicauda	Upland Sandpiper		SE	G5	S3B
Buteo lineatus	Red-shouldered Hawk		SSC	G5	S3
Certhia americana	Brown Creeper			G5	S2B
Dendroica cerulea	Cerulean Warbler		SSC	G4	S3B
Ixobrychus exilis	Least Bittern		SE	G5	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Thryomanes bewickii	Bewick's Wren			G5	S1B
Mammal					
Lynx rufus	Bobcat	No Status		G5	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Armoracia aquatica	Lake Cress		SE	G4?	S1
Chelone obliqua var. speciosa	Rose Turtlehead		WL	G4T3	S3
Drosera intermedia	Spoon-leaved Sundew		SR	G5	S2
Platanthera leucophaea	Prairie White-fringed Orchid	LT	SE	G3	S1
High Quality Natural Community					
Forest - floodplain wet-mesic	Wet-mesic Floodplain Forest		SG	G3?	S3
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3

Table 7. Madison County Endangered, Threatened, and Rare Species (IDNR)

Page 1 of 1
11/22/2005

Indiana County Endangered, Threatened and Rare Species List

County: Madison

Species Name	Common Name	FED	STATE	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Epioblasma torulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Plethobasus cyphyus	Sheepnose	C	SE	G3	S1
Pleurobema clava	Clubshell	LE	SE	G2	S1
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Quadrula cylindrica cylindrica	Rabbitsfoot		SE	G3T3	S1
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Toxolasma parvum	Lilliput			G5	S2
Villosa lienosa	Little Spectaclecase		SSC	G5	S2
Insect: Odonata (Dragonflies & Damselflies)					
Cordulegaster bilineata	Brown Spiketail		SE	G5	S1
Bird					
Ardea herodias	Great Blue Heron			G5	S4B
Lanius ludovicianus	Loggerhead Shrike	No Status	SE	G4	S3B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Rallus elegans	King Rail		SE	G4	S1B
Mammal					
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Deschampsia cespitosa	Tufted Hairgrass		SR	G5	S2
Hypericum pyramidatum	Great St. John's-wort		ST	G4	S1
Juglans cinerea	Butternut		WL	G3G4	S3
Onosmodium hispidissimum	Shaggy False-gromwell		SE	G4	S1
Poa paludigena	Bog Bluegrass		WL	G3	S3
Selaginella apoda	Meadow Spike-moss		WL	G5	S1
Spiranthes lucida	Shining Ladies'-tresses		SR	G5	S2
Valerianella chenopodiifolia	Goose-foot Corn-salad		SE	G5	S1
High Quality Natural Community					
Forest - upland mesic	Mesic Upland Forest		SG	G3?	S3
Wetland - fen	Fen		SG	G3	S3
Wetland - marsh	Marsh		SG	GU	S4

SECTION 3.0 LAND USE

Land use plays a significant role in water quality. The different types of land use that water encounters as it flows over the surface of the land contributes different contaminants. Water flowing across agricultural fields may pick up sediment, fertilizers, herbicides, pesticides, and manure, whereas water flowing off a parking lot may pick up motor oil, axle grease, and transmission fluid. Impervious surfaces also restrict infiltration causing greater water volumes to reach the nearest waterway and cause greater velocities downstream. Water flowing over highly erodible soils cause greater erosion; adding more sediment into waterways. Consequently, an investigation of the ground cover, soil characteristics, and other land uses of the Duck Creek Watershed can be helpful in identifying its potential water quality impairments.

3.1 LAND USE DATA

Land use within the Duck Creek Watershed is primarily agricultural (93%), with row crops comprising 56,510 acres (84%) and 5,880 acres (9%) of pastureland. Corn and soybeans make up the majority of these crops. Approximately 2,171 acres, only 3%, of the watershed are residential, commercial, and industrial areas. The remaining 2,626 acres (4%) of the watershed is composed of deciduous forests, grassland, wetlands, and open water, in small proportions.

Land use is expected to convert from agricultural to residential, commercial, and industrial slowly in general, but may occur rapidly in the southern tip where the watershed enters the greater Indianapolis metropolitan area and in the central area of the watershed around the City of Elwood. The Hamilton County Comprehensive Plan shows most of the watershed in that county zoned to remain in agriculture. Land use is summarized in **Table 8** and shown on **Figure 20**.

Table 8. Duck Creek Watershed Land Use (HYMAPS-OWL)

Land Use	Acres	Percentage
Open Water	11	0.02%
Low Intensity Residential	1,718	2.54%
High Intensity Residential	154	0.20%
Commercial/Industrial/Transportation	298	0.40%
Deciduous Forest	1,152	1.70%
Pasture/Hay	5,880	8.80%
Row Crops	56,509	84.10%
Urban/Recreational Grasses	654	1.00%
Woody Wetlands	779	1.20%
Emergent Herbaceous Wetlands	27	0.04%
Total Acreage	**67,185**	**100%**

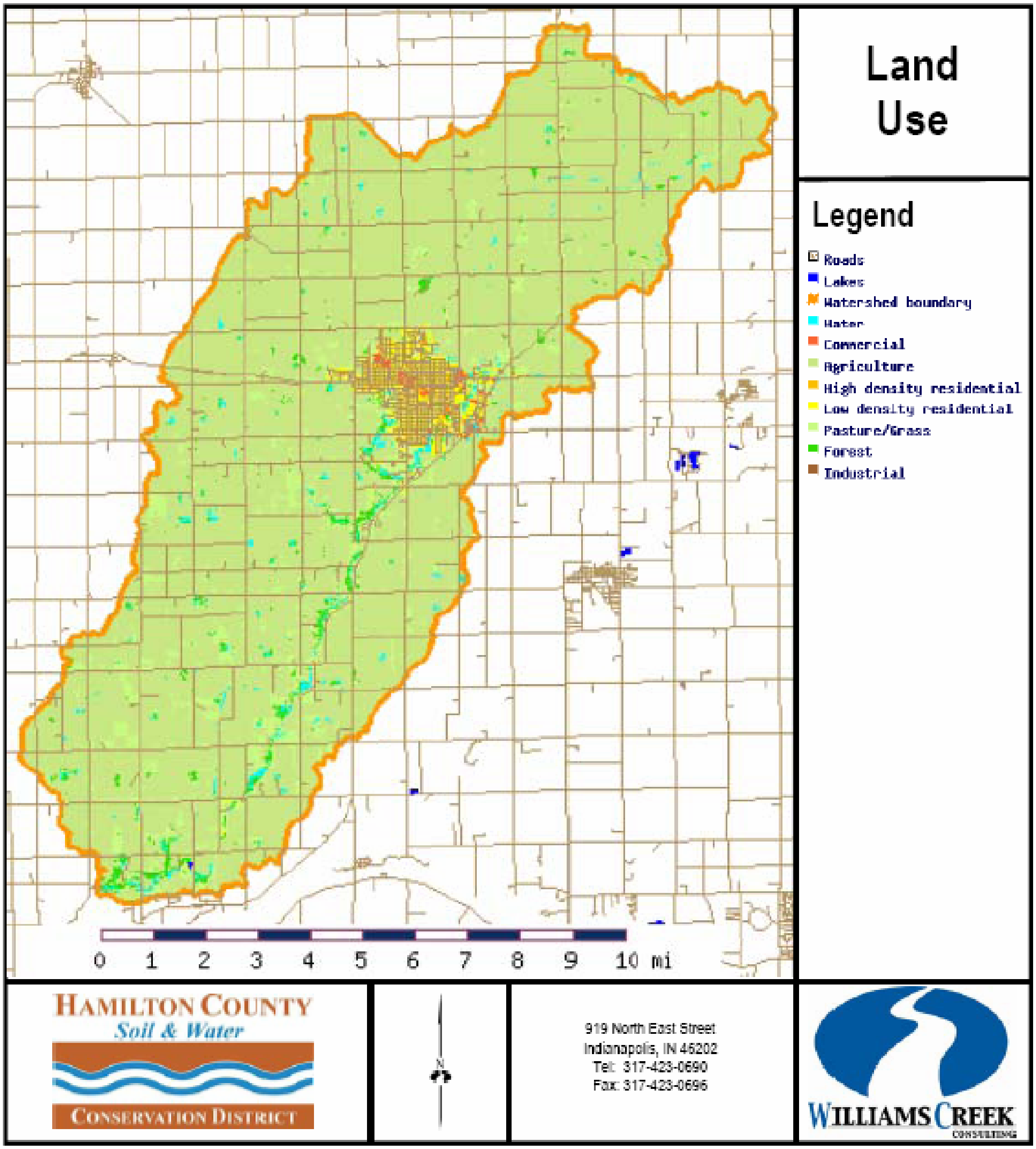


Figure 20. Duck Creek Watershed Land Use (HYMAPS-OWL)

The land use of each of the 14-digit HUC subwatersheds proportionally resembles the land use ratios of the larger Duck Creek Watershed. Each Subwatershed is dominated by agricultural row crops; ranging from 70% to 94%. The Little Duck Creek watershed (W5) is the only subwatershed that has significant differences in that it contains almost all of the low intensity residential, high intensity residential and commercial/industrial/transportation land uses located in the entire Duck Creek Watershed. **Table 9** shows the land use broken down by subwatershed.

Table 9. Subwatershed Land Use (HYMAPS-OWL)

	W1		W2		W3	
Land Use	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Open Water	5	0.07	0	0	1	0.01
Low Intensity Residential	17	0.23	6	0.05	18	0.17
High Intensity Residential	0	0	0	0	0	0
Commercial/Industrial/Transportation	0	0	3	0.03	16	0.15
Deciduous Forest	299	4.14	176	1.59	228	2.21
Pasture/Hay	934	12.91	1358	12.31	1086	10.51
Row Crops	5829	80.63	9379	85.09	8830	85.47
Urban/Recreational Grasses	0	0	0	0	9	0.09
Woody Wetlands	145	2.01	101	0.92	143	1.37
Emergent Herbaceous Wetlands	0	0	1	0.01	2	0.02
Total	**7230**		**11024**		**10332**	
	W4		**W5**		**W6**	
Land Use	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
Open Water	3	0.02	1	0.01	1	0.01
Low Intensity Residential	86	0.59	1595	12.33	0	0
High Intensity Residential	3	0.02	151	1.17	0	0
Commercial/Industrial/Transportation	3	0.02	275	2.13	1	0.01
Deciduous Forest	196	1.36	187	1.44	69	0.60
Pasture/Hay	1139	7.91	808	6.25	558	4.95
Row Crops	12823	89.0	9092	70.34	10562	93.76
Urban/Recreational Grasses	30	0.21	615	4.76	0	0
Woody Wetlands	118	0.82	202	1.56	72	0.64
Emergent Herbaceous Wetlands	3	0.02	1	0.01	1	0.01
Total	**14405**		**12928**		**11267**	

3.2 DEMOGRAPHICS

Analysis of population trends can be used to predict future changes in land use. Population growth can be associated with development growth, and can have a dramatic impact on water quality.

The Duck Creek Watershed lies within Hamilton, Madison, and Tipton Counties, and covers 10.5% of Madison County, 7.6% of Hamilton County, and 6.9% of Tipton County. Population trends for these three counties are shown in **Table 10,** derived from US Census Bureau, Census 2000. Using the percentages of the watershed area within each county, an estimation of the population of the watershed was calculated (**Table 11**). The county information is helpful at estimating the watershed population trends, but may be significantly skewed. For instance, the southern portion of Hamilton County is heavily populated, and the population is growing exponentially. However, the northeastern portion of Hamilton County where the Duck Creek Watershed is located is extremely rural and zoned to remain rural. Therefore, the population estimated for the Hamilton County portion of the Duck Creek Watershed is much too high, and the population growth for Hamilton County is not indicative of the population growth within the Duck Creek Watershed. The Madison and Tipton County population trends are however indicative of the portions of the county that the Duck Creek Watershed lies within. Tipton County is almost entirely rural; therefore the population trends are consistent across the county. Madison County is primarily rural with populated areas scattered throughout, similar to the Duck Creek Watershed portion of the county which is mostly rural but contains Elwood.

Table 10. County Demographics (US Census Bureau, 2000)

County	Area (Acres)	Population (2005)	Pop. Growth (1990-2005)	Pop. Density	Covered Employment	Unemployment Rate
Hamilton	254,656	240,685	120.90%	604.9	95,246	3.1
Madison	289,344	130,412	-0.20%	288.5	42,404	6.6
Tipton	254,656	16,385	1.70%	62.9	4,424	5.7

Table 11. Estimated Watershed Demographics

County	Area (Acres)	Population (2005)
Hamilton	19,354	18,292
Madison	30,336	13,693
Tipton	17,495	1,131
TOTAL WATERSHED	**67,185**	**33,116**

The majority of the Duck Creek Watershed is zoned to remain rural agricultural except for two areas (**Figure 21**). Based on the Madison County Zoning Map of 2004, an area surrounding Elwood is zoned as Conservation Residential. This district is established to provide for the development of clusters of residences in rural areas. The intent of the district is to permit small-scale, large-lot residential developments in a manner that protects adjacent agricultural operations. A very small area at the southern tip of the watershed in Hamilton County is zoned as Priority Growth – Mixed Use. According to the Hamilton County Comprehensive Plan updated in 2006, areas designated as Priority Growth – Mixed Use are adjacent to high-speed arterial roadways where mixed use development includes homes and other uses such as schools, shops, businesses, churches, and other uses that benefit from the visibility and access these locations provide.

Based on the population growth for Madison and Tipton Counties; that the only area zoned for development in the Madison County portion of the watershed is intended for small-scale, large-lot residential development; and the small size of the area zoned for development in Hamilton County; it can be assumed that development in the near future is not a current concern.

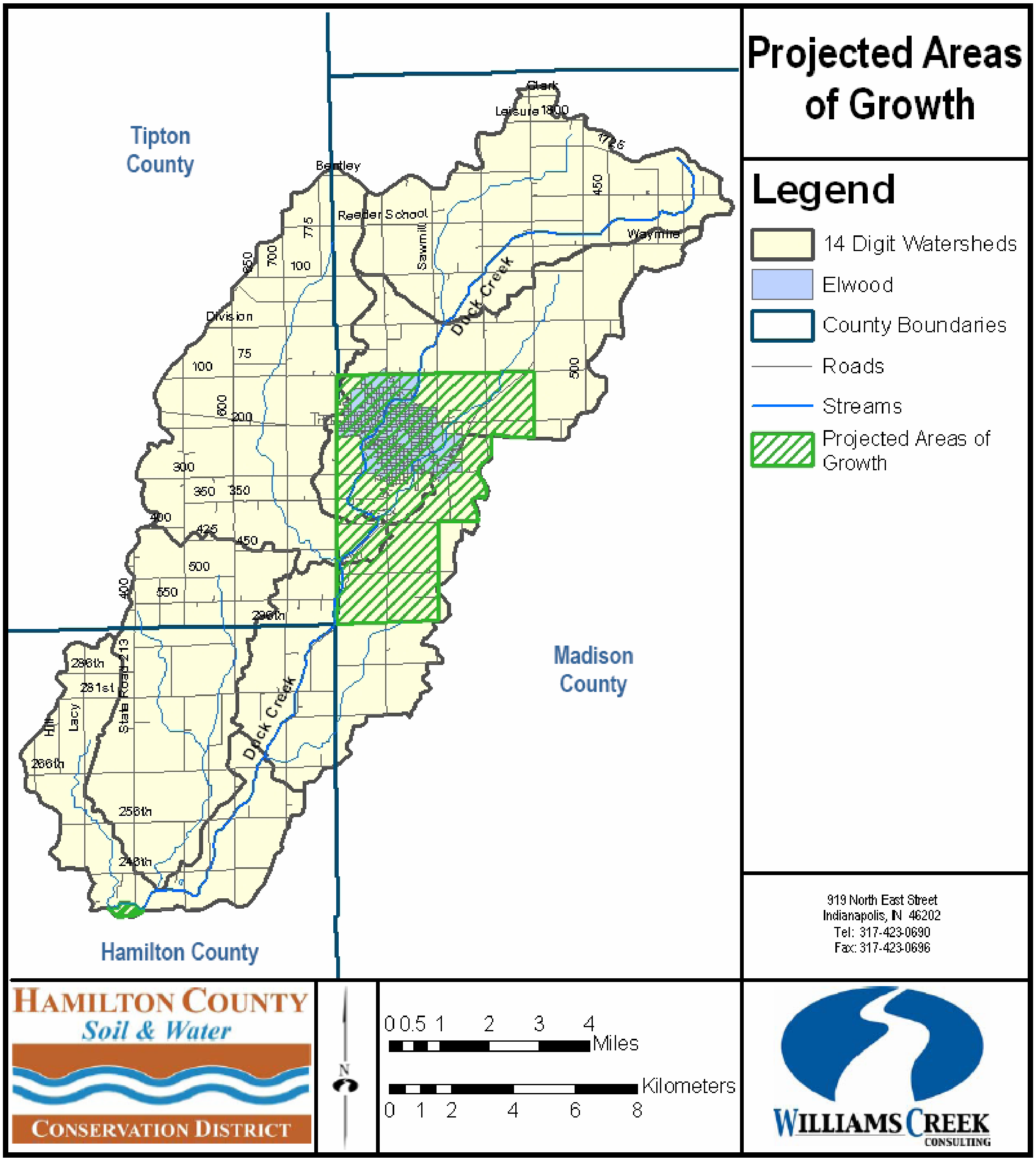


Figure 21. Projected Areas of Growth in the Duck Creek Watershed

3.3 IMPERVIOUS SURFACE ANALYSIS

One negative impact on water quality associated with development is the increase of impervious surface, which is defined by EPA as "hard surface area that either prevents or retards the entry of water into the soil mantle or causes water to run off the surface in greater quantities or at an increased rate of flow." The area of impervious surface in the Duck Creek Watershed and its subwatersheds was calculated using the typical impervious fraction from the *Watershed Inventory Workbook for Indiana* (**Table 12)**. A study published by Elvidge *et al.*, (2004) showed that watersheds with 11 – 25% impervious cover had streams that exhibited clear signs of degradation. The Little Duck Creek watershed (W6) contains the highest percent of impervious cover (6.76%); however, none of the subwatersheds or the Duck Creek Watershed as a whole (2.20%) contain 11% impervious cover. The percentage of impervious cover in the Duck Creek Watershed is not expected to change dramatically. Therefore, impervious surface is not a major current threat to the water quality of the Duck Creek Watershed.

Table 12. Subwatershed Percent Impervious Surfaces

	W1	W2	W3	W4	W5	W6	Duck Creek Watershed
Percent Impervious Surfaces	1.05%	1.03%	1.17%	1.19%	6.76%	1.01%	2.20%

3.4 PARKS AND OTHER MAINTAINED GREENSPACE

The land in the Duck Creek Watershed is primarily privately owned agricultural land. There are however, four small and one large public parks located in Elwood. A 54 acre golf course, Cattails Golf Club, is located just south of Elwood near the confluence of Duck Creek and Little Duck Creek. All of these parks and other maintained greenspaces are located in the Little Duck Creek Watershed (W5) (**Figure 22**).

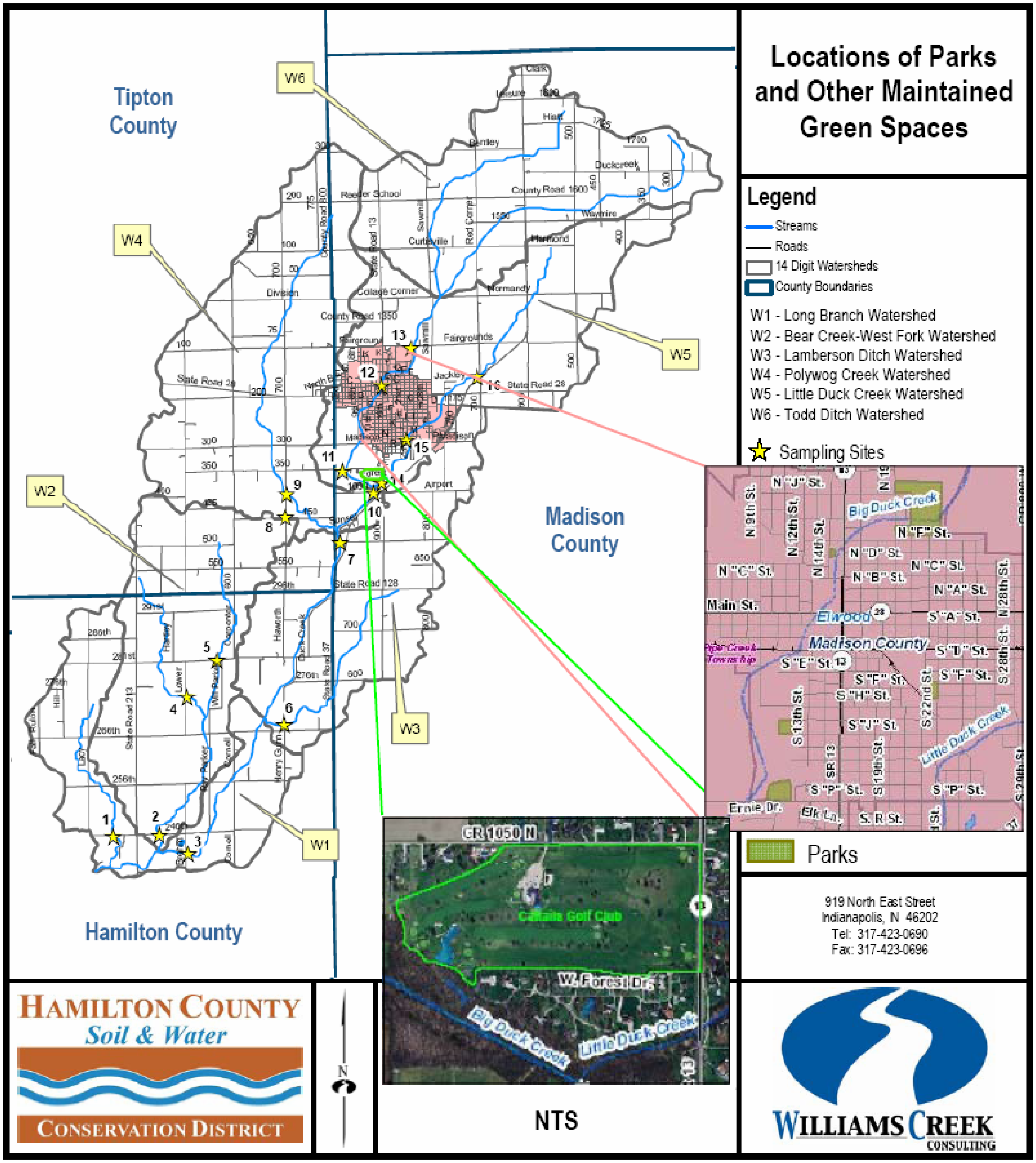


Figure 22. Locations of Parks and the Cattails Golf Club in the Duck Creek Watershed

The community expressed concern about the impact that the expansion of the nine hole course into an eighteen hole course would have on water quality. However, after researching the architect, Ron Kern, it was found that he places a strong emphasis on preserving the natural landscape. His past work as a drainage engineer has given him experience working with regulatory agencies regarding floodways, wetlands and other related environmental concerns. Also, WCC was involved with the permitting and construction of this project. WCC delineated the floodway, floodplain, and watershed for the site and coordinated with all necessary regulatory agencies to obtain all required permits. WCC also completed the grading plan, and determined that the site development was completed in a manner that would not increase flooding up-gradient or down-gradient from the site. A Rule 5 Erosion Control Plan that was in compliance with all IDEM standards was prepared by WCC. These management practices reduce nutrient loading from the golf course, therefore reducing the concern. Although precautions were taken during construction to reduce sediment loading, golf courses typically create high nutrient loads associated with fertilizer use. There have been adequate forested buffers left along the portions of the Duck Creek and Little Duck Creek which are adjacent to the golf course and also surrounding the small ditch which drains from the golf course to Duck Creek. These buffers should help remove most of the nutrients in the runoff from the golf course before entering the streams.

3.5 AGRICULTURE

Agriculture is by far the predominate land use in the Duck Creek Watershed; therefore a more thorough investigation into this land use was conducted.

3.5.1 Tillage Practices

Tillage transects are surveys conducted by the Indiana Conservation Partnership to assess tillage trends within each county. Tillage trends are a valuable tool in determining projected sediment erosion rates. The transects look at approximately 450 predetermined sites throughout the county to measure the amount of crop residue after crop planting.

Tillage Data

In the spring of 2004, Hamilton, Madison, and Tipton Counties conducted tillage surveys. All three of these counties have high conventional till rates for corn, but all have high no-till rates for soybeans. Included is a summary of trends associated with the adoption of no-till crop production, crop residue cover and soil loss (Lake et. al. 2000). This data was obtained as a result of spring surveys of Indiana cropland. In an “average sized” Indiana county, a sample size of 450 crop fields produces a 95 percent level of confidence (Hill 1995).

Figures 23 through 25 show till trends in each of the three Duck Creek Watershed counties for 2004 (*Indiana State Department of Agriculture Division of Soil Conservation*). The windshield survey conducted as part of preparing this watershed management plan concurs in general with the 2004 tillage transect data. Example photos of different tillage practices are shown on **Figures 26 through 28**.

Although the tillage transects reflect comparisons for the entire county, windshield tours of the Duck Creek Watershed revealed that most tillage completed in the three counties is completed in the spring. This means the soil remains covered with residue during the fall, winter, and early spring providing more soil protection and less erosion.

No-till Trends

No-till is defined by NRCS as the practice of managing the amount, orientation, and distribution of crop residue on the soil surface year-round. Crops are then planted in the untilled seedbed of the previous crop. No-till revolutionized the industry of agricultural production during the 1990s. Less than 10 percent of all cropland was managed in a no-till system in 1990. Initially, corn was considered the better adapted crop for no-till. In 1990, the percentage of crops managed in a no-till system were nine and eight percent for corn and soybean, respectively. By 1992, the curves for corn and soybean no-till adoption were diverging.

Soybeans were better adapted to the no-till environment than the corn hybrids of that time. Management skills for no-till corn were realized to be more demanding than for no-till soybean. The no-till drill facilitated a no-till soybean production boom. By 1995, Indiana became the first corn-belt state to produce more than half of its soybean acres on no-till managed fields.

While no-till is beneficial for soil conservation, it can result in an increased use of agricultural chemicals. Herbicides are used to treat weeds in no-till system that would be mechanically controlled in a conventional tillage system. Based on a Purdue University publication, no-till, however, reduces pesticide run-off by an average of 70 percent, water run-off by 69 percent, and soil erosion by 93 percent (Conservation Technology Information Center). Therefore, although no-till may require more herbicide use, it traps most of these and other chemicals before they can be transported to streams and ditches. Pairing buffer strips with no-till would increase the chemical, nutrient, and sediment removal efficiency rates.

Mulch Tillage

Mulch tillage is defined as any tillage system leaving 30 percent or more crop residue cover on the soil surface after planting. No-till is without question the most effective conservation practice for reducing soil erosion and improving water quality. The crop residue cover and infiltration rates associated with no-till maximize the volume reduction of agricultural runoff and contaminants, when compared to other conservation tillage systems. The 30 percent soil cover that is achieved by conservation tillage is significant to reducing soil erosion by 50 percent or more compared to bare soil. Soil erosion and runoff are considered by volume the greatest contaminant of surface water in most Indiana watersheds.

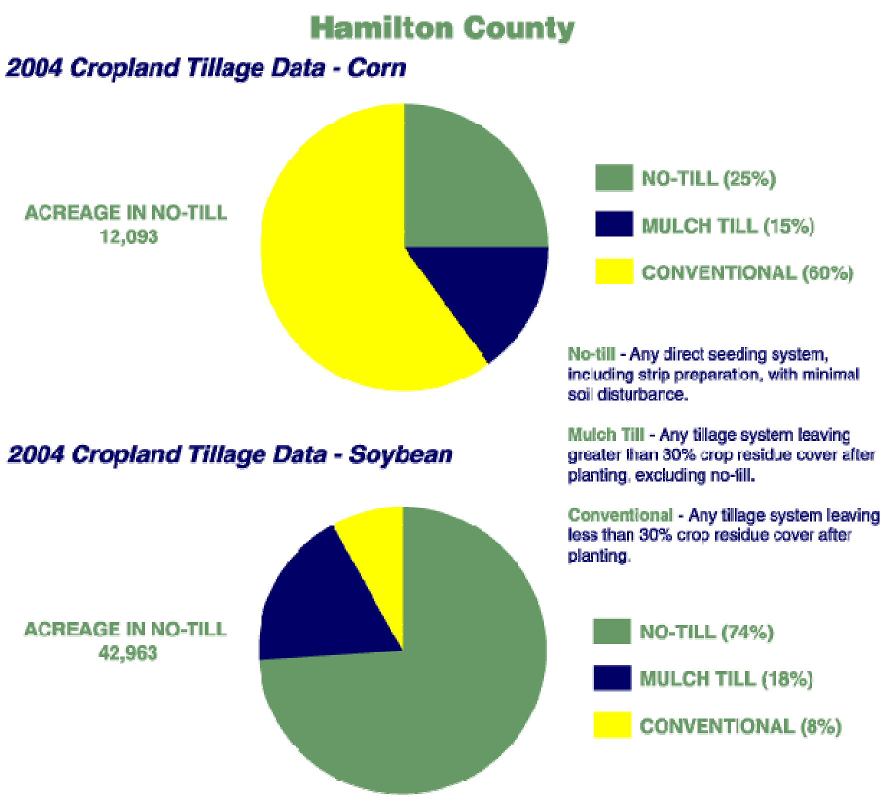


Figure 23. Hamilton County 2004 Tillage Data

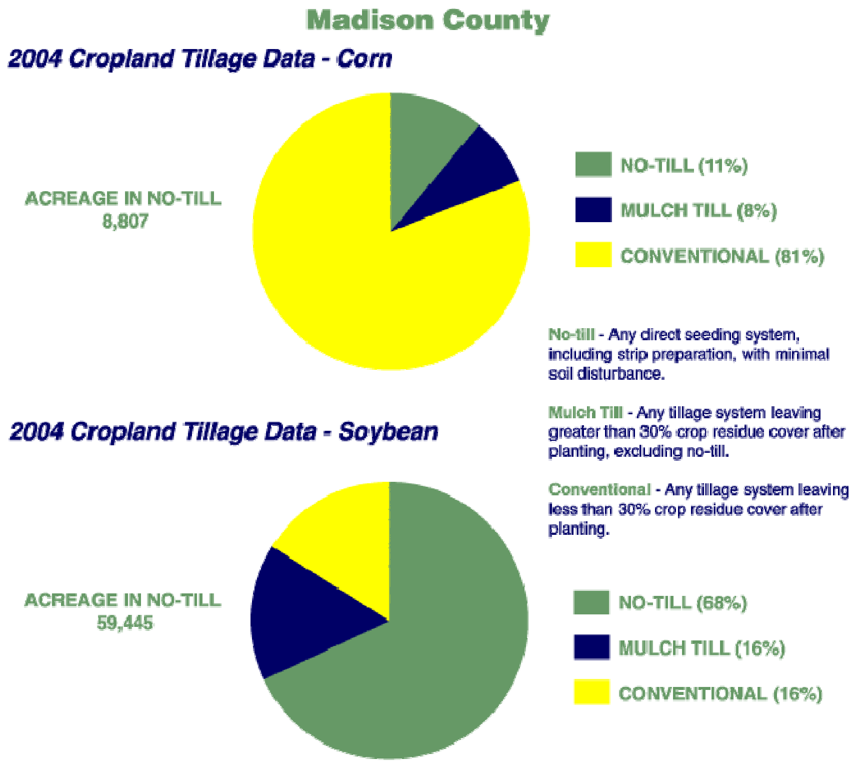


Figure 24. Madison County 2004 Tillage Data

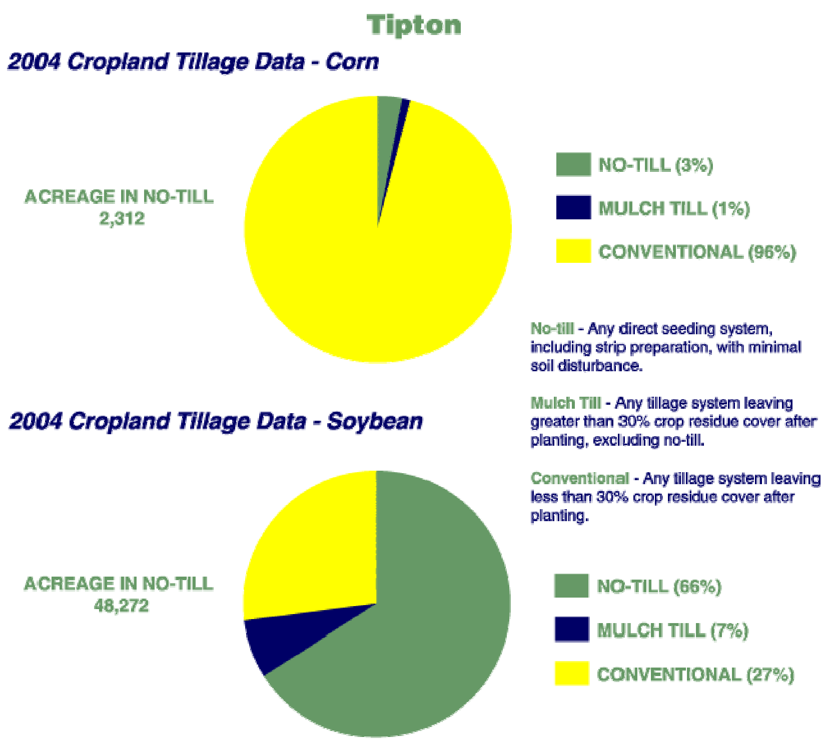


Figure 25. Tipton County 2004 Tillage Data

Figure 26. Conventional Tillage

Figure 27. Mulch Tillage

Figure 28. No-Till

3.5.2 Agricultural Chemicals

Agricultural fertilizers, herbicides, and pesticides are commonly applied to row crops in Indiana. The nutrients in these chemicals can be carried to streams through surface runoff and tile drains, especially if a rain event occurs before the chemicals have a chance to break down and be used by the crops.

As information on agricultural chemical use is not available for the Duck Creek Watershed, values were estimated based on Indiana usage. The National Agricultural Statistics Service (NASS), USDA collected the following information on agricultural chemical usage in Indiana in 2006; type, area applied, number of applications per year, and application rates. Corn and soybeans are the primary crops in Hamilton, Madison, and Tipton Counties, and between these three counties, approximately 47% of the cropland is planted to corn, while 53% is planted to soybeans (**Table 13**). Applying these percentages to the Duck Creek Watershed cropland, and using the statewide agricultural chemical data from the Office of Indiana State Chemist (2005), agricultural chemical usage for the Duck Creek Watershed was estimated (**Tables 14 and 15**).

Most of the fertilizers in the Duck Creek Watershed are applied to corn. Based on the estimations described above, corn receives 98% of the nitrogen and 87% of the phosphorus. The soil composition, tillage practices, crop types, crop rotations, and weather determine the fertilizer type and application method. Typically, two applications of nitrogen based fertilizers are applied a year to corn in Indiana, one at or just before planting, and another, larger application when corn is approximately one foot tall (Indiana Agricultural Statistics Service, 1992).

Herbicides and pesticides are also applied to crops, with herbicide application being the more prevalent of the two in Indiana. Atrazine is the top active ingredient in corn herbicides, while Glyphosate is the top active ingredient in soybean herbicides. An increase of herbicide use in Indiana is resultant of the increase of no-till farming practices in Indiana. Chemical testing was not conducted during this study to detect Atrazine or Glyphosate levels in the Duck Creek Watershed.

Table 13. Acres of Corn and Soybeans in Hamilton, Madison, and Tipton Counties (NASS USDA 2006)

Counties	Corn (Acres)	Soybeans (Acres)
Hamilton	52,100	57,000
Madison	80,500	98,600
Tipton	73,400	75,600

Table 14. Agricultural Chemical Usage for Corn in the Duck Creek Watershed

	Acres of Corn	Area Applied (%)	Applications (#/year)	Rate/Application (lbs./acre)	Rate/Crop Year (lbs./acre)	Total Applied Per Year (Mill. Lbs.)
Nitrogen	26,559	100	2.2	67	147	**3.9**
Phosphorus	26,559	93	1.4	56	77	**1.9**

Table 15. Agricultural Chemical Usage for Soybeans in the Duck Creek Watershed

	Acres of Soybeans	Area Applied (%)	Applications (#/year)	Rate/Application (lbs./acre)	Rate/Crop Year (lbs./acre)	Total Applied Per Year (Lbs.)
Nitrogen	29,950	16	1.0	16	17	**81,464**
Phosphorus	29,950	20	1.1	44	47	**281,530**

3.5.3 Tile Drains

Tile drains have been determined to affect water quality in many parts of Indiana. Newer tile drains usually consist of perforated, flexible tubes, while older tile drains are commonly clay tile. Information on the number and location of tile drain systems in Indiana is not available, but agricultural experts expect that nearly all poorly drained farmland contain tile drain systems (Schnoebelen et al., in press). Based on the majority of poorly drained soils and the heavy emphasis on agriculture in the Duck Creek Watershed, it can be assumed that most of the land in the watershed outside of Elwood is artificially drained. Tile drains short circuit infiltration into the soil and bypass riparian buffers, therefore transporting nutrient laden water directly to nearby ditches or streams. Tile drains can be particularly problematic to water quality if rainfall occurs shortly after the application of fertilizers or manure. Studies are being conducted that may link the hypoxic zone or "dead zone" in the Gulf of Mexico to high nitrogen loads from agricultural drainage in the Midwest to the Mississippi River. Numerous studies, including a Purdue University study, *Interpreting Nitrate Concentration in Tile Drainage Water*, have found high nitrogen concentrations in tile drains, and determined that agricultural fertilizers, manure application, conventional tillage, crop rotation, and the spacing of the tile drains all influence the amount of nitrogen entering tile drains (Bongen *et. al.*). **Figure 29** displays two tile drains outletting into a drain in the Duck Creek Watershed.

Figure 29. Tile Drains in the Duck Creek Watershed

SECTION 4.0 IDENTIFICATION OF WATERSHED ISSUES

Identification of watershed issues was conducted using public participation and an evaluation of baseline data. Results of these efforts are described in this section. Based on these two efforts, the steering committee formulated primary watershed issues to be addressed during implementation of this plan.

4.1 STAKEHOLDER INPUT

4.1.1 Watershed Partnerships

A steering committee was formed early in the development of the plan to guide the planning process. The steering committee consisted of representatives from the Hamilton, Tipton, and Madison County SWCD offices, the Hamilton County Surveyor's Office, Indiana Farm Bureau, IDEM, and Local Farmers, Residents, and Landowners. Appendix A includes a full list of the steering committee members; the Steering Committee Original Mailing List consisting of everyone that was invited to join the steering committee; and the mailing invitation for the Stakeholder Public Meeting. The Steering Committee met five times throughout the planning phase to address social issues, identify public outreach topics, identify problems and their sources, prioritize problems, develop goals, and create a management plan. During these meetings a total list of Watershed Partners/Stakeholders were discussed for potential future alliances (Appendix B).

WCC worked closely with the watershed coordinator for the Little Duck Creek Watershed Management Plan in order to coordinate efforts and ensure that the two plans complimented each other. WCC also partnered with Commonwealth Biomonitoring, who performed the macroinvertebrate sampling and habitat evaluation.

4.1.2 Public Outreach

Public participation is critical, not only in developing a WMP, but also in creating a connection between land use practices and water quality. Education and outreach are essential in establishing this connection of how everyday decisions affect water quality. Information was presented through targeted mailings, an interactive public participation meeting and workshop, postings to the Hamilton County SWCD's webpage, newsletters, and steering committee meetings.

Targeted Mailings

In an effort to provide better public understanding, a mailing describing the project was sent to over 800 residents within the watershed. A copy of the mailer is included in Appendix A

Public Participation Meeting

After the mailer distribution, a public meeting was held on December 13, 2006 to identify any concerns the public had regarding the watershed. Through open discussion, a list of these concerns was generated (**Table 16**). Those in attendance then participated in an activity in which they placed red, yellow, or green dots on the list next to a concern. The red dots meant the issue was of high priority, the yellow was of moderate concern, and the green indicated low priority.

Table 16. Public Meeting - Identified Concerns

Concern	Red	Yellow	Green
Log Jams	22	3	0
Dumping Waste in Waterways	9	2	0
Increase in Deer Numbers	8	2	0
Sediment Deposition Causing Flooding in Fields	6	8	2
Downed Trees Causing Soil Erosion	6	5	2
Sewer Discharge - Fish Kill	4	6	1
High Geese Numbers	4	3	1
Landowner Hunting	4	0	5
Industrial Discharge	3	2	1
Streambank Erosion	1	7	2
Loss of Farmland	1	6	1
Flooding South of Elwood	1	0	0
Limited Fishing	0	4	5
Seasonal Roadway Flooding	0	0	10

4.2 BASELINE CONDITIONS

To help define and prioritize potential watershed issues, the planning team evaluated existing data, conducted limited sampling, and applied theoretical pollutant load models. Specifically, these efforts included:

1. Review of IDEM 305(b) and 303(d) water quality studies and the Total Maximum Daily Load (TMDL) Assessment - Data gathered through previous studies conducted in the past five years is a viable source of information that may be helpful in understanding the current conditions of the water quality within a watershed.
2. Water quality samples collected as part of a separate study of the Little Duck Creek Watershed.
3. Macroinvertebrate sampling and habitat evaluations conducted as part of this grant.
4. QHEI evaluations collected as part of a US Fish and Wildlife Service fish community and habitat assessment.
5. Windshield Survey of Watershed Features.
6. Pollutant load modeling.

4.2.1 IDEM 305(b) and 303(d) Water Quality Studies

2006 Indiana Integrated Water Quality Report

Section 305(b) of the federal Water Pollution Control Act (the Clean Water Act most recently amended in 1987) requires states to prepare and submit to the U.S. Environmental Protection Agency (U.S. EPA) a water quality assessment report of state water resources every two years. The Indiana Department of Environmental Management (IDEM), Office of Water Quality (OWQ) has prepared the 2006 Indiana Integrated Water Quality Report following the guidelines provided by U.S. EPA.

Results from this assessment determined support of designated uses for each stream according to U.S. EPA assessment guidelines (U.S. EPA 1997b). Sampling results allowed IDEM to assess the suitability of Duck Creek and its major tributaries for aquatic life use and primary contact use (**Table 17**). Five of twelve studied stream segments in the watershed failed to meet their designated aquatic life use, and all twelve studied segments failed to meet primary contact use criteria.

303(d) List of Impaired Waters

Section 303(d) of the Clean Water Act requires states to identify waters that do not or are not expected to meet applicable water quality standards with federal technology-based standards alone. States are also required to develop a priority ranking for these waters taking into account the severity of the pollution and the designated uses of the waters. The EPA approved Indiana's initial 303(d) list, and IDEM publishes and updates this list once every two years. **Table 18** lists relevant water bodies within the Duck Creek Watershed and on the 303(d) list. Impaired streams are shown on **Figure 30**.

Total Maximum Daily Load Assessment – E. coli

Primary contact use can be assessed by measuring *E. coli* concentrations. *E. coli* is one member of the fecal coli form bacteria group. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. For point discharges, the IAC sets the geometric mean standard at 125 *E. coli* colonies/100 milliliters and maximum standard at 235 *E. coli* colonies/100 milliliters in any one sample within a 30 day period.

As part of evaluating TMDLs, IDEM completed a draft of the Duck Creek TMDL Report for E. coli Bacteria, in which *E. coli* samples were collected from multiple stations within the Duck Creek Watershed. Geometric means for *E.coli* were calculated based on five samples collected over a thirty-day period at 16 locations within the Duck Creek Watershed. Of the 16 locations, only two met the 125 colony forming unit (cfu)/100ml standard. Results indicate that all areas sampled may not be consistently attaining their designated primary contact use goals (IDEM, 2005). **Figures 31 through 33** show *E. coli* sampling locations and results from the TMDL study. **Figure 31** illustrates the sampling sites that met the standard with yellow dots and the sites that did not meet the standard with red dots.

Table 17. IDEM 305(b) Site Specific Water Body Assessment

WATERBODY SEGMENT NAME	WATERBODY SEGMENT ID	14-DIGIT HUC	SIZE (MILES)	AQUATIC LIFE USE	PRIMARY CONTACT USE	FISH CONSUMPTION	DRINKING WATER USE	MOST RECENT ASSESSMENT DATE (yyyymmdd)
DUCK CREEK-TODD DITCH	INW0161_00	05120201060010	13.04	F	**N**	X		20030121
BIG DUCK CREEK	INW0162_T1228	05120201060020	6.81	X	**N**	X		20030410
DUCK CREEK - Elwood to Ltl Duck Cr	INW0162_T1028	05120201060020	2.63	**P**	**N**	X		20030121
LITTLE DUCK CREEK BASIN	INW0162_00	05120201060020	2.67	F	**N**	X		20010121
DUCK CREEK - Ltl Duck Cr to Polywog Cr	INW0163_T1029	05120201060030	1.22	**P**	**N**	X		20030121
POLYWOG CREEK	INW0163_00	05120201060030	8.19	F	**N**	X		20030121
DUCK CREEK	INW0164_T1030	05120201060040	4.48	**P**	**N**	X		20030121
LAMBERSON DITCH	INW0164_00	05120201060040	4.81	**N**	**N**	X		20030121
BEAR CREEK-WEST FORK BEAR CREEK	INW0165_00	05120201060050	11.37	F	**N**	X		20030122
LONG BRANCH	INW0166_T1227	05120201060060	4.28	F	**N**	X		20030122
DUCK CREEK	INW0166_T1031	05120201060060	4.14	**P**	**N**	X		20030410
DUCK CREEK	INW0166_00	05120201060060	1.71	F	**N**	X		20030122
F = fully supporting; N = not supporting; P = partially supporting; X = not assessed								

NOTES

Aquatic Life Use

IDEM Office of Water Quality believes that the most consistent way to evaluate overall use support is best represented by the stream miles supporting aquatic life use, which is a designated use in the Indiana Administrative Code. For these comprehensive assessments, a stratified random sampling design was used to computer generate sampling sites, which provided a representative sample set for each basin in the state. Fish community index of biotic integrity (IBI) was determined for each sampling location, and the results of each year's sample data set were analyzed to estimate the percentage of stream miles supporting aquatic life use for each basin. This approach allows IDEM to make statistically valid estimates of aquatic life use support for a large geographic area (e.g. a basin) with a relatively small number of representative samples. This probability-based approach to water quality monitoring and assessment as well as its advantages and limitations are described in more detail in the section on Surface Water Assessment.

Primary Contact Use

Primary contact refers to direct contact during recreational exposure to surface water (swimming, wading, or other direct contact). IDEM relied primarily on *E. coli* sampling results in making primary contact suitability assessments.

Table 18. IDEM's 2006 303(d) List of Impaired Water bodies for the Duck Creek Watershed

CATEGORY 4A WATERS

BASIN	14-DIGIT HUC	COUNTY	WATERBODY SEGMENT ID	WATERBODY SEGMENT NAME	IMPAIRMENT FOR WHICH TMDL HAS BEEN DEVELOPED
WEST FORK WHITE	5120201060020	MADISON CO	INW0162_00	LITTLE DUCK CREEK BASIN	*E. COLI*
WEST FORK WHITE	5120201060020	MADISON CO	INW0162_T1028	DUCK CREEK - Elwood to Ltl Duck Cr	*E. COLI*
WEST FORK WHITE	5120201060020	MADISON CO	INW0162_T1228	BIG DUCK CREEK	*E. COLI*
WEST FORK WHITE	5120201060030	MADISON CO	INW0163_00	POLYWOG CREEK	*E. COLI*
WEST FORK WHITE	5120201060030	MADISON CO	INW0163_T1029	DUCK CREEK - Ltl Duck Cr to Polywog Cr	*E. COLI*
WEST FORK WHITE	5120201060040	HAMILTON CO	INW0164_T1030	DUCK CREEK	*E. COLI*
WEST FORK WHITE	5120201060050	HAMILTON CO	INW0165_00	BEAR CREEK-WEST FORK BEAR CREEK	*E. COLI*
WEST FORK WHITE	5120201060060	HAMILTON CO	INW0166_00	DUCK CREEK	*E. COLI*
WEST FORK WHITE	5120201060060	HAMILTON CO	INW0166_T1031	DUCK CREEK	*E. COLI*
WEST FORK WHITE	5120201060060	HAMILTON CO	INW0166_T1227	LONG BRANCH	*E. COLI*
WEST FORK WHITE	5120201060040	HAMILTON CO	INW0164_00	LAMBERSON DITCH	*E. COLI*
WEST FORK WHITE	5120201060040	HAMILTON CO	INW0164_00	LAMBERSON DITCH	IMPAIRED BIOTIC COMMUNITIES

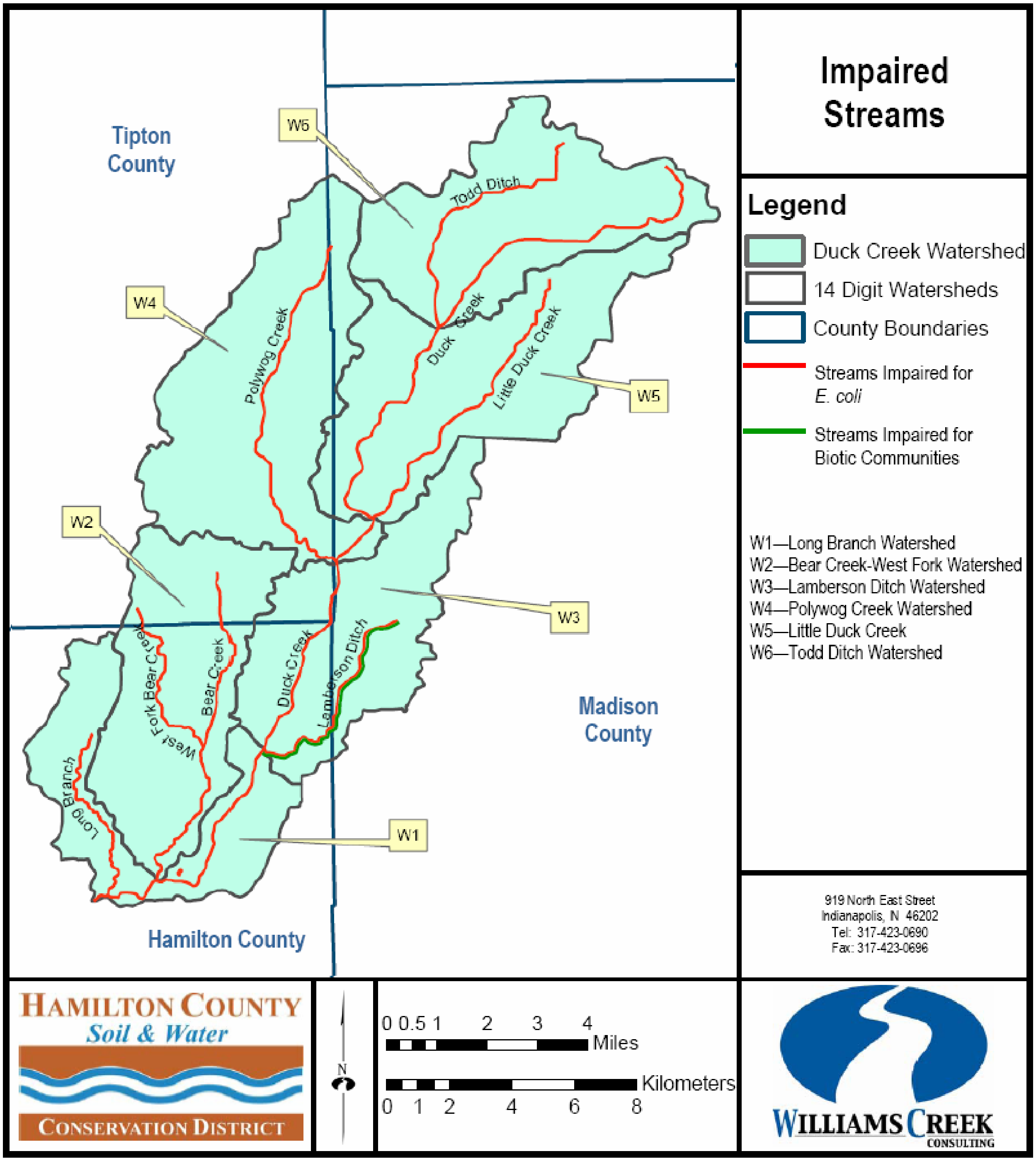


Figure 30: Impaired Streams within the Duck Creek Watershed (Indiana GIS Map using IDEM Data)

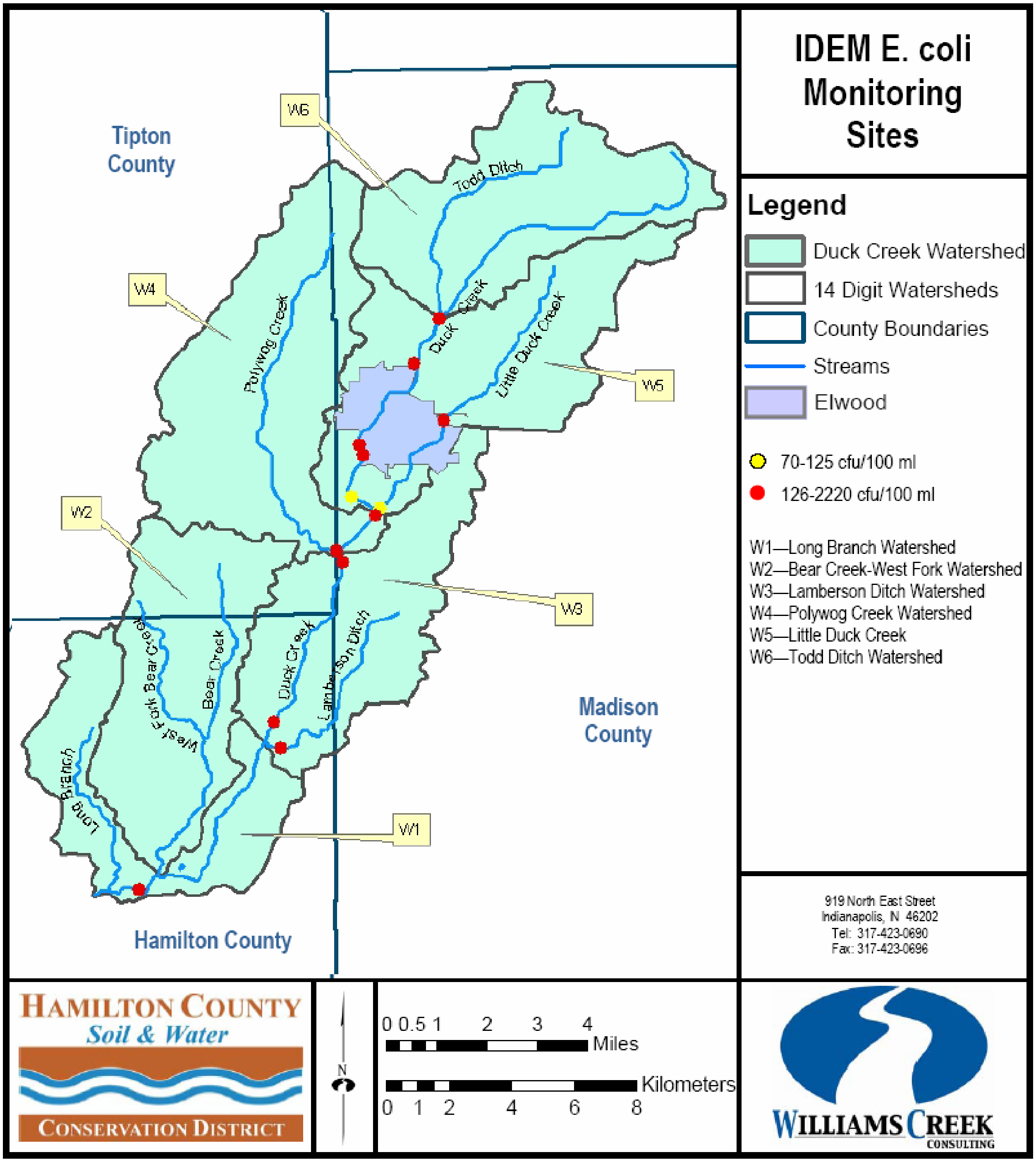


Figure 31. IDEM TMDL Draft Report *E. coli* Monitoring Sites

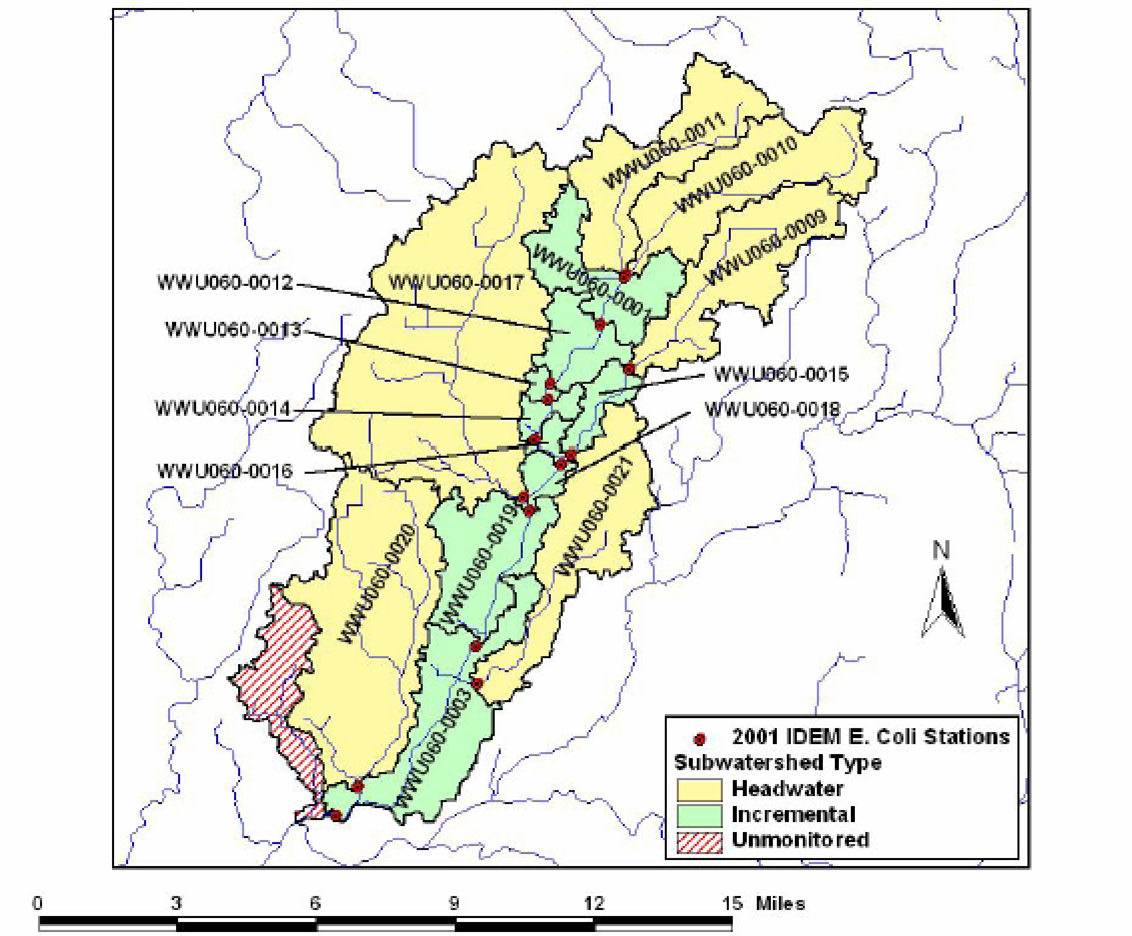


Figure 32. Subwatersheds Delineated for the TMDL Study

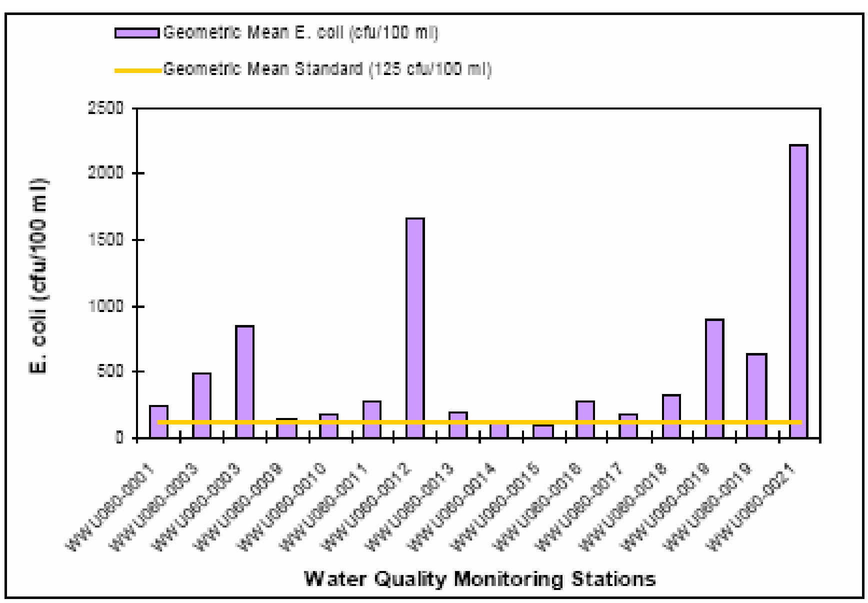


Figure 33. Geometric Mean for *E. coli* for Monitoring Stations in Duck Creek Watershed

4.2.2 Water Quality Sampling in the Little Duck Creek Watershed

No water chemistry sampling was conducted as part of the Duck Creek Watershed Management Plan; however, as part of a separate study for the Little Duck Creek watershed, water chemistry was sampled at six locations. Sites 11, 12, and 13 were located on Big Duck Creek, and Sites 14, 15, and 16 were on Little Duck Creek (**Figure 34 and Table 19**). The Little Duck Creek data represents the Little Duck Creek watershed at a certain point in time and may not be reflective of the entire Duck Creek Watershed.

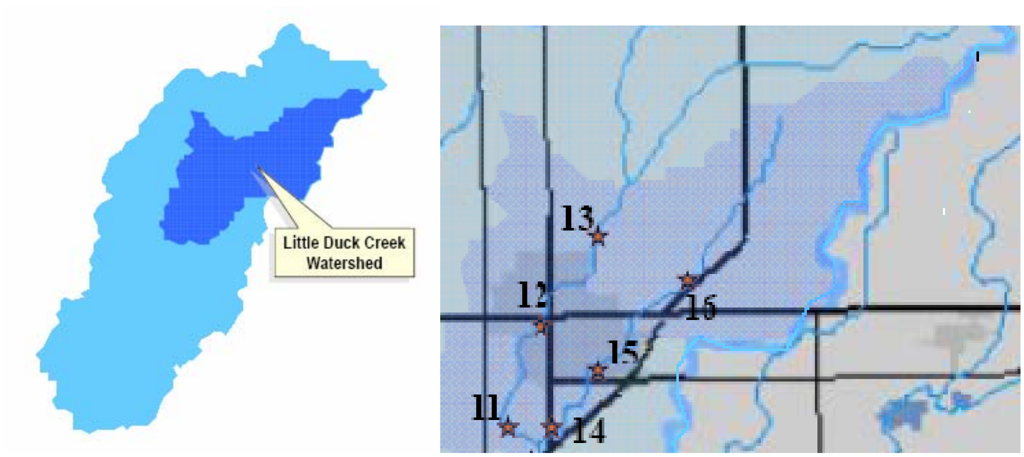


Figure 34. Water Quality Sampling Locations from Little Duck Creek Watershed Study

Table 19. Little Duck Creek Watershed Study Sampling Locations
(Data Source: Little Duck Creek DRAFT WMP)

Site #	Creek	Location
11	Duck Creek	CR 1050 North, Madison Co.
12	Duck Creek	SR 13, Madison Co.
13	Duck Creek	CR 1300 North, Madison Co.
14	Little Duck Creek	SR 13, Madison Co.
15	Little Duck Creek	CR 1100 North, Madison Co.
16	Little Duck Creek	CR 700 West, Madison Co

Little Duck Creek Watershed Study Sampling Summary

Various parameters were measured over a two year period (2005-2006) including Total Suspended Solids, Nitrate, Ammonia, Phosphorus, *E. coli*, Dissolved Oxygen, and Turbidity. Six sets of samples were collected during normal flow conditions, and two sets of water chemistry samples were collected during a period of more than one inch of rain in a 24-hour period. **Table 20** lists sampling results and whether they exceed the minimum water quality standards used in the Little Duck Creek WMP. Because Indiana does not have numeric nutrient criteria for all the parameters tested in this study, other standards were used. **Table 21** shows the standards used in the Little Duck Creek WMP. These standards differ from those used in this WMP as later designated in Section 4.2.6.

Table 20. Water Quality Sampling Results from 2005-2006 Little Duck Creek Watershed Study
(Data Source: Little Duck Creek DRAFT WMP)

Site	Date	Timing	TSS (mg/L)	NO3-N (mg/L)	NH4-N (mg/L)	TP (mg/L)	*E. coli* (col/100 mL)	DO (mg/L)	Turbidity (NTU)
11	8/3/05	base	3.3	7.624	0.029	0.290	12,096	6.4	1.8
	9/6/05	base	5.3	5.411	0.144	0.637	600	5.7	2.0
	9/26/05	storm	43.2	0.365	0.221	0.269	141,360	4.5	23.5
	10/19/05	base	1.5	5.487	0.107	0.527	518	6.2	0.8
	5/9/06	base	1.8	7.587	0.018	0.071	60	9.1	2.2
	6/15/06	base	6.2	13.782	0.173	0.148	623	10.6	2.4
	7/12/06	storm	3.3	4.368	0.512	0.283	241,920	5.1	2.3
	8/2/06	base	3.0	4.059	0.241	0.808	1,218	5.7	1.9
12	8/3/05	base	1.8	0.043	0.048	0.063	149	6.9	1.6
	9/6/05	base	3.5	0.075	0.116	0.142	10	4.1	2.0
	9/26/05	storm	73.5	5.852	0.100	0.063	2,063	4.4	42.0
	10/19/05	base	23.5	0.268	0.096	0.109	172	7.5	3.5
	5/9/06	base	1.8	8.402	0.018	0.024	1,032	8.4	2.4
	6/15/06	base	4.0	14.806	0.033	0.055	572	11.2	1.7
	7/12/06	storm	2.7	5.380	0.149	0.044	960	5.4	3.1
	8/2/06	base	10.8	0.027	0.044	0.233	63	5.6	2.6
13	8/3/05	base	5.3	0.146	0.120	0.090	180	8.9	2.5
	9/6/05	base	2.5	0.020	0.081	0.073	20	12.9	2.0
	9/26/05	storm	78.2	7.094	0.090	0.015	7,481	4.9	44.0
	10/19/05	base	2.9	0.259	0.057	0.068	142	15.2	2.2
	5/9/06	base	1.4	8.245	0.018	0.014	312	13.1	1.8
	6/15/06	base	3.5	14.571	0.034	0.045	228	12.2	1.6
	7/12/06	storm	8.6	5.670	0.080	0.034	1,017	6.3	2.8
	8/2/06	base	6.8	0.042	0.096	0.140	31	9.2	2.4
14	8/3/05	base	2.0	7.250	0.059	0.260	12,096	6.9	2.3
	9/6/05	base	2.1	0.186	0.109	0.120	480	6.2	3.3
	9/26/05	storm	24.8	7.860	0.203	0.025	38,730	6.2	15.0
	10/19/05	base	3.0	0.412	0.138	0.127	2,652	6.5	3.6
	5/9/06	base	3.4	5.455	0.018	0.034	677	8.7	3.3
	6/15/06	base	3.6	12.456	0.054	0.073	1,301	8.8	1.6
	7/12/06	storm	2.3	5.518	0.082	0.085	11,199	6.6	4.4
	8/2/06	base	4.2	0.364	0.069	0.190	1,090	7.0	2.6
15	8/3/05	base	19.2	0.836	0.018	0.176	194	12.5	7.3
	9/6/05	base	12.9	0.246	0.212	0.234	366	4.5	8.7
	9/26/05	storm	23.0	7.395	0.050	0.070	3,873	5.5	18.0
	10/19/05	base	5.8	0.358	0.045	0.198	82	7.6	1.5
	5/9/06	base	4.8	6.716	0.027	0.041	12,096	6.6	2.5
	6/15/06	base	8.0	13.801	0.079	0.066	1,628	8.3	3.2
	7/12/06	storm	8.2	6.135	0.099	0.106	2,909	5.5	1.4
	8/2/06	base	43.6	0.373	0.033	0.504	386	8.1	10.3
16	8/3/05	base	1.8	0.072	0.084	0.185	508	12.3	4.1
	9/6/05	storm	No samples collected-stagnant water						
	9/26/05	storm	21.4	9.557	0.072	0.021	2,909	6.0	18.0
	10/19/05	base	7.8	2.671	0.110	0.118	556	18.2	2.0
	5/9/06	base	1.8	7.759	0.018	0.010	139	15.2	1.7
	6/15/06	base	2.4	14.423	0.059	0.041	1,724	13.1	1.3
	7/12/06	storm	2.5	7.838	0.070	0.034	984	5.7	11.9
	8/2/06	base	34.4	0.013	0.072	0.460	221	13.2	10.2

Notes: Value in excess of water quality targets listed in Table 21 (■).

Table 21. Water Quality Targets Used in the Little Duck Creek WMP

Parameter	Target	Unit
Total Suspended Solids (TSS)	50	mg/L
Nitrate (NO3)-Nitrogen	1.5	mg/L
Ammonium (NH4)-Nitrogen	0.5	mg/L
Total Phosphorous (TP)	0.17	mg/L
E. coli	235	CFU/100 ml
Dissolved Oxygen (DO)	5	mg/L
Turbidity	9.89	NTU

Results of the Little Duck Creek Watershed Study Sampling

Total Suspended Solids (TSS)

Streams throughout the Little Duck Creek Watershed possessed elevated TSS concentrations on several occasions; however, only two of the samples exceeded 50 mg/L, the target used for the Wabash River Nutrient and Pathogen TMDL.

Nitrate (NO3)-Nitrogen

Nitrate-nitrogen concentrations during base and storm flow conditions were elevated throughout the watersheds. In both 2005 and 2006, the majority of the samplings within the Little Duck Creek watershed exceeded the target of 1.5mg/L, and all sites exceeded the target at least once.

The high nitrate concentrations and resultant productivity in these tributaries may be altering the tributaries' biotic community structure and impairing aquatic life in the tributaries. These pollutant levels may also prevent the use of these tributaries by mainstem biota as refuges.

Ammonium (NH4)-Nitrogen

Ammonium-nitrogen concentrations exceeded the target concentration of 0.5 mg/L only once during sampling.

Phosphorus

Under both base and storm flow conditions, total phosphorus concentrations were generally high in the Little Duck Creek Watershed. At all of these sampling sites total phosphorus concentrations exceeded the target for total phosphorus of 0.17 mg/L, the target used for the Wabash River Nutrient and Pathogen TMDL.

E. coli

E. coli concentrations exceeded the Indiana state standard of 235 cfu/100 ml for state waters at least once at every sampling site during each sampling season (2005 and 2006). Little Duck Creek at SR 13 exceeded the state standard during all eight sampling events, Big Duck Creek at CR 1050N exceeded the state standard during seven of the eight sampling events. Only Big Duck Creek at CR 1300N exceeded the state standard during less than half of the sampling events.

Dissolved Oxygen (DO)

Dissolved oxygen is a measure of the amount of oxygen available for biological respiration by fish and other aquatic organisms. The Indiana state minimum standard for DO is 5 mg/L in warm water streams.

Fish kills were cited as a potential concern in this watershed by public participants in the study. These often occur when dissolved oxygen levels suddenly drop below their normal levels in an area of stream. However, data from the Little Duck Creek watershed study showed DO samples in all streams exceeded the Indiana state minimum warm water standard of 5 mg/l at all sites in the Little Duck Creek watershed indicating that oxygen was sufficient to support aquatic life.

All of the sampling sites, with the exception of the two headwater sites within Little Duck and Big Duck Creeks, possessed saturation levels (84-95%), which is within the typical range for streams the size of Little Duck. However, Big Duck Creek at CR 1050N (Site 11) and Little Duck Creek at South P Street routinely exhibited dissolved oxygen saturation levels less than 60%.

Turbidity

All sampling sites exceeded USEPA recommended nutrient criteria turbidity levels of 9.89 NTU at least once during the 2005 sampling events. The highest turbidity was recorded at most sites during the August 2005 storm event. In 2006, none of the Big Duck Creek sampling sites exhibited turbidity levels above the recommended criteria, while the Little Duck Creek at CR 1100N and 700W sampling sites both possessed turbidity levels in excess of the recommended criteria at least once during the 2006 sampling events.

4.2.3 Macroinvertebrate Sampling and Habitat Evaluations for the Duck Creek Watershed

Although no water chemistry sampling was conducted as part of the Duck Creek Watershed Management Plan, macroinvertebrate sampling and habitat evaluations were completed. Because they are considered to be sensitive to local conditions and respond relatively rapidly to changes in environmental conditions, the Hamilton County SWCD chose to use benthic macroinvertebrate monitoring as part of its data-gathering. Benthic (bottom-dwelling) organisms are a commonly used tool in documenting the biological condition of streams. The Duck Creek 2006 Benthic Report completed by Commonwealth Biomonitoring is included as Appendix C.

Sampling Locations

To better define baseline conditions in the Duck Creek Watershed, ten additional sampling locations were selected to supplement data collected as part of the IDEM 305(b), 303(d), and Little Duck Creek studies. Benthic macroinvertebrates were sampled from and habitat assessments were conducted at these ten sites and also from the six Little Duck Creek sites. **Table 22 and Figure 35** list and show the locations of these 16 sites. Photos of these sampling sites are included as Appendix D.

Table 22. Benthic Macroinvertebrate Sampling Locations

Site #	Stream	Subwatershed	Location
1	Long Branch	Long Branch (W1)	246th St., Hamilton Co.
2	Bear Creek	Bear Creek (W2)	246th St., Hamilton Co.
3	Duck Creek	Long Branch (W1)	Brehm Rd., Hamilton Co.
4	Bear Creek West Fork	Bear Creek (W2)	Lower Rd., Hamilton Co.
5	Bear Creek	Bear Creek (W2)	286th St., Hamilton Co.
6	Lamberson Ditch	Lamberson Ditch (W3)	Henry Gunn Rd., Hamilton Co.
7	Duck Creek	Lamberson Ditch (W3)	CR 900 North, Madison Co.
8	Polywog Creek West Fork	Polywog Creek (W4)	CR 700 North, Tipton Co.
9	Polywog Creek East Branch	Polywog Creek (W4)	CR 700 East, Tipton Co.
10	Duck Creek	Polywog Creek (W4)	CR 1000 North, Madison Co.
11	Duck Creek	Little Duck Creek (W5)	CR 1050 North, Madison Co.
12	Duck Creek	Little Duck Creek (W5)	SR 13, Madison Co.
13	Duck Creek	Little Duck Creek (W5)	CR 1300 North, Madison Co.
14	Little Duck Creek	Little Duck Creek (W5)	SR 13, Madison Co.
15	Little Duck Creek	Little Duck Creek (W5)	CR 1100 North, Madison Co.
16	Little Duck Creek	Little Duck Creek (W5)	CR 700 West, Madison Co

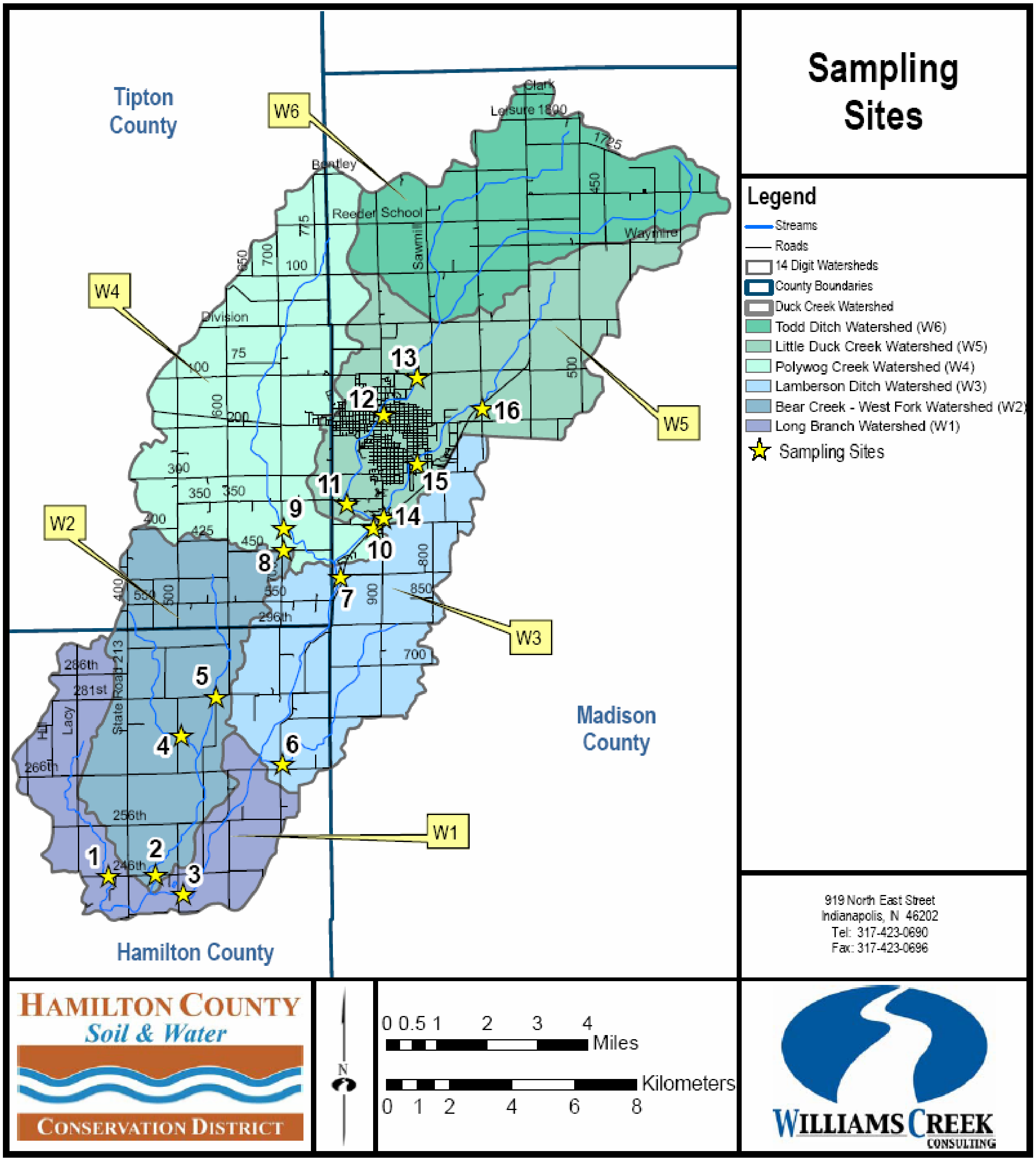


Figure 35. Benthic Macroinvertebrate Sampling Locations

Sampling and Habitat Evaluation Methods

Two methods were used to evaluate aquatic life support capabilities – the Macroinvertebrate Index of Biotic Integrity (m-IBI) and the Qualitative Habitat Evaluation Index (QHEI)

Macroinvertebrate Index of Biotic Integrity (m-IBI)

Sites 1 thorough 10 were sampled October 24 and 25, 2006 by use of a kick-net in riffles where the current speed approached 30 cm/sec. A duplicate sample was taken at site three for quality control purposes. All samples were preserved on-site with 70% isopropanol.

In the laboratory, organisms were separated from debris by visual examination and identified to the family level. The data set was analyzed according to the IDEM, Family Level Macroinvertebrate Index of Biotic Integrity. This method uses a set of ten metrics to evaluate the biological condition of a stream. Each metric is assigned a score of 0, 2, 4, 6, or 8 (8 is best, summed to give an overall score, and then divided by ten (range 0 to 8). Sites with scores greater than four are considered to be fully supporting of aquatic life use, while those between four and two are partially supporting, and those with scores less than two are non-supporting. The scores for the two replicates at site three were averaged.

The metric “Family Level HBI” refers to the Hilsenhoff Biotic Index [2], which was developed based on the varying tolerances of benthic organisms to organic pollution. The term “EPT taxa” refers to Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies), insect orders that are considered to be sensitive to environmental degradation. Conversely, chironomids (midges) are considered to be more tolerant of environmental degradation. The last metric, “total number of individuals to number of squares sorted” is a measure of organism abundance in the sample.

Qualitative Habitat Evaluation Index (QHEI)

The aquatic habitat at each study site was evaluated according to the method described by Ohio EPA [3]. This Qualitative Habitat Evaluation Index (QHEI) assigns values to various habitat parameters (e.g. substrate quality, riparian vegetation, channel morphology, etc.), which are then summed to result in a numerical score for each site. Higher scores indicate higher habitat value. The maximum value for habitat using this assessment technique is 100. According to IDEM, sites with a QHEI greater than 64 are fully supporting of aquatic life use, those between 51 and 64 are partially supporting, while those less than 51 are non-supporting.

m-IBI and QHEI Results and Discussion

Table 23 and Figure 36 display the data and calculated m-IBI and QHEI scores for each of the 16 sampling sites. Sites with m-IBI scores greater than four are considered to be fully supporting of aquatic life use, while those between two and four are considered partially supporting, and those with scores less than two are non-supporting.

Higher QHEI scores indicate higher habitat value. The maximum value for habitat using this assessment technique is 100. According to IDEM, sites with a QHEI greater than 64 are fully supporting of aquatic life use, those between 51 and 64 are partially supporting, while those less than 51 are non-supporting. **Figure 37** shows which sites were fully, partially, or non-supporting of aquatic life based on both m-IBI and QHEI scores in relation to the watershed and to each other.

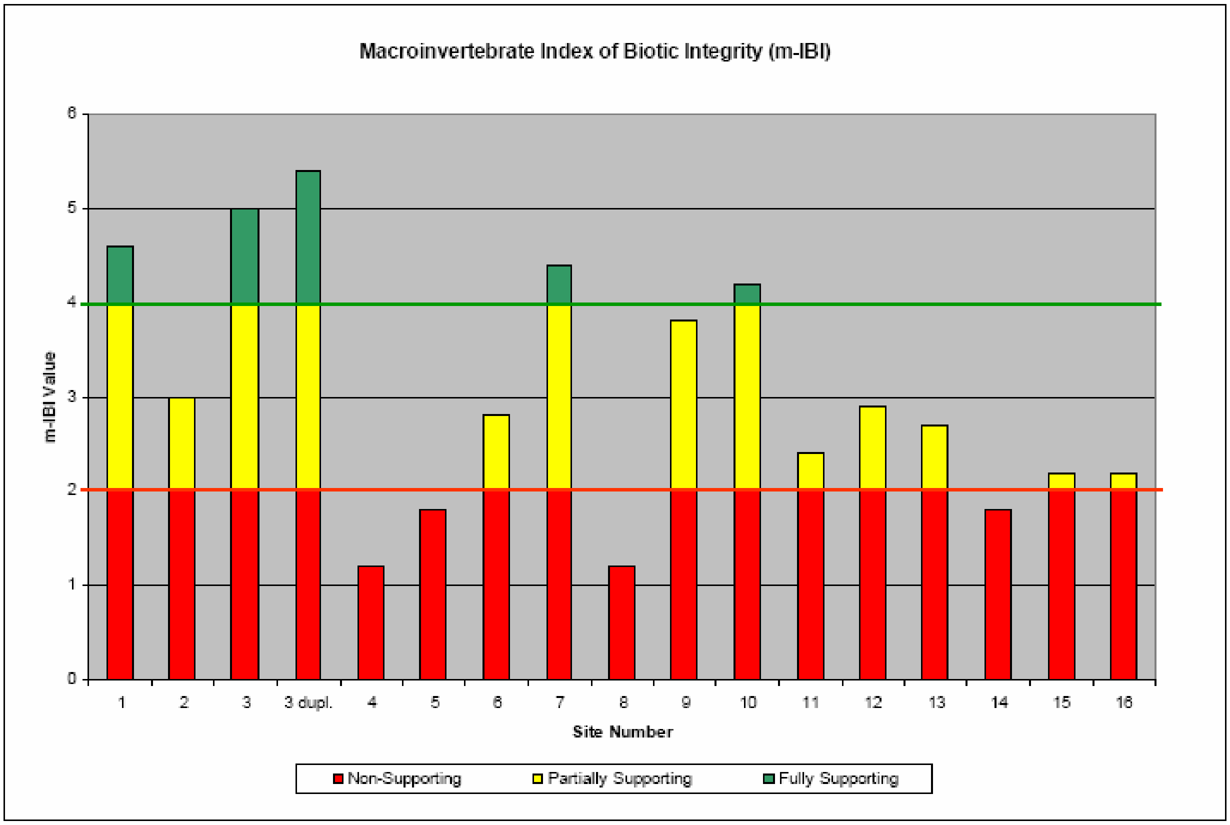
Aquatic life depends both on habitat and water quality. Life cannot thrive where habitat is lacking. The sites with the most degraded aquatic communities were 4 and 8. Both of these sites had low total numbers of organisms, low numbers and types of EPT taxa, and the dominant family was Chironomidae. The QHEI scores for these sites (42 and 45), and the m-IBI scores (both 1.2) are considered to be non-supporting of aquatic life uses. At Site 5, EPT taxa were almost absent, with only one mayfly individual present. Its m-IBI score (1.8) and QHEI (46) are both non-supporting of aquatic life uses. It is probable that all of these sites are affected both by degraded habitat and degraded water quality.

Based on the m-IBI and QHEI evaluations the following recommendations are noted. Reduce or eliminate sources of organic pollution in Bear Creek West Fork, lower Bear Creek and Pollywog Creek West Fork. Possible sources include failing septic systems and livestock wastes. Enhance habitat by planting riparian vegetation and increasing the amount of in-stream cover, especially at Bear Creek West Fork, Bear Creek at 286th street, un-named tributary at Henry Gunn Road, and Pollywog Creek. Protect Duck Creek and its un-named tributary at 246th street from future habitat destruction, such as channelization.

Table 23. Bioassessment Data

Data for Macroinvertebrate Metrics																	
Site Number	**1**	**2**	**3**	**3***	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Family HBI	4.3	4.8	4.1	4.1	5.7	5.1	4.6	4.24	5.3	4.6	4.5	5.5	6.7	6.0	5.3	5.8	6.8
No. Taxa	12	15	13	13	12	10	12	10	11	12	9	7	11	14	8	6	12
No. Individuals	331	191	198	284	90	135	210	246	75	195	308	18	74	68	75	17	80
% Dominant Taxon	52	32	67	72.9	72	37	48	71.1	41	28	69	38.9	37.8	23.5	54.7	41.2	36.3
EPT Index	5	4	5	3	3	1	4	4	3	4	1	2	2	2	2	3	1
EPT Count	207	53	149	216	9	1	32	184	6	94	211	8	35	14	20	7	15
EPT Count/No. Individuals	0.6	0.3	0.8	0.8	0.1	0.0	0.2	0.1	0.1	0.5	0.7	0.4	0.5	0.2	0.3	0.4	0.2
EPT Count/Chironomid Count	9.9	0.9	12.0	18.0	0.1	0.1	0.6	5.3	0.2	2.2	2.9	2.7	1.8	3.5	0.5	1.0	0.5
Chironomid Count	21	60	12	12	65	12	53	35	31	41	73	3	19	4	41	7	29
Total No. Individuals/No. Squares Sorted	17	10	10	14	5	7	11	12	4	10	15	NA	NA	NA	NA	NA	NA
Family HBI	6	4	6	6	0	2	4	6	2	4	6	2	0	0	2	0	0
No. Taxa	4	6	4	4	4	2	4	2	4	4	2	0	4	4	2	0	4
No. Individuals	6	4	4	6	2	4	4	6	0	4	6	0	0	0	0	0	2
% Dominant Taxon	2	4	4	6	2	4	4	6	0	4	6	4	4	6	2	4	4
EPT Index	4	4	4	2	2	0	4	4	2	4	0	0	0	0	0	2	0
EPT Count	8	4	6	8	0	0	2	6	0	6	8	0	2	0	2	0	0
EPT Count/ No. Individuals	6	2	8	8	0	0	2	6	0	6	8	4	6	2	2	4	2
EPT Count/ Chironomid Count	6	0	8	8	0	0	0	4	0	2	4	4	2	4	0	2	0
Chironomid Count	4	2	6	6	2	6	4	4	4	4	2	8	8	8	6	8	8
m-IBI Score	**4.6**	**3**	**5**	**5.4**	**1.2**	**1.8**	**2.8**	**4.4**	**1.2**	**3.8**	**4.2**	**2.4**	**2.9**	**2.7**	**1.8**	**2.2**	**2.2**

Qualitative Habitat Evaluation Index (QHEI) Values																	
Site Number	**1**	**2**	**3**		**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Substrate	17	15	19		14	14	15	15	14	15	15	15	-1	10	18	-1	12
Cover	6	10	14		3	4	4	10	5	4	10	8	15	7	7	6	3
Channel	14	14	14		7	8	8	13	8	8	13	9	6	6	8	7	5
Riparian	3	7	7		3	4	3	5	3	3	3	8	5	3.5	8.5	5.5	3
Pool/Current	5	7	10		4	5	5	9	5	5	9	4	9	0	0	5	4
Riffle/Run	5	6	7		5	5	5	6	3	8	6	0	0	0	4	4	3
Gradient	6	6	6		6	6	6	6	6	6	6	10	6	6	6	6	6
Total QHEI Score	**56**	**65**	**77**		**42**	**46**	**46**	**64**	**45**	**49**	**62**	**54**	**40**	**32.5**	**53.5**	**32.5**	**36**



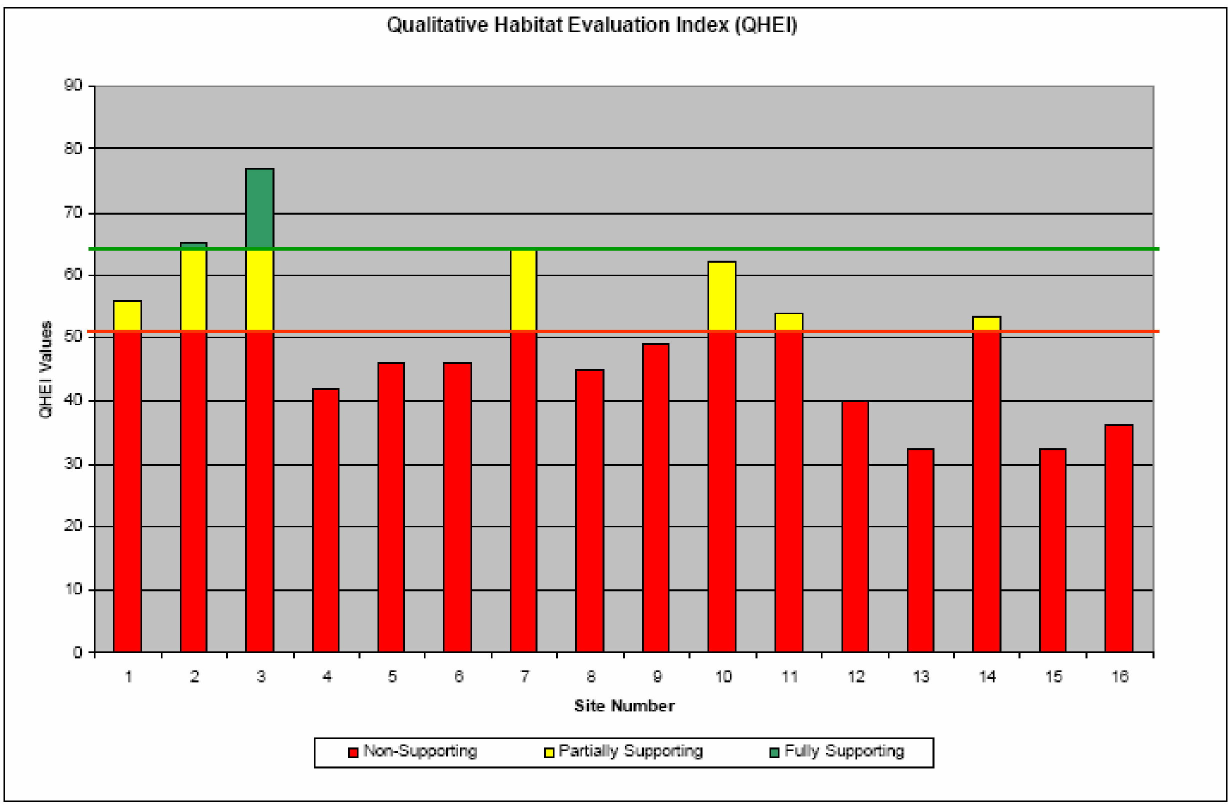


Figure 36. m-IBI and QHEI Results

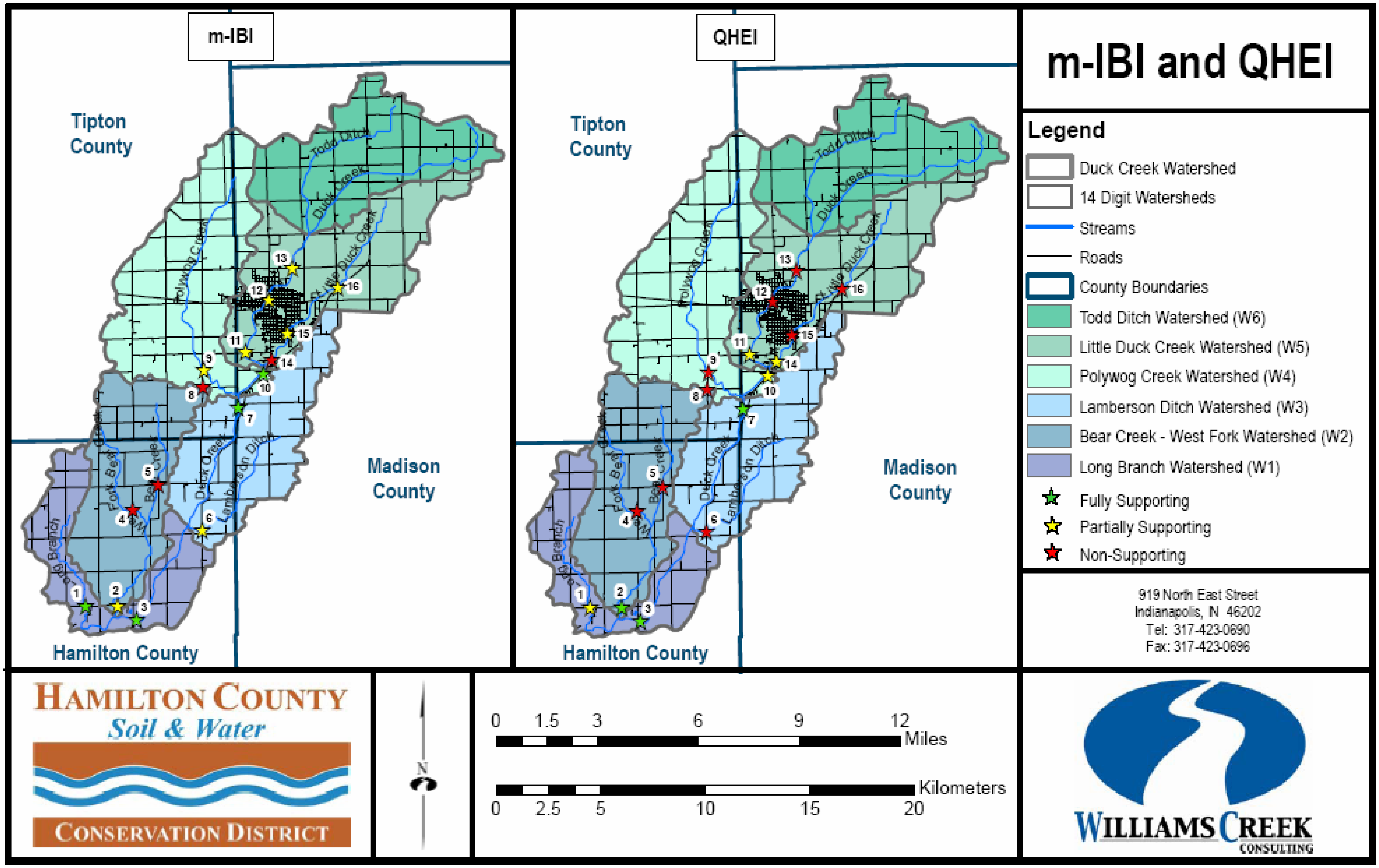


Figure 37. m-IBI (left) and QHEI (right) Aquatic Life Support Results

4.2.4 US Fish and Wildlife Service Fish Community and Habitat Assessment for the West Fork White River

Fish community and habitat assessments were conducted by the US Fish and Wildlife Service as part of the study titled *Assessing the Fish Communities and Habitat Quality of the Upper White River Tributaries from Indianapolis to Muncie, Indiana* (Simon, 2004). The study area was 77 stream reaches of the West Fork of the White River in the fish kill zone of 1999. Toxic wastewater was released in the West Fork White River, resulting in a devastating fish kill from the City of Anderson past downtown Indianapolis.

Habitat evaluations were conducted on August 20 and October 15, 2002 on all primary tributaries draining the West Fork White River in the fish kill zone. Fifteen of these sites were located in the Duck Creek Watershed. Only one of these sites was given a fully supporting QHEI score, and was located in the Long Branch watershed (W1). Five of the remaining sampling sites were partially supporting and nine were non-supporting. **Table 24** shows the number of fully, partially, and non supporting sampling sites were located in each subwatershed of the Duck Creek Watershed.

Table 24. QHEI Assessment from the 2002 US Fish and Wildlife Service Study

Subwatershed	Fully Supporting	Partially Supporting	Non-Supporting
W1	1	1	
W2		1	2
W3		1	
W4		1	2
W5		1	3
W6			2

4.2.5 Watershed Windshield and Desktop Survey

A windshield survey of the Duck Creek Watershed was conducted in order to locate potential sources of water quality degradation and to obtain a grasp on general trends within the watershed (**Figures 38 and 39**). On November 16, 2006 the Hamilton County SWCD and WCC conducted a windshield survey in the Hamilton County portion of the Duck Creek Watershed. The Tipton and Madison County portions were surveyed on January 30, 2007.

Noted observations included:

- areas with stream bank erosion, log jams
- livestock with access to the stream
- hobby farms
- animal feeding operations (AFOs, CFOs, and CAFOs)
- waste dumping sites
- areas with potentially malfunctioning septic systems
- lack of buffer strips
- tillage trends

Four log jams, which are the number one public concern, were observed during the windshield survey. Three of the log jams were located in the southern portion of the Lamberson Ditch watershed (W3) along Duck Creek and Lamberson Ditch, and the other log jam was located in the southern portion of the Long Branch watershed (W1) on Duck Creek. In general, these areas of stream bank erosion range form 40 to

200 feet in length and 8 to 30 feet in height. Log jams are a natural part of stream meandering. They may cause erosion in one area, but may stop erosion in another.

Areas where livestock have direct access to the stream were observed at six locations in the watershed. While only observed at a few sites throughout the watershed, livestock with stream access have been documented because they deposit fecal material in or near streams and may trample stream banks, which therefore makes them a potential source of *E. coli* and TSS. One was in the central portion of the Long Branch watershed (W1) on Long Branch near sampling site number one. Two areas were located in the central portions of Bear Creek – West Fork watershed (W2) on the west fork of Bear Creek at sampling site number four. The southern portion of Polywog Creek watershed (W4) contained two areas where livestock could enter the stream. One was on the unnamed tributary to Polywog Creek at sampling site number eight, while the other was on Polywog Creek at sampling site number nine. The final area was located in the southern portion of the Todd Ditch watershed (W6) on Todd Ditch just north of its confluence with Duck Creek.

A total of 27 hobby farms, which are small farms that are maintained without expectation of being a primary source of income, were observed throughout the watershed. The hobby farms observed in the Duck Creek Watershed were mainly farms with small numbers of livestock. The numbers were too small for manure spreading or overgrazing to be a concern. Locations where livestock had direct access to the stream were noted separately above. Small gardens were observed, but were not large enough to pose the threat of overfertilization. **Figure 38** shows them scattered throughout the watershed. Two hobby farms were located in the Long Branch watershed (W1), one in the western portion and one in the central portion. Bear Creek – West Fork (W2) contains six hobby farms, three in the north and three in the central portion. Four hobby farms were located in the Lamberson Ditch watershed (W3), three in the central and one in the northern portions. Polywog Creek watershed (W4) has two hobby farms in the southern portion, three in the central portion, and two in the north, for a total of seven in the entire watershed. Little Duck Creek watershed (W5) contains four hobby farms, two in the central and two in the northern portions of the watershed. There were also four in the Todd Ditch watershed (W6), all of which are in the central portion of the watershed.

There were a total of four active animal feeding operations in the Duck Creek Watershed all of which raise swine. Animal feeding operations with 600 or more hogs need to be permitted by IDEM as a confined feeding operation (CFO). Operations with 2,500 or more hogs that are greater than 55 pounds or 10,000 or more hogs that are less than 55 pounds must obtain a confined animal feeding operation (CAFO) permit. Operations with less than 600 swine are animal feeding operations (AFOs) and do not require a permit. A check of IDEM's records did not indicate that any of these operations violated their permit. There was one AFO, two CFOs, and one CAFO located in the Duck Creek Watershed. One was located in the Long Branch watershed (W1), and is permitted as a CAFO, but according to a local farmer, there are currently less than 200 hogs at this farm. A CFO with, according to a local farmer, approximately 600 hogs is located in the Polywog Creek watershed (W4). Todd Ditch watershed (W6) contains one AFO and a CFO with approximately 1,000 hogs.

Dumping waste in waterways, being of the next highest priority to the public, was observed in four locations. Two were in the southern portion of the Lamberson Ditch watershed (W3) along Duck Creek, one was located in the southern portion of the Little Duck Creek watershed (W5) on Duck Creek, and the fourth was in the northern portion of the Polywog Creek watershed on Polywog Creek. Items observed in these dumps included appliances, tires, bricks, concrete, and garbage.

Because permits were not required before 1978 to install septic systems and the permits obtained after that time are often imbedded in county records, information on the location and function of septic systems is not easily accessed or searched. It can however be assumed that any residences in rural areas of Indiana are not hooked up to sewer systems. Subsequently, most areas in the Duck Creek Watershed except Elwood presumably use septic systems. As stated in a Hoosier Environmental Council publication, "EPA has stated that a density of greater then 40 septic systems per square mile is a potential water quality problem." Therefore, 10 houses within a quarter square mile outside of known sewer service districts in the Duck Creek Watershed were considered a threat to the water quality and were identified as unsewered communities. Unsewered communities within the watershed were identified by aerial map investigation, visual assessment, and local resident knowledge. During the windshield survey, these communities were observed to be residential neighborhoods or clusters of roughly or more houses that may have been developed before the year 1978, when permits were not required to install a septic system. Consequently, most of the septic systems installed prior to this time are not currently up to code and many of them are failing. A steering committee member reported observing raw sewage in Duck Creek in the Lamberson Ditch watershed (W3). This raw sewage could be the result of failing septic systems upstream or from CSO discharges in Elwood. A total of 13 unsewered communities were identified within the Duck Creek Watershed. Four communities were located in the Long Branch watershed (W1), three along Duck Creek and one along Long Branch. Two communities were located in the Bear Creek watershed (W2) with one near the West Fork of Bear Creek. In the Lamberson Ditch watershed (W3), 3.5 communities were located along Duck Creek. There were 2.5 communities located in the Polywog Creek watershed (W4) with 1.5 along Polywog Creek. The final community was located in the Little Duck Creek watershed (W5).

The presence of grassed or forested buffers or the lack thereof was assessed first by desktop review of aerial maps and then confirmed during the windshield survey. Areas were only considered a buffer if it was grassed or forested at least 20 feet from top of bank on either side of the stream as stated in The U.S. Department of Agriculture, Natural Resource Conservation Service's *Conservation Practice Standard, Filter Strip, 393.* The buffers on the reaches of the Duck Creek located within the Long Branch (W1), Bear Creek – West Fork (W2), Lamberson Ditch (W3), and Polywog Creek (W4) watersheds were almost entirely forested. Within the Little Duck Creek (W5) and Todd Ditch (W6) watersheds, the buffers along the Duck Creek were mostly grassed or inadequate. The major headwater tributaries within the Duck Creek Watershed primarily had either grassed or inadequate buffers. Large reaches of streams with inadequate buffers include the upstream reaches of both Polywog Creek and Todd Ditch.

After reviewing the tillage transects for Hamilton, Madison, and Tipton Counties, WCC assessed tillage trends within the Duck Creek Watershed. It was observed that most tillage in the three counties is completed in the spring. This means the soil remains covered with residue during the fall, winter, and early spring providing more soil protection and less erosion. WCC estimated that an average of 28 percent of all cropland in the watershed for all three counties uses conservation tillage practices.

Farms for sale, in relation to the public concern of loss of farmland, were observed but not pinpointed. Other areas with log jams, eroding banks, livestock with direct access to stream, dumped waste, or malfunctioning septic systems may exist, however those pinpointed during the windshield survey were visible from roads or identified by local residents.

Land placed in conservation programs, such as the conservation reserve program (CRP) and the wetland reserve program (WRP). was observed from aerial maps, other desktop sources, and during the windshield survey. The exact locations of this land were not identified to protect the confidentiality of these programs; however, driving through the Duck Creek Watershed, one can readily see many areas planted to permanent vegetation and trees. Land planted to permanent vegetation reduces erosion and therefore sediment and nutrient loads.

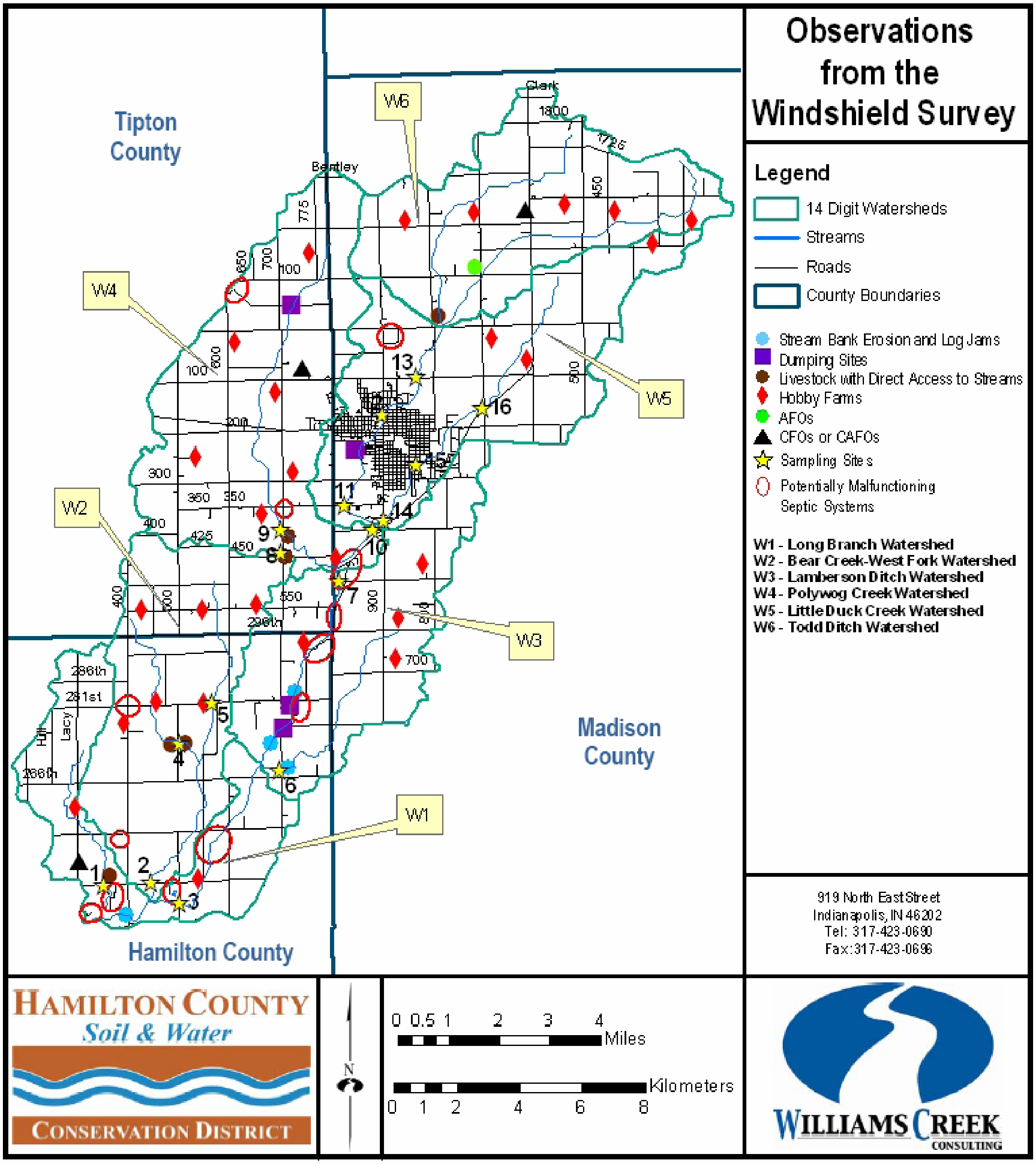


Figure 38. Observations from the Windshield Survey

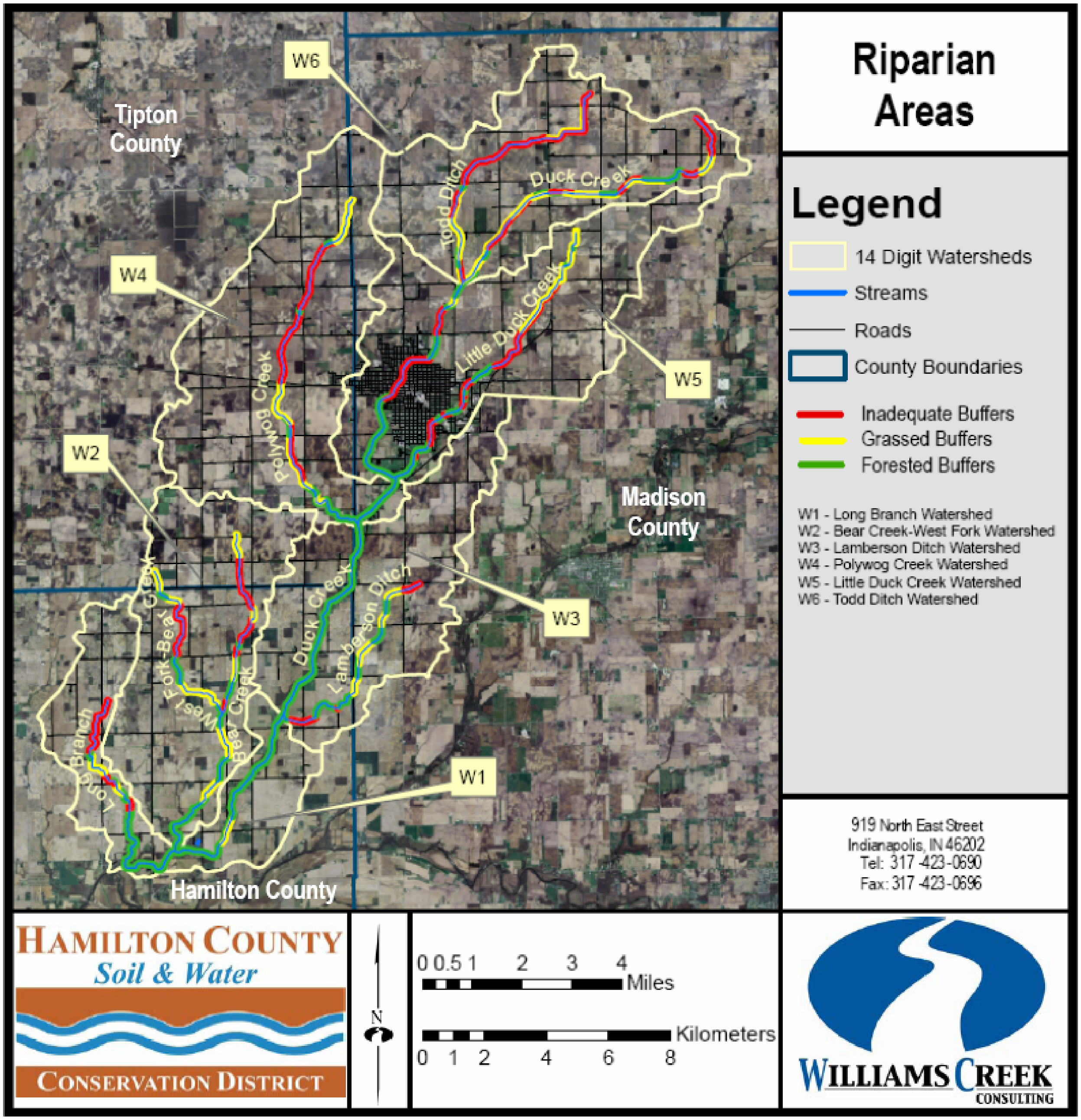


Figure 39. Riparian Areas with Inadequate Buffers, Grassed Buffers, or Forested Buffers

4.2.6 Pollutant Load Modeling

In order to help identify potential areas of concern within the watershed, The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was applied using available soil and rainfall data. IDEM recommended several computer modeling programs, which included STEPL (http://it.tetratech-ffx.com/stepl/default.htm). STEPL is a computer modeling program developed by the US Environmental Protection Agency. STEPL employs simple algorithms to calculate nutrient and TSS loads from different land uses and the load reductions that would result from the implementation of various BMPs. Using county rainfall and soil data, it computes watershed surface runoff and nutrient loads, including nitrogen, phosphorus, and 5-day biological oxygen demand (BOD5); and sediment delivery based on various land uses and management practices. For each watershed, the annual nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. The annual sediment load (sheet and rill erosion only) is calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using the known BMP efficiencies.

STEPL Input

STEPL uses watershed size, land use, agricultural animal data, onsite wastewater data, universal soil loss equation parameters, national weather service rainfall data, and soil type to generate pollutant loading rates. Input parameters used for this watershed plan are included in STEPL data in Appendix E. Sources for these inputs are described below.

Subwatershed Areas

Subwatershed areas were based on predelineated 14-digit HUC basins. The six subwatersheds are listed in **Table 25**.

Table 25. Subwatersheds – name, number and acreage

Watershed ID	Watershed Name	Area (acres)
W1	Long Branch	7223
W2	Bear Creek - West Fork Bear Creek	12637
W3	Lamberson Ditch	10329
W4	Polywog Creek	14402
W5	Little Duck Creek	12924
W6	Todd Ditch	11264

Land Use

There are six types of primary land use in STEPL – Urban, Cropland, Pastureland, Forest, User Defined, and Feedlots. Areas for each land use were derived using HYMAPS-OWL (2005, Purdue Research Foundation). The HYMAPS-OWL (http://cobweb.ecn.purdue.edu/~watergen/) is a web based interactive GIS database that allows the user to delineate watershed characteristics by HUC. These areas can be found in **Table 9**.

Agricultural Animal Use

Animal use data was derived using National Agricultural Statistics Service and the Indiana Agricultural Statistics databases, the windshield survey, and local landowner interviews were used to estimate the type and number of agricultural animals by subwatershed. Animal types included beef cattle (including elk), dairy cattle, swine, sheep (including goats), and horses.

Wastewater Data
Onsite septic system data was based on homes noted on aerial maps, but outside of known sewer service districts.

Universal Soil Loss Equation (USLE)
USLE parameters were automatically generated by STEPL based on county.

Best Management Practices
BMP amounts can be input into STEPL and using the known BMP efficiencies the program generates pollutant loads based on the BMP amounts input. BMP amounts for the Duck Creek Watershed were compiled from aerial maps, the windshield survey information, tillage transect information, and observations from landowners within the watershed. First the existing BMPs currently in place in the Duck Creek Watershed were input into STEPL to calculate existing loads. Later in the study the program was run with the BMPs proposed in this plan to project possible pollutant load reductions. The existing BMPs in the Duck Creek Watershed are reduced tillage and filter strips. Among the land in row crops in the watershed, 30 percent is considered to practice “Reduced Tillage”. The estimated acreage of reduced tillage within the watershed is 16,953 acres. “Filter Strips” were included as best management practices based on actual occurrences, an estimated 47 percent of the streams in the watershed were adequately buffered.

Gully and Streambank Erosion
Streambank erosion features were based on field observations and measurements of erosion features noted during the windshield survey. Four separate erosion areas were input as part of this model. More areas may exist, but the level of effort available under the scope of this study limited identification to significant features readily observable from the road or reports of erosion from residents at public and/or steering committee meetings.

STEPL Results
STEPL generated annual mass loads for existing and proposed conditions in the Duck Creek Watershed by subwatershed for nitrogen, phosphorus, and TSS based on the inputs described above. These parameters are briefly described below:

- *Nitrogen* is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of air is nitrogen gas. This nitrogen can diffuse into water where it can be "fixed", or converted, by blue-green algae for their use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia through runoff from numerous sources. Because of this, there is an abundant supply of available nitrogen to aquatic systems.

- *Phosphorus* is an essential plant nutrient, and the one that most often controls aquatic plant (algae and macrophyte) growth. It is found in fertilizers, human and animal wastes, and yard waste. There are few natural sources of phosphorus to streams other than that which is attached to soil particles, and there is no atmospheric (vapor) form of phosphorus.

- *Total Suspended Solids (TSS)* measurement quantifies all particles suspended in stream water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in stream water. In general, the concentration of suspended solids is greater during high flow events due to increased overland flow. The increased overland flow erodes and carries more soil and other particulates to the stream.

Table 26 shows the current Nitrogen, Phosphorus, and TSS loads, as modeled by the STEPL program, in the subwatersheds of the Duck Creek Watershed. These modeled loads are generated with the existing conditions of the watershed, including the BMPs currently in place. **Table 27** shows the Nitrogen, Phosphorus, and TSS loads generated by various land uses in the Duck Creek Watershed as modeled by STEPL under existing conditions in the watershed. As shown in this table, the largest Nitrogen, Phosphorus, and TSS loads are produced by the cropland land use. Following cropland, the pastureland and urban land uses produced the next largest loads. The combination of the subwatershed loads and the loads by land use, shows that agricultural land in the subwatersheds with the highest pollutant loads, Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2), is the largest source of TSS, TN, and TP in the Duck Creek Watershed. **Figures 40 through 42** compare the subwatershed by their Nitrogen, Phosphorus, and TSS loads modeled by STEPL under existing conditions.

Table 26. STEPL Results – Nitrogen, Phosphorus, and TSS Loads with Existing Best Management Practices

Watershed	N Load lb/year	P Load lb/year	TSS Load tons/year
Long Branch (W1)	5767	874.6	189.1
Bear Creek (W2)	12033.6	1424.2	267.7
Lamberson Ditch (W3)	9071.4	1171.5	257.5
Polywog Creek (W4)	11304.7	1973.2	343.5
Little Duck Creek (W5)	20836.9	2973.6	533.2
Todd Ditch (W6)	8064.2	1308.2	265.4
Total	**67077.8**	**9725.2**	**1856.4**

Table 27. STEPL Results - Total Load by Land Use per Year with Existing BMPs

Sources	N Load (lb/yr)	P Load (lb/yr)	TSS Load (tons/yr)
Urban	12317.01	1895.51	282.82
Cropland	27910.04	5387.33	1273.37
Pastureland	13997.84	987.90	113.94
Forest	469.14	230.79	10.28
Feedlots	11131.43	736.93	0.00
User Defined (Wetlands)	549.88	211.70	171.84
Septic	695.75	272.50	0.00
Gully	0.00	0.00	0.00
Streambank	6.69	2.58	4.18
Groundwater	0.00	0.00	0.00
Total	**67077.79**	**9725.24**	**1856.44**

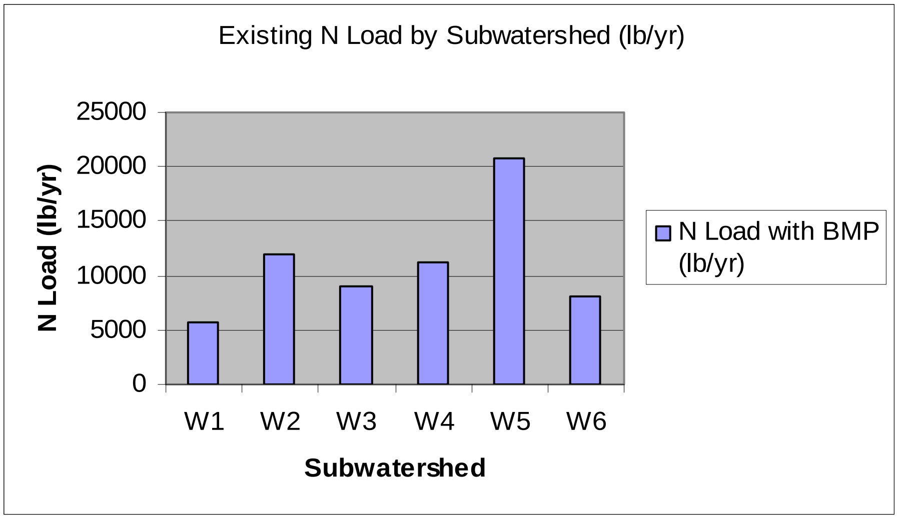


Figure 40. Nitrogen Loads by Subwatershed per Year with Existing BMPs

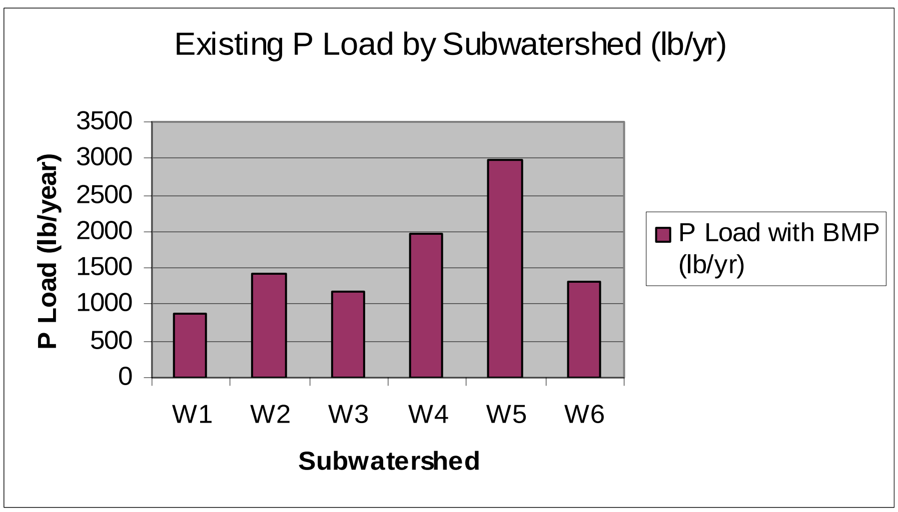


Figure 41. Phosphorous Loads by Subwatershed per Year with Existing BMPs

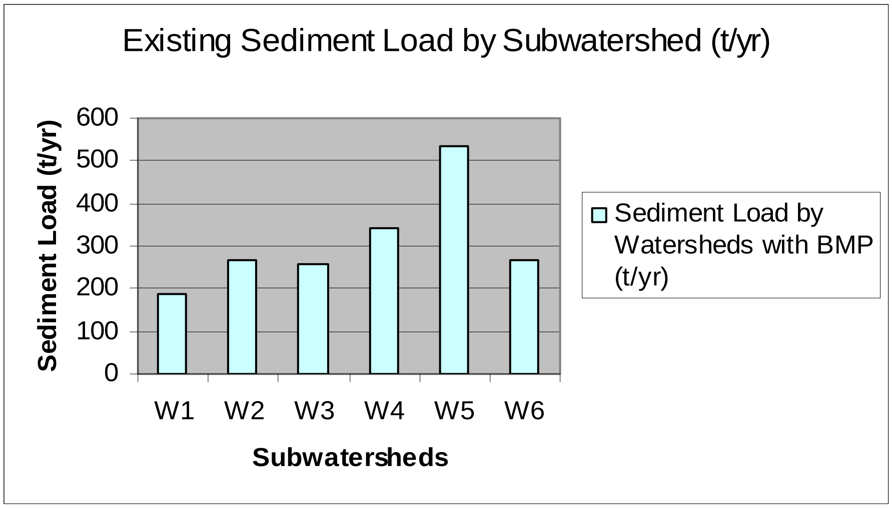


Figure 42. TSS Loads by Subwatershed per Year with Existing BMPs

Flow Modeling

Understanding the flow in a watershed is important because it tells you how much water is entering the watershed, picking up pollutants, and flowing to a stream. Flow data for the Duck Creek Watershed was obtained from the Long-Term Hydrologic Impact Assessment (LTHIA) modeling program, which considers land use, soil characteristics, and 30 years of precipitation data for a given watershed (**Table 28**).

Pollutant Concentration Calculations

The pollutant to flow ratio is concentration, which shows where more pollutant is available to a constant amount of water. Concentrations of Nitrogen, Phosphorous, and TSS were calculated for each sub-watershed using the LTHIA flow data and the STEPL loading information (**Table 29**). The target standards are in concentrations so when comparing the pollutant concentrations, as opposed to the pollutant loads, to the standards it is easier to see the degree of impairment. The concentrations will be converted back into loads to determine the pollutant load reductions required by IDEM to meet the goals set in this plan. Note the sub-watersheds with the lowest flow also have the highest Pollutant Concentrations.

Table 28. LTHIA Flow Data

Sub-watershed	Area (Acres)	Flow (cfs)
W1	7,230	3.15
W2	11,024	5.25
W3	10,332	1.42
W4	14,405	5.69
W5	12,928	6.83
W6	11,267	7.38
Total	**67,186**	**29.72**

Table 29. Calculated Average Annual Pollutant Concentrations by Subwatershed

Subwatershed	Nitrogen mg/liter	Phosphorus mg/liter	Total Suspended Solids mg/liter
W1	0.9	0.14	60
W2	1.2	0.14	51
W3	3.2	0.41	182
W4	1.0	0.17	61
W5	1.5	0.22	79
W6	0.5	0.09	36
Duck Creek Watershed	**1.1**	**0.2**	**62.9**

Target water quality standards for *E. coli*, Total Suspended Solids, Total Phosphorus, and Total Nitrogen were determined to distinguish areas of poor water quality. **Table 30** shows these targets and associated references. The pollutant concentrations from each subwatershed were compared to the targets for each parameter. All of the subwatersheds except Todd Ditch (W6) exceeded the target for Total Nitrogen of 0.63 mg/L set by the US EPA. The targets for both TSS and Total Phosphorus set by the US EPA of 30 mg/L and 0.075 mg/L respectively, were exceeded by all of the subwatersheds in the Duck Creek Watershed.

Figure 43 shows the subwatersheds with the three highest loads for TSS, TN, and TP. The Little Duck Creek watershed (W5) has the highest load for all three of the modeled priority pollutants. The Bear Creek watershed (W2) has the second highest TP and TSS loads and the third highest TN load, while the Polywog Creek watershed has the second highest TN load and the third highest TP and TSS loads.

Table 30. Target Water Quality Standards

Parameter	Threshold	Units	Reference
E. coli	235	CFU/100mg	IAC Title 327 – Full Body Contact
TSS	30	mg/L	US EPA
Total P	0.075	mg/L	US EPA
Total N	0.63	mg/L	US EPA

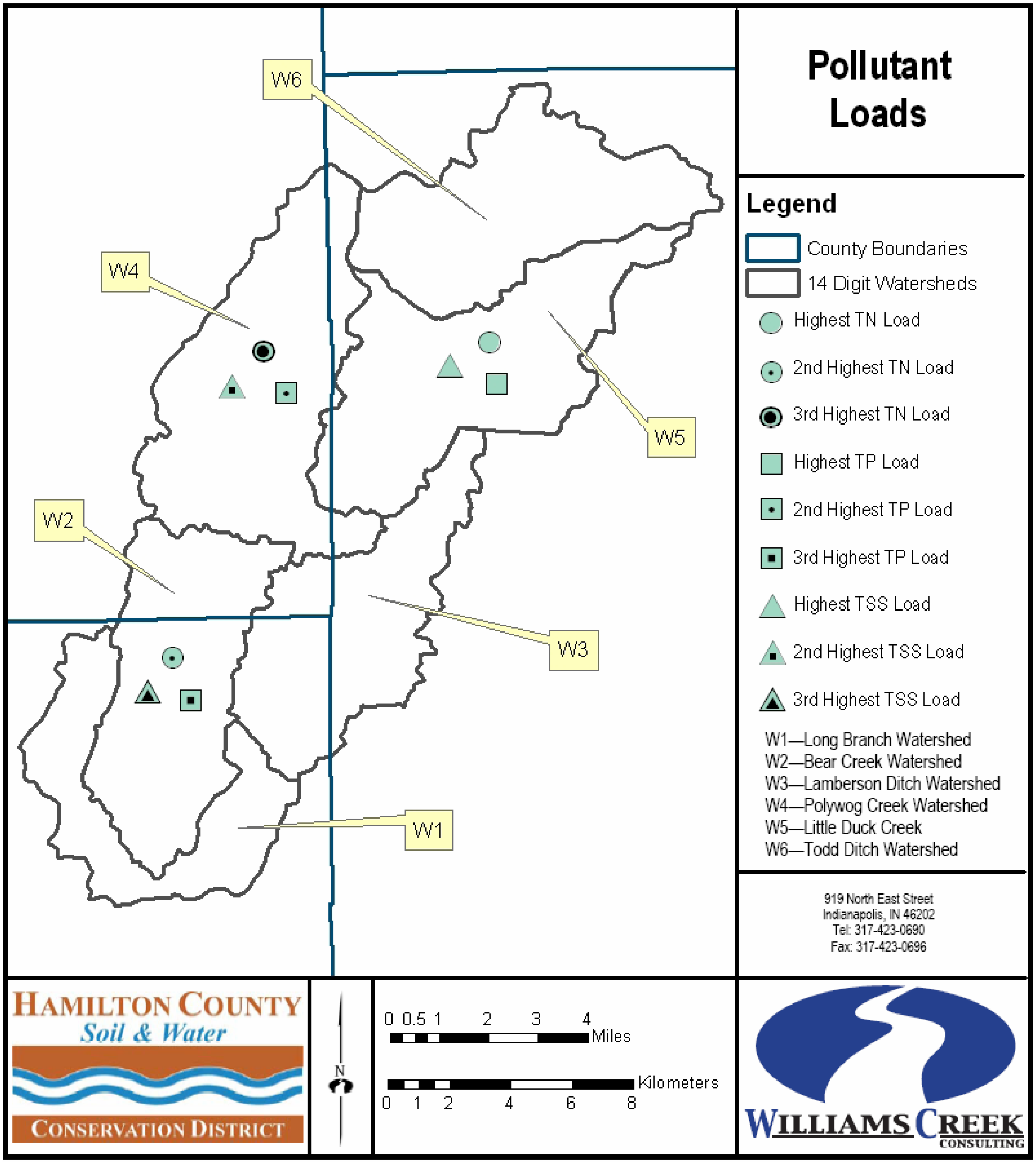


Figure 43. Pollutant Loads with Existing BMPs

SECTION 5.0 WATERSHED MANAGEMENT ISSUES

The steering committee evaluated the expressed public concerns and information from the baseline data to formulate the primary issues to be addressed by this watershed plan. Based on these combined factors, the steering committee decided to focus on suspended solids, excessive *E.coli*, and nutrients. These three priority issues directly or indirectly relate to both expressed public concerns and problems identified as part of ongoing IDEM studies in the watershed. The public concerns have been classified under the three priority issues in **Table 31**. Some of the concerns were beyond the scope of study and therefore not addressed. These concerns are marked with an asterisk and remain on the list for future consideration. During the discussion of public concerns the steering committee noted a need for education was evident for many of the concerns. The committee decided that education would be addressed as a separate issue, and there is considered to be a lack of education for all of the following concerns.

Table 31. Public Concerns Classified by Steering Committee

Concern	Red	Yellow	Green
Suspended Solids			
Seasonal Roadway Flooding*	0	0	10
Flooding South of Elwood*	1	0	0
Log Jams	22	3	0
Downed Trees Causing Soil Erosion	6	5	2
Sediment Deposition Causing Flooding in Fields*	6	8	2
Streambank Erosion	1	7	2
Limited Fishing*	0	4	5
Loss of Farmland	1	6	1
E. coli			
Sewer Discharge - Fish Kill	4	6	1
High Geese Numbers	4	3	1
Increase in Deer Numbers	8	2	0
Landowner Hunting*	4	0	5
Nutrients (Nitrogen and Phosphorous)			
Seasonal Roadway Flooding*	0	0	10
Flooding South of Elwood*	1	0	0
Log Jams	22	3	0
Downed Trees Causing Soil Erosion	6	5	2
Sediment Deposition Causing Flooding in Fields*	6	8	2
Streambank Erosion	1	7	2
Limited Fishing*	0	4	5
Loss of Farmland	1	6	1
Sewer Discharge - Fish Kill	4	6	1
High Geese Numbers	4	3	1
Increase in Deer Numbers	8	2	0
Landowner Hunting*	4	0	5
Others			
Dumping Waste in Waterways	9	2	0
Industrial Discharge	3	2	1

Well capping or decommissioning was discussed by the steering committee, as abandoned water and gas wells provide a direct point of entry for contaminated surface water into wells and migration of contaminants into ground water sources. The Hamilton SWCD has provided limited cost share in the past to permanently seal wells, thus eliminating the point of entry and eliminating the physical hazard of an open hole to people, animals, and farm machinery. The sites would need to be identified on a local level and was beyond the scope of this watershed management plan.

5.1 ANALYSIS OF WATERSHED MANAGEMENT ISSUES – TSS

Based on STEPL modeling, field observations, data from the Little Duck Creek WMP, and other Central Indiana Watershed Management Plans, TSS constitutes a valid concern in the Duck Creek Watershed. The USEPA has established TSS as the primary pollutant of concern in non-point source stormwater runoff. This is based on a correlation of TSS with the presence of nutrients, pathogens, and other pollutants of concern. Therefore, USEPA asserts that reductions in TSS loads will result in improved stream water quality. For this reason the steering committee decided to focus on TSS as a priority concern.

Elevated TSS concentrations are directly or indirectly related to inadequate buffers, conventional tillage practices, and stream obstructions and streambank erosion, and can cause a decline in selected species of game fish and other aquatic organisms. Sediment also carries E. coli and nutrients with it, making it a very good target pollutant for improving overall water quality in a water body. The BMPs recommended in this plan to reduce TSS are bank stabilization, buffer strips, conservation tillage, exclusion fencing, education/outreach, grassed waterways, log jam removal, restored wetlands, and whole farm management.

STEPL results indicate the majority of the stormwater runoff sediment load in the watershed comes from agricultural land, while higher concentrations come from non-agricultural areas. However, erosion from construction sites was not deemed a likely significant source because:

- the watershed is overwhelmingly agricultural
- runoff controls for construction sites are required and already regulated by IDEM

5.1.1 Conventional Tillage

Based on tillage transects, all three of the involved counties have high conventional till rates for corn. Conventional tillage loosens the soil when the crops are removed and leaves the soil exposed throughout the winter, making it more susceptible to erosion. STEPL results indicate the great majority of suspended solids in runoff are generated from agricultural land. Areas and land use used in the STEPL model are detailed in Appendix E. When fields where conventional tillage is practiced are paired with highly erodible soils or inadequate buffers, an even greater amount of sediment is likely to be carried to streams via runoff. The three subwatersheds that have the highest percentages of conventional tillage, Pollywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2), also have the highest percentages of inadequate buffers and Polywog Creek (W4) and Little Duck Creek (W5) have the highest STEPL generated TSS loads.

Based on statewide data collected by NASS, acreages of land planted to corn and soybeans in the Duck Creek Watershed were estimated. Approximately 47% of the cropland in the Duck Creek Watershed is planted to corn, while approximately 53% is planted to soybeans. These acreages combined with the percentages of conventional tillage from the Hamilton, Madison, and Tipton County Tillage Transects was used to estimate the acres of conventional tillage in the watershed (**Table 32**).

Table 32. Acreages of Conventional Tillage by Subwatersheds (NASS USDA 2006)

	Corn			Soybeans			Total
	Acres Planted to Corn	% Conventional Tillage	Acres Conventional Tillage	Acres Planted to Soybeans	% Conventional Tillage	Acres Conventional Tillage	Acres Conventional Tillage
W1	2740	60	1644	3089	8	247	**1891**
W2	4408	60	2645	4971	8	398	**3043**
W3	4150	81	3362	4680	16	749	**4111**
W4	6027	96	5786	6796	27	1835	**7621**
W5	4273	81	3461	4819	16	771	**4232**
W6	4964	81	4021	5598	16	896	**4917**
Total	**26562**		**20919**	**29953**		**4896**	**25815**

5.1.2 Areas Lacking Buffer Strips

Buffers are, according to The U.S. Department of Agriculture, Natural Resource Conservation Service's *Conservation Practice Standard, Filter Strip, 393*A, grassed or forested areas that extend 20 feet from either side of a stream. Buffers can also be located along ditches, roads, and contours within a field, and are an extremely effective way of slowing runoff down and filtering out potentially harmful substances such as sediment, nutrients, animal waste, and chemicals from fertilizers, pesticides, herbicides, etc. They are especially important when located along conventionally tilled fields or fields to which manure has been applied because they filter out some of the sediment, nutrients, and pathogens associated with those practices. A lack of adequate buffers has been observed in certain areas in the watershed, especially along the headwater streams of the watershed. These areas are identified in **Figure 39**. The three subwatersheds; Polywog Creek (W4), Little Duck Creek (W5), and Todd Ditch (W6); with highest percentages of inadequate butters are the same three watersheds that have the most acres of conventionally tilled fields and Polywog Creek (W4) and Little Duck Creek (W5) also have the highest pollutant loads for TSS. These subwatersheds are the headwater reaches of the larger Duck Creek Watershed. **Table 33** shows the percent of inadequate buffers by subwatershed and **Figures 44 and 45** show examples of adequate grassed and forested buffers.

Table 33. Percent Inadequate Buffers by Subwatershed

Subwatershed	Total Stream Lengths (meters)	Stream Lengths with Inadequate Buffers (meters)	Inadequate Buffers (%)
Todd Ditch (W6)	23,462	13,877	59
Little Duck Creek (W5)	18,361	9,641	53
Polywog Creek (W4)	15,118	7,708	51
Bear Creek (W2)	17,407	7,148	41
Long Branch (W1)	14,983	4,758	32
Lamberson Ditch (W3)	14,929	3,890	26

Figure 44. Adequate Grassed Buffer

Figure 45. Adequate Forested Buffer

5.1.3 Stream Obstructions and Streambank Erosion

Stream bank erosion is occurring in several areas throughout the watershed. The erosion is more severe in the southern portion of the Lamberson Ditch Watershed along both Duck Creek and Lamberson Ditch, where large log jams are located. Typical areas of stream bank erosion range from 40 to 200 feet in length and 8 to 30 feet in height. (See **Figure 37** for location of known log jams.) **Figure 46** shows streambank erosion caused by a log jam in the Long Branch watershed (W1). **Figure 47** shows a less severe case of streambank erosion in the Lamberson Ditch watershed (W3).

Figure 46. Log Jam and Erosion on SR 213 in the Long Branch Watershed (W1)

Figure 47. Streambank Erosion on Lamberson Ditch

Stream obstructions, specifically log jams, were identified by the watershed stakeholders to be the number one public concern. However, addressing these areas will likely require further engineering study and coordination with the County Surveyors office. The Hamilton County Surveyors office suggests residents petition to have the drain placed on maintenance in order to fund log jam removal.

Removal of stream obstructions restores natural flow and conveyance of streams and ditches, reduces erosion, sedimentation, and flood potential, and may improve wildlife habitat and water quality (Indiana Drainage Handbook, 1996). According to the Indiana Drainage Handbook:

> "Logjams restrict the flow and conveyance of natural streams and ditches which can cause increased flooding, destruction of property and wildlife habitat, and erosion and sedimentation. However, not all in-stream structures cause problems. Submerged and overhanging logs provide important wildlife habitat. In many cases, the ripples caused by obstructions oxygenate the water to improve water quality. It is therefore useful to classify in-stream obstructions based on severity, and employ management techniques based on each category."

5.2 ANALYSIS OF WATERSHED MANAGEMENT ISSUES – *E. coli*

E. coli levels in the Duck Creek Watershed exceed the state's standards for primary human contact. High *E. coli* concentrations suggest the presence of other pathogens. These pathogens may impair the tributaries biota and limit human use of the creeks. The causes of high *E. coli* levels in the watershed could be combined sewer discharges, livestock, malfunctioning or non-existent septic systems, and wildlife and domestic pets. The BMPs recommended in this plan to reduce *E. coli* are buffer strips, drainage water management, education/outreach, exclusion fencing, nutrient management, restored wetlands, rural regional sewer districts, and whole community planning.

5.2.1 Malfunctioning Septic Systems and Direct Sanitary Waste

E. coli loads were estimated in the TMDL Report assuming that 100% of sewage disposal is via septic systems in rural areas, that 10% of sewage disposal is via septic systems in urban areas, and that 50% of septic systems are malfunctioning. Assumptions of 75 gallons/day per person and a typical domestic sewage *E. coli* concentration of 1.07×10^6 counts/100 ml were also used to estimate the *E. coli* loads of the Duck Creek Watershed in the TMDL Report in combination with the 2000 U.S. Census Bureau population data for the watershed. The *E. coli* load from septic systems in the Duck Creek Watershed was estimated to be 6.28E+12 count/day (IDEM, 2005).

Houses built before the year 1978, did not require a permit to install a septic system. Consequently, most of the septic systems installed prior to that time are not currently up to code and many of them may likely be failing, if at all present. It is assumed that all houses in rural areas are not connected to sewers and therefore use septic systems or have been illegally connected to drain tiles. According to the Indiana State Department of Health, an estimated 25 percent of the septic systems in the state are inadequate or malfunctioning, and over 82,000 gallons of untreated wastewater per malfunctioning septic system is released into the environment every year (Lee *et al*., 2004).

As the numbers used to estimate the amount of untreated wastewater generated from malfunctioning septic systems by the TMDL Report and the Department of Health vary greatly, it is clear that a rough estimate is all that is possible. This estimate is enough; however, to conclude that malfunctioning septic systems are a significant threat to water quality in the Duck Creek Watershed.

Based on the combination of a majority of poorly drained soils and rural areas in the Duck Creek Watershed, it can be assumed that most of the watershed uses septic systems and most of these systems do not function properly. Neighborhoods and clusters of 10 or more houses per quarter square mile in rural areas of the watershed were identified as potential threats of *E. coli* contamination from septic systems; particularly those with close proximity to a stream or ditch (see **Figure 38**).

Septic systems that have been appropriately installed and maintained should not be considered a source of *E. coli* loading. There are however, many factors that can cause septic systems to malfunction, such as high seasonal water tables, limited leach field transmissivity due to areas of compact glacial till and bedrock interference, high transmissivity due to leach field interaction with quickly draining soils, and systems that have been illegally connected to drain tiles. These malfunctions could cause raw sewage to be discharged into receiving surface waters (IDEM, 2005).

5.2.2 Wastewater Facilities

The National Pollutant Discharge Elimination System (NPDES) regulates facilities that discharge into water bodies by requiring a permit from IDEM that limits the amount of a pollutant discharged. Any NPDES facility having *E. coli* effluent limits includes the respective geometric mean and "never-to-exceed" standards of 125 col/100mL and 235 col/100mL.

The Elwood Sewage Treatment Plant (**Figure 48**) is permitted to discharge up to 3.22 million gallons per day (MGD). The *E. coli* load associated with this discharge amount was estimated in the Draft TMDL Report to be 1.52E+10 count/day (**Table 34**). This treatment plant violated the *E. coli* daily maximum effluent limit in 2001 and consequently signed an Agreed Order with IDEM (IDEM, 2005). The IDEM definition of an agreed order; Agreed Order - By statute, the Respondent has a 60-day settlement period after receiving a Notice of Violation in which to enter into an Agreed Order with IDEM. Agreed Orders contain steps the Respondent must take to comply with the law. In most cases, Agreed Orders include a fine for past violations and stipulated penalties for failure to complete future compliance steps. Agreed Orders will not necessarily require a Respondent to admit that a violation of law occurred. Fines may be lessened if the Respondent can demonstrate that mitigating circumstances existed.

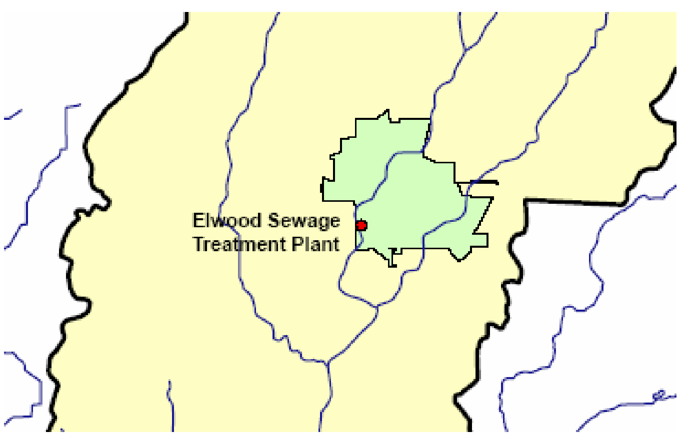


Figure 48. Elwood Municipal Sewage Treatment Plant (●) Location

Table 34. NPDES Facilities with the Potential to Discharge *E.coli* to the Duck Creek Watershed

NPDES ID	County	Subwatershed	Facility Name	Receiving Water	Flow (MGD)	*E. coli* Load (count/day)
IN0032719	Madison	Little Duck Creek (W5)	Elwood Sewage Treatment Plant	Duck Creek	3.22	1.52E+10

According to the 2005 IDEM TMDL for *E. coli* Report, there are 14 CSO outfalls in Elwood (**Figure 49**). A CSO is a single pipe that conveys both wastewater (domestic, commercial, and industrial) and storm water to a sewage treatment plant. A combined sewer overflow is the discharge from this system at a point before the water gets to the sewage treatment plant. Overflows usually occur during or after large storm events, when the volume of flow overloads the sewage treatment plant causing it to divert the flow directly (untreated) into the receiving water (Frankenberger, 2002). All of the samples collected under storm flow conditions as part of the TMDL study were in excess of the state standard for *E. coli*, indicating *E. coli* is correlated to storm runoff and/or CSO discharges. The E. coli load from the Elwood CSO Community was estimated in the TMDL Draft Report to be 2.22E+12 count/day (**Table 35**). **Figure 50** shows a sign located a CSO discharge site in the Little Duck Creek.

According to IDEM's publication entitled Indiana's Approach to Combined Sewer Overflow Compliance Work plan for CSO Long Term Control Plan Review and Implementation (IDEM, August 2005), the City of Elwood is listed on the Schedule for CSO Long Term Control Plan Approval Workplan Final List for the year 2008. A November 2007 review by WCC of a schedule last updated by IDEM on 10/19/07 indicates Elwood has submitted a Long Term Control Plan on 12/29/06, however, the updated schedule indicates the plan has not been reviewed by IDEM.

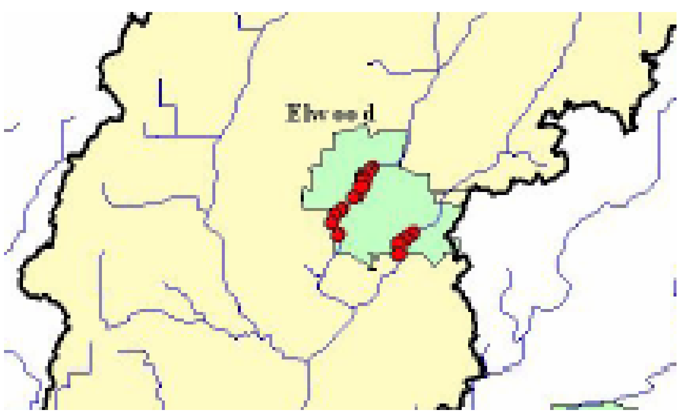


Figure 49. CSO Outfall Locations in Elwood

Table 35. Estimated *E. coli* Loads from CSO Community in the Duck Creek Watershed

Community	Subwatershed	2000 Population	% of City Contributing to CSOs	*E. coli* Load (count/day)
Elwood	Little Duck Creek (W5)	9,737	100%	2.22E+12

Figure 50. Sign for CSO Outfall in the Little Duck Creek Watershed (W5)

5.2.3 Animal Feeding Operations and Livestock

Animal manure contains large amounts of *E. Coli*. Manure produced at CFOs and CAFOs is generally applied to pasture and cropland as fertilizer under a permit issued by IDEM, making it a potential source of *E. coli* in the watershed during stormwater runoff events. *E. coli* can be transported to streams and ditches by surface runoff or by leaching into tile drains, therefore fields with inadequate buffers or tile drainage systems contribute more *E. coli* to the watershed. Also affecting the E. coli load is the amount of time between manure applications and a storm event and the incorporation of manure into the soil. The TMDL Report identified five active CFO/CAFOs in the Duck Creek Watershed, but further record investigation determined that only three are still active today, the Bryant Premium Pork, LLC., Idlewine, and Wimmer Farms (**Figure 51**). The TMDL Report states that 90 percent of all manure produced at CFO/CAFOs is assumed to be collected and used for fertilizer on nearby row crops, making the associated *E. coli* load a nonpoint source. The remaining 10 percent is assumed to be located at the facility, making the associated *E. coli* load a point source. *E. coli* from both the point and nonpoint sources could potentially be transported to waterbodies via runoff. **Table 36** shows the number of animals at each operation and the total potential conservative daily *E. coli* load produced from each operation. There is no evidence of CFOs/CAFOs within the watershed violating their permits.

There is also one AFO and many smaller hobby farms with livestock within the watershed that do not require a permit. *E. coli* may also be entering streams in the watershed by manure application from these farms. Any farm, whether it is regulated or not, with livestock that have access near or in a stream are also a potential source of *E. coli*. **Figure 51** shows the locations of the AFO, CFOs, CAFO, and hobby farms within the Duck Creek Watershed.

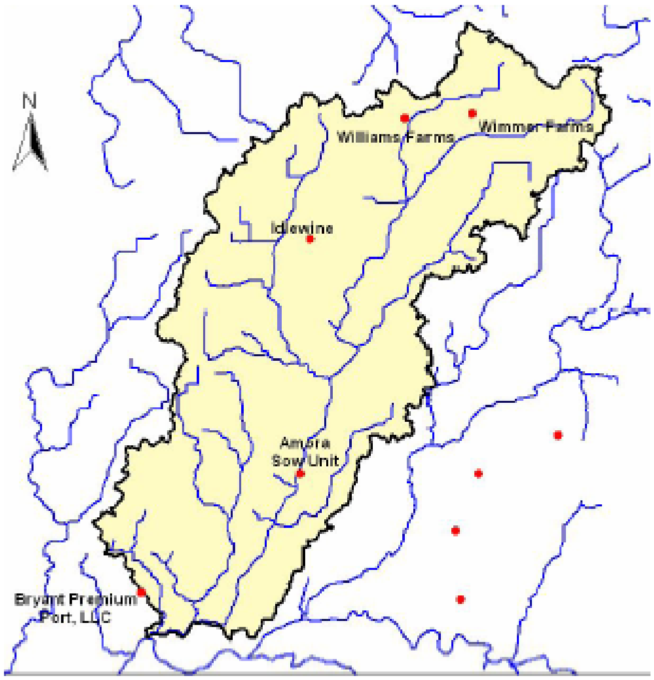


Figure 51. CFO/CAFO Locations in the Duck Creek Watershed

Table 36: Number of Animals Associated with the Active Duck Creek CFOs and CAFOs and Estimate Loads of those Facilities (IDEM, 2005)

Farm Name	Nursery Pigs	Grower/ Finishers	Sows/ Boars	Total Pigs	Total Cows	Total *E. coli* Load (count/day)
Bryant Premium Port LLC	400	220	16	636	0	6.28E+12
Wimmer Farms	400	1575	304	2279	0	2.25E+13
Idlewine	0	1520	0	1520	0	1.50E+13

5.2.4 Wildlife and Domestic Pets

Fecal matter from wildlife can be directly deposited in the stream or can be transported to the stream by runoff from the surrounding cropland, pastureland, and forested land. According to personnel from IDNR District 11, the predominant wildlife species in the study area are deer, raccoon, and Canadian geese (Hanauer, 2005). The TDML Report estimated the *E. coli* load in the Duck Creek Watershed from these three types of wildlife to be 1.32E+13 count/day.

The fecal matter deposited by cats and dogs and transported by runoff to streams can also be a source of *E. coli*. Using data from the 2000 US Census, 36.1% of households own at least one dog (American Veterinary Medical Association, 2002), with a national average of 1.6 dogs per dog-owning household. According to the study, 36.7% of dog owners rarely pick up after their dogs. Similarly, 31.6% of households own a cat, with 2.1 cats per cat-owning household, and 50% outdoor cats. The estimated *E. coli* load from pets within the Duck Creek Watershed is 4.48E+12 count/day.

Although the E. coli load from pets and wildlife is a high number, remediation strategies for the other sources of *E. coli* result in higher E. coli load reductions. Therefore, more focus will be placed on these other sources. However, education and outreach was decided by the steering committee to be the best approach to limit the *E. coli* load from wildlife and pets. Although many local governments have ordinances such as leash and pooper-scooper laws, some pet owners neglect to collect the wastes left behind. An ordinance would be difficult to enforce, however educational methods to create an understanding of pets and their effect on water quality will improve voluntary cooperation.

5.3 ANALYSIS OF WATERSHED MANAGEMENT ISSUES - NUTRIENTS

Excessive nutrient loads, nitrogen and phosphorus particularly, appear to be present in the watershed based on STEPL modeling and limited sampling. The total phosphorus and total nitrogen concentrations projected by STEPL exceeded minimum recommended concentrations of 0.075 mg/L for TP and 0.63 mg/L for TN. High P and N in freshwater systems leads to excessive primary productivity in the form of algae, noxious weeds, and other unwanted vegetation and makes the system more prone to diurnal fluctuations in DO that can produce fish kills. Resultant biodiversity and higher trophic-level productivity in these tributaries is likely inhibited. Because public concerns include improved fishing conditions, and because IDEM studies find many areas in the watershed in need of improved aquatic life support, nutrients were retained as a focus of this watershed management plan.

Because the majority of nutrients present in non-point source runoff are present in organic form, particulate form, or are physically attached to sediments or organic material, a major source of excess nutrients is excess sediments present in runoff. The BMPs recommended in this plan to reduce nutrients are buffer strips, conservation tillage, drainage water management, education/outreach, exclusion fencing, grassed waterways, nutrient management, restored wetlands, rural regional sewer districts, whole community planning, and whole farm management.

5.3.1 Malfunctioning Septic Systems or Straight Pipes and Elwood CSOs

As described above in section 5.2.2 malfunctioning or nonexistent septic systems contribute an outstanding amount of not only pathogens, but also nutrients. Multiple studies conclude that 100 percent of rural areas can be assumed to be on septic systems, the Purdue study assumes that 25 percent of all septic systems can be assumed to be failing while the Duck Creek TMDL Report assumes that up to 50 percent are failing. The TMDL Report calculated that 75 gallons/day per person of wastewater is generated in the Duck Creek Watershed with an estimated population of 33,116. This would correspond to a potential wastewater discharge of approximately 2,500,000 gallons of wastewater generated per day. While this fails to consider the proximity to streams, it provides a reasonable first assessment of the potential impact of septic systems in the Duck Creek Watershed. The Elwood CSO issues as discussed a length in 5.2.1 are a large contributor to the nutrient loading as well.

5.3.2 Tile Drains

A study on Leary Weber Ditch in Hancock County investigated agricultural chemical movement in overland flow and tile drains. The study showed that during most storms and between storms, tile drains are the most important contributor for the movement of agricultural chemicals to Leary Weber Ditch. Leary Weber Basin and the Duck Creek Watershed are both located in the Tipton Till Plain physiographic region of central Indiana. They share drainage characteristics and soil types, indicating that the results should be similar in the Duck Creek Watershed. Other studies are being conducted that may link the hypoxic zone or “dead zone” in the Gulf of Mexico to high nitrogen loads from agricultural drainage in the Midwest to the

Mississippi River. These studies have also found high nitrogen concentrations in tile drains. Agricultural fertilizers, manure application, conventional tillage, and the spacing of the tile drains all influence the amount of nitrogen entering tile drains.

Based on the majority of poorly drained soils and the heavy emphasis on agriculture in the Duck Creek Watershed, it is assumed that most of the watershed outside of Elwood uses a tile drainage system. Although nutrient loads from tile drains were not measured as part of this study, based on the studies mentioned above and the presumed prevalence of tile drainage systems in the watershed, it can be assumed that tile drains are one of the largest sources of nutrient loading in the Duck Creek Watershed. Consequently, drainage water management should be implemented as a BMP in the Duck Creek Watershed to reduce nutrient loads from tile drains.

5.3.3 Agricultural Fertilizers

Phosphorus and nitrogen are the primary limiting nutrients in agricultural row crops; consequently agricultural fertilizers contain large amounts of phosphorus and nitrogen. Soybeans can fix nitrogen from the atmosphere, while corn cannot. Therefore, corn requires more N containing fertilizers. When fertilizers are overused, the excess nutrients remain in the soil and are readily lost to tile drains or runoff during rain events. Soil analysis should be conducted prior to applying fertilizers, to determine the amount and type of nutrients needed. Fertilizer should be applied immediately before planting to limit the chance of a rain event flushing the fertilizer before planting occurs. Winter cover crops can also reduce the amount of nutrients entering streams by uptaking the excess nutrients from fertilizers or plant decomposition after crops are harvested. Crop rotations can reduce the amount of fertilizers needed because after corn has depleted the nitrogen in the soil soybeans can fix nitrogen from the air. When the soybeans decompose they return nitrogen to the soil which can be used by corn.

Almost 4 million pounds of Nitrogen fertilizers and almost 2 million pounds are estimated to be applied to the Duck Creek Watershed per year (**Tables 14 and 15**). Although some of the nutrients in these fertilizers may be used up by crops, the remainder of the nutrients are reaching waterways via tile drains or surface runoff. Therefore, a heavy emphasis should be placed on installing buffers, practicing conservation tillage or no-till, and implementing drainage water management.

5.3.4 Lack of Buffers Along Streams

Buffer strips along ditches, streams, roads, and contours within a field are an extremely effective way of slowing runoff down and filtering out potentially harmful substances such as sediment, nutrients, animal waste, and chemicals from fertilizers, pesticides, herbicides, etc. A lack of buffer strips has been observed in certain areas in the watershed, these areas are identified in **Figure 39**. The three subwatersheds; Polywog Creek (W4), Little Duck Creek (W5), and Todd Ditch (W6); with highest percentages of inadequate buffers are the same three watersheds that have the most acres of conventionally tilled fields and Polywog Creek (W4) and Little Duck Creek (W5) also have the highest STEPL pollutant loads for TN and TP.

5.3.5 Conventional Tillage

Nutrients bind to soil so the sediment that runs off the exposed soils in conventionally tilled fields also carries nutrients with it to the stream. The large percentage of conventional tillage in the Duck Creek Watershed therefore contributes to the excess of nutrients in the streams within the watershed. The three subwatersheds that have the highest percentages of conventional tillage, Polywog Creek (W4), Little Duck Creek (W5), and Todd Ditch (W6), also have the highest percentages of inadequate buffers and the highest STEPL generated TN and TP loads.

5.3.6 Animal Waste
There are multiple sources of animal waste, both from domestic and wild animals. For example in the City of Elwood, while there may be no livestock, there are domestic animals. Recent studies indicate that an average of 35 percent of households own at least one cat or dog. It is crucial that pet owners pick up their pet waste to prevent diseases and stormwater pollution. Although many local governments have ordinances such as leash and pooper-scooper laws, some pet owners neglect to collect the wastes left behind. An ordinance would be difficult to enforce, however educational methods to create an understanding of pets and their effect on water quality will improve voluntary cooperation. As mentioned above, fecal matter contains nutrients such as nitrogen and phosphorus, therefore any livestock manure or pet and wildlife waste entering a stream in the Duck Creek Watershed is contributing to the excess of nutrients in the watershed.

5.3.7 Lawn Fertilizers
Fertilizers contain large amounts of phosphorous and some nitrogen. Homeowners are much more likely than farmers to overuse fertilizer since it costs less to treat a lawn than it does an entire field. Vegetation can only use so many nutrients at a time, therefore when fertilizers are overused the plants cannot use all the nutrients contained in those fertilizers. The excess nutrients bind with soil particles and are susceptible to run off.

5.4 OTHER WATERSHED MANAGEMENT ISSUES

5.4.1 Dumping Waste in Waterways
Although dumping waste in waterways may not have a direct impact on water quality, it could be harmful to the stream and its habitat. Therefore, dumping waste locations have been noted and identified, but are not considered a source of the priority pollutants in this plan. Locations of dumping sites are shown on **Figure 38**, and **Figure 52** shows a dumping site in the Lamberson Ditch watershed (W3)

Figure 52. Dumping Site on Henry Gunn Road

5.4.2 Abandoned Wells

Abandoned gas, oil, and water wells are located across the state of Indiana, and pose significant threats to ground and surface water. As stated in an IDNR, Division of Water publication, "Water wells are conduits between the land surface and the ground water resource. If not sealed or plugged properly, abandoned wells can contribute to ground water contamination. Common surface pollutants including animal and human waste, herbicides, pesticides, and fertilizers can take the path of least resistance down an abandoned well and into an aquifer (water-bearing formation)" (IDNR 2004). Noxious liquids from abandoned oil and gas wells have been discovered to potentially kill crops and taint drinking water. Abandoned wells may be a source of TSS, nutrients, and E. coli in the Duck Creek Watershed, and should therefore be located and sealed or plugged. The state requires that abandoned wells be sealed or plugged (312 IAC 13, Rule 10); however, many abandoned wells remain unsealed or unplugged. The locations of oil and gas wells in Indiana are illustrated on **Figure 53**, with gas wells represented in red and oil wells in green.

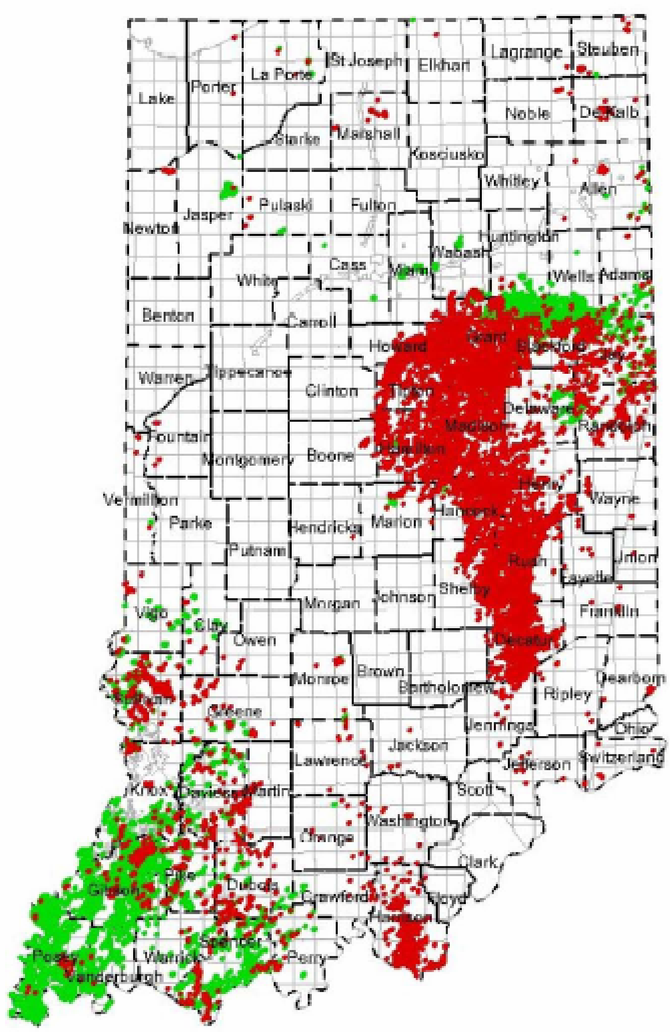


Figure 53. Gas and Oil Well Locations in Indiana (Map Source: Indiana Geological Survey)

SECTION 6.0 SUBWATERSHED ASSESSMENT

To gain an understanding of the areas with the greatest impairments and degradation in the Duck Creek Watershed, a subwatershed assessment was conducted. In this assessment baseline conditions and potential causes and sources of water quality impairments were ranked by subwatershed and then associated with the four priority pollutants, TSS, TN, TP, and *E.coli*. This allows the subwatersheds with the greatest impairments for each pollutant to be identified, and targeted for future remediation. The following tables are used to prioritize the subwatersheds. The subwatersheds given a lower rank in these tables are regarded as higher priority for the corresponding parameter. The primary pollutants address the three primary concerns, TSS, *E. coli*, and nutrients, of the steering committee.

6.1 IDEM STUDIES

6.1.1 IDEM's 305(b) Water Quality Assessment

Under IDEM's 305(b) Water Quality Assessment Report the aquatic life use and primary contact use for each of the major tributaries in the Duck Creek Watershed were assessed. All of these tributaries were not supportive of primary contact use (**Table 37**). In **Table 38**, Aquatic Life Use assessments were ranked with the subwatersheds that are less supportive having the lowest rank and those that are more supportive having a higher rank. Rank analysis shows that Lamberson Ditch (W3) is the least supportive of aquatic life, and Bear Creek (W2) and Todd Ditch are the most supportive.

Table 37. Subwatershed Rank by IDEM's Water Quality Assessment for Primary Contact Use

Sub-Watershed	Primary Contact Use	Rank
Long Branch (W1)	N	1
Bear Creek (W2)	N	1
Lamberson Ditch (W3)	N	1
Polywog Creek (W4)	N	1
Little Duck Creek (W5)	N	1
Todd Ditch (W6)	N	1

N = no supporting; P = fully supporting; F = fully supporting

Table 38. Subwatershed Rank by IDEM's Water Quality Assessment for Aquatic Life Use

Sub-Watershed	Aquatic Life Use	Rank
Lamberson Ditch (W3)	P and N	1
Long Branch (W1)	F and P	2
Polywog Creek (W4)	F and P	2
Little Duck Creek (W5)	F and P	2
Bear Creek (W2)	F	5
Todd Ditch (W6)	F	5

N = no supporting; P = fully supporting; F = fully supporting

6.1.2 IDEM's 303(d) List of Impaired Waters
All of the major tributaries in the Duck Creek Watershed were placed on IDEM's 303(d) List of Impaired Waters for *E. coli*, therefore they all received a rank of one (1).

6.2 WATER CHEMISTRY
Water chemistry results cannot be ranked by subwatershed because sampling only occurred in the Little Duck Creek Watershed (W5) under separate study.

6.3 BIOLOGICAL SAMPLING

6.3.1 Macroinvertebrate Sampling
More than one sample was taken in most of the subwatersheds therefore all of the m-IBI scores for each subwatershed were averaged and then ranked. The subwatersheds with lower scores were given a lower rank, while those with higher scores received higher ranks. **Table 39** reveals that Bear Creek (W2), Little Duck Creek (W5), and Polywog Creek (W4) were most impaired while Long Branch (W1) and Lamberson Ditch (W3) were least impaired.

Table 39. Subwatershed Rank by m-IBI Scores

Subwatershed	Average m-IBI Score	Rank
Bear Creek (W2)	2	1
Little Duck Creek (W5)	2.4	2
Polywog Creek (W4)	3.1	3
Lamberson Ditch (W3)	3.6	4
Long Branch (W1)	5	5
Todd Ditch (W6)	*	

* No samples were taken in this subwatershed

6.3.2 Habitat Evaluation
More than one sample was taken in most of the subwatersheds therefore all of the QHEI scores for each subwatershed were averaged and then ranked. The subwatersheds with lower scores were given a lower rank, while those with higher scores received higher ranks. As shown in **Table 40**, Little Duck Creek (W5), Bear Creek (W2), and Polywog Creek had the least supportive habitat while Long Branch (W1) and Lamberson Ditch (W3) had the most supportive habitat.

Table 40. Subwatershed Rank by QHEI Scores

Subwatershed	Average QHEI Score	Rank
Little Duck Creek (W5)	41.5	1
Bear Creek (W2)	51	2
Polywog Creek (W4)	52	3
Lamberson Ditch (W3)	55	4
Long Branch (W1)	66.5	5
Todd Ditch (W6)	*	

* No samples were taken in this subwatershed

6.4 POLLUTANT LOAD MODELING

Because no water chemistry was performed in this study, existing pollutant loads for the Duck Creek Watershed were modeled using the STEPL program. STEPL modeled loads for TSS, Nitrogen, and Phosphorus based on soil, rainfall, and land use information as well as existing BMPs.

6.4.1 Total Suspended Solids

The STEPL program modeled the TSS load, and using that number and the flow for each watershed, the TSS concentration was calculated. The subwatersheds with higher loads and concentrations were given a lower rank, while those with lower loads were given a higher rank. This analysis shows that Little Duck Creek (W5), Polywog Creek (W4), and Bear Creek (W2) have the highest loads of TSS while Long Branch (W1), Lamberson Ditch (W3), and Todd Ditch (W6) have the lowest loads (**Table 41**). The highest TSS concentrations are in Lamberson Ditch (W3), Little Duck Creek (W5), and Polywog Creek (W4), while the lowest concentrations are in Todd Ditch (W6), Bear Creek (W2), and Long Branch (W1) (**Table 42**). This shows that Lamberson Ditch has a very low flow because it has low load but a high concentration.

Table 41. Subwatershed Rank by TSS Load

Subwatershed	TSS Load (t/yr)	Rank
Little Duck Creek (W5)	533.2	1
Polywog Creek (W4)	343.5	2
Bear Creek (W2)	267.7	3
Todd Ditch (W6)	265.4	4
Lamberson Ditch (W3)	257.5	5
Long Branch (W1)	189.1	6

Table 42. Subwatershed Rank by TSS Concentration

Subwatershed	TSS Concentration (mg/L)	Rank
Lamberson Ditch (W3)	182	1
Little Duck Creek (W5)	79	2
Polywog Creek (W4)	61	3
Long Branch (W1)	60	4
Bear Creek (W2)	51	5
Todd Ditch (W6)	36	6

6.4.2 Total Nitrogen

Again, the Total Nitrogen loads were calculated by the STEPL program, and then converted into concentrations based on the flow of each subwatershed. Little Duck Creek (W5), Bear Creek (W2), and Polywog Creek (W4) have the highest TN loads while Long Branch (W1), Todd Ditch (W6), and Lamberson Ditch have the lowest loads (**Table 43**). Again, Lamberson Ditch (W3) has one of the lowest loads, but has the highest concentration of TN. Little Duck Creek (W5) and Bear Creek (W2) also have high TN concentrations compared to the other subwatersheds, while Todd Ditch (W6), Long Branch (W1), and Polywog Creek (W4) have the lowest concentrations (**Table 44**).

Table 43. Subwatershed Rank by Total N Load

Subwatershed	TN Load (lb/yr)	Rank
Little Duck Creek (W5)	20,837	1
Bear Creek (W2)	12,034	2
Polywog Creek (W4)	11,305	3
Lamberson Ditch (W3)	9,071	4
Todd Ditch (W6)	8,064	5
Long Branch (W1)	5,767	6

Table 44. Subwatershed Rank by Total N Concentration

Subwatershed	TN Concentration (lb/yr)	Rank
Lamberson Ditch (W3)	3.2	1
Little Duck Creek (W5)	1.5	2
Bear Creek (W2)	1.2	3
Polywog Creek (W4)	1.0	4
Long Branch (W1)	0.9	5
Todd Ditch (W6)	0.5	6

6.4.3 Total Phosphorus

The loads for Total Phosphorus in each subwatershed were generated by the STEPL program and then converted into concentrations using flow data. Little Duck Creek (W5), Polywog Creek (W4), and Bear Creek (W2) had the highest loads. Long Branch (W1), Lamberson Ditch (W3), and Todd Ditch (W6) had the lowest loads (**Table 45**). Lamberson Ditch (W3), Little Duck Creek (W5), and Polywog Creek (W4) had the highest concentrations, while Todd Ditch (W6), Long Branch (W1), and Bear Creek (W2) had the lowest concentrations of Total Phosphorus (**Table 46**).

Table 45. Subwatershed Rank by Total P Load

Subwatershed	TP Load (lb/yr)	Rank
Little Duck Creek (W5)	2,974	1
Polywog Creek (W4)	1,973	2
Bear Creek (W2)	1,424	3
Todd Ditch (W6)	1,308	4
Lamberson Ditch (W3)	1,172	5
Long Branch (W1)	875	6

Table 46. Subwatershed Rank by Total P Concentration

Subwatershed	TP Concentration (mg/L)	Rank
Lamberson Ditch (W3)	0.41	1
Little Duck Creek (W5)	0.22	2
Polywog Creek (W4)	0.17	3
Long Branch (W1)	0.14	4
Bear Creek (W2)	0.14	4
Todd Ditch (W6)	0.09	6

6.5 WINDSHIELD AND DESKTOP SURVEY

Ranking analysis of the concerns observed during the windshield survey was based on the number of occurrences of the concern within each subwatershed.

6.5.1 Inadequate Buffers

The lengths of inadequate or nonexistent buffers, adequate grassed buffers, and adequate forested buffers were measured using ArcGIS. The percentage of inadequate buffers were then calculated. These percentages were ranked with subwatersheds having the highest percentages given the lowest rank and those with the lowest percentages given the highest rank. As shown in **Table 47**, Todd Ditch (W6), Little Duck Creek (W5), and Polywog Creek had the highest percentages of inadequate buffers, while Lamberson Ditch (W3), Long Branch (W1), and Bear Creek (W2) had the lowest percentages.

Table 47. Subwatershed Rank by Inadequate Buffers

Subwatershed	% Inadequate Buffers	Rank
Todd Ditch (W6)	59	1
Little Duck Creek (W5)	53	2
Polywog Creek (W4)	51	3
Bear Creek (W2)	41	4
Long Branch (W1)	32	5
Lamberson Ditch (W3)	26	6

6.5.2 Tillage Practices

The acreages of conventional tillage in the watershed were estimated based on the acres planted to corn and soybeans and the respective percentages of conventional tillage determined by the Tillage Transects. The subwatersheds with the most conventional tillage received lower ranks, while the subwatersheds with less conventional tillage were ranked higher. Based on this assessment, Polywog Creek (W4), Todd Ditch (W6), and Little Duck Creek (W6) practiced the most conventional tillage, while Long Branch (W1), Bear Creek (W2), and Lamberson Ditch (W3) practiced less conventional tillage (**Table 48**).

Table 48. Subwatershed Rank by Tillage Practices

Subwatershed	Acres Conventional Tillage	Rank
Polywog Creek (W4)	7621	1
Todd Ditch (W6)	4917	2
Little Duck Creek (W5)	4232	3
Lamberson Ditch (W3)	4111	4
Bear Creek (W2)	3043	5
Long Branch (W1)	1891	6

6.5.3 Stream Obstructions and Streambank Erosion

Stream obstructions and streambank erosion were ranked by the number of occurrences that were observed during the windshield survey. The subwatershed with the most occurrences was given a lower rank while the subwatershed with the least occurrences was given a higher rank. As displayed in **Table 49**, Lamberson Ditch (W3) had the most stream obstructions or streambank erosion, and Long Branch (W1) had the second most. No stream obstructions or streambank erosion was observed in Bear Creek (W2), Polywog Creek (W4), Little Duck Creek (W5), and Todd Ditch (W6).

Table 49. Subwatershed Rank by Stream Obstructions and Bank Erosion

Subwatershed	# of Occurrences	Rank
Lamberson Ditch (W3)	3	1
Long Branch (W1)	1	2
Bear Creek (W2)	0	6
Polywog Creek (W4)	0	6
Little Duck Creek (W5)	0	6
Todd Ditch (W6)	0	6

6.5.4 Malfunctioning or Nonexistent Septic Systems

Subwatersheds were ranked by the number of unsewered communities, with the subwatersheds with the most communities receiving a lower rank and those with fewer communities receiving a higher rank. An unsewered community consists of 10 or more houses within a quarter square mile that is located outside of known sewer service districts. **Table 50** indicates that Long Branch (W1), Lamberson Ditch (W3), and Polywog Creek (W4) contained the most unsewered communities, while Todd Ditch (W6), Little Duck Creek (W5), and Bear Creek (W2) contained the fewest.

Table 50. Subwatershed Rank by Unsewered Communities

Subwatershed	# of Unsewered Communities	Rank
Long Branch (W1)	4	1
Lamberson Ditch (W3)	3.5	2
Polywog Creek (W4)	2.5	3
Bear Creek (W2)	2	4
Little Duck Creek (W5)	1	5
Todd Ditch (W6)	0	6

6.5.5 Combined Sewer Overflows

The number of CSOs located in each subwatershed were ranked; Little Duck Creek was the only subwatershed that contained CSOs (**Table 51**).

Table 51. Subwatershed Rank by CSOs

Subwatershed	# of Occurrences	Rank
Little Duck Creek (W5)	14	1
Long Branch (W1)	0	6
Bear Creek (W2)	0	6
Lamberson Ditch (W3)	0	6
Polywog Creek (W4)	0	6
Todd Ditch (W6)	0	6

6.5.6 AFO/CFO/CAFOs

AFO/CFO/CAFOs were ranked based on the number of occurrences in each subwatershed discovered through a permit search and from local knowledge. The subwatersheds with more AFO/CFO/CAFOs were given a lower rank while those with fewer occurrences were given a higher rank. As shown in **Table 52**, Todd Ditch (W6) had the most AFO/CFO/CAFOs, while Long Branch (W1) and Polywog Creek (W4) contained one AFO/CFO/CAFOs each. Bear Creek (W2), Lamberson Ditch (W3), and Little Duck Creek (W5) did not contain any AFO/CFO/CAFOs.

Table 52. Subwatershed Rank by AFO/CFO/CAFOs

Subwatershed	# of Occurrences	Rank
Todd Ditch (W6)	2	1
Long Branch (W1)	1	2
Polywog Creek (W4)	1	2
Bear Creek (W2)	0	6
Lamberson Ditch (W3)	0	6
Little Duck Creek (W5)	0	6

6.5.7 Livestock with Stream Access

Subwatersheds were ranked by the number of occurrences of livestock with access to the stream observed during the windshield survey. The subwatershed with the most occurrences was given a lower rank while the subwatershed with the least occurrences was given a higher rank. **Table 53** shows that Polywog Creek (W4) and Bear Creek (W2) had the most occurrences of livestock with access to streams, while Long Branch (W1) and Todd Ditch (W6) had one occurrence each. Little Duck Creek (W5) and Lamberson Ditch (W3) had no livestock with access to the stream visible during the windshield survey.

Table 53. Subwatershed Rank by Livestock with Access to Stream

Subwatershed	# of Occurrences	Rank
Bear Creek (W2)	2	1
Polywog Creek (W4)	2	1
Long Branch (W1)	1	3
Todd Ditch (W6)	1	3
Lamberson Ditch (W3)	0	6
Little Duck Creek (W5)	0	6

6.5.8 Hobby Farms with Livestock

The number of hobby farms located in each subwatershed were ranked with the subwatersheds with the most hobby farms given a lower rank and those with the least given a higher rank. Polywog Creek (W4) and Bear Creek (W2) contained the most hobby farms, while Todd Ditch (W6), Little Duck Creek (W5), Lamberson Ditch (W3), and Long Branch (W1) had least hobby farms (**Table 54**).

Table 54. Subwatershed Rank by Hobby Farms with Livestock

Subwatershed	# of Occurrences	Rank
Polywog Creek (W4)	7	1
Bear Creek (W2)	6	2
Lamberson Ditch (W3)	4	3
Little Duck Creek (W5)	4	3
Todd Ditch (W6)	4	3
Long Branch (W1)	2	6

6.5.9 Agricultural Fertilizers

The acreages of row crops in the subwatersheds of the Duck Creek Watershed and the 2005 Indiana agricultural chemical application rates calculated by NASS, USDA were used to estimate amounts of agricultural chemicals applied to the Duck Creek Watershed. These amounts were ranked by subwatershed with the subwatershed applying the most fertilizer having the lowest rank. Because the estimated fertilizer usage was based on acreage of row crops, the subwatersheds with most row crops consistently showed the highest fertilizer use. **Table 55** reveals that Polywog Creek (W4), Todd Ditch (W6), and Bear Creek (W2) applied the most N and P fertilizer, while Long Branch (W1), Lamberson Ditch (W3), and Little Duck Creek (W5) applied the least.

Table 55. Subwatershed Rank by N and P Fertilizers

Subwatershed	Total N Applied Per Year (Lbs.)	Rank	Total P Applied Per Year (Lbs.)	Rank
Polywog Creek (W4)	904,454	1	495,475	1
Todd Ditch (W6)	744,935	2	408,093	2
Bear Creek (W2)	661,497	3	362,384	3
Little Duck Creek (W5)	641,239	4	351,289	4
Lamberson Ditch (W3)	622,780	5	341,174	5
Long Branch (W1)	411,182	6	225,248	6

6.5.10 Dumping Waste in Waterways

Dumping of waste in streams was ranked by the number of occurrences in each subwatershed. The subwatersheds with the most occurrences were a lower rank, while those with fewer occurrences were given a higher rank. The most sites with waste dumped in the stream corridor were located in Lamberson Ditch (W3), while Polywog Creek (W4) and Little Duck Creek (W5) contained one site each. Long Branch (W1), Bear Creek (W2), and Todd Ditch (W6) contained no sites with waste dumped in the stream corridor (**Table 56**).

Table 56. Subwatershed Rank by Dumping of Waste in Waterways

Subwatershed	# of Occurrences	Rank
Lamberson Ditch (W3)	2	1
Polywog Creek (W4)	1	2
Little Duck Creek (W5)	1	2
Long Branch (W1)	0	6
Bear Creek (W2)	0	6
Todd Ditch (W6)	0	6

6.6 RESULTS OF SUBWATERSHED ASSESSMENT

Once the subwatersheds were ranked for all of the water quality factors, including the baseline conditions and potential causes and sources of water quality impairments, these factors were then related to TSS, TN, TP, and *E. coli*. Next, with all factors equally weighted, the ranks in each of these categories were averaged to determine the level of degradation of each subwatershed related to each priority pollutant. **Table 57** ranks the subwatersheds by the water quality factors that are associated with TSS, and indicates that Polywog Creek (W4), Little Duck Creek (W5), Bear Creek (W2), and Lamberson Ditch (W3) are the most impaired for TSS. The subwatersheds were ranked by the water quality factors that are related to *E. coli* in **Table 58**, which shows that Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2) are the most impaired for *E. coli*. **Table 59** ranks the subwatersheds by the water quality factors that are associated with TN, and indicates that Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2) are the most impaired for TN. The subwatersheds were ranked by the water quality factors that are associated with TP in **Table 60**, which indicates that Polywog Creek (W4), Little Duck Creek (W5), Bear Creek (W2), and Todd Ditch (W6) are the most impaired for TP. The results of Tables 57-60 are summarized in **Table 61** to compare how the subwatersheds ranked for each priority pollutant and then how they ranked overall with all of the priority pollutants combined. Again, the subwatersheds with a higher level of degradation received a lower rank, while those that were less degraded were given a higher rank.

This overall subwatershed assessment indicates that the Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2) subwatersheds were the most impaired overall and for each priority pollutant, while the Long Branch (W1), Lamberson Ditch (W3), and Todd Ditch (W6) subwatersheds were the least impaired. This corresponds with the STEPL pollutant loads as displayed in **Figure 43** and also corresponds with the m-IBI and QHEI assessments.

Table 57. Subwatershed Rank Related to TSS

PARAMETERS	W1	W2	W3	W4	W5	W6
305(b) - aquatic life	2	5	1	2	2	5
305(b) - primary contact	1	1	1	1	1	1
m-IBI	5	1	4	3	2	
QHEI	5	2	4	3	1	
STEPL TSS Load	6	3	5	2	1	4
TSS Concentration	4	5	1	3	2	6
Streambank Erosion	2	6	1	6	6	6
Livestock in Stream	3	1	6	1	6	3
Adequate Buffers	5	4	6	3	2	1
Conventional Tillage	6	5	4	1	3	2
TOTAL	39	33	33	25	26	28
AVERAGE	3.9	3.3	3.3	2.5	2.6	3.5
OVERALL TSS RANK	**6**	**3**	**3**	**1**	**2**	**5**

Table 58. Subwatershed Rank Related to *E. coli*

PARAMETERS	W1	W2	W3	W4	W5	W6
305(b) - aquatic life	2	5	1	2	2	5
305(b) - primary contact	1	1	1	1	1	1
m-IBI	5	1	4	3	2	
QHEI	5	2	4	3	1	
CSOs	6	6	6	6	1	6
Livestock in Stream	3	1	6	1	6	3
Hobby Farms	6	2	3	1	3	3
AFO/CFO/CAFOs	2	6	6	2	6	1
Septic Systems	1	4	2	3	5	6
Adequate Buffers	5	4	6	3	2	1
TOTAL	36	32	39	25	29	26
AVERAGE	3.6	3.2	3.9	2.5	2.9	3.25
OVERALL *E. COLI* **RANK**	**5**	**3**	**6**	**1**	**2**	**4**

Table 59. Subwatershed Rank Related to TN

PARAMETERS	W1	W2	W3	W4	W5	W6
305(b) - aquatic life	2	5	1	2	2	5
305(b) - primary contact	1	1	1	1	1	1
m-IBI	5	1	4	3	2	
QHEI	5	2	4	3	1	
STEPL TN Load	6	2	4	3	1	5
TN Concentration	5	3	1	4	2	6
Streambank Erosion	2	6	1	6	6	6
CSOs	6	6	6	6	1	6
Livestock in Stream	3	1	6	1	6	3
Hobby Farms	6	2	3	1	3	3
AFO/CFO/CAFOs	2	6	6	2	6	1
Septic Systems	1	4	2	3	5	6
Adequate Buffers	5	4	6	3	2	1
Conventional Tillage	6	5	4	1	3	2
N Fertilizers	6	3	5	1	4	2
TOTAL	61	51	54	40	45	47
AVERAGE	4.1	3.4	3.6	2.7	3	3.6
OVERALL TN RANK	**6**	**3**	**4**	**1**	**2**	**4**

Table 60. Subwatershed Rank Related to TP

PARAMETERS	W1	W2	W3	W4	W5	W6
305(b) - aquatic life	2	5	1	2	2	5
305(b) - primary contact	1	1	1	1	1	1
m-IBI	5	1	4	3	2	
QHEI	5	2	4	3	1	
STEPL TP Load	6	3	5	2	1	4
TP Concentration	4	4	1	3	2	6
Streambank Erosion	2	6	1	6	6	6
CSOs	6	6	6	6	1	6
Livestock in Stream	3	1	6	1	6	3
Hobby Farms	6	2	3	1	3	3
AFO/CFO/CAFOs	2	6	6	2	6	1
Septic Systems	1	4	2	3	5	6
Adequate Buffers	5	4	6	3	2	1
Conventional Tillage	6	5	4	1	3	2
P Fertilizers	6	3	5	1	4	2
TOTAL	60	53	55	38	45	46
AVERAGE	4	3.5	3.7	2.5	3	3.5
OVERALL TP RANK	**6**	**3**	**5**	**1**	**2**	**3**

Table 61. Overall Subwatershed Rank by TSS, TN, TP, and *E. coli*

Overall Rank	TSS	TN	TP	*E. coli*	All Pollutants
1	W4	W4	W4	W4	W4
2	W5	W5	W5	W5	W5
3	W2/W3	W2	W2/W6	W2	W2
4		W3/W6		W6	W6
5	W6		W3	W1	W3
6	W1	W1	W1	W3	W1

SECTION 7.0 PROBLEM STATEMENTS

Based on the Subwatershed Assessment, four areas of primary concern were identified, and a fifth concern was identified by the steering committee.

7.1 TOTAL SUSPENDED SOLIDS

Problem Statement:
Based on the STEPL generated TSS loads and subsequent calculated concentrations, all of the subwatersheds in the Duck Creek Watershed exceed the US EPA standard for Total Suspended Solids of 30 mg/L.

Discussion:
High TSS loading occurs during storm events due to increased overland flow. The subwatersheds ranked of the highest priority for TSS, Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2), are also ranked of high priority for TSS loads generated from the STEPL program, inadequate buffers, conventional tillage, livestock with access to streams, and streambank erosion. These three subwatersheds with the highest TSS loads are also the three lowest ranked subwatersheds for supporting aquatic life based on m-IBI scores. Suspended solids decrease the clarity and the dissolved oxygen in the water, both blocking sunlight and limiting oxygen needed by aquatic plants and animals for growth and respiration. Also, suspended solids carry nutrients with them. An excess of nutrients feeds algal blooms, further limiting sunlight and oxygen for other aquatic organisms.

7.2 *E. coli*

Problem Statement:
E. coli counts in all streams of the Duck Creek Watershed exceed the Indiana single sample daily maximum of 235 colonies per 100 mL.

Discussion:
All of the streams in the Duck Creek Watershed were listed on IDEM's 2006 303(d) List of Impaired Waterbodies for *E. coli*. Out of 16 sampling locations in IDEM's TMDL study, only one met the geometric mean standard of 125 cfu/100mL. Based on the subwatershed assessment and the windshield survey, the subwatersheds ranked of the highest priority for *E. coli*, Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2), were also ranked of high priority for livestock with access to streams, CSOs, hobby farms, inadequate buffers, and their ability to support aquatic life based on m-IBI and QHEI scores. These subwatersheds were also ranked of moderate priority for unsewered communities and AFO/CFO/CAFOs. *E. coli* indicates the presence of fecal contamination in the water from warm-blooded animals, and also suggests the presence of other pathogens in the water which may be harmful to humans and animals.

7.3 TOTAL NITROGEN

Problem Statement:
Based on the STEPL generated Total Nitrogen loads and subsequent calculated concentrations, all but one of the subwatersheds in the Duck Creek Watershed exceed the 0.63 mg/L standard set by US EPA.

Discussion:
Based on the STEPL results, the Total Nitrogen load for all of the subwatersheds except the Todd Ditch Watershed (W6) exceeded the USEPA standard. The three subwatersheds with the highest STEPL generated TN loads, Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2), also have the highest STEPL generated TSS loads, and are the three least supportive of aquatic life based on m-IBI and QHEI scores. These subwatersheds are ranked of high priority for streambank erosion, livestock with access to the stream, hobby farms, CSOs, inadequate buffers, conventional tillage, high N fertilizer application rates, and are ranked of moderate priority for AFO/CFO/CAFOs and septic systems. Nitrogen which is found in organic matter and is present in animal waste, is therefore highly likely to be washed into streams with runoff during storm events. Nitrogen can also be leached through the soil into tile drains through which it is quickly transported to streams. An excess of nitrogen combined with other nutrients such as phosphorus in an aquatic system causes algal blooms, which depletes dissolved oxygen, suffocating other aquatic plants and animals.

7.4 TOTAL PHOSPHORUS

Problem Statement:
Based on the STEPL generated Total Phosphorus loads and subsequent calculated concentrations, all of the subwatersheds in the Duck Creek Watershed exceed the 0.075 mg/L standard set by US EPA.

Discussion:
Polywog Creek (W4), Little Duck Creek (W5), and Bear Creek (W2) which are the subwatersheds with the three highest STEPL generated TSS and TN loads, also have the highest Total Phosphorus loads. The largest source of Phosphorus is fertilizers. Therefore, the low percentages of adequate buffers, high percentages of conventional tillage, and high P fertilizer application rates present in these subwatersheds may be responsible for the respectively high Phosphorus loads. These subwatersheds are also ranked of high priority for streambank erosion and livestock with access to streams, which contribute sediment and therefore phosphorus to waterways. As with Nitrogen, Phosphorus can also be attached to sediment, or can be leached into tile drains. Through these means it is transported to streams during rain events, causing algal blooms, and consequently limiting the habitat for aquatic life.

7.5 EDUCATION PROGRAMS

Problem Statement:
An adequate education program that helps residents understand their role in the overall water quality of the watershed is not in place in the Duck Creek Watershed.

Discussion:
Education through ongoing efforts of many entities in the watershed needs to be coordinated and increased. Education through public meetings, BMP demonstrations, literature distribution, news articles, and discussion of existing ordinances will help to increase public awareness of the issues within the watershed. Topics of the needed educational programs include proper installation and maintenance of septic systems, proper fertilizer use, proper pet waste disposal, land stewardship, wildlife management, agricultural BMPs, and development pressure. Increased public awareness will help citizens understand the interconnectivity of water quality, the watershed and their everyday lives.

SECTION 8.0 CRITICAL AREAS

Based on pollutant load modeling, other information in the baseline assessment, and public input, the steering committee decided to focus on TSS, *E. coli*, TN, and TP. **Tables 62 through 65** lists the subwatersheds in the order they were ranked for each priority pollutant by the subwatershed assessment. The causes and sources of the pollutants in each subwatershed along with their corresponding rank from the subwatershed assessment are also listed in the tables. The source "Agricultural Runoff" is a general term being used to encompass all other agricultural sources, such as areas needing grassed waterways, farms needing whole farm management, and a lack of education about agricultural sources. In the following tables, the sources listed for each subwatershed are being designated as critical areas and the subwatersheds are being prioritized for implementation. The locations of these sources can be found earlier in the report on **Figures 37 and 38**. Also included in these tables are the potential remediation types for each critical area. **Table 66** provides descriptions of these remediation types. As discussed previously, well capping or decommissioning plays a role in preventing contaminants into ground water sources and needs to be considered for all subwatersheds.

Table 62. Critical areas for TSS as Determined by the Subwatershed Assessment and STEPL Modeling. 1 = Highest Priority – 6 = Lowest Priority

Subwatershed	TSS Load Rank	Cause or Source (Rank from Subwatershed Assessment)	Potential Remediation Type
Polywog Creek (W4)	1	▪ Livestock with access to stream (1) ▪ Agricultural Runoff ▪ Inadequate Buffers (2) ▪ Conventional Tillage (3)	▪ Exclusion Fencing ▪ Education/Outreach ▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Restored Wetlands
Little Duck Creek (W5)	2	▪ Agricultural Runoff ▪ Inadequate Buffers (2) ▪ Conventional Tillage (3)	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Restored Wetlands
Bear Creek (W2)	3	▪ Livestock with access to stream (1) ▪ Agricultural Runoff ▪ Inadequate Buffers (4) ▪ Conventional Tillage (5)	▪ Exclusion Fencing ▪ Education/Outreach ▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Restored Wetlands
Lamberson Ditch (W3)	3	▪ Streambank Erosion (1) ▪ Agricultural Runoff ▪ Inadequate Buffers (6) ▪ Conventional Tillage (4)	▪ Log Jam Removal ▪ Bank Stabilization ▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Restored Wetlands
Todd Ditch (W6)	5	▪ Livestock with access to stream (3) ▪ Agricultural Runoff ▪ Inadequate Buffers (1) ▪ Conventional Tillage (2)	▪ Exclusion Fencing ▪ Education/Outreach ▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Restored Wetlands
Long Branch (W1)	6	▪ Livestock with access to stream (3) ▪ Streambank Erosion (2) ▪ Agricultural Runoff ▪ Inadequate Buffers (5) ▪ Conventional Tillage (6)	▪ Exclusion Fencing ▪ Education/Outreach ▪ Log Jam Removal ▪ Bank Stabilization ▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Restored Wetlands

Table 63. Critical Areas for *E. coli* as Determined by the Subwatershed Assessment and STEPL Modeling. 1 = Highest Priority – 6 = Lowest Priority

Subwatershed	TSS Load Rank	Cause or Source (Rank from Subwatershed Assessment)	Potential Remediation Type
Polywog Creek (W4)	1	▪ Livestock with access to stream (1) ▪ Hobby Farms (1) ▪ AFO/CFO/CAFOs (2) ▪ Septic Systems ▪ Inadequate Buffers (3) ▪ Tile Drain Discharge	▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Buffer Installation ▪ Rural Regional Sewer Dist. ▪ Drainage Water Management ▪ Restored Wetlands
Little Duck Creek (W5)	2	▪ Hobby Farms (3) ▪ Septic Systems ▪ Inadequate Buffers (2) ▪ Tile Drain Discharge ▪ CSOs (1)	▪ Nutrient Management ▪ Buffer Installation ▪ Rural Regional Sewer Dist. ▪ Education/Outreach ▪ Drainage Water Management ▪ Whole Community Planning ▪ Restored Wetlands
Bear Creek (W2)	3	▪ Livestock with access to stream (1) ▪ Hobby Farms (2) ▪ Septic Systems ▪ Inadequate Buffers (4) ▪ Tile Drain Discharge	▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Buffer Installation ▪ Rural Regional Sewer Dist. ▪ Drainage Water Management ▪ Restored Wetlands
Todd Ditch (W6)	4	▪ Livestock with access to stream (3) ▪ Hobby Farms (3) ▪ AFO/CFO/CAFOs (1) ▪ Septic Systems ▪ Inadequate Buffers (1) ▪ Tile Drain Discharge	▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Buffer Installation ▪ Rural Regional Sewer Dist. ▪ Drainage Water Management ▪ Restored Wetlands
Long Branch (W1)	5	▪ Livestock with access to stream (3) ▪ Hobby Farms (6) ▪ AFO/CFO/CAFOs (2) ▪ Septic Systems ▪ Inadequate Buffers (5) ▪ Tile Drain Discharge	▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Buffer Installation ▪ Rural Regional Sewer Dist. ▪ Drainage Water Management ▪ Restored Wetlands
Lamberson Ditch (W3)	6	▪ Hobby Farms (3) ▪ Septic Systems ▪ Inadequate Buffers (6) ▪ Tile Drain Discharge	▪ Nutrient Management ▪ Buffer Installation ▪ Rural Regional Sewer Dist. ▪ Education/Outreach ▪ Drainage Water Management ▪ Restored Wetlands

Table 64. Critical Areas for Total Nitrogen as Determined by the Subwatershed Assessment and STEPL Modeling. 1 = Highest Priority – 6 = Lowest Priority

Subwatershed	TN Load Rank	Cause or Source (Rank from Subwatershed Assessment)	Potential Remediation Type
Polywog Creek (W4)	1	▪ Agricultural Runoff ▪ Inadequate Buffers (3) ▪ Conventional Tillage (1) ▪ Nitrogen Fertilizers (1) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (1) ▪ Hobby Farms (1) ▪ AFO/CFO/CAFOs (2) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Nutrient Management ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Rural Regional Sewer Districts ▪ Restored Wetlands
Little Duck Creek (W5)	2	▪ Agricultural Runoff ▪ Inadequate Buffers (2) ▪ Conventional Tillage (3) ▪ Nitrogen Fertilizers (4) ▪ Tile Drain Discharge ▪ Hobby Farms (3) ▪ Septic Systems ▪ CSOs (1)	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Nutrient Management ▪ Drainage Water Management ▪ Rural Regional Sewer Districts ▪ Education/Outreach ▪ Whole Community Planning ▪ Restored Wetlands
Bear Creek (W2)	3	▪ Agricultural Runoff ▪ Inadequate Buffers (4) ▪ Conventional Tillage (5) ▪ Nitrogen Fertilizers (3) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (1) ▪ Hobby Farms (2) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Nutrient Management ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Rural Regional Sewer Districts ▪ Restored Wetlands
Lamberson Ditch (W3)	4	▪ Agricultural Runoff ▪ Inadequate Buffers (6) ▪ Conventional Tillage (4) ▪ Nitrogen Fertilizers (5) ▪ Tile Drain Discharge ▪ Hobby Farms (3) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Nutrient Management ▪ Drainage Water Management ▪ Rural Regional Sewer Districts ▪ Education/Outreach ▪ Restored Wetlands

Table 64 (cont'd). Critical Areas for Total Nitrogen as Determined by the Subwatershed Assessment and STEPL Modeling. 1 = Highest Priority – 6 = Lowest Priority (cont.)

Subwatershed	TN Load Rank	Cause or Source (Rank from Subwatershed Assessment)	Potential Remediation Type
Todd Ditch (W6)	4	▪ Agricultural Runoff ▪ Inadequate Buffers (1) ▪ Conventional Tillage (2) ▪ Nitrogen Fertilizers (2) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (3) ▪ Hobby Farms (3) ▪ AFO/CFO/CAFOs (1) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Nutrient Management ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Rural Regional Sewer Districts ▪ Restored Wetlands
Long Branch (W1)	6	▪ Agricultural Runoff ▪ Inadequate Buffers (5) ▪ Conventional Tillage (6) ▪ Nitrogen Fertilizers (6) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (3) ▪ Hobby Farms (6) ▪ AFO/CFO/CAFOs (2) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Nutrient Management ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Rural Regional Sewer Districts ▪ Restored Wetlands

Table 65. Critical Areas for Total Phosphorus as Determined by the Subwatershed Assessment and STEPL Modeling. 1 = Highest Priority – 6 = Lowest Priority

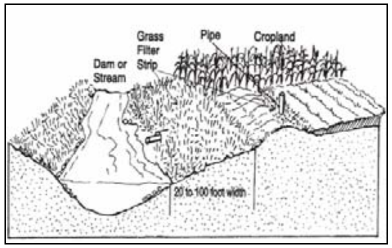
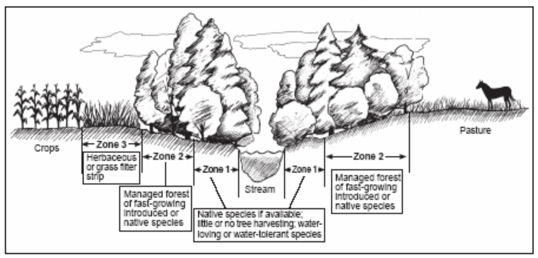
Subwatershed	TP Load Rank	Cause or Source (Rank from Subwatershed Assessment)	Potential Remediation Type
Polywog Creek (W4)	1	▪ Agricultural Runoff ▪ Inadequate Buffers (3) ▪ Conventional Tillage (1) ▪ Phosphorus Fertilizers (1) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (1) ▪ Hobby Farms (1) ▪ AFO/CFO/CAFOs (2) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Soil Analysis ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Rural Regional Sewer Dist. ▪ Restored Wetlands
Little Duck Creek (W5)	2	▪ Agricultural Runoff ▪ Inadequate Buffers (2) ▪ Conventional Tillage (3) ▪ Phosphorus Fertilizers (4) ▪ Tile Drain Discharge ▪ Hobby Farms (3) ▪ Septic Systems ▪ CSOs (1)	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Soil Analysis ▪ Drainage Water Management ▪ Nutrient Management ▪ Rural Regional Sewer Dist. ▪ Education/Outreach ▪ Whole Community Planning ▪ Restored Wetlands
Bear Creek (W2)	3	▪ Agricultural Runoff ▪ Inadequate Buffers (4) ▪ Conventional Tillage (5) ▪ Phosphorus Fertilizers (3) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (1) ▪ Hobby Farms (2) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Soil Analysis ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Rural Regional Sewer Dist. ▪ Restored Wetlands
Todd Ditch (W6)	3	▪ Agricultural Runoff ▪ Inadequate Buffers (1) ▪ Conventional Tillage (2) ▪ Phosphorus Fertilizers (2) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (3) ▪ Hobby Farms (3) ▪ AFO/CFO/CAFOs (1) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Soil Analysis ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Rural Regional Sewer Dist. ▪ Restored Wetlands

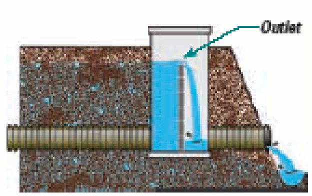
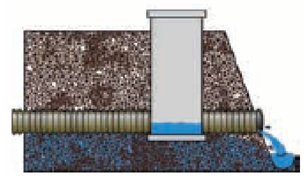
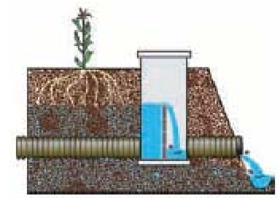
Table 65 (cont'd). Critical Areas for Total Phosphorus as Determined by the Subwatershed Assessment and STEPL Modeling. 1 = Highest Priority – 6 = Lowest Priority

Subwatershed	TP Load Rank	Cause or Source (Rank from Subwatershed Assessment)	Potential Remediation Type
Lamberson Ditch (W3)	5	▪ Agricultural Runoff ▪ Inadequate Buffers (6) ▪ Conventional Tillage (4) ▪ Phosphorus Fertilizers (5) ▪ Tile Drain Discharge ▪ Hobby Farms (3) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Soil Analysis ▪ Drainage Water Management ▪ Nutrient Management ▪ Rural Regional Sewer Dist. ▪ Education/Outreach ▪ Restored Wetlands
Long Branch (W1)	6	▪ Agricultural Runoff ▪ Inadequate Buffers (5) ▪ Conventional Tillage (6) ▪ Phosphorus Fertilizers (6) ▪ Tile Drain Discharge ▪ Livestock with Access to Stream (3) ▪ Hobby Farms (6) ▪ AFO/CFO/CAFOs (2) ▪ Septic Systems	▪ Whole Farm Management ▪ Buffer Installation ▪ Grassed Waterways ▪ Reduced or No Till ▪ Soil Analysis ▪ Drainage Water Management ▪ Exclusion Fencing ▪ Education/Outreach ▪ Nutrient Management ▪ Rural Regional Sewer Dist. ▪ Restored Wetlands

Table 66 lists conventional best management practices that may be used as remediation in the watershed. The BMPs suggested may be related to or used in conjunction with BMPs listed in Appendix F.

Table 66. Potential Remediation Types Explanations for BMPs listed in Tables 44-47. *Explanations listed in alphabetical order*.

Buffers/Filter Strips	A buffer/filter strip is a vegetated area located between a human land use and a water body, which traps and absorbs sediment, nutrients, and other pollutants from sheet flow off of the human land use before it reaches the water body. Buffers have been shown to reduce sediment loads by 50 – 90%, Total P by 20 – 90%, Total N by 63 – 76%, depending on the type and width of installed buffer (Coote and Gregorich, 2000). Grassed Buffers:   Purdue University Cooperative Extension Service USDA Natural Resource Conservation Service Forested Buffers:   USDA Natural Resource Conservation Service USDA Natural Resource Conservation Service

Drainage Water Management	In Drainage Water Management the removal of surface or subsurface runoff is controlled by water-control structures. Water is retained during dry periods to provide moisture for crops, and released during wet months to prevent pooling in fields or over saturating crop roots. Drainage Water Management Structures (shown below) have been found to reduce annual nitrate loads by 15 – 75%.
	 ***Figure 1.** The outlet is raised after harvest to reduce nitrate delivery.*  ***Figure 2.** The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.*  ***Figure 3.** The outlet is raised after planting to potentially store water for crops.*
	Purdue Extension
Education	Education through ongoing efforts of many entities in the watershed needs to be coordinated and increased. Education through public meetings, BMP demonstrations, literature distribution, news articles, and discussion of existing ordinances will help to increase public awareness of the issues within the watershed. Increased public awareness will help citizens understand the interconnectivity of water quality, the watershed and their everyday lives.
Grassed Waterways	A grassed waterway is a natural or constructed channel which conveys runoff from concentrated flow areas where erosion control is needed. These waterways are seeded to sod-forming grasses which slow water allowing infiltration and filters out sediment and nutrients.  USDA Natural Resource Conservation Service

Livestock Exclusion Fencing	Fencing can be installed along streams and ditches to keep livestock away from the waterways. This prevents the livestock from trampling and eroding the streambanks or from depositing waste in or near the streams.  USDA Natural Resource Conservation Service
Nutrient Management	Nutrient Management involves analyzing the nutrient content of soil, manure, or fertilizers so the amount, placement, and timing of these nutrients can be managed to obtain optimum crop yields and minimize the impact on water quality.

Residue Management	Reducing tillage, reduces erosion by providing ground cover, improves soil tilth by adding organic matter, reduces evaporation from the soil, and saves time and labor. Reduced tillage is therefore effective in reducing sediment and nutrient loading to streams and ditches. Mulch Till: According to NRCS, Mulch Tillage entails managing crop residue on a year round basis to provide an acceptable erosion rate, conserve moisture, and maintain or improve soil tilth.  WCC No-Till: The NRCS definition for No-Till is managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round. Crops are planted and grown in narrow slots or tilled strips established in the untilled seedbed of the previous crop.  CTIC
Rural Regional Sewer Districts	Installing sewer systems in rural areas would greatly reduce the number of malfunctioning or nonexistent septic systems, therefore significantly decreasing the E. coli load from this source.

Stream Obstruction Removal	Removal of unwanted or hazardous structures, vegetation, debris, or other material restores the natural flow of a waterway, usually reducing in stream erosion.  USDA Natural Resource Conservation Service
Streambank Stabilization	Regrading or vegetating an unstable streambank reduces erosion and therefore sedimentation and may provide wildlife habitat. Any undertaking on a regulated drain or the drain easement will require permit approval from and meet the standards and specifications as published by the county surveyors' office. Other state and federal permits may be required.  WCC  WCC
Well Decommissioning (Well Capping)	The sealing and permanent closure of a well no longer in use. The practice serves to prevent entry of animals, debris, or other foreign substances into a well; eliminate the physical hazard of an open hole to people, animals, and farm machinery; and prevent entry of contaminated surface water into wells and migration of contaminants into ground water sources. Water wells abandoned prior to January 1, 1988, maybe plugged by the landowner. Water wells abandoned on or after January 1, 1988, must be plugged by an Indiana licensed water well driller.

Wetland Restoration	Wetlands slow water down allowing sediment, nutrients, and other contaminants to settle out. They also act as biological filters, provide wildlife habitat, reduce the risk and damage of flooding by providing overflow storage during storm events, and recharge groundwater. Wetlands have been found beneficial in reducing nutrient and *E. coli* concentrations to flowing streams (DeBusk, 1999). A study by the University of California found that wetlands reduced E. coli loads by an average of 73% (Atwill et al. 2007).  WCC
Whole Community Planning	Whole community planning is a holistic approach to urban planning which encourages land stewardship and sustainable practices. In the Duck Creek Watershed, whole community planning could be used to minimize impacts from CSOs in Elwood.
Whole Farm Planning	Whole Farm Planning is a holistic approach to farm management which focuses on land stewardship and sustainable practices. These practices include riparian buffers, filter strips, conservation tillage, grassed waterways, livestock exclusion, nutrient management, drainage water management, manure management, rotational grazing, wildlife habitat, contour farming, field borders, windbreaks, crop rotations, cover crops, pest management, and erosion control.

SECTION 9.0 GOALS AND DECISIONS

Based on the concerns and the problem statements the overall watershed management goal is to improve the water quality and habitat of the Duck Creek Watershed by reducing and preventing pollutant loads in the watershed such that, at a minimum, the waterbodies meet Indiana water quality standards. This plan provides specific recommendations for actions (including BMPs) and educational programs to address the water quality issues impacting the Duck Creek Watershed. Recommendations for the BMPs came from the Duck Creek Steering Committee. The BMPs need to meet the standards and specifications of the USDA, Natural Resource Conservation Service Field Office Technical Guide. The implementation of these BMPs combined with the educational programs and outreach about water quality and land use will lead to lower pollutant loads.

Phase One of this plan's implementation will last five years. Within that time efforts will be focused on reaching the target loads by implementing the short term goals in all of the subwatersheds following the prioritization determined in the subwatershed assessment. If the target is not reached during Phase One, efforts will be redirected to reducing pollutant loads by implementing the long term goals in all of the subwatersheds following the prioritization determined in the subwatershed assessment. The milestones and indicators set in the following sections will be used to indicate if the goals have been met. **Table 67** shows the relations between the potential sources of the priority pollutants and the goals and action items.

9.1 POLLUTANT REDUCTION GOALS

These are the goals listed in their order of importance:

Goal 1: Reduce TSS loads in the Duck Creek Watershed.

Based on STEPL modeling, the current TSS concentration in the Duck Creek Watershed (63 mg/L) exceeds the concentration that the US EPA considers to cause impairment in streams (30 mg/L). If the action items in the TSS Action Register are completed, the TSS target concentration will be met within fourth years. See the following sections 9.2 and 9.3 for more details.

Goal 2: Reduce *E. coli* loads in the Duck Creek Watershed.

The current E. coli concentration of the Duck Creek Watershed (4,352 colonies/100 ml), as determined by the IDEM TMDL Report, exceeds the state's standard of 235 colonies/100 ml. A reduction of 4,117 colonies/100ml is needed in order to meet the standard. See the following sections 9.2 and 9.3 for more details.

Goal 3: Reduce Nitrogen loads in the Duck Creek Watershed.

Based on STEPL modeling, the current TN concentration of the Duck Creek Watershed (1.1 mg/L) exceeds the concentration recommended by the US EPA (0.63 mg/L). If the action items listed in the TN action register are completed, the TN target concentration will be met within five years. See the following sections 9.2 and 9.3 for more details.

Goal 4: Reduce Phosphorus loads in the Duck Creek Watershed.
Based on STEPL modeling, the current TP concentration in the Duck Creek Watershed (0.2 mg/L) exceeds the concentration recommended by the US EPA (0.075 mg/L). If the action items listed in the TP action register are completed, the TP target concentration will be met within five years. See the following sections 9.2 and 9.3 for more details.

Goal 5: Create and implement water quality educational programs in the Duck Creek Watershed.
It is believed that an increase in awareness of how everyday activities affect water quality will help attain the load reductions needed for each priority pollutant in the Duck Creek Watershed.

Table 67: Summary of Pollutant Sources with Links to Goals.

Priority Parameter	Potential Source	Goals	Activity	Approach	Basis/Evidence
TSS	Streambank Erosion	1, 3, 4, 5	Livestock Exclusion	Education and provide fencing through cost-share	Livestock that have access to streams trample and erode the banks.
TSS	Streambank Erosion	1, 3, 4, 5	Promote Land Stewardship	Education	Fallen trees loosen sediment on streambanks and cause log jams, both adding excess sediment to waterways.
TSS	Conventional Tillage	1, 3, 4, 5	Promote Conservation Tillage	Education, provide rental equipment, and cost-share equipment modifications	Conventional Tillage leaves unstabilized soil exposed through the winter and loosens soil when corn stalks are removed.
TSS	Lack of Buffer Strips	1, 3, 4, 5	Install Buffer Strips	Education and Cost-share	Buffer strips help filter pollutants out of runoff.
E. coli	Failing Septic Systems	2, 5	Promote Compliance	Education	Failing septics load fecal material into waterways.
E. coli	Livestock Waste	2, 5	Livestock Exclusion	Education and provide fencing through cost-share	Excess fecal waste is entering waterways because livestock have access to streams.
E. coli	Wildlife	5	Promote Wildlife Management	Education	Growing wildlife populations are adding increasing amounts of fecal material to the water.
E. coli	CSOs	2	Promote Compliance	Education	CSOs are releasing raw sewage into waterways.
E. coli	Manure Spreading	2, 5	Deter overuse and install buffer strips	Education and Cost-share	Animal waste is entering streams and ditches from spreading manure on fields without sufficient buffer strips.
E. coli	Pet Waste	2, 5	Promote proper disposal	Education	Pet waste that is not properly disposed of can be carried to waterways by runoff.
E. coli	CFOs/CAFOs		Promote Compliance	Education	CFOs/CAFOs that violate their permits add excess animal waste into waterways.
Nutrients	Homeowner Fertilization	3, 4, 5	Deter overuse	Education	Fertilizers can be carried to waterways by runoff.
Nutrients	Agricultural Fertilizers	3, 4, 5	Deter overuse	Education	Fertilizers can be carried to waterways by runoff.

9.2 PROPOSED POLLUTANT REDUCTION STRATEGIES

Goal 1: Reduce TSS loads in the Duck Creek Watershed

Problem: TSS loads in the Duck Creek Watershed are high during event flows transporting sediment and nutrients to ditches and streams in exceedance of US EPA standards.

Short-term Target: Reduce TSS loading in headwater streams through use of buffers and agronomic BMPs.

Long-term Target: Address identified areas of streambank erosion and coordinate efforts with county surveyors' office to petition for maintenance and to develop standards for sustainable natural channels.

Phase One for this goal will focus on the Polywog Creek watershed (W4), Little Duck Creek watershed (W5), and Bear Creek watershed (W2).

Table 68 shows the TSS load and concentration in the Duck Creek Watershed under its current conditions, the target TSS load and concentration set by the US EPA, the load and concentration reduction needed in order to reach the target, and the percent reduction needed. **Table 69** shows the proposed strategies for reaching the TSS target load.

Table 68. Total Load Reductions Needed in the Duck Creek Watershed to Reach TSS Target Concentration set by US EPA

	Concentration	Load
Current	63 mg/L	1,856.4 tons/year
Target	30 mg/L *(US EPA)*	878 tons/year
Reduction Needed	33 mg/L	965 tons/year
Percent Reduction Needed	52%	52%

Table 77 in Section 9.3 summarizes the estimated load reductions for the watershed through the year 2025. Based on the load reductions in **Table 69** estimated from IDEM/EPA Region 5 Pollution Load Reduction Model, the TSS load reduction will be met in 2012.

Table 69. TSS Goal Action Register

Objective	Load Reduction	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Increase Conservation Tillage and No Till Practices Milestone for this objective is increasing reduced tillage by 580 acres per year for 5 years (or as needed to reach the goal).	0.17 t/ac/yr	2900 ac.	Create cost share program	$1500 to create and advertise cost share program, $33,640 for cost share	SWCDs NRCS[1]	Apr 08 – On-going
			Provide Cost-share funding			Apr 08 – Apr 09
			Determine other sources of equipment modification funding			Apr 08 – On-going
			Monitor conservation tillage and no till effectiveness through modeling(See Education Goal Action Register)			
Increase Buffer Strips Milestone for this objective is adding 45 acres of buffers per year for 5 years (or as needed to reach the goal).	0.39 t/ac/yr	212 ac.	Provide Cost-share funding	$150 per ac. Per NRCS FOTG $31,800 Total	SWCDs NRCS[1] ISDA	Apr 08 – On-going
			Determine other sources of funding			Present – Apr 09
			Monitor buffer effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Stabilize Stream Banks/Remove Stream Obstructions Milestone for this objective is implementing maintenance funds on stream sections (4), completing design and construction on 1 identified area every 2 years until completed.	0.12 t/ft/yr	335 ft.	Design/Construct	$200 per ft $67,000 Total	Outside engineer, SWCDs, County Surveyors	On-going as funds are available
			Promote the removal of log jams through maintenance funds			On-going as funds are available
			Monitor bank stabilization effectiveness through modeling(See Education Goal Action Register)			After Implementation
Install Grassed Waterways Milestone for this objective is to increase the number of waterways by 1 ac per year for 5 years (or as needed to reach goal).	10 t/ac/yr	5 ac.	Identify areas in need of grassed waterways	$3420 per acre $85,500 Total	SWCDs NRCS[1]	Apr 08 – On-going
			Install grassed waterways			Present – Apr 09
			Monitor grassed waterway effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going

[1] NRCS is included in this column only as a means to give credit for the USDA program work they are doing that may result in the installation of BMPs in the Duck Creek Watershed it is not meant to add additional workload with the IDEM 319 program.

Goal 2: Reduce *E. coli* loads in the Duck Creek Watershed.

Problem: Streams in the Duck Creek Watershed exceed the Indiana single sample daily maximum of 235 colonies per 100 milliliters for *E. coli*.

Short-term Target: Continue to work on Elwood CSO plan and implement livestock exclusion where needed.

Long-term Target: Assess septic systems and prioritize areas not suitable for septics.

Phase One for this goal will focus on the Polywog Creek watershed (W4), Little Duck Creek watershed (W5), and Bear Creek watershed (W2).

Table 70 shows the *E. coli* load and concentration in the Duck Creek Watershed under its current conditions, the target *E. coli* load and concentration set by the state, the load and concentration reduction needed in order to reach the target, and the percent reduction needed. **Table 71** shows the proposed strategies for reaching the target *E. coli* load.

Table 70. Total Reduction Needed in the Duck Creek Watershed to Reach *E. coli* Target set by the State

Load Type	Amount
Current Load	4,351.9 colonies/ 100 ml
Target Load	235 colonies/ 100 ml *(IAC 327)*
Reduction Needed	4,116.9 colonies/ 100ml
Percent Reduction Needed	94.6%

Please Note:
In **Table 71** load reductions will need to be calculated on an individual basis due to the parameter variances.

Table 71. *E. coli* Goal Action Register

Objective	Load Reduction	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Livestock Exclusion Milestone for this objective is to install fencing at 6 sites for a total of 16,000 ft over five years.	2	N/A	Work with NRCS and SWCDs to identify partners	$68,000	SWCDs NRCS[1]	Apr 08 – On-going
			Install fencing			Apr 08 – On-going
			Monitor fencing effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Reduce Number of Non-functioning Septic Systems Milestone for this objective is to develop a program to assess septics within the next 5 years and begin correcting septic systems within the next 20 years.	2	N/A	Work with the Local Health Departments to Identify malfunctioning or absent septic systems	Hamilton-[3] $1.7 mil Madison- $12.5 mil Tipton- $117,000.	SWCDs Local Health Departments Property Owners	On-going
			Eliminate malfunctioning septic systems and implement rural regional sewer districts			On-going
			Develop septic maintenance ordinance			
Reduce runoff from fields with manure spreading Milestone for this objective is to promote Manure Management Planning for non CAFO/CFO producers within the next five years.	2	N/A	Create and Promote a Manure Management Strategy	$1500 to create educational program and display.	SWCDs NRCS[1]	Apr 08 – On-going
			Monitor effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
			(Note: Nutrient Management implementation milestones and costs per acre listed in Nitrogen goal action register Table 73.)			
Combined Sewer Overflows (CSO) Milestone for this objective is to monitor the progress of the Elwood CSO Long Term Plan as mandated by IDEM and make correctives actions per the plan.	2	N/A	Identify CSO Locations	As funds become available to meet with IDEM's Long Term Plan	SWCDs Local Health Departments Local Planning Officials, IDEM	On-going
			Work with Local Officials to promote alternatives			On-going
Reduce pathogens in runoff from pet waste See Goal 5 action register.	2	N/A	Promote proper pet waste management	Cost built into education cost estimate	Property Owners	Apr 08 – On-going

Table 71 (cont'd). ***E. coli*** **Goal Action Register**

Objective	Load Reduction	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Wetland Restoration Milestone for this objective is to identify potential areas, and restore 1 acre of wetlands per year for 5 years	2	N/A	Identify potential wetland restoration sites	$10,000-25,000 per acre depending on site	SWCDs NRCS[1]	Apr 08 – On-going
			Restore wetlands			Apr 08 – On-going
			Monitor wetland effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Abandoned Well Closures The milestone for this objective is to provide cost share for three well closures per year for 5 years (or as needed in the watershed).	N/A	N/A	Promote cost share program	$250 per well $3750 Total	SWCDs NRCS[1] IDNR	Apr 08 – On-going
			Identify and close wells			Apr 08 – On-going
			Report number of closures			Apr 08 – On-going

[1] NRCS is included in this column only as a means to give credit for the USDA program work they are doing that may result in the installation of BMPs in the Duck Creek Watershed it is not meant to add additional workload with the IDEM 319 program.
[2] Load reductions will be calculated on an individual basis due to the parameter variances.
[3] Based on SPEA study costs, using percent of county located in Duck Creek Watershed.

Goal 3: Reduce Nitrogen loads in the Duck Creek Watershed.

> Problem: Nitrogen concentrations in the Duck Creek Watershed exceed the US EPA standard.
>
> Short-term Target: Coordinate urban and agricultural activities to ensure nutrient management plans are in place.
>
> Long-term Target: Further study tile drain impact and potential BMPs to moderate the effects of tile drains on water quality.

Phase One for this goal will focus the Little Duck Cree watershed (W5), Bear Creek watershed (W2), and Polywog Creek watershed (W4).

Table 72 shows the TN load and concentration in the Duck Creek Watershed under its current conditions, the target TN load and concentration set by the US EPA, the load and concentration reduction needed in order to reach the target, and the percent reduction needed. **Table 73** shows the proposed strategies for reaching the target TN load.

Table 72. Total Load Reductions Needed in the Duck Creek Watershed to Reach Total N Target Concentration set by US EPA

	Concentration	Load
Current	1.1mg/L	67,077 lbs/year
Target	0.63 mg/L *(US EPA)*	38,395 lbs/year
Reduction Needed	0.47 mg/L	28,682 lbs/year
Percent Reduction Needed	43%	43%

Table 77 in Section 9.3 summarizes the estimated load reductions for the watershed through the year 2025. Based on the load reductions in **Table 73** estimated from IDEM/EPA Region 5 Pollution Load Reduction Model, the Nitrogen load reduction will be met in 2013.

Table 73. Nitrogen Goal Action Register[1]

Objective	Load Reduction	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Increase Conservation Tillage and No Till Practices Milestone for this objective is increasing reduced tillage by 580 acres per year for five years (or as needed to reach the goal).	2 lbs/ac/yr	2900 ac.	Provide Cost-share funding	Cost built into sediment cost est.	SWCDs	Apr 08 – On-going
			Determine other sources of equipment modification funding			Present – On-going
			Monitor conservation tillage and no till effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Increase Buffer Strips Milestone for this objective is adding 45 acres of buffers per year for five years (or as needed to reach the goal).	5.4 lbs/ac/yr	212 ac.	Provide Cost-share funding	Cost built into sediment cost est.	SWCDs	Apr 08 – On-going
			Determine other sources of funding			Present – On-going
			Monitor buffer effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Stabilize Stream Banks/Remove Stream Obstructions Milestone for this objective is implementing maintenance funds on stream sections (4), completing design and construction on 1 identified area every 2 years until completed	2.3 lbs/ft/yr	335 ft.	Design/Construct	Cost built into sediment cost est.	Outside engineer SWCDs County Surveyors	Apr 08 – On-going
			Promote the removal of log jams through maintenance funds			On-going
			Monitor bank stabilization effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Reduce amount of fertilizer being carried by runoff from urban lawns See Goal 5 action register	N/A	N/A	Promote minimal fertilizer use through education programs	Cost built into sediment and educational cost est.	SWCDs Property Owners	Apr 08 – On-going
Nutrient Management Planning Milestone for this objective is implementing nutrient management planning on 75 acres per year for five years while maintaining soil productivity	2.0 lbs/ac/yr	375 ac.	Promote Nutrient Management Planning	$20 per acre	SWCDs Property Owners	Present – On-going
			Implement Nutrient Management Planning			Apr 08 – On-going
			Monitor effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going

Table 73 (cont'd). Nitrogen Goal Action Register[1]

Objective	Load Reduction	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Reduce N Loads from Tile Drains Milestone for this objective is installing 2 drainage water control structures per year for five years.	122 lbs/ structure/yr	10 structures	Install drainage water control structures Determine funding sources for drainage water control structures	$700-2,200 per structure[2]	SWCDs NRCS County Surveyors Property Owners	Apr 08 – On-going
Install Grassed Waterways Milestone for this objective is to increase the number of waterways by 1 ac per year for 5 years (or as needed to reach goal).	4.5 lbs/ac/yr	5 ac.	Identify areas in need of grassed waterways	Cost built into sediment cost est.	SWCDs NRCS[1]	Apr 08 – On-going
			Install grassed waterways			Present – Apr 09
			Monitor grassed waterway effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Abandoned Well Closures The milestone for this objective is to provide cost share for three well closures per year for 5 years (or as needed in the watershed).	N/A	N/A	Promote cost share program	$250 per well $3750 Total	SWCDs NRCS[1] IDNR	Apr 08 – On-going
			Identify and close wells			Apr 08 – On-going
			Report number of closures			Apr 08 – On-going

[1] All items in the E. coli Goal Action Register apply to this action register.
[2] Purdue Extension *Drainage Water Management for the Midwest* WQ-44

Goal 4: Reduce Phosphorus loads in the Duck Creek Watershed.

> Problem: Phosphorus concentrations in the Duck Creek Watershed exceed the US EPA standard.
>
> Short-term Target: Coordinate urban and agricultural activities to ensure nutrient management plans are in place.
>
> Long-term Target: Further study tile drain impact and potential BMPs to moderate the effects of tile drains on water quality.

Phase One for this goal will focus on the Little Duck Creek watershed (W5), Polywog Creek watershed (W4), and Bear Creek watershed (W2).

Table 74 shows the TP load and concentration in the Duck Creek Watershed under its current conditions, the target TP load and concentration set by the US EPA, the load and concentration reduction needed in order to reach the target, and the percent reduction needed. **Table 75** shows the proposed strategies for reaching the target TP load.

Table 74. Total Load Reductions Needed in the Duck Creek Watershed to Reach Total P Target Concentration set by US EPA

	Concentration	Load
Current	(0.2 mg/L)	9,725 lbs/year
Target	0.075mg/L *(US EPA)*	3647 lbs/year
Reduction Needed	(0.125 mg/L)	6078 lbs/year
Percent Reduction Needed	63%	63%

Table 77 in Section 9.3 summarizes the estimated load reductions for the watershed through the year 2025. Based on the load reductions in **Table 75** estimated from IDEM/EPA Region 5 Pollution Load Reduction Model, the Phosphorus load reduction will be met in 2013.

Table 75. Phosphorous Goal Action Register[1]

Objective	Load reductions	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Increase Conservation Tillage and No Till Practices Milestone for this objective is increasing reduced tillage by 580 acres per year for five years (or as needed to reach the goal).	0.25 lbs/ac/yr	2900 ac.	Provide Cost-share funding	Cost built into sediment cost est.	SWCDs	Apr 08 – On-going
			Determine other sources of equipment modification funding			Present – On-going
			Monitor conservation tillage and no till effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Increase Buffer Strips Milestone for this objective is adding 45 acres of buffers per year for five years (or as needed to reach the goal).	3.5 lbs/ac/yr	212 ac.	Provide Cost-share funding	Cost built into sediment cost est.	SWCDs	Apr 08 – On-going
			Determine other sources of funding			Present – On-going
			Monitor buffer effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Stabilize Stream Banks/Remove Stream Obstructions Milestone for this objective is implementing maintenance funds on stream sections (4), completing design and construction on 1 identified area every 2 years until completed	1.2 lbs/ft/yr	335	Design/Construct	Cost built into sediment cost est.	Outside engineer SWCDs County Surveyors	Apr 08 – On-going
			Promote the removal of log jams through maintenance funds			On-going
			Monitor bank stabilization effectiveness through modeling(See Education Goal Action Register)			Apr 08 – On-going
Reduce amount of fertilizer being carried by runoff from urban lawns See Goal 5 action register	N/A	N/A	Promote minimal fertilizer use through education programs	Cost built into sediment and educational cost est.	SWCDs Property Owners	Apr 08 – On-going
Nutrient Management Planning Milestone for this objective is implementing nutrient management planning on 75 acres per year for five years while maintaining soil productivity	0.25 lbs/ac/yr	375 ac.	Promote nutrient management planning	Cost built into Nitrogen cost est.	SWCDs Property Owners	Apr 08 – On-going

Table 75 (cont'd). Phosphorous Goal Action Register[1]

Objective	Load reductions	# Needed for Load Reduction	Action Items	Cost	Responsible Party	Schedule
Install Grassed Waterways Milestone for this objective is to increase the number of waterways by 1 ac per year for 5 years (or as needed to reach goal).	2.5 lbs/ac/yr	5 ac.	Identify areas in need of grassed waterways	Cost built into sediment cost est.	SWCDs NRCS[1]	Apr 08 – On-going
			Install grassed waterways			Present – Apr 09
			Monitor grassed waterway effectiveness through modeling (See Education Goal Action Register)			Apr 08 – On-going
Abandoned Well Closures The milestone for this objective is to provide cost share for three well closures per year for 5 years (or as needed in the watershed).	N/A	N/A	Promote cost share program	$250 per well $3750 Total	SWCDs NRCS[1] IDNR	Apr 08 – On-going
			Identify and close wells			Apr 08 – On-going
			Report number of closures			Apr 08 – On-going

[1] All items in the E. coli Goal Action Register apply to this action register

Goal 5: Create and implement water quality educational programs in the Duck Creek Watershed.

Problem: An adequate educational program is not in place in the Duck Creek Watershed to inform residents of their role in the overall water quality of the watershed.

Short-term Target: Coordinate numerous education programs already in place with SWCDs, MS4s, Extension, Health Depts., County Surveyors, IDNR, IDEM and elected officials.

Long-term Target: Create awareness of the interconnecting nature of water quality throughout the watershed.

Table 76 indicates the educational goals developed by the Duck Creek Watershed steering committee. The committee identified numerous areas where education needs to be coordinated and increased. The table provides a breakdown of educational areas.

Table 76. Education Goal Action Register

Topic	Objective	Action Items	Target Audience	Cost	Responsible Party	Schedule
Septic Systems	Proper Maintenance Connecting to Sewers	Brochure and Media Campaign	Property Owners	$1,000 per year	SWCDs Health Departments	Present – Dec 08+
Proper Fertilizer Use (Urban)	Overuse Keeping it on your lawn	Media Campaign	Urban Landowners	$500 per year	SWCDs Purdue Extension	Present – Dec 08+
Proper Pet Waste Disposal	Keeping it out of the water	Media Campaign	All Landowners	$500 per year	SWCD Humane Society	Present – Dec 08+
Land Stewardship	Dumping Waste	Promote Stewardship through all SWCD efforts Encourage ordinance compliance for dumping	All Landowners	$1,250 per year	SWCDs	Present – Dec 08+
	Log Jam Removal	Coordinate efforts with appropriate agencies				
Wildlife Management	Address Nuisance Animals	Presentation at Public Meeting by IDNR Conservation Officer	All Landowners	N/A	SWCDs IDNR Conservation Officer	2nd Duck Creek Public Meeting
Agricultural Practices	Conservation Tillage/No Till Buffer Strips Livestock Exclusion Manure Spreading Fertilizer Use Drainage Water Management	Promote on-going conservation practices through direct contact, newsletters, website, direct mailings, and/or field days	Agricultural Landowners	$2,500 per year	SWCDs NRCS[1] ISDA	Present – Dec 08+

Table 76 (cont'd). Education Goal Action Register

Topic	Objective	Action Items	Target Audience	Cost	Responsible Party	Schedule
Development Pressure	Sustainable Stormwater BMPs	Media Campaign	Developers Landowners	$500 per year	SWCDs Surveyor's Office Planning Commission	Present – Dec 08+
Monitoring through modeling	Monitor effectiveness of BMPs and their associated load reductions	Collect BMP implementation information Complete computer modeling on a yearly basis Share results through newsletters, website, publications, etc.	All Landowners Regulatory Agencies	$3,200 per year	SWCDs	Jan 2010 – On-going

[1] NRCS is included in this column only as a means to give credit for the USDA program work they are doing that may result in the installation of BMPs in the Duck Creek Watershed it is not meant to add additional workload with the IDEM 319 program.

9.3 LOAD REDUCTIONS BASED ON MILESTONES

Based on the milestones presented in the goals for TSS, Nitrogen, and Phosphorus, the following load reductions were summarized from the estimates from IDEM/EPA Region 5 Pollution Load Reduction Model. The load reduction results are in **Table 77**. If implemented by 2009 this watershed management plan will exceed the goals for the TSS load reductions in 2012, the Nitrogen and Phosphorus load reductions will be met in 2013.

Table 77. Long Range Load Reductions Based on Milestones

Year	Post BMP years	TSS Reduction Tons	Nitrogen Reduction lbs	Phosphorus Reductions lbs
2010	**2**	408.9	5,895	1,274
2012	**4**	1363	19,950	4,248
2013	**5**	2,044.5	29,925	6,372
2015	**7**	3,816.4	55,860	11,894
2020	**12**	10,631.4	155,610	33,134
2025	**17**	20,853.9	305,235	64,994

9.4 MODELING GOALS WITH STEPL

As a comparison STEPL was used to model the two top priority BMPs recommended in this plan, conservation tillage and filter strips. **Table 78** shows the N, P, and TSS loads under existing conditions in the watershed, the loads that would occur if the top priority BMPs recommended in this plan were implemented, and the load reductions that would occur if these BMPs were implemented according to the STEPL model. **Table 79** shows the N, P, and TSS loads produced by various land uses as if these BMPs were in place.

Table 78. Annual Nitrogen, Phosphorous, and TSS Loads per Year with Existing BMPs, Proposed BMPs, and Load Reductions from Existing BMPs to Proposed BMPs

Watershed	Load with Existing BMPs			Load with Proposed BMPs			Load Reduction		
	N lb/yr	P lb/yr	TSS t/yr	N lb/yr	P lb/yr	TSS t/yr	N lb/yr	P lb/yr	TSS t/yr
W1	5767	875	189	4353	497	79	1414	378	110
W2	12034	1424	268	9534	802	93	2500	622	175
W3	9071	1172	258	6896	608	97	2175	564	161
W4	11305	1973	344	7987	1136	110	3318	837	234
W5	20837	2974	533	18549	2443	379	2288	531	154
W6	8064	1308	265	5143	594	66	2921	714	199
Total	**67078**	**9725**	**1856**	**52460**	**6079**	**824**	**14618**	**3646**	**1032**

Table 79. Total Nitrogen, Phosphorus, and TSS Loads by Land Use per Year with Proposed BMPs

Sources	N Load (lb/yr)	P Load (lb/yr)	TSS Load (t/yr)
Urban	12317.01	1895.51	282.82
Cropland	13292.05	1741.50	240.42
Pastureland	13997.84	987.90	113.94
Forest	469.14	230.79	10.28
Feedlots	11131.43	736.93	0.00
User Defined	549.88	211.70	171.84
Septic	695.75	272.50	0.00
Gully	0.00	0.00	0.00
Streambank	6.69	2.58	4.18
Groundwater	0.00	0.00	0.00
Total	52459.79	6079.41	823.49

SECTION 10.0 MEASURING PROGRESS

The first measure of success will be the completion of the Duck Creek Watershed Management Plan in compliance with IDEM's checklist guidelines. The overall success of the plan is dependent upon implementation of action items for improving water quality to attain *E. coli* and water quality standards. The implementation of the Duck Creek Watershed Management Plan will be tracked through a system of administrative, social, and environmental indicators. For example, environmental indicators will include the acres of conservation tillage and no-till implemented and the length of buffers installed; and administrative indicators will be the number and type of best management practices (BMPs) implemented once the implementation phase is underway. Water quality improvements in the Duck Creek Watershed will be monitored through computer pollutant load modeling. As BMPs are implemented in the watershed, modeling will be conducted on a yearly basis to track the subsequent improvements in water quality. Future pollutant load modeling results will help document the impact of implementation projects. Social or behavioral indicators will focus on documenting involvement, such as the number of property owner responses, the number of volunteer hours logged, the number of stakeholders recruited and involved in the Steering Committee and public meetings, the number of partners providing project support, and the amount of match received. Community indicators of social change such as public policy/ordinance will also be used.

10.1 PROGRESS INDICATORS

The following section describes concrete milestones for stakeholders to reach and tangible deliverables produced while they work toward each goal. All of the goals include long-term goals (i.e. it will take more than 5 years to attain).

Goal 1: Reduce TSS loads in the Duck Creek Watershed.

Indicators: (Except for annual or continuous tasks, this goal should be reached by 2017.)

- Number of acres of conservation tillage implemented.
- Number of acres of no-till implemented.
- Number and length of buffers installed
- Number of stabilized banks
- Number of log jams removed
- Reduction in bank erosion around log jams
- Creation of a database for other funding sources
- Reduction of TSS concentrations during event flows

Goal attainment: The goal is attained when the TSS concentration in each watershed waterbody meets the target load concentration of 30 mg/L.

Goal 2: Reduce *E. coli* loads in the Duck Creek.

Indicators: (Except for continuous or annual tasks, this is a long-term goal. The goal should be reached by 2037.)

- Identification of landowners with livestock willing to install fencing
- Miles of fencing installed
- Visual reduction of livestock with access to streams
- Number and length of buffers installed.

- Identification of landowners with malfunctioning or absent septic systems willing to rehabilitate septic system or connect to sewer.
- Number of un-sewered homes sewered
- Number of rehabilitated septic systems
- Creation of map showing the locations of CSOs
- Reduction of *E. coli* concentrations during event flows
- Reduction of overflow events or treatment of overflow effluent
- Number of well closures

Goal attainment: The goal is attained when the *E. coli* concentration in each watershed waterbody meets the state standard (235 CFU /100 mL).

Goal 3: Reduce Nitrogen loads in the Duck Creek Watershed.
Indicators: (Except for annual/continuous tasks milestones should be reached by the end of 2017.)

- Number of acres of conservation tillage implemented.
- Number of acres of no-till implemented
- Number and length of buffers installed
- Number of stabilized banks
- Number of log jams removed
- Reduction in bank erosion around log jams
- Creation of a database for other funding sources
- Reduction of nitrogen concentrations during event flows
- Survey of amount of fertilizer used per acre
- Reduction of nitrogen concentrations during event flows
- Number of well closures

Goal attainment: The goal is attained when the nitrogen load concentrations in each watershed waterbody meets the state standard 0.63 mg/L.

Goal 4: Reduce Phosphorus loads in the Duck Creek Watershed.
Indicators: (Except for annual/continuous tasks milestones should be reached by the end of 2017.)

- Number of acres of conservation tillage implemented
- Number of acres of no-till implemented
- Number and length of buffers installed
- Number of stabilized banks
- Number of log jams removed
- Reduction in bank erosion around log jams
- Creation of a database for other funding sources
- Reduction of nitrogen concentrations during event flows
- Survey of amount of fertilizer used per acre
- Reduction of nitrogen concentrations during event flows
- Number of well closures

Goal attainment: The goal is attained when the phosphorus load concentrations in each watershed waterbody meets the state standard 0.075 mg/L.

Goal 5: Create and implement water quality educational programs in the Duck Creek Watershed.

Indicators: (This is an ongoing activity.)

- Number of landowners involved in NRCS/SWCD/ISDA projects
- Circulation of newspapers, newsletters and website hits
- Number of people in attendance
- Number of people in attendance
- Visual enhanced aesthetics
- Number of log jams removed
- Number of septic system repairs or replacements
- Number of homes connected to sewers
- Reduction of nutrients in future water quality monitoring

Goal Attainment: This goal lacks a specific water quality target similar to that which the other goals possess. This goal will be a continued effort.

10.2 MONITORING PROGRESS

Monitoring is an important component of this watershed management plan. Without monitoring, stakeholders will not know when or whether they have achieved their goals; or worse, they will not make timely refinements to their actions to ensure the actions they are taking will achieve their goals. The previous section details how stakeholders will monitor their progress toward achieving the goals set in this watershed management plan.

10.3 PLAN REVISIONS

This watershed management plan is meant to be a living document. Revisions and updates to the plan will be necessary as stakeholders begin to implement the plan and as other stakeholders become more active in implementing the plan.

SECTION 11.0 IMPLEMENTATION

The Hamilton County Soil and Water Conservation District will be the lead entity promoting the implementation of the Duck Creek Watershed Management Plan, in cooperation with the Madison and Tipton County Soil and Water Conservation Districts. Expanding upon the partnerships developed during the plan development phase, Hamilton County SWCD will solicit additional partners to support the implementation plan. Once approved, SWCD will coordinate the funding, implementation, and evaluation of the Duck Creek Watershed Management Plan. Annual updates will be posted on http://www.hamiltonswcd.org/. Upcoming events can also be found at http://www.hamiltonswcd.org/.

SECTION 12.0 REFERENCES

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Appendix A

Duck Creek Watershed Steering Committee Information

Duck Creek Steering Committee Members

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Madison County SWCD

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Madison County Landowner

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Noblesville, IN 46060
317-776-8500
health@co.hamilton.in.us

NRCS – Hamilton County
Chris Torp, Acting DC
1108 S. 9TH St.,
Noblesville, IN 46060-3745
317-773-2181 or 1432

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13490 E 281st St
Atlanta IN 46031-9752
765-552-0987

Phil Henderson
14380 East 281 Street
Arcadia, IN 46030

Madison County Health Department
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206 East 9th Street
Anderson, IN 46016
(765) 641-9536
bclidence@madisoncty.com

Madison County Surveyor
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Anderson, IN 46016
641-9638
bnewman@madisoncty.com

Purdue University Cooperative Extension Service
Madison County Government Center
16 E. 9th Street, STE 303
Anderson, IN 46016-1598
madisonces@purdue.edu
765/641-9514

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Nolan Pyke
1000 S Main St.
Tipton, Indiana 46072
765.675.8741

Tipton County Surveyor
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101 E Jefferson St.
Tipton, Indiana 46072
765.675.2793

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gbohlander@infarmbureau.org

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765-552-3729

Purdue University Cooperative Extension Service
James Woolf, CED
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Tipton, IN 46072
tiptonces@purdue.edu
Phone: 765/675-2694

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Charles E. Kiphart, Director
One Hamilton County Square Suite 306
Noblesville, IN 46060
(317) 776-8490
planning@co.hamilton.in.us

Hamilton County FSA
Jeff Trisler, Executive Director
1108 S 9th St.
Noblesville, IN 46060-3745
(317) 773-2181
Jeff.Trisler@in.usda.gov

Madison County Plan Commission
16 E. 9th St., Box 13
Anderson, IN 46016
(765)641-9541

Madison County FSA
Susan K. Allen, Executive Director
182 W 300 N Suite D
Anderson, IN 46012-1266
765.644.4249
susan.allen@in.usda.gov

White River Watchers
Judy Delury
533-4552
jdelury@iupui.edu

Madison County Council of Governments
Jerry Bridges – Executive Director
Rob Shumowsky – GIS Manager
16 E. 9th St. Room 100
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765.641.9482
rjshum@mccog.net
jbridges@mccog.net

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Tipton County Plan Commission
101 E Jefferson St.
Tipton, IN 46072
765.675.6063

Upper White River Watershed Alliance
Dr. Lenore P. Tedesco, Director
723 West Michigan Street, SL118
Indianapolis, IN 46202
317.274.7154
ltedesco@iupui.edu

Duck Creek Watershed
Stakeholder
Public Meeting Invitation

Williams Creek Consulting and the Hamilton County Soil and Water Conservation District (SWCD) are looking for concerned citizens to take an active role in providing community information to help protect the Duck Creek Watershed as part of **IDEM 319 Grant.**

Target Area: The Duck Creek Watershed covers 67,000 acres in Hamilton, Madison, and Tipton Counties. The area includes Long Branch, Bear Creek, Lamberson Ditch, Polywog, Little Duck Creek and Todd Ditch. *(We will be complementing the work in progress by Madison County SWCD for Little Duck Creek.)*

Goals and Objectives: The issues and concerns identified in the planning process will be used to develop a cost share program to install best management practices in the watershed. The cost share program will begin in October 2007.

Date and Time: December 13, 2006 at 7 p.m.

Location: Walnut Grove Community Building, NW corner of SR 213 & 256 Street

Contact Information: Beth or Heather at Williams Creek Consulting (317) 432-0690
Mark McCauley, Hamilton SWCD (317) 773-2181, Ext.3

Hamilton County SWCD
1108 South 9th Street
Noblesville, IN 46060-3745

Appendix B

Duck Creek Watershed Partners/Stakeholders

WATERSHED PARTNERS/STAKEHOLDERS

A. State and Federal Agency Stakeholders

Indiana Department of Natural Resources (IDNR)
402 W. Washington Street
Indianapolis, IN 46204-2748

Division of Nature Preserves
Room W267
317-232-4052

Division of Fish & Wildlife
Room W273
317-232-4080

Division of Entomology & Plant Pathology
Room W290
317-232-4120

Division of Forestry
Room W296
317-232-4105

Division of Water
Room W264
317-232-4160

Division of Outdoor Recreation
Room W271
317-232-4070

Indiana Department of Environmental Management (IDEM)
100 N. Senate Avenue
P.O. Box 6015
Indianapolis, IN 46206-6015
317-233-8491
800-451-6027

Natural Resources Conservation Service (NRCS)
6013 Lakeside Boulevard
Indianapolis, IN 46278
317-290-3200

Farm Service Agency (FSA)
5981 Lakeside Boulevard
Indianapolis, IN 46278
317-290-3030

U.S. Army Corps of Engineers (USACE)
Louisville District
P.O. Box 59
Louisville, KY 40201-0059
502-582-5607

U.S. Environmental Protection Agency (USEPA)
Region 5
77 West Jackson Boulevard
Chicago, IL 60604-3590
800-632-8431

U.S. Fish & Wildlife Service (USFWS)
620 S. Walker Street
Bloomington, IN 47403-2121
812-334-4261

Indiana Association of Soil & Water Conservation Districts (IASWCD)
225 S. East Street, Suite 740
Indianapolis, IN 46202

Indiana Department of Transportation (INDOT)
100 N. Senate Avenue, Room N808
Indianapolis, IN 46204
317-232-5468

Indiana Chamber of Commerce
115 W. Washington Street #850 S.
Indianapolis, IN 46204
317-264-6881

Indiana State Department of Health
2 N. Meridian Street
Indianapolis, IN 46204
317-233-1325
Contact person: Gregory Wilson

Indiana Association of County Commissioners
County Office Building
20 N. 3rd Street
Lafayette, IN 47901-1214
765-423-9215
Contact person: Ruth Shedd

Indiana Association of Cities and Towns
150 W. Market Street, Suite 728
Indianapolis, IN 46204
317-237-6200
Contact person: Tonya Galbraith

Indiana Farm Bureau, Inc.
225 S. East Street
Indianapolis, IN 46202
317-692-7851

U.S. Senator Richard Lugar
(senator_lugar@lugar.senate.gov)
Federal Building Room 3158
1300 S. Harrison Street
Fort Wayne, IN 46802
260-422-1505

U.S. Senator Evan Bayh
(senator@bayh.senate.gov)
10 W. Market Street, Suite 1650
Indianapolis, IN 46204
317-554-0750

U.S. Representative Mike Pence
1134 Meridian Plaza
Anderson, IN 46016
765-640-2919

U.S. Representative Dan Burton (r5@ai.org)
8900 Keystone at the Crossing, Suite 1050
Indianapolis, IN 46240
317-848-0201

B. Local Offices of State & Federal Agency Stakeholders

Indiana Department of Environmental Management (IDEM)
100 N. Senate Ave.
Mail Code 65-42
Indianapolis, IN 46204-2251
800-451-6027

Natural Resources Conservation Service (NRCS)

Hamilton County
Contact Person: Chris Torp
1108 S. 9th St.
Noblesville, IN 46060
317-773-2181

Madison County
Contact Person: Tod Herrli
182 W. 300 N., Suite D, 462012
Anderson, IN 46725
765-644-4249

Tipton County
Contact Person: Kerry Smith
243 Ash St
Tipton, IN 46072
765-675-2316

Farm Service Agency (FSA)

Hamilton County
Contact Person: Jeff Trisler
1108 S. 9th St.
Noblesville, IN 46060
317-773-2181

Madison County
Contact Person: Susan K. Allen
1911 E. Business 30
Columbia City, IN 46725
260-244-6780

Tipton County
Contact Person: Joanne Mann
243 Ash St
Tipton, IN 46072
765-675-2316

Indiana Department of Natural Resources (IDNR)

Division of Fish & Wildlife
Contact Person: District 7 Wildlife Biologist, Rick Peercy
5753 Glenn Rd.
Indianapolis, IN 46216

Contact Person: District 5 Fisheries Biologist, Rhett Wisenger
Cikana State Fish Hatchery
2560 SR 44
Martinsville, IN 46151
765-342-5527

Soil & Water Conservation District

Hamilton County
Contact Person: Mark McCaully
1108 S. 9th St.
Noblesville, IN 46060
317-773-2181

Madison County
Contact Person: Crist Blassaras
1911 E. Business 30
Columbia City, IN 46725
260-244-6780

Tipton County
Contact Person: Judy Baird
243 Ash St
Tipton, IN 46072
765-675-2316

C. <u>State Government Stakeholders</u>

State Senator Luke Kenley
200 W. Washington St.
Indianapolis, IN 46204
317-232-9400
(s20@IN.gov)

State Senator Timothy Lanane
200 W. Washington St.
Indianapolis, IN 46204
800-382-9467
(s25@IN.gov)

State Representative L. Jack Lutz
200 W. Washington St.
Indianapolis, IN 46204
800-382-9841
(h35@IN.gov)

State Representative Terri Austin
200 W. Washington St.
Indianapolis, IN 46204
800-382-9842
(h36@IN.gov)

State Representative P. Eric Turner
200 W. Washington St.
Indianapolis, IN 46204
800-382-9841
(h32@IN.gov)

D. <u>County Government Stakeholders</u>

Hamilton County Commissioners
33 North 9th Street, Suite L21
Noblesville, IN 46060
317-776-8401
Contact Persons: Christine Altman, Steven C. Dillinger, Steven A. Holt

Hamilton County Council
33 North 9th Street, Suite L21
Noblesville, IN 46060
317-776-8401
Contact Persons: Brad Beaver, Jim Belden, Meredith Carter, Judy Levine, John Hiatt, Rick McKinney, Steve Schwartz

Hamilton County Health Department
One Hamilton County Square, Suite 30
Noblesville, IN 46060
317-776-8500
Contact Person: Barry McNulty

Hamilton County Plan Commission
One Hamilton County Square, Suite 306
Noblesville, IN 46060
317-76-8490
Contact Person: Charles E. Kiphart

Hamilton County Solid Waste Board
c/o Hamilton County Auditor
33 North 9th Street, Suite L21
Noblesville, IN 46060
317-776-8462

Hamilton County Surveyor
One Hamilton County Square, Suite 188
Noblesville, IN 46060
317-776-8595
Contact Person: Kenton C. Ward

Hamilton County Extension Service
2003 Pleasant Street
Noblesville, IN 46060
317-776-0854
Contact Person: Susan Peterson

Hamilton County Parks & Recreation
15513 S. Union Street
Carmel, IN 46033
317-896-5874
Contact Person: Allen Patterson

Madison County Commissioners
16 East 9th Street
Anderson, IN 46016
765-641-9474
Contact Persons: Patricia Dillon, Paul Wilson, John Richwine

Madison County Council
16 East 9th Street
Anderson, IN 46016
765-641-9474
Contact Persons: Jeff Hardin, Dan Dykes, Gary Gustin, Mike Price, Larry Crenshaw, Scott Tischler

Madison County Surveyor
16 East 9th Street
Anderson, IN 46016
765-641-9638
Contact Person: Brad Newman

Madison County Highway Department
16 East 9th Street
Anderson, IN 46016
765-646-9240
Contact Person: Commissioners

Madison County Health Department
16 East 9th Street
Anderson, IN 46016
765-641-9523
Contact Person: Steve Ford

Madison County Area Planning Department
16 East 9th Street
Anderson, IN 46016
765-641-9541
Contact Person: Michael Hershman

Madison County Extension Service
16 East 9th Street
Anderson, IN 46016
765-641-99514
Contact Person: Janet Stafford

Madison County Chamber of Commerce
205 W. 11th St.
Anderson, IN 46016
765-642-0264
Contact Person: Keith Pitcher

Tipton County Commissioners
101 E. Jefferson St.
Tipton, IN 46072
765-675-7921
Contact Persons:

Tipton County Council
101 E. Jefferson St.
Tipton, In 46072
765-675-2794
Contact Persons:

Tipton County Building Inspector
113 Court St.
P.O. Box 288
Tipton, IN 46072
765- 675-3994
Contact Person:

Tipton County Highway Department
405 Market Rd.
Tipton, IN 46072
765-675-4508
Contact Person: Sherry Crawford

Tipton County Health Department
1000 S. Main St.
Tipton, In 46072
765-675-8741
Contact Persons:

Tipton County Area Planning Department
101 E. Jefferson St.
Tipton, In 46072
765-675-6063
Contact Person:

Tipton County Solid Waste District
119 E Washington St.
Tipton, IN 46072
765-675-9006
Contact Person:

Tipton County Surveyor
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Tipton, IN 46072
765-675-2793
Contact Person:

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239 Ash Street, Suite A
Tipton, IN 46072
765-675-2694
Contact Person: Mary Day
(mley2@purdue.edu)

Tipton County Chamber of Commerce
136 East Jefferson St.
Tipton, IN 46072
765-675-7533
Contact Person: Diane Timm

E. Duck Creek Watershed Stakeholders

Hoosier Heartland RC & D
633 E. 13th Street
Winamac, IN 46996
Contact Person: Becky Fletcher

Builders Association of Greater Indianapolis
P.O. Box 44670
Indianapolis, IN 46244
317-236-6330

Ducks Unlimited
Madison County
812/273-1847
Contact Person: Andy Crozier

Ducks Unlimited
Hamilton County
Alexandria, IN 46001
765/425-0222
Contact Person: Kyle Williams

Ducks Unlimited
Tipton County
765/675-9864
Contact Person: Rick Powell

Hoosier Audubon Council
PO Box 80024
Indianapolis, IN 46280
317-299-5675
Contact Person: Donna McCarty

Hoosier Environmental Council
520 E. 12th Street, Suite 14
P.O. Box 1145
Indianapolis, IN 46206-1145
(317) 685-8800 ext. 114
Contact Person: Clarke Kahlo

Indiana Beef Cattle Association
8770 Guion Road, Suite A
Indianapolis, IN 46268
317-872-2333
Contact Person: Joe Moore

Indiana Corn Growers Association
5757 W 74th Street
Indianapolis, IN 46278
800-735-0195
Contact Person:

Indiana Farm Bureau
225 S. East Street
Indianapolis, IN 46202
800-866-1160
Contact Persons :
Hamilton/Madison Counties:
Greg Bohlander (765.552.7160)
Tipton County:
Steve Palmer (765.998.7094)

Indiana Farmers Union, Inc.
3901 W. 86th Street
Indianapolis, IN 46268
Contact Person:

Indiana Forestry & Woodland Owners Association
Board of Directors
5578 S. 500 W.
Atlanta, IN 46031

Indiana Geological Survey
611 N. Walnut Grove
Bloomington, IN 47405-2208
812-855-7636
(igsinfo@indiana.edu)

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Consolidated Grain & Barge
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Contact Person: Vicki Carson

Indiana Plant Food & Agicultural Chemicals Association Inc.
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1622 County Road 52
Garrett, IN 46738
260-357-5432
Contact Person: Curt Custer
(custergrain@fwi.com)

Indiana Pork Producers Association
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Indianapolis, IN 46268
Contact Person: Terry Fleck

Indiana Rural Water Association
P.O. Box 679
Nashville, IN 47448
Contact Person: Marilyn Gambold

Indiana Seed Trade Association
Holdens Foundation Seeds LLC
RR1, Box 149
Franklin, IN 46131
317-535-8357
Contact Person: Scott Williams
(scott.Williams@holden.com)

Indiana Soybean Growers Association
423 W. South Street
Lebanon, IN 46052
Contact Person: Anita Stuever

Indiana Sportsman's Roundtable
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Noblesville, IN 46060
317-773-2944/317-575-4555
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Indiana State Dairy Association
208 Poultry Science Building
West Lafayette, IN 47907-1016
Contact Person: Robert Jones

Indiana State Poultry Association Inc.
Hy-Line International
1029 Mill Site Drive
Warren, IN 46792
Contact Person: Curt Schmidt

Izaak Walton League
1793 Sugar Creek Trail
Greenfield, IN 46140
317-326-8567
Contact Person: William S. Kriech
(kriech@hrtc.net)

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50 Rangeline Road, Suite A
Carmel, IN 46032
317-571-1220
Contact Person: Charlie O'Neill

National Wild Turkey Federation
8818 N. 400 W.
Roann, IN 46974
765-982-7935
Contact Person: Randy Showalter

Nature Conservancy
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Indianapolis, IN 46202
317-951-8818
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Pheasants Forever
1240 Clay Springs Drive
Carmel, IN 46032
(317) 571-9698
Contact Person: Jim Horton

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Anderson, IN 46016-1598
765/641-9514
Tipton County Office
239 Ash Street, Suite A
Tipton, IN 46072
765/675-2694
Contact Person: James Woolf

Quail Unlimited
10364 S 950 E
Stendal, IN 47585
812-536-2272
Contact Person: David Howell

Sierra Club – Hoosier Chapter
Heartlands Group - Hamilton
Five Rivers Group - Madison
1915 West 18th St., Suite D
Indianapolis, IN 46202-1016
317-822-3750
Contact Person:

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The Noblesville Ledger
13095 Publishers Dr
Fishers, IN 46038
(317) 444-5500

The Indianapolis Star
307 N Pennsylvania St
Indianapolis, IN 46204
(317) 444-4000

The Herald Bulletin
1133 Jackson St
Anderson, IN 46016
(765) 622-1212

The Call Leader
317 South Anderson St.
P.O. Box 85
Elwood, IN 46036
(765) 552-3355

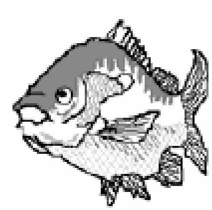
WFYI 20 TV
WFYI TelePlex
1401 N. Meridian St.
Indianapolis, IN 46202-2389
Phone: (317) 636-2020

Appendix C

Duck Creek Watershed
Benthic and Habitat Study
2006

Duck Creek Watershed
Benthic Macroinvertebrate Monitoring
October 2006

Prepared For:
Hamilton County Soil and Water Conservation District
1108 S. 9th Street
Noblesville, IN 46060-3745



Commonwealth Biomonitoring, Inc.
8061 Windham Lake Drive
Indianapolis IN 46214
(317) 297 - 7713

Introduction

The Hamilton County, Indiana Soil and Water Conservation District (SWCD) was awarded a Section 319 grant from the Indiana Department of Environmental Management to develop a Watershed Management Plan for the Duck Creek watershed. Duck Creek is a tributary of the West Fork of the White River and is located in central Indiana (Figure 1). Many of the streams in the area have been artificially channelized to allow for better drainage. The city of Elwood lies within the watershed.

One of the tasks involved in developing the watershed management plan is to assess water quality in Duck Creek and its tributaries. Because they are considered to be sensitive to local conditions and respond relatively rapidly to change, benthic (bottom-dwelling) organisms are considered to be a primary tool to document the biological condition of streams. The Hamilton County SWCD chose to use benthic macroinvertebrate monitoring as part of its data-gathering.

Figure 1. Location of Duck Creek watershed within the State of Indiana

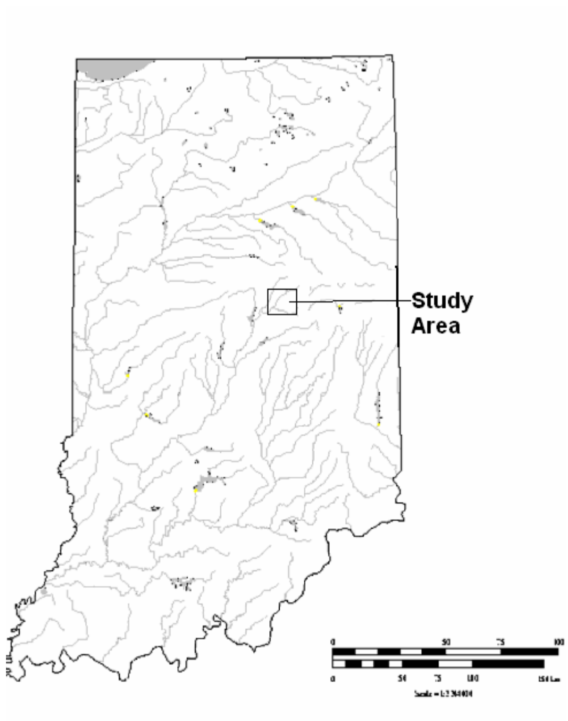
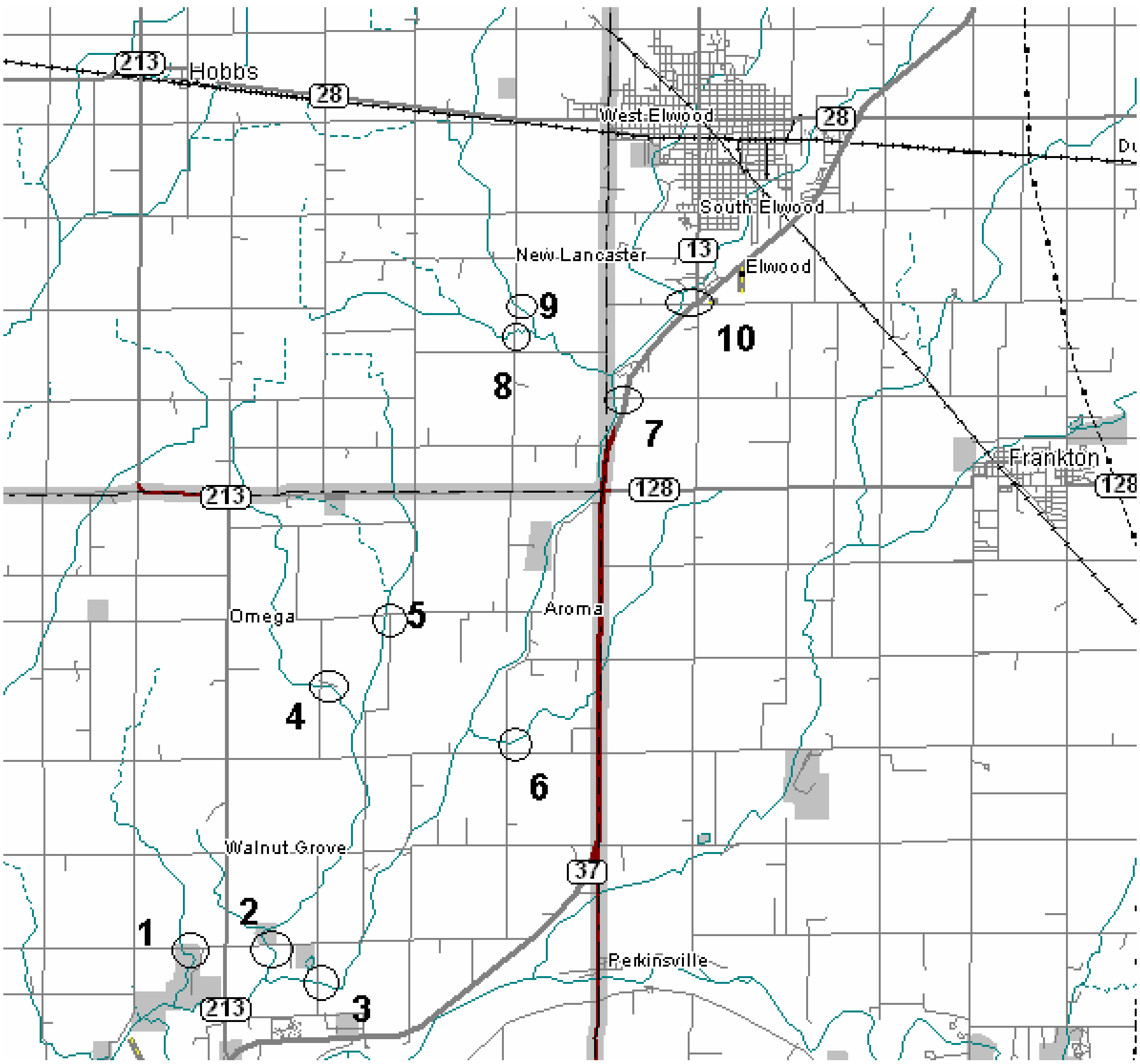


Table 1. Study sites in Duck Creek watershed.

Site 1	Un-named tributary of Duck Creek	246th St., Hamilton Co.
Site 2	Bear Creek	246th St., Hamilton Co.
Site 3	Duck Creek	Brehm Rd., Hamilton Co.
Site 4	Bear Creek West Fork	Lower Rd., Hamilton Co.
Site 5	Bear Creek	286th St., Hamilton Co.
Site 6	Un-named tributary of Duck Creek	Henry Gunn Rd., Hamilton Co.
Site 7	Duck Creek	CR 900 North, Madison Co.
Site 8	Pollywog Creek West Fork	CR 700 North, Tipton Co.
Site 9	Pollywog Creek East Branch	CR 700 East, Tipton Co.
Site 10	Duck Creek	CR 1000 North, Madison Co.

Figure 2. Location of study sites in Duck Creek watershed.



Methods

<u>Macroinvertebrates</u>

Samples were collected October 24 and 25, 2006 by use of a kicknet in riffles where the current speed approached 30 cm/sec. A duplicate sample was taken at site 3 for quality control purposes. All samples were preserved on-site with 70% isopropanol.

In the laboratory, organisms were separated from debris by visual examination and identified to the family level. The data set was analyzed according to the Indiana Department of Environmental Management (IDEM) Family Level Macroinvertebrate Index of Biotic Integrity (Table 2). This method uses a set of ten metrics to evaluate the biological condition of a stream. Each metric is assigned a score of 0, 2, 4, 6, or 8 (8 is best, summed to give an overall score, and then divided by ten (range 0 to 8). Sites with scores greater than 4 are considered to be fully supporting of aquatic life use; those between 4 and 2 are partially supporting, while those with scores less than 2 are non-supporting. The scores for the two replicates at site 3 were averaged.

The metric "Family Level HBI" refers to the Hilsenhoff Biotic Index [2], which was developed based on the varying tolerances of benthic organisms to organic pollution. The term "EPT taxa" refers to Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies), insect orders that are considered to be sensitive to environmental degradation. Conversely, chironomids (midges) are considered to be more tolerant of environmental degradation. The last metric, "total number of individuals to number of squares sorted" is a measure of organism abundance in the sample.

Table 2. IDEM Scoring Criteria for the Family Level Macroinvertebrate Index of Biotic Integrity (mIBI) for Riffle Kick Samples [1].

	Classification Scores				
	0	2	4	6	8
Family HBI	≥ 5.63	5.06-5.62	4.55-5.05	4.09-4.54	≤ 4.08
No. Taxa	≤ 7	8-10	11-14	15-17	≥ 18
No. Individuals	≤ 79	80-129	130-212	213-349	≥ 350
% 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/No. Individuals	≤ 0.13	0.14-0.29	0.30-0.46	0.47-0.68	≥ 0.69
EPT Count/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 Individuals/No. Squares Sorted	≤ 29	30-71	72-171	172-409	≥ 410

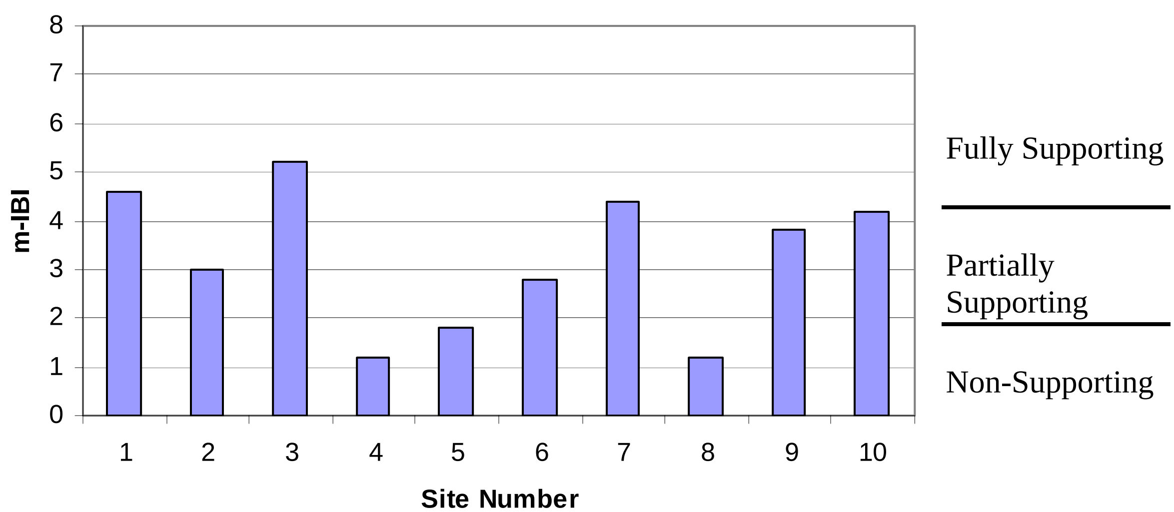
<u>Habitat Evaluation</u>

The aquatic habitat at each study site was evaluated according to the method described by Ohio EPA [3]. This Qualitative Habitat Evaluation Index (QHEI) assigns values to various habitat parameters (e.g. substrate quality, riparian vegetation, channel morphology, ect.), which are then summed to result in a numerical score for each site. Higher scores indicate higher habitat value. The maximum value for habitat using this assessment technique is 100. According to IDEM, sites with a QHEI greater than 64 are fully supporting of aquatic life use, those between 51 and 64 are partially supporting, while those less than 51 are non-supporting.

Results

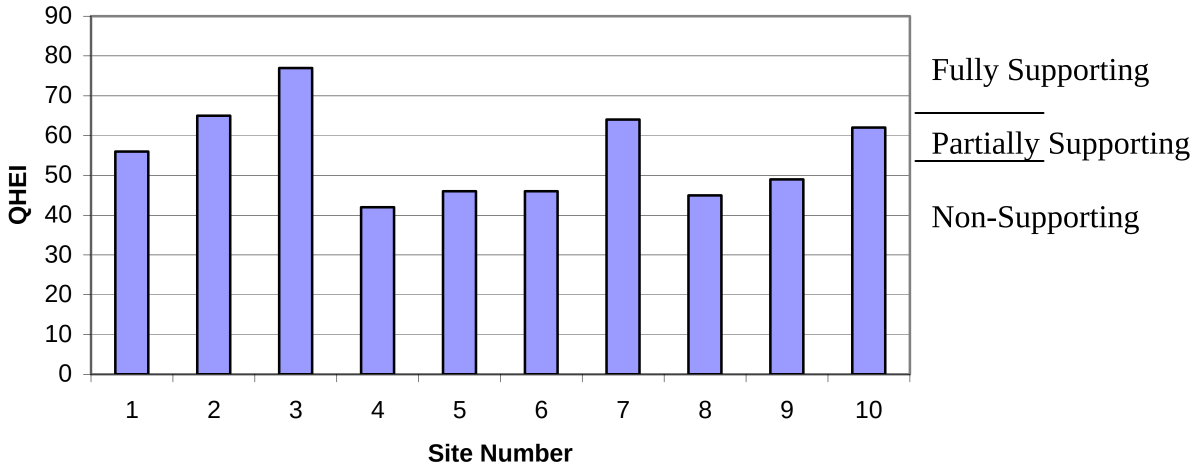
A total of 27 macroinvertebrate families was identified, with the most abundant being Hydropsychidae (net-spinning caddisflies) and Chironomidae (midges). Macroinvertebrate IBI scores ranged from 1.2 to 5.2 (Figure 3). Sites 1, 3, 7 and 10 were “fully supporting” of aquatic life use, Sites 2, 6 and 9 were “partially supporting”, while Sites 4, 5, and 8 were “non-supporting”. A complete list of macroinvertebrate identifications, metrics data, and metric scoring may be found in the appendix.

Figure 3. Macroinvertebrate Index of Biotic Integrity (m-IBI) scores



Habitat scores ranged from 42 to 77 (Figure 4). Sites 2, 3 and 7 had habitat that was “fully supporting” of aquatic life use, Sites 1 and 10 were “partially supporting”, while the rest were “non-supporting”. A complete list of the metrics values for the habitat evaluation may be found in the appendix.

Figure 4. Aquatic Habitat Values



Discussion

Aquatic life depends both on habitat and water quality. Life cannot thrive where habitat is lacking. The sites with the most degraded aquatic communities were 4 and 8. Both of these sites had low total numbers of organisms, low numbers and types of EPT taxa, and the dominant family was Chironomidae. The QHEI scores for these sites (42 and 45), and the m-IBI scores (both 1.2) are considered to be non-supporting of aquatic life uses. At Site 5, EPT taxa were almost absent, with only one mayfly individual present. Its m-IBI score (1.8) and QHEI (46) are both non-supporting of aquatic life uses. It is probable that all of these sites are affected both by degraded habitat and degraded water quality.

Site 2 had a low ratio of EPT to Chironomidae. The m-IBI score at Site 2 was 3.0 (partially supporting), while its QHEI score was 65 (fully supporting). This could indicate that water quality problems are likely to be present.

Sites 6 and 9 had QHEI (46 and 49) scores that were non-supporting, while the m-IBI scores (28 and 38) were partially supporting. It is likely that habitat, rather than water quality problems are affecting benthic communities at these sites.

Sites 1, 3, 7 and 10 all have m-IBI scores that were fully supporting of aquatic life uses. At Sites 1 and 10, the QHEI scores (56 and 62) were partially supporting of aquatic life uses. This would indicate no serious water quality problems and only minor habitat degradation.

An examination of some of the metrics used to calculate the m-IBI can give us a clue as to the source of water quality problems. At Sites 4, 5and 8, the metric “family HBI” was in the range of “fairly substantial organic pollution likely” [2] while at Site 2 it was in the range of “some organic pollution probable”.

Recommendations

Reduce or eliminate sources of organic pollution in Bear Creek West Fork, lower Bear Creek and Pollywog Creek West Fork. Possible sources include failing septic systems and livestock wastes.

Enhance habitat by planting riparian vegetation and increasing the amount of in-stream cover, especially at Bear Creek West Fork, Bear Creek at 286th street, un-named tributary at Henry Gunn Road, and Pollywog Creek.

Protect Duck Creek and its un-named tributary at 246th street from future habitat destruction, such as channelization.

References

1. Indiana Department of Environmental Management, 1999. Metrics for analysis of benthic macroinvertebrate samples collected from artificial substrates. PowerPoint presentation to the Ohio Valley Chapter of SETAC. Office of Water Management, Biological Studies Section, Indianapolis, IN.

2. Hilsenhoff, W.L. 1988, Rapid field assessment of organic pollution with a family-level biotic index. Journal of the North American Benthological Society 7:65-68.

3. Ohio EPA, 1987. Biological criteria for the protection of aquatic life: Vol. II. Users manual for biological field assessment of Ohio surface waters. Div. Of Water Quality Monitoring and Assessment, Columbus, Ohio.

Appendix

Macroinvertebrate family-level identifications

Macroinvertebrate metrics data

Macroinvertebrate metrics scoring

Qualitiative Habitat Evaluation Index scoring

Macroinvertebrate Family-Level Identifications

	Site Number				
	1	2	3	3 Duplicate	4
Chironomidae	21	60	12	12	65
Tipulidae	6	3	4	4	1
Simuliidae	20	5		2	1
Ephydridae		1			
Heptageniidae	23	29	14	8	
Baetidae	2	5	1		1
Caenidae		1	1		
Capnidae	7				2
Hydropsychidae	171	18	132	207	6
Helicopsychidae					
Philopotamidae	4		1	1	
Elmidae	71	61	28	44	2
Hydrophilidae			1	1	
Psephenidae	1				
Coernagrionidae			1	1	
Aeshnidae		1			
Cordulegastridae		1			
Corydalidae		1		1	
Isopoda		1			1
Amphipoda				1	2
Decapoda		1			
Turbellaria			1	1	
Hirudinea	1				2
Oligochaeta		2			2
Corbiculidae			1		
Sphaeridae	4	2			5
Gastropoda				11	
Total	331	191	198	284	90

Macroinvertebrate Family-Level Identifications, con't.

	Site Number					
	5	6	7	8	9	10
Chironomidae	12	53	35	31	41	73
Tipulidae	2	2	3			3
Simuliidae			2	5	6	2
Ephydridae						
Heptageniidae	1	21	1		35	
Baetidae		1	1		1	
Caenidae		4		2	4	
Capnidae						
Hydropsychidae		6	175	1	54	211
Helicopsychidae				3		
Philopotamidae			7			
Elmidae	12	100	20	18	18	15
Hydrophilidae			1			1
Psephenidae		2			1	
Coernagrionidae					1	1
Aeshnidae						
Cordulegastridae						
Corydalidae						
Isopoda						
Amphipoda					31	
Decapoda		1		1	1	
Turbellaria	36	18		5	2	
Hirudinea	10	1		5		1
Oligochaeta	1					
Corbiculidae						1
Sphaeridae	50			1		
Gastropoda	9	1	1	3		
Total	135	210	246	75	195	308

Data for Macroinvertebrate Metrics

	Site Number				
	1	2	3	3 dupl.	4
Family HBI	4.29	4.78.	4.14	4.10	5.70
No. Taxa	12	15	13	13	12
No. Individuals	331	191	198	284	90
% Dominant Taxon	51.7	31.9	66.7	72.9	72.2
EPT Index	5	4	5	3	3
EPT Count	207	53	149	216	9
EPT Count/No. Individuals	0.63	0.28	0.75	0.76	0.10
EPT Count/Chironomid Count	9.86	0.88	12.40	18.0	0.14
Chironomid Count	21	60	12	12	65
Total number Individuals/No. Squares Sorted	17	10	10	14	5

Data for Macronvertebrate Metrics, con't.

	Site Number					
	5	6	7	8	9	10
Family HBI	5.10	4.61	4.24	5.25	4.58	4.50
No. Taxa	10	12	10	11	12	9
No. Individuals	135	210	246	75	195	308
% Dominant Taxon	37.0	47.6	71.1	41.3	27.7	68.5
EPT Index	1	4	4	3	4	1
EPT Count	1	32	184	6	94	211
EPT Count/No. Individuals	0.01	0.15	.075	0.08	0.48	0.69
EPT Count/Chironomid Count	0.08	0.60	5.26	0.19	2.23	2.89
Chironomid Count	12	53	35	31	41	73
Total number Individuals/No. Squares Sorted	7	11	12	4	10	15

Scoring for Macroinvertebrate Metrics

	Site Number				
	1	2	3	3 dupl.	4
Family HBI	6	4	6	6	0
No. Taxa	4	6	4	4	4
No. Individuals	6	4	4	6	2
% Dominant Taxon	2	4	4	6	2
EPT Index	4	4	4	2	2
EPT Count	8	4	6	8	0
EPT Count/No. Individuals	6	2	8	8	0
EPT Count/Chironomid Count	6	0	8	8	0
Chironomid Count	4	2	6	6	2
Total number Individuals/No. Squares Sorted	0	0	0	0	0
m-IBI	4.6	3.0	5.0	5.4	1.2

Scoring for Macronvertebrate Metrics, con't.

	Site Number					
	5	6	7	8	9	10
Family HBI	2	4	6	2	4	6
No. Taxa	2	4	2	4	4	2
No. Individuals	4	4	6	0	4	6
% Dominant Taxon	4	4	6	0	4	6
EPT Index	0	4	4	2	4	0
EPT Count	0	2	6	0	6	8
EPT Count/No. Individuals	0	2	6	0	6	8
EPT Count/Chironomid Count	0	0	4	0	2	4
Chironomid Count	6	4	4	4	4	2
Total number Individuals/No. Squares Sorted	0	0	0	0	0	0
m-IBI	1.8	2.8	4.4	1.2	3.8	4.2

Qualitative Habitat Evaluation Index (QHEI) values

	Site Number									
	1	2	3	4	5	6	7	8	9	10
Substrate	17	15	19	14	14	15	15	14	15	15
Cover	6	10	14	3	4	4	10	5	4	10
Channel	14	14	14	7	8	8	13	8	8	13
Riparian	3	7	7	3	4	3	5	3	3	3
Pool/Current	5	7	10	4	5	5	9	5	5	9
Riffle/Run	5	6	7	5	5	5	6	3	8	6
Gradient	6	6	6	6	6	6	6	6	6	6
Total	56	65	77	42	46	46	64	45	49	62

Appendix D

Duck Creek Watershed
Photos of
Benthic and Habitat
Sampling Sites
2006

Sampling Site 1, Long Branch, 246th St., Hamilton County

Sampling Site 2, Bear Creek, 246th St., Hamilton County

Sampling Site 3, Duck Creek, Brehm Rd., Hamilton County

Sampling Site 4, West Fork Bear Creek, Lower Rd., Hamilton County

Sampling Site 5, Bear Creek, 286th St., Hamilton County

Sampling Site 6, Lamberson Ditch, Henry Gunn Rd., Hamilton County

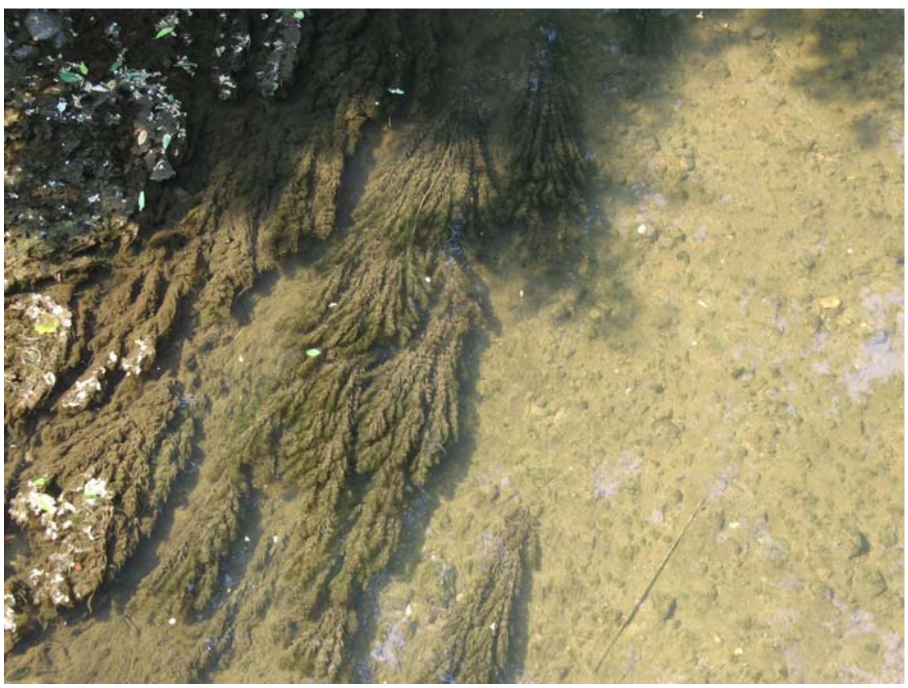
Sampling Site 7, Duck Creek, CR 900 North, Madison County

Sampling Site 8, West Fork Polywog Creek, CR 700 North, Tipton County

Sampling Site 9, East Branch Polywog Creek, CR 700 East, Tipton County

Sampling Site 9, East Branch Pollywog Creek, CR 700 East, Tipton County

Sampling Site 10, Duck Creek, CR 1000 North, Madison County



Sampling Site 10, Duck Creek, CR 1000 North, Madison County

Photos taken in May 2007

Sampling Sites from the Little Duck and Lilly Creek Watershed Management Plan

Site 11 Downstream, 08/03/05, Base Flow, Big Duck Creek, County Road 1050 North, Madison Co.

Site 11 Downstream, 09/26/05, Storm Flow, Big Duck Creek, County Road 1050 North, Madison Co.

Site 12 Downstream, 09/06/05, Base Flow, Big Duck Creek, State Road 13, Madison Co.

Site 12 Downstream, 09/26/05, Storm Flow, Big Duck Creek, State Road 13, Madison Co.


Site 13 Upstream, 08/02/06, Base Flow, Big Duck Creek, County Road 1300 North, Madison Co.


Site 13 Upstream, 07/12/06, Storm Flow, Big Duck Creek, County Road 1300 North, Madison Co.


Site 14 Upstream, 09/06/05, Base Flow, Little Duck Creek, State Road 13, Madison Co.


Site 14 Upstream, 09/26/05, Storm Flow, Little Duck Creek, State Road 13, Madison Co.


Site 15 Downstream 08/03/05, Base Flow, Little Duck Creek, County Road 1100 North (South P Street), Madison Co.


Site 15 Downstream, 09/26/05, Storm Flow, Little Duck Creek, County Road 1100 North (South P Street), Madison Co.


Site 16 Downstream 08/03/05, Base Flow, Little Duck Creek, County Road 700 West, Madison Co.


Site 16 Downstream 09/26/05, Storm Flow, Little Duck Creek, County Road 700 West, Madison Co.

Appendix E

Duck Creek Watershed STEPL Modeling Data

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom. You entered 6 subwatershed(s).

This sheet is composed of eight input tables. The first four tables require users to change initial values. The next four tables (initially hidden) contain default values users may choose to change.

Step 1: Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.

Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2; (c) enter values for septic system parameters in Table 3; and (d) if desired, modify USLE parameters associated with the selected county in Table 4.

Step 3: You may stop here and proceed to the BMPs sheet. If you have more detailed information on your watersheds, click the Yes button in row 10 to display optional input tables.

Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5; (b) modify the curve number table by landuse and SHG in Table 6; (c) modify the nutrient concentrations (mg/L) in runoff in Table 7; and (d) specify the detailed land use distribution in the urban area in Table 8.

Step 5: Select BMPs in BMPs sheet. **Step 6**: View the estimates of loads and load reductions in Total Load and Graphs sheets.

Show optional input tables? Yes No ☑ **Treat all the subwatersheds as parts of a single watershed** ☐ **Groundwater load calculation**

State: Indiana **County**: Hamilton **Weather Station (for rain correction factors)**: IN INDIANAPOLIS WSFO AP

1. Input watershed land use area (ac) and precipitation (in)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Avg. Rain/Event
								Rain correction factors	0.870	0.417	
W1	17	5828	933	299	145	1	0-24%	7223	35.8	110.6	0.675
W2	19	9379	1357	1775	103	4	0-24%	12637	35.8	110.6	0.675
W3	33	8828	1095	228	144	1	0-24%	10329	35.8	110.6	0.675
W4	91	12822	1170	196	121	2	0-24%	14402	35.8	110.6	0.675
W5	2020	9091	1423	186	203	1	0-24%	12924	35.8	110.6	0.675
W6	1	10561	558	68	73	3	0-24%	11264	35.8	110.6	0.675

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied
W1	25	0	200	22	66	0	0	0	0
W2	75	0	0	74	85	0	0	0	0
W3	34	0	0	45	46	0	0	0	0
W4	15	0	800	18	25	0	0	0	0
W5	6	0	0	12	67	0	0	0	0
W6	50	0	1400	28	26	0	0	0	0
Total	205	0	2400	199	315	0	0	0	

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
W1	146	2.43	2	0	0
W2	183	2.43	2	0	0
W3	158	2.43	2	0	0
W4	268	2.43	2	0	0
W5	196	2.43	2	0	0
W6	168	2.43	2	0	0

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland					Forest					User Defined				
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P
W1	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W2	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W3	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W4	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W5	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W6	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000

Best Management Practice Select an appropriate BMP except "Combined BMPs-Calculated" for each subwatershed in each land use table using the pull-down list-box if interactions between BMPs are not considered. Select "Combined BMPs-Calculated" if multiple BMPs and their interactions in the subwatersheds are considered; use BMP calculator (under STEPL menu) to obtain the combined BMP efficiencies and enter them in Table 7.

Urban BMP Tool

Gully and Streambank Erosion

1. BMPs and efficiencies for different pollutants on CROPLAND, ND=No Data

Watershed	**Cropland**					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0.861	0.859	0	0.905	Combined BMPs-Calculated	100
W2	0.863	0.861	0	0.909	Combined BMPs-Calculated	100
W3	0.864	0.862	0	0.91	Combined BMPs-Calculated	100
W4	0.864	0.862	0	0.911	Combined BMPs-Calculated	100
W5	0.864	0.862	0	0.911	Combined BMPs-Calculated	100
W6	0.863	0.861	0	0.909	Combined BMPs-Calculated	100

2. BMPs and efficiencies for different pollutants on PASTURELAND, ND=No Data

Watershed	**Pastureland**					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W2	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W3	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W4	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W5	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W6	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100

3. BMPs and efficiencies for different pollutants on FOREST, ND=No Data

Watershed	**Forest**					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0	0	0	0	0 No BMP	100
W2	0	0	0	0	0 No BMP	100
W3	0	0	0	0	0 No BMP	100
W4	0	0	0	0	0 No BMP	100
W5	0	0	0	0	0 No BMP	100
W6	0	0	0	0	0 No BMP	100

4. BMPs and efficiencies for different pollutants on USER DEFINED land use, ND=No Data

Watershed	**User Defined**					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0	0	0	0	0 No BMP	100
W2	0	0	0	0	0 No BMP	100
W3	0	0	0	0	0 No BMP	100
W4	0	0	0	0	0 No BMP	100
W5	0	0	0	0	0 No BMP	100
W6	0	0	0	0	0 No BMP	100

5. BMPs and efficiencies for different pollutants on FEEDLOTS, ND=No Data

Watershed	Feedlots					
	N	P	BOD	Sediment	BMPs	%Area BMP Applied
W1	0.8	0.9	ND	ND	Waste Mgmt System	100
W2	ND	0.85	ND	ND	Filter strip	100
W3	ND	0.85	ND	ND	Filter strip	100
W4	0.65	0.6	ND	ND	Waste Storage Facility	100
W5	ND	0.85	ND	ND	Filter strip	100
W6	0.8	0.9	ND	ND	Waste Mgmt System	100

6. BMPs and efficiencies for different pollutants on URBAN

To change/set BMP/LID for urban land uses, click the 'Urban BMP Tool' button on the top-left of this sheet.

7. Combined watershed BMP efficiencies from the BMP calculator

Watershed	Watershed Combined BMP Efficiencies				
	N	P	BOD	Sediment	BMPs
W1-Crop	0.861	0.859	0	0.905	Combined BMPs
W2-Crop	0.863	0.861	0	0.909	Combined BMPs
W3-Crop	0.864	0.862	0	0.91	Combined BMPs
W4-Crop	0.864	0.862	0	0.911	Combined BMPs
W5-Crop	0.864	0.862	0	0.911	Combined BMPs
W6-Crop	0.863	0.861	0	0.909	Combined BMPs
W1-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W2-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W3-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W4-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W5-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W6-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W1-Forest	0	0	0	0	Combined BMPs
W2-Forest	0	0	0	0	Combined BMPs
W3-Forest	0	0	0	0	Combined BMPs
W4-Forest	0	0	0	0	Combined BMPs
W5-Forest	0	0	0	0	Combined BMPs
W6-Forest	0	0	0	0	Combined BMPs
W1-User	0	0	0	0	Combined BMPs
W2-User	0	0	0	0	Combined BMPs
W3-User	0	0	0	0	Combined BMPs
W4-User	0	0	0	0	Combined BMPs
W5-User	0	0	0	0	Combined BMPs
W6-User	0	0	0	0	Combined BMPs

Gully and Streambank Pollutant Load Reduction

This sheet contains two input tables: the first table is for inputing the gully dimensions, and the second is for inputing the eroding streambank dimensions.

Gully:	**Step 1**. Specify the gully dimensions and assign each gully to a watershed. **Step 2**. Specify the time (number of years) that the gully has taken to form the current size. **Step 3**. Specify the gully stabilization (BMP) efficiency (0-1) and the gully soil textural class.
Streambank:	**Step 1**. Specify the stream bank dimensions and assign each bank to a watershed. **Step 2**. Specify the lateral recession rate (ft/yr) of the eroding streambank. Click to see "Streambank Lateral Recession Rate" table **Step 3**. Specify the streambank stabilization (BMP) efficiency (0-1) and the streambank soil textural class.

Close this sheet

1. Gully dimensions in the different watersheds

Watershed	Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)

2. Impaired streambank dimensions in the different watersheds

Watershed	Strm Bank	Length (ft)	Height (ft)	Lateral Recession	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
W1	Bank1	40	8	2. Moderate	0.06 - 0.2	0.13	0.95	Silt Loam	0.0425	1	1.7680	1.6796
W3	Bank2	75	25	3. Severe	0.3 - 0.5	0.4	0.95	Silt Loam	0.0425	1	31.8750	30.2813
W3	Bank3	100	15	3. Severe	0.3 - 0.5	0.4	0.95	Silt Loam	0.0425	1	25.5000	24.2250
W3	Bank4	120	12	3. Severe	0.3 - 0.5	0.4	0.95	Silt Loam	0.0425	1	24.4800	23.2560

Total Load This is the summary of annual nutrient and sediment load for each subwatershed. This sheet is initially protected.

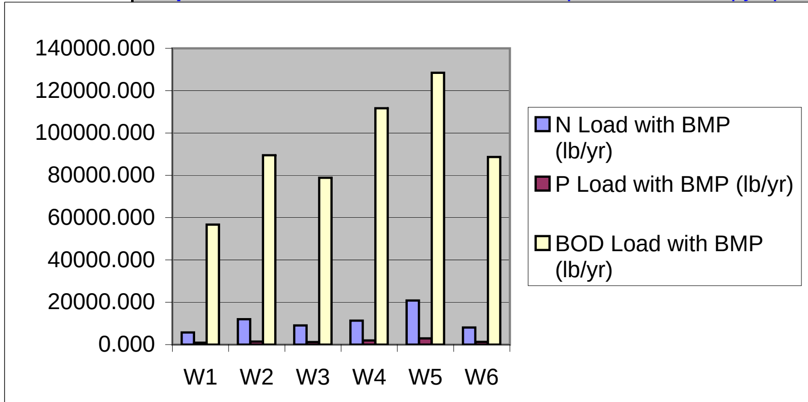
1. Total load by subwatershed(s)

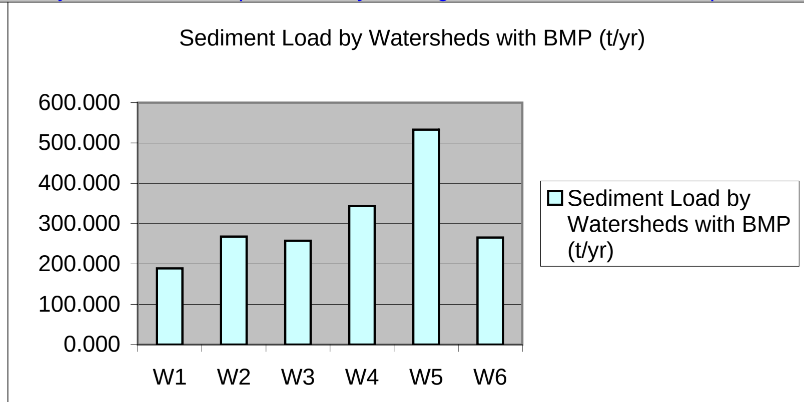
Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	29727.1	5601.5	65313.4	1534.6	23960.1	4727.0	8605.5	1345.4	5767.0	874.6	56708.0	189.1	80.6	84.4	13.2	87.7
W2	47174.3	8785.6	103332.0	2434.9	35140.7	7361.4	13870.0	2167.2	12033.6	1424.2	89462.0	267.7	74.5	83.8	13.4	89.0
W3	41854.3	7893.3	92145.1	2371.5	32783.0	6721.9	13280.3	2113.9	9071.4	1171.5	78864.8	257.5	78.3	85.2	14.4	89.1
W4	60880.9	11815.9	130508.6	3290.4	49576.2	9842.7	18860.5	2947.0	11304.7	1973.2	111648.1	343.5	81.4	83.3	14.5	89.6
W5	55208.1	9826.8	141925.7	2641.8	34371.2	6853.1	13495.4	2108.7	20836.9	2973.6	128430.3	533.2	62.3	69.7	9.5	79.8
W6	51088.6	10140.1	104070.2	2674.3	43024.4	8832.0	15417.0	2408.9	8064.2	1308.2	88653.3	265.4	84.2	87.1	14.8	90.1
Total	285933.4	54063.2	637295.0	14947.5	218855.6	44338.0	83528.5	13091.1	67077.8	9725.2	553766.5	1856.4	76.5	82.0	13.1	87.6

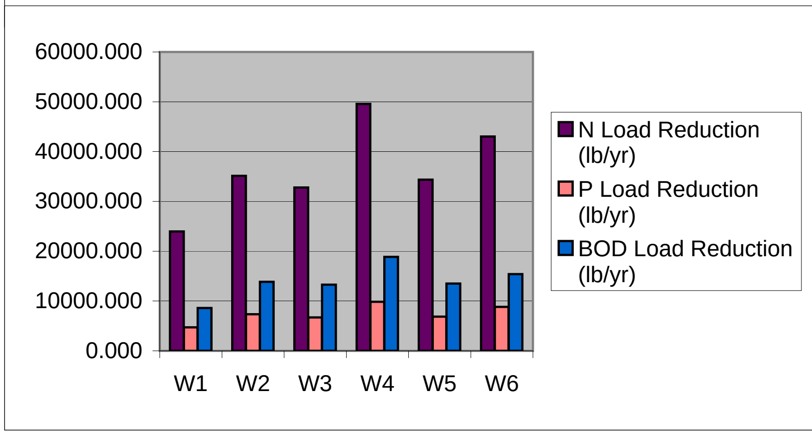
2. Total load by land uses (with BMP)

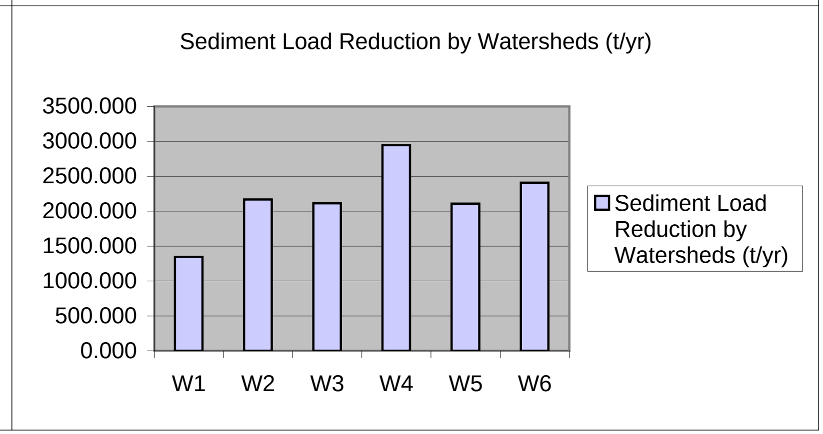
Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	12317.01	1895.51	47371.70	282.82
Cropland	27910.04	5387.33	375328.46	1273.37
Pastureland	13997.84	987.90	95505.65	113.94
Forest	469.14	230.79	1156.40	10.28
Feedlots	11131.43	736.93	30450.16	0.00
User Defined	549.88	211.70	1099.76	171.84
Septic	695.75	272.50	2841.00	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	6.69	2.58	13.38	4.18
Groundwater	0.00	0.00	0.00	0.00
Total	67077.79	9725.24	553766.50	1856.44

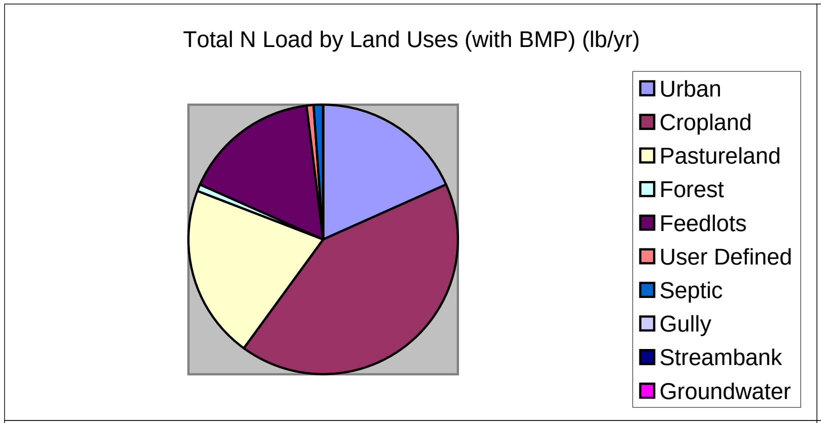
Graphs This sheet is protected. To copy specific objects, remove the protection by clicking Tools -> Protection -> Unprotect sheet.



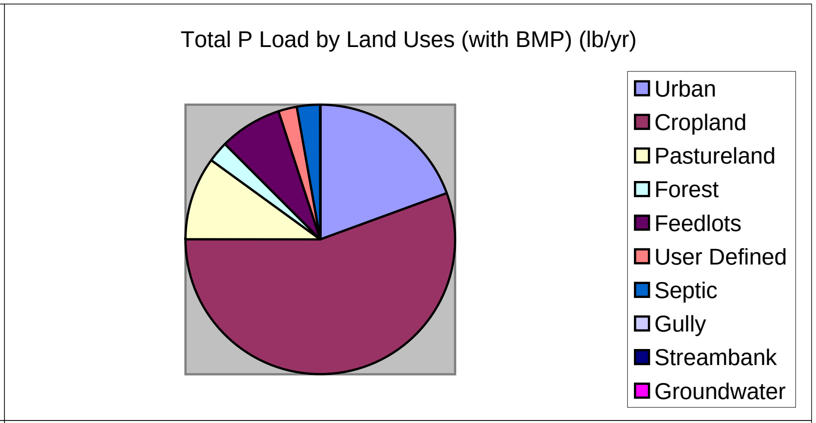




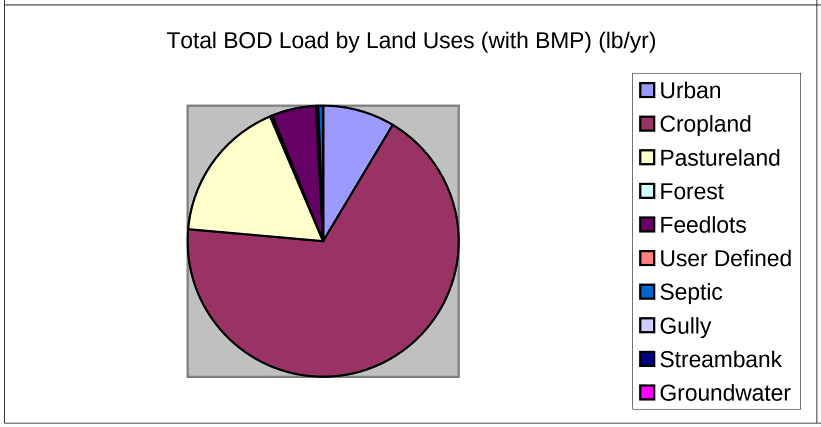




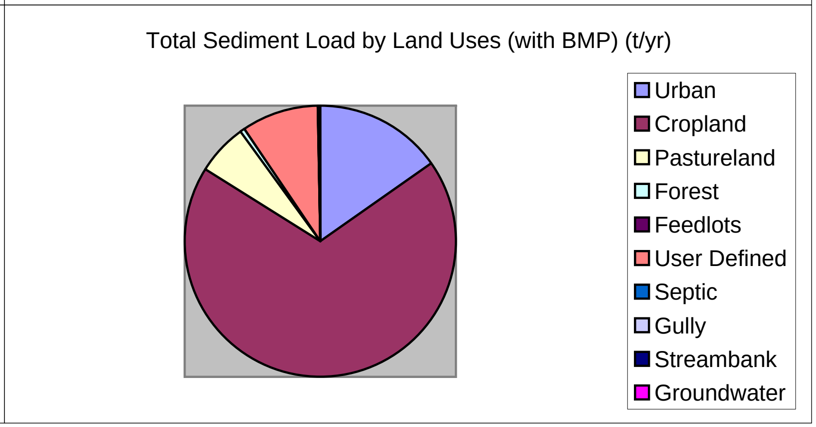
Total N Load by Land Uses (with BMP) (lb/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater



Total P Load by Land Uses (with BMP) (lb/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater



Total BOD Load by Land Uses (with BMP) (lb/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater



Total Sediment Load by Land Uses (with BMP) (t/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater

STEPL Input Sheet: Values in RED are required input. Change worksheets by clicking on tabs at the bottom. You entered 6 subwatershed(s).

This sheet is composed of eight input tables. The first four tables require users to change initial values. The next four tables (initially hidden) contain default values users may choose to change.

Step 1: Select the state and county where your watersheds are located. Select a nearby weather station. This will automatically specify values for rainfall parameters in Table 1 and USLE parameters in Table 4.

Step 2: (a) Enter land use areas in acres in Table 1; (b) enter total number of agricultural animals by type and number of months per year that manure is applied to croplands in Table 2;
(c) enter values for septic system parameters in Table 3; and (d) if desired, modify USLE parameters associated with the selected county in Table 4.

Step 3: You may stop here and proceed to the BMPs sheet. If you have more detailed information on your watersheds, click the Yes button in row 10 to display optional input tables.

Step 4: (a) Specify the representative Soil Hydrologic Group (SHG) and soil nutrient concentrations in Table 5; (b) modify the curve number table by landuse and SHG in Table 6;
(c) modify the nutrient concentrations (mg/L) in runoff in Table 7; and (d) specify the detailed land use distribution in the urban area in Table 8.

Step 5: Select BMPs in BMPs sheet. **Step 6**: View the estimates of loads and load reductions in Total Load and Graphs sheets.

Show optional input tables? Yes No

☑ **Treat all the subwatersheds as parts of a single watershed**

☐ **Groundwater load calculation**

State	County	Weather Station (for rain correction factors)
Indiana	Hamilton	IN INDIANAPOLIS WSFO AP

1. Input watershed land use area (ac) and precipitation (in)

Rain correction factors: 0.870 | 0.417

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Feedlots	Feedlot Percent Paved	Total	Annual Rainfall	Rain Days	Avg. Rain/Event
W1	17	5828	933	299	145	1	0-24%	7223	35.8	110.6	0.675
W2	19	9379	1357	1775	103	4	0-24%	12637	35.8	110.6	0.675
W3	33	8828	1095	228	144	1	0-24%	10329	35.8	110.6	0.675
W4	91	12822	1170	196	121	2	0-24%	14402	35.8	110.6	0.675
W5	2020	9091	1423	186	203	1	0-24%	12924	35.8	110.6	0.675
W6	1	10561	558	68	73	3	0-24%	11264	35.8	110.6	0.675

2. Input agricultural animals

Watershed	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck	# of months manure applied
W1	25	0	200	22	66	0	0	0	0
W2	75	0	0	74	85	0	0	0	0
W3	34	0	0	45	46	0	0	0	0
W4	15	0	800	18	25	0	0	0	0
W5	6	0	0	12	67	0	0	0	0
W6	50	0	1400	28	26	0	0	0	0
Total	205	0	2400	199	315	0	0	0	

3. Input septic system and illegal direct wastewater discharge data

Watershed	No. of Septic Systems	Population per Septic System	Septic Failure Rate, %	Wastewater Direct Discharge, # of People	Direct Discharge Reduction, %
W1	146	2.43	2	0	0
W2	183	2.43	2	0	0
W3	158	2.43	2	0	0
W4	268	2.43	2	0	0
W5	196	2.43	2	0	0
W6	168	2.43	2	0	0

4. Modify the Universal Soil Loss Equation (USLE) parameters

Watershed	Cropland					Pastureland					Forest					User Defined				
	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P	R	K	LS	C	P
W1	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W2	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W3	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W4	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W5	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000
W6	180.000	0.362	0.201	0.200	1.000	180.000	0.362	0.201	0.040	1.000	180.000	0.362	0.201	0.003	1.000	180.000	0.362	0.201	0.175	1.000

Best Management Practice Select an appropriate BMP except "Combined BMPs-Calculated" for each subwatershed in each land use table using the pull-down list-box if interactions between BMPs are not considered. Select "Combined BMPs-Calculated" if multiple BMPs and their interactions in the subwatersheds are considered; use BMP calculator (under STEPL menu) to obtain the combined BMP efficiencies and enter them in Table 7.

Urban BMP Tool

Gully and Streambank Erosion

1. BMPs and efficiencies for different pollutants on CROPLAND, ND=No Data

Watershed	Cropland					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0.92	0.944	0	0.981	Combined BMPs-Calculated	100
W2	0.93	0.95	0	0.984	Combined BMPs-Calculated	100
W3	0.925	0.947	0	0.983	Combined BMPs-Calculated	100
W4	0.929	0.95	0	0.984	Combined BMPs-Calculated	100
W5	0.928	0.939	0	0.979	Combined BMPs-Calculated	100
W6	0.933	0.952	0	0.985	Combined BMPs-Calculated	100

2. BMPs and efficiencies for different pollutants on PASTURELAND, ND=No Data

Watershed	Pastureland					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W2	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W3	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W4	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W5	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100
W6	0.5325	0.6125	0	0.65	Combined BMPs-Calculated	100

3. BMPs and efficiencies for different pollutants on FOREST, ND=No Data

Watershed	Forest					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0	0	0	0	0 No BMP	100
W2	0	0	0	0	0 No BMP	100
W3	0	0	0	0	0 No BMP	100
W4	0	0	0	0	0 No BMP	100
W5	0	0	0	0	0 No BMP	100
W6	0	0	0	0	0 No BMP	100

4. BMPs and efficiencies for different pollutants on USER DEFINED land use, ND=No Data

Watershed	User Defined					
	N	P	BOD	Sediment	BMPs	% Area BMP Applied
W1	0	0	0	0	0 No BMP	100
W2	0	0	0	0	0 No BMP	100
W3	0	0	0	0	0 No BMP	100
W4	0	0	0	0	0 No BMP	100
W5	0	0	0	0	0 No BMP	100
W6	0	0	0	0	0 No BMP	100

5. BMPs and efficiencies for different pollutants on FEEDLOTS, ND=No Data

Watershed	Feedlots					
	N	P	BOD	Sediment	BMPs	%Area BMP Applied
W1	0.8	0.9	ND	ND	Waste Mgmt System	100
W2	ND	0.85	ND	ND	Filter strip	100
W3	ND	0.85	ND	ND	Filter strip	100
W4	0.65	0.6	ND	ND	Waste Storage Facility	100
W5	ND	0.85	ND	ND	Filter strip	100
W6	0.8	0.9	ND	ND	Waste Mgmt System	100

6. BMPs and efficiencies for different pollutants on URBAN

To change/set BMP/LID for urban land uses, click the 'Urban BMP Tool' button on the top-left of this sheet.

7. Combined watershed BMP efficiencies from the BMP calculator

Watershed	Watershed Combined BMP Efficiencies				
	N	P	BOD	Sediment	BMPs
W1-Crop	0.92	0.944	0	0.981	Combined BMPs
W2-Crop	0.93	0.95	0	0.984	Combined BMPs
W3-Crop	0.925	0.947	0	0.983	Combined BMPs
W4-Crop	0.929	0.95	0	0.984	Combined BMPs
W5-Crop	0.928	0.939	0	0.979	Combined BMPs
W6-Crop	0.933	0.952	0	0.985	Combined BMPs
W1-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W2-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W3-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W4-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W5-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W6-Pasture	0.5325	0.6125	0	0.65	Combined BMPs
W1-Forest	0	0	0	0	Combined BMPs
W2-Forest	0	0	0	0	Combined BMPs
W3-Forest	0	0	0	0	Combined BMPs
W4-Forest	0	0	0	0	Combined BMPs
W5-Forest	0	0	0	0	Combined BMPs
W6-Forest	0	0	0	0	Combined BMPs
W1-User	0	0	0	0	Combined BMPs
W2-User	0	0	0	0	Combined BMPs
W3-User	0	0	0	0	Combined BMPs
W4-User	0	0	0	0	Combined BMPs
W5-User	0	0	0	0	Combined BMPs
W6-User	0	0	0	0	Combined BMPs

Gully and Streambank Pollutant Load Reduction	
This sheet contains two input tables: the first table is for inputing the gully dimensions, and the second is for inputing the eroding streambank dimensions.	
Gully:	**Step 1**. Specify the gully dimensions and assign each gully to a watershed. **Step 2**. Specify the time (number of years) that the gully has taken to form the current size. **Step 3**. Specify the gully stabilization (BMP) efficiency (0-1) and the gully soil textural class.
Streambank:	**Step 1**. Specify the stream bank dimensions and assign each bank to a watershed. **Step 2**. Specify the lateral recession rate (ft/yr) of the eroding streambank. Click to see "Streambank Lateral Recession Rate" table **Step 3**. Specify the streambank stabilization (BMP) efficiency (0-1) and the streambank soil textural class.

Close this sheet

1. Gully dimensions in the different watersheds

Watershed	Gully	Top Width (ft)	Bottom Width (ft)	Depth (ft)	Length (ft)	Years to Form	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)

2. Impaired streambank dimensions in the different watersheds

Watershed	Strm Bank	Length (ft)	Height (ft)	Lateral Recession	Rate Range (ft/yr)	Rate (ft/yr)	BMP Efficiency (0-1)	Soil Textural Class	Soil Dry Weight (ton/ft3)	Nutrient Correction Factor	Annual Load (ton)	Load Reduction (ton)
W1	Bank1	40	8	2. Moderate	0.06 - 0.2	0.13	0.95	Silt Loam	0.0425	1	1.7680	1.6796
W3	Bank2	75	25	3. Severe	0.3 - 0.5	0.4	0.95	Silt Loam	0.0425	1	31.8750	30.2813
W3	Bank3	100	15	3. Severe	0.3 - 0.5	0.4	0.95	Silt Loam	0.0425	1	25.5000	24.2250
W3	Bank4	120	12	3. Severe	0.3 - 0.5	0.4	0.95	Silt Loam	0.0425	1	24.4800	23.2560

Total Load This is the summary of annual nutrient and sediment load for each subwatershed. This sheet is initially protected.

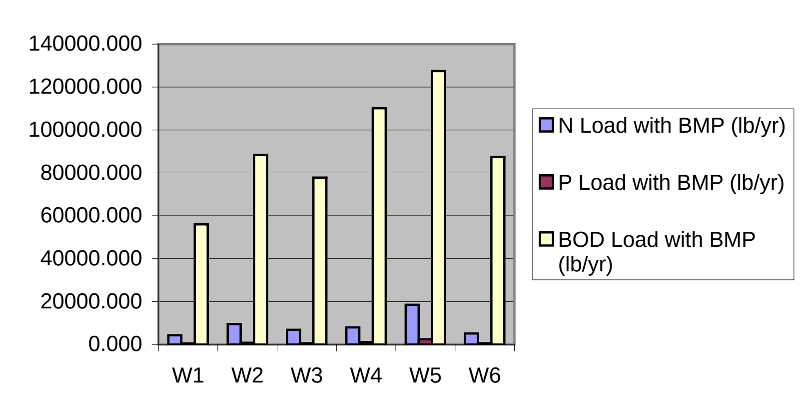
1. Total load by subwatershed(s)

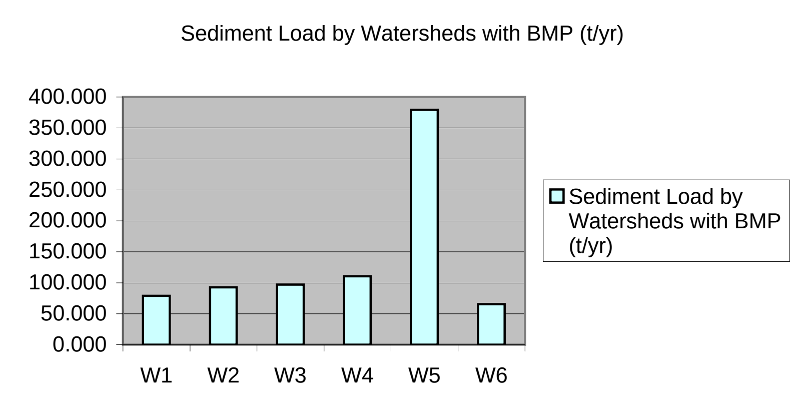
Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)	%N Reduction	%P Reduction	%BOD Reduction	%Sed Reduction
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	%	%	%	%
W1	29727.1	5601.5	65313.4	1534.6	25374.4	5104.3	9311.4	1455.8	4352.7	497.2	56002.0	78.8	85.4	91.1	14.3	94.9
W2	47174.3	8785.6	103332.0	2434.9	37640.8	7984.0	14991.2	2342.4	9533.5	801.6	88340.8	92.6	79.8	90.9	14.5	96.2
W3	41854.3	7893.3	92145.1	2371.5	34958.6	7285.3	14307.5	2274.4	6895.7	608.0	77837.7	97.1	83.5	92.3	15.5	95.9
W4	60880.9	11815.9	130508.6	3290.4	52894.5	10679.8	20352.4	3180.1	7986.5	1136.1	110156.2	110.4	86.9	90.4	15.6	96.6
W5	55208.1	9826.8	141925.7	2641.8	36659.6	7383.9	14480.7	2262.6	18548.5	2442.8	127445.0	379.2	66.4	75.1	10.2	85.6
W6	51088.6	10140.1	104070.2	2674.3	45945.7	9546.6	16696.3	2608.8	5142.8	593.6	87374.0	65.5	89.9	94.1	16.0	97.6
Total	285933.4	54063.2	637295.0	14947.5	233473.6	47983.8	90139.4	14124.0	52459.8	6079.4	547155.6	823.5	81.7	88.8	14.1	94.5

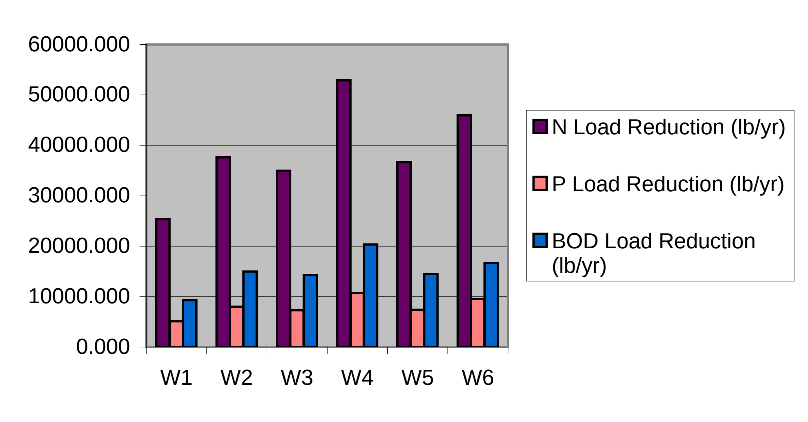
2. Total load by land uses (with BMP)

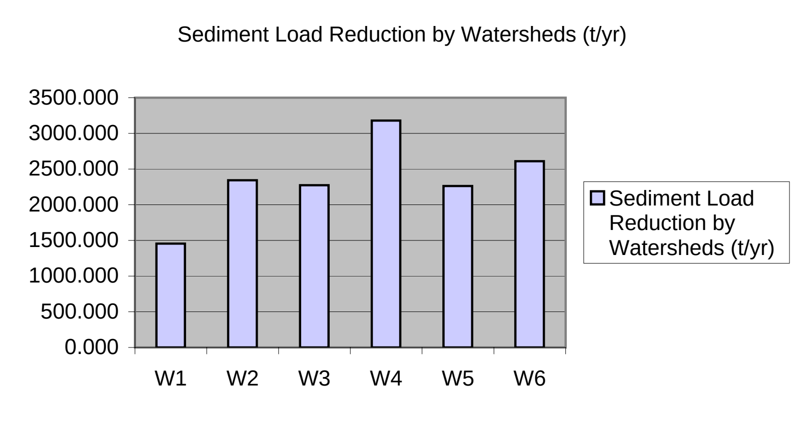
Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	12317.01	1895.51	47371.70	282.82
Cropland	13292.05	1741.50	368717.56	240.42
Pastureland	13997.84	987.90	95505.65	113.94
Forest	469.14	230.79	1156.40	10.28
Feedlots	11131.43	736.93	30450.16	0.00
User Defined	549.88	211.70	1099.76	171.84
Septic	695.75	272.50	2841.00	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	6.69	2.58	13.38	4.18
Groundwater	0.00	0.00	0.00	0.00
Total	52459.79	6079.41	547155.61	823.49

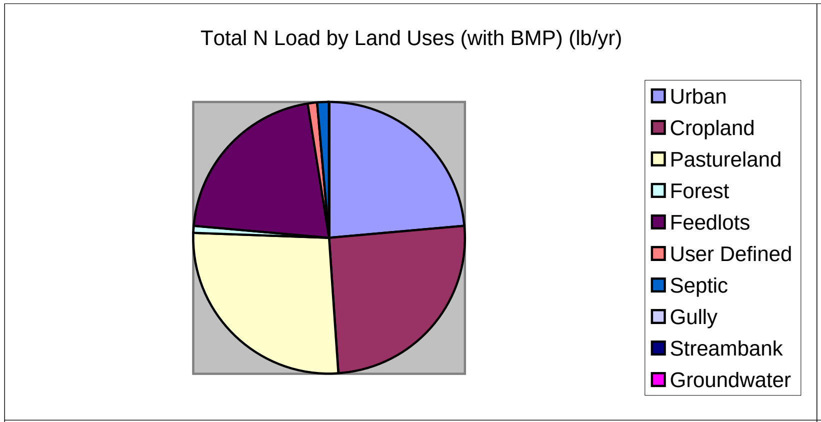
Graphs This sheet is protected. To copy specific objects, remove the protection by clicking Tools -> Protection -> Unprotect sheet.

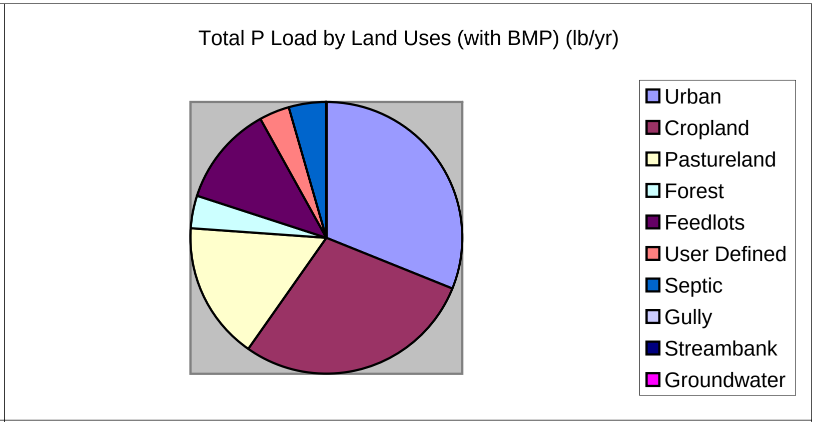


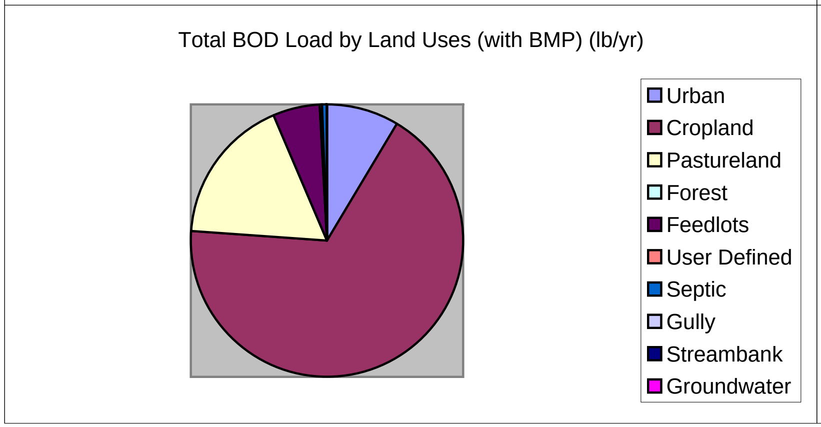


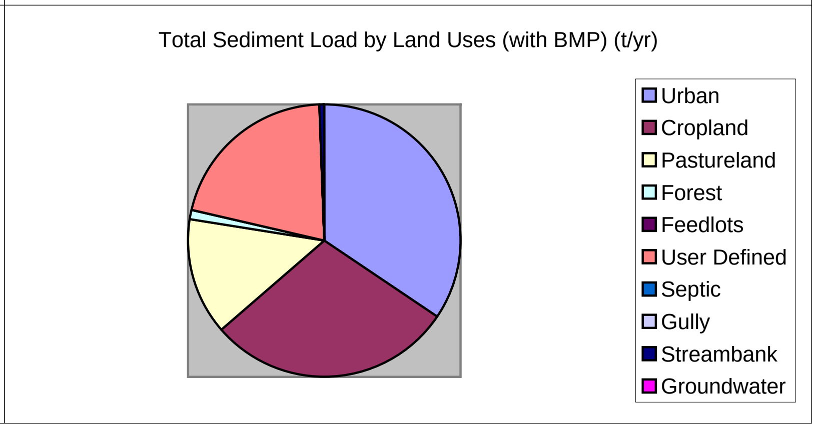





Total N Load by Land Uses (with BMP) (lb/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater


Total P Load by Land Uses (with BMP) (lb/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater


Total BOD Load by Land Uses (with BMP) (lb/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater


Total Sediment Load by Land Uses (with BMP) (t/yr)
Urban
Cropland
Pastureland
Forest
Feedlots
User Defined
Septic
Gully
Streambank
Groundwater

Appendix F

Duck Creek Watershed
List of Recommended
BMPs from USDA, NRCS
Field Office Technical Guide

Appendix F
Recommended Best management Practices
Referenced from USDA, Natural Resources Conservation Service
Field Office Technical Guide (FOTG)

To prevent excess pages in the appendices the actual Standards and Specifications were not copied here. The Standards and Specifications are available in the FOTG on line at http://efotg.nrcs.usda.gov/treemenuFS.aspx
A hardcopy of the FOTG may be viewed at any local USDA Service Center location.

This list of BMPs may be related to or used in conjunction with BMPs listed in the Duck Creek Watershed Management Plan.

Conservation Cover (Acre)	Code 327
Conservation Crop Rotation (Acre)	Code 328
Drainage Water Management (Acre)	Code 554
Early Successional Habitat Development/Management (Acre)	Code 647
Fence (Feet)	Code 382
Field Border (Feet)	Code 386
Filter Strip (Acre)	Code 393
Forage Harvest Management (Acre)	Code 511
Forest Stand Improvement (Acre)	Code 666
Forest Trails and Landings (Acre)	Code 655
Grassed Waterway (Acre)	Code 412
Nutrient Management (Acre)	Code 590
Pipeline (Feet)	Code 516
Prescribed Grazing (Acre)	Code 528
Residue and Tillage Management, Mulch Till (Acre)	Code 345
Residue and Tillage Management No Till/Strip Till/Direct Seed (Acre)	Code 329
Riparian Forest Buffer (Acre)	Code 391
Riparian Herbaceous Cover (Acre)	Code 390
Stream Channel Stabilization (Feet)	Code 584
Streambank and Shoreline Protection (Feet)	Code 580
Use Exclusion (Acre)	Code 472
Waste Utilization (Acre)	Code 633
Watering Facility (No.)	Code 614
Well Decommissioning (No.)	Code 351
Wetland Restoration (Acre)	Code 657
Wildlife Wetland Habitat Management (Acre)	Code 644