

# SECTION TWO - 319 WATER QUALITY STUDIES

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 2



# 319 Chemical Studies Overview

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 1

To supplement/expand the existing water quality data (and the reporting on that data), the WRWP, in conjunction with the Muncie BWQ, has developed a water quality sampling program specifically for Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds. See MAP 2.67 for Water Quality Sampling Locations. The Muncie BWQ was contracted to sample and process water quality data for the WRWP. The following pages outline the analysis performed by the WRWP pursuant to the 319 grant program.

In conjunction with Hamilton Ditch-Muncie Creek and Truitt Ditch-White River data, other data from the Muncie BWQ was used for comparison (adjacent watersheds). The BWQ's public data on the main stem White River is the product of 40 years of research (water quality sampling data was one of the first actions taken by the Bureau following its establishment.) This monitoring, which includes 16 sites sampled on a monthly basis, has continued largely unchanged for almost 40 years. Their monitoring program consists either daily, weekly, or monthly monitoring of certain waterways, depending on the history and needs of each waterway.

The following parameters were sampled and the results are discussed for each waterway below. Their individual procedures and methods can be found in Table 2.52.

- Ammonia as N
- Dissolved Oxygen
- E. coli by membrane filtration
- Nitrate+Nitrite as N
- Total Phosphorus as P
- Total Suspended Solids
- pH value
- Turbidity
- Temperature

It is important to note that the current WMP and 319 WQ monitoring program is being developed at a smaller scale (area) than other WMPs being developed state-wide. Our Subwatershed drainage areas (2 HUC 12s) are relatively small in comparison to some Watershed Projects (some analyze multiple HUC 10s). When developing critical or priority areas for planning, the smaller the management areas, the more difficult it is to compare Subwatersheds at the HUC12 level, as their opportunity for a relative comparison (ranking) is limited.

Therefore, our approach considers three different strategies for developing water quality information and for discerning critical areas in these Subwatersheds:

The first (a baseline analysis) consists of comparing Subwatersheds at the HUC12 level i.e. comparing Hamilton Ditch - Muncie Creek and Truitt Ditch - White River to each other to determine the relative water quality issues in the two Subwatersheds. This study looked at sampling points on the main stem of the White River at the HUC 12 drainage points, giving us an overall picture of WQ at the Subwatershed level. This study was helpful in determining which of these two Subwatersheds has priority over the other in terms of WQ impairment.

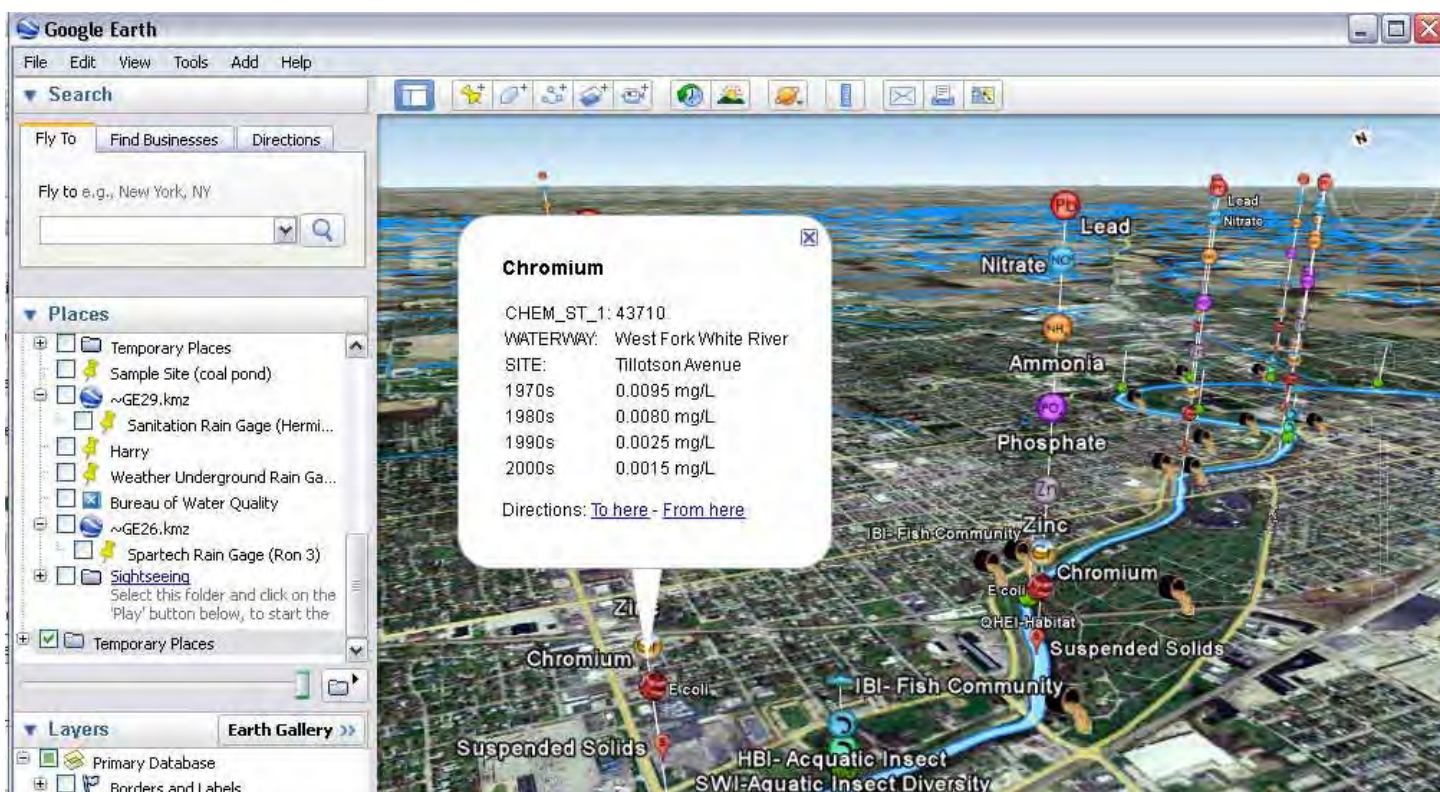
Our second level study compared main stem White River sampling points in Hamilton Ditch – Muncie Creek and Truitt Ditch – White River to other main stem White River sampling points in the Muncie BWQ database. We wanted to see how WQ on the main stream evolved/changed as it made its way through the City of Muncie. Truitt Ditch - White River Subwatershed is at the headwaters of all City of Muncie Watersheds and provides a baseline of water quality as it moves through the City.

This study looks at seven points along the main stem of the White River. Each point is compared to the proceeding points. Six of the Seven sampling points along the White River in Muncie fall in the York-Prairie Creek Subwatershed (which is a linear Subwatershed that runs Northwest through the urban core of Muncie). The final sampling point is at the discharge point of Buck Creek Subwatershed. Therefore, these studies are simultaneously comparing Hamilton Ditch –Muncie Creek and Truitt Ditch – White River to York-Prairie and Buck Creek Subwatersheds.

The third level of analysis looks at Hamilton Ditch –Muncie Creek and Truitt Ditch -White River at a basin/tributary level. Tributary sampling occurred on four sites, Muncie Creek, Holt ditch, Unnamed Tributary, and Truitt Ditch. Because some of the tributaries/ditches in Truitt Ditch –White River were not sampled, the Memorial Drive sampling on the White River functions as a comparative basin. The cross basin data analysis helped us discover how those individual basins were performing (relative to each other) and how the basin scale WQ (tributary WQ) are influencing our studies at the HUC12 level (on the main stem). Both scales of analysis will determine priority areas and aid in the development of critical areas.

TABLE 2.52: Analytical procedures and methods.

Parameter	Method	Method Detection Limit
pH	SM 20th, 4500-H+ B	NA
DO	SM 20th, 4500-O G.	0.1 mg/L
Temperature	EPA 170.1	0.1 °C
TSS	SM 20th, 254-O D	4.0/250 mL
Ammonia	SM 20th, 4500-NH3 E	0.05 mg/L
TP-P	SM 20th 4500-P E	0.05 mg/L
(NO3+NO2)-N	EPA 353.2	0.02 mg/L
E. coli	EPA 1603	1 CFU/100 mL
Atrazine by Immunoassay	EPA 4670	< 1 µg/L
Stream discharge	Buchanan & Somers, 1969	NA



IMG. 2.9 / MAP 2.68 BWQ Google Earth Resources. BWQ

Today, the Muncie Bureau of Water Quality takes advantage of numerous avenues for disseminating water quality information to the public. Accessibility to a wealth of information is now available in many formats including geographic information system (GIS) linked databases and GoogleEarth™ online formats (IMG 2.9). Every effort is made to inform the local residents and anyone with access to the internet of the tremendous improvement in water quality that has occurred in Muncie.<sup>1</sup>

1 BWQ Annual Pretreatment Report





# Chemical Parameters

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 2

### **Ammonia (NH<sub>3</sub>)**

Ammonia is a colorless gas with a pungent odor. It is easily liquefied and solidified and is very soluble in water. According to the Indiana Administrative Code (IAC), maximum unionized ammonia concentrations within the temperature and pH ranges measured for the study streams should range between approximately 0.015 and 0.21 mg/L (327 IAC 2-1-6). Toxic levels are both pH and temperature dependent. High pH increases the conversion of NH<sub>4</sub> to NH<sub>3</sub>. Ammonia was analyzed by the Muncie Bureau of Water Quality using method 4500-NH<sub>3</sub> E from the Standard Methods 20th Edition.

### **Dissolved Oxygen (DO)**

Dissolved oxygen refers to the volume of oxygen that is contained in water. Oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure. Gas solubility increases with decreasing temperature (colder water holds more oxygen). Gas solubility also decreases as atmospheric pressure decreases. Fish need at least 3-5 parts per million (ppm) of DO. The IAC (317 IAC 2-1-6) sets the minimum average DO concentrations at 5 mg/L per day and no less than 4 mg/L at any time for Indiana streams. The Muncie analyzed DO using method 4500-O G from the Standard Methods 20th Edition.

### **Escherichia coli (E. coli)**

This is a type of bacteria normally found in the intestines of people and animals. Although most strains of E. coli are harmless, some can cause illness or even death. Testing for E. coli is a simple, inexpensive process that provides valuable information regarding water quality, as E. coli often indicates the presence of other pathogenic organisms. The IAC (327 IAC 2-1-6) sets the E. coli standard for full body contact recreation uses at 235 cfu/100mL for any one sampling time. For the purposes of this document, we will use the 235 cfu/100mL target. E. coli levels were analyzed by the Muncie Bureau of Water Quality using EPA method 1603.

### **Nitrate + Nitrite as N**

Nutrients such as Nitrate and Nitrite are essential to plant and algae growth in water systems. The measurement of nutrients is used as a predictor of plant growth in a water system. While total elimination of all plant and algae growth is not desirable, the excessive growth of these organisms is undesirable as well. Nitrate is a form of nitrogen which is readily available to plants as a nutrient. Generally, nitrate is the primary inorganic form of nitrogen in aquatic systems. The IAC (327 IAC 2-1-6) sets the maximum level of Nitrate + Nitrite at 10.0 mg/L in waters designated as a drinking water source, but does not set a standard for aquatic life. The Ohio Environmental Protection Agency suggests a level of 1.0 mg/L for nitrate to protect Warm Water Habitat (WWH) headwater streams and Modified Warm Water Habitat (MWH) headwater streams. For the purposes of this document, a level of 1.0 mg/L of Nitrate + Nitrite Nitrogen will be used. Nitrate and nitrite as N was analyzed by the Muncie Bureau of Water Quality using EPA method 353.2.

### **pH**

The negative log of the hydrogen ion concentration ( $-\log [H^+]$ ) is a measure of the acidity or alkalinity of a solution. The scale range is 0-14. Water pH is 7 for neutral solutions, increases with increasing alkalinity and decreases with increasing acidity. The IAC (327 IAC 2-1-6) establishes a pH range of 6 to 9 for the protection of aquatic life. For the purpose of this document, pH was analyzed using the 4500-H<sup>+</sup> B method from the Standard Methods 20th Edition.

### **Total Phosphorus as P**

Total Phosphorus is the measure of both the soluble form of phosphorus dissolved in water, as well as particulate forms suspended in water. Phosphorus is a nutrient that is utilized by plants and algae for growth. It is often the limiting nutrient in lacustrine systems; an excess of phosphorus leads to an explosion of algal growth. The IAC does not set a standard for phosphorus in Indiana streams. There are numerous thresholds developed by other researchers and agencies. Dodd et al. 1998 put forth that 0.07 mg/L is the dividing line between mesotrophic and eutrophic streams. The Ohio EPA suggests that 0.08 mg/L is needed to protect aquatic biotic integrity in warm water headwater streams. For the purposes of this document, the US EPA's recommendation of 0.076 mg/L will be used as a water quality target. Total Phosphorus was analyzed using method 4500-P E from the Standard Methods, 20th Edition.

### **Total Suspended Solids (TSS)**

TSS is the weight of particles that are suspended and dissolved in water. This parameter is closely related to Turbidity, due to the relationship between higher concentrations of suspended solids and cloudier water. The concentration of TSS is generally higher during high flow events due to the increase in surface runoff and the suspension of previously deposited sediment particles. Increased amounts of total suspended solids have many detrimental effects on the quality of a stream. Increased cloudiness can interfere with the gill functions of aquatic organisms. Solids that settle to the bottom of the channel can cover spawning areas for aquatic organisms. Solids also provide a place for toxic chemicals to bond. The IDEM TMDL target is 30 mg/L. For the purposes of this document, TSS levels were analyzed using method 254-O D from the Standard Methods 20th Edition.

### **Turbidity**

Turbidity is the measure of the cloudiness of water caused by suspended solids. It is very similar to the measurements for total suspended solids. Turbidity is measured using Nephelometric Turbidity Units (NTU). The USEPA recommends a maximum of 10.4 NTU. For the purposes of this document, we will use the same threshold.

### **Stream Temperature**

The temperature of water has a direct effect on the form, solubility, and toxicity of numerous chemical compounds. For example, the temperature of a water sample has an inverse relationship with the amount of dissolved oxygen present. The Indiana Administrative Code (327 IAC 2-1-6) sets the maximum limit of stream temperature depending on calendar month. For instance, Indiana Streams cannot exceed 90°F (32.2°C) from June through September. For the purposes of the water quality data in this document, the stream temperature is measured at each sampling location using EPA method 170.1 and reported in degrees Celsius.

### **Atrazine**

Atrazine is typically detected in surface water samples during the growing season, much less frequently if at all during the remainder of the year. Peak Atrazine concentrations can be found in late May or early June, typically following the first runoff event after application. Atrazine, an herbicide used in the agricultural production of corn, was found at the downstream most point in all three Subwatersheds. The USEPA standard of Atrazine for drinking water is 3.0 µg/L. Atrazine will be analyzed by Immunoassay using EPA method 4670.



# Water Quality Targets

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 3

The WRWP will generally use Indiana WQS as a method to analyze water quality data generated by the 319 Chemical Sampling program. TABLE 2.53 outlines the surface water quality guidelines used in our Water Quality Program for parameters sampled.

Indiana's WQS underwent significant revision in 1990. At that time, numerical criteria for all pollutants for which USEPA had developed either human health or aquatic life ambient water quality criteria were added to the standards. Procedures for developing additional criteria were also included in these rules. Additionally, all waters were designated for full body (primary) contact recreational use, and the bacteriological indicator organism was changed from fecal coliform to *E. coli* to conform to USEPA's guidance on bacteriological indicators.<sup>1</sup>

In 1993, the rules and regulations that guide the implementation of Indiana's WQS through Indiana's NPDES permits were extensively revised. Although this revision resulted in significant changes to these rules, only minor changes were made to Indiana's WQS. With the issuance of the final Great Lakes Water Quality Guidance in 1995, Indiana began the process of revising the WQS and implement regulations for those waters in Indiana's Great Lakes system. This rulemaking, for the most part, had no immediate effect on Indiana's waters located outside the Great Lakes system. These revisions incorporated the various criteria and procedures (or equivalent ones) identified in the guidance into Indiana's WQS. As a part of this rulemaking, Indiana also developed procedures to implement the antidegradation policy for all substances discharged to waters in the Great Lakes system. These revisions were adopted by the Indiana Water Pollution Control Board (WPCB) effective in February 1997 and submitted to USEPA for approval. In August of 2000, USEPA formally approved these revisions with the exceptions of the sections on reasonable potential for whole effluent toxicity and variances. For these parts of the rule, USEPA promulgated the federal guidance language for Indiana.<sup>2</sup>

Indiana is currently working with USEPA Region 5, other Region 5 states and the United States Geological Survey (Soil Survey of Delaware County Indiana. US Department of Agriculture) to develop nutrient criteria for different water body types throughout the region. Indiana has submitted a Nutrient Criteria Development Plan and schedule for the development of nutrient criteria to the USEPA and provides updates to the plan on an annual basis. IDEM has worked with the Soil Survey of Delaware County Indiana. The US Department of Agriculture has worked with Indiana to collect information pertinent to the development of nutrient criteria in all of our major water basins over the past five years, and Soil Survey of Delaware County Indiana. US Department of Agriculture is currently in the process of analyzing this data. USEPA guidance appears to give states additional flexibility in the development of nutrient criteria, especially if the state and USEPA have agreed on a plan to accomplish this goal. Indiana is actively participating in this effort, and IDEM's plan has been approved by USEPA.<sup>3</sup>

1 Indiana Integrated Water Monitoring and Assessment Report

2 Indiana Integrated Water Monitoring and Assessment Report

3 Indiana Integrated Water Monitoring and Assessment Report

TABLE 2.53: Surface water quality guidelines for parameters sampled

Parameter	Target	Source/Reason
Ammonia as N	Variable; depends on pH and Temperature	IAC 2-1-6
Dissolved Oxygen	Min: 4.0 mg/L	IAC 2-1-6
E. coli by membrane filtration	Max 235 cfu/100mL	IAC 2-1-6
Nitrate+Nitrite as N	Max: 1 mg/L	Ohio EPA recommended criteria for Warm Water Habitat (WWH) headwater streams and Modified Warm Water Habitat (MWH) headwater streams
Phosphorus as P	Max: 0.076 mg/L	US EPA recommendation
Total Suspended Solids	Max: 30 mg/L	IDEM target
pH value	Min: 6; Max: 9	IAC 2-1-6
Turbidity	Max: 10.4 NTU	U.S. EPA recommendation
Temperature	Variable; depends on time of year	IAC 2-1-6
Atrazine	Max: 3.0 ug/L	US EPA Drinking Water Standard

# Mainstem White River

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 4

The Mainstem White River study analyzed sampling points along the Mainstem of the White River at Hamilton Ditch - Muncie Creek and Truitt Ditch - White River near Subwatershed discharge points; the Hamilton Ditch - Muncie Creek (discharge) sampling point was Walnut Street and the Truitt Ditch-White River (discharge) sampling point was Memorial Drive. (MAP 2.69) This baseline analysis compares the two Subwatersheds against each other to determine the relative water quality issues in these two Subwatersheds. This gives us a overall picture of WQ at the Subwatershed level.

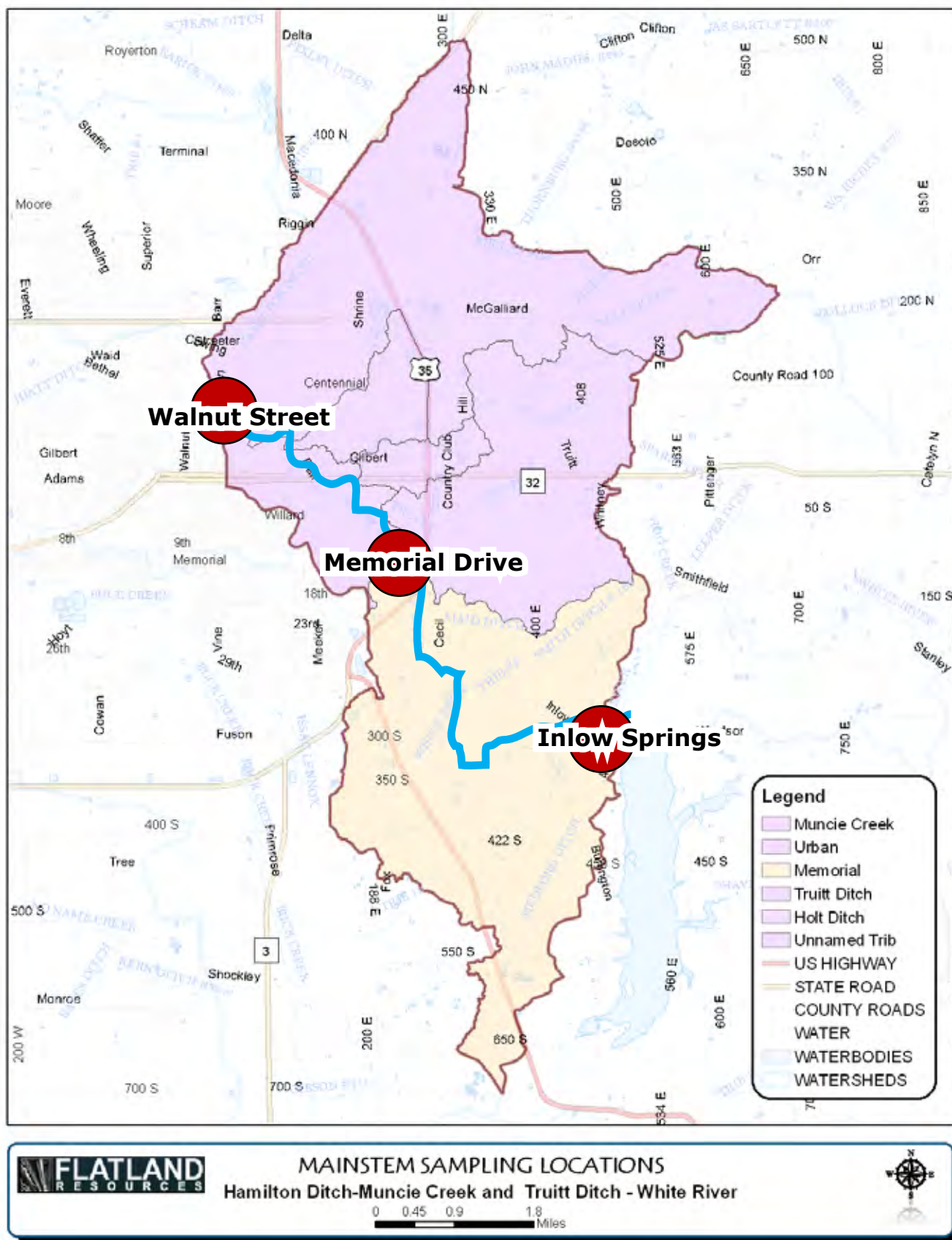
This data was also compared to data collected at Inlow Springs Road (since 2001). This sampling point is at the headwaters of the Subwatersheds. The Inlow Springs sampling site has very limited samples and although included as a point of discussion, will be inconclusive due to limited comparative sampling taken at varying and inconsistent time periods.

The following water quality parameters were tested.

- Ammonia as N
- Dissolved Oxygen
- E. coli
- Nitrate+Nitrite as N
- Total Phosphorus as P
- Total Suspended Solids
- pH value
- Temperature
- Atrazine
- Discharge

Results for all WQ impairments are available on the Muncie Bureau of Water Quality website. Ammonia, Nitrogen, Phosphorus, Total Suspended Solids and E. coli will be reported on in the following pages as they are the chosen impairments of the White River Watershed Project.

This study also includes graphing of the 10 year sampling histories to compare current averages and exceedences to historical data. These graphs also include flow gauge data from the Main stem of the White River.



MAP. 2.69 Mainstem Sampling Locations

# Walnut Street

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 5

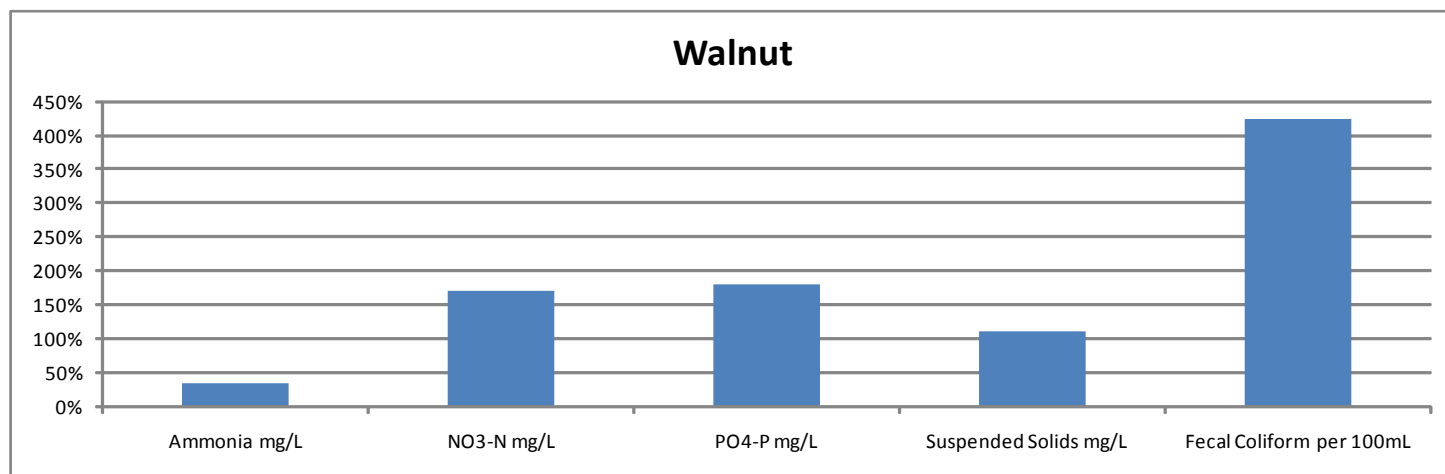
The Walnut Street sampling site is located on the main stem of the White River on the east side of Muncie. It is located at the discharge point of the Muncie Creek-Hamilton Ditch Subwatershed Basin which also flows from the Truitt Ditch-White River Subwatershed.

TABLE 2.54: Walnut Street Nonpoint Source Pollutants

Walnut	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.07	77	0	0%
NO3-N mg/L	1.00	1.70	74	33	45%
PO4-P mg/L	0.08	0.14	77	34	44%
Suspended Solids mg/L	30.00	33.40	77	18	23%
Fecal Coliform per 100mL	235.00	997.62	77	51	66%

This site had 77 samples taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.07 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 0 times. Nitrates and Nitrite as N levels averaged 1.70 mg/L and exceeded the target of 1.0 mg/L 33 times. Phosphorus as P levels averaged 0.14 mg/L and exceeded the EPA recommended target of 0.076 mg/L 34 times. Total suspended solids averaged 33.40 mg/L and exceeded the target of 30.0 mg/L 18 times. E. coli levels averaged 997.62 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 51 times.

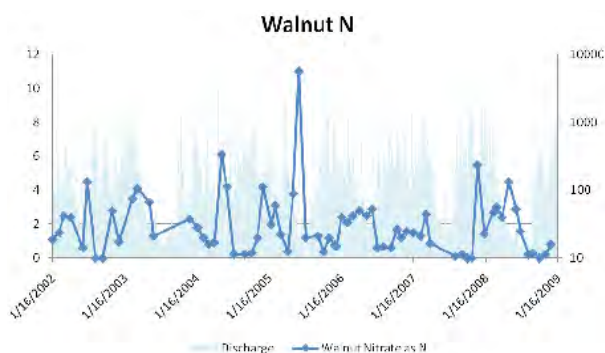
Charts 2.29 - 2.34 graph water quality impairments over a 10 year sampling period for the purposes of comparing current averages and exceedences to historical data. These graphs also include flow gauge data from the Main stem of the White River.



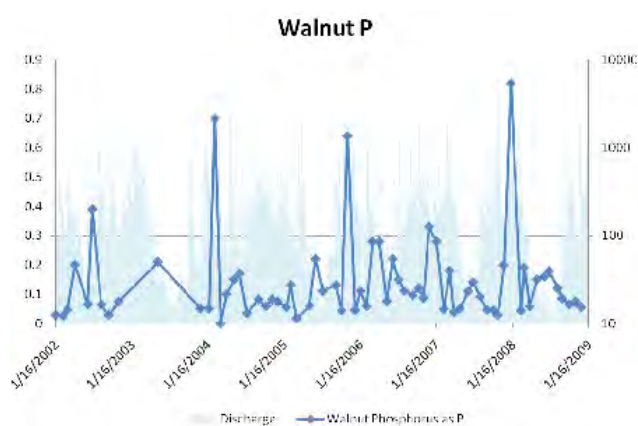
CHA. 2.29 Walnut St. Pollutant by Percentage of Exceedence



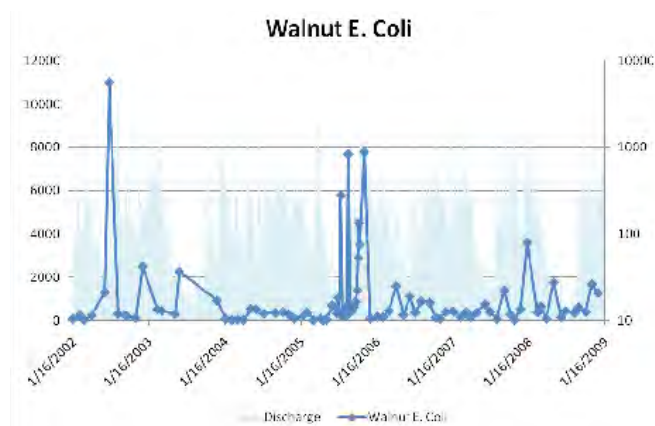
CHA.2.30 Walnut St. Ammonia



CHA.2.31 Walnut St. Nitrogen

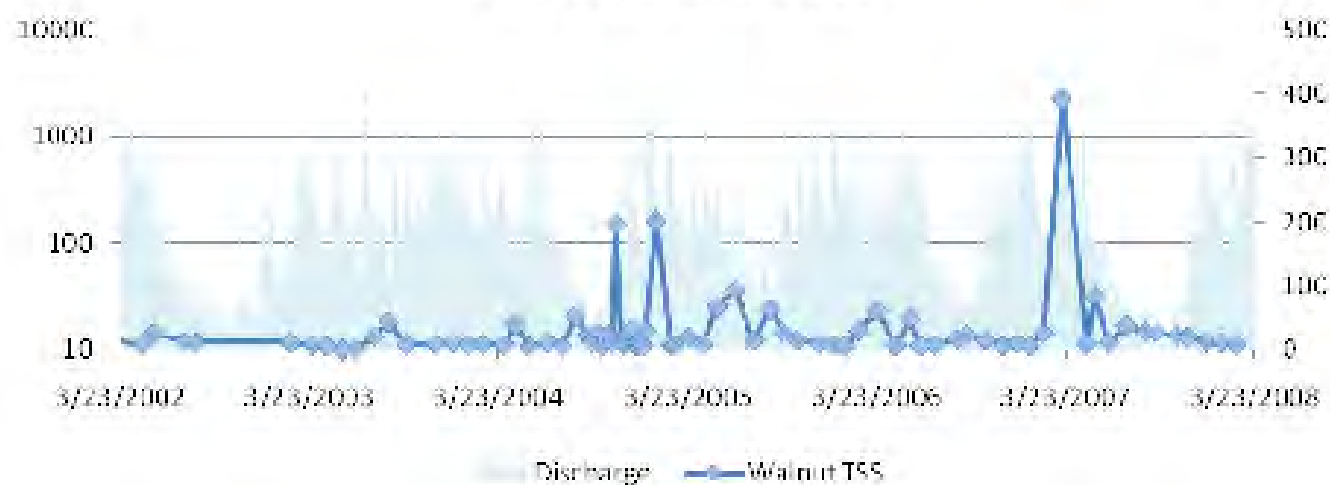


CHA. 2.32 Walnut St. Phosphorus



CHA. 2.33 Walnut St. E. coli

## TSS Walnut Street



CHA. 2.34 Walnut St. TSS



# Memorial Drive

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 6

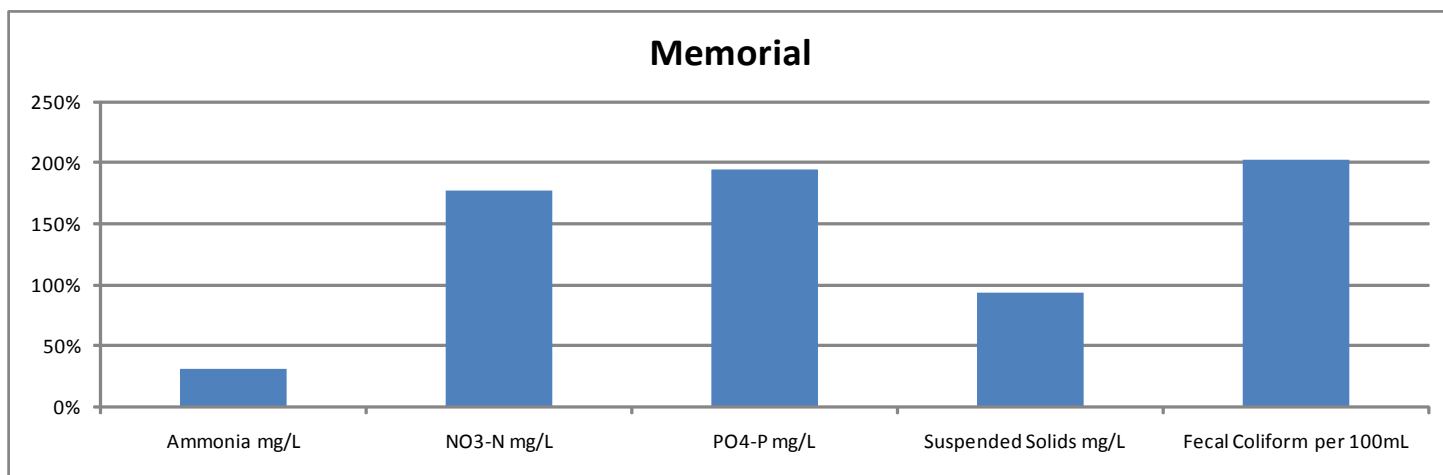
The Memorial Drive sampling site is located on the main stem of the White River on the east side of Muncie. It is located directly upstream of the Indiana American Water Company drinking water facility.

TABLE 2.55: Memorial Drive Nonpoint Source Pollutants

Memorial	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.06	1006	20	2%
NO3-N mg/L	1.00	1.76	184	36	20%
PO4-P mg/L	0.08	0.15	187	41	22%
Suspended Solids mg/L	30.00	27.88	1007	193	19%
Fecal Coliform per 100mL	235.00	476.91	557	209	38%

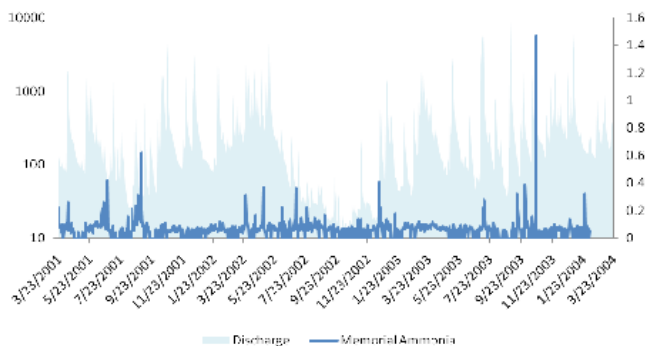
This site had a varying amount of samples per impairment taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.06 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 20 times. Nitrates and Nitrite as N levels averaged 1.76 mg/L and exceeded the target of 1.0 mg/L 36 times. Phosphorus as P levels averaged 0.15 mg/L and exceeded the EPA recommended target of 0.076 mg/L 41 times. Total suspended solids averaged 27.88 mg/L and exceeded the target of 30.0 mg/L 193 times. E. coli levels averaged 476.91 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 557 times.

Charts 2.35 - 2.40 graph water quality impairments over a 10 year sampling period for the purposes of comparing current averages and exceedences to historical data. These graphs also include flow gauge data from the Main stem of the White River.



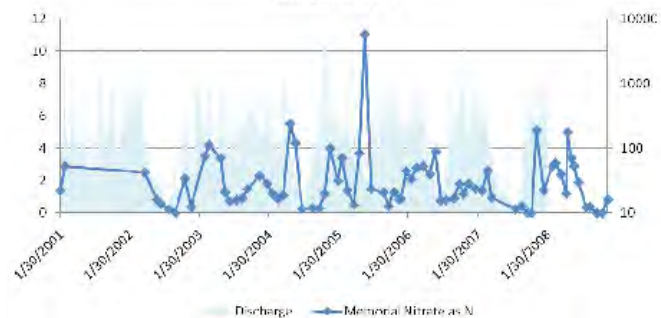
**CHA. 2.35** Memorial Drive Pollutant by Percentage of Exceedence

Memorial Ammonia



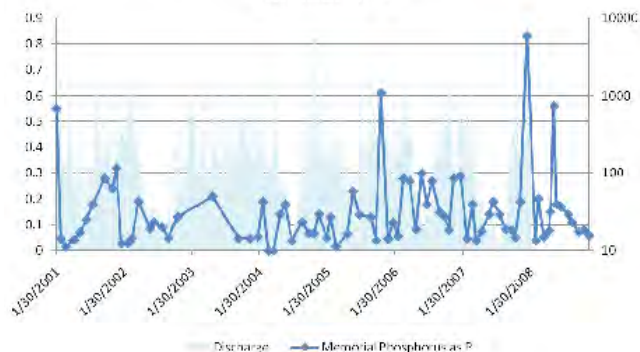
CHA. 2.36 Memorial Drive Ammonia

Memorial N



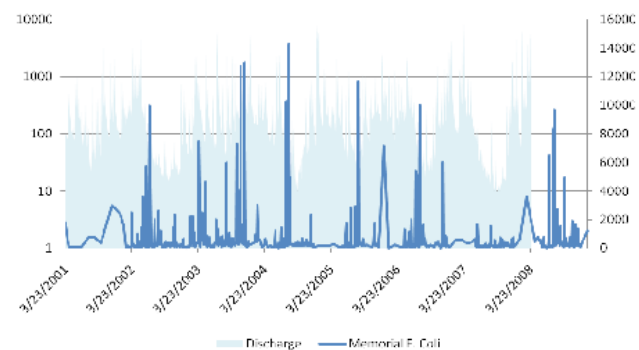
CHA. 2.37 Memorial Drive Nitrogen

Memorial P



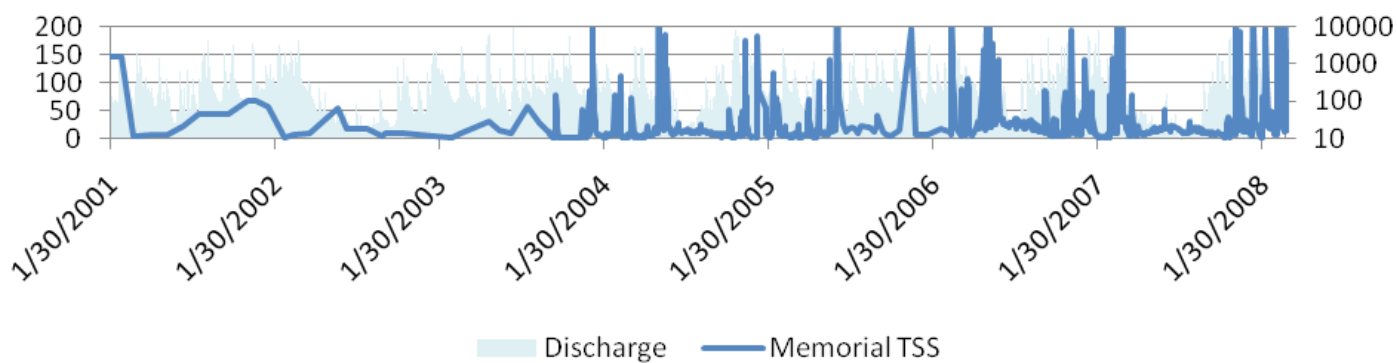
CHA.2.38 Memorial Drive Phosphorus

Memorial E. Coli



CHA. 2.39 Memorial Drive E. coli

TSS Memorial Drive

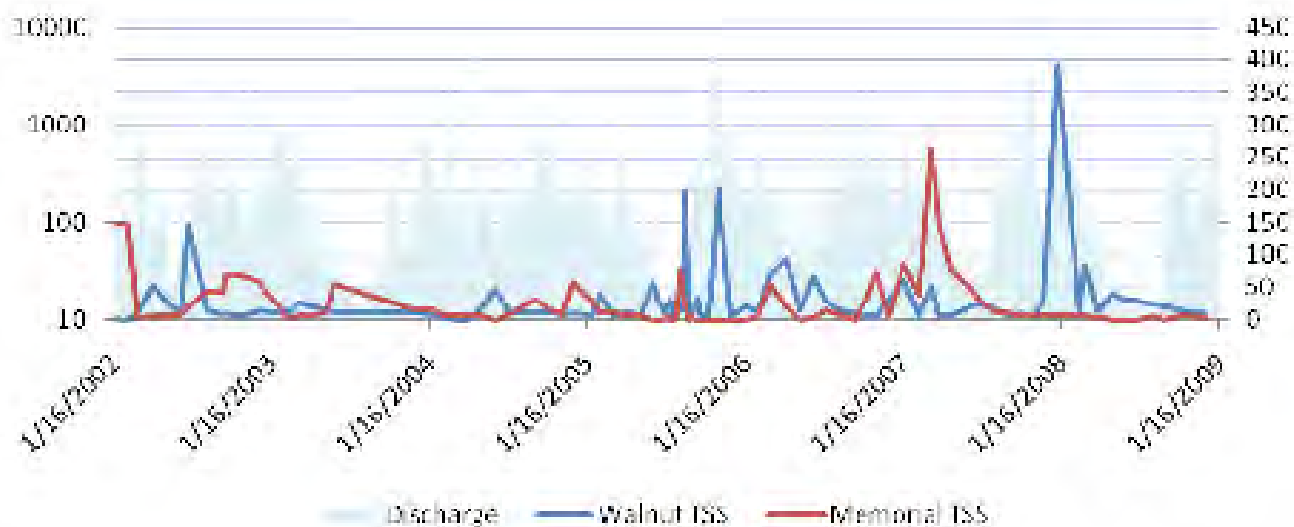


CHA. 2.40 Memorial Drive TSS

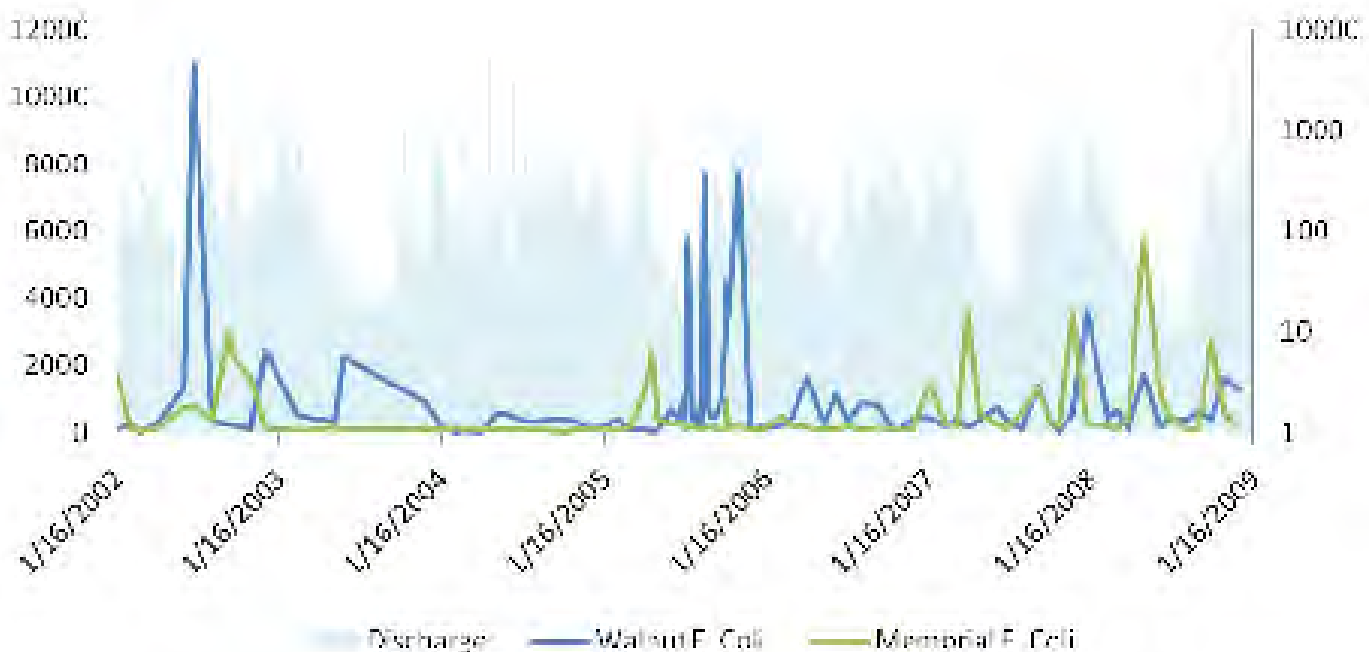
# Comparative Studies

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 6

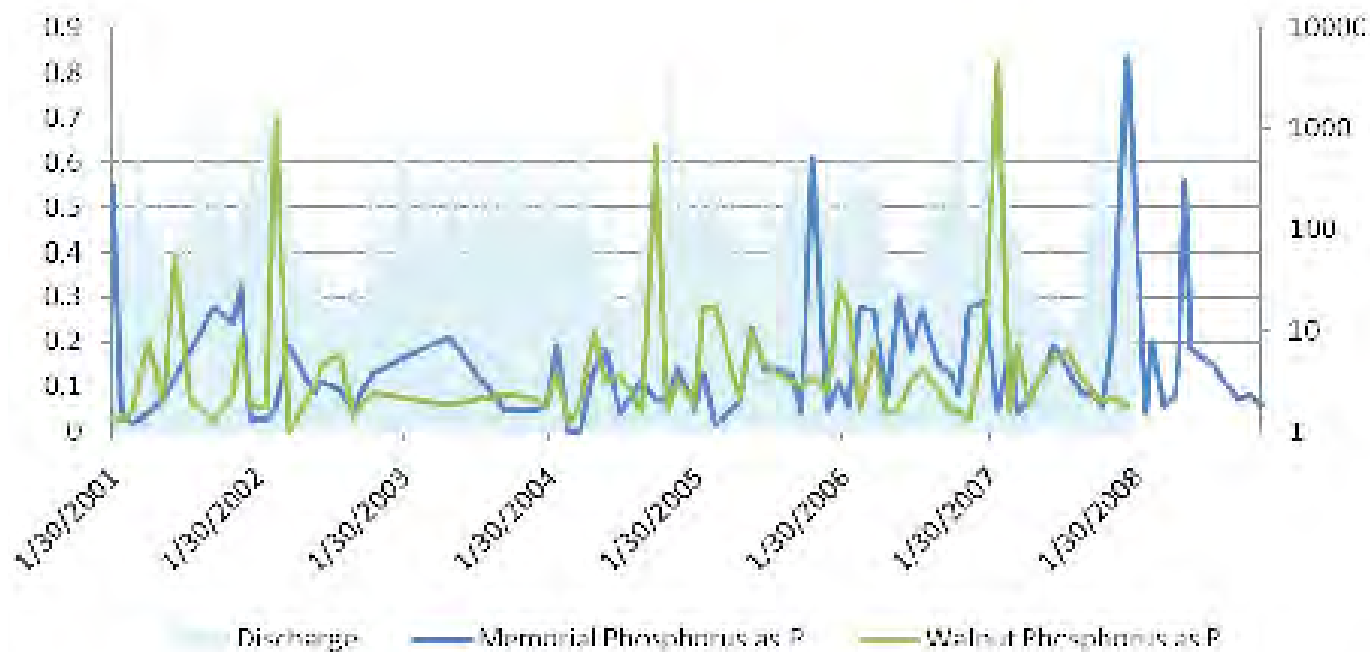
Charts 2.41 - 2.44 graph water quality impairments at the Walnut Street and Memorial Drive Sampling locations (over a 10 year sampling period) for the purposes of comparing current averages and exceedences to historical data as well as the sampling points relative to each other. These graphs also include flow gauge data from the Main stem of the White River.



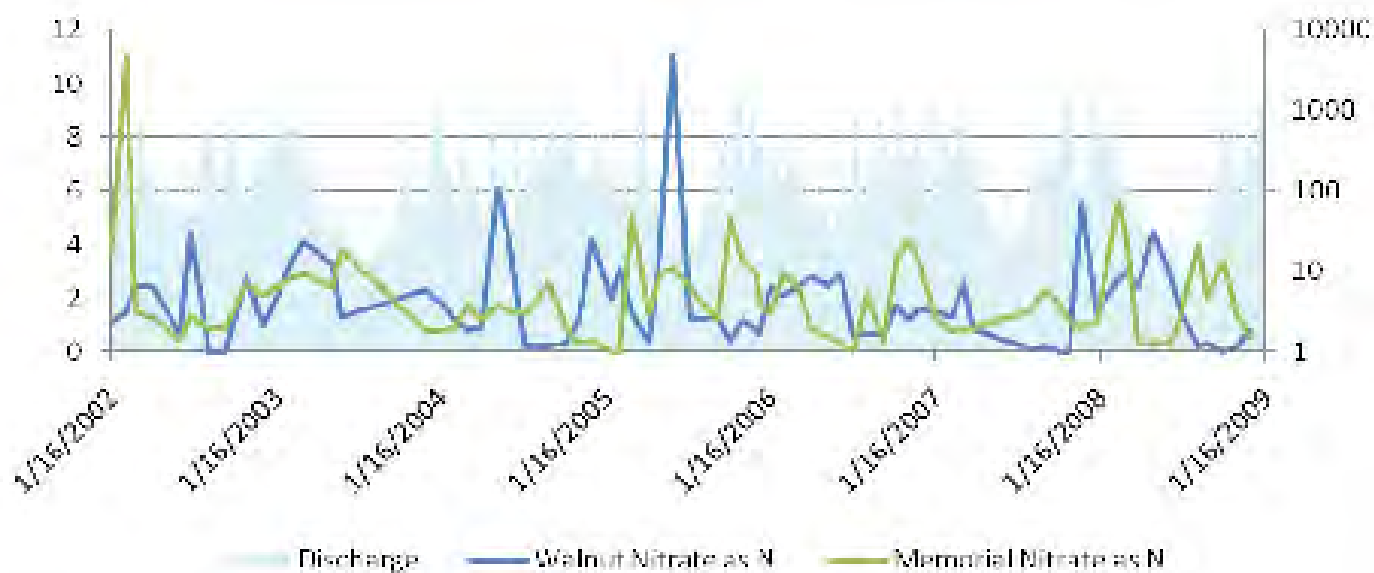
**CHA. 2.41** TSS: Comparison of Memorial Drive and Walnut Street



**CHA. 2.42** E. coli: Comparison of Memorial Drive and Walnut Street



**CHA. 2.43** Phosphorus: Comparison of Memorial Drive and Walnut Street



**CHA. 2.44** Nitrogen: Comparison of Memorial Drive and Walnut Street

# Inlow Springs Road

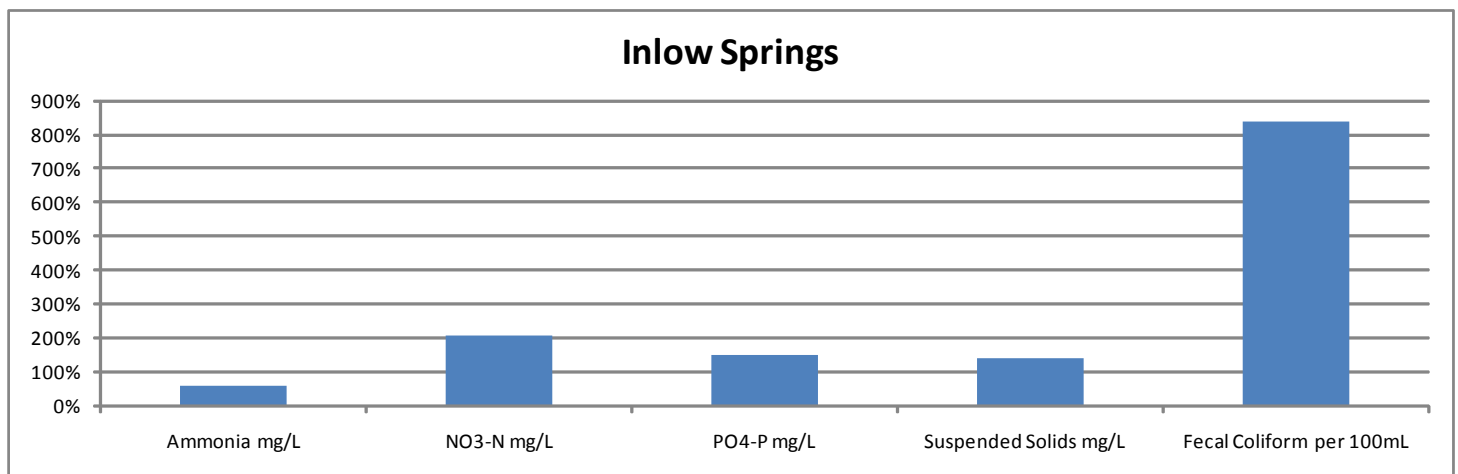
## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 7

The Inlow Springs Road sampling site is located on the main stem of the White River on the east side of Muncie. It is located at the headwaters of the Truitt-Ditch-White River Subwatershed and flows into the Muncie Creek-Hamilton Ditch Subwatershed Basin.

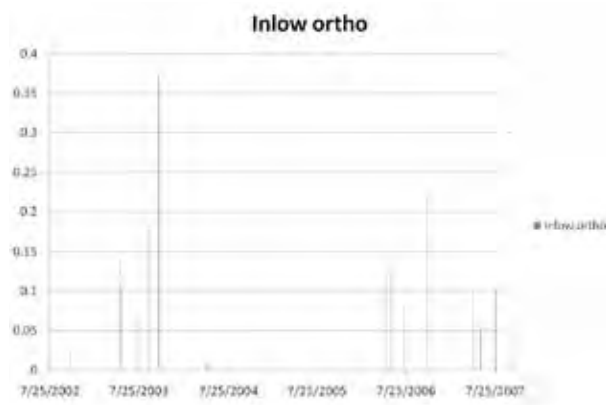
TABLE 2.56: Inlow Springs Nonpoint Source Pollutants					
Inlow Springs	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.13	16	2	13%
NO3-N mg/L	1.00	2.06	16	9	56%
PO4-P mg/L	0.08	0.11	16	10	63%
Suspended Solids mg/L	30.00	42.10	16	7	44%
Fecal Coliform per 100mL	235.00	1968.80	20	14	70%

This site had a total of 16 samples taken over the ten year sampling period. The Ammonia as N levels at this site averaged 0.13 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 2 times. Nitrates and Nitrite as N levels averaged 2.06 mg/L and exceeded the target of 1.0 mg/L 16 times. Phosphorus as P levels averaged 0.11 mg/L and exceeded the EPA recommended target of 0.076 mg/L 10 times. Total suspended solids averaged 42.10 mg/L and exceeded the target of 30.0 mg/L 7 times. E. coli levels averaged 1968.80 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 14 times.

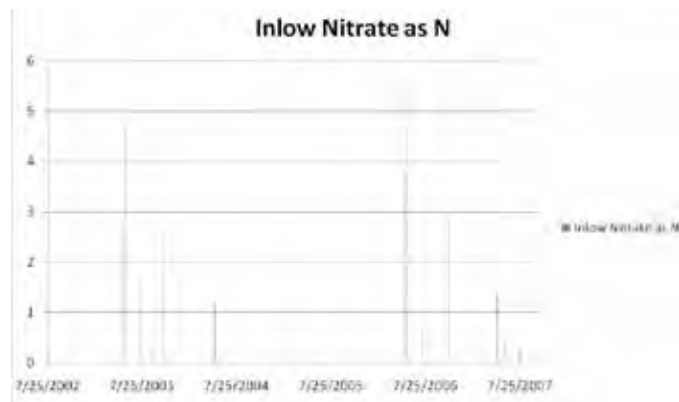
Charts 2.45 - 2.50 graph water quality impairments over a 10 year sampling period for the purposes of comparing current averages and exceedences to historical data. These graphs also include flow gauge data from the Main stem of the White River.



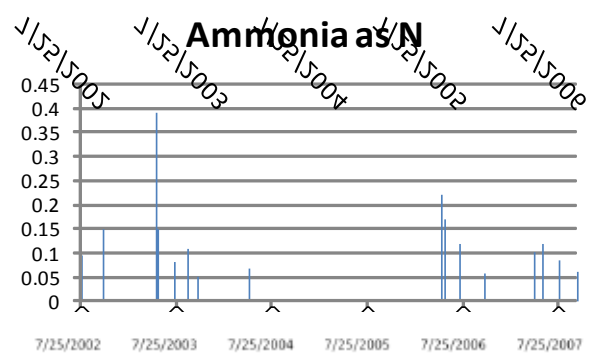
**CHA. 2.45** Inlow Springs Pollutant by Percentage of Exceedence



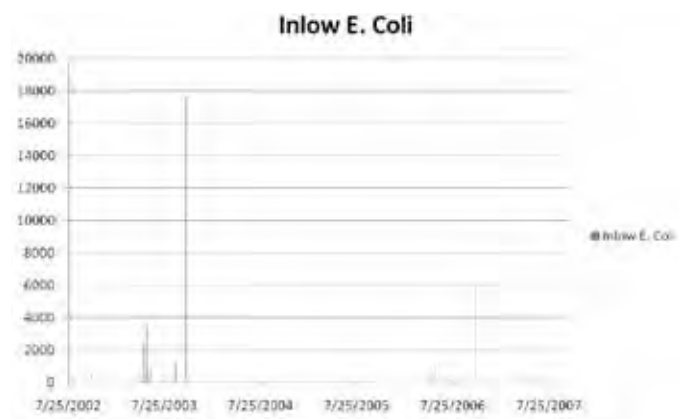
**CHA. 2.46** Inflow Springs Orthophosphates



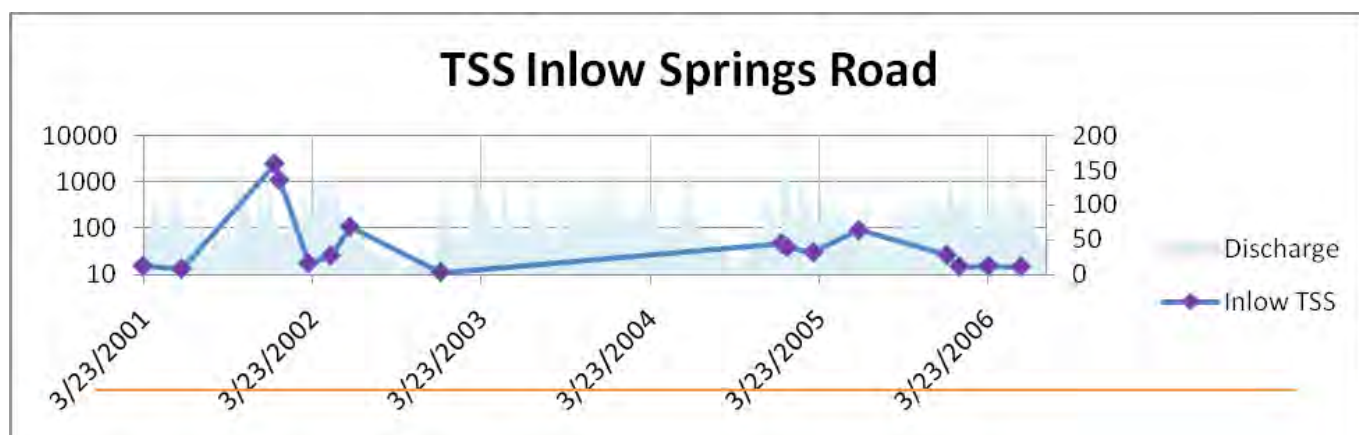
**CHA. 2.47** Inflow Springs Nitrogen



**CHA. 2.48** Inflow Springs Ammonia



**CHA. 2.49** Inflow Springs E. Coli



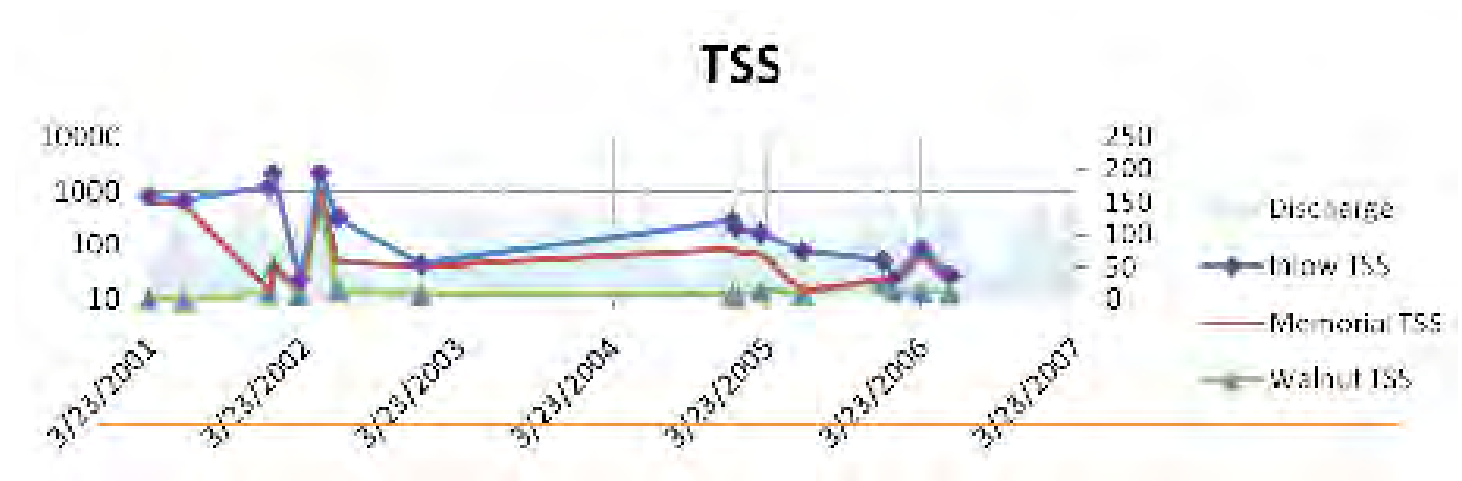
**CHA. 2.50** Inflow Springs TSS



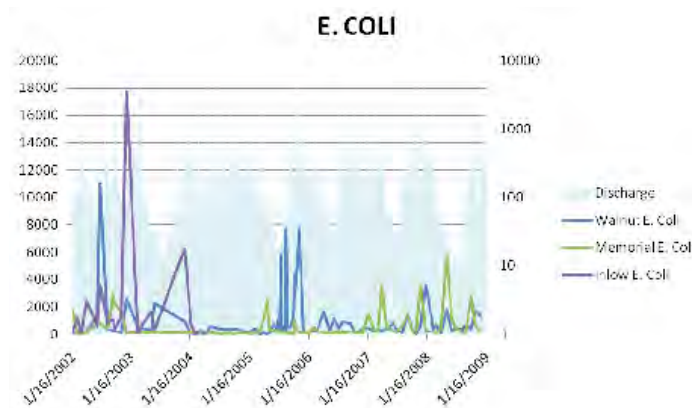
# Comparative Studies

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 6

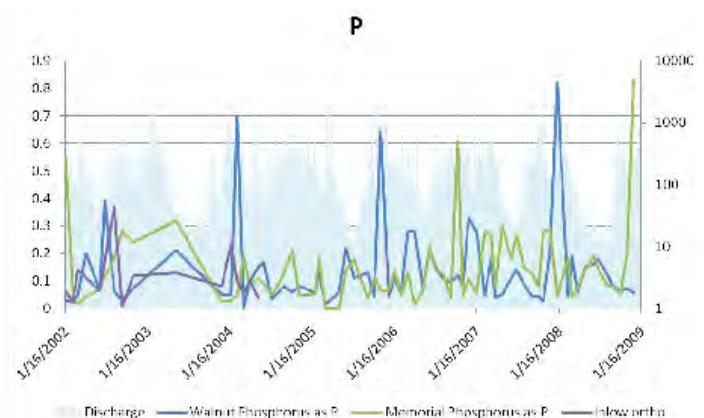
Charts 2.51 - 2.53 graph water quality impairments at the Walnut Street, Memorial Drive, and Inlow Springs sampling locations (over a 10 year sampling period) for the purposes of comparing current averages and exceedences to historical data - as well as the sampling points relative to each other. Nitrogen and Ammonia were not compared due to inconsistent sampling days. These graphs also include flow gauge data from the Main stem of the White River.



**CHA. 2.51** TSS: Comparison of Memorial Drive, Walnut Street, and Inlow Springs



**CHA. 2.52** E. coli: Comparison of Memorial Drive, Walnut Street, and Inlow Springs



**CHA. 2.53** Phosphorus: Comparison of Memorial Drive, Walnut Street, and Inlow Springs



# HUC12 Study Summary

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 8

The first study analyzed data along the main stem of the White River in Hamilton Ditch - Muncie Creek and Truitt Ditch-White River Subwatershed areas. During this study, the non-point source pollutants Ammonia, Nitrate, Phosphorus, TSS and E. Coli were analyzed. Findings are summarized in Table 2.57 and 2.58.

Congruent with IDEM 305(b), 303(d), and TMDL program, as well as IDEM data analysis done by GRW engineers, in each Subwatershed E. Coli was the leading pollutant. In the Truitt Ditch-White River Subwatershed E. coli exceeded the state standard by 100% and in the Hamilton Ditch - Muncie Creek Subwatershed, 300% for E. coli. (Chart 2.54) E. Coli was shown to decrease in these Subwatersheds comparative to the Inlow Springs (headwaters) (although as noted, Inlow Spring had substantially lower samples taken).

Ammonia was under the state standard in both Subwatersheds. Nitrogen and Phosphorus were above the state standards in both Subwatersheds (Chart 2.56) and TSS was above the state standard in Muncie Creek-Hamilton Ditch (Chart 2.55).

When the three year baseline period was compared to the ten year sampling period, there was insignificant differences discovered. We intend to watch TSS pollution more closely in future studies as it appears slightly on the rise in both sampling locations.

TABLE 2.57: Critical Pollutants on Mainstem Sampling Points

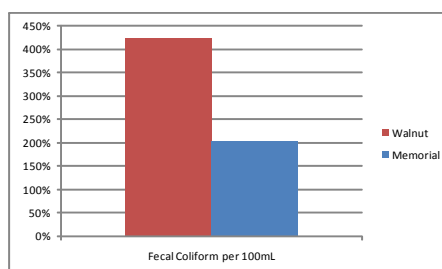
Exceedence	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Inlow Springs	60%	206%	149%	140%	838%
Memorial	30%	176%	194%	93%	203%
Walnut	34%	170%	180%	111%	425%

Ranking	Ammonia	NO3-N	PO4-P	TSS	E.Coli	Rank
Memorial	1	2	2	1	1	7
Walnut	2	1	1	2	2	8

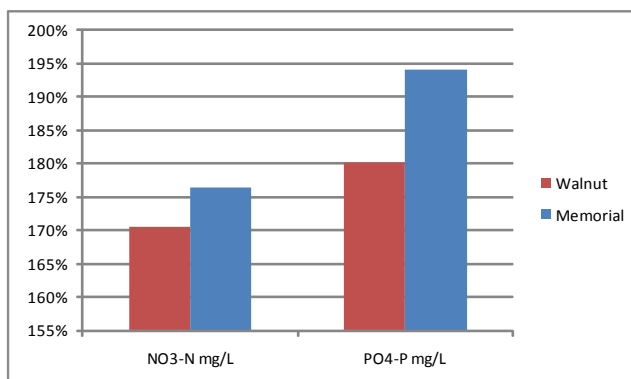
Exceedence	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Inlow Springs		X	X	X	X
Memorial		X	X		X
Walnut		X	X	X	X

TABLE 2.58: IDEM Impairment Summary

	Ammonia	Nitrogen	Phosphorus	Dissolved Oxygen	Biochemical Oxygen Demand	Flouride	Coliforms	Cyanide	E. Coli	Total Suspended Solids	Phenolics	Copper	Iron	Lead
Hamilton Ditch - Muncie Creek		X	X				X		X	X				
Truitt Ditch - White River		X	X	X	X		X	X	X	X	X	X	X	X

**CHA. 2.54 E. coli Exceedence****CHA. 2.55 TSS Exceedence**

Muncie Creek- Hamilton Ditch is more impaired for E. Coli and TSS than Truitt Ditch- White River

**CHA. 2.56 Nitrogen and Phosphorus Exceedence**

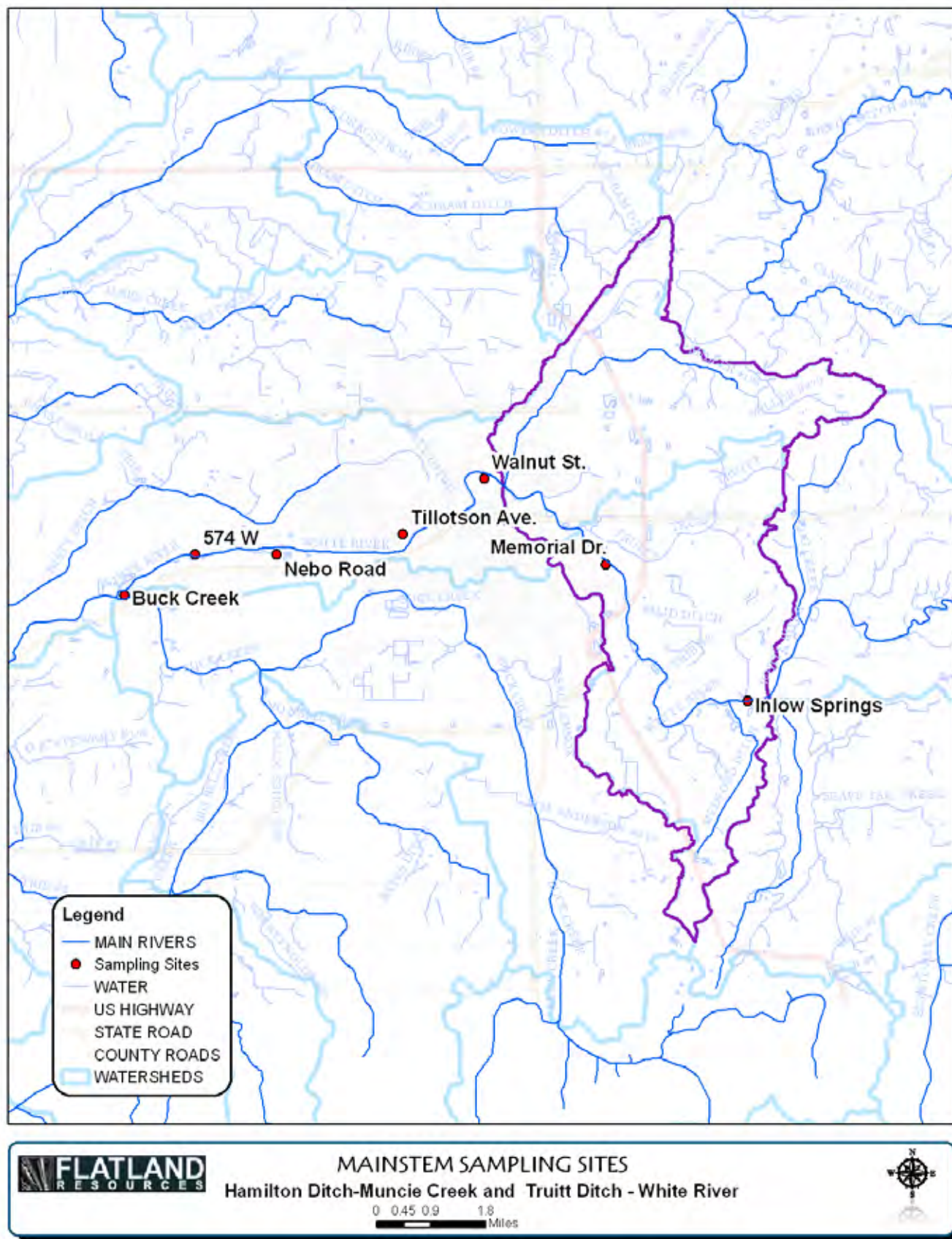
Truitt Ditch- White River is more impaired for Nitrogen and Phosphorus than Muncie Creek - Hamilton Ditch

# White River | Mainstem Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 9

The second study compared the mainstem White River sampling points in Hamilton Ditch – Muncie Creek and Truitt Ditch – White River (Walnut Street, Memorial Drive, Inlow Springs) (MAP 2.70) to other main stem sampling points in the Muncie BWQ database (Nebo Road, 574W, Tillotson Avenue, Buck Creek Confluence). We wanted to see how WQ on the main stream evolved/changed as it made its way through the City of Muncie. Truitt Ditch - White River is at the headwaters of the City of Muncie Watersheds and provides a baseline of water quality (against changes) as it moves through the City. This study looks at seven points along the main stem of the White River. Each point is compared to the proceeding points.

Six of the Seven sampling points along the White River in Muncie fall in the York-Prairie Subwatershed (which is a linear Subwatershed that runs North-West through the core of Muncie). The final sampling point is at the discharge point of Buck Creek Subwatershed. Therefore, these studies are simultaneously comparing Hamilton Ditch –Muncie Creek and Truitt Ditch – White River to York-Prairie Creek and Buck Creek Subwatersheds.



**MAP. 2.70** Mainstem White River Sampling Points



# White River | Mainstem Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 10

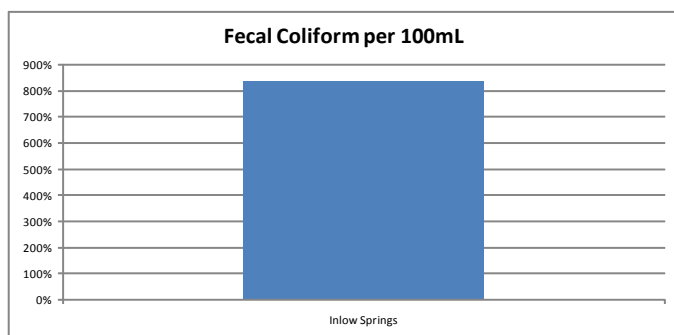
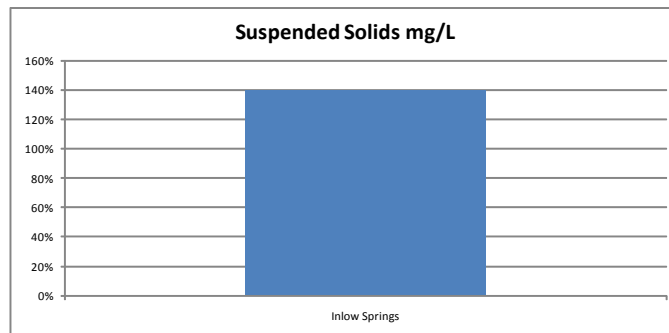
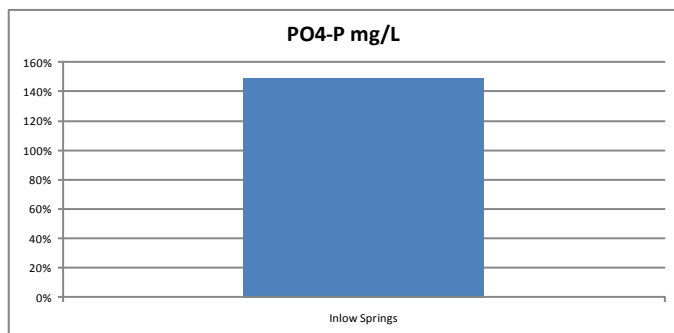
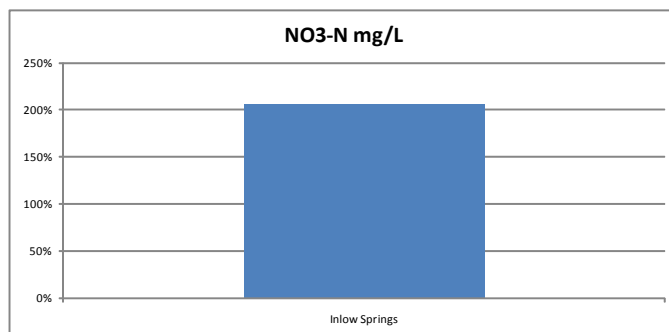
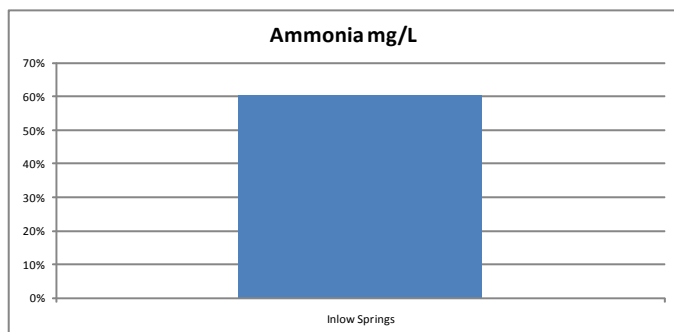
The Inlow Springs Road sampling site is located on the main stem of the White River on the east side of Muncie as seen in Map 2.71. It is located at the headwaters of the Truitt-Ditch-White River Subwatershed. The water tested at this sampling point flows into the Muncie Creek-Hamilton Ditch Subwatershed.

TABLE 2.59: Inlow Springs Nonpoint Source Pollutants					
Inlow Springs	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.13	16	2	13%
NO3-N mg/L	1.00	2.06	16	9	56%
PO4-P mg/L	0.08	0.11	16	10	63%
Suspended Solids mg/L	30.00	42.10	16	7	44%
Fecal Coliform per 100mL	235.00	1968.80	20	14	70%

This site had a total of 16 samples taken over the ten year sampling period. The Ammonia as N levels at this site averaged 0.13 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 2 times. Nitrates and Nitrite as N levels averaged 2.06 mg/L and exceeded the target of 1.0 mg/L 16 times. Phosphorus as P levels averaged 0.11 mg/L and exceeded the EPA recommended target of 0.076 mg/L 10 times. Total suspended solids averaged 42.10 mg/L and exceeded the target of 30.0 mg/L 7 times. E. coli levels averaged 1968.80 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 14 times. Chart 2.57 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.71** Inflow Springs Sampling Location



**CHA. 2.57** Pollutants by Exceedence

# White River | Mainstem Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 11

The Memorial Drive sampling site is located on the main stem of the White River on the east side of Muncie as seen in Map 2.72. It is located directly upstream of the Indiana American Water Company drinking water facility.

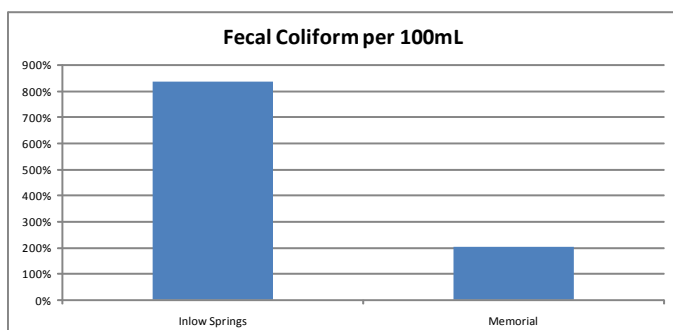
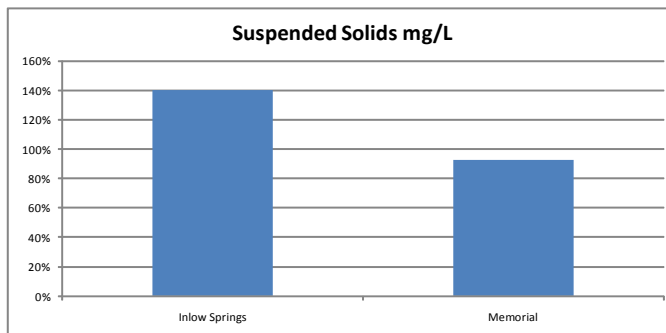
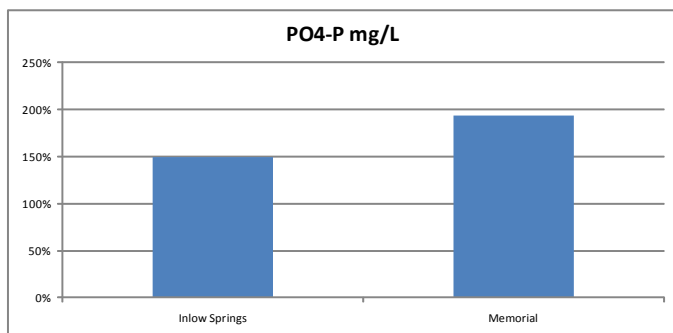
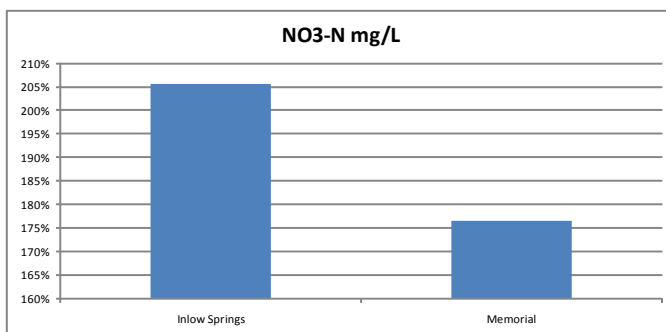
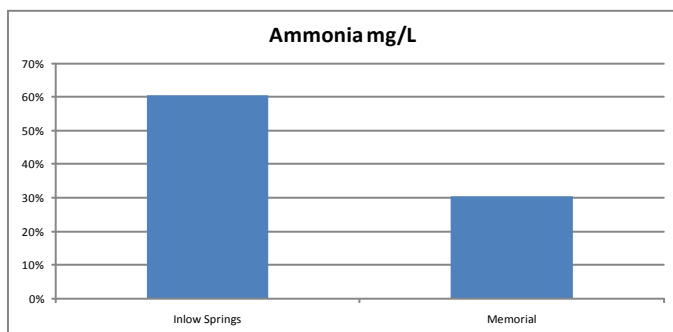
TABLE 2.60: Memorial Drive Nonpoint Source Pollutants

Memorial	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.06	1006	20	2%
NO3-N mg/L	1.00	1.76	184	36	20%
PO4-P mg/L	0.08	0.15	187	41	22%
Suspended Solids mg/L	30.00	27.88	1007	193	19%
Fecal Coliform per 100mL	235.00	476.91	557	209	38%

This site had a varying amount of samples per impairment taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.58; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.06 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 20 times. Nitrates and Nitrite as N levels averaged 1.76 mg/L and exceeded the target of 1.0 mg/L 36 times. Phosphorus as P levels averaged 0.15 mg/L and exceeded the EPA recommended target of 0.076 mg/L 41 times. Total suspended solids averaged 27.88 mg/L and exceeded the target of 30.0 mg/L 193 times. E. coli levels averaged 476.91 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 557 times. Chart 2.58 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.72** Memorial Drive Sampling Location



**CHA. 2.58** Pollutants by Exceedence

# White River | Mainstem Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 12

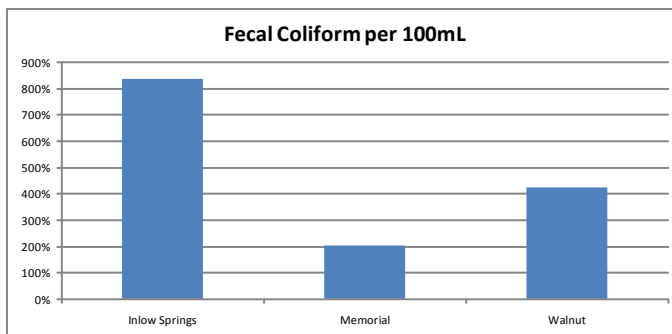
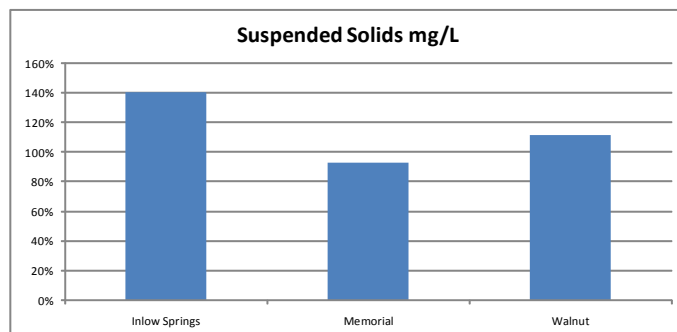
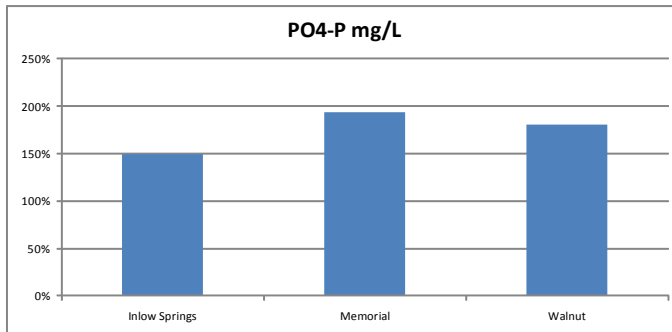
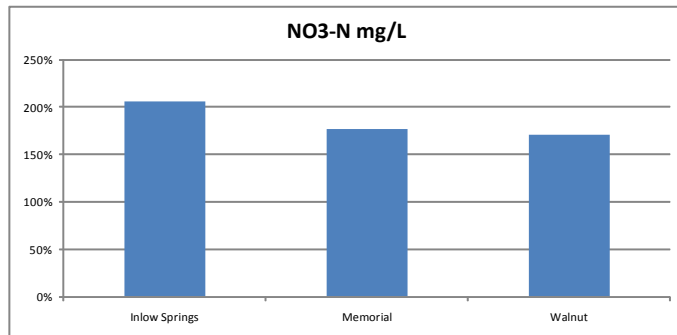
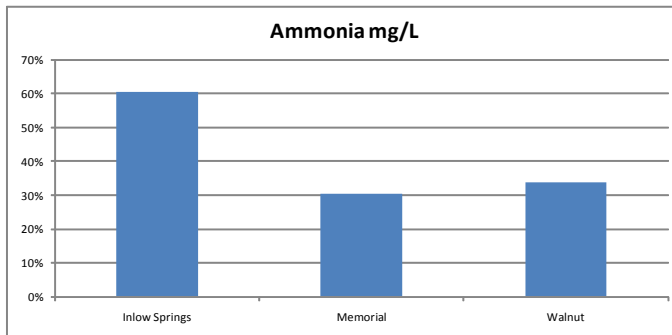
The Walnut Street sampling site is located on the main stem of the White River on the east side of Muncie as seen in Map 2.73. It is located at the discharge point of the Muncie Creek-Hamilton Ditch Subwatershed Basin which also flows from the Truitt Ditch-White River Subwatershed.

Walnut	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.07	77	0	0%
NO3-N mg/L	1.00	1.70	74	33	45%
PO4-P mg/L	0.08	0.14	77	34	44%
Suspended Solids mg/L	30.00	33.40	77	18	23%
Fecal Coliform per 100mL	235.00	997.62	77	51	66%

This site had 77 samples taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.59; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.07 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 0 times. Nitrates and Nitrite as N levels averaged 1.70 mg/L and exceeded the target of 1.0 mg/L 33 times. Phosphorus as P levels averaged 0.14 mg/L and exceeded the EPA recommended target of 0.076 mg/L 34 times. Total suspended solids averaged 33.40 mg/L and exceeded the target of 30.0 mg/L 18 times. E. coli levels averaged 997.62 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 51 times. Chart 2.59 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.73** Walnut Street Sampling Location



**CHA. 2.59** Pollutants by Exceedence



# White River | Mainstem Study

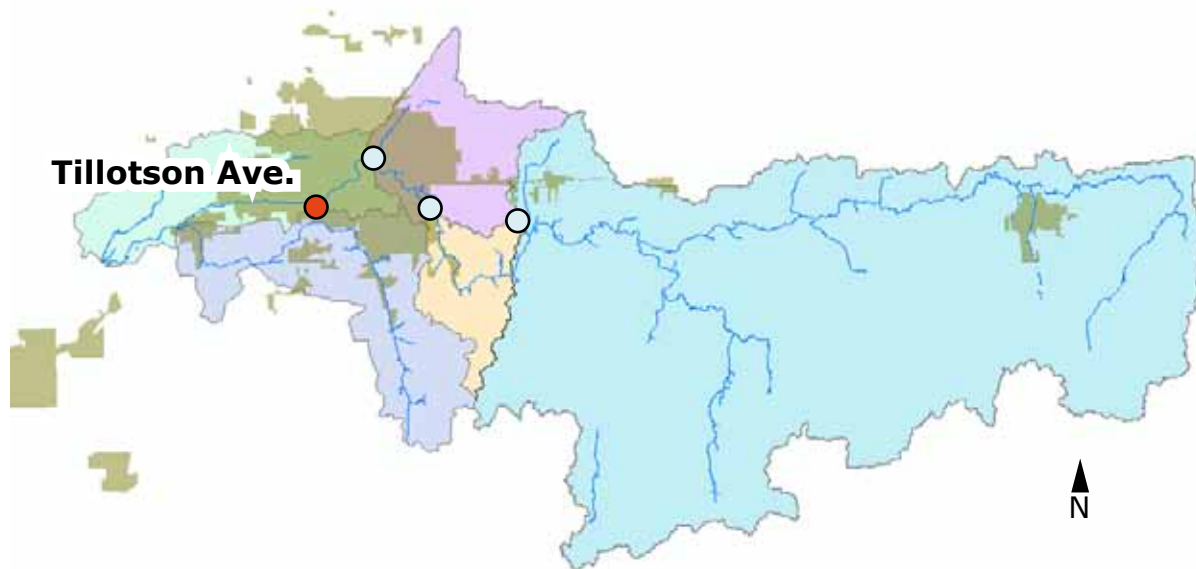
## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 13

The Tillotson Avenue sampling site is located on the main stem of the White River on the south central of Muncie as seen in Map 2.74. It is located in York-Prairie Creek Subwatershed.

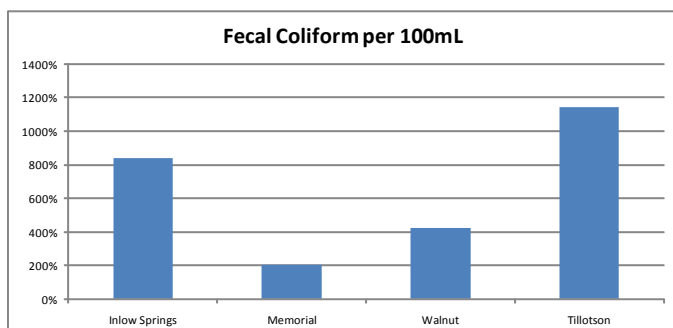
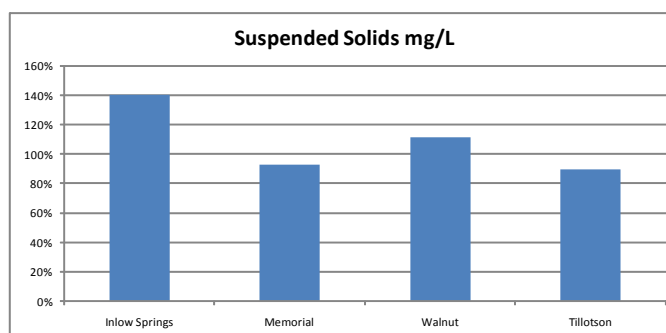
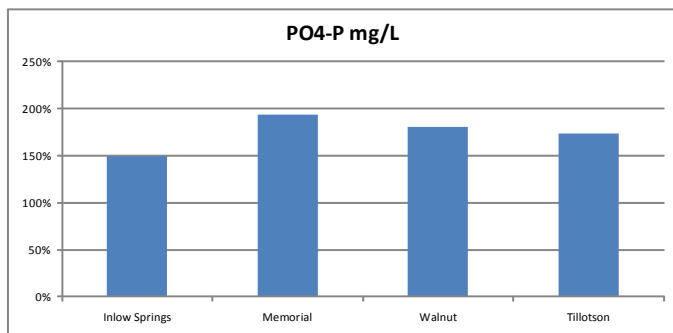
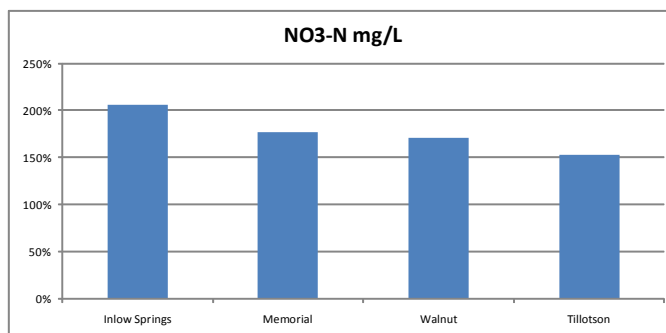
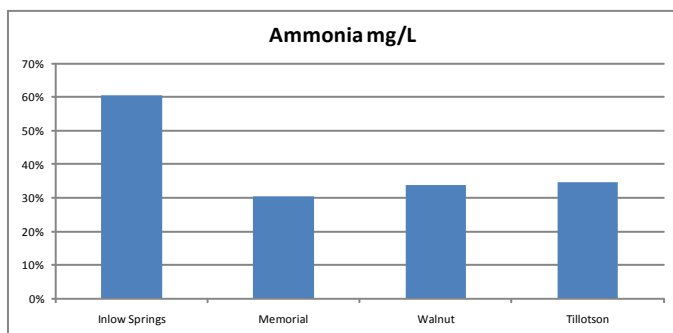
TABLE 2.62: Tillotson Ave. Nonpoint Source Pollutants

Tillotson Ave.	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.07	1154	27	2%
NO3-N mg/L	1.00	1.52	281	33	12%
PO4-P mg/L	0.08	0.13	284	39	14%
Suspended Solids mg/L	30.00	26.94	1155	224	19%
E. coli per 100mL	235.00	2689.56	786	436	55%

This site had varying degrees of samples (per impairment) over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.60; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.07 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 27 times. Nitrates and Nitrite as N levels averaged 1.52 mg/L and exceeded the target of 1.0 mg/L 33 times. Phosphorus as P levels averaged 0.13 mg/L and exceeded the EPA recommended target of 0.076 mg/L 39 times. Total suspended solids averaged 26.94 mg/L and exceeded the target of 30.0 mg/L 224 times. E. coli levels averaged 2689.56 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 436 times. Chart 2.60 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.74** Walnut Street Sampling Location



**CHA. 2.60** Pollutants by Exceedence; comparison of sampling points.

# White River | Mainstem Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 14

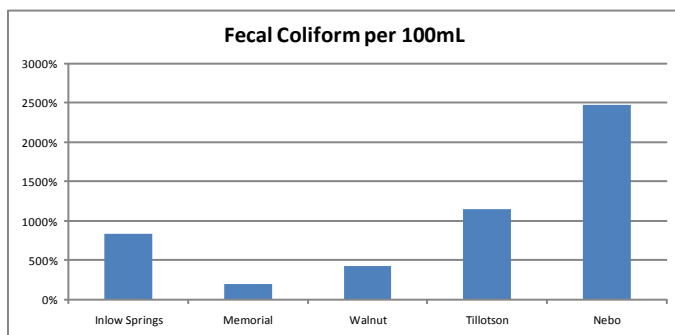
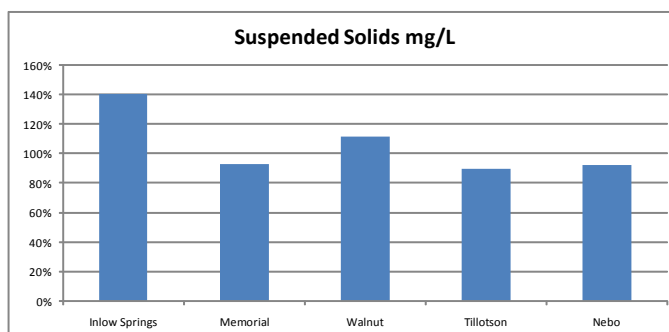
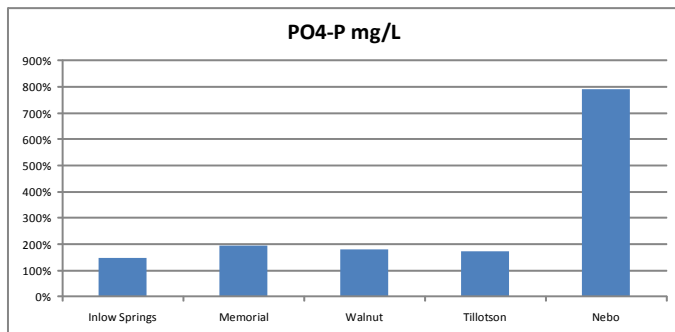
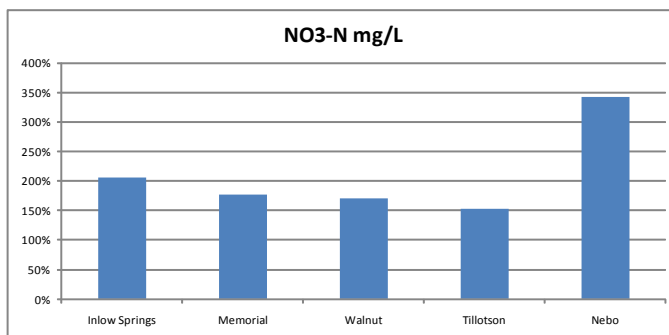
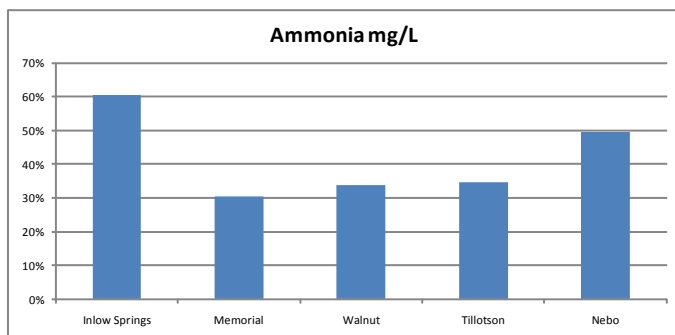
The Nebo Road sampling site is located on the main stem of the White River on the west side of Muncie as seen in Map 2.75. It is located in York-Prairie Creek Subwatershed.

TABLE 2.63: Nebo Road Nonpoint Source Pollutants					
Nebo Road	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.10	86	6	7%
NO3-N mg/L	1.00	3.42	80	59	74%
PO4-P mg/L	0.08	0.60	50	50	100%
Suspended Solids mg/L	30.00	27.69	86	19	22%
Fecal Coliform per 100mL	235.00	5823.72	92	64	70%

This site had 96 samples taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.61; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.10 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 6 times. Nitrates and Nitrite as N levels averaged 3.42 mg/L and exceeded the target of 1.0 mg/L 80 times. Phosphorus as P levels averaged 0.60 mg/L and exceeded the EPA recommended target of 0.076 mg/L 50 times. Total suspended solids averaged 27.69 mg/L and exceeded the target of 30.0 mg/L 86 times. E. coli levels averaged 5823.72 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 64 times. Chart 2.61 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.75** Nebo Road Sampling Location



**CHA. 2.61** Pollutants by Exceedence; comparison of sampling points.

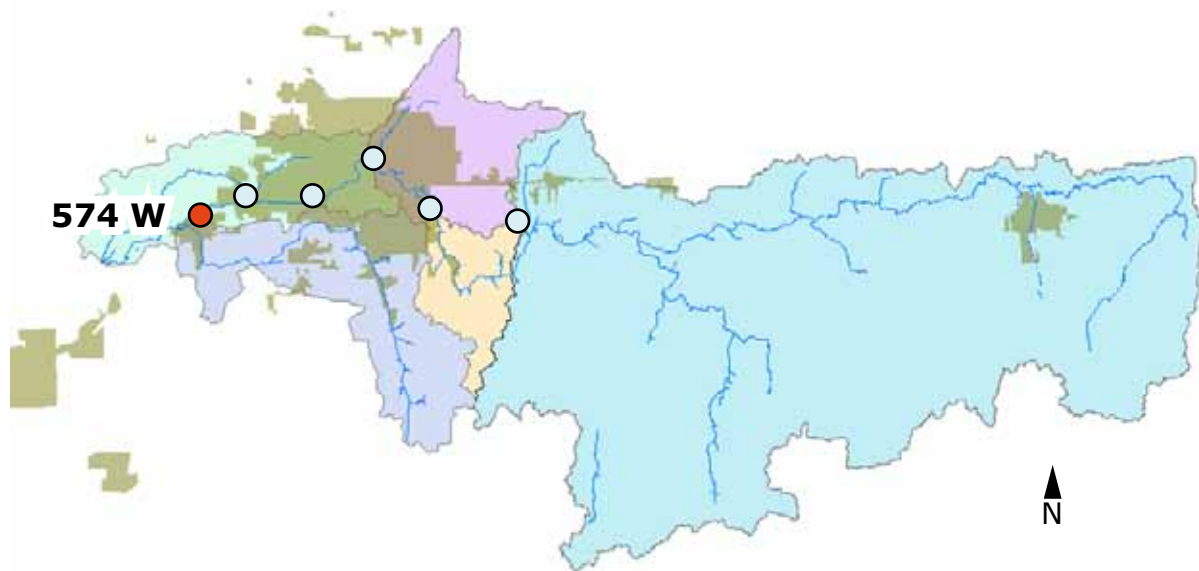
# White River | Mainstem Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 15

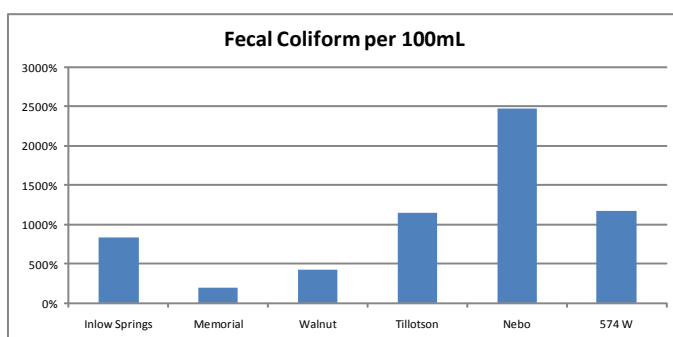
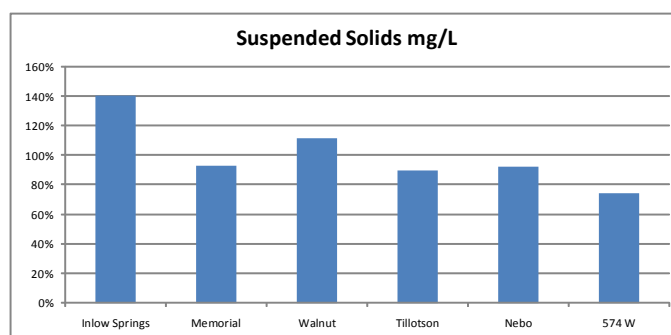
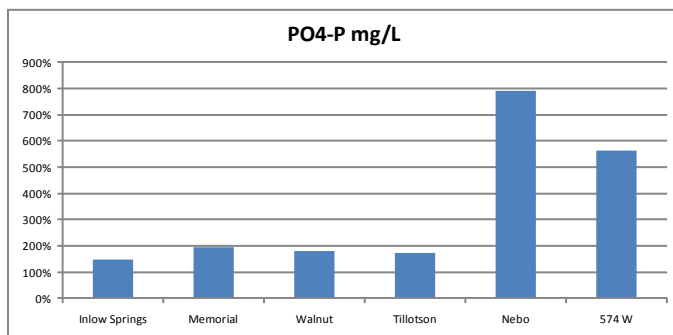
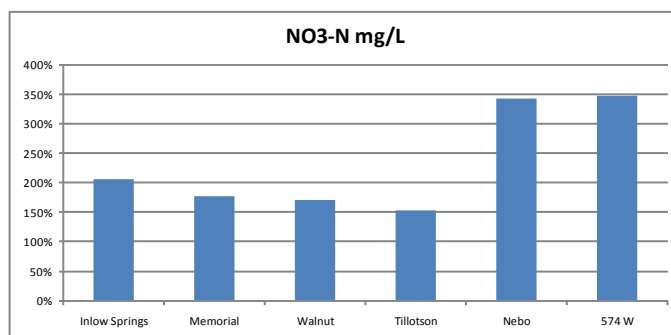
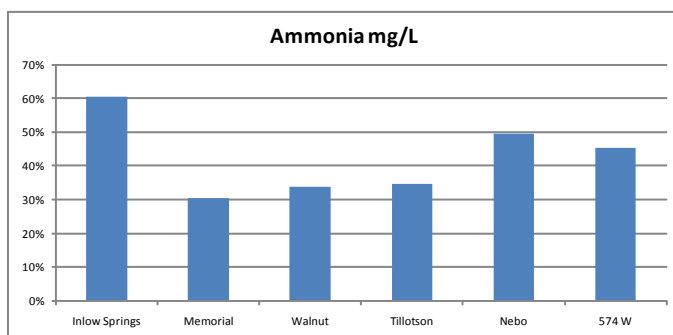
The 574 W sampling site is located on the main stem of the White River on the west side of Muncie as seen in Map 2.76. It is located in York-Prairie Creek Subwatershed.

TABLE 2.64: 574 W Nonpoint Source Pollutants					
574 W	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.10	1166	56	5%
NO3-N mg/L	1.00	3.47	279	60	22%
PO4-P mg/L	0.08	0.43	282	61	22%
Suspended Solids mg/L	30.00	22.17	1167	196	17%
E. coli per 100mL	235.00	2762.96	785	352	45%

This site had varying degrees of samples (per impairment) over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.62; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.10 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 56 times. Nitrates and Nitrite as N levels averaged 3.47 mg/L and exceeded the target of 1.0 mg/L 60 times. Phosphorus as P levels averaged 0.43 mg/L and exceeded the EPA recommended target of 0.076 mg/L 282 times. Total suspended solids averaged 22.17 mg/L and exceeded the target of 30.0 mg/L 196 times. E. coli levels averaged 2762.96 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 352 times. Chart 2.62 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.76** 574 W Sampling Location



**CHA. 2.62** Pollutants by Exceedence; comparison of sampling points.



# White River | Mainstem Study

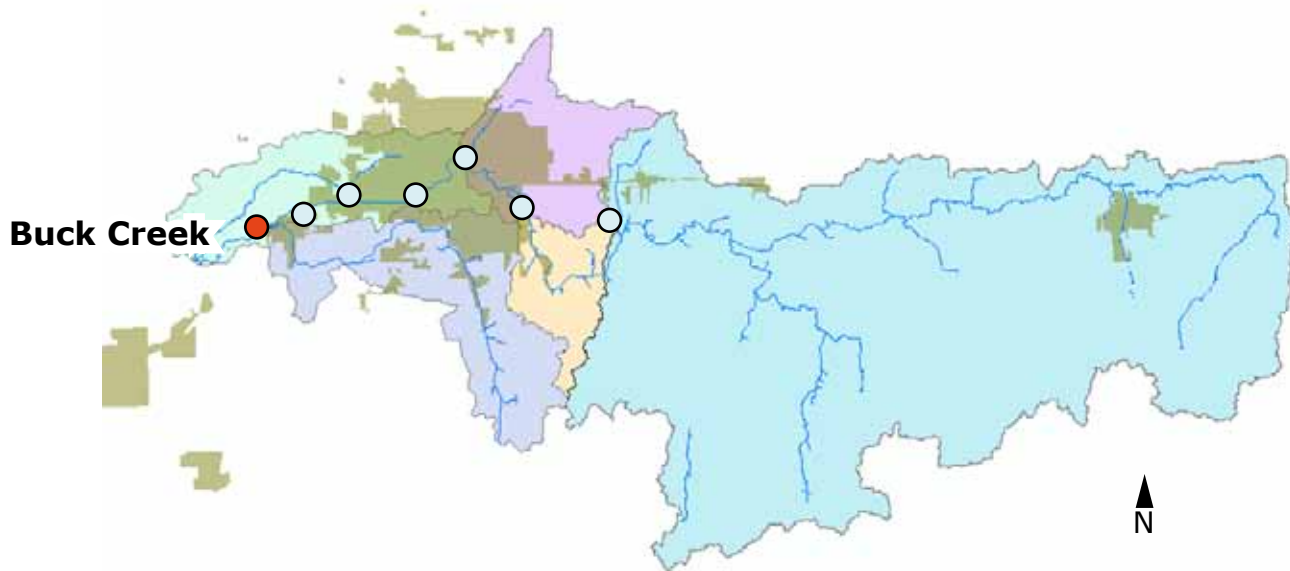
## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 16

The Buck Creek confluence sampling site is located on the main stem of the White River on the west side of Muncie as seen in Map 2.77. It is located at the confluence of Buck Creek and the White River.

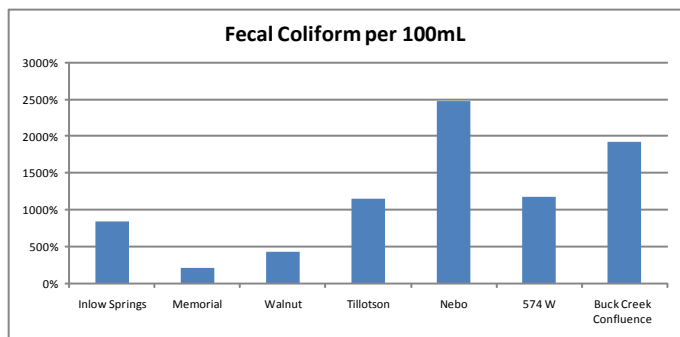
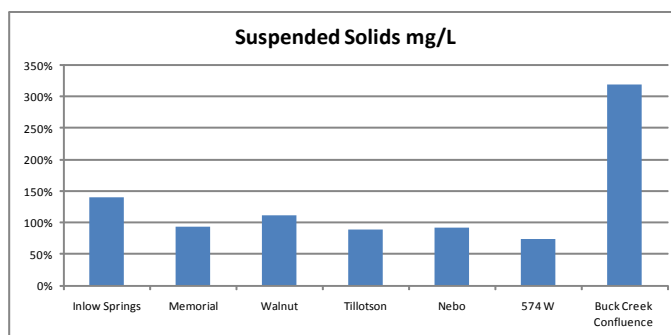
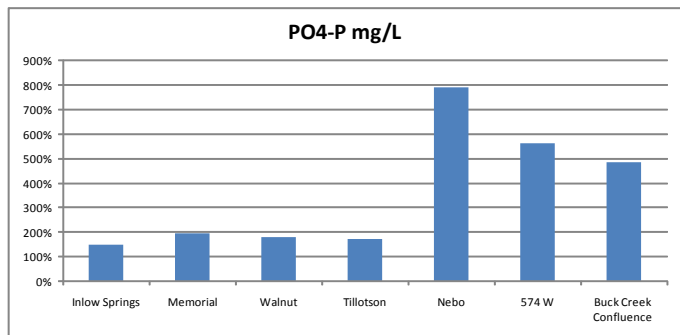
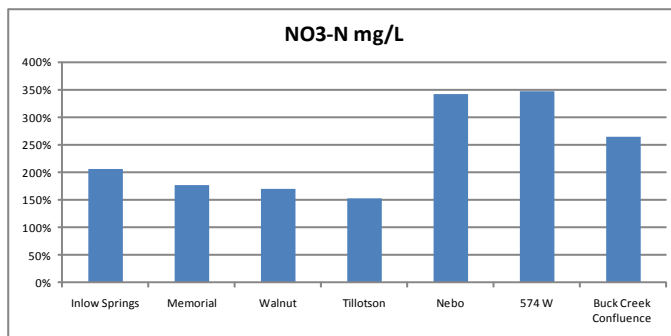
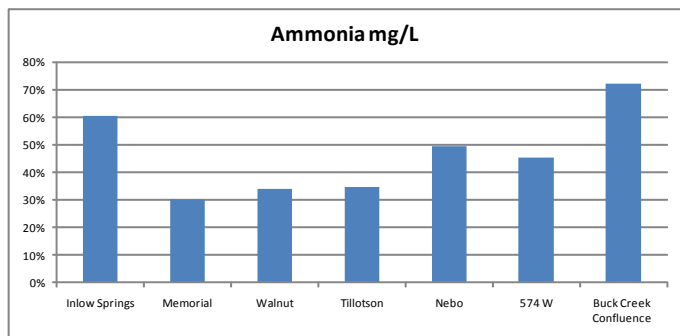
TABLE 2.65: Buck Creek Confluence Nonpoint Source Pollutants

Buck Creek Confluence	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.15	8	2	25%
NO3-N mg/L	1.00	2.65	8	7	88%
PO4-P mg/L	0.08	0.37	8	8	100%
Suspended Solids mg/L	30.00	95.65	8	3	38%
Fecal Coliform per 100mL	235.00	4528.75	8	6	75%

This site had 8 samples taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.63; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.15 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 2 times. Nitrates and Nitrite as N levels averaged 2.65 mg/L and exceeded the target of 1.0 mg/L 7 times. Phosphorus as P levels averaged 0.37 mg/L and exceeded the EPA recommended target of 0.076 mg/L 3 times. Total suspended solids averaged 95.65 mg/L and exceeded the target of 30.0 mg/L 3 times. E. coli levels averaged 4528.75 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 6 times. Chart 2.63 shows the degree in which the pollutant is exceeding the state water quality standard.



**MAP. 2.77** Buck Creek Confluence Sampling Location



**CHA. 2.63** Pollutants by Exceedence; comparison of sampling points.

# Summary of White River Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 17

Because this Watershed Management Plan only consists of two Subwatersheds, the WRWP determined it would be important to compare the Hamilton Ditch-Muncie Creek and Truitt Ditch-White River mainstem data to all of the data on the White River mainstem; available from the BWQ's public data repository. The intention was to discover how the White River data ranks comparatively along the transect of Muncie's Urban Core (and how the City of Muncie influenced WQ along the White River). (Chart 2.64.)

Comparatively, Ammonia ranks low in Hamilton Ditch-Muncie Creek and Truitt Ditch-White River compared to the sampling points in York- Prairie Creek sites, and in all cases along the White River, Ammonia is below the state standard.

Nitrogen and Phosphorus exceedence decreases or remain stable as water travels downstream of the WPCF. It is presumed by stakeholders that the major source of this Phosphorus and Nitrogen comes from lawn care fertilizers that enter the stormwater systems (and therefore sewer system) and make their way to the WPCF for treatment. Although the WPCF is not designed to eliminate Phosphorus from the influent it does reduce Phosphorus by 10% as a by-product.

E. coli begins to exceed the state standard by more than 1000% as it moves into the Muncie Urban core. A significant spike occurs at Nebo road downstream of the WPCF. The Muncie BWQ tests the plant daily and it rarely exceeds 10 cfu/100 ml due to chlorination. Water from the plant is almost sterile in comparison to the river. The spike is due primarily to the two largest CSOs in Muncie, one of which is just upstream from Tillotson Ave. and one which is just upstream of the plant. After rains, the samples below these CSOs can easily exceed 30,000 cfu/ml. This was the major evidence in the case to support complete separation of the CSOs, which Muncie has accepted and is working with IDEM to implement over the next 20 to 30 years.

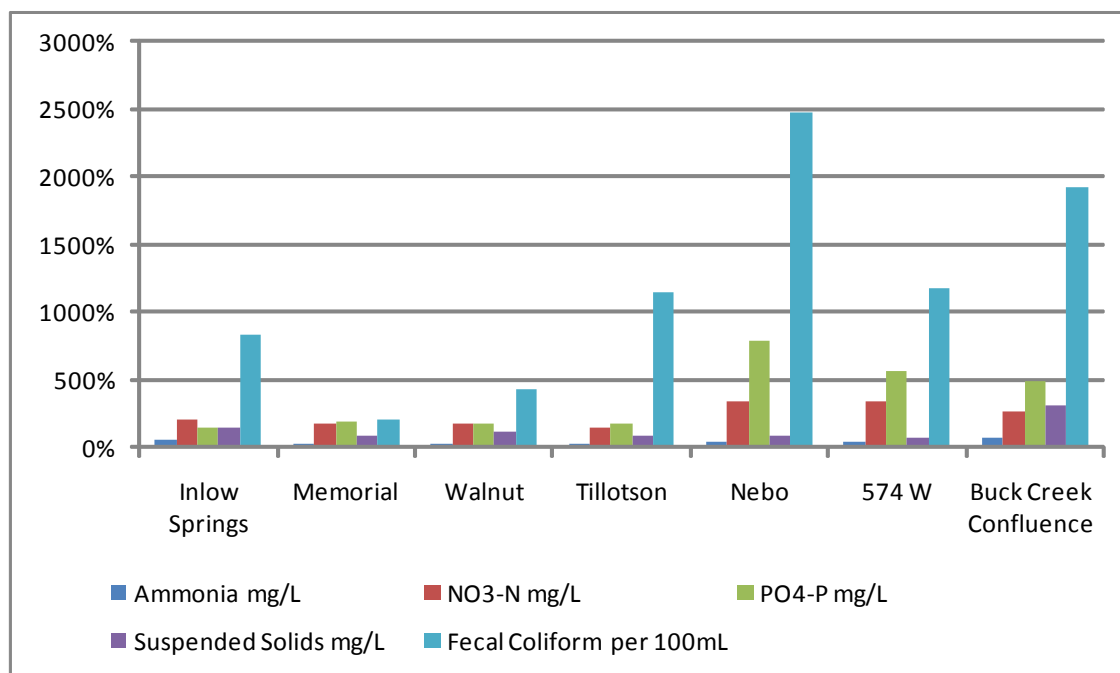
Total Suspended Solids stay relatively stable along the White River and spike at the confluence of Buck Creek.

These studies indicate that although Hamilton Ditch - Muncie Creek and Truitt Ditch - White River are above state standards for E. coli, Nitrogen, Phosphorus, and TSS (Muncie Creek only) they are not as critical as York-Prairie Creek and Buck Creek in regards to overall impairment. From a County-wide perspective, this would de-prioritize Hamilton Ditch - Muncie Creek and Truitt Ditch-White River in comparison to York Prairie Creek and Buck Creek (which are both on the downstream side of the City of Muncie).

This study did not aid us in better understanding the relative relationship between Hamilton Ditch-Muncie Creek and Truitt Ditch - White River. However, it is important to note the broader level of understanding of water quality along the river at this county-wide scale. These conclusions will lead to justification for future Watershed Management Planning in the Jakes Creek and York Prairie Creek Subwatersheds.

TABLE 2.66: Summary of Exceedence and Priority Rankings

	Ammonia		NO3-N	PO4-P	TSS	E. coli	
Inlow Springs	60%		206%	149%	140%	838%	
Memorial	30%		176%	194%	93%	203%	
Walnut	34%		170%	180%	111%	425%	
Tillotson	35%		152%	174%	90%	1144%	
Nebo	50%		342%	789%	92%	2478%	
574 W	45%		347%	564%	74%	1176%	
Buck Creek (confl.)	72%		265%	485%	319%	1927%	
	Ammonia	NO3-N	PO4-P	TSS	E. coli		total
Inlow Springs	6	4	1	6	3	20	
Memorial	1	3	4	4	1	13	
Walnut	2	2	3	5	2	14	
Tillotson	3	1	2	2	4	12	
Nebo	5	6	7	3	7	29	
574 W	4	7	6	1	5	23	
Buck Creek (confl.)	7	5	5	7	6	30	
	Ammonia		NO3-N	PO4-P	TSS	E. coli	
Inlow Springs			X	X	X	X	
Memorial			X	X		X	
Walnut			X	X	X	X	
Tillotson			X	X		X	
Nebo			X	X		X	
574 W			X	X		X	
Buck Creek (confl.)			X	X	X	X	



CHA. 2.64 Comparison of Exceedence at all Mainstem sampling locations

# Sub-basin Trends Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 18

The third level of analysis looks at Hamilton Ditch –Muncie Creek and Truitt Ditch - White River at a basin/tributary level. Tributary sampling occurred on four sites, Muncie Creek, Holt Ditch, Un-named Tributary, and Truitt Ditch. Because some of the tributaries/ditches in Truitt Ditch –White River were not sampled, the Memorial Drive sampling on the White River functions as a comparative basin. (See Table 2.67 and Map 2.78) The cross basin analysis helped us discover how those individual basins were performing (relative to each other) and how the basin scale WQ (tributary WQ) is influencing WQ results at the HUC12 level. Both scales of analysis will determine priority areas and aid in the development of critical areas.

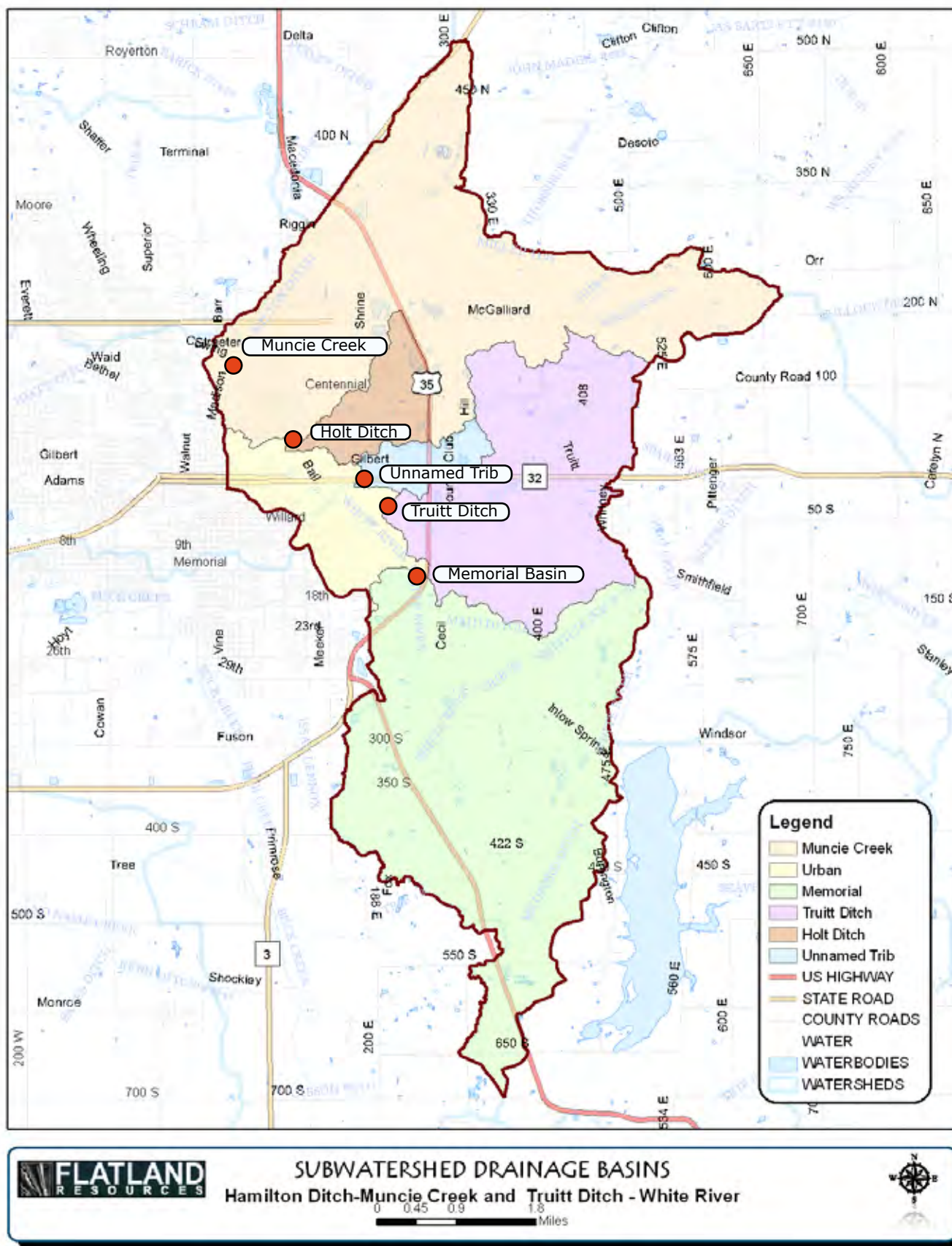
### Primary Subwatershed Drainage Basins

The following drainage basin groupings have been created in response to sampling points generated by the Muncie Bureau of Water Quality and GIS topological maps. These drainage basin delineations will enable water quality conclusions to be isolated/extracted based on topography/region. The subsequent pages outline the water quality results at each of these sampling points.

At some points, data has been available over the past thirty years but only recent data, (the last three years), will be used to develop baseline conditions. This data period is consistent across all sampling locations unless noted. <sup>1</sup>

TABLE 2.67: Primary Drainage Basins	Acres	Stream Mi.
Total Combined Subwatersheds	19,654	31
<b>Walnut Basin</b>	12,470	19
Walnut Basin: Secondary Basin - Muncie Creek	6,468	10
Walnut Basin: Secondary Basin - Holt Ditch	724	1
Walnut Basin: Secondary Basin - Unnamed Trib	414	1
Walnut Basin: Secondary Basin - Truitt Ditch	3,646	6
Walnut Basin: Secondary Basin - Urban (non monitored)	1,218	2
<b>Memorial Basin</b>	7,184	11
Randolph County - Upper White River Headwaters Basin	130,842	204
SOURCE: ArcGIS Indianamap.org		

<sup>1</sup> Data Generated by ArcGIS



**MAP. 2.78** Location of Drainage Basins



# Sub-basin Trends Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 19

### Muncie Creek at McCulloch Boulevard

This site had 44 samples taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.15 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 4 times. Nitrates and Nitrite as N levels averaged 1.15 mg/L and exceeded the target of 1.0 mg/L 20 times. Phosphorus as P levels averaged 0.12 mg/L and exceeded the EPA recommended target of 0.076 mg/L 16 times. Total suspended solids averaged 30.43 mg/L and exceeded the target of 30.0 mg/L 11 times. E. coli levels averaged 1129.30 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 34 times. Table 2.68 summarizes the data for this sampling point.

TABLE 2.68: Muncie Creek Basin Nonpoint Source Pollutants					
Muncie Creek	max	average	count	exceedence	%
Ammonia mg/L	0.21	0.15	44	4	9%
NO3-N mg/L	1.00	1.15	41	20	49%
PO4-P mg/L	0.08	0.12	44	16	36%
Suspended Solids mg/L	30.00	30.43	44	11	25%
Fecal Coliform per 100mL	235.00	1129.30	44	34	77%

### Holt Ditch at Bunch Boulevard

This site had varying degrees of samples over the three year sampling period. The Ammonia as N levels at this site averaged 0.16 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 4 times. Nitrates and Nitrite as N levels averaged 0.47 mg/L and exceeded the target of 1.0 mg/L 0 times. Phosphorus as P levels averaged 0.13 mg/L and exceeded the EPA recommended target of 0.076 mg/L 2 times. Total suspended solids averaged 24.52 mg/L and exceeded the target of 30.0 mg/L 5 times. E. coli levels averaged 3752.94 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 24 times. Table 2.69 summarizes the data for this sampling point.

TABLE 2.69: Holt Ditch Basin Nonpoint Source Pollutants					
Holt Ditch	max	average	count	exceedence	%
Ammonia mg/L	0.21	0.16	30	4	13%
NO3-N mg/L	1.00	0.47	9	0	0%
PO4-P mg/L	0.08	0.13	3	2	67%
Suspended Solids mg/L	30.00	24.52	9	5	56%
Fecal Coliform per 100mL	235.00	3752.94	34	24	71%



### Unnamed Named Tributary at State Route 32

This site had 33 samples taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.23 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 9 times. Nitrates and Nitrite as N levels averaged 0.45 mg/L and exceeded the target of 1.0 mg/L 1 times. Phosphorus as P levels averaged 0.21 mg/L and exceeded the EPA recommended target of 0.076 mg/L 30 times. Total suspended solids averaged 20.64 mg/L and exceeded the target of 30.0 mg/L 6 times. E. coli levels averaged 5988.34 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 28 times. Table 2.70 summarizes the data for this sampling point.

Unnamed Tributary	max	average	count	exceedence	%
Ammonia mg/L	0.21	0.23	33	9	27%
NO3-N mg/L	1.00	0.45	30	1	3%
PO4-P mg/L	0.08	0.21	33	30	91%
Suspended Solids mg/L	30.00	20.64	33	6	18%
Fecal Coliform per 100mL	235.00	5988.34	33	28	85%

### Truitt Ditch at Butterfield Road

This site had 44 samples taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.18 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 13 times. Nitrates and Nitrite as N levels averaged 1.08 mg/L and exceeded the target of 1.0 mg/L 18 times. Phosphorus as P levels averaged 0.18 mg/L and exceeded the EPA recommended target of 0.076 mg/L 13 times. Total suspended solids averaged 21.04 mg/L and exceeded the target of 30.0 mg/L 9 times. E. coli levels averaged 525.93 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 27 times. Table 2.71 summarizes the data for this sampling point.

Truitt Ditch	max	average	count	exceedence	%
Ammonia mg/L	0.21	0.18	44	13	30%
NO3-N mg/L	1.00	1.08	41	18	44%
PO4-P mg/L	0.08	0.18	44	13	30%
Suspended Solids mg/L	30.00	21.04	44	9	20%
Fecal Coliform per 100mL	235.00	525.93	44	27	61%

# Sub-basin Trends Study

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 20

### Memorial Basin at Memorial Drive

This site had a varying amount of samples per impairment taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.06 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 20 times. Nitrates and Nitrite as N levels averaged 1.76 mg/L and exceeded the target of 1.0 mg/L 36 times. Phosphorus as P levels averaged 0.15 mg/L and exceeded the EPA recommended target of 0.076 mg/L 41 times. Total suspended solids averaged 27.88 mg/L and exceeded the target of 30.0 mg/L 193 times. E. coli levels averaged 476.91 cfu/100mL and exceeded the guideline of 235 cfu/100mL a total of 557 times. Table 2.72 summarizes the data for this sampling point.

TABLE 2.72: Memorial Basin Nonpoint Source Pollutants

Memorial	max	average	count	exceedence	%
Ammonia mg/L	0.21	0.06	1006	20	2%
NO3-N mg/L	1.00	1.76	184	36	20%
PO4-P mg/L	0.08	0.15	187	41	22%
Suspended Solids mg/L	30.00	27.88	1007	193	19%
Fecal Coliform per 100mL	235.00	476.91	557	209	38%

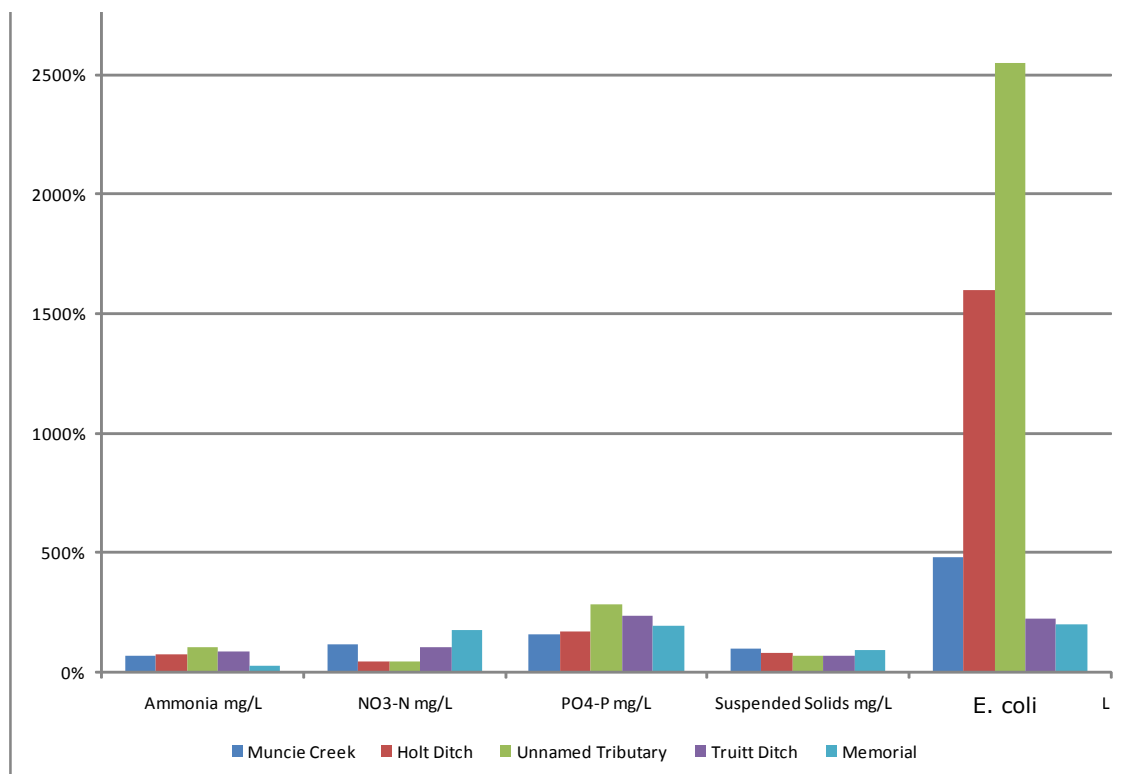


# Sub-basin Trends

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 21

TABLE 2.73: Summary of Historical Water Quality Data - Average amounts of water quality parameters over three year sampling period for each sampling site

Parameter	Target Level	Units	White River at Memorial Bridge	UNT at State Route 32	Truitt Ditch at Butterfield Road	Holt Ditch at Bunch Boulevard	Muncie Creek at McCullough Boulevard
Ammonia as N	Variable	mg/L	0.086	0.233	0.225	0.162	0.164
E. coli by Membrane Filtration	Max: 235	cfu/100 mL	475.278	5988.344	402.469	3757.828	1286.719
Nitrate+Nitrite as N	Max: 1	mg/L	1.737	0.454	1.354	0.488	1.494
Phosphorous as P	Max: 0.076	mg/L	0.161	0.215	0.214	0.138	0.169
pH Value	Min:6	Max:9	7.800	7.452	7.603	7.632	7.612
Total Suspended Solids	Max: 30	mg/L	39.439	20.642	26.253	25.322	36.013
Turbidity	Max: 10.4	NTU	43.367	20.348	33.236	25.168	42.782
Dissolved Oxygen	Min: 4	mg/L	8.575	6.464	8.661	11.303	8.652
Temperature of Sample	Variable	C	12.267	10.339	9.918	10.048	10.182



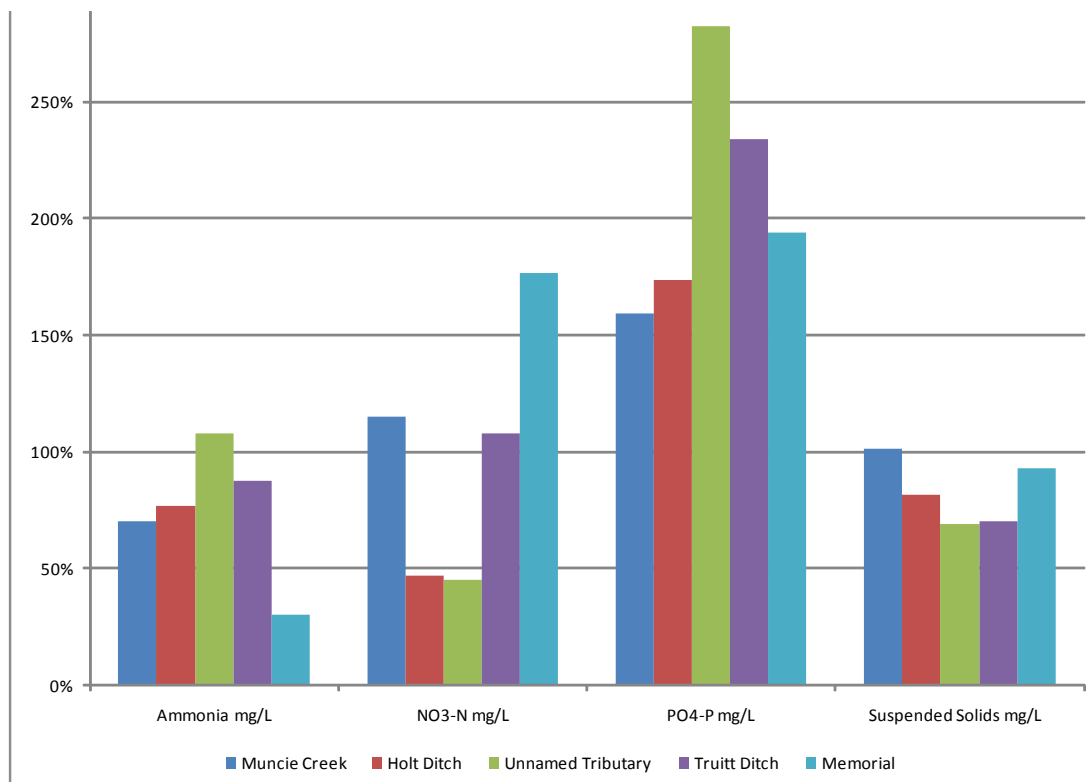
**CHA. 2.65** Basin comparison of Nonpoint Source Pollutants

# Sub-basin Trends

## WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 22

TABLE 2.74: Percentage of exceedance of water quality samples for each parameter and site

Parameter	White River at Memorial Bridge	UNT at State Route 32	Truitt Ditch at Butterfield Road	Holt Ditch at Bunch Boulevard	Muncie Creek at McCullough Boulevard
Ammonia as N	38.89	93.94	80.65	90.91	75.76
E. coli by Membrane Filtration	47.22	81.82	64.52	48.48	60.61
Nitrate+Nitrite as N	51.28	3.03	61.29	3.03	57.58
Phosphorous as P	75.00	93.94	35.48	63.64	33.33
pH Value	0.00	0.00	0.00	0.00	0.00
Total Suspended Solids	30.56	18.18	16.13	27.27	15.15
Turbidity	75.00	63.64	45.16	51.52	87.88
Dissolved Oxygen	2.78	33.33	3.23	0.00	3.03
Temperature of Sample	0.00	0.00	0.00	0.00	0.00



**CHA. 2.66** Basin comparison of Nonpoint Source Pollutants (sans E. Coli)

# Sub-basin Trends

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 23

### General Basin Level trends

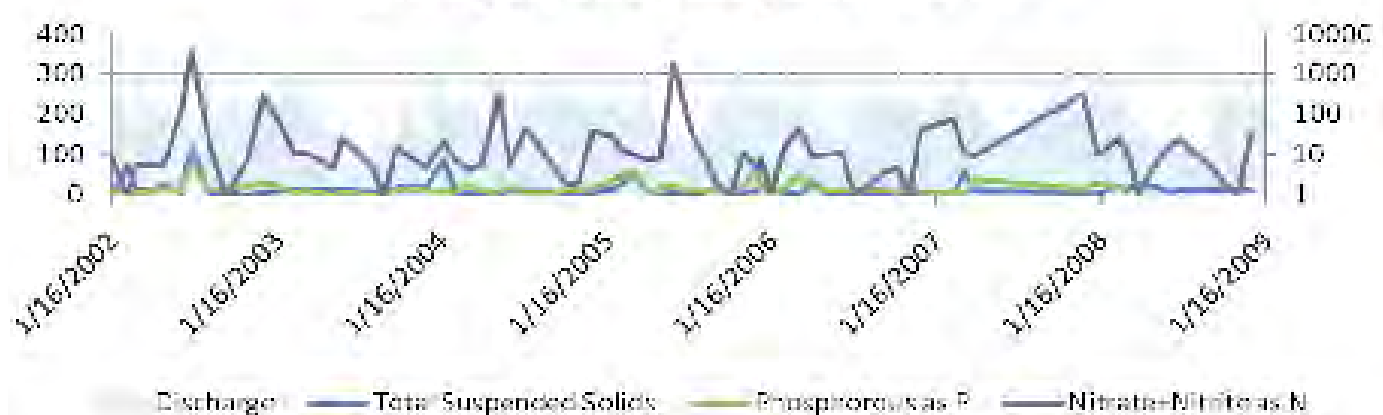
A few supplemental studies were performed with data from the Hamilton Ditch-Muncie Creek and Truitt Ditch- White River Subwatershed basins. The tributaries Truitt Ditch and Muncie Creek were analyzed for sediment contribution in relationship to monthly rainfall. (Chart 2.69, 2.70) The sampling point at Truitt Ditch is a predominantly agricultural while the sampling point on Muncie Creek is urban. For Truitt Ditch, sediment contribution increased during the non-growing seasons (late fall, winter, early spring) where soil was exposed on surfaces susceptible to sediment runoff ( especially from agricultural fields which dominate the basin). For Muncie Creek, sediment was consistently high (atypical for urban areas) leading us to believe its source may be in channel contribution.

Nitrogen, phosphorus, and sediment were also compared at two sampling locations. Data shows a greater correlation between sediment and phosphorus than nitrogen and all others, confirming national trends that indicate show phosphorus attaching and migrating with sediment. (Chart 2.67) Nitrogen fluctuation occurred at greater rates and were less tied to the vegetated season as did Phosphorus and TSS. (Chart 2.68)

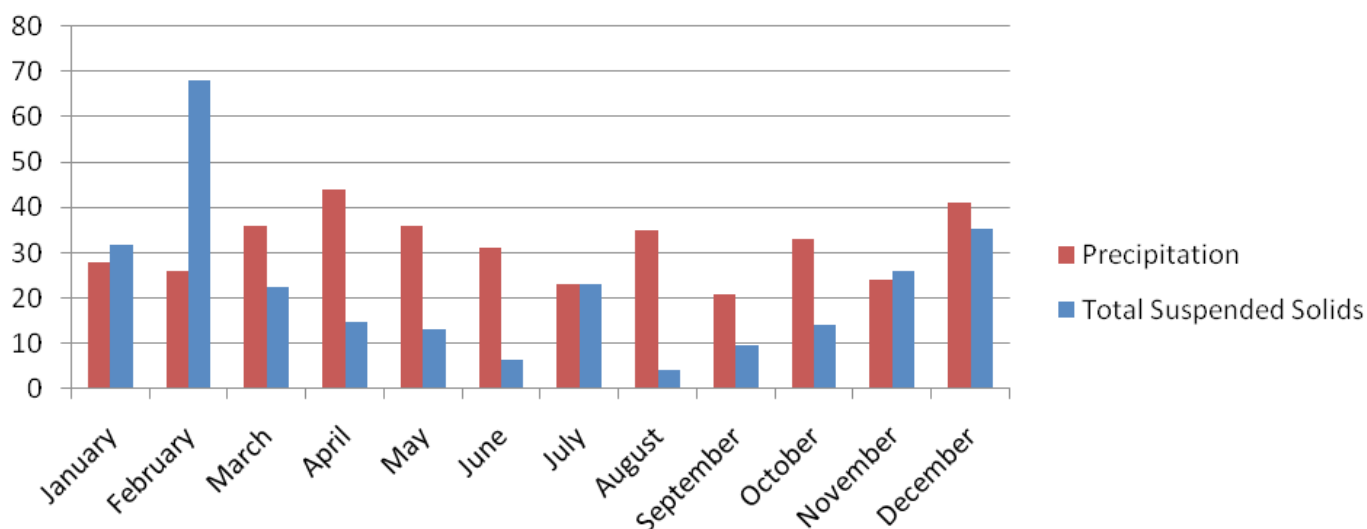


CHA. 2.67 Spikes in TSS and Phosphorus During non growing seasons

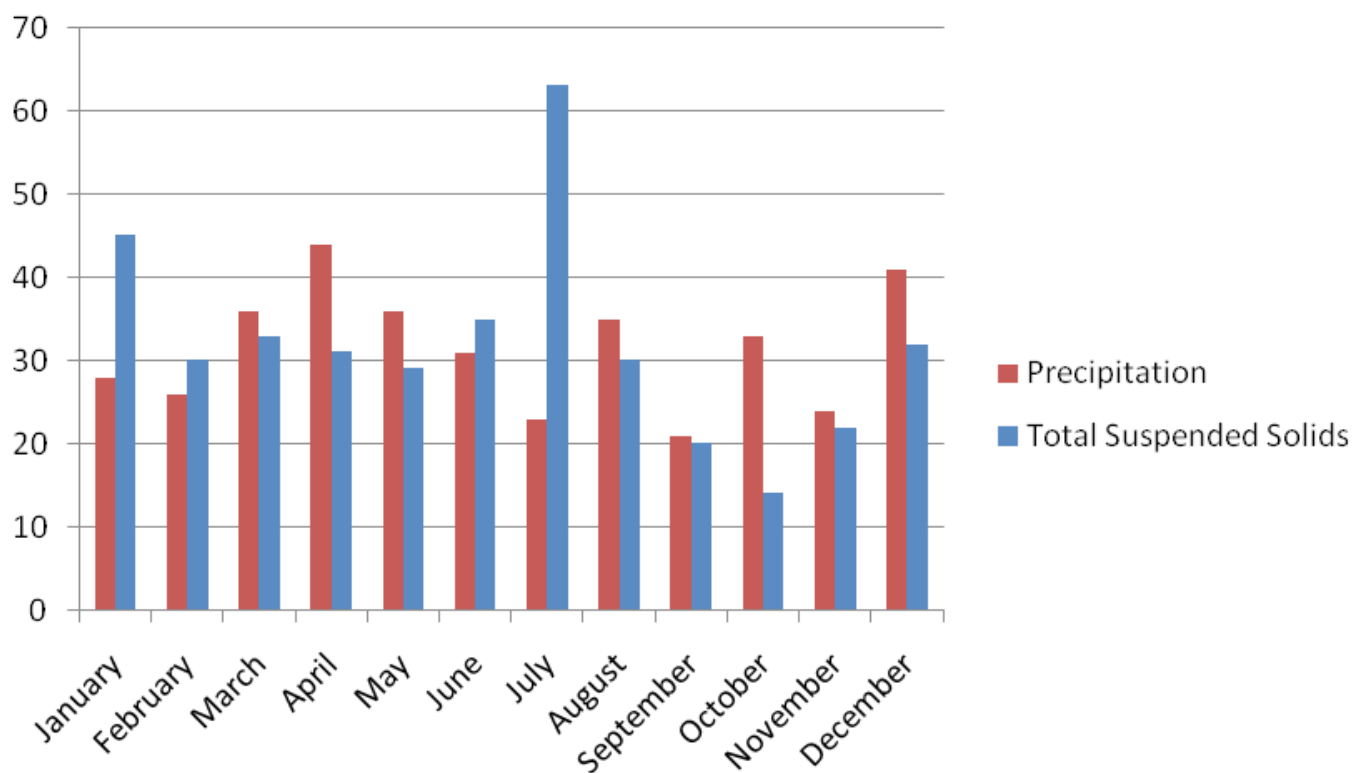
### Nitrogen and Guage vs TSS / P



CHA. 2.68 Relationship between TSS, Phosphorus, and Nitrogen



**CHA. 2.69** Relationship between Precipitation and TSS on Truitt Ditch (Butterfield Road Bridge)



**CHA. 2.70** Relationship between Precipitation and TSS at Muncie Creek (Highland Ave Bridge)

These studies were important in demonstrating the role vegetation can play as a means to stabilizing soil and concurrently reducing the amount of phosphorus and ammonia entering our streams (through soil attachment). When we compare phosphorus and sediment spikes to the growing seasons, we see increases during winter and spring months (where vegetation was not growing as strong). This data supports the notion that by stopping soil transport we can stop other nutrients. These conclusions support BMPs like no-till and cover crops.

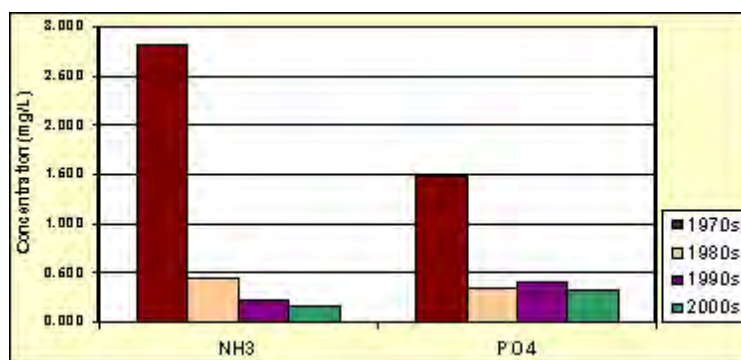


# Historic vs. Baseline Data

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 24

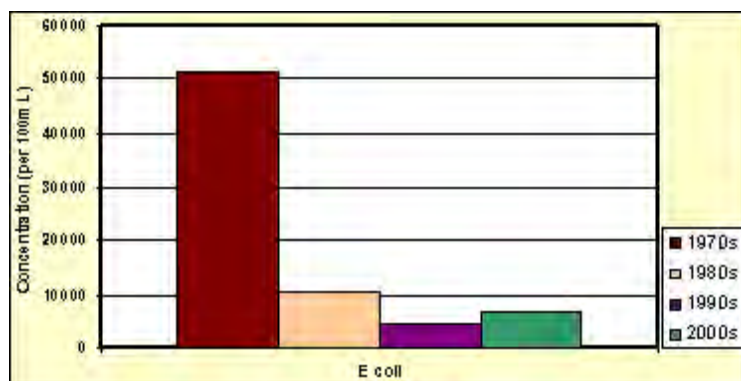
### Historic vs. Baseline Water Quality Data Trends

The historic data, taken over a three year period from 2006 to 2008 (Table 2.76, 2.77), shows higher average concentrations for almost all of the water quality parameters than the baseline data that was sampled in 2009 (Table 2.75). For example, the total suspended solids historic levels for Truitt Ditch are 218% higher than the baseline data. The higher concentrations could be the result of higher incidents of precipitation during the historical time frame, the seasonality of fertilizer applications, and increased erosion in the winter due to the lack of vegetation. Since the number of samples is higher for the historic water quality data, this is more likely the more accurate measurement of water quality. Additionally, the baseline data was taken during a 10 week period in the fall, while the historical data was taken over a three year period during all seasons. Because of this, the data is more representative of true water quality conditions. Since the baseline data is to be used to generate the loading rates for each water quality parameter, it must be taken into consideration that the data is lower than the three-year averages obtained from the historical data.



Ammonia (NH<sub>3</sub>) has seen a 94% reduction since the 1970s, while phosphate (PO<sub>4</sub>) has seen a 78% reduction

CHA. 2.71 Historic Ammonia Reductions



E. coli concentrations have been reduced 87% from the 1970s.

CHA. 2.72 Historic E. coli Reductions

TABLE 2.75: Summary of baseline water quality data

Parameter	Target Level	Units	Truitt Ditch at Butterfield Road	Muncie Creek at McCullough Boulevard
Ammonia as N	Variable	mg/L	0.071	0.10036
E. coli by Membrane Filtration	Max: 235	cfu/100 mL	885.091	671.27273
Nitrate+Nitrite as N	Max: 1	mg/L	0.349	0.24391
Phosphorous as P	Max: 0.076	mg/L	0.076	0.02891
pH Value	Min:6			
Max:9	S.U.	7.200	7.20000	
Total Suspended Solids	Max: 30	mg/L	8.245	14.18182
Dissolved Oxygen	Min: 4	mg/L	6.609	7.30909
Temperature of Sample	Variable	C	13.973	14.43636
Atrazine	Max: 3	µg/L	0.137	0.30440
Discharge	NA	cfs	0.323	1.52536

# Large Basin Comparisons

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 25

The two largest basins (Muncie Creek and Truitt Ditch) in the Hamilton Ditch - Muncie Creek and Truitt Ditch-White River Subwatersheds were compared to each other on a wider range of WQ parameters. Baseline monitoring occurred weekly for ten consecutive weeks from 8/26/2009 to 11/12/2009. Two sites were sampled, Truitt Ditch at Butterfield Road and Muncie Creek at McCullough Boulevard. (Table 2.76 and Table 2.77) At both sampling locations, the pH, temperature, and dissolved oxygen values had no instances in which the measured amounts exceeded the guidelines put forth by the Indiana Administrative Code.

TABLE 2.76: Comparison of Historic and Baseline Water Quality Studies at Truitt Ditch Basin					
Parameter	Units	Historic Data for Truitt Ditch at Butterfield Road	Baseline Data for Truitt Ditch at Butterfield Road	Difference Between Historic and Baseline data	Percent Increase or Decrease
Ammonia as N	mg/L	0.225	0.071	0.154	218.03
E. coli by Membrane Filtration	cfu / 100 mL	402.469	885.091	-482.622	-54.53
Nitrate+Nitrite as N	mg/L	1.354	0.349	1.005	288.00
Phosphorous as P	mg/L	0.214	0.076	0.138	180.82
pH Value	S.U.	7.603	7.200	0.403	5.60
Total Suspended Solids	mg/L	26.253	8.245	18.008	218.39
Dissolved Oxygen	mg/L	8.661	6.609	NA	NA
Temperature of Sample	C	9.918	13.973	NA	NA

For Truitt Ditch (Table 2.76), the Ammonia as N levels averaged 0.07mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 7 times. E. coli averaged 885.1 cfu/100mL and exceeded the guidelines of 235 cfu/100mL on all ten sampling instances. Nitrates and Nitrite as N levels averaged 0.35 mg/L and never exceeded the target of 1.0 mg/L. Phosphorus as P levels averaged 0.08 mg/L and exceeded the IDEM target of 0.076 mg/L only one time. The high average stems from a single instance of a high concentration on 9/2/09 when Phosphorus levels recorded at 0.39 mg/L. Total suspended solids averaged 8.25 mg/L and never exceeded the target of 30.0 mg/L. Atrazine averaged 0.14 ug/L and never exceeded 3.0 ug/L as set by the EPA as the drinking water standard. It should be noted that all water quality sampling occurred in the late summer to fall, a time when Atrazine is usually not used. It would be expected that the levels would be low.

TABLE 2.77: Comparison of Historic and Baseline Water Quality Studies at Muncie Creek Basin				
Parameter	Units	Historic Data for Muncie Creek at McCullough Boulevard	Baseline Data for Muncie Creek at McCullough Boulevard	Difference Between Historic and Baseline data
Ammonia as N	mg/L	0.164	0.100	0.064
E. coli by Membrane Filtration	cfu/100 mL	1286.719	671.273	615.446
Nitrate+Nitrite as N	mg/L	1.494	0.244	1.250
Phosphorous as P	mg/L	0.169	0.029	0.140
pH Value	S.U.	7.612	7.200	0.412
Total Suspended Solids	mg/L	36.013	14.182	21.831
Dissolved Oxygen	mg/L	8.652	7.309	NA
Temperature of Sample	C	10.182	14.436	NA

For Muncie Creek (Table 2.77), the Ammonia as N levels averaged 0.1 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 6 times. E. coli averaged 671.27 cfu/100mL and exceeded the guidelines of 235 cfu/100mL 6 instances. Nitrates and Nitrite as N levels averaged 0.24 mg/L and never exceeded the target of 1.0 mg/L. Phosphorus as P levels averaged 0.02 mg/L and never exceeded the target of 0.076 mg/L. Total suspended solids averaged 14.18 mg/L and exceeded the target of 30.0 mg/L on only one occasion. Atrazine concentrations average 0.3 ug/L and never exceeded the target of 3.0 ug/L. It should be noted that all water quality sampling occurred in the late summer to fall, a time when Atrazine is usually not used. It would be expected that the levels would be low.

# Summary of Sub Basin Trends

## WMP - CHAPTER 2 - PART 2 - SECTION 2 - SUBSECTION 26

Sub basins were analyzed in Hamilton Ditch - Muncie Creek and Truitt Ditch-White River using sampling points by the Muncie Bureau of Water Quality from 2006-2008 (Table 2.78, 2.79, 2.80). This study will aid in critical area determinations within the Subwatersheds for future cost-share implementation. The four sub basins (tributaries) included Muncie Creek, Holt Ditch, Unnamed Tributary, and Truitt Ditch. Because some of the tributaries/ditches in Truitt Ditch-White River were not sampled, the sampling at Memorial Drive serves as a comparative basin. The data or analysis of these cross basin comparisons helped us discover how those individual basins were performing (relative to each other) and how the basin scale WQ (tributary WQ) are influencing our studies at the HUC12 level. Both scales of analysis will determine priority areas and aid in the development of critical areas.

The Unnamed Tributary basin was the only basin that exceeded the state standard for Ammonia during the sampling period.

Muncie Creek, Truitt Ditch, and Memorial basins all exceeded the state standard for nitrogen. All basins exceeded the federal guidelines for Phosphorus with the following ranking (1 being the greatest impaired) (1) Unnamed Tributary (2) Truitt Ditch (3) Holt Ditch (4) Memorial (5) Muncie Creek. Muncie Creek was the only basin to exceed the state standard for TSS. Similarly to the Subwatershed wide study, all basins exceed the state standard for E. coli with the following ranking. (1) Unnamed Tributary (2) Holt Ditch (3) Muncie Creek (4) Truitt Ditch (5) Memorial Basin.

TABLE 2.78: Percentage Exceedence of State Water Quality Standards

	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek	70%	115%	159%	101%	481%
Holt Ditch	77%	47%	174%	82%	1597%
Unnamed Tributary	108%	45%	282%	69%	2548%
Truitt Ditch	87%	108%	234%	70%	224%
Memorial	30%	176%	194%	93%	203%

TABLE 2.79: Basin Level Priority Ranking (1 being the greatest)

	Ammonia	NO3-N	PO4-P	TSS	E.Coli	total
Muncie Creek	2	4	1	5	3	15
Holt Ditch	3	2	2	3	4	14
Unnamed Tributary	5	1	5	1	5	17
Truitt Ditch	4	3	4	2	2	15
Memorial	1	5	3	4	1	14

TABLE: 2.80 Basins where State Water Quality Exceedence Occured

	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek		X	X	X	X
Holt Ditch			X		X
Unnamed Tributary	X		X		X
Truitt Ditch		X	X		X
Memorial		X	X		X



Ammonia

Nitrogen

Phosphorus

Sediment

E. Coli

**DIA. 2.14** Critical Pollutants in each Basin

# SECTION THREE - BIOLOGICAL INVENTORIES

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 2





# Biological Inventories

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 1

"The BWQs Biological studies are a supplement to 319 Chemical Studies. Historically, threats to water quality have been evaluated with a single faceted chemistry approach. Chemical testing and bioassays provide empirical and legal validity to assessments but can not accurately provide a holistic representation of water quality. The main deficiencies of this approach include (Hughes 1990); 1) failure to account for naturally occurring differences in conventional water quality parameters, 2) failure to consider combined chemical effects, 3) toxicity tests may not be representative of indigenous species or the most sensitive species, 4) chemical testing is expensive, and 5) factors that prevent attainment of biological integrity are not limited to toxins. Finally, a chemical representation of water quality by itself fails to meet all of the fundamental goals of the Clean Water Act." <sup>1</sup>

"Biological indicators provide many benefits to a water quality program. Biological communities reflect the cumulative impacts of the watershed condition. Fish are long lived and disturbances in their environment can be reflected at the community or individual level (e.g. DELT anomalies, % tolerant species and age and growth). Fish represent a variety of trophic levels; omnivores, herbivores, insectivores, planktivores, and piscivores. Fish are ubiquitous and found in even the smallest of streams. Biological sampling is also relatively inexpensive compared to chemical analysis. In addition, descriptors of the fish community are more easily related to the public." <sup>2</sup>

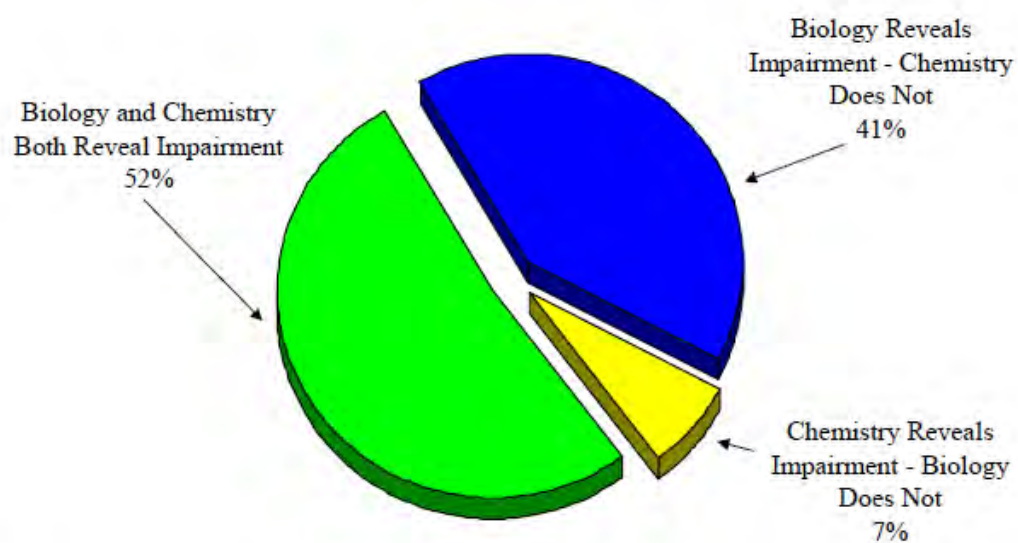
"While the benefits of biological criteria are widely known they are not intended to replace chemical sampling. Implementation of the two in concert provides the most holistic representation of water quality. It has been found that 40% of impaired streams in Ohio were detected by biological assessments and missed by chemical sampling (OEPA 1994) (Chart 2.73). While 7% was found only with chemical sampling. In addition, chemical testing is sometimes necessary as a follow up to pinpoint the exact cause of disturbances found by biological testing. A single approach or a single statistical framework (e.g. Shannon Diversity Index) is insufficient at describing every variable that affects water quality. Multiple sampling approaches coupled with multiple analyses which take into account the nuances of the relationship at hand is necessary to formulate a holistic conclusion on water quality." <sup>3</sup>

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1 BWQ Annual Fish Community Report

2 BWQ Annual Fish Community Report

3 BWQ Annual Fish Community Report



**CHA. 2.73** Efficacy of Chemical and biological assessment in detecting stream impairment, BWQ

# 319 Biological Studies Fish

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 2

### IBI Overview

"The Index of Biotic Integrity (IBI), originally developed by James Karr, and the Modified Index of Well-being (MIwb) (Gammon 1976) provide sensitive and reproducible measurements of the integrity of fish communities (OEPA 1989) (Table 2.81). These indices have been calibrated for use in specific Ecoregions defined by the mutual presence of geographic variables pertinent to biological potential. Streams within the same ecoregion and with comparable drainage will contain similar structural communities that have predictable and measurable responses to perturbation.

The IBI is composed of twelve metrics that measure functional aspects of fish communities including species composition, trophic composition, and fish condition. Each metric is scored according to the degree of deviation from a "healthy" or least impacted stream of comparable size (1 = severe deviation, 3 = moderate deviation, and 5 = little or no deviation). The total score of 12 to 60 is used to assign a narrative description of very poor, poor, fair, good, or excellent to the biological integrity of the community within the sampled stream segment."<sup>1</sup>

### Index of Biotic Integrity and Modified Index of Well-Being

"The Muncie Bureau of Water Quality sampled 62 sites from the West Fork White River and its tributaries in Delaware County in 2010 in order to evaluate the health and integrity of their fish communities. IBI scores for 2010 ranged from a low of 18 very poor at York Prairie Creek near Mad-dox Drive (YPC-9.0), to a high of 58 excellent at White River near the West Side Park (WHI-313.4) (MAP 2.79, 2.80, 2.81)."

"Data was provided to the WRWP for interpreting the data specific for the Subwatershed areas. General conclusions regarding all of Delaware County can be applied to the subwatershed areas."<sup>2</sup>

### The Difference between Tributaries and Mainstem

"A significant difference was found between IBI scores on White River and tributary sites (Wilcoxon test;  $Z = 6.14$ ,  $P < 0.001$ ). Wadeing sites on White River had a mean score of 50.9 (SE = 0.681) good, while the mean score for sites on tributaries was 37.1 (SE = 1.282) fair. The tributary mean is similar to 2009 (36 fair) but lower than 2008 (41 fair). The higher average in 2008 was due to the sampling on Cabin Creek (IBI average = 50 good) and Stoney Creek (IBI average = 48 good) in 2008."

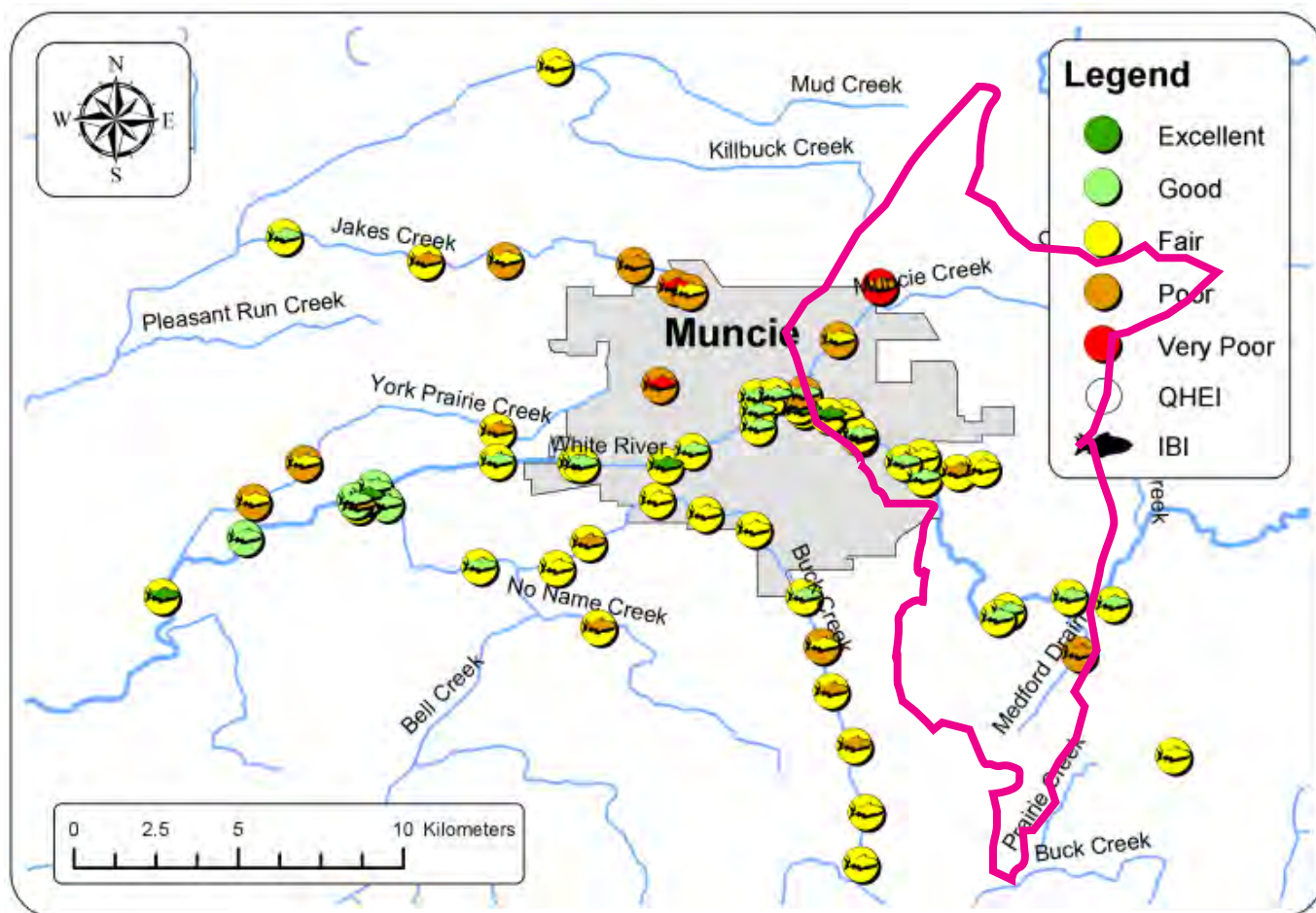
### Overall quality

"Despite the presence of a wide range of negative human impacts, the overall health of the fish communities within the West Fork White River in and around Muncie is good. While some minor differences were identified, namely the slight drop in total IBI scores downstream of Muncie, White River meets the goal of maintaining good biological integrity."<sup>3</sup> (Chart 2.74, 2.75)

1 BWQ Annual Fish Community Report

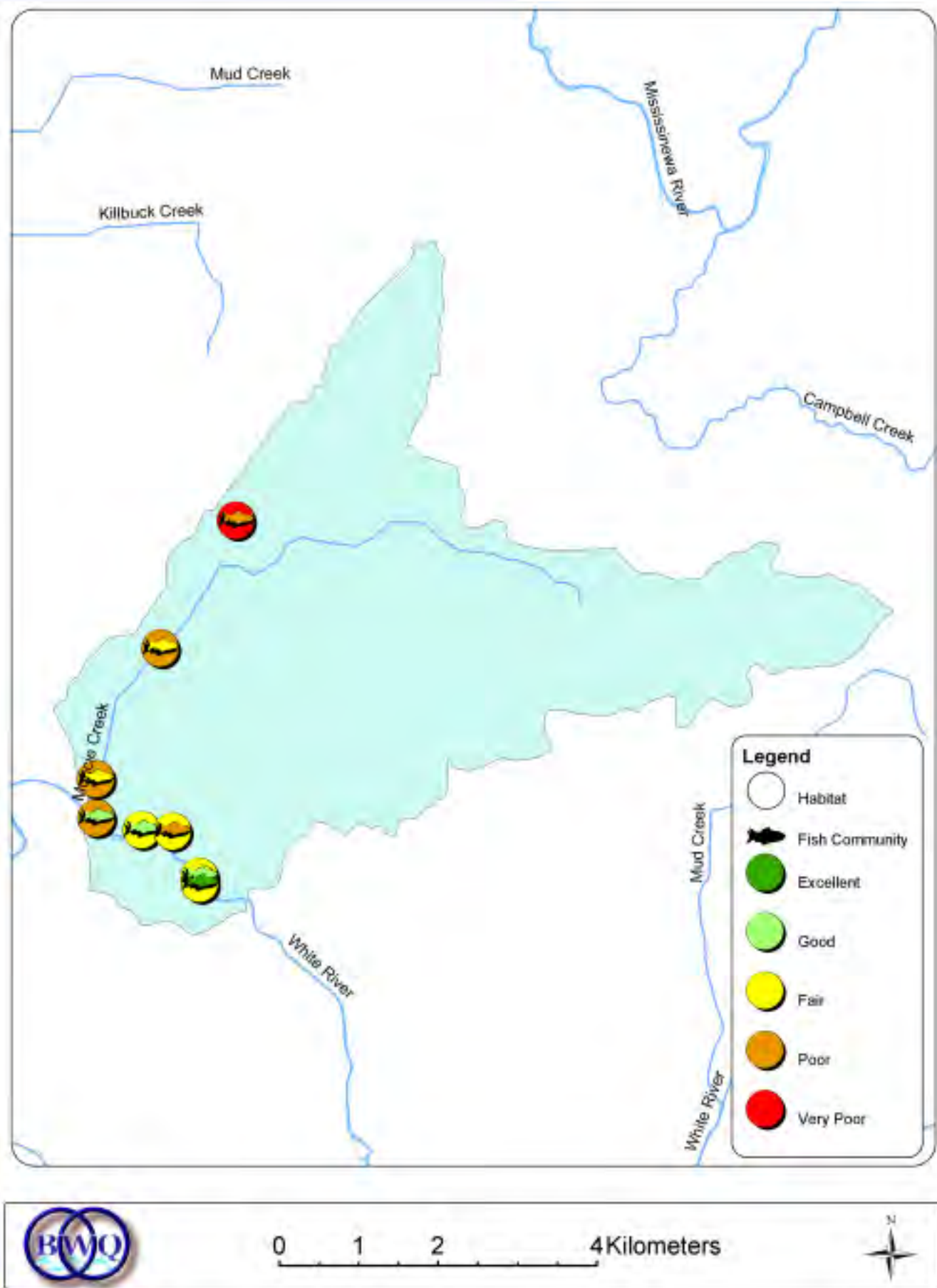
2 BWQ Annual Fish Community Report

3 BWQ Annual Fish Community Report



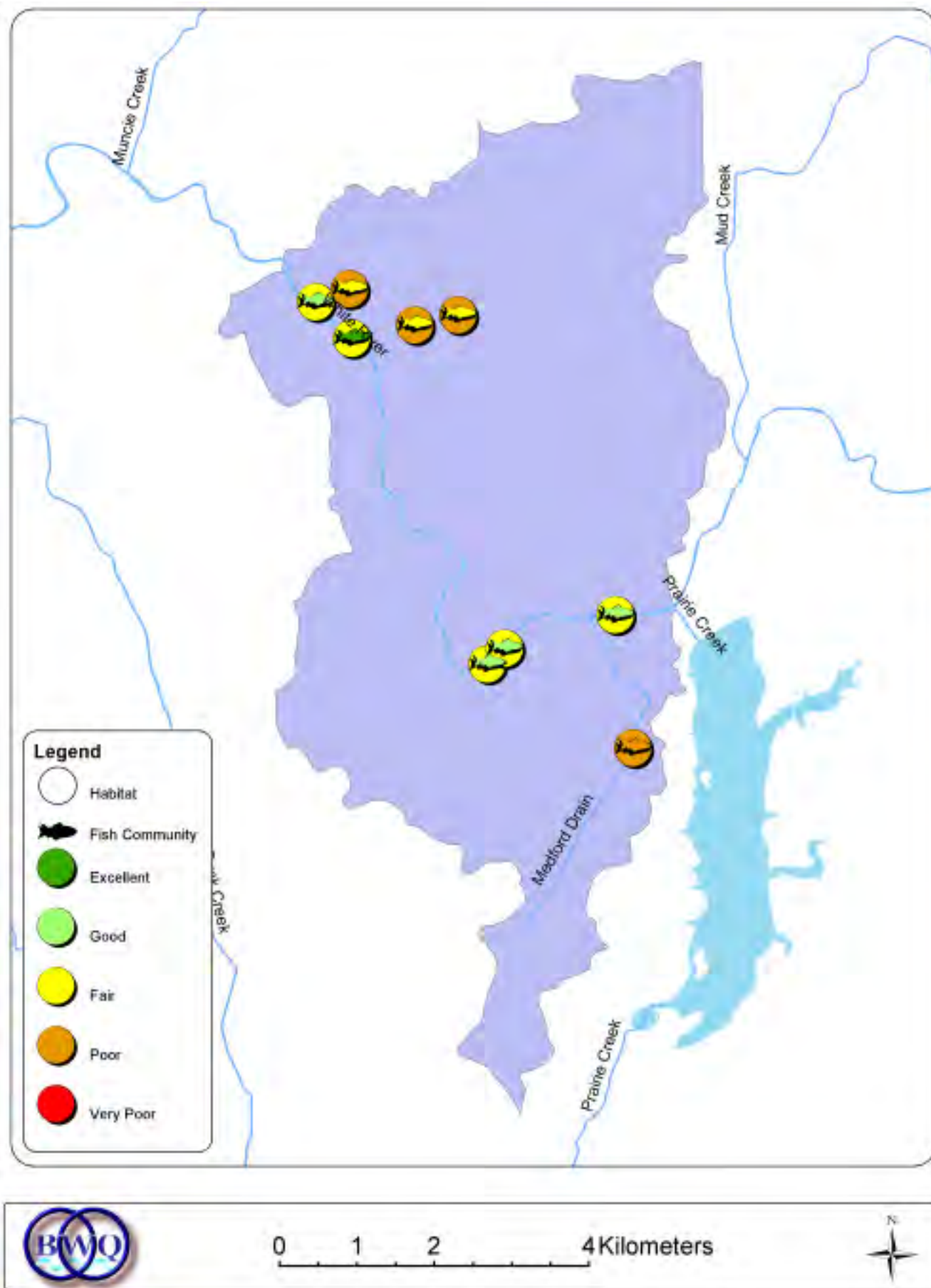
**MAP. 2.79** QHEI and IBI Scores in Delaware County, BWQ

TABLE 2.81: Biological Methodologies	
Habitat Analysis	Rankin, 1989
Fish	Ohio and US EPA
Macroinvertebrates	IDEM mIBI



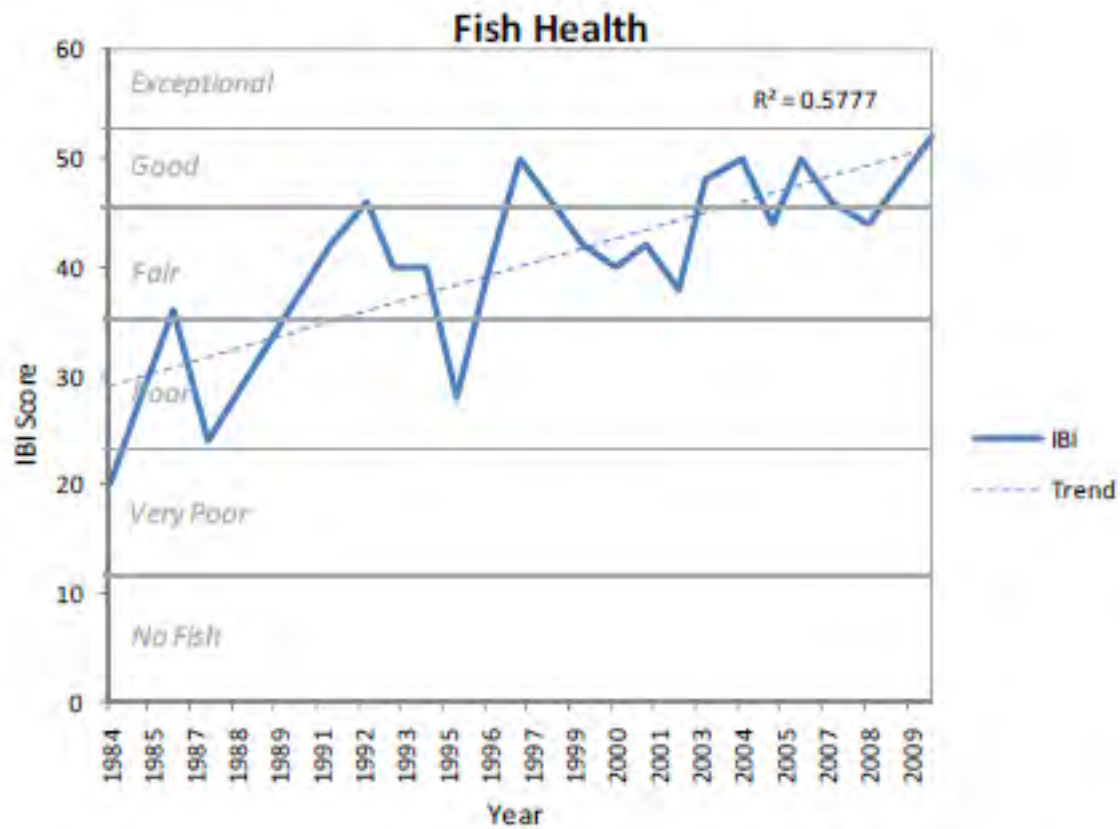
**MAP. 2.80** Hamilton Ditch-Muncie Creek QHEI and IBI Scores



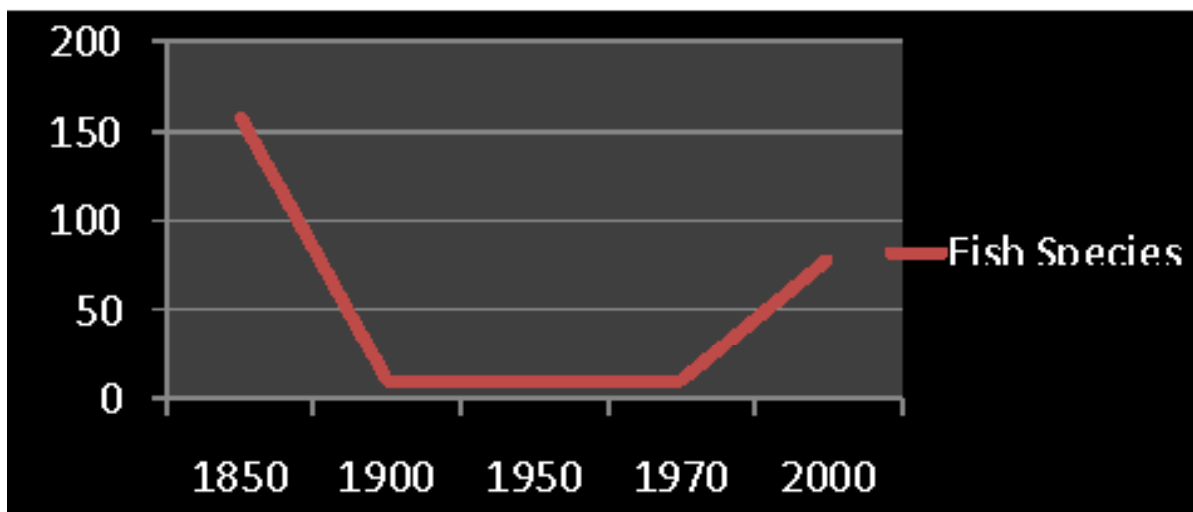


**MAP. 2.81** Truitt Ditch - White River QHEI and IBI Scores





**CHA. 2.74** IBI Trending 1984 - 2009, all sites on the Mainstem of the White River, BWQ



**CHA. 2.75** Fish Species response 1850 - 2000 on all sites on the Mainstem of the White River, BWQ



# 319 QHEI

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 3

### QHEI

"Beginning in 2002, QHEI measurements were taken in conjunction with each sampling event according to the guidelines provided by Rankin (1989). Habitat assessments allow a preliminary estimation of the potential contribution of habitat alterations (as opposed to chemical pollution) as the cause of impairment. The Qualitative Habitat Evaluation Index (QHEI) measures variables that are pertinent to biological potential including the quality of substrate, cover, channel morphology, riparian zone, and riffle-run-pool complexes. Habitat quality is scored from 0 (poor quality) to 100 (high quality)." <sup>1</sup>

### Qualitative Habitat Evaluation Index

"QHEI scores for 2010 ranged from a low of 19 poor at Hamilton Ditch near C.R. 300 N. (HAM-0.2) to a high of 72.5 good at White River near C.R. 575 W. (WHI-308.5 & WHI-308.7). As with IBI scores, QHEI scores were significantly lower in White River tributaries (Wilcoxon test;  $Z = -3.53$ ,  $P < 0.001$ ). Agriculturally related hydromodifications such as channelization and riparian removal on smaller streams were noted as the primary causes of low QHEI scores. Of the QHEI metrics, Channel Morphology, Riparian, and Riffle/Run Quality had the poorest overall quality when compared to expected maximum score, and functional riffle/run/pool complexes were absent from 36% of all sites sampled. The majority of which were located in tributaries." <sup>2</sup> (Chart 2.76, Table 2.82)

### QHEI Comparison to IBI

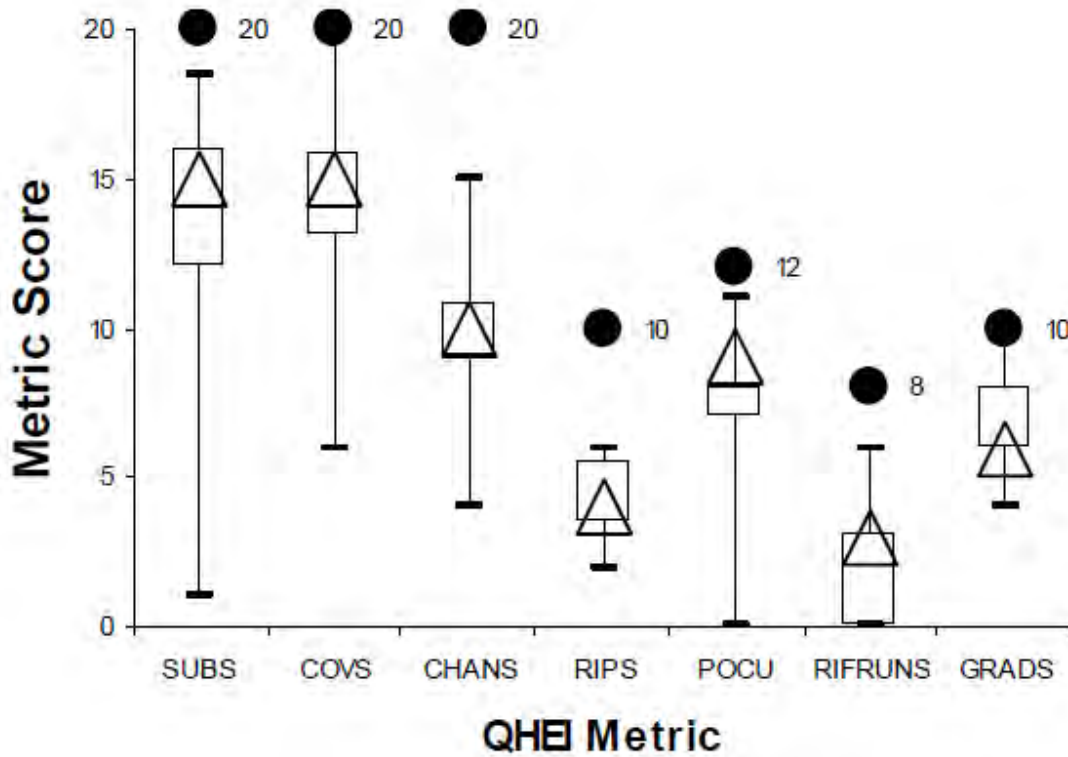
"Comparison of QHEI scores to biological index scores is a vital step in determining potential sources of impaired biological communities. Habitat quality is often the limiting factor of biological integrity; therefore, the quality of a fish community rarely exceeds the quality of habitat in which they live (Wang et al. 2001). Sites that have severely altered habitats due to channelization or dredging, for example, would not be expected to hold high quality fish communities. In these cases, the source of the disturbance is described clearly by the habitat assessment. Conversely, high quality habitat and poor biological integrity may be an indication of point source pollution. In addition, spatial differences in IBI, QHEI, and the fish community composition are analyzed." <sup>3</sup> (Chart 2.77)

TABLE 2.82: Stand Alone Indices		
	TD-1	MC-1
Hilsenhoff Index	7.13	4.91
Shannon Index of Diversity	2.70	2.77
Shannon Evenness Index	0.90	0.90
% Dominance of Top Three Taxa	0.44	0.41
% Chironomidae	0.09	0.33
QHEI Scores	46.5	54.3
	Fair	Good
*results (except QHEI) are an average of duplicate QAQC samples; submetrics results for both samples are shown.		
SOURCE: BWQ Fish community and Habitat Quality Report		

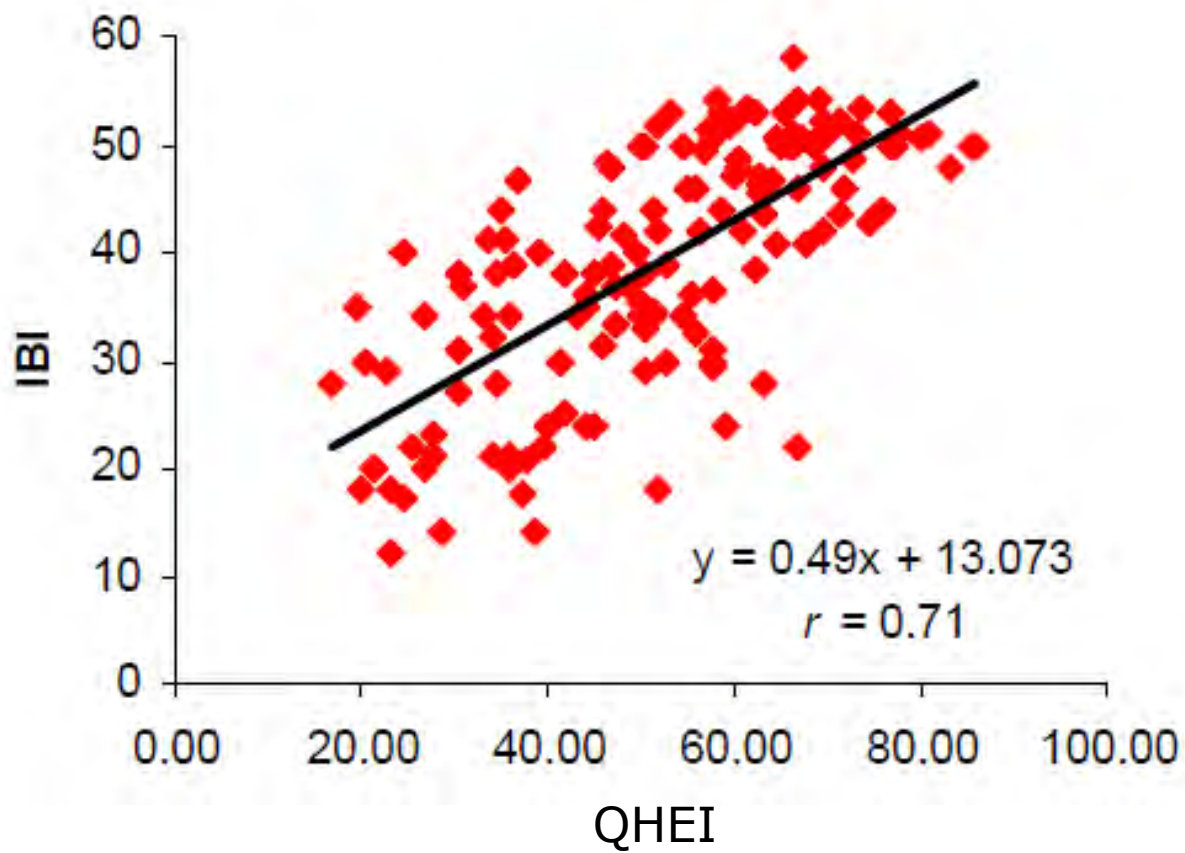
1 BWQ Annual Fish Community Report

2 BWQ Annual Fish Community Report

3 BWQ Annual Pretreatment Report



**CHA. 2.76** QHEI Metric Scores, BWQ



**CHA. 2.77** IBI Metric Scores, BWQ

## Correlation Tables

The following tables list the Pearson's correlation coefficient ( $r$ ) between IBI and QHEI scores. Significant relationships ( $P < 0.05$ ) are highlighted in orange.

All sites from 2004 - 2010

	IBI score	Metric #1	Metric #2	Metric #3	Metric #4	Metric #5	Metric #6	Metric #7	Metric #8	Metric #9	Metric #10	Metric #11	Metric #12
QHEI	0.72	0.38	0.34	0.55	0.26	0.68	0.59	0.61	0.60	0.35	0.41	0.34	0.49
Substrate Score	0.66	0.31	0.32	0.47	0.27	0.56	0.58	0.58	0.50	0.32	0.42	0.32	0.44
Cover Score	0.56	0.34	0.22	0.47	0.23	0.51	0.31	0.49	0.51	0.32	0.32	0.28	0.32
Channel Score	0.60	0.36	0.33	0.46	0.20	0.59	0.52	0.50	0.46	0.24	0.30	0.25	0.40
Riparian Score	0.39	0.18	0.17	0.45	-0.01	0.42	0.34	0.28	0.32	0.25	0.24	0.16	0.18
Pool/Current Score	0.65	0.37	0.33	0.45	0.21	0.64	0.46	0.53	0.58	0.27	0.32	0.31	0.50
Riffle/Run Score	0.62	0.37	0.34	0.39	0.21	0.62	0.56	0.47	0.52	0.27	0.30	0.26	0.47
Gradient Score	0.46	0.10	0.07	0.39	0.19	0.37	0.49	0.42	0.35	0.30	0.34	0.18	0.28

**TABLE. 2.83** IBI Correlation. BWQ

## IBI, MIwb, and QHEI Ratings

Wading Sites:			
<u>IBI Score</u>	<u>MIwb Score</u>	<u>QHEI Score</u>	<u>Rating</u>
53-60	> 9.4	90-100	Excellent
45-52	8.3-9.3	71-89.9	Good
35-44	5.9-8.2	52-70.9	Fair
23-34	4.5-5.8	27-51.9	Poor
12-22	< 4.5	0-26.9	Very poor
<12	0		NO FISH FOUND

Headwater Sites:			
<u>IBI Score</u>	<u>MIwb Score</u>	<u>QHEI Score</u>	<u>Rating</u>
53-60	Not applicable to headwater sites	90-100	Excellent
45-52		71-89.9	Good
35-44		52-70.9	Fair
23-34		27-51.9	Poor
12-22		0-26.9	Very poor
<12			NO FISH FOUND

TABLE. 2.84 IBI, MIwb, and QHEI Ratings, BWQ



# 319 QHEI, IBI, Drainage

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 4

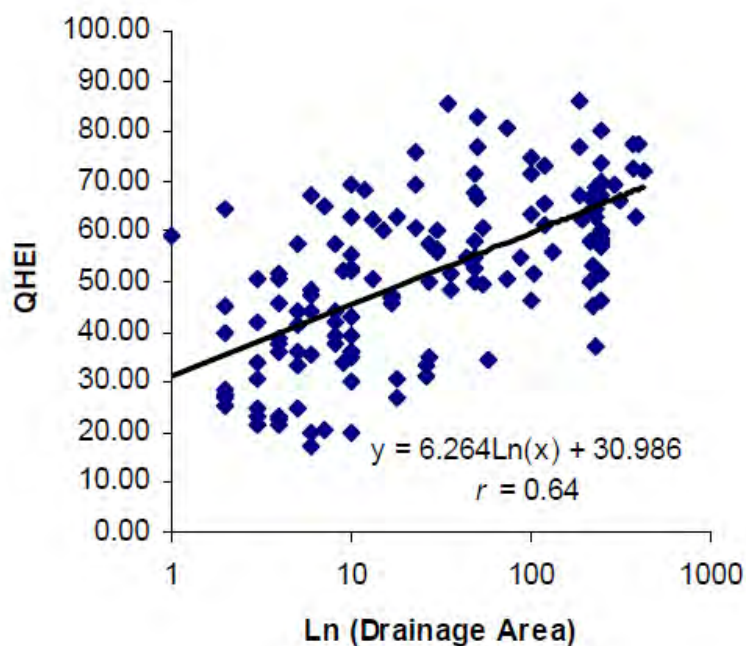
### IBI, QHEI, and drainage

"Since 2004, the Muncie Bureau of Water Quality has sampled 147 individual sites (many sampled more than once). During this time period, a significant positive relationship was detected between IBI scores and QHEI scores as would be expected given the dependency of biota on habitat. All QHEI metrics were found to be significantly correlated to IBI scores. Additionally, IBI metric #4, the number of sucker/minnow species, appeared to have the weakest correlation to QHEI metrics."<sup>1</sup>

In addition to examining the relationship between IBI and QHEI scores, IBI and QHEI scores were compared with drainage area (Chart 2.78). Drainage area had a significant positive relationship with IBI and QHEI scores. Each index is designed to assess streams irrespective of drainage area; therefore, the implication is that smaller streams are either more likely to be altered or are more susceptible to equivalent alterations than larger streams.<sup>2</sup>

Based on the studies, QHEI does not appear to influence IBI scores as strongly as standard linear regression suggests. It is important to note that this analysis does not suggest habitat is not influencing the fish community at the other sites. The analysis is merely suggesting that there are limiting factors at those sites other than reach scale instream habitat. It is also possible that individual metrics within the QHEI are having conflicting or differential influences on the fish community.<sup>3</sup>

This analysis suggests that the IBI can not be compared with the QHEI using standard linear models.<sup>4</sup>



CHA. 2.78 QHEI per Drainage Area, BWQ

- 1 BWQ Annual Fish Community Report
- 2 BWQ Annual Fish Community Report
- 3 BWQ Annual Fish Community Report
- 4 BWQ Annual Fish Community Report



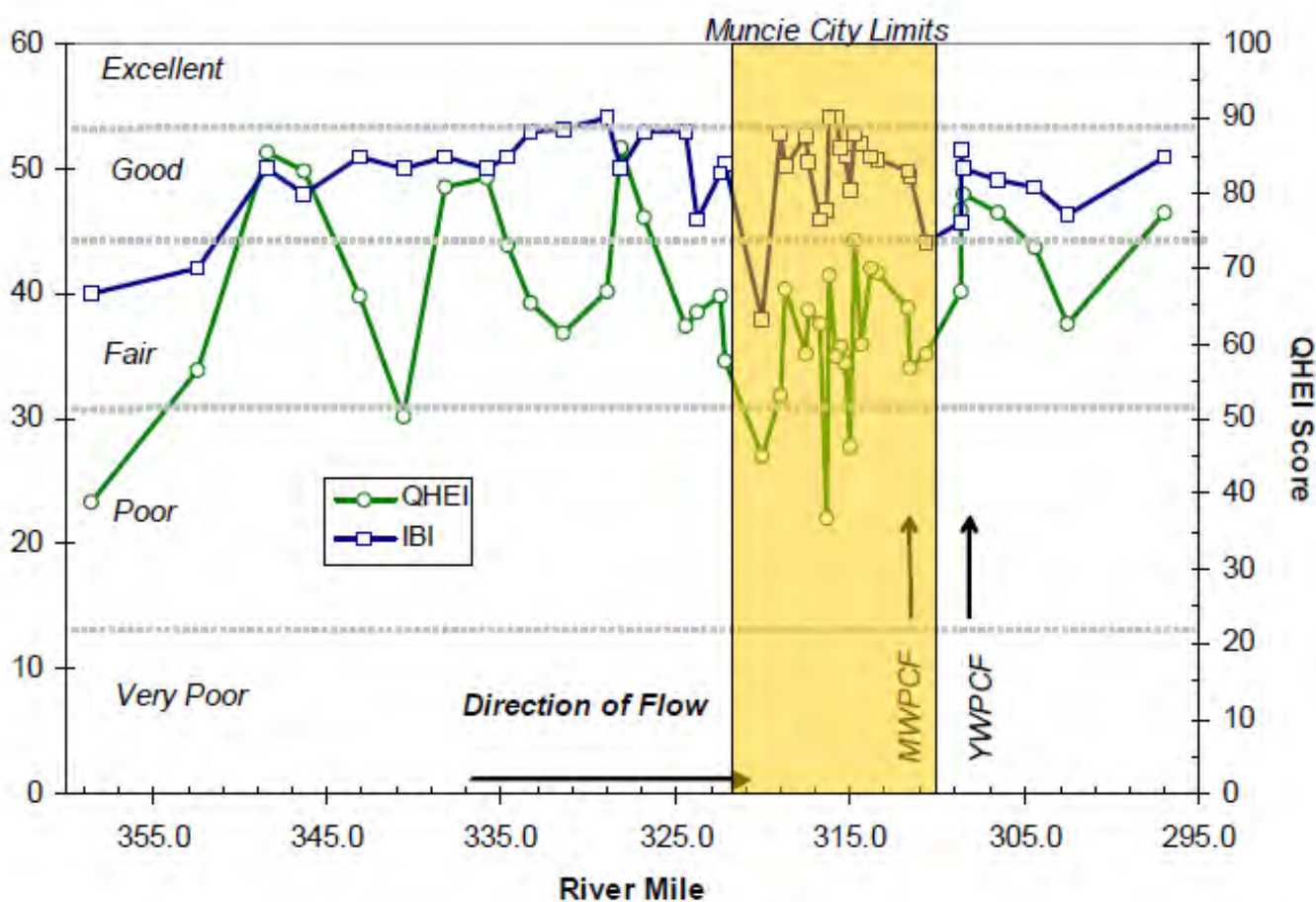
# White River Spatial Variability

## WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 5

### White River spatial variability

"Spatial biotic integrity and habitat index score trends through Muncie reflect the cumulative impact the city imparts on the water quality of White River. Index of Biotic Integrity scores fluctuate along White River as it flows from sites above Muncie's influence to within the city where there is impact of urban land use, CSOs, and the Muncie Water Pollution Control Facilities (MWPCF) and Yorktown (YWPCF) are present."<sup>1</sup>

"The results suggest that both habitat and urbanization pressures are related to a higher percentage of omnivores while the actual percentage remains below a level for concern. However, if a noticeable (and significant) increase can be detected with only the influence of Muncie the combined influences of other municipalities downstream in addition to Muncie likely compound the effects. Pair-wise comparisons of this model suggest sites downstream of Muncie are significantly lower than sites within city limits but not significantly different than sites upstream. These results suggest urbanization is imparting a marginally negative affect."<sup>2</sup>



CHA. 2.79 Mainstem White River IBI and QHEI scores, BWQ

<sup>1</sup> BWQ Annual Fish Community Report  
<sup>2</sup> BWQ Annual Fish Community Report

# Comparison of Subwatersheds

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 6

### HUC-12 watershed comparisons

"Six HUC-12 watersheds were evaluated to determine differences in IBI scores. Both QHEI scores and watershed had a significant effect on total IBI scores. The interaction term was also significant indicating that the relationship between IBI and QHEI scores differ among watersheds. This outcome is not surprising since some watersheds are dominated by White River sites while others are dominated by headwater streams. As discussed in the previous section, headwater streams are more susceptible to equivalent alterations than larger streams." <sup>1</sup>

"Pair-wise comparisons indicated the White River – York Prairie Creek (WRYPC) (Map 2.82) watershed was the most unique as it was significantly different than all the other watersheds except the Jake's Creek – Eagle Branch (JCEB) watershed. The WRYPC watershed primarily includes sites on York Prairie Creek which typically has the lowest scoring IBI sites. This watershed is also heavily influenced by urbanization pressures such as storm water runoff. Likewise the JCEB watershed is also influenced by urbanization pressures. Adjusted means for the two watersheds were the lowest of the 6 analyzed." <sup>2</sup>

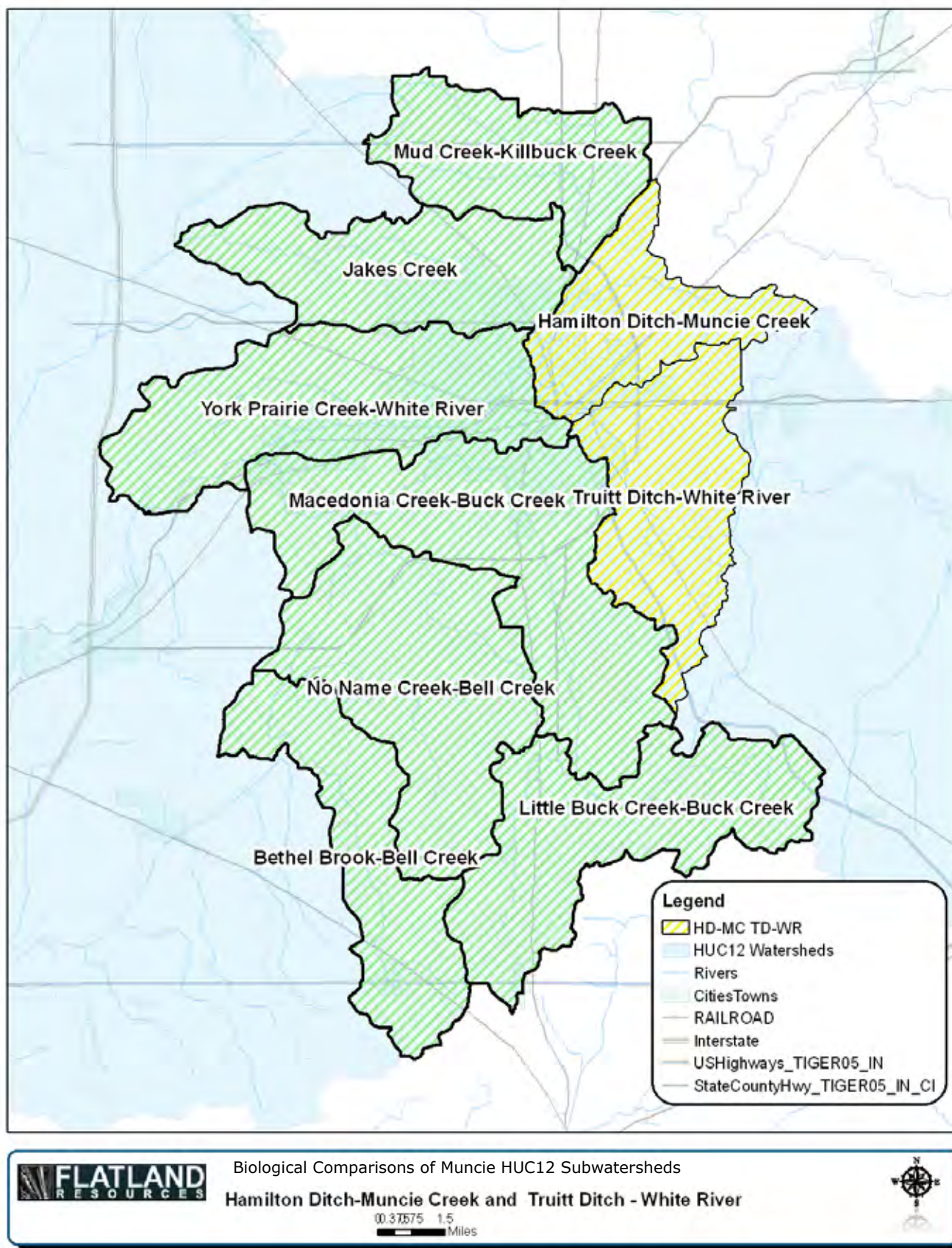
"Both being below the score the Indiana Department of Environmental Management considers "Impaired". However, it is important to note the adjusted mean is the estimated score after removing the influence of habitat and treating each watershed as if they all had the same quality of habitat. The raw means at these watersheds are 33.8 (WRYPC) and 29.4 (JCEB). This suggests that while habitat is playing a role in determining biological integrity, these two watersheds are notably different from the others when habitat (i.e. QHEI) is held equal among watersheds." <sup>3</sup>

"Similarly, the three highest scoring watersheds; White River – Buck Creek (WRBC), White River – Truitt Ditch (WRTD), and White River – Muncie Creek (WRMC) were not significantly different from each other. These watersheds contain four or more White River sites each contributing to the similarities. The highest scoring watershed, White River – Buck Creek (raw mean IBI = 48.5) is made up of 13 sites from White River and 3 from Buck Creek. Even after accounting for habitat these sites are generally of fair quality (adjusted mean IBI = 44.8). The WRTD watershed has the second highest raw IBI score (45.1) and the second highest adjusted mean IBI score (42.1). This watershed contains the lowest percentage of total impervious cover (3.5%) and second lowest amount of agricultural row crop (29%). The third watershed of this group, WRMC, also has relatively low impervious cover (7.1%) but one of the highest agricultural row crop (43%) and agricultural pasture (17%)." <sup>4</sup>

This data confirms Maintstem White River Studies that concluded York Prairie Creek - White River and Jake's Creek were more impaired than Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds.

1 BWQ Annual Fish Community Report  
2 BWQ Annual Fish Community Report  
3 BWQ Annual Fish Community Report  
4 BWQ Annual Fish Community Report





**MAP. 2.82** Biological Comparisons of Muncie HUC12 Subwatersheds

# Ecoregional Comparisons

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 7

The Muncie Bureau of Water Quality compared IBI scores based on locations in specific ecoregions. (2.81) Because the City of Muncie is on the cusp of three major ecoregions, one for one comparisons between sampling points could be influenced by ecoregional differences.

### Clayey High Lime Till Plains (CHLTP)

"Biotic integrity and habitat scores were poor at most sites sampled in this ecoregion. The mean IBI score was 34.0 poor, and the mean QHEI score was 47.5 poor. The most abundant taxon by number were Cyprinids (51%) followed by Catostomidae (22%), Centrarchidae (11%), and Percidae 9%. The bluntnose minnow, *Pimephales notatus*, was the dominant species by number (25%) and goldenredhorse *Moxostoma erythrurum* (32%) were the dominant species by weight." <sup>1</sup>

### Loamy High Lime Till Plains (LHLTP)

"Mean IBI score for this region was 44.6 fair and the mean QHEI score was 62.3 fair. Sample site selection within the LHLTP was biased towards White River due to its proportional presence within the ecoregion. Cyprinids were the dominant family (41%). Similar to the CHLTP, bluntnose minnow was the dominant species by number (13%) followed by golden redhorse (13%), spotfin shiner *Cyprinella spiloptera* (9%) and rock bass (6%). Golden redhorse were the dominant species by weight (33%) followed by common carp *Cyprinus carpio* (16%)." <sup>2</sup>

### Whitewater Interlobate Area (WIA)

"The mean IBI score from this region was a 39.9 fair and the mean QHEI score was a 60.1 fair. Centrarchidae was the dominant family (32%) followed by Cyprinidae (26%), Catostomidae (17%), and Cottidae (16%). Green sunfish was the dominant taxon by number (30%) followed by mottled sculpin *Cottus bairdi* (16%) and creek chub *Semotilus atromaculatus* (14%). White suckers *Catostomus commersonii* were the dominant species by weight (37%) followed by creek chubs (15%) and northern hog suckers *Hypentelium nigricans* (12%). The thermal regime of Buck Creek is indicative of a coolwater stream (Conrad 2005). Therefore, the fish community is biased towards species that prefer coolwater and the Indiana IBI is not calibrated to adequately represent a coolwater fish community." <sup>3</sup>



**MAP. 2.83** Ecoregions of Delaware County, BWQ

1 BWQ Annual Fish Community Report

2 BWQ Annual Fish Community Report

3 BWQ Annual Fish Community Report

## QHEI

"Four QHEI metrics were significantly different among Ecoregions. Overall the CHLTP has the lowest QHEI score on average ( $47.5 \pm 4.3$ ) followed by the WIA ( $60.1 \pm 1.5$ ) and the LHLTP ( $62.3 \pm 1.8$ ). Of the significant metrics, Cover, Channel, Pool/Current, and Gradient Scores were lowest in the CHLTP. It is interesting that the Riparian Scores were not significantly different and the median values were the same for all three Ecoregions. Considering the difference in lithophilic spawners you would assume varying degrees of Riparian Scores. This is explained by the difference in Substrate Scores. Lithiphiles need both high quality substrate and low to moderate amount of silt. Therefore it is concluded that while the Riparian Scores are relatively low and act as a negative influence on the fish communities the difference in Substrate Scores are driving the observed differences in lithophilic spawners."

## IBI

"The three Level IV Ecoregions within Delaware County have significantly different IBI and QHEI scores. The LHLTP has the highest mean IBI score and the highest mean QHEI score while the CHLTP has the lowest mean IBI score and the lowest mean QHEI score. Seven IBI metrics and 4 QHEI metrics were significantly different among Ecoregions (MAP 2.83). Three IBI metrics, the number of sunfish species (3), the number of sucker species (4), and percent individual top carnivores (9), were only significant for wading sites. Their corresponding headwater metrics were not significant. Metric 3 and 4 differences reflect the dominance of Buck Creek sites in the WIA where the coolwater regime tends to favor sculpins over darters and tend to have a more diverse sucker assemblage. In contrast Metric 9 differences reflect the dominance of White River sites in the LHLTP. Due to its size, White River is more conducive to a higher abundance of top carnivores particularly Smallmouth Bass and rock bass. Similarly differences in Metrics 1, 5, and 10 are due in large part to White River being the predominant stream sampled in the LHLTP. These metrics are calibrated to reflect a positive relationship with drainage area. For example, collecting 10 species at a site with a drainage area of 10 mi<sup>2</sup> would yield an IBI metric rating of 3 while the same number of species at a site with a drainage area of 1000 mi<sup>2</sup> would yield an IBI metric rating of 1. The remaining metrics that were significantly different does not show the same relationship with drainage area. Metric 6, percent tolerant individuals were highest in the WIA (59.14) and CHLTP (49.21). This metric detects a decline in stream quality from fair to poor (Simon & Dufour 1997). The differences are likely due to poor habitat, storm water, and agricultural pressures at the headwater streams in these Ecoregions. Similarly Metric 10, percent simple lithophilic spawners, reflects pressure from poor habitat, storm water, and agricultural pressures. Lithophilic spawners require clean gravel or cobble for successful reproduction and have been shown to have a negative relationship with increased siltation (Berkman and Rabeni 1987). Siltation originates from stream bank erosion and row crop agriculture brought on by poor riparian zone practices." <sup>4</sup>

## EcoRegions

"Underlying ecoregion characteristics have led to a differentiation in habitat and fish communities. The CHLTP is described as having less productive soil with turbid, low gradient streams. These characteristics have led to more artificial drainage and clear cutting of the stream riparian zone to increase drainage efficiency, compounding anthropogenic influences on the fish communities. In contrast, the LHLTP are inherently more efficient in natural drainage reducing the amount of channelization and clear cutting that has been necessary to increase drainage. Lastly, the WIA contains distinctively cool water that is predominantly fed by groundwater. The unique thermal regime has led to a fish community that includes mottled sculpin, two species of dace, and native lampreys. When attempting to compare fish communities from these three Ecoregions it is important to take into consideration the unique characteristics that are beyond the control of managers and inherently promote different fish communities." <sup>5</sup>

4 BWQ Annual Fish Community Report

5 BWQ Annual Fish Community Report



# Fish Consumption Advisory

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 8

Three state agencies collaborate annually to compile the Indiana Fish Consumption Advisory (FCA). The Indiana Department of Natural Resources, Indiana Department of Environmental Management, and Indiana State Department of Health have worked together since 1972 on this effort (Table 2.85). Samples are collected through IDEM's rotating basin assessment for bottom feeding, mid-water column feeding, and top feeding fish. Fish tissue samples are then analyzed for heavy metals, PCBs, and pesticides. Advisories listings are as follows:<sup>1</sup>

TABLE 2.85: Group Classifications for Fish Consumption Advisory	
Group 1	Unrestricted consumption. One meal per week for women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15.
Group 2	Limit to one meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15.
Group 3	Limit to one meal per month (12 meals per year) for adult males and females. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 do not eat.
Group 4	Limit to one meal every 2 months (6 meals per year) for adult males and females. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 do not eat.
Group 5	No consumption (DO NOT EAT).

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

- (1) All streams in the Muncie Creek-Hamilton Ditch and Truitt-Ditch-White River are Impaired for carp and should not be eaten.
- (2) The White River is under a fish consumption advisory for selected fish of select size within the length of the river.

<sup>1</sup> Wabash River (Region of the Great Bend) WMP

TABLE 2.86: Delaware County Fish Consumption Advisory Ranking

Location	Species	Fish (in.)	Contaminant	Group
All Rivers and Streams	Carp	15-20	PCBs	3
All Rivers and Streams	Carp	20-25	PCBs	4
All Rivers and Streams	Carp	25+	PCBs	5
Buck Creek	Longear Sunfish	5-6	PCBs	3
Buck Creek	Longear Sunfish	6+	PCBs	4
Buck Creek	Smallmouth Bass	11+	PCBs	3
Buck Creek	White Sucker	14+	PCBs	3
West Fork White River	Black Bullhead	9+	PCBs	3
West Fork White River	Bluegill	6+	PCBs	3
West Fork White River	Channel Catfish	ALL	PCBs	5
West Fork White River	Green Sunfish	6+	PCBs	3
West Fork White River	Largemouth Bass	10-15	Mercury,PCBs	3
West Fork White River	Largemouth Bass	15+	PCBs	4
West Fork White River	Quillback	13-18	PCBs	3
West Fork White River	Quillback	18+	PCBs	4
West Fork White River	Redhorse species	Up to 16	PCBs	3
West Fork White River	Redhorse species	16+	PCBs	4
West Fork White River	Rock Bass	9+	PCBs	3
Prairie Creek Res.	Bluegill	Up to 8	NA	1
Prairie Creek Res.	Carp	Up to 19	NA	1
Prairie Creek Res.	Carp	19+	Mercury,PCBs	2
Prairie Creek Res.	Largemouth Bass	Up to 11	NA	1
Prairie Creek Res.	Smallmouth Bass	Up to 11	NA	1
Prairie Creek Res.	Yellow Perch	Up to 7	NA	1
Prairie Creek Res.	Walleye	Up to 14	NA	1
Prairie Creek Res.	White Crappie	Up to 8	NA	1

SOURCE: Fish Consumption Advisory Ranking



# Public Health IWMA

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 9

The release of toxic materials into the aquatic environment can produce effects in several ways:

- (1) Contaminants present in acutely toxic amounts may kill fish or other aquatic organisms directly;
- (2) Substances present in lesser, chronically toxic amounts can reduce densities and growth rates of aquatic organisms and/or become concentrated in their body tissues. These substances can be further passed on to humans through consumption of the organism; and
- (3) Toxic materials in the water could potentially affect human health by contaminating public water supplies. However, at this time IDEM has no data to indicate that there have been any adverse human health effects due to toxic substances in surface water supplies.

In the last several years, advances in analytical capabilities and techniques and the generation of more and better toxicity information on chemicals have led to an increased concern about their presence in the aquatic environment and the associated effects on human health and other organisms. Because many pollutants are likely to be found in fish tissue and bottom sediments at levels higher than in the water, much of the data on toxic substances used for fishable use assessments in this report were obtained through the fish tissue and surficial aquatic sediment contaminants monitoring program.<sup>1</sup>

While not all species of fish found in Indiana lakes and streams nor all waters have been tested, carp are commonly found to be contaminated with both polychlorinated biphenyls and mercury at levels exceeding the state's benchmark criteria for these contaminants in fish tissue. Fishable use assessments are reported separately from aquatic life use in order to provide more information about each individual designated use.<sup>2</sup>

It is expected that as more lakes and streams are monitored, toxicants will be found at levels of concern in the new samples (i.e., mercury and/or PCBs).<sup>3</sup>

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1 Surface Water Assessment Report

2 Indiana Integrated Water Monitoring and Assessment Report

3 Fish Consumption Advisory

A diverse and healthy fish community is considered an indication of good water quality. Serious public concern is generated when dead and dying fish are noted in the aquatic environment since this is sometimes evidence of a severe water quality problem and may indicate the long term loss of use of affected water as a fishery.<sup>1</sup>

A fish kill can result from:

- (1) The accidental or intentional spill of a toxic compound or oxygen-depleting substance into the aquatic environment;
- (2) Continuous industrial or municipal discharge which may release, due to a system upset, an atypical effluent containing high concentrations of pollutants; and
- (3) Natural causes such as disease, extreme drought, or depletion of dissolved oxygen from extreme weather conditions.

IDEM's Office of Land Quality tracks spills and fish kills that are reported to IDEM or discovered by agency staff. The total number of each recorded from 1998 to 2007 are listed in Table 2.87.<sup>2</sup> No fish-kills have been reported in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds.

A significant fish kill occurred downstream of Muncie in mid-December 1999. An unknown pollutant had passed through the Anderson wastewater treatment plant and entered the river, causing one of the state's worst environmental disasters. The pollution spread for 50 miles into three counties.<sup>3</sup>

TABLE 2.87: Statewide Fishkill Data			
Year	Calls	Spills	Fish Kills
1998	2649	1393	28
1999	2507	1246	41
2000	2930	1491	43
2001	3093	1591	51
2002	3043	1666	55
2003	3026	1551	30
2004	2829	1406	37
2005	3319	1271	40
2006	3319	1368	31
2007	2852	1354	36
SOURCE: Surface Water Assessment Report			

<sup>1</sup> Indiana Integrated Water Monitoring and Assessment Report

<sup>2</sup> Indiana Integrated Water Monitoring and Assessment Report

<sup>3</sup> Indianapolis Star, indystar.com

# Macroinvertebrates

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 10

"As with fish communities, benefits to using mussels and macroinvertebrate communities as indicators of water quality is their longevity and sensitivity to disturbances in the habitat in which they live. The observed condition of the aquatic biota, at any given time, is the result of the chemical and physical dynamics that occur in a water body over time (OEPA DWQMA 1987). Alone, neither gives a complete picture of water quality, however, the combination of biological and chemical monitoring increases the chances that degradation to the water body will be detected (Karr 1991)".

### **Mussels as biomonitors**

"Mussels are in a rapid state of decline (Ricciardi and Rasmussen 1999, Vaughn and Taylor 1999, Strayer and Smith 2003, Lydeard et al. 2004, Poole and Downing 2004, Strayer et al. 2004). At one time, 90 species of Unionid (of the family Unionidae) mussels were known to have existed in the eight Great Lake and Upper Mississippi states. Now, 33% are listed as extinct, endangered, or are candidates for that listing (Ball and Schoenung 1995). In the United States, 71 taxa are currently listed as endangered or threatened by the Endangered Species Act (USFW 2005), and are suffering an extinction rate higher than any other North American fauna (Ricciardi and Rasmussen 1999). Contributors to this decline include commercial harvest, degradation of habitat (including channelization and dredging), toxic chemicals, and siltation. Other significant contributors include: impoundments (Watters 2000, Vaughn and Taylor 2004), water pollution (organic, inorganic, and thermal), habitat alterations, and land use practices (Clarke 1981; Ball and Schoenung 1995; Biggins et al. 1995; Couch 1997; Gatenby et al. 1998; Payne et al. 1999; Watters 1999; Poole and Downing 2004). In 1990, the US EPA listed sedimentation as the top pollutant of rivers in the United States (Box and Mossa 1999). This affects mussels by reducing interstitial flow rates, clogging mussel gills and reducing light for photosynthesis of algae (primary forage of the mussel). Suspended particles also cause difficulty with the necessary fish and mussel interactions needed for reproduction and survival (Box and Mossa 1999). These indicate the importance of water quality as a factor in mussel survival. It is for these reasons, as well as their long life span, feeding habits, persistent shells (Strayer 1999) and sensitive growth and reproductive rates (Burky 1983) that mussels serve well as biological indicators."

### **Macroinvertebrates as biomonitors**

"There are numerous reasons for using macroinvertebrates as indicators of water quality. Their ubiquitous nature, large numbers (individuals and species), and relative ease of sampling with inexpensive equipment make them ideal for bioassessments (Lenat et al. 1980; Hellawell 1986; Lenat and Barbour 1993). Macroinvertebrates are relatively sessile, allowing a spatial analysis of disturbances (Tesmer and Wefring 1979; Hellawell 1986; Abel 1989). The extended 7 life cycles of most aquatic insects allows for temporal analysis as well (Lenat et al. 1980; Hellawell 1986; Abel 1989). Finally, macroinvertebrate species are well documented; many identification keys and forms of analysis are available, and specific responses to pollutants and stressors are well known (Hellawell 1986; Abel 1989; Rosenberg and Resh 1993)".



Macroinvertebrate (Aquatic Insect) And Mussel Community Report 2010  
Muncie Bureau of Water Quality.

TABLE 2.88: Macroinvertebrate Data for Muncie Creek and Truitt Ditch Basins

	TD-1	MC-1
mIBI Submetrics		
Total # of Taxa	5	3
Total Abundance	3	1
Number EPT Taxa	3	3
% Orthocladiinae & Tanytarsini	5	5
% Non-Insects (-Crayfish)	3	5
# Diptera Taxa	1	1
% Intolerant Taxa (Score 0-3)	1	1
% Tolerant Taxa (Score 8-10)	5	5
% Predators	3	5
% Shredders & Scrapers	5	1
% Collectors/Filterers	5	5
% Sprawlers	3	5
	42 (Fair)	40 (Fair)

SOURCE: Muncie Bureau of Water Quality

# Macroinvertebrates Results

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 11

### Macroinvertebrates- 319 Watershed Grant

"Sites in the 319 Watershed Grant study are highly variable (Table 2.88). The best sites appear to be Huffman Ditch, with the best mIBI, H', % Chironomidae, and QHEI score, and Killbuck Creek, with the best mIBI, H', "Percent Dominance of Top Three Taxa", and "Percent Chironomidae". The worst sites appear to be Buck Creek, with one of the worst mIBI, HBI, and "Percent Dominance of Top Three Taxa", and Prairie Creek Spillway, with the worst mIBI, HBI, and "Percent Chironomidae". Prairie Creek Spillway also had one of the worst QHEI scores, limiting biological potential at this site. This site is a non-traditional site; it is essentially a drain from the Prairie Creek Reservoir Spillway to White River. Assessments at this site must be made with this consideration. The other site with the lowest QHEI score was Truitt Ditch, which was recently clear-cut on the south bank. This indicates that biological quality is most likely limited by the habitat quality at this site."

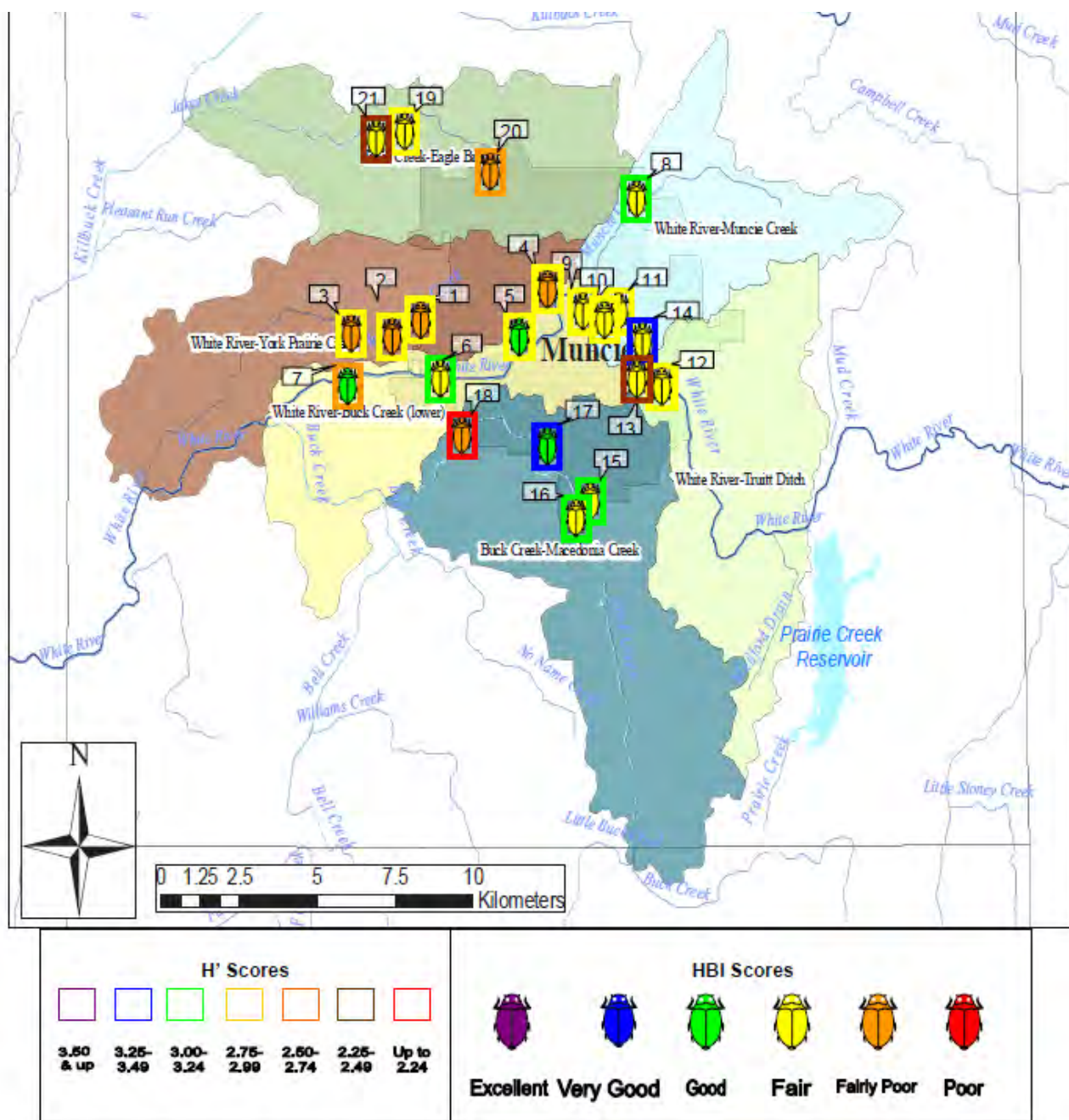
"Dramatic improvements have been seen County-wide since the inception of Muncie Bureau of Water Quality's macroinvertebrate and mussel sampling program. Point source pollutants have been controlled through the utilization of local permits regulated by the Bureau of Water Quality. Improvements have been and continue to be made to our Water Pollution Control Facility. Whereas most analyses have been focused on White River, studying the tributaries and nonpoint source pollution impacting them has become critical. These impacts on water quality include hydromodifications (channelization, impoundments, dredging, and removal of riparian zone), storm water (sources include CSOs, SSOs, and impervious surfaces), and sedimentation. In 1990, the US EPA listed sedimentation as the top pollutant of rivers in the United States (Box and Mossa 1999), and it has been determined that reduces water quality is detectable at > 15% impervious surface (Roy et al. 2003)."

"This shift in focus requires public outreach, education, and cooperation to instill better agricultural and storm water practices throughout Delaware County. These include buffer strips, rain barrels, rain gardens, better construction site practices, and the further separation of CSOs. As better management practices are implemented, it is expected that water quality will continue to improve."

"Overall, the systems in this area appear to be in good condition, especially considering the industrial, urban, and agricultural areas through which they flow. Efforts by the citizens of Delaware County, the City of Muncie, the Muncie Sanitary District, the Bureau of Water Quality, and the industrial community are responsible for the improvements in water quality since the Muncie was established in 1972."



Macroinvertebrate (Aquatic Insect) And Mussel Community Report 2010  
Muncie Bureau of Water Quality.



**MAP. 2.84** Macroinvertebrate Scores



# Macroinvertebrates Results

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 12

### Macroinvertebrates (mIBI)

"Aquatic macroinvertebrates are important indicators of environmental change in streams and rivers. The insect community composition reflects water quality and research demonstrates that different macroinvertebrate orders and families react differently to pollution sources. Indices of biotic integrity are valuable because aquatic biota integrate cumulative effects of sediment and nutrient pollution (Ohio EPA, 1995). The scores range from 0 to 60. Macroinvertebrates are sampled according to the current macroinvertebrate Index of Biotic Integrity (mIBI) (IDEM 1992). Each site was sampled once per year between July and September."

### White River/Muncie Creek Subwatershed (HUC 05120201010130)

"All sites in this Subwatershed were rated Fair. The HBI score at Holt Ditch 0.1 has consistently improved since 2005. An average of mean HBI and H' scores for 2005-2009 and 2009 mean HBI and H' scores were one of the highest at this Subwatershed. H' scores at Muncie Creek 2.2 and White River 317.2 were the highest recorded since 2005. EPTC ratios were highly dominated by Chironomidae at Muncie Creek 2.2, White River 317.2, and Holt Ditch 0.1. The EPTC ratio at Muncie Creek 0.1 was dominated by intolerant organisms. QHEI scores ranged from Poor to Fair. The Poor QHEI score at Holt Ditch 0.1 indicates that biological potential is limited at this site due to inadequate habitat."

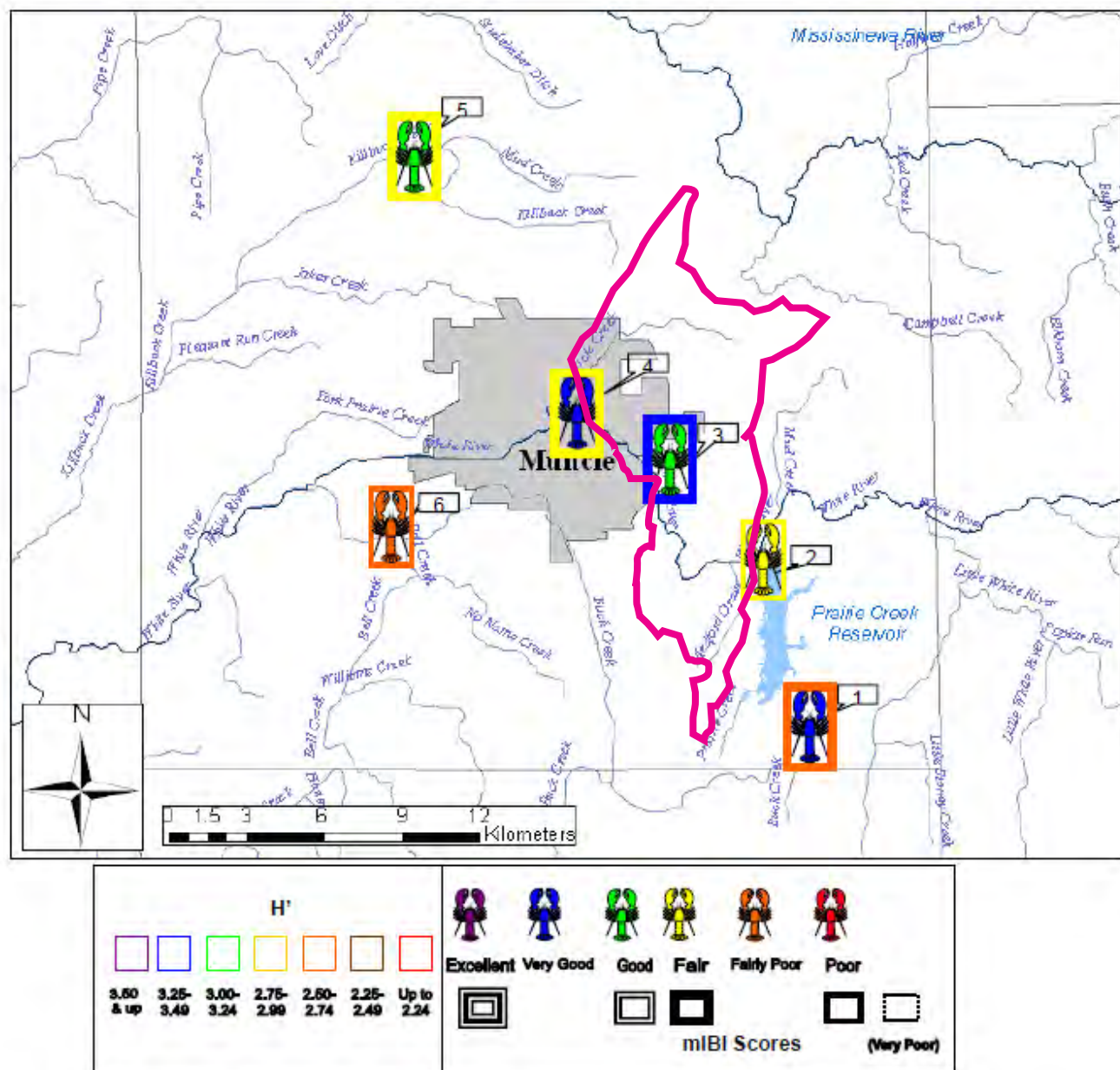
### White River/Truitt Ditch Subwatershed (HUC 05120201010120)

"The HBI score at White River 319.9 was the lowest recorded since 2005. H' scores were the highest of all 2009 sites at Truitt Ditch 0.1, and the highest recorded since 2005 at this site. An average of mean HBI and H' scores for 2005-2009 and the 2009 mean H' scores for this Subwatershed were one of the highest at this Subwatershed. Despite a Fair HBI score, the highest H' score of all sites in 2009, and a Good QHEI score, Truitt Ditch 0.1 was highly dominated by Chironomids, with little representation by intolerant orders. EPTC ratios were dominated by intolerant organisms at White River 319.9 and 318.3, and by tolerant organisms (Chironomidae) at TRU 0.1. QHEI scores were Poor at White River 319.9, and Good at the remaining sites in this Subwatershed."



Macroinvertebrate (Aquatic Insect) And Mussel Community Report 2010  
Muncie Bureau of Water Quality.





**MAP. 2.85** Aquatic Insect Scores

Total Score	Rating
55-60	Excellent
45-54	Good
35-44	Fair
22-34	Poor
0-21	Very Poor

# Summary of Biological Reports

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 13

### Overall Findings

The primary purpose of the biological reports are to confirm existing chemical data conclusions, and/or discover new impairments. The rationale for incorporating these biological studies (as with all studies) is to aid in discovering and developing a method of prioritizing water quality mitigation (i.e. a method to rank Subwatersheds/basins).

As a stand alone metric (with our current range of data) the biological studies are ineffective at ranking at the sub basin level. That is to say, the WRWP lacks the ability to make 100% correlation between the biological and chemical data because less sample sites occurred along the tributaries than on the White River, and in some cases, no IBI scores were taken on tributaries where there was chemical testing. Because the Subwatershed wide IBI/QHEI scores were rated on sampling points dominated by sites along the main stem of the White River, it is inconclusive when considering the same rating based on tributary analysis (or basin by basin comparisons) as used by the chemical studies. Furthermore, the Subwatersheds (Hamilton Ditch-Muncie Creek and Truitt Ditch - White River) rank out equal.

The ecoregional comparison does not rank out equal. The study concludes that Hamilton Ditch - Muncie Creek, has greater impairment due to its location in proximity to the CLP ecoregion and other general/overall county-wide ecoregional trending. However, as noted by the Muncie BWQ, the ecoregional comparison also has the most variables and prohibits one-for-one comparison (due to ecoregional differences). Because conclusions based on ecoregional comparisons are suspect, we will not use the ecological conclusions as a case for cost-share prioritizing.

Although this analysis does not aid in prioritizing Hamilton Ditch - Muncie Creek and Truitt Ditch-White River Subwatersheds against each other, holistically (due to limited sampling points), it does demonstrate the relationship between the IBI and chemical data monitoring. It confirms that there are impairments inhibiting healthy fish communities along the Muncie Creek and Truitt Ditch tributaries (because we don't have data on the other tributaries we can't say that these tributaries have priority over other non sampled tributaries). This is consistent with other research (319, 303(d) etc) indicating that Muncie Creek and Truitt Ditch are both impaired.

In conclusion, it is difficult to make priority area decisions with the current Biological data, when decisions are based on comparisons of HUC12 Subwatersheds, especially when most of the sampling is done on the Main stem of the White River and all rankings average out to be fair-good.

Overall the IBI scores along the West Fork of the White River are good. However, county tributaries in the county are considered impaired. This is supported in the IBI studies and comparisons of IBI and QHEI. These County-wide IBI/QHEI studies correspond to the Mainstem chemical studies when Subwatershed comparison indicate the greatest impaired HUC 12 Subwatershed to be York-Prairie Creek and Jakes Creek. Hamilton Ditch - Muncie Creek and Truitt Ditch-White River rate "Fair" in these HUC12 comparisons. Subwatershed to Subwatershed comparisons (in the Muncie MS4 area) indicate that Hamilton Ditch - Muncie Creek and Truitt Ditch-White River fair well in these HUC12 comparisons.

### QHEI

In order to quantify the relationship between IBI score and habitat, the Muncie BWQ performs a

study called a QHEI. This analysis is performed at the location of IBI measurements and this makes it possible to do a direct comparison of the fish communities and the quality of habitat. This shows a correlation in the QHEI metrics (vegetation on the banks, and substrate, etc.) to the fish community. It supports the notion that the presence of a thriving fish community indicates the presence of a thriving overall ecology. (This is more of the case in tributaries than in the main stem of the White River). There is a strong correlation between IBI and QHEI scores, meaning there is direct correlation between a fish community and its habitat.

There is less of a correlation between a strong QHEI score and IBI score when drainage is considered a factor. (Ie. size of stream channels). General trends show that tributaries are more susceptible to impaired fish communities when habitat is rated with a low QHEI score, than on the main stem of the White River. When one compares the IBI/QHEI relationship on tributaries and on main stems, there is less of a correlation on the main stems. Main stem areas that lack vegetation do not have as a dramatic negative impact on the fish communities as do when the same linear feet are missing on the tributaries. The Main stem essentially allocates the negative impacts (of loss of habitat) across itself and distributes it. When the riparian community is compromised along a tributary, the impacts on the fish community are greater. One can notice this trending on the Mainstem of the White River. QHEI drops at a higher frequency in Muncie City limits, but the IBI does not move with this increase of activity. The White River has a relatively high overall QHEI score when compared to most Tributaries in the County but a low QHEI score in the city limits when compared to the County. This is largely in fact due to the Levee system (hydromodification) and the devegetation of one side of the bank for cultural reasons. For these reasons, tributaries that lack habitat will be considered priority over mainstem White River sections that lack habitat.

### **Muncie Creek**

Muncie Creek, as we will discover in our aerial analysis, lacks a strong vegetated buffer and this corresponds to the low QHEI score and the resulting lower IBI scores at these assessment points. Muncie Creek is impaired for IBI and this corresponds to its QHEI impairments. We know from aerial surveys that these banks have been de-vegetated and this de-vegetation may be linked to a sediment problem. This creek demonstrates how all of these assessment methodologies are tied together.

### **Fish Consumption Advisories / Fish Kills**

There is no direct link to these impairments and the Muncie biological data. The DNR fish advisory covered the main stem of the White River. The advisory recommends zero carp consumption and consuming other fish with a great deal of mindfulness corresponding to their inventories and ratings. The fish consumption advisory does not specify specific levels of contaminant (using the PCBs in tissues and mercury metrics). No fish kills have been reported in IDEM IWA. The FCA and fish kill data correspond to the impaired Fishable uses metric on the 305b list and on the rating criteria for Indiana Stream and Rivers.

### **Macroinvertebrates**

Macroinvertebrates at these sample points both rate relatively equal and do not aid in prioritizing one Subwatershed over the other. This study looked at the state of Rivers across the entire county, and scores within the individual Subwatersheds. The 319 scores are more limited due to a generally nascent program (and the inability to discern trending). Both Subwatersheds rate as fair for macroinvertebrates. Like IBI, main stem data does not help prioritize data at the tributary level.

# Biological Trends in WQ Reports

## WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 14

We have observed from our previous studies the interconnection between chemical, biological data, state water quality standards, and the beneficial uses of water. The beneficial uses of water outlined by IDEM consists of:

- Aquatic Life Use
- Fishable Uses
- Drinking Water Supply
- Recreation / Human Health

Fishable Uses are a by product of a strong aquatic ecosystem (aquatic life use) and opportunities for recreation and human health are a by product of having a water supply that is consumable (or able to contact).

### **E. Coli**

Our studies found that the number one impairment to Muncie Creek - Hamilton Ditch and Truitt Ditch - White River Subwatershed streams and river (and all Delaware County streams and rivers) is E. Coli – this is the number one deterrent to human health; drinking water and having direct contact with streams and rivers (inhibiting recreation: swimming, boating, etc.). E. coli has no negative impact on aquatic life community (such as a fish) because it only survives in warm blooded animals.

The findings on E. Coli are consistent throughout all water sampling data, and through all analysis of that data. Later sections of this WMP will begin to develop an action strategy for E. Coli and provide opportunities for the WRWP to address nonpoint E. coli sources through our action plan.

### **Impaired Biotic Communities**

The second major metric for discerning stream and rivers beneficial uses in Delaware County (by IDEM) is impaired biotic communities. This is a metric for aquatic life uses (and as a byproduct, fishable uses.) Two major conclusions can be drawn when reviewing the Muncie IBI reports (and through ongoing discussion with Muncie Bureau of Water Quality Biologists):

(1) Regardless of the severity of WQ conditions, aquatic life cannot survive without a healthy stream ecosystem. As demonstrated, there is a strong interrelationship between QHEI and IBI (stream ecosystem and aquatic life communities). The metrics of the QHEI are Substrate, Instream Cover, Channel Morphology, Riparian Zone, Pool Quality, Riffle Quality, and Map Gradient. Therefore, the presence of certain types of fish communities are primarily an indicator of good habitat, but not always an indicator of perfect water quality.

(2) Aside from a lack of habitat, there are three significant dangers to aquatic life communities, (a) Poisoning due to extreme amounts of nutrients or pesticides injected into the stream channel (fish kills, rare), (b) gradual transformation of the food web due the presence of excess nutrients in the water system. As an example, gradual transformation (eutrophication) can occur with an increase in nutrients - therefore increasing the food supply, such as algae, increasing the presence of algae consuming aquatic life, and therefore simplifying the food web. Rivers naturally have a low level of nutrients and therefore a more diversified ecosystem (as aquatic life has to be more creative as to how they consume nutrients.) The growth of algae also absorbs in-stream oxygen. And (c) Sediment: Sediment has the capacity to choke out living creatures, and reduce oxygen,

light and smother bottom dwelling macroinvertebrates. Silt intolerant species are generally missing from the Muncie habitat studies and according to the Muncie Bureau of Water Quality Biologists, sediment is the number one impairment to aquatic life. Positively charged nutrients, such as phosphorus and ammonia, attach to sediment and have the capacity to enter streams through the sediment in runoff.

Based on this discussion, a lack of instream cover/habitat, (and other natural channel design principals) is the number one impairment to the overall survival of aquatic life communities and the second major impairment is sediment.

There is a direct relationship between vegetation (on banks) and sediment. Recent WRWP studies (i.e. Buck Creek Sediment Study) have found that when banks are not stabilized with vegetation, near bank stress has a greater capacity to cause erosion of streams and rivers, especially when they are channelized (have poor Channel Morphology, Pool Quality, Riffle Quality, and Map Gradient). The Buck Creek study confirmed that stream banks are the leading source of sediment in our rivers when agricultural BMPs such as no till and riparian buffers are in place. Establishing vegetation on streams has a significant capacity to improve beneficial uses of our streams.

The vegetation on streams also has three additional benefits.

- (1) Vegetation on stream banks serves as a waddle for surface runoff. Surface runoff, especially from agricultural fields, can contain high levels of sediment; this sediment has the capacity to drop out of the water when traversing a riparian buffer.
- (2) Vegetation not only prevents the movement of sediment, it also prevents the movement of sediment attaching nutrients (positively charged chemicals such as phosphorus and ammonia). By keeping sediment out of our streams, we also stop the contamination or movement of phosphorus and ammonia.
- (3) When vegetated habitat covers entire riparian zones (indicated by hydric soils) approximately 40 feet wide, it does have the capacity to filter nitrogen from water as it moves across the surface of land. These large riparian buffers have the capacity to improve water quality by buffering water soluble nitrogen, essentially creating a forest wetland near stream channel collection zones.

Furthermore, sediment has the greatest link to economics in the region, as the land use is predominately agricultural and sediment the primary capital for agricultural systems.

# SECTION FOUR - LAND USE SURVEYS

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 2





# Watershed Inventory Methods

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 1

Based on the observed trends between impaired biotic communities, vegetated banks, and sediment, WRWP Project Managers and Ball State University GIS students did aerial surveys of vegetated banks and sediment run off sources in the Subwatersheds. The analysis was completed using Geographic Information Systems (GIS). The primary purpose of our aerial survey was to answer three target questions:

- (1) What is the quality of vegetative habitat along our rivers and streams in the Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds? We analyzed the location of vegetation and rated stream banks on whether they had 1 side, 2 sides or zero vegetated sides of the bank.
- (2) What is the quality of riparian buffers along our rivers and streams in the Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds? We analyzed agricultural buffers and rated stream banks on whether they had 1 side, 2 sides or zero buffered sides of the bank.
- (3) What is the impact, if any, of surface erosion on farm fields and how does it effect adjacent streams? Items targeted during the surveys included, but were not limited to the following: Field or gully erosion, Pasture locations and condition, Livestock access and impact to streams, Buffer condition and width, and Bank erosion or head-cutting.

These three target factors (vegetation, buffers, agricultural runoff pressures) aid us in prioritizing re vegetation efforts in the Subwatershed for the purposes of reducing sediment impacts to our streams (the number one impairment to aquatic life ) and reducing the impacts sediment attaching pollutants (and water soluble nutrients) have to our streams.

In the effort to ground-truth these aerial surveys, three windshield stream assessments were completed in support of the aerial survey findings. These multiple strategies work together to confirm and validate the stream bank conditions. The first study looked primarily at 319 Chemical Program sampling points, a second study looked at IDEM sampling points, and a third study looked at all stream/road crossings in the Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds. This final study was documented with a GPS enabled camera, the results of which are available online through the Delaware County Department of Geographic Information Systems website.

All of these windshield surveys confirmed both the general land use and overall status of our streams determined by the aerial surveys.



# WRWP Aerial Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 2

### Aerial Survey #1

An aerial survey using the 2005 statewide Aerial Orthophotograph, the 2008 Delaware County Aerial Orthophotograph, and the bird's eye view map from Bing.com was conducted to examine the areas of the watershed. The following parameters were examined during the survey: eroded stream banks, eroded agricultural ditches, rill erosion & gully formation, areas needing grass waterways, banks lacking filter strips, invasive species present on banks, and the number of storm water outfalls. As these three different aerals were taken at different times, they can show areas where these parameters are recurring. For a summary of the findings, see Table 2.90.

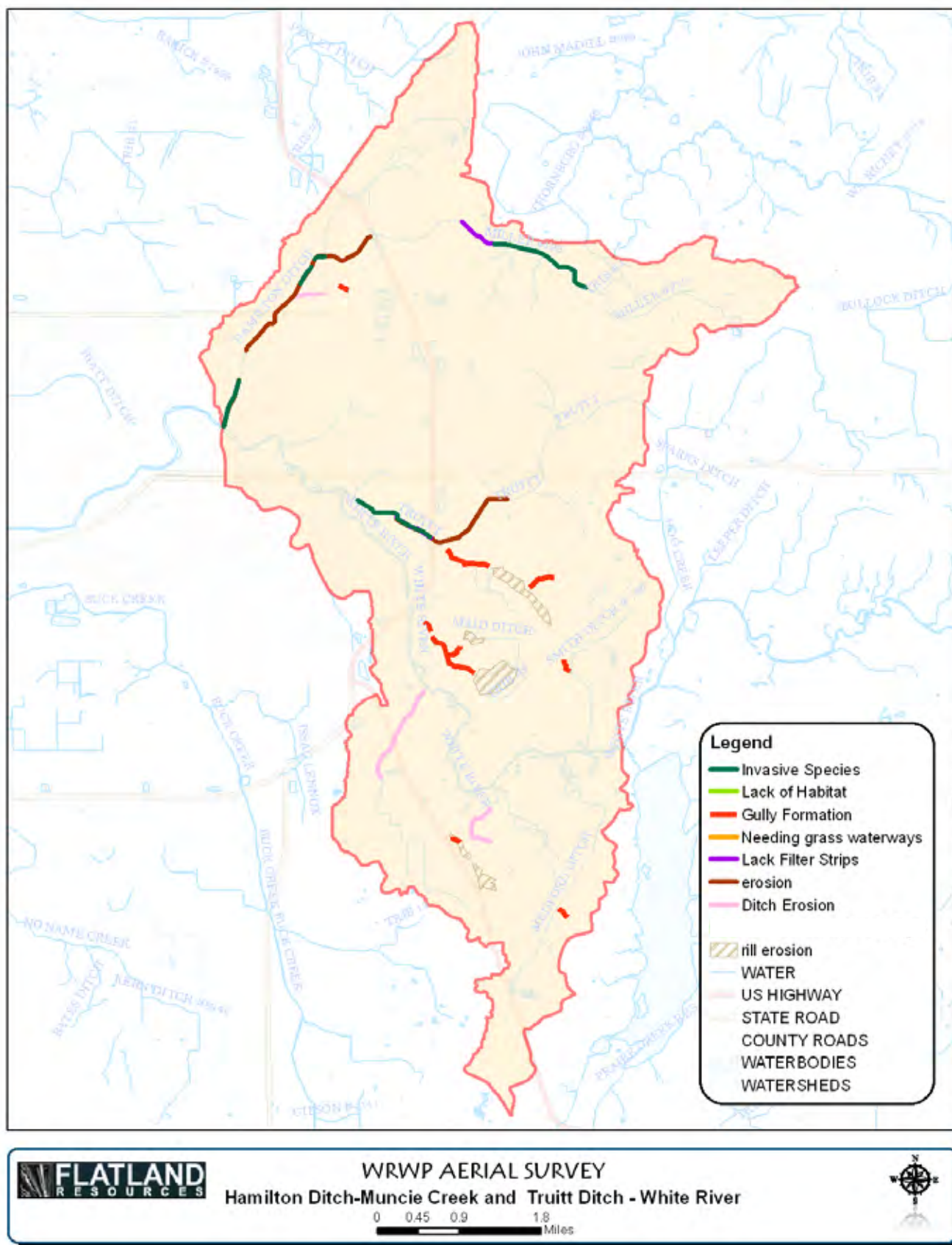
TABLE 2.90: Aerial Survey #1		
Parameter	Truitt Ditch - White River Subwatershed	Hamilton Ditch - Muncie Creek Subwatershed
Eroded Stream banks	9,400 feet	13,700 feet
Eroded Agricultural Ditches	9,250 feet	1,750 feet
Rill Erosion & Gully Formation	200 acres	50 acres
Areas Needing Grass Waterways	12,000 feet	610 feet
Banks Lacking Filter Strips	3,150 feet	5,400 feet
Invasive Species Present on Banks	4,000 feet	12,000 feet
Number of Outfalls	23 outfalls	157 outfalls

### Muncie Creek-Hamilton Ditch Watershed

The examination of the aerals from the Hamilton Ditch - Muncie Creek Subwatershed showed a large number of areas where nonpoint source pollution could be potentially occurring. There was 13,700 feet on the mainstem of Muncie Creek and 1,750 feet of agricultural ditches that had moderate to severe erosion.

There was approximately 50 acres that showed repetitive rill erosion and gully formation. In addition to these areas, there was a total of 610 linear feet that possibly needed grassed waterways. This amount is lower than the Truitt Ditch-White River Subwatershed due in part to the larger number of agricultural fields that already have grass waterways in place.

Along the banks of the main stem of Muncie Creek and the numerous feeder ditches there is approximately 5,400 feet of banks that lack either grass or wooded filter strips (Map 2.86). Of the remaining length, there is around 12,000 feet that have invasive species as the dominate species. The majority of this is Asian Bush honeysuckle (*Lonicera* sp.), but there are some areas that are dominated by Japanese Knotweed (*Polygonum cuspidatum*). Within the boundaries of the Muncie Sanitary District (generally the limit of the urban core), there are a total of 157 storm water outfalls.



**MAP. 2.86** Aerial Survey: Surface Erosion

# WRWP Aerial Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 3

### **Truitt Ditch-White River Watershed**

The examination of the aerals from the Truitt Ditch Watershed (Map 2.87) showed a large number of areas where nonpoint source pollution could be potentially occurring. There were large sections of the main stem of Truitt Ditch and the agriculture ditches that showed signs of moderate to severe erosion. This type of erosion is indicated by slopes greater than 1:1, with vegetation overhanging the banks, and the presence of rills and gullies. There were a total of 9,400 feet of eroded stream bank on the main stem and another 9,250 feet of eroded agricultural ditches.

There was approximately 200 acres of agricultural and cool season grass fields that showed rill erosion and gully formation. In addition to those areas, it appears that 12,000 linear feet could benefit from the installation of grass waterways. This number is a rough estimate, as it is impossible to determine the need for grass waterways without field work. The middle portion of the watershed has numerous locations that appear to have repetitive gully formation, leading to the need for grass waterways. This is especially true around the Academy of Model Aeronautics (AMA), where a large portion of their fields show these types of formations.

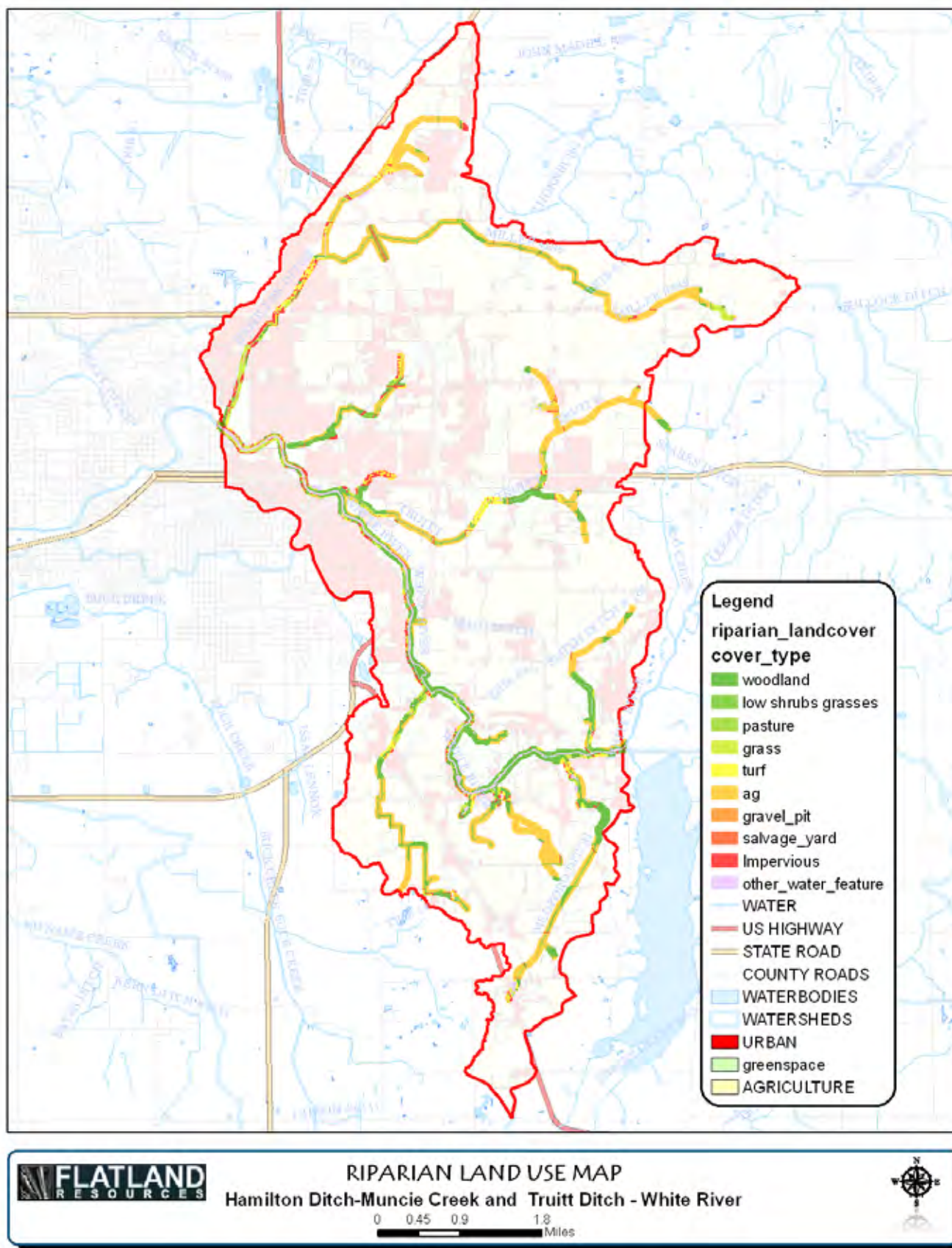
Along the banks of the main stem of Truitt Ditch and the smaller feeder ditches, there was approximately 3,150 feet of bank that lacked either grass or wooded filter strips. In addition to the areas lacking filter strips, there was another approximately 4,000 feet of bank that had filter strips, but the plant material was predominately invasive species. The dominant plant was usually Asian Bush honeysuckle (*Lonicera* sp.). Along the length of the main stems of Truitt Ditch that are in the limits of the Muncie Sanitary District (generally the limit of the urban core), there was a total of 23 storm water outfalls.

### **White River Riparian Area**

The riparian area of the White River is being dealt with separately in this section because of the inability to properly survey it due to overstory cover, the higher magnitude of issues along the river, and the relatively few river crossings. In general, the White River riparian corridor is heavily wooded, with moderate to severe erosion throughout. In areas where channel modification has occurred, the severity of the erosion increases. In the urban areas, the channel has undergone substantial modification, including the building of low-head dams and a system of flood control levees. This has led to erosion in the past. Many of the issues have been addressed through a series of construction projects for the White River Greenway that began in 2009. Long stretches of bank have been stabilized to ensure the Greenway would not be washed out from erosion. Current areas of concern are being monitored and addressed for the future.

The previous attributes of the White River riparian corridor is based upon anecdotal evidence supplied by the White River Watershed Project Steering Committee. This evidence is based upon previous visits to landowners' properties. As the riparian area is private property and hard to view from an aerial; an in-depth survey would be impossible to accomplish without a major undertaking to secure right-of-entry from all landowners.





**MAP. 2.87** Riparian Land Use Map



# BSU Aerial Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 4

### Aerial Survey #2

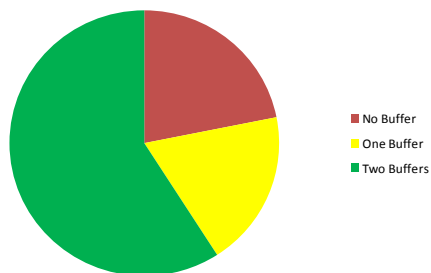
BSU GIS students analyzed stream GIS layers and augmented them to sync with the most recent aerial photography (2010). Students then updated and developed new stream files to match with flow lines indicated by current aerial imagery. Their stream coding method allows for an efficient way of indicating the presence of trees and buffer strips along stream banks. By storing and coding these attributes within a hydrology file, analyzing the presence of various features vis-à-vis segments of each stream can be achieved much more efficiently than storing these attributes in another file or data model.

The students used the following stream Attribute Coding: Trees, Trees on both sides=2, Trees on one sides=1, Trees on zero sides=0 Buffers; Buffer on two side=2, Buffer on one side=1, Buffer on zero side=0 (Chart 2.80, 2.81, Map 2.89, 2.90). If tributaries do not have designation, it was due to the fact they were intermittent waterways being used for farming.

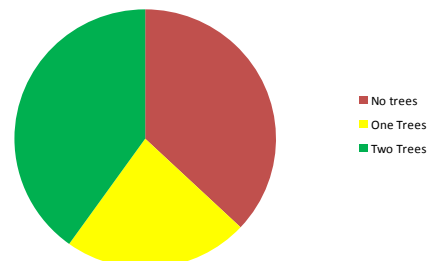
WRWP then isolated those stream segments for the purposes of determining critical areas and plotted them to show (Map 2.88):

- 1) zero trees and zero buffers in HES
- 2) zero trees and zero buffers
- 3) 1 tree and one buffer

The highest percentage of streams lacking trees and buffer occurred on Muncie Creek.



**CHA. 2.80** Buffers in Riparian Zones



**CHA. 2.81** Vegetation in Riparian Zones

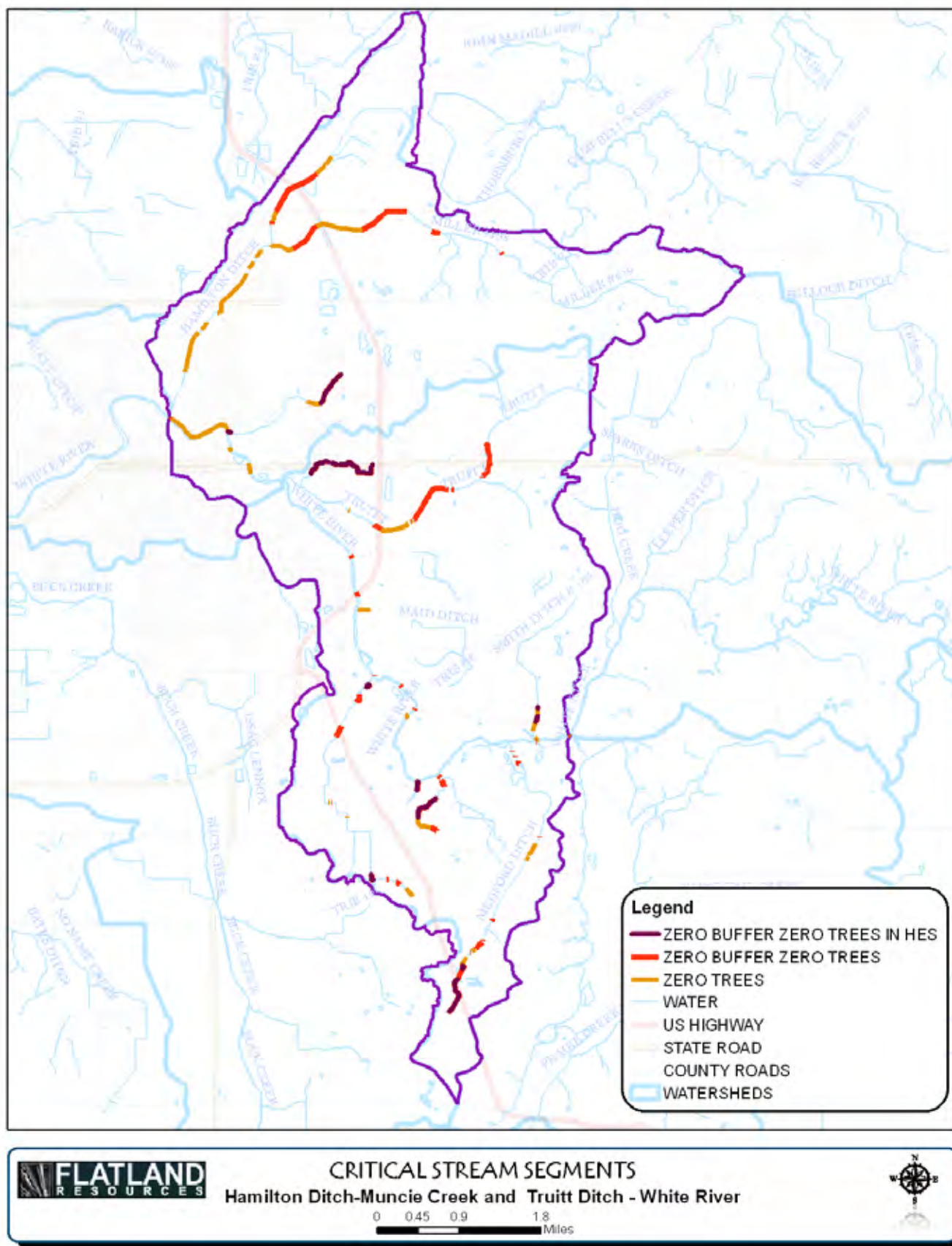
TABLE 2.91: Buffers in Riparian Zones

	feet	total miles	%
No Buffer	35,684.68	6.76	22%
One Buffer	31,001.46	5.87	19%
Two Buffers	96,406.16	18.26	59%
total		30.89 mile	

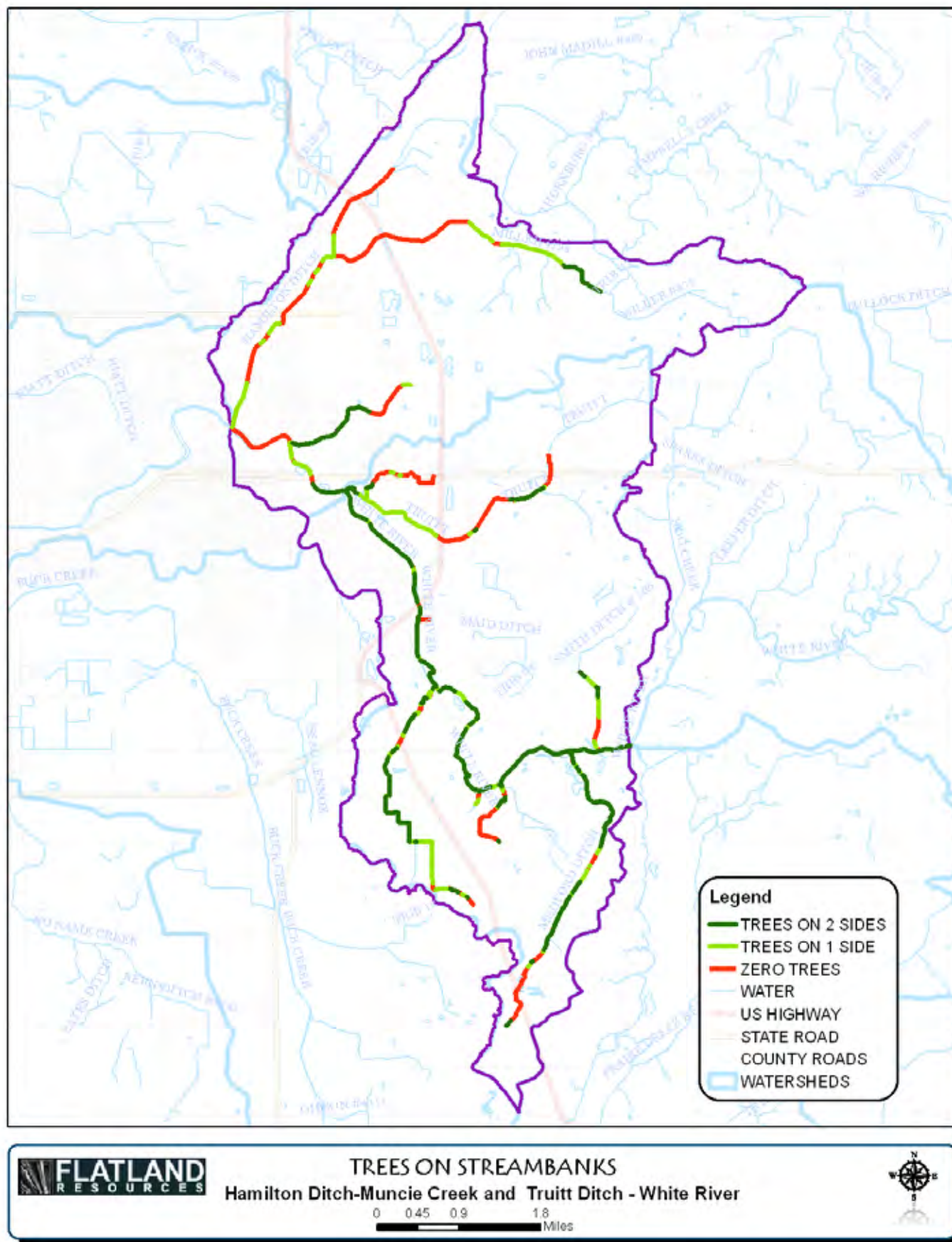
TABLE 2.92: Vegetation in Riparian Zones

	feet	total miles	%
No trees	60346	11.43	37%
One Trees	37315	7.07	23%
Two Trees	65429	12.39	40%
total		30.89	

11.43 miles of no trees  
 6.31 miles of no trees and no buffers  
 2.42 miles of no trees and no buffers in HES

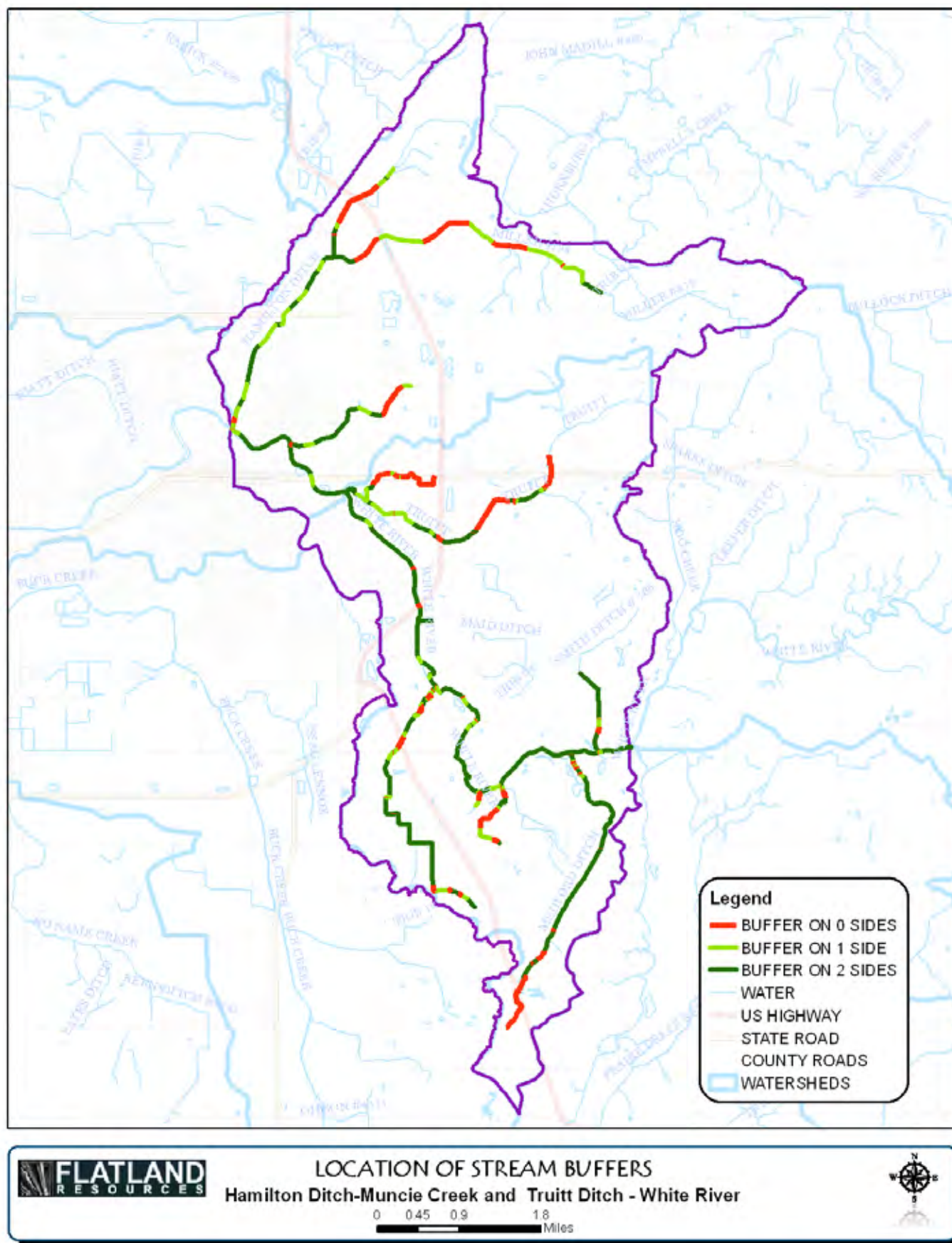


**MAP. 2.88** Areas Critical for Stream bank Habitat



**MAP. 2.89** Vegetation in Riparian Zones





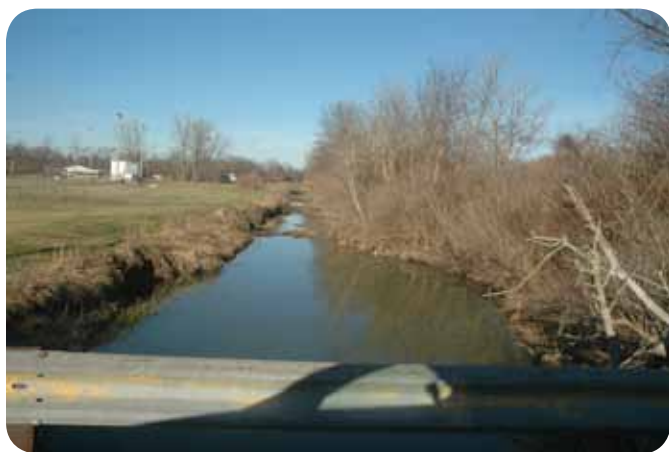
**MAP. 2.90** Buffers in Riparian Zones

# WRWP Windshield Surveys

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 5

### Survey #1

Windshield surveys of both Truitt Ditch-White River Hamilton Ditch-Muncie Creek watersheds were conducted on November 19th, 2009 and March 16th, 2010. This survey examined 12 stream crossings in the Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds. In addition to the results from specific crossings, it was noted that there were numerous places where trash had been dumped. Many of these locations were close to waterbodies. This finding supports the public concern over illegal/illicit dumping in the watersheds. For a map of the survey locations and landmarks see MAP 2.91.



IMG. 2.10 Truitt Ditch at Butterfield Road

### Crossing #1 Truitt Ditch at Butterfield Road

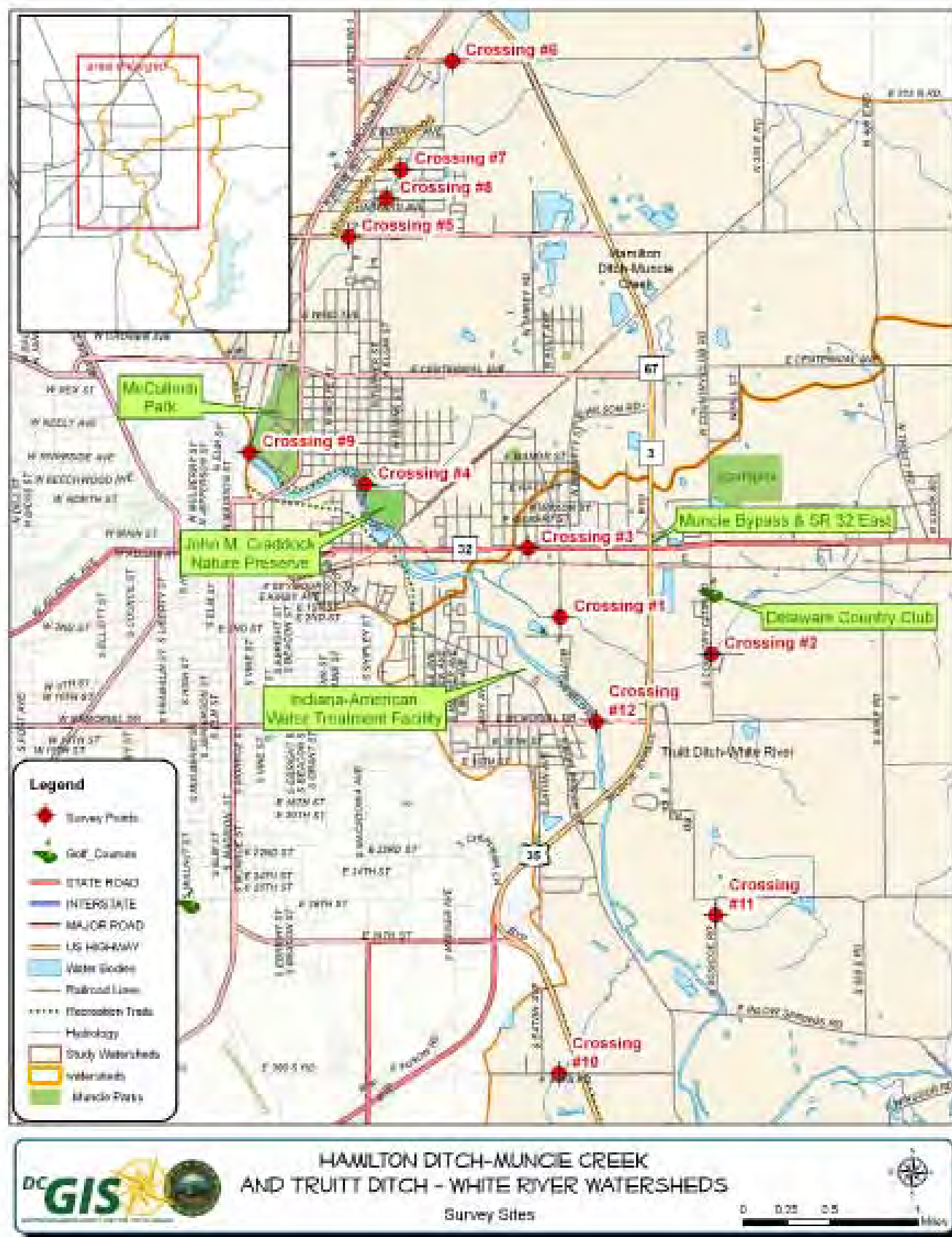
Crossing number one is located east of Muncie, and south of State Route 32. This location is one of the sampling points for chemical analysis used by the Bureau of Water Quality. There is bank erosion present downstream from the crossing. The southern bank has cool season grasses planted and mowed almost to the banks edge. During monitoring that occurred in the late summer to early fall, discharge was shown to be variable ( $< .1 \text{ ft}^3/\text{sec}$  to  $1.1 \text{ ft}^3/\text{sec}$ ). This location also shows signs of sediment deposition from upstream erosion.



IMG. 2.11 Truitt Ditch at Country Club Road

### Crossing #2 Truitt Ditch at Country Club Road

Crossing number two is located east of Muncie, directly downstream of the Delaware Country Club. It is known from on-the-ground recognizance and aerial photos that the Country Club has areas along the creek that are plagued with severe erosion. Signs of erosion are not as severe at the road crossing, but they are still present. For instance, 60 feet of the left bank of the creek has severe erosion, with overhanging vegetation and a  $>1:1$  slope. While this is less severe than on the Country Club's property, it is still indicative of the erosion associated with this stretch of Truitt Ditch.



MAP. 2.91 Stream Crossing Analysis



# WRWP Windshield Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 6



IMG. 2.12 UNT at State Route 32

### Crossing #3 UNT at State Route 32

Crossing number three is located east of Muncie, in a section of town with residential, commercial, former industrial, and brownfield areas. The Unnamed Tributary begins as a swale approximately 1500 feet from the crossing with SR 32 and has numerous feeder pipes emptying into the channel that increase the storm water input. Elevation analysis using GIS software shows that water flowing off of the Muncie Bypass (Indiana State Route 67) flows under SR 32 from the southeast into this tributary. The tributary continues under SR 32 again and then joins with Truitt Ditch approximately one-quarter mile from Truitt Ditch's confluence with the White River. South of SR 32, the channel is highly modified and shows signs of moderate erosion. As discussed in the historical water quality data section, this tributary has very high levels of E. coli. As there are no livestock, or wildlife influence in the watershed of this tributary, it is assumed that the E. coli originates from failing or failed septic systems, or systems that are illegally tied into drainage tiles.



IMG. 2.13 Holt Ditch at Bunch Boulevard

### Crossing #4 Holt Ditch at Bunch Boulevard

Crossing number four is located on the east side of Muncie, directly north of the John M. Craddock Wetland Nature Preserve. The road crossing is approximately 100 feet upstream of Holt Ditch's confluence with the White River. In late 2009, the crossing underwent reconstruction. There are signs of moderate bank erosion directly upstream of the crossing. The erosion is severe in that the banks are eroded to a  $>1:1$  slope, but the banks are only 1-2 feet high, so sediment pollution from banks is minimal.

# WRWP Windshield Survey

## WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 7



IMG. 2.14 Muncie Creek at McGalliard Boulevard

### **Crossing #5 Muncie Creek at McGalliard Boulevard**

Crossing number five is located in a commercial district of Muncie. Directly downstream of the crossing is a big box retail store with a large parking lot. The banks of the stream have been covered in concrete, allowing only a small strip of vegetation to grow near the toe of the bank. Sections of the concrete are in danger of falling into the stream due to erosion that is undercutting the concrete slabs. Additionally, the roofs of the store and the parking lot drain into the creek via an asphalt swale. This allows for no filtration; providing a direct route into the stream for pollutants.



IMG. 2.15 Muncie Creek at Riggin Road

### **Crossing #6 Muncie Creek at Riggin Road**

Crossing number six is located northeast of Muncie in an area that is mostly agricultural fields. The stream has undergone immense hydromodification and is trapezoidal in cross section. The banks have no overhead vegetation, and are predominately cool-season grasses. There is little bank erosion present at this location. This section is typical of the creek as it flows through the agricultural headwaters.

# WRWP Windshield Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 8



IMG. 2.16 Muncie Creek at Yale Road

### **Crossing #7 Muncie Creek at Yale Road**

Crossing number seven is located in the Morning-side neighborhood on Muncie's northeast side. The channel has undergone major hydromodification. There are numerous buildings within the floodway of the creek, with some as close as 80 feet from the channel. There is severe erosion of the banks in numerous places. Additionally, there are a number of storm water pipes that empty into the channel at this location. The most common groundcover is cool-season grasses, with some areas that have trees and shrubs present.



IMG. 2.17 Muncie Creek at N. Muncie Creek Blvd.

### **Crossing #8 Muncie Creek at N. Muncie Creek Boulevard**

Crossing number eight is located in the Morning-side neighborhood on Muncie's northeast side. This section of Muncie Creek has been straightened and the banks have been cleared of vegetation. A road runs parallel with the creek in two different sections. There are numerous storm water conveyance ditches and pipes that drain the neighborhood and lead into the stream.



IMG. 2.18 Muncie Creek at McCullough Road

### **Crossing #9 Muncie Creek at McCullough Road**

Crossing number nine is located at the confluence of Muncie Creek and the White River in central Muncie. This area is directly south of McCullough Park. Due to its proximity to the park, the area is often used as a fishing hole. Right at the confluence of the two waterbodies are a dam on the White River, a railroad trestle, and a road crossing. In late 2009 - early 2010, the road crossing was repaired and a cantilever trail was added to the White River side of the road. This area is often flooded during high rain events. There is erosion on the banks of the White River downstream of this area.



# WRWP Windshield Survey

## WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 9



IMG. 2.19 Elwood Reese Ditch

### Crossing #10 Elwood Reese Ditch

Crossing number ten is located south of Muncie in the Truitt Ditch Watershed. Approximately one mile of the entire 1.5 miles of Elwood Reese Ditch has moderate to severe erosion. This ditch has undergone hydro-modification and has had little maintenance in the past as shown by the large number of trees growing on the banks. Despite the large number of trees present on the banks, the stream is slowly beginning to meander, causing erosion. It flows through a golf course, and then a large farm, complete with dammed areas to form ponds. It then flows under Burlington Drive and joins the White River.



IMG. 2.20 UNT to White River

### Crossing #11 UNT to White River

Crossing number eleven is a gully formed from an eroded agricultural field that is southeast of Muncie. It is located south of Memorial Drive and east of the White River. Storm water from agricultural fields and drainage from grass and asphalted areas flows across the area, towards the river, eroding the fields along its path. The water then flows into a ditch and tile system that has numerous blowouts, causing headcut erosion in the ditch. This erosion is within one-half mile of the tributaries confluence with the White River.



IMG. 2.21 White River at Memorial Drive

### Crossing #12 White River at Memorial Drive

Crossing number twelve is located east of Muncie in the Truitt Ditch watershed. This crossing is directly upstream of the Indiana-American water treatment facility that supplies the drinking water for Muncie. There are two storm water concrete inlets that have water which flows toward the river at this point. There is rill erosion that feeds into this forming ditch. Evidence shows that the ditch has been plowed over before and has reformed.

# WRWP Windshield Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 10

### Survey #1

TABLE 2.93: Overview of findings from WRWP Windshield Survey	
Location	Summary of Findings
Crossing # 1	Bank erosion present; low flow during summer months
Crossing #2	Severe bank erosion present
Crossing #3	Water present from numerous outfall pipes, possible septic influence; bank erosion present south of SR 32
Crossing # 4	Moderate bank erosion present
Crossing # 5	Concrete covered banks; bank erosion present; asphalt swale into creek
Crossing # 6	Representative stretch of Muncie Creek in agricultural area
Crossing # 7	Severe bank erosion present; large number of storm water outfall pipes
Crossing # 8	Road directly adjacent to Muncie Creek
Crossing # 9	Confluence of Muncie Creek and White River; bank erosion present; area often flooded
Crossing # 10	Moderate to severe erosion present
Crossing # 11	Gully formation; series of gullies downstream all the way to the White River
Crossing # 12	Representative of White River; storm water outfall present

### Survey #2 IDEM Sampling Sites (MAP. 2.61 IDEM Sampling Sites)

A second Windshield survey was completed by six White River Watershed Project stakeholders during a site visit by IDEM project managers working on a TMDL for the West Fork White River from East Muncie to the headwaters of the West Fork White River. Comprehensive results from this windshield survey will be published in the TMDL once completed.

TABLE 2.94: Overview of findings from IDEM Windshield Survey	
Location	Summary of Findings
Crossing #A	Evidence of failed tiles resulting in murky water
Crossing #B	Trash, junkyard sources near seepage zones. Site needs more buffers. Runoff from East Central Recycling is contributing to smell. Pre-treatment may be missing. Direct discharge from floor drains resulting in grey water.
Crossing #C	North bank devegetated for cultural reasons
Crossing # D	Indiana steel and wire, Muncie CSOs upstream from site.
Crossing # E	Excessive trash in river potential river clean up sites. Rumored septic system failings.
Crossing # F	Different E. Coli limits. Health Department monitors these septic systems
Crossing # G	Medford Drain, major issues is this area of land is septic.

# IDEM Sampling Sites Survey



**IMG. 2.22** IDEM Crossing #A



**IMG. 2.23** IDEM Crossing #A



**IMG. 2.24** IDEM Crossing #B



**IMG. 2.25** IDEM Crossing #C



**IMG. 2.26** IDEM Crossing #C



**IMG. 2.27** IDEM Crossing #D



**IMG. 2.28** IDEM Crossing #E



**IMG. 2.29** IDEM Crossing #E



**IMG. 2.30** IDEM Crossing #F



**IMG. 2.33** Crossing IDEM #F



**IMG. 2.31** Crossing IDEM #G



**IMG. 2.32** Crossing IDEM #G



# BSU Windshield Survey

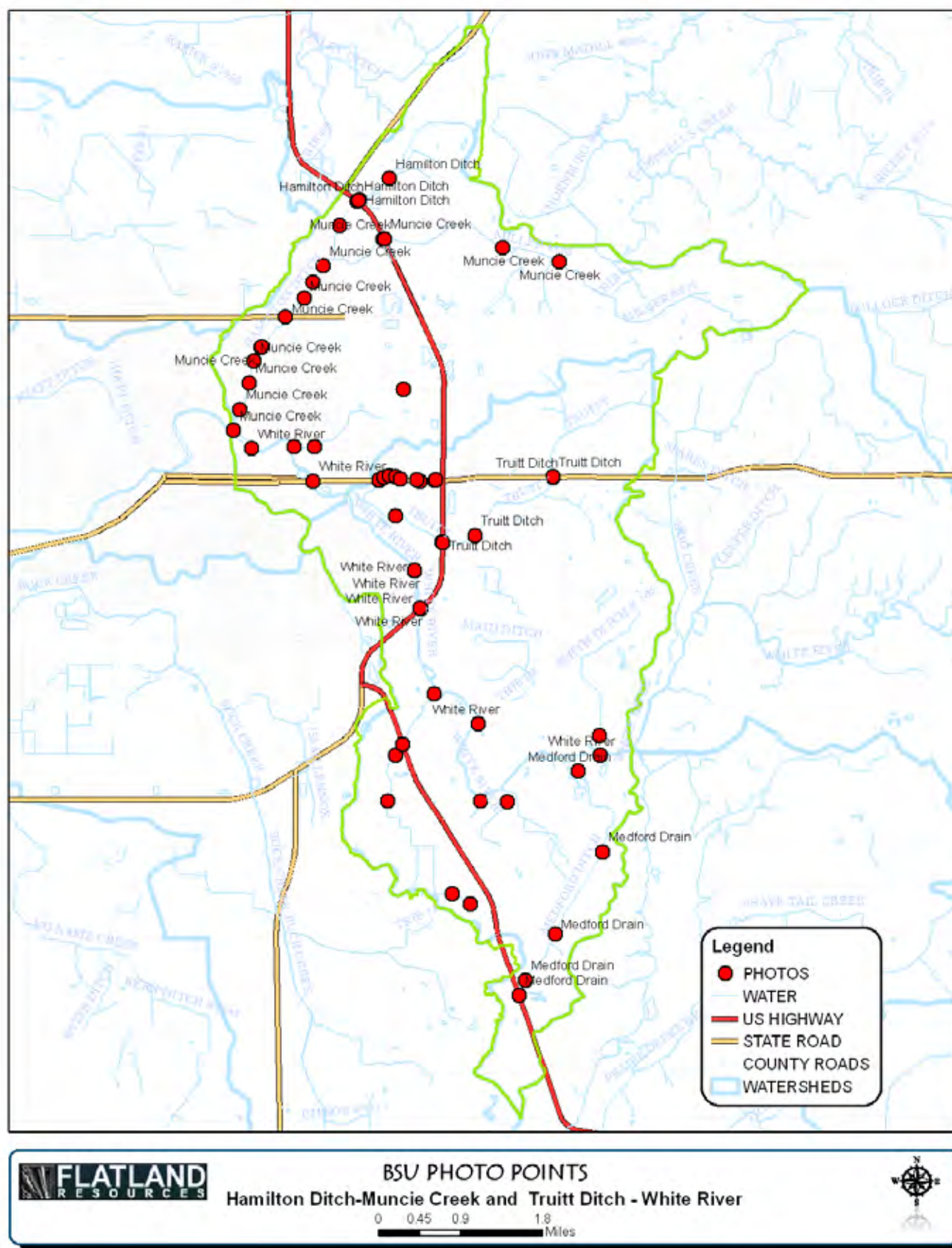
## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 11

### **Survey #3**

Ball State Students took pictures of stream conditions at all stream and road intersections in the Hamilton Ditch - Muncie Creek and Truitt Ditch-White River Subwatersheds. By determining where streams and streets within the watershed intersect, we have created a quick reference for future groups and researchers to be able to head out into the field with the requisite knowledge of where they are permitted to collect data.

Their work with DCGIS's Trimble Yuma and ArcPad was the most important contribution. Each photo point was documented by stream direction and uploaded to the Delaware County GIS servers.

Pictures of the sampling sites are too numerous to list in this WMP, the following pages give examples of the type of photos taken and their accessibility through the Delaware County Department of Geographic Information Systems website.



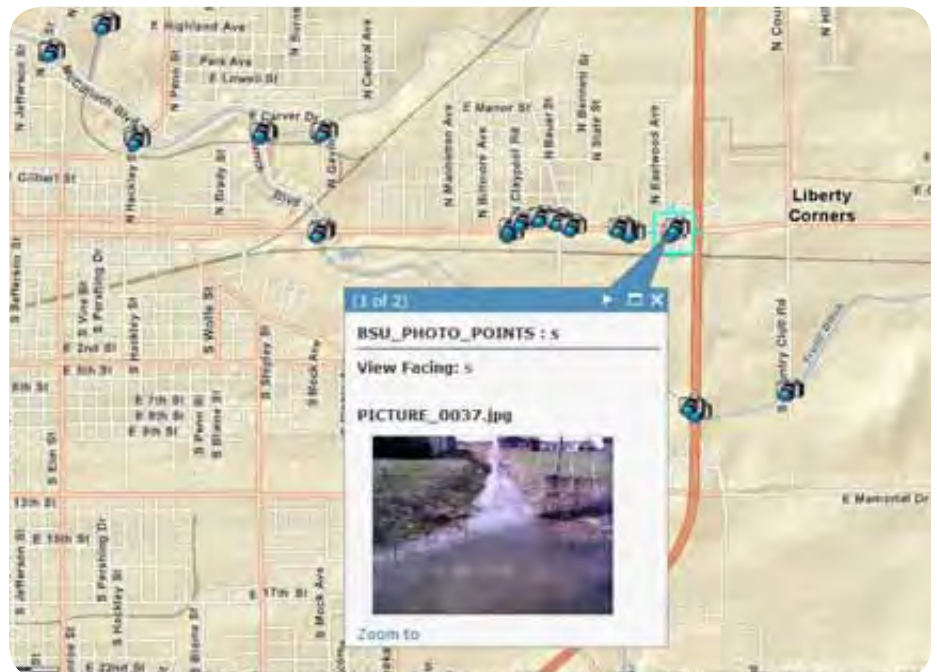
**MAP. 2.92** Photo Location Points

# BSU Windshield Survey

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 12

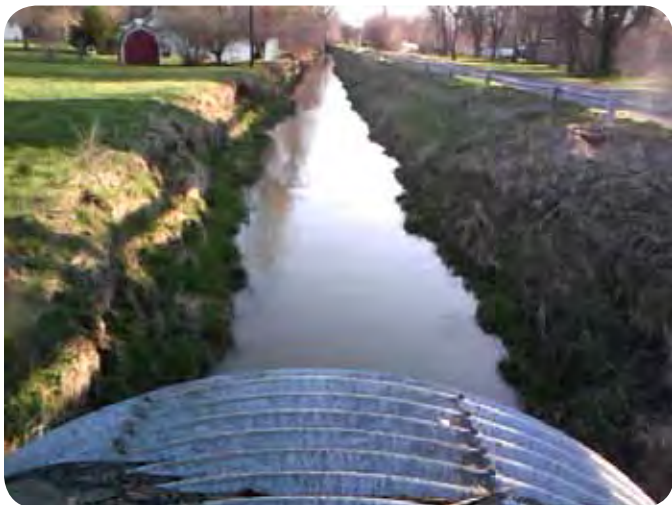


**MAP. 2.93** Data Generated by ArcGIS Web based Map



**MAP. 2.94** Example Descriptions





**IMG. 2.34** Example Crossing #1



**IMG. 2.35** Example Crossing #2



**IMG. 2.36** Example Crossing #3



**IMG. 2.37** Example Crossing #4



**IMG. 2.38** Example Crossing #5



**IMG. 2.39** Example Crossing #6

# Summary of Surveys

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 13

### **Native Vegetation**

The removal of overstory, shrub, and herbaceous vegetation and replacing it with cool season grasses is a commonly accepted practice of the management of legal drains in Delaware County. The presence of trees and shrubs that shade the water aids in keeping water temperatures low, allowing for higher levels of dissolved oxygen. The removal of the native herbaceous layer and the subsequent replacement with cool season grass reduces the biodiversity of the riparian area.

Preliminary monitoring show that fish (IBI) and macroinvertebrate (mIBI) samples are in the fair range, while habitat ratings are on the poor range for both Hamilton Ditch-Muncie Creek and Truitt Ditch - White River. Aerial surveys of the waterways show a lack of an overstory throughout much of their length.

A visual assessment of the streams show that over 80% of the main stem of Truitt Ditch and 90% of the main stem of Muncie Creek have had their native riparian vegetation removed and replaced with either cool season grasses, crops, or invasive species. The only water body that has relatively good shading and a riparian corridor lush with habitat is the White River.

Concern from the steering committee was raised over the lack of vegetation on the banks leading to erosion and poor quality of habitat.

### **Hydromodification**

Both the main stems of Truitt Ditch and Muncie Creek have undergone major modifications over their entire lengths. It is impossible to tell exactly how much has been modified since settlement, but through examination of the straight channels and trapezoidal design throughout the length of both streams, it would appear that they have completely changed from their original course. The one exception would be the White River through these watersheds. While it has undergone some modification (i.e. the removal of meanders and oxbows, the installation of low height dams, the creation of a levy system, etc.), for the majority of the length in these watersheds, the flood plain is intact and the channel meanders slightly.

There are 9,250 feet of agriculture ditches in Truitt Ditch watershed and 1,750 feet of agricultural ditches in Muncie Creek watershed that have moderate to severe erosion present. Moderate erosion of ditches is characterized by bare banks, with slight overhang from vegetation on the top of bank. Severe erosion is characterized by the presence of massive failures, gullies, and bare rills. There is observable erosion on Smith Ditch, Elwood Reese Ditch (West of Burlington Drive), and on channelized ditches in Hamilton Ditch - Muncie Creek Subwatershed. Major erosion is also occurring on the main stem of Truitt Ditch through the Delaware Country Club.

### **Stream bank Erosion**

Historic data shows high levels of total suspended solids and turbidity in Muncie Creek and the White River and moderate levels of both parameters in Truitt Ditch. Aerial orthophotograph and windshield surveys show agricultural fields that do not have vegetated drainage ditches which has resulted in bank erosion. Aerial orthophotograph and windshield surveys show agricultural fields that do not use conservation tillage (lack BMPs such as grass waterways and filter strips) and have rill erosion and gully formation.

Stream bank erosion is a major source of sediment pollution in both the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. The windshield and aerial surveys have uncovered that 9,400 feet of stream bank in the Truitt Ditch - White River Watershed and 13,700 feet of stream bank in Hamilton Ditch - Muncie Creek Subwatershed are moderately to severely eroded. Specific locations include the erosion of White River banks near SR 32, and the erosion of White River behind houses on Burlington Drive.

### **Ground Surface Erosion**

Areas that show the tendency to have repeated rill and gully formation were inventoried using the information gathered through the windshield and aerial surveys. The process of uncovering this information included examining the oblique images from bing.com, the 2005 Indiana statewide orthophotograph, the 2008 Delaware County orthophotograph (for areas that show rill and gully formation) and windshield surveys. As these images range from 2005 to 2009, they provide a long time frame to see areas with repeated erosion. In the Truitt Ditch - White River Subwatershed, approximately 200 acres show repeated rill and gully erosion. There are fewer areas in the Hamilton Ditch - Muncie Creek watershed with these problems, totaling approximately 50 acres.

Lack of agricultural no-till practices BMPs and the erosion of agriculture fields and ditches in the watersheds cause excessive sediment and nutrient pollution that is degrading habitat and limiting use of the waterways for recreation, drainage, and aesthetic purposes.

According to the 2009 Indiana tillage transect, in Delaware County 21% of corn fields and 6% of soybean fields use conventional tillage. These are relatively high numbers of conservation tillage in the county. It should be noted that this survey uses the same points every year and is not a true random sampling of all cropland in the county.

Historic data shows high levels of total suspended solids and turbidity in Muncie Creek Basin and the White River and moderate levels of both parameters in Truitt Ditch.

Aerial orthophotograph and windshield surveys show agricultural fields that do not have vegetated drainage ditches resulting in bank erosion.

In addition to the aerial survey parameters discussed earlier, the watersheds were examined looking for lengths of streams without filter strips and areas where grass waterways were needed.

Truitt Ditch-White River Subwatershed had approximately 3,150 feet of ditch bank that was in need of filter strips and 12,000 feet of gully formations that should be planted as grass waterways. Hamilton Ditch - Muncie Creek watershed had approximately 5,400 feet of bank that was in need of filterstrips, and 610 feet of gully formations that should be planted as grass waterways.

More in-depth understanding of conservation practices of agricultural producers would aid in making this document more comprehensive. With this in mind, it is suggested that in the future, a survey is mailed out to producers in the watersheds to get a comprehensive inventory of all conservation initiatives used by the producers.



# Summary of Surveys (cont.)

## WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 14

### **Nutrients (Water Soluble)**

Aerial orthophotograph and windshield surveys show agricultural fields that do not use conservation tillage (lack BMPs such as grass waterways and filter strips) and have rill erosion and gully formation. Ditches and field tiles (on agricultural fields) that lack BMPs can provide pollutants with direct access to the watershed's waterways.

There has been no watershed wide study of the locations of tile inverts or outfalls. There have been no identified tile invert or outfall BMP's in the subwatersheds.

There has been no best management practice recommendation for the percentage of storm water that should be managed on site (at the watershed or individual site scale) – so there is no way to quantify the lack of filtering and on site infiltration other than the aerial surveys.

According to the EPA region 5 model for estimating load reductions for agricultural and urban BMPs, an eroded 500 foot section of bank that is 10 feet high, with silt loam soils, would contribute over 4500 tons of sediment for every three inches of erosion. Assuming a concentration of nitrogen in the soil of 0.1% and phosphorus of 0.05%, this is equivalent to over two tons of phosphorus and almost 5 tons of nitrogen that would also be polluting the waterway with the sediment.

### **Conclusions**

Aerial surveys indicated that a high percentage of streams in the Subwatersheds are devoid of any vegetative habitat. Furthermore, it can be concluded from the analysis that our tributaries are extremely impaired due to channelization and devegetation. This study confirmed that the data is strong supporting the need for restoration of riparian communities along stream banks as the number one strategy for addressing the overall water quality issues related to impaired biotic communities. Due to the direct link between aquatic life/fishable uses, sediment stressor, and vegetation.

The surveys could not determine if farming applications were using manure, or if there was exclusion fencing along rivers due to the aerial resolution, so land use data related to E. coli was inconclusive.



# **WATERSHED INVENTORY PART THREE**

**MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP**  
**CHAPTER 2**



# SECTION ONE - WATERSHED INVENTORY SUMMARY

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 2





# Watershed Inventory Summary

## WMP - CHAPTER 2 - PART 3 - SECTION 1 - SUBSECTION 1

The State of Indiana publishes a biannual water quality report called the Integrated Water Quality Monitoring Report. This report is the mechanism for assessing Indiana Streams and Rivers for the purposes of determining if they meet the “beneficial uses of water” defined in the Indiana Administrative Code. While many streams in Indiana have been assessed (using state water quality standards) for the benefits of aquatic life, fishable uses, and recreational uses - the total amount is too low for a comprehensive picture (Statewide: aquatic life 54% streams assessed, fishable uses 13% streams assessed, recreational uses 37% streams assessed) of the Hamilton Ditch–Muncie Creek and Truitt Ditch-White River Subwatersheds. The problem is exacerbated due to a rotational probabilistic monitoring method that interpolates stream conditions rather than through ongoing and consistent annual sampling. Many of these un-assessed streams are in Delaware County including tributaries in the Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds.

The goal of this plan (as with the IDEM Nonpoint Source Control Program in general) is to focus restoration efforts on streams that do not support the beneficial uses of water. Since the Integrated Monitoring report does not assess all streams in Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds, this WMP supplements the Integrated Monitoring report with water quality data and land use analysis specific to Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds. This supplemental data will aid us in determining which streams are critical - for the purposes of developing an even greater focus for restoration efforts at the Sub-basin level and allowing these areas to support “beneficial uses”.

The Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds are downstream of predominately agricultural landuses (Randolph County). It is part of the Upper (West Fork) White River Watershed (a target watershed in the Indiana Conservation Reserve Enhancement Program) and greater Mississippi River Basin which is the most impaired regional watershed for sediment in the United States of America.

Comparing historical maps of Delaware County to contemporary ones shows a drastic modification of the landscape post European settlement. The Ecoregion classification system by the EPA paints a picture of what these historic landscapes might have looked like from an ecological perspective (before the wide-spread removal of temperate forest-wetlands). Delaware County shares biome classification with the Eastern United States.

The absence of many species of native wildlife is an indicator of poor natural habitat. The systemic impact to the native wildlife is noted by the Endangered Species list for Delaware County. In these voids of natural habitat are opportunities for invasive species and other “nuisance” wildlife to thrive. The invasive plant species that take residence (like bush honeysuckle, *Lonicera* sp. ) in the County have been found (through WRWP land use studies) to exist on streambanks of tributaries and rivers where they shade out native understory habitat that would otherwise have assisted in stabilizing streambanks from erosion. Unstable streambanks is one of the primary reasons why sediment levels are high in Subwatersheds that are predominantly agricultural (i.e. that rely on stream/ditch infrastructure for conveyance of water) when compared to urban areas (that have extensive network of concrete storm water pipe). This was confirmed through previous comparative studies of sediment discharge from stream banks compared to surface runoff in agricultural areas (Buck Creek Critical Area study). Aerial windshield surveys confirm extensive streambank erosion in the Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds.

Delaware County has relatively high rainfall when compared to rainfall data nation-wide. The removal of the widespread temperate forest has only exacerbated the impacts that rainfall has on the landscape (by removing the absorptive canopy). Yet, despite the removal of surface level habitat, the “foundation” of the land remains relatively intact; these “foundational elements” are high clay content in soils, hydric soils, gentle topography, and bedrock depth (all of which contributed to the historic forest-wetland landscape). The same surficial conditions that once resulted in wetland conditions continue to plague farmers today; despite efforts to drain land. The poorly drained soils and existing hydric soils indicate where historic wetlands may have been located.

Stormwater removal is the driving land management practice in Delaware County. As part of the transformation of the wetland landscape for agricultural purposes, an extensive drainage system has been created. Streams, rivers, and tributaries have been drastically augmented in the establishment of county-wide stormwater infrastructure. Land use studies show a lack of buffers and vegetation along stream channels; the result of poor stream management. Floodplains in the Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds - at the least - have been found to lack agricultural buffers and - at worst - are being farmed up to the edges of the ordinary high water mark. The Mainstem White River also has a series of levees and dams that disrupt natural stream habitat (Dams are sinks for phosphorus and other nutrients). Conventional volume control and conveyance (combined with poor soil infiltration) has resulted in an over widening or deepening (incision) of channels. Opportunities should be sought to expand floodplain access for streams or a greater application of water retention/detention methods such as ponds. Since ponds are potential nutrient sinks, the need for wetland plant materials in conjunction with these projects is necessary.

The presence of urban storm sewers and outfall drains confirm the need for extensive water management in urban areas - but an outdated storm-sewer system in the City of Muncie causes CSOs to the White River during major rain events. Poorly draining soils (perhaps even hydric ones) are now being used for septic systems and with detrimental results. Soil types that are not suitable for septic systems do not permit leach fields to complete their full anaerobic process. This confirms the need for rural sanitary systems for the purposes of effective waste management (evidence for successful reduction in E. coli through the implementation of rural sanitary systems can be found in the results of the Royerton sewer project monitoring program). E. coli has been found to be the greatest exceeding impairment in the Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds largely because of these waste management failures.

Failing septic systems and other groundwater risks are addressed locally through the Bureau of Water Quality and the Delaware County Department of Health. Mitigation strategies for these “point sources” (i.e. septic systems and groundwater contamination) will not be incorporated into this management plan.

Point source water pollutants are currently being regulated by the Muncie Bureau of Water Quality. Forty years of regulations has resulted in a tremendous reduction of point source contaminants (through various industrial pre-treatment programs). The WRWP will follow the BWQs lead for point source pollution and will not incorporate point source strategies into this management plan.

# Watershed Inventory Summary

## WMP - CHAPTER 2 - PART 3 - SECTION 2 - SUBSECTION 2

Land use modification is predicted to continue to change west of Muncie and the city has no plans to mitigate abandoned (and non-polluted) impervious areas of the City on the east side. There has been relatively minor population change in the past 5 years and what drops have occurred are expected to return in 2030 – therefore, it is inter-county relocation and sprawl in the western portion of Muncie that will continue to create impervious surfaces ( if the city continues to not remove abandoned impervious areas east of the city). Jobs and economic forecasting continue to predict employment to be associated with Ball State University and IU-Health Ball Memorial Hospital (located west of Muncie). New residential development is occurring in proximity to these facilities (relative to the county).

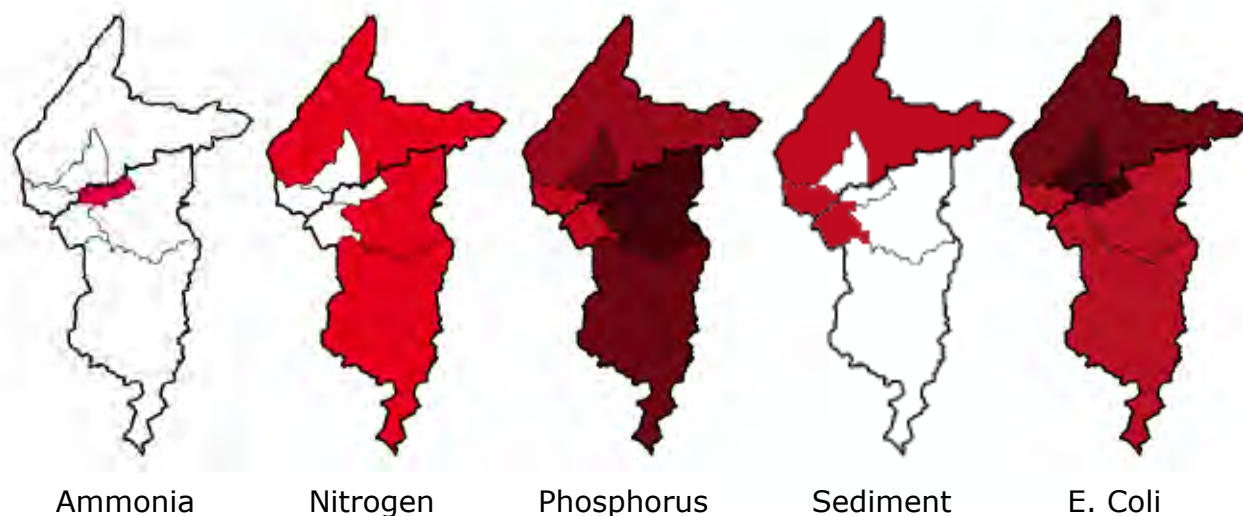
The Muncie Parks System currently maintains Park space below the recommendations of the LOI index. There may be opportunity to create more natural areas (co-functioning as stormwater BMPs) in conjunction with the Muncie Parks Department and Cardinal Greenways mindful of abandoned land uses on the east side. The John M Craddock Wetland Nature Preserve is a case study for this type of partnership development.

WRWP Studies of target Delaware County landuse change (over a 10 year period) indicate relatively stable agricultural land uses. Cuts to governmental conservation practices may revert protected land to agricultural ones. In agriculture, chemical application rates have been reduced (through the guidance of the Purdue Extension Office) and no-till practices are on the rise. However, WQ studies continue to show the increase of Phosphorus, Nitrogen, and Sediment to the rivers during non-growing season which is consistent with national studies. This emphasizes the importance of cover crops and other green plant material on the ground on both streambanks and agricultural land during the dormant months. Rill and gully erosion was discovered throughout the Hamilton Ditch – Muncie Creek and Truitt Ditch – White River Subwatersheds. However, data suggests that the water quality indicators phosphorus, nitrogen, and e. coli are at higher levels downstream of Muncie than at sampling points upstream of the city (downstream of predominately Agricultural Randolph County). This goes against commonly held notions that agricultural producers are the biggest contributors to these nonpoint source pollutants at the watershed level. Sediment (TSS) remains to be a higher pollutant in agricultural areas.

Concentrated Animal Feeding Operations are often seen as a primary source of E. coli in streams and rivers yet E. coli levels are low upstream of Delaware County (downstream of predominately Agricultural Randolph County) compared to city CSO discharge points. While CAFOs and septic systems may continue to be a source of E. coli the critical polluter is clearly the sanitary system.

Many planning efforts are happening community-wide and we will look to expand the role this WMP can serve as a strategic environmental plan to be used in conjunction with this community guidance documents.

A review of existing IDEM probabilistic monitoring data give limited and outdated results. However, consistent with all other studies, we discovered that E. coli is the dominant pollutant and typical point sources (e.g. metals and toxic organics) are on the decline. The Muncie Bureau of Water Quality Biological studies confirm the chemical study conclusions where data is comparable and provides a more long-term snapshot compared to IDEM probabilistic monitoring.



**DIA. 2.15** Critical Pollutants in each Basin

The above diagrams show results from the tributary basin study. Red areas designate tributary basins that are exceeding the state water quality standard for the designated pollutant. For pollutants that are exceeding state water quality standards in all tributaries in the Hamilton Ditch - Muncie Creek and Truitt- Ditch Subwatersheds, the darker the red the greater the impairment per tributary by tributary comparison. Larger scale maps of these areas can be found in later sections of this WMP.

# Watershed Inventory Summary

## WMP - CHAPTER 2 - PART 3 - SECTION 1 - SUBSECTION 3

The limited biological sampling in the tributaries of Hamilton Ditch – Muncie Creek and Truitt Ditch White-River Subwatersheds make it problematic to determine critical areas based on the biological data alone. Discoveries on sampled tributaries are consistent with data county-wide that show a relationship between decline in habitat (QHEI) and a decline in fish (IBI) (this relationship is greater on tributaries and lesser on main stems). These studies connect low IBI scores to low QHEI scores to high TSS scores (especially in the Muncie Creek Subbasin). The impacts of sediment on fish communities due to hydromodification, lack of overstory, and other poor in-stream bank habitat such substrate and riffle run patterning suggested by these studies (Page 321-357).

The 319 WQ monitoring program (at the tributary level) are the most effective means of prioritizing the Subwatershed impairments to beneficial uses. Operational data for Watershed Planning purposes focus on TSS, N, P, and E. coli. This basin-level data is used for determining critical areas.

The Unnamed Tributary basin was the only basin that exceeded the state standard for Ammonia during the sampling period. Muncie Creek, Truitt Ditch, and Memorial basins all exceeded the state standard for nitrogen. All basins exceeded the federal guidelines for Phosphorus with the following ranking, 1 being the most impaired: (1) Unnamed Tributary (2) Truitt Ditch (3) Holt Ditch (4) Memorial (5) Muncie Creek. Muncie Creek was the only basin to exceed the state standard for sediment. Similarly to the Subwatershed wide study, all basins exceed the state standard for E. coli with the following ranking. (1) Unnamed Tributary (2) Holt Ditch (3) Muncie Creek (4) Truitt Ditch (5) Memorial Basin.

When compared to other areas on the White River, Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds are less impaired than Jakes Creek, York Prairie Creek, and Buck Creek (all Subwatersheds downstream of the City of Muncie). These conclusions will lead to justification for future Watershed Management Planning in the Jakes Creek and York Prairie Creek Subwatersheds.

This inventory (Table 2.95) has worked to clarify and rank critical areas at the tributary basin level and justify action strategies for our planning goals and objectives.



	Ammonia	Nitrogen	Phosphorus	Dissolved Oxygen	Biochemical Oxygen Demand	Flouride	Coliforms	Cyanide	E. Coli	Total Suspended Solids	Phenolics	Copper	Iron	Lead
TABLE 2.95: Critical Pollutant Level by Subbasin														
Hamilton Ditch - Muncie Creek		X	X				X		X	X				
Muncie Creek		X	X						X	X				
Holt Ditch			X						X					
Truitt Ditch - White River		X	X	X	X		X	X	X	X	X	X	X	X
Unnamed Tributary	X		X						X					
Truitt Ditch		X	X						X					
Memorial		X	X						X					

# SECTION TWO - ANALYSIS OF STAKEHOLDER CONCERNS

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 2



# Stakeholder Concerns & Implementation

## WMP - CHAPTER 2 - PART 3 - SECTION 2 - SUBSECTION 1

The purpose of the Inventory and Analysis process is to collect scientific information (existing data resources and the creation of new data via WQ sampling and GIS layering) into a catalog that could be referenced in the process of analyzing Stakeholder water quality concerns. A summary of this Inventory can be found beginning on page 390. Without valid scientific data, we cannot judge Community Concerns qualitatively and substantively.

In the effort to improve water quality in the Hamilton Ditch – Muncie Creek and Truitt Ditch-White River Subwatersheds, the WRWP needs a solid and defensible framework to guide improvement goals and individual project implementation. This framework not only justifies cost-share spending, but advances the community process by allowing people to see their concerns (in the framework), and how they rank rationally and comparatively to other issues. Conversely, participants whose concerns are not ranked as high priority are provided a justified reason why. Outlining this framework as a clear, linear process, is a fundamental aspect of a results oriented planning process and one built on authentic community consensus.

To that end, the following chapters outline a method for analyzing community concerns and carrying forth the relevant concerns into tangible goals and implementation objectives.

The first step in the process is a comparative analysis of local concerns and normative State concerns.

Indiana's water quality standards (WQS) provide the basis for IDEM's Clean Water Act Section 305(b) water quality assessments, which functions to designate the beneficial uses that Indiana waters must support. Of the beneficial uses designated in the State's Water Quality Standards IC 14-25-7-2 (Table 2.96), IDEM assesses aquatic life use support, recreational use support, and support of "fishable" uses. IDEM also assesses drinking water use support on surface waters that serve as a public water supply. (Table 2.97) Although there are additional uses designated in Indiana's Water Quality Standards, IDEM limits its assessments to these four uses because the criteria in place to protect them are more stringent than those necessary to protect other uses. Thus, by protecting these four uses, other uses such as agricultural and industrial uses are supported.<sup>1</sup>

The White River Watershed Project employs a similar logic in assessing community concerns. The WRWP categorized the beneficial uses of water into three major categories (Table 2.98): Aquatic Life Uses, Human Health Uses, and Socioeconomic Uses and, in turn, categorized Hamilton Ditch – Muncie Creek and Truitt Ditch – White River concerns into these three categories. These categorizations are outlined in Tables 2.99-2.103. This represents the WRWP's theory that all specific concerns can be ultimately rooted in a general concern that the beneficial uses of water are not being met in the Hamilton Ditch – Muncie Creek and Truitt Ditch – White River Subwatersheds; be it for aquatic life, Human well being, or socioeconomic growth and development.

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<sup>1</sup> Indiana Integrated Water Monitoring and Assessment Report

The second step in the framework development process is to look at all Community Concerns and determine if they are quantifiable. If community concerns are not quantifiable, they cannot be confirmed with our available data. Concerns that we cannot quantify (because we don't have enough data) aren't neglected or abandoned entirely, they simply are not processed and confirmed formally. It is important to note that a lot of concerns are crossed referenced or linked by overarching concerns. Participants who voiced non quantifiable concerns are asked to see their concerns represented in similar (quantifiable) concerns. When future updates to the plan are initiated, the development of new data for concerns currently lacking quantifiable data will be considered.

TABLE 2.96: IC 14-25-7-2

**"Beneficial use" defined**

As used in this chapter, "beneficial use" means the use of water for any useful and productive purpose. The term includes the following uses:

- (1) Domestic
- (2) Agricultural, including irrigation
- (3) Industrial
- (4) Commercial
- (5) Power generation
- (6) Energy conversion
- (7) Public water supply
- (8) Waste assimilation
- (9) Navigation
- (10) Fish and wildlife
- (11) Recreational

TABLE 2.97: IDEM LIST

**Designated Beneficial Use**

Aquatic Life Use

Fishable Uses

Drinking Water Supply

Recreational (Human Health)

TABLE 2.98: WRWP LIST

**Designated Beneficial Use**

Fish and Aquatic Wildlife

Recreational (Human Health)

Socio Econmoic

# Analysis of Stakeholder Concerns

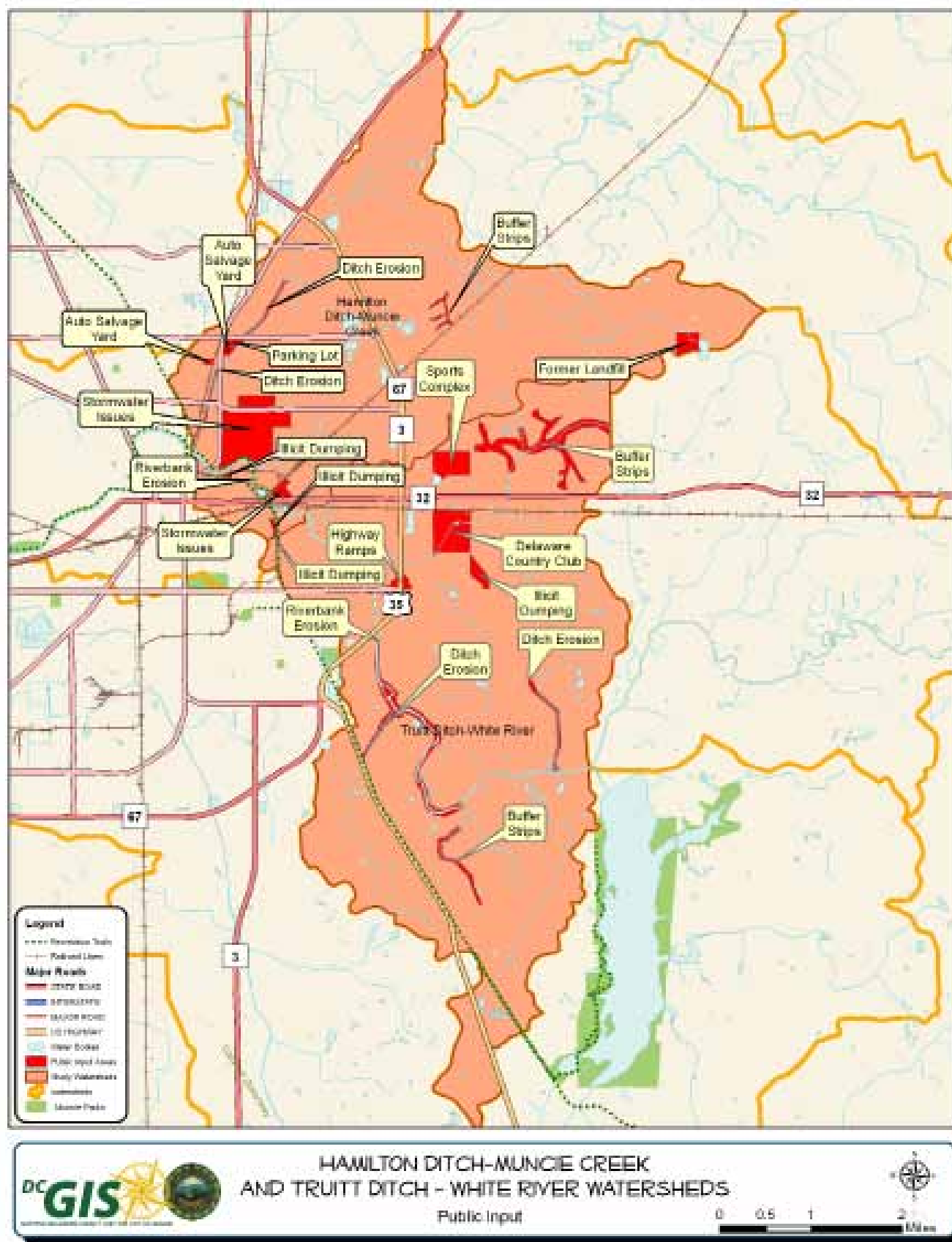
## WMP - CHAPTER 2 - PART 3 - SECTION 2 - SUBSECTION 1

Upon selection of the two Subwatersheds, citizens from each were brought together to identify their local water quality concerns. A public meeting was held on Monday April 27, 2009 at 6:30 pm at Minnetrista. A press release was printed in the Star Press on the Sunday before the meeting. Eleven people attended, the majority of which were members or former members of the WRWP steering committee. During the meeting, the public was invited to examine aerial maps and mark down areas where there are known or suspected nonpoint-source water quality issues. (Map 2.95) Further discussion on which concerns the steering committee wanted to focus on occurred during subsequent Steering Committee meetings (See Page 30).

All of the identified concerns generated from both stakeholder input and through water quality and watershed inventory efforts are detailed in Tables 2.99-2.103.

This list represents a work in progress and additional concerns may be added as the steering and monitoring committees work through data analysis. The steering committee rated each concern based on it's type of concern, what evidence does or does not support the concern, whether the concern is quantifiable, whether it is in the scope of the watershed management plan, and if it is something on which the committee wants to focus.





MAP. 2.95 Public Input

# Fish and Aquatic Wildlife Concerns

## WMP - CHAPTER 2 - PART 3 - SECTION 2 - SUBSECTION 2

TABLE 2.99: Fish and Aquatic Wildlife Concerns					
Sediment (Streambank Sources) Concerns					
Concern	Evidence	A	B	C	
streambank sediment loss	Area streams are cloudy and turbid	N	Y	Y	
High near bank stress on channelized streams	Area streams are cloudy and turbid	Y	N	Y	
Lack of riparian habitat on stream segments	Area streams are cloudy and turbid	Y	N	Y	
Removal of gravel from riffles	Area streams are cloudy and turbid	N	Y	Y	
Disregard for the headwaters of stream systems	Area streams are cloudy and turbid	N	Y	Y	
Altered floodplain with more hydromodification	Area streams are cloudy and turbid	Y	N	Y	
Destabilized stream bank with removal of vegetation	Area streams are cloudy and turbid	Y	N	Y	
Abutments and impoundments	Area streams are cloudy and turbid	N	Y	Y	
Erosion of banks near SR 32	Area streams are cloudy and turbid	Y	N	Y	
Channelized ditches eroding in Muncie Creek Watershed	Area streams are cloudy and turbid	N	Y	Y	
Lack of vegetation/habitat along river systems	Area streams are very cloudy and turbid	Y	N	Y	
Memorial Drive ramps to IN-67, located adjacent to Truitt Ditch	Area streams are very cloudy and turbid	N	Y	Y	
Sediment (Sheetflow Sources) Concerns					
Concern	Evidence	A	B	C	
Poor sediment management strategies	Area streams are very cloudy and turbid	N	Y	Y	
Destabilization of soil do to ground cover removal	Area streams are very cloudy and turbid	Y	N	Y	
Lack of BMP on tile intake points	Area streams are very cloudy and turbid	N	Y	Y	
Shrink swell	Area streams are very cloudy and turbid	N	Y	Y	
Poorly managed HES	Area streams are very cloudy and turbid	N	Y	Y	
Small or nonexistent buffer strips on Truitt Ditch and feeder ditches	Area streams are very cloudy and turbid	Y	N	Y	
Increase in impervious land cover	Area streams are very cloudy and turbid	Y	N	Y	
Runoff from Urban Areas	Area streams are very cloudy and turbid	N	Y	Y	
storm water system to outfalls in the river	Area streams are very cloudy and turbid	N	Y	Y	
Runoff from various parking lots sitting adjacent to Muncie Creek.	Area streams are very cloudy and turbid	Y	N	Y	
Storm water issues in Whitely area (high gradient, impermeable surfaces, etc.)	Area streams are very cloudy and turbid	Y	N	Y	
Auto salvage yards directly adjacent to Muncie Creek	Area streams are very cloudy and turbid	Y	N	Y	
Increased water discharge	Area streams are cloudy and turbid	Y	N	Y	

TABLE 2.100: Fish and Aquatic Wildlife Concerns Continued				
Nutrients (Sheetflow Sources) Concerns				
Concern	Evidence	A	B	C
Lack of wetlands for chemical processing	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y
Lack of on site infiltration on farmland	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y
Chemicals from fertilizers and agricultural practices	Area streams have nutrient levels exceeding the target set by this project	Y	N	Y
Lack of agricultural BMPs	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y
Fear of the ignorance of underground drainage tiles.	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y
Chemical Usage on Genetically Engineered Agriculture crops	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y
Runoff from the former Indiana Steel and Wire Company buildings	Area streams have nutrient levels exceeding the target set by this project	Y	N	Y
Nutrient rich runoff from fertilizers used by the Delaware Country Club	Area streams have nutrient levels exceeding the target set by this project	Y	N	Y
Nutrient rich runoff from Sports Complex	Area streams have nutrient levels exceeding the target set by this project	Y	N	Y
Removal of forests and wetland systems	Area streams have nutrient levels exceeding WQS	Y	N	Y
Miscellaneous Fish and Aquatic Wildlife Concerns				
Concern	Evidence	A	B	C
larger rain events with climate change	High discharge rates	N	Y	Y
High stream temperatures	High stream temperatures	Y	N	Y
Riparian Zones neglected	Lack of public education	N	Y	Y
Disregard for historic natural systems	removal of biotic communities	N	Y	Y
Lack of Wildlife Diversity (threatened/endangered species, and invasive/exotic species)	Widespread removal of communities	Y	N	Y

(A) Quantifiable? (B) Outside Scope? (C) Group wants to focus on?

# Recreational/Human Health Concerns

## WMP - CHAPTER 2 - PART 3 - SECTION 2 - SUBSECTION 3

TABLE 2.101: Recreational/Human Health Concerns				
E. coli Concerns				
Concern	Evidence	A	B	C
Some farms lack manure management BMPs	Area streams are impaired on IDEM's 303(d) list for E. coli	N	Y	Y
Drinking well and river water is unhealthy	Area streams are impaired on IDEM's 303(d) list for E. coli	Y	N	Y
E. coli from animal waste	Area streams are impaired on IDEM's 303(d) list for E. coli	Y	N	Y
public knowledge of High E. coli from TMDL studies in the area	Area streams are impaired on IDEM's 303(d) list for E. coli	N	Y	Y
Livestock have access to streams at multiple points	Area streams are impaired on IDEM's 303(d) list for E. coli	N	Y	Y
Reduced recreation opportunities do to fear of contaminants	Area streams are impaired on IDEM's 303(d) list for E. coli	Y	N	Y
Geese – potential relationship between ammonia and E. coli contamination	Area streams are impaired on IDEM's 303(d) list for E. coli	N	Y	Y
Water contact is unhealthy	Area streams are impaired on IDEM's 303(d) list for E. coli	Y	N	Y
failing septs, lack of septic system maintenance	Area streams are impaired on IDEM's 303(d) list for E. coli	N	Y	Y
Sediment Concerns				
Concern	Evidence	A	B	C
Destabilization of soil do to ground cover removal	Area streams are very cloudy and turbid	Y	N	Y
Lack of BMP on tile intake points	Area streams are very cloudy and turbid	N	Y	Y
Shrink swell	Area streams are very cloudy and turbid	N	Y	Y
Poorly managed HES	Area streams are very cloudy and turbid	N	Y	Y
Erosion of White River behind houses on Burlington drive	Area streams are very cloudy and turbid	Y	N	Y
Poor fish population for recreation such as fishing	Area streams are very cloudy and turbid	Y	N	Y
Erosion of main stem of Truitt Ditch through Delaware Country Club	Area streams are very cloudy and turbid	Y	N	Y

(A) Quantifiable? (B) Outside Scope? (C) Group wants to focus on?

TABLE 2.102: Recreational/Human Health Concerns Continued					
Nutrient Concerns					
Concern	Evidence	A	B	C	
Non filtering drainage tiles	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y	
direct runoff from areas managed for recreation were brought up	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y	
direct access to the stream for nutrients applied to the turfgrass.	Area streams have nutrient levels exceeding the target set by this project	Y	N	Y	
Public Education Concerns					
Concern	Evidence	A	B	C	
Lack of education regarding non-structural BMPs	Lack of public education	N	Y	Y	
Dumping area south of Delaware Country Club with unknown contents	Lack of public education	Y	N	Y	
Various illicit dumping areas	Lack of public education	N	Y	Y	
Former buried landfill in headwaters of Muncie Creek	Lack of public education	Y	N	Y	
The public doesn't know who to contact about watershed related concerns	Lack of public education	N	Y	Y	
Lack of Aesthetics	Widespread removal of biotic communities	N	Y	Y	

(A) Quantifiable? (B) Outside Scope? (C) Group wants to focus on?

# Socio Economic Concerns

## WMP - CHAPTER 2 - PART 3 - SECTION 2 - SUBSECTION 4

TABLE 2.103: Socio Economic Concerns

Sediment Concerns				
Concern	Evidence	A	B	C
Drainage laws	Area streams are cloudy and turbid	Y	N	Y
Poorly designed field ditches	Area streams are very cloudy and turbid	N	Y	Y
potential loss of fertile soils	Area streams are very cloudy and turbid	N	Y	Y
Lack of no-till/grassed waterways throughout both watersheds	Area streams are very cloudy and turbid	Y	N	Y
Erosion on Smith Ditch very visible from Inlow Springs Road	Area streams are very cloudy and turbid	Y	N	Y
Ditch erosion on Elwood Reese Ditch west of Burlington drive	Area streams are very cloudy and turbid	Y	N	Y
Erosion control practices don't appear to be used properly	Area streams are very cloudy and turbid	N	Y	Y
Sprawl	Area streams are very cloudy and turbid	Y	N	Y
Nutrient Concerns				
Concern	Evidence	A	B	C
The public lacks education about fertilizer use	Area streams have nutrient levels exceeding the target set by this project	N	Y	Y
Increasing discharge rates collecting more surface pollutants	Area streams have nutrient levels exceeding the target set by this project	Y	N	Y
Under appreciation of eco-system services	Area streams have nutrient levels exceeding WQS	N	Y	Y
Public Education Concerns				
Concern	Evidence	A	B	C
Watershed restoration is underfunded	Lack of public education	Y	N	Y
Homogenized watershed planning	Lack of public education	N	Y	Y
Limited BMP Concerns				
Concern	Evidence	A	B	C
Lack of low impact storm water planning	Low amount of urban BMPs per square foot of impervious surface	N	Y	Y
Lack of smaller scale planning efforts	Low amount of urban BMPs per square foot of impervious surface	N	Y	Y
Best Management practices not always considered in new developments	Low amount of urban BMPs per square foot of impervious surface	N	Y	Y
Over engineered water management solutions	low amount of urban BMPs per square foot of impervious surface	N	Y	Y

(A) Quantifiable? (B) Outside Scope? (C) Group wants to focus on?





# IDENTIFICATION OF PROBLEMS AND CAUSES

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 3



# Problems

## WMP - CHAPTER 3 - PART 1 - SECTION 1 - SUBSECTION 1

The third step in the framework development process is determining which concerns have common problems. This is an effort to take a broad range of partner voices/concerns and simplify them in to a few core concerns (Table 3.1). This enables a diverse steering committee to have a singular focus and a common language/semantics going forward. Because the causes of these problems are directly caused by Non Point Source Pollutants (stressors), we can also easily test the concerns with generated data available through our water quality studies.

### Key Concerns Framework

As described in previous sections, point source pollution and pollutants that are typically the by-product of point source sources (e.g. industry) (such as toxic organics, metals, toxic inorganics, and bio solids) will not be addressed through planning efforts due to local governmental redundancy. The Muncie Bureau of Water Quality has a track history of successful point source regulations and we have every reason to believe this will continue under their assortment of effective water quality programs. Similarly, the Delaware County Department of Health works to address a multitude of environmental pollutants, most notably point source E. coli pollution arising from failing septic systems. And finally, the City of Muncie has a Long Range Control Plan for addressing E. coli impact from CSOs.

Nonpoint source chemical parameters such as Dissolved Oxygen, pH, and Temperature will not be addressed directly, as they are often indicators of the presence of particular pollutants/stressors (e.g. chemicals and TSS) which can be the driving force when these indicators are exceeding state standards (along with low QHEI scores).

As stated, the White River Watershed Project, in efforts to focus on quantifiable reductions and equitable critical area determinations, will not focus on concerns that currently lack existing and quantifiable research supported by data. While some of these non-quantifiable concerns are legitimate, planning efforts will be ineffective and problematic due the lack of data in all Subwatershed areas to support the prioritizing of planning efforts through the IDEM “critical area” framework. Again, when appropriate, the WRWP will work to develop data to support the critical area determination process for concerns that currently lack the necessary data support (in preparation for future revisions of this planning document).

When processing the table of concerns outlined in the previous pages using these limiting factors, key over-arching concerns emerge that serve as a framework for classifying public concerns across beneficial use types. Categorizing these concerns is a process similar to IDEMs simplification of IC 14-25-7-2 “Beneficial Uses of Water” in that it also focuses on concerns that are general enough to capture the more specific concerns listed under their subset (or various configurations thereof). These key concerns are chemical and sediment impacts to fish and wildlife, e. coli impacts to recreational opportunities vis-à-vis human health risks, and loss of agricultural capital through the erosion of streams and rivers. (Table 3.1)

These key public concerns, when analyzed for validity (as this Watershed Inventory has done) have their root in legitimate problems facing streams and tributaries in the Hamilton Ditch – Muncie Creek and Truitt – Ditch White River Subwatersheds. Table 3.1 Outlines these problems and subsequent subsections begin to describe the White River Watershed Project’s understanding of where these problems originate.

TABLE 3.1: Key Concerns and their associated problem.		
Designated Beneficial Use	Key Concern	Problem
<b>Fish and Wildlife</b> - Sediment (Streambank Sources) - Sediment (Sheetflow Sources) - Nutrients (Sheetflow Sources) - Miscellaneous	(a) gradual disrupting of aquatic life due to presence of excess nutrients in water.	Indicators of excessive nutrients in water column such as algae and simplified food web.
	(b) sediment impacts on fish and wildlife communities from instream river sources and poor sediment management in agricultural and urban areas.	Area streams are very cloudy and turbid
<b>Recreational</b> - E. coli - Sediment - Nutrients - Public Education	(a) livestock entering waterways and pets waste improperly dispose	Water contact can result in health issues during major rain events.
	(c) loss of recreation opportunities through erosion of resources.	Area streams are very cloudy and turbid
<b>Economic</b> - Sediment - Nutrient - Public Education - Limited BMPs	Loss of agricultural capital through erosion.	Area streams are very cloudy and turbid

# Causes / Stressors

## WMP - CHAPTER 3 - PART 1 - SECTION 1 - SUBSECTION 2

Specific nonpoint source pollution (stressors) are varied, yet common throughout almost any watershed. Causes/stressors are those pollutants or other stressors that contribute to the actual or threatened impairment of designated uses in a waterbody. Toxic substances listed in the state water quality numeric standards and conditions such as habitat alterations, presence of exotic species, etc. are all examples of causes or stressors. The stressor inhibits the waterbody from providing a habitat that can support aquatic life or creates a situation that is hazardous to human health or animal life.<sup>1</sup>

Table 3.2 represents a Statewide cause/stressor inventory of Indiana streams and rivers. A waterbody may be impaired by several different causes/stressors. Biotic community status represents streams where the cause of impairment is not identified. The fish and/or benthic macroinvertebrate community at sampling sites in the watershed have responded to as yet unidentified stressors. (The White River Watershed project assumes that the primary stressors of these Impaired Biotic Communities in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River is sediment based on BWQ biological research on Delaware County Streams and Rivers.)

Total Suspended Solids, E. coli, and Nutrients were considered by the WRWP to be the primary causes of problems (identified via overarching concerns) through the stakeholder input and confirmed through Water Quality Studies. Justification for their concern is below:

(1) The 2000 National Water Quality Inventory<sup>2</sup> states that agricultural nonpoint source pollution (nutrients) is the leading source of water quality impacts on surveyed rivers and lakes in some states (EPA 2005). Through the WRWP 319 Chemical Analysis Program it was determined that the chemical stressor nitrogen and phosphorus are even greater within City Limits than agricultural areas. These conclusions further the notion that nutrients are crucial stressors to Delaware County streams and rivers.

(2) The Muncie Bureau of Water Quality identifies sediment as the critical pollutant in water systems in Delaware County for aquatic life. The Hoosier River Watch program states the sediment is the most significant impairment to aquatic life in all Indiana streams and rivers.

(3) State (IDEM) data and studies (TMDL, 303(d)) indicate that E. Coli is the highest exceeding nonpoint source pollutant in Delaware County. This was confirmed by 319 Chemical studies and through IDEM data review by GRW's water quality engineers.

The following stressors: TSS, E. coli, and nutrients are the primary stressor that effect virtually all concerns raised by the public through the WRWP Watershed Management Planning process. These stressors are described on the following pages.

<sup>1</sup> Indiana Integrated Water Monitoring and Assessment Report  
<sup>2</sup> 2000 National Water Quality Inventory



# IDEM Cause/Stressor Inventory

## WMP - CHAPTER 3 - PART 1 - SECTION 1 - SUBSECTION 2

TABLE 3.2: IDEM Cause/Stressor Inventory	
Cause/Stressor	Miles
Cause unknown	
<b>Impaired Biotic Communities</b>	<b>2,469</b>
Pesticides	
Atrazine	7
Toxic Organics	
PAHs	22
Dioxins	154
Bioaccumulative Chemicals of Concern	
PCBs in Fish Tissue	3,194
Mercury in Fish Tissue	1,703
Metals	
Cadmium	17
Copper	13
Lead	93
Nickel	13
Zinc	26
Aluminum	27
Toxic Inorganics (metals excluded)	
Cyanide	79
Sulfates	248
Ammonia (Un-ionized)	39
Chlorides	80
Other	
<b>Total dissolved solids</b>	<b>341</b>
<b>Nutrient/Eutrophication Indicators</b>	<b>749</b>
Organic Enrichment (Sewage) Indicators	36
pH	81
Oxygen Depletion	702
Temperature	15
Siltation	118
Flow alteration	57
<b>Other habitat alterations</b>	<b>89</b>
<b>Pathogens (E. coli indicator)</b>	<b>8,322</b>
Oil and grease	11
Algal Growth	123
SOURCE:Indiana Integrated Water Monitoring and Assessment Report	

# WRWP Causes / Stressors

## WMP - CHAPTER 3 - PART 1 - SECTION 1 - SUBSECTION 2

TABLE 3.3: Identification of Causes

IDENTIFY CAUSES	
The potential causes(s) for each identified problem	
Problem	Potential Cause(s)
Area streams are very cloudy and turbid	Total Suspended Sediment (TSS) levels exceed the target set by this project
Indicators of excessive nutrients in water column such as algae and simplified food web.	nutrient levels exceed state water quality targets
Water contact can result in health issues during major rain events.	E. coli levels exceed the water quality standard

### Sediment<sup>1</sup>

Sediment can cause a number of problems. These include changes in the flow regime, alteration of sedimentation patterns, higher water temperature, lower dissolved oxygen, the reduction in the quality of aquatic life habitat, and the loss of aquatic biotic populations. Sediment degrades water quality for drinking, wildlife, and the land surrounding bodies of water. Hydromodification can cause potential flooding due to the altering of flow or depth of the water body. This can result in an increase of sediment. It also prevents natural vegetation and wildlife to thrive due to murky water, disrupts the natural food chain by destroying habitat, can clog fish gills, reduce resistance to disease and lower growth rates and affect development. Sediment can also interfere with drinking water treatment and make recreational activities dangerous. Sediment pollution is a major contributor to the degradation of aquatic life and their associated habitats. This sediment pollution can block out sunlight in the water reducing the available light for aquatic plants, and it can cover spawning areas and streambed food supplies, reducing the population over the long term.

### Pathogens<sup>2</sup>

Pathogens can cause short-term illness, such as diarrhea, cramps, nausea, headaches, or other symptoms. These symptoms can lead to kidney infections and failure and possibly death. They pose higher risks for infants, young children, the elderly, and others with compromised or weak immune systems. E. Coli has shown minimum effects to aquatic environments. However, these fecal pathogens can cause other fungus or virus strains that can effect plant and aquatic life. E. Coli can in turn also contaminate irrigation water if pulled from larger bodies of water. The presence of pathogens can cause the closure of water bodies for recreation.

<sup>1</sup> Tom Reeve, White River Watershed Project

<sup>2</sup> Tom Reeve, White River Watershed Project

## Nutrients<sup>1</sup>

Water systems require phosphates to support plant growth. However, when their levels increase dramatically, this causes eutrophication. Eutrophication is the natural aging process of a body of water. This process results in an increase in plant growth (particularly algal blooms) due to an increase in nutrients and decrease of oxygen levels in the water body. Decomposition of the plant material slows and the dead plant matter builds up along with an increase in sediment. This fills the water body making it shallow and sometime destroying the environment entirely by killing fish and other aquatic organisms. This can usually be recognized by plant decay, increase in algae, signs of ill or dead organisms, and an unpleasant smell. This can have dramatic effects on ecosystems, with increased effects in the winter months as the ground freezes and run-off increases across land forms. While phosphates are essential for human health, extremely high levels, if consumed, can cause illness.

Excessive concentrations of nitrate-nitrogen or nitrite-nitrogen in drinking water can be hazardous to human health, especially for infants, pregnant women, nursing mothers, and the elderly. This occurs when nitrate is transformed to nitrite in the digestive system. The nitrite oxidizes iron in the hemoglobin of the red blood cells to form methemoglobin, which lack the oxygen-carrying ability of hemoglobin. Nitrites are carried by the blood throughout the body replacing oxygen causing methemoglobinemia, "Blue Baby Syndrome". This can also decrease with age, or for those who have genetically impaired enzyme systems for metabolizing methemoglobin. Most humans over one year have the ability to rapidly convert methemoglobin back to oxyhemoglobin, controlling the level within their system despite a relatively high level of uptake. While adults can tolerate higher levels, little is known about possible long-term chronic effects of drinking high nitrate water. A possibility exists that nitrate can react with amines or amides in the body to form nitrosamine which is known to cause cancer; however, the magnitude of the cancer risk is still unknown.

Ammonia toxicity harms aquatic life and can cause loss of equilibrium, hyper excitability, increased respiratory activity and oxygen uptake, and increased heart rate. At extreme levels, fish may experience convulsions, coma, and death. Short exposure can cause skin, eye, and gill damage, reduction in hatching success, reduction in growth rate and morphological development, or injury to gill tissue, liver, and kidneys. This in turn can have similar effects to human health if exposed to high concentrations or consumed. Acute Ammonia exposure can be irritating to the eyes, respiratory tract and skin. If exposed to higher levels, coughing, bronchospasm, chest pain, severe eye irritation, chemical bronchitis, fluid accumulation in the lungs, chemical burns, permanent lung damage, and even death can occur. Source: Site Fertilizers and Animal Waste (From Livestock and Field uses) collected by Sheet flow and Sediment.

<sup>1</sup> Tom Reeve, White River Watershed Project

# Stressor Interrelationship / Priority

## WMP - CHAPTER 3 - PART 1 - SECTION 1 - SUBSECTION 3

E. coli, TSS and nutrients are exceeding state water quality standards in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. As described, each pollutant has a particular way of impacting Beneficial Uses of Water. While each type of non-point source pollutant is important for the health and well being of our communities and aquatic life, the sediment stressor is significant in its impact for the following reasons:

- (1) Soil (sediment) is agricultural capital and its preservation is directly linked to the economic viability of farmers.
- (2) Sediment acts as nutrient collectors and carriers: Positively charged Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where the pollutants may settle with the sediment or detach and become soluble in the water column<sup>1</sup> (i.e. stop the flow of sediment and stop the flow of nutrients and pathogens).
- (3) Contaminated sediments can threaten creatures in the benthic environment, exposing worms, crustaceans and insects to hazardous concentrations of toxic chemicals. Some kinds of toxic sediments kill benthic organisms, reducing the food available to larger animals such as fish. Some contaminants in the sediment are taken up by benthic organisms in a process called bioaccumulation. When larger animals feed on these contaminated organisms, the toxins are taken into their bodies, moving up the food chain in increasing concentrations in a process known as biomagnification. As a result, fish and shellfish, waterfowl, and freshwater and marine mammals may accumulate hazardous concentrations of toxic chemicals.<sup>2</sup>
- (4) According to the DNR Hoosier River Watch Program, Sediment is the # 1 Source of Water Pollution by Volume to Indiana Streams and Rivers. Soil erosion and sediment as a result of poor construction, logging, landscaping, and agricultural practices, as well as eroding stream banks, cause many physical changes in streams that lead to decreased water quality.

The White River Watershed acknowledges that efforts to remove sediment from our water bodies can have a synergistic impact to fish and wildlife concerns as well as socioeconomic concerns (agricultural capital). Keeping sediment on our fields and streambanks alone will have the most significant positive impact to fish and other aquatic life communities while simultaneously keeping positively charged nutrients (e.g. phosphorus and ammonia) on our fields, which also augment river ecosystems. Furthermore, BMPs for sediment reduction such as cover crops, filter strips, and bench wetlands create opportunities for nitrogen uptake, when appropriate vegetation is planted in conjunction with these BMPs. These vegetative buffers also function as a “living wall” that blocks or filters animal waste (from natural sources or from manure applications, etc.) That may contain pathogens harmful to human health. In this way, sediment management is the “kingpin” in holistic water quality management.

Table 3.4 outlines the negative impacts sediment can have on stream ecology.

1 Scorecard  
2 Scorecard

TABLE 3.4: Sediment as Leading Pollutant	
Physical Changes in Streams Affected by Sediment	Resulting Direct and Indirect Effects on Aquatic Organisms
Heat is absorbed resulting in increased water temperature	Metabolic rates of organisms increases wasted energy not available for growth and reproduction
Water clarity is decreased turbidity is increased Increased siltation and embeddedness on stream bottom	Reduction in visual feeding and visual mating Clogging of gills during breathing and feeding Smothering of nests and eggs Change in habitat and filling of crevices in bottom gravel
Excess organic debris is carried with soil may result in increased biochemical oxygen demand and decreased dissolved oxygen	Oxygen sensitive species are detrimentally affected pH is reduced (water becomes more acidic) resulting in: Phosphorus becoming more available Ammonia becoming more toxic More leaching of heavy metals
Excess phosphorus is attached to soil particles and is carried into streams	Phosphorus acts as a 'fertilizer'. Algal growth increases higher daytime dissolved oxygen & lower nighttime dissolved oxygen Can upset normal feeding on the aquatic food chain
Heavy metals may be leached from soil increased toxicity	Developmental deformities Behavioral changes in feeding, mate attraction and activity, and parental care
SOURCE: Hoosier Riverwatch - Volunteer Stream Monitoring Training Manual	

# Concerns/Problems/Stressors

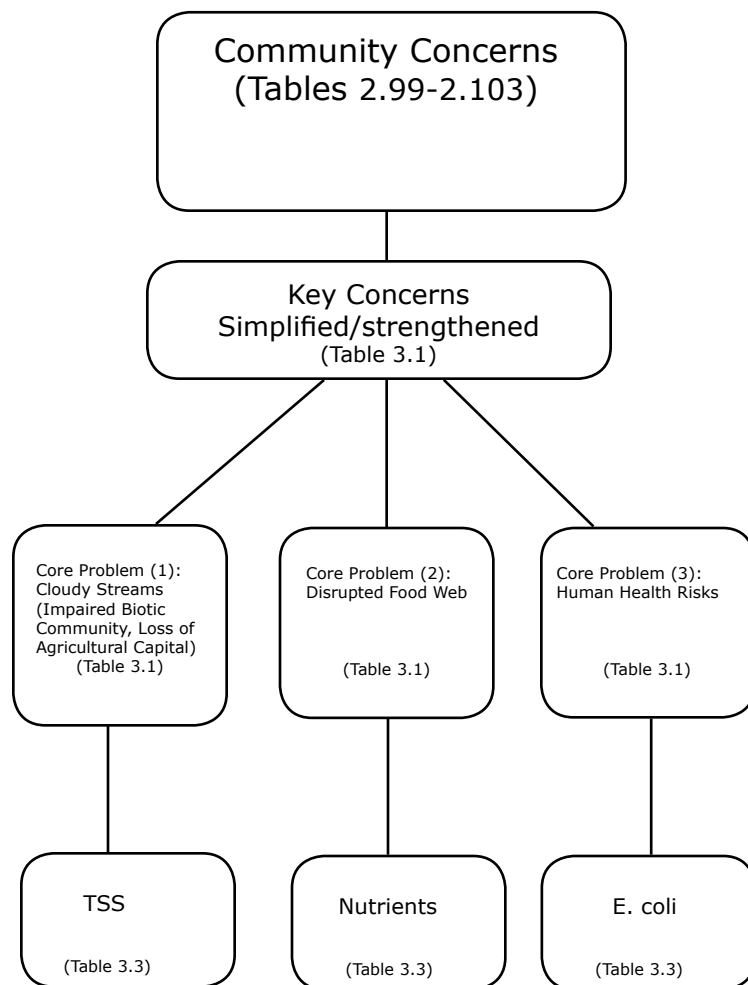
## WMP - CHAPTER 3 - PART 1 - SECTION 1 - SUBSECTION 4

This Chapters objective has been to outline our methodology for facilitating a planning process based upon Stakeholder consensus. We have outlined a method for linking diverse and superficial concerns (from a dynamic group of Community Stakeholders) to realistic and quantifiable ones (Chart 3.1). This has been accomplished by funneling Community Stakeholder concerns into key/collectively shared concerns that have a direct connection to problems and stressors that can be easily studied and analyzed. This has created a common language/common framework based upon the group's perception of key stressors (pollutants): E. coli, TSS, and nutrients . Since we have the capacity to analyze these stressors through water quality science (quantitative data) we can confirm that these four key pollutants are legitimate concerns/stressors by the way in which they compare to state standards and federal water quality guidelines.

Stakeholder consensus built on the scientific method (showing that NPS data/concerns have been validated and legitimized by Muncie BWQ data), sets the stage for rational plan implementation. In subsequent chapters, we will begin to develop means/method for addressing these Nonpoint Source stressors.



## [Concerns -> Problems -> Stressor] Process



# IDENTIFICATION OF SOURCES

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 4



# Basin Contribution

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 1

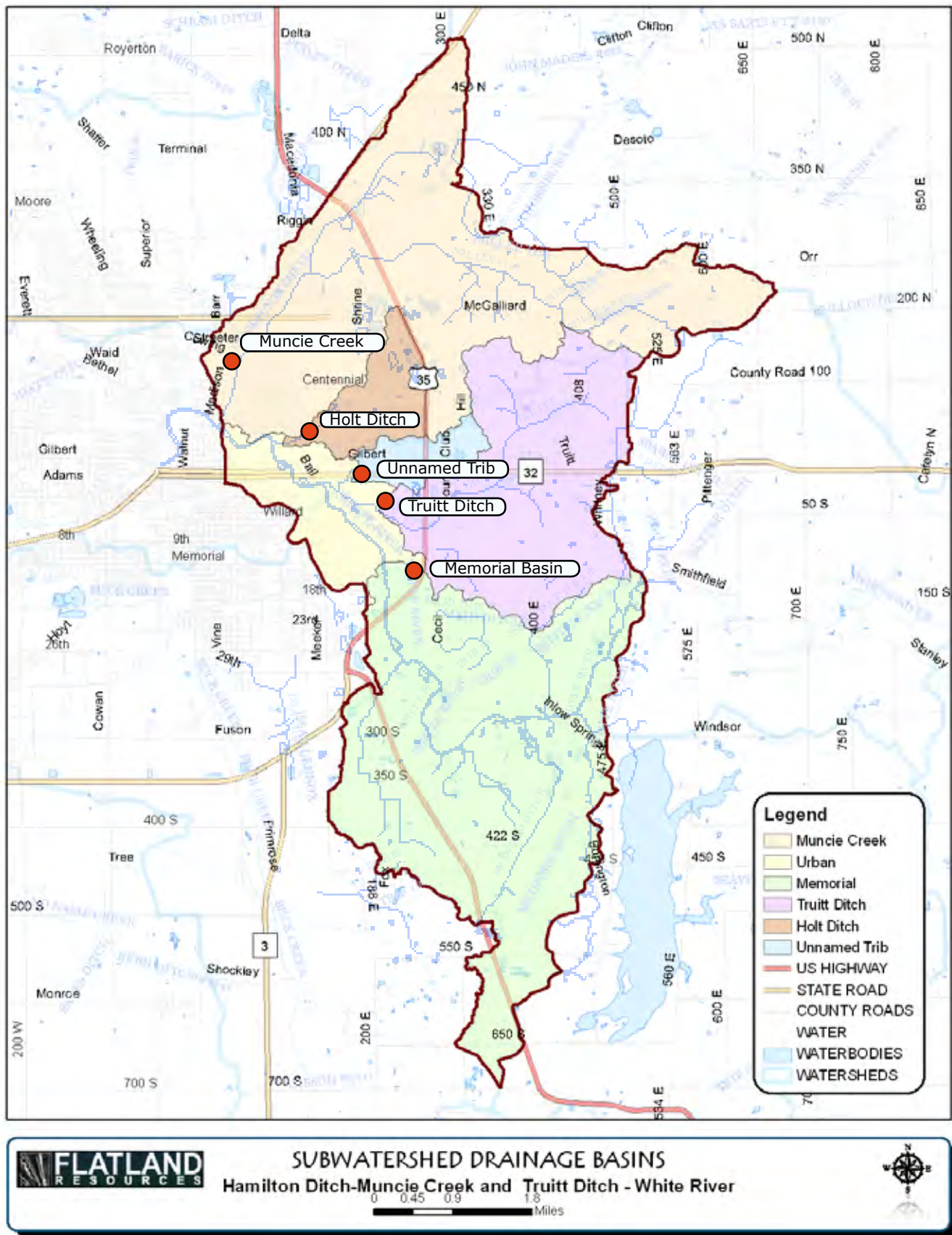
The next step in this process is to develop an action strategy for Water Quality Improvement. In chapter three we developed a justification for addressing three types of water quality stressors : E. Coli, TSS, and Nutrients., in this chapter we will begin to develop a process for how to best improve water quality through mitigating these nonpoint source pollutants.

By reviewing our basin-level (Table 4.2, Map 4.1) water quality studies, we can determine which sub basins are exceeding state standards for these impairments (Table 4.1) . According to 319/ Muncie Bureau of Water Quality Studies, the following basins are exceeding state standards and/ or federal (EPA) guidelines:

TABLE 4.1: Percentage above state water quality standard					
	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek	70%	115%	159%	101%	481%
Holt Ditch	77%	47%	174%	82%	1597%
Unnamed Tributary	108%	45%	282%	69%	2548%
Truitt Ditch	87%	108%	234%	70%	224%
Memorial	30%	176%	194%	93%	203%

The Unnamed Tributary basin was the only basin that exceeded the state standard for Ammonia during the sampling period. Muncie Creek, Truitt Ditch, and Memorial basins both exceeded the state standard for nitrogen. All basins exceeded the federal guidelines for Phosphorus with the following ranking (1) Unnamed Tributary (2) Truitt Ditch (3) Holt Ditch (4) Memorial (5) Muncie Creek. Muncie Creek was the only basin to exceed the state standard for sediment. Similarly to the Subwatershed wide study, all basins exceed the state standard for E. coli with the following ranking. (1) Unnamed Tributary (2) Holt Ditch (3) Muncie Creek (4) Truitt Ditch (5) Memorial Basin.

TABLE 4.2: Primary Drainage Basins		
	Acres	Stream MI.
Total Combined Subwatersheds	19654	31
<b>Walnut Basin</b>	12470	19
Walnut Basin: Secondary Basin - Muncie Creek	6468	10
Walnut Basin: Secondary Basin - Holt Ditch	724	1
Walnut Basin: Secondary Basin - Unnamed Trib	414	1
Walnut Basin: Secondary Basin - Truitt Ditch	3646	6
Walnut Basin: Secondary Basin - Urban (non monitored)	1218	2
<b>Memorial Basin</b>	7184	11
Randolph County - Upper White River Headwaters Basin	130842	204
SOURCE: ArcGIS Indianamap.org		

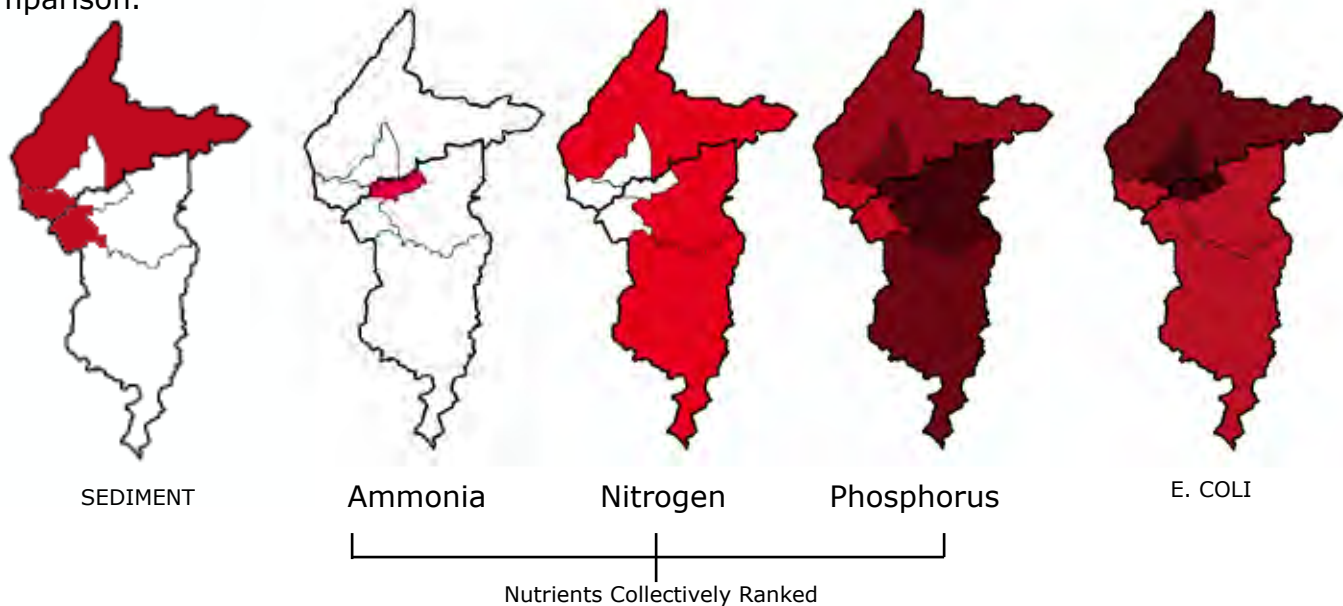


**MAP. 4.1** Location of Drainage Basins

# Basin Contribution

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 1

The below table (Table 4.3) and diagram (Diagram 4.1) show results from the tributary basin study and provide a visual glance at basins exceeding standards/guidance. Red areas designate tributary basins that are exceeding standards/guidance for the designated pollutant. For pollutants that are exceeding standards/guidance in all tributaries in the Hamilton Ditch - Muncie Creek and Truitt-Ditch Subwatersheds, the darker the red the greater the impairment per tributary by tributary comparison.



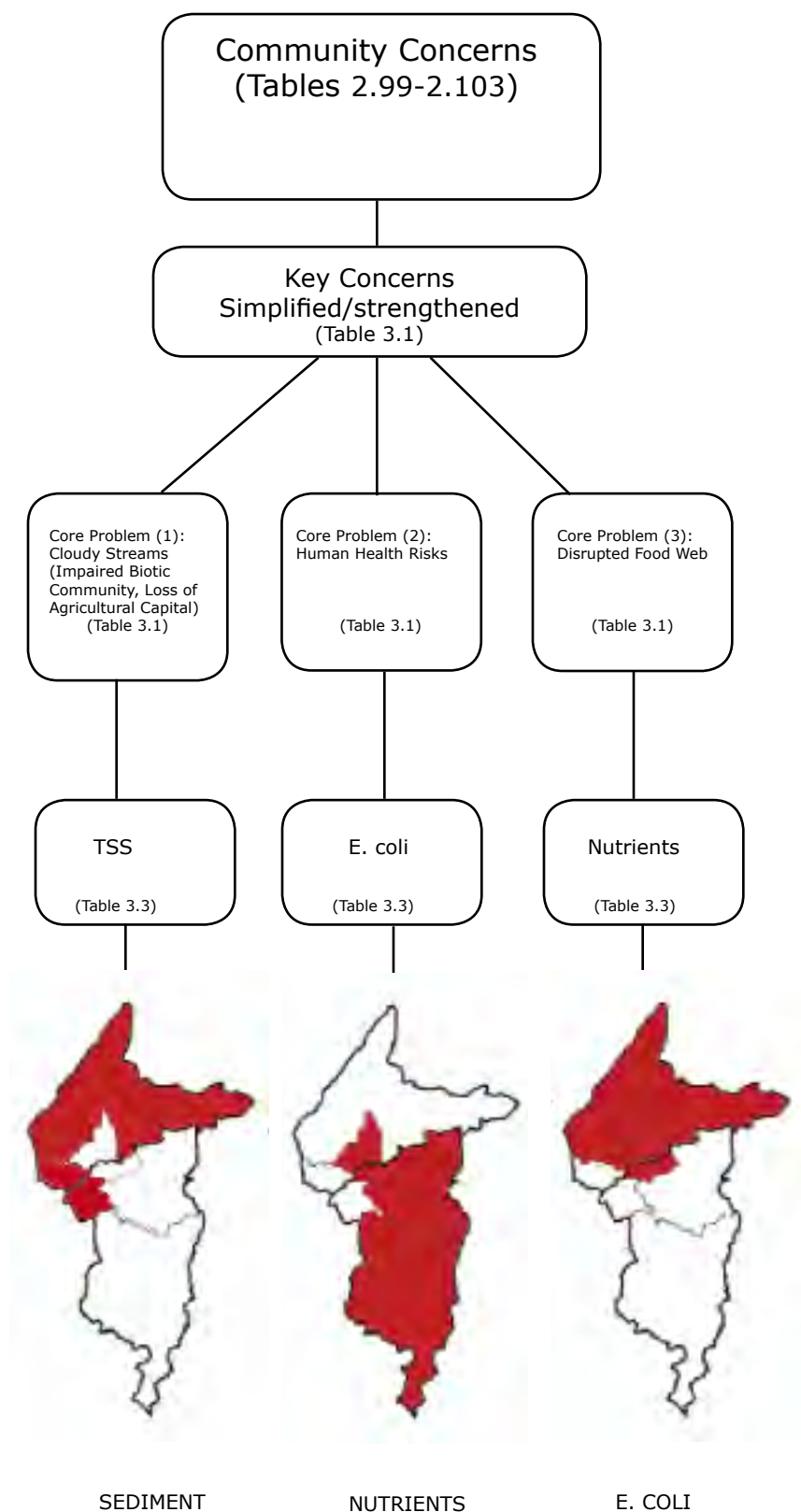
**DIA. 4.1** Basin Level Critical Areas

Knowing that we can not designate entire HUC12 Subwatersheds as critical areas when planning at a scale smaller than a HUC10 watershed, we must prioritize basins based on the degree they are exceeding the state standards/federal guidance. Accordingly, the WRWP will only focus on the top three exceeding basins when all HUC12 areas are impaired for a particular pollutant. Note: nutrients Ammonia, Nitrogen, and Phosphorus will be ranked collectively.

	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek	70%	115%	159%	101%	481%
Holt Ditch	77%	47%	174%	82%	1597%
Unnamed Tributary	108%	45%	282%	69%	2548%
Truitt Ditch	87%	108%	234%	70%	224%
Memorial	30%	176%	194%	93%	203%

Table 4.3 highlights in yellow the basins that are to be selected for critical area determination based on the "top three impaired basins by exceedance" policy. The basins highlighted in Table in 4.3 are represented in Chart 4.1. These basins are then considered critical areas for Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds. These basins will be the focus basins for all WRWP implementation activities in Hamilton Ditch-Muncie Creek and Truitt- Ditch White River Subwatersheds. Cost-share funding available through the IDEM Section 319 program can only be spent in these basins. Eligible applicants must have BMPs selected to match the pollutant critical areas designation for each basin. GIS aerial overlay maps presenting these critical areas can be found in Chapter 5 (See Page 452).





# Sources

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 2

Nonpoint source pollution (NPS), unlike point source pollution from industrial and wastewater treatment plants, comes from many diffuse sources. It is caused by rainfall, snowmelt, or water usage that is moving over or through the ground. As run-off moves, it picks up and carries away natural and human made pollutants, finally depositing them into lakes, rivers, wetlands, and even our underground sources of drinking water.<sup>1</sup>

Sources are the activities that contribute pollutants or stressors to surface water resulting in impairment of designated uses in a waterbody. The structure of IDEM's Assessment Database (ADB), which was designed by USEPA for states to use in their CWA section 305(b) reporting, requires that a source be identified for each assessment made whether or not specific sources are precisely known. For most assessments, the sources identified in the ADB for a given impairment are not proven. Rather they represent those sources determined by IDEM staff to be the most likely sources given a variety of factors, including but not limited to: Land uses (as indicated by field observations and land use data from published sources such as GAP, L-Thia, areal photography, etc.); field observations of potential sources such as illegal straight pipes, tillage to the stream's edge, livestock in the stream, etc; the presence of permitted facilities within close proximity of the impaired stream in cases where the impairment is something that could reasonably be expected to be associated with the discharge of those facilities; naturally occurring conditions that could contribute to impairment.<sup>2</sup>

IDEM believes that by using best professional judgment, its scientists can apply these types of information to distinguish the most likely sources of impairment in the watershed, providing a starting point for a TMDL, watershed planning or other activities aimed at restoring the stream. Within this context, the sources identified in the ADB do not identify any entities or practices known to contribute to a specific impairment. Lacking more detailed and resource-intensive sampling and analyses, accurately attributing a given impairment to specific sources is difficult at best and is, in many cases, impossible to do with a high degree of certainty. In 2004, IDEM implemented a second-year sampling strategy to address this issue. IDEM's second-year studies are aimed at providing sufficient data to more confidently attribute specific sources to impairments than previously possible.

The activities listed in Table 4.4 represent the total state-wide stream miles impaired due to each potential source. Several potential sources may contribute to impairment of a single stream or stream reach, so the total miles in the table may be greater than the actual stream miles impaired reported elsewhere in IDEM reports. This table is included to guide Stakeholders in the source identification process. Table 4.4 highlights in yellow sources applicable to the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds.

The WRWP will operate under IDEM's guidance and methodology for determining "the most likely" sources of Nonpoint Source pollution using Chapter 2's natural systems and land use inventories as a method of source determination.

<sup>1</sup> Indiana Integrated Water Monitoring and Assessment Report

<sup>2</sup> Indiana Integrated Water Monitoring and Assessment Report

TABLE 4.4: IDEM Sources	
Source	Miles
<b>Municipal Point Sources</b>	
Package plants (small flows)	901
<b>Combined Sewer Overflow</b>	<b>402</b>
Collection System Failure	4
<b>Agriculture</b>	
Grazing Related Sources	1,465
Animal Feeding Operations (NPS)	1,191
<b>Crop Production</b>	<b>1,473</b>
<b>Land Application/Waste Disposal</b>	
Sludge Application or Disposal	1
Landfills	7
Illegal Dumps or Other Inappropriate Waste Disposal	45
<b>On site Wastewater Treatment Systems (septic systems)</b>	<b>768</b>
Hazardous waste	3
<b>Hydromodification</b>	
<b>Channelization</b>	<b>179</b>
<b>Dam Construction</b>	<b>16</b>
Upstream Impoundment	1
Flow Regulation/Modification	383
<b>Habitat Alterations (not directly related to hydromodification)</b>	
<b>Loss of Riparian Habitat</b>	<b>549</b>
<b>Bank or shoreline modification/destabilization</b>	<b>312</b>
<b>Other</b>	
Contaminated Sediments	165
Debris and Bottom deposits	18
Natural sources	132
Groundwater Loadings	6
<b>Urban Runoff/Storm water</b>	<b>430</b>
Land Development	2
<b>Erosion and sedimentation</b>	<b>3</b>
Resource Extraction (Mining)	182
<b>Industrial Point Sources</b>	<b>333</b>
Illicit connections	165
Nonpoint Source	6,308
Source Unknown (applied to fish tissue impairments)	3,863
SOURCE: Indiana Integrated Water Monitoring and Assessment Report	

The activities listed in Table 4.4 represent the total stream miles impaired due to each potential source. Several potential sources may contribute to impairment of a single stream or stream reach, so the total miles in the table may be greater than the actual stream miles impaired reported elsewhere in this document.

# Sources

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 2

To increase our effectiveness at implementing Water Quality improvements, the WRWP seeks to understand the sources of selected critical water quality pollutants. To affect the greatest impact per project, we need to know, for each impairment, the most significant source of the stressor per basin.

For example, we know through our water quality studies that sediment is a problem in Muncie Creek, but sediment can come from different sources (e.g. stream banks and surface runoff). To ensure effective planning, we need to outline each potential pollutant source (identified in our studies) and discuss any relevant data that would suggest one source is a greater contributor than the other. This is a crucial step in the process of outlining an effective action strategy. Table 4.5 outlines potential sources of non point source stressors (causes) in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds.

TABLE 4.5: WRWP Sources

Problem	Potential Cause(s)	Potential Source(s)
Area streams are very cloudy and turbid	TSS levels exceed the target set by this project	<p>Potential Sources include:</p> <p>(1) stream banks due to poor vegetative and structural integrity, channelization and increased sheer stress, dams and backwater pooling, and ditching</p> <p>(2) sheet flow due to lack of ground cover and on site infiltration opportunities, lack of tile out let BMPs , and lack of buffer strips.</p>
Area streams have nutrient levels exceeding the target set by this project	Nutrient levels exceed the target set by this project	<p>(1) stream banks due to dams and backwater pooling</p> <p>(2) sheet flow due to lack of ground cover, lack of tile out let BMPs, lack of buffer strips, lack of ground cover and on site infiltration opportunities, over application of lawn, garden, recreational, agricultural fertilizers, poor timing in application of lawn, garden, recreational, agricultural fertilizers, waste entering streams from Live-stock, and animal wastes used as field applications</p>
Area streams are impaired on IDEM's 303(d) list for E. coli	E. coli levels exceed the water quality standard	(1) Pet Waste, Animal Wastes from Agricultural Sources, Animal Wastes from Wildlife Sources

# Sources: Sediment

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 3



IMG. 4.1 Stream banks



IMG. 4.2 Ag. Runoff

### Sources of the Erosion Control Problem: TSS levels exceed the target set by this project

Sediment comes from channel sources like sloughing, bed scouring and overland erosion in both agricultural and urban areas. Sediments in water poses as solids (like clay, silt and sand) for contaminants to bind to. Sediment is the loose clay, silt, sand, and other soil particles that settle at the bottom of a body of water. Sediment can come from soil erosion, from decomposition of plants and animals, from streams modified for quick drainage, and from the deterioration of structural infrastructure, like roads. Wind, water, and ice help carry these particles to rivers, lakes, and streams. Sediment is also a source of nutrient pollution: Acting as nutrient collectors and carriers is one of the main concerns with sediment. Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where the pollutants may settle with the sediment or detach and become soluble in the water column.<sup>1</sup> (i.e. stop the flow of sediment and stop the flow of nutrients and pathogens). Contaminated sediments do not always remain at the bottom of a water body. Anything that stirs up the water, such as dredging, can resuspend sediments. Resuspension may mean that all of the animals in the water, and not just the bottom-dwelling organisms, will be directly exposed to toxic contaminants.<sup>2</sup>

### Streambank Erosion

Knowing that TSS is exceeding the WRWP standard in Muncie Creek, we begin to look at locations where sediment sourcing may be occurring. In support of this process, we reference back to the BSU stream bank analysis (Map 4.2). In this analysis we discovered 60,346 linear feet of stream that had no trees on either side of the stream bank. We know from our studies that tree roots are an essential means of stabilizing stream banks. We can hypothesize that – where vegetation is missing, TSS is being contributed to the water column at a greater rate – than where vegetation is not missing (sheer stress being equal).

We also know from our chemical studies that Muncie Creek sediment levels are exceeding WRWP standards throughout the entire year. If soil contribution was predominantly from sheet flow, we would expect sediment to be higher during the nongrowing season (that was not the case for Muncie Creek as it was in other tributaries in Hamilton Ditch-Muncie Creek and Truitt- Ditch White River Subwatersheds). This leads us to the conclusion that stream banks are a higher contributor of sediment in Muncie Creek than other areas of the subwatersheds.

1 Scorecard  
2 Scorecard



Stream bank augmentation can occur due to near bank shear stress, channelization, hydromodification, or other impairments that can cause an alteration of water's natural flow (e.g. log jams). This is often a result of changes in land use and/or the alteration of waterways. Modification or channelization of the natural channel can cause the pollutant levels to increase in a waterway. When a natural channel is modified and straightened into a drainage ditch (e.g. trapezoidal cross section, loss of floodplain, loss of sinuosity), the resulting changes to how water moves through the system results in increased erosion. For instance, the removal of a flood plain, the creation of a uniform channel depth, and the straightening of the channel, cause storm water to move through the waterway much faster, increasing the chance for erosion and long-distance sediment transport. As stated before, hydromodification can lead to serious problems by adversely affecting stream flow and gradient, the amount of sediment load, and the channel width to depth ratio.

Erosion from agricultural drainage ditches can be an easily identifiable large source of sediment and nutrient pollution. The main difference between ditches and streams is magnitude. Agricultural ditches tend to be smaller, and therefore produce less pollution from erosion. Agricultural ditches also tend to have little to no filter strips flanking them and they often lack an overstory. Often, ditches were created in locations where no waterway was present before western settlement. The location and condition of the ditches is a major factor in their potential to supply and transport nonpoint source water pollution. Direct measurement of this potential can only occur with intensive fieldwork.

Often overlooked, stream bank erosion is a significant contributor of sediment in our nation's waterways. According to the EPA Region 5 model for Estimating Load Reductions for Agricultural and Urban BMPs, an eroded 500 foot section of bank that is 10 feet high, with silt loam soils, would contribute over 4500 tons of sediment for every three inches of erosion. A recent study in a neighboring Subwatershed, Buck Creek, found stream banks contributing more tons per acre than sheet runoff. For the Lower Buck Creek drainage area - it was estimated that on an annual basis, a total of 5,000 tons of sediment enter the river network from stream banks (with 20% of the sediment coming from only 867' of the total 20,000'). This is compared to 1,951 tons of sediment that enter the river system from sheet runoff in the same drainage basin. The amount of acres containing stream banks in the Buck Creek study reach is 4.59 acres compared to the 4,990 acres of land generating sheet runoff. Sediment contribution from channel modification and stream bank erosion can be easily identifiable using BEHI and NBS analysis. On Buck Creek streams, a loss of vegetation often was tied to an increase of erosion.

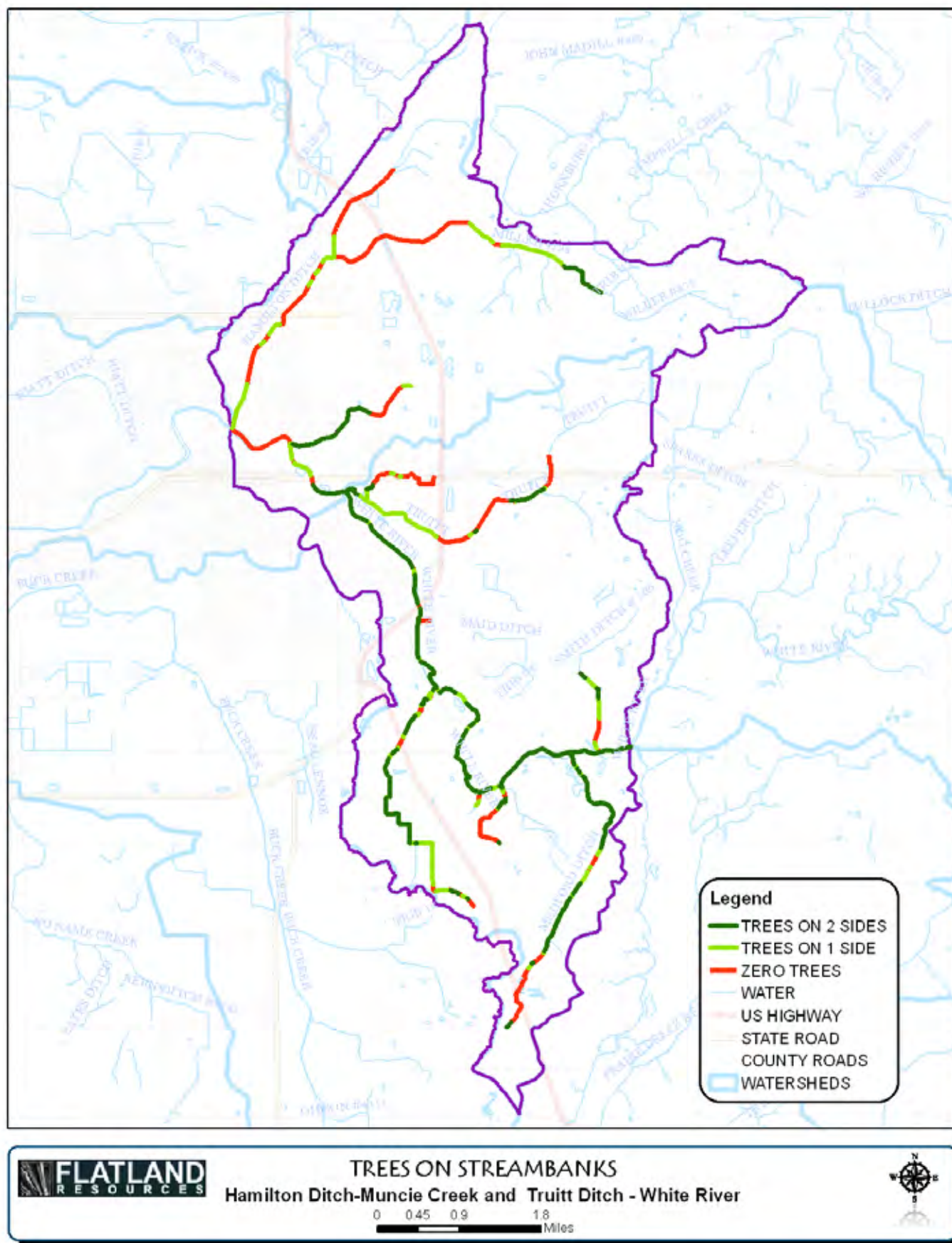
Severely eroded stream banks can lead to the removal of riparian vegetation. Bed scouring can lead to a loss of habitat for aquatic insects and other Macroinvertebrates. A lack of vegetation on the banks can compromise structural integrity and lead to erosion and poor quality of habitat. The presence of trees and shrubs that shade the water aids in keeping water temperatures low, allowing for higher levels of dissolved oxygen. The removal of the native herbaceous layer and the subsequent replacement with cool season grass reduces the biodiversity of the riparian area. These changes to channel morphology can lead to a degradation of natural habitat.

# Sources: Sediment (Continued)

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 3

TABLE 4.6: Sediment Sources

Source
Streambanks
<b>SUPPORT</b>
<p>The removal of overstory, shrub, and herbaceous vegetation and replacing it with cool season grasses is a common practice of the management of legal drains in Delaware County.</p> <p>A visual assessment of the streams shows that over 80% of the main stem of Truitt Ditch and 90% of the main stem of Muncie Creek have had their native riparian vegetation removed and replaced with either cool season grasses, crops, or invasive species. The only water body that has relatively good shading and a riparian corridor lush with habitat is the White River.</p> <p>Historic data shows high levels of total suspended solids and turbidity in Muncie Creek and the White River and moderate levels of both parameters in Truitt Ditch.</p> <p>Stream bank erosion is a major source of sediment pollution in both Truitt Ditch-White River and Hamilton Ditch-Muncie Creek Subwatersheds. The windshield and aerial surveys have identified more 9,400 feet of stream bank in the Truitt Ditch-White River Subwatershed and 13,700 feet of stream bank in the Hamilton Ditch - Muncie Creek Subwatershed; most are moderately to severely eroded. Specific location of erosion on the White River banks are near SR 32, and White River behind houses on Burlington drive.</p> <p>Preliminary monitoring show that fish (IBI) and macroinvertebrate (mIBI) samples are in the fair range, while habitat ratings are on the poor range for both Muncie Creek and Truitt Ditch. Aerial surveys of the waterways show a lack of an overstory throughout much of their length.</p> <p>Both the main stems of Truitt Ditch and Muncie Creek have undergone major modifications over their entire lengths. It is impossible to tell exactly how much has been modified since settlement, but through examination of the straight channels and trapezoidal design throughout the length of both streams, it would appear that they have completely changed from their original course. The one exception would be the White River through these watersheds. While it has undergone some modification (e.g. the removal of meanders and oxbows, the installation of low height dams, the creation of a levy system, etc.), for the majority of the length in these watersheds, the flood plain is intact and the channel meanders slightly.</p> <p>There are 9,250 feet of agriculture ditches in Truitt Ditch watershed and 1,750 feet of agricultural ditches in Muncie Creek watershed that have moderate to severe erosion present. Moderate erosion of ditches is characterized by bare banks, with slight overhang from vegetation on the top of bank. Severe erosion is characterized by the presence of massive failures, gullies, and bare rills. Erosion on Smith Ditch is visible from Inlow Springs Road, there is ditch erosion on Elwood Reese ditch west of Burlington drive, and channelized ditches eroding in Muncie Creek watershed. Major erosion is occurring on the main stem of Truitt Ditch through Delaware Country Club.</p>



**MAP. 4.2** Streambank Tree Assessment

# Sources: Sediment

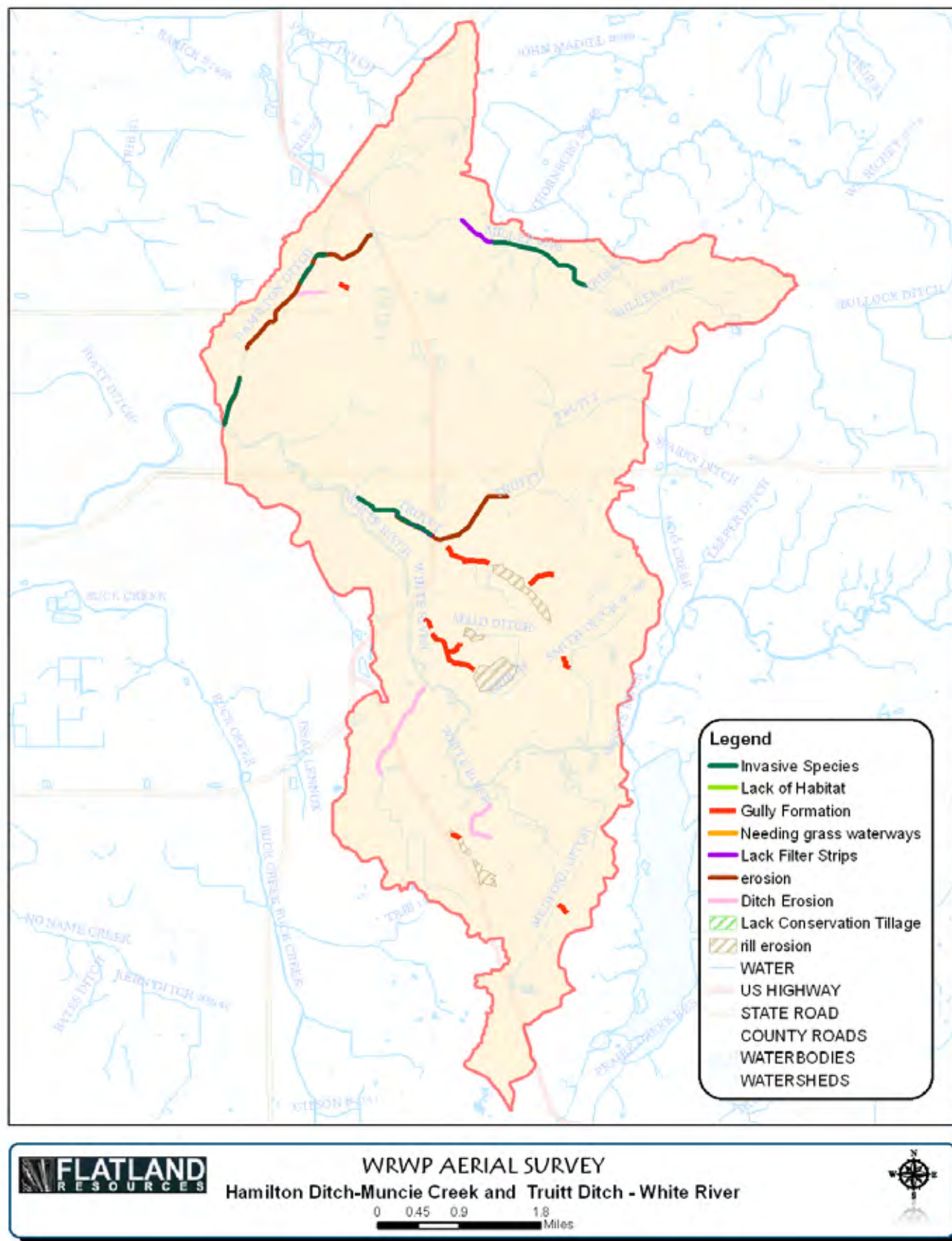
## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 3

Additionally, as part of the WRWP aerial photo analysis, areas of Truitt Ditch – White River showed evidence for rill and gully formation. There seemed to be a greater lack of conservation practices in Muncie Creek and Truitt Ditch subwatershed (in general) when compared to other areas of the County. Because the aerial photos begin to identify the presence of surface erosion, we can conclude that sheetflow is a significant source of sediment contribution in the Truitt Ditch - White River Subwatershed.

### **Sheetflow**

Rill erosion and gully formation occur when storm water runoff moves across the land, picking up soil particles as it moves. Rills, or small channels, begin to form. As the erosion continues, the rills get deeper and wider, causing gullies to form. These gullies can then become exacerbated if a head cut forms, forcing the channel to rapidly move uphill, eroding sediment as it goes. Lack of ground cover or other agricultural no-till practices (BMPs) on agriculture fields and ditches in the watersheds can cause excessive sediment pollution, degrading habitat and limiting the use of the waterways for recreation, drainage, and aesthetic purposes. Lack of tile, ditch invert BMPs and the proximity of ditches and field tiles to agricultural fields can provide sediment with direct access to the watershed's waterways. Best Management Practices can reduce the frequency and amount of the sediment that enters the waterway. Increases in run off volume duration from tiles and hydro-modification can cause increased flashiness of streams, leading to increased stream bank erosion, degrading habitat, and limiting use of waterways for recreation, drainage, and aesthetic purposes.





**MAP. 4.3** WRWP Aerial Survey

# Sources: Sediment (Continued)

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 3

TABLE 4.7: Sediment Sources
Source
Sheetflow
SUPPORT
<p>Areas that show the tendency to have repeated rill and gully formation were inventoried using the information gathered through the windshield and aerial surveys. The process of uncovering this information included examining the oblique images from bing.com, the 2005 Indiana state-wide orthophotograph, and the 2008 Delaware County orthophotograph for areas that show rill and gully formation. As these images range from 2005 to 2009, they provide a long time frame to see areas with repeated erosion. In the Truitt Ditch - White River watershed, (Memorial Basin) approximately 200 acres show repeated rill and gully erosion. There are fewer areas in the Hamilton Ditch - Muncie Creek watershed with these problems, totaling approximately 50 acres.</p> <p>Historic data shows high levels of sediment and turbidity in Muncie Creek and the White River and moderate levels of both parameters in Truitt Ditch. Aerial orthophotograph and windshield surveys show agricultural fields that do not have vegetated drainage ditches resulting in bank erosion. Aerial orthophotograph and windshield surveys show agricultural fields that do not use conservation tillage, lack BMPs (such as grass waterways and filter strips), and have rill erosion and gully formation.</p> <p>In addition to the aerial survey parameters discussed earlier, the watersheds were examined looking for lengths of streams without filter strips and areas where grass waterways were needed. Truitt Ditch - White River Subwatershed had approximately 3,150 feet of ditch bank that was in need of filter strips and 12,000 feet of gully formations that should be planted as grass waterways. Hamilton Ditch - Muncie Creek Subwatershed had approximately 5,400 feet of bank that was in need of filterstrips, and 610 feet of gully formations that should be planted as grass waterways. More in-depth understanding of conservation practices of agricultural producers would aid in making this document more comprehensive. Currently, the FSA will not grant access to private information. All presented information has been sumerized from aerial imagery. With this in mind, it is suggested that in the future, a survey is mailed out to producers in the Subwatersheds.</p> <p>According to the 2009 Indiana tillage transect, in Delaware County 21% of corn fields and 6% of soybean fields use conventional tillage. These are relatively high numbers of conservation tillage in the County. It should be noted that this survey uses the same points every year and is not a true random sampling of all cropland in the county.</p>





# Sources: Nutrients

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 4



IMG. 4.3 Nutrients

### **Nutrient levels exceed the target set by this project**

Nutrient Pollutants come from decaying organic matter naturally but are also added to the environment through the usage of fertilizers, leaking septic tanks, manure, and surface run-off. Nutrients are placed into different categories: Phosphates, Nitrates, and Ammonia.

#### **Phosphates<sup>1</sup>**

Phosphates enter water through natural decay of organic matter or phosphorus rich bedrock, but are also added from human and animal waste, laundry detergents, cleaning solutions, industrial effluents, leaking septic tanks, and fertilizers. There are three forms of phosphates: orthophosphate, metaphosphate (or polyphosphate) and organically bound phosphate. Each compound contains phosphorous in a different chemical formula. Ortho forms are produced by natural processes and are found in sewage. Poly forms are used for treating boiler waters and in detergents. In water, they change into the ortho form. Organic phosphates are important in nature. Their occurrence may result from the breakdown of organic pesticides which contain phosphates. They may exist in solution, particles, loose fragments or in the bodies of aquatic organisms in lakes, rivers, or even underground water sources.

#### **Nitrates<sup>2</sup>**

Nitrogen is essential for all living things. It exists in many forms in the natural environment and changes forms as it moves through the nitrogen cycle: nitrogen, nitrates, nitrites, nitrogen oxides, nitric acid, nitrous oxide, and ammonia. Nitrate-nitrogen is commonly found in groundwater due to point sources such as sewage disposal systems and livestock facilities, or non-point sources such as fertilized cropland, parks, golf courses, lawns, gardens, and naturally occurring sources. Nitrates in water are undetectable without testing because nitrogen is colorless, odorless, and tasteless. Annual testing is recommended in most areas. Typically nitrogen enters water systems through run-off or through leaching through the soil profile, usually from excessive fertilizer application.

#### **Ammonia<sup>3</sup>**

Ammonia is a colorless gas with a strong odor. When it reacts with water it forms unionized or ionized ammonia. Toxicity in water is primarily attributable to the unionized form. Toxic levels of Ammonia are commonly attributed to fertilizers, pesticides, herbicides, livestock waste, cleaning products, septic systems, improper disposal of ammonia products, and the atmosphere due to domestic heating, burning of municipal waste, and internal-combustion engines. Many point source pollution sources associated with industrial process attribute to a large portion of ammonia emissions and effluent, some of these include: coal to coke in coke plants, metallurgic operations, chemical synthesis, sewage treatment plants, production of household cleaners, oil refineries, food processing, and others.

1 Non Point Source Pollution, [whiteriverwatershedproject.org](http://whiteriverwatershedproject.org)

2 Non Point Source Pollution, [whiteriverwatershedproject.org](http://whiteriverwatershedproject.org)

3 Non Point Source Pollution, [whiteriverwatershedproject.org](http://whiteriverwatershedproject.org)

It is common knowledge that nutrients are applied as fertilizers by farmers and urban residents for either agricultural purposes or lawn care maintenance. Nutrients can also enter the water column through animal/human waste. As with NPS pollution in general, nutrients are difficult to track because of their diffuse usage in the Subwatersheds and because we do not have an effective method to survey usage of chemical fertilizers aside from county wide data (included in our Inventory and Analysis). We can confirm that these nutrients are being applied because they are detected by our water quality studies at levels higher than natural baselines. However, neither sources of information tell us where they are exactly being applied. Aside from actually seeing farmers/urban residents applying these nutrients/ fertilizers (at the time they are doing it) there is no way to quantify Subwatershed specific locations or loading (with our available data resources).

Since we know that nutrients are transported in water, there are certain studies that we can use to help us focus our efforts. We know that we are not going to stop agriculture and urban users for applying fertilizers (as a non regulatory entity this sort of enforcement is not in our jurisdiction) – besides advocating a reduction in usage (only what is necessary) we can help to fund strategies that keep nutrients on site or help to filter nutrients out of the water as it leaves a chemical users property. The BSU Stream Buffer Analysis maps (Map 4.5) help us identify locations where there are zero agricultural/urban buffers on either side of the stream. We know that these sites are weak points in storm water filtration.

Additionally, the same applies for the streambank analysis. Trees and other riparian vegetation have the capacity to absorb water soluble nutrients. Furthermore, we know that phosphorus and other positively charged nutrients attach to sediment. Trees and vegetation form an additional filtration medium and are more effective in sediment management than buffers alone. Stabilizing sediment with stream bank vegetation, filter strips, and winter cover crops can do a lot to stop nutrient transport.

Finally, there is a persistent potential that phosphorus (applied in the past) may be embedded into soils that were once trapped by a streambank riparian zone. When we remove vegetation, streambank soils that are contaminated by phosphorus may finally have the opportunity to enter the water system.

Again, these maps show the breakdown in the buffering and filtering process. These weak points are key locations and potential sites where nutrient sources can be prevented from entering our water systems.

Although one of the most significant contributors of nutrient pollutants in rural areas are agricultural producers – until the national clean water act is willing to perceive growing and centralizing agricultural system as industries – it will remain unregulated under current law.

We must continue to use methods for volunteer compliance with standards in order to find ways to reduce the impact of these agricultural processes. The 319 program, along with other programs administered through USDA/FSA, ISDA, and DNR will continue to play a role in implementing mitigations for these agricultural byproducts. Agricultural BMPs are the means of agricultural pre-treatment in the mechanism of nature's eco-system service. If we begin seeing nature and the river as a large water pollution control facility we can see the need for some sort of buffer to the farming infrastructure discharge in the same way that we have programs for industrial processing units.

# Sources: Nutrients (Continued)

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 4

Nutrient input is a problem in locations with direct access to waterways via storm water outfalls, swales, or areas directly adjacent to the streams through runoff. This is only an issue in those locations where people use fertilizers. This includes commercial, agricultural, and residential properties, and only those that apply too much fertilizers or at the inappropriate time, like before a rainfall.

Runoff provides nutrients (applied to the turfgrass or productive landscapes) direct access to streams. Nutrient rich runoff is predominantly from agricultural sources (the majority of land use in both the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds is agricultural land) and exacerbated by the small or nonexistent buffer strips on Truitt Ditch and feeder ditches, chemical Usage on Genetically Engineered Agriculture crops, and lack of no-till/grassed waterways throughout both watersheds. Non agricultural concerns have been raised by users such as the Delaware Country Club and Sports Complex.

Animal waste improperly used on agricultural lands can be a major contributor to nutrient pollution in watersheds through runoff. One potential contributor to livestock waste pollution is farms, ranches and pastures that house livestock.

Another potential contributor of animal waste pollution is the improper placement or timing of manure applications which can result in the movement of the wastes into the waterway through runoff. Manure management on agricultural fields is a long-term process; without undergoing an in-depth survey of all agricultural producers in the watershed, it is impossible to locate the specific sources of this problem. It is suggested that in the future, this data be uncovered using social survey techniques.

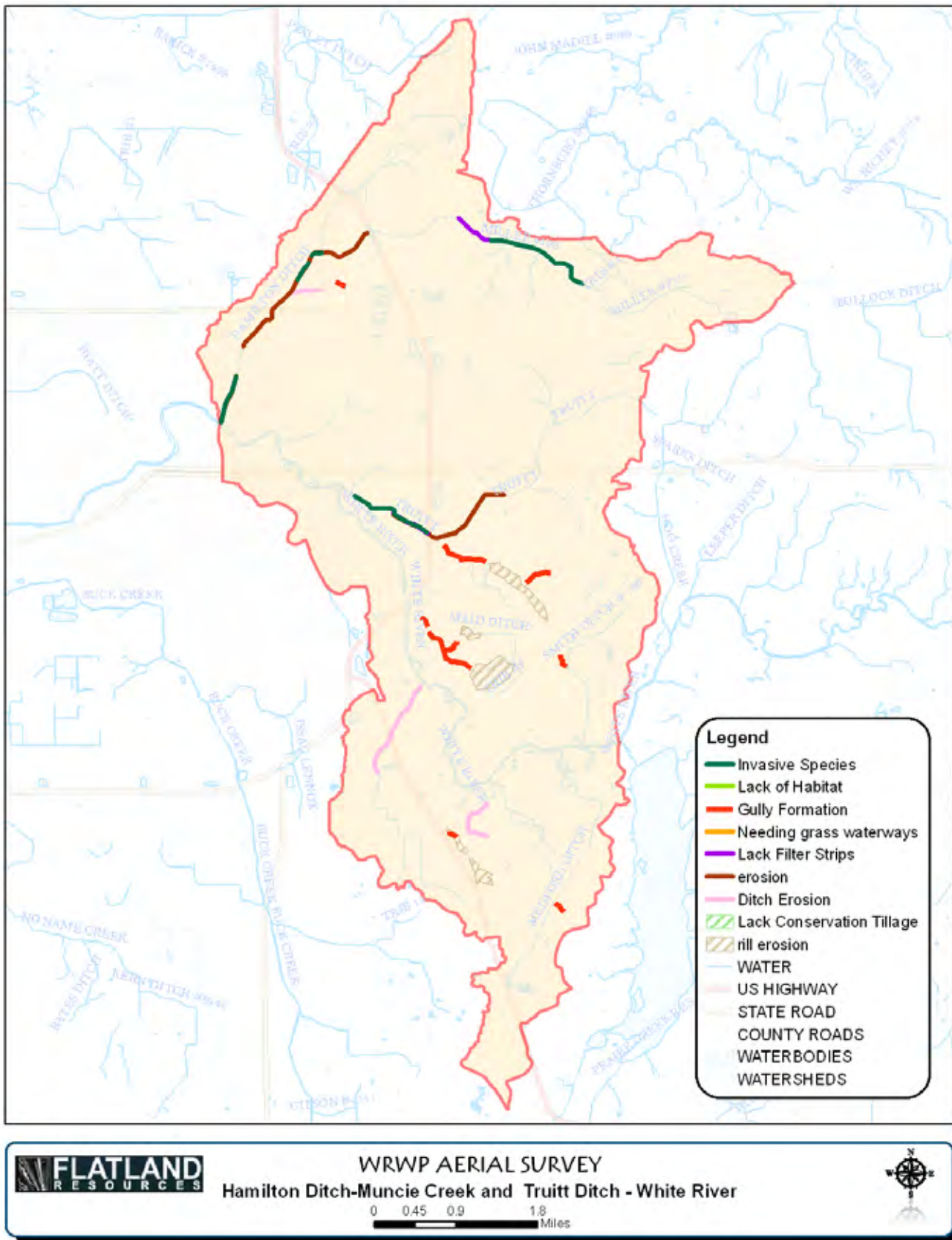
### **Source: Sheet Flow and Streambanks**

#### **Sheetflow/Drainage**

Erosion of agriculture fields and ditches in the watersheds cause excessive sediment and nutrient pollution that is degrading habitat and limiting use of the waterways for recreation, drainage, and aesthetic purposes. There is a lack of knowledge of where tiles exist in Delaware County. The current practice, or ones that have been identified, is to have a direct discharge of the pipe into the river. We believe that BMPs at tile inverts and outfalls may begin to buffer the systems from high concentrations of chemicals. There is a general lack of filtering and on site infiltration. Improperly applied manure, fertilizer, and pesticide applications can runoff into drainage ditches that then flow into the larger streams and rivers. Best Management Practices can reduce the frequency and amount of the chemicals that enters the waterway.

#### **Streambanks**

Lack of ground cover is mostly likely caused by numerous human activities that have altered the natural chemical and physical environment of the riparian areas. These activities impair aquatic life communities by degrading habitat, disrupting natural processes like reproduction, and altering the chemical/physical properties of the water to a point where life struggles to survive.

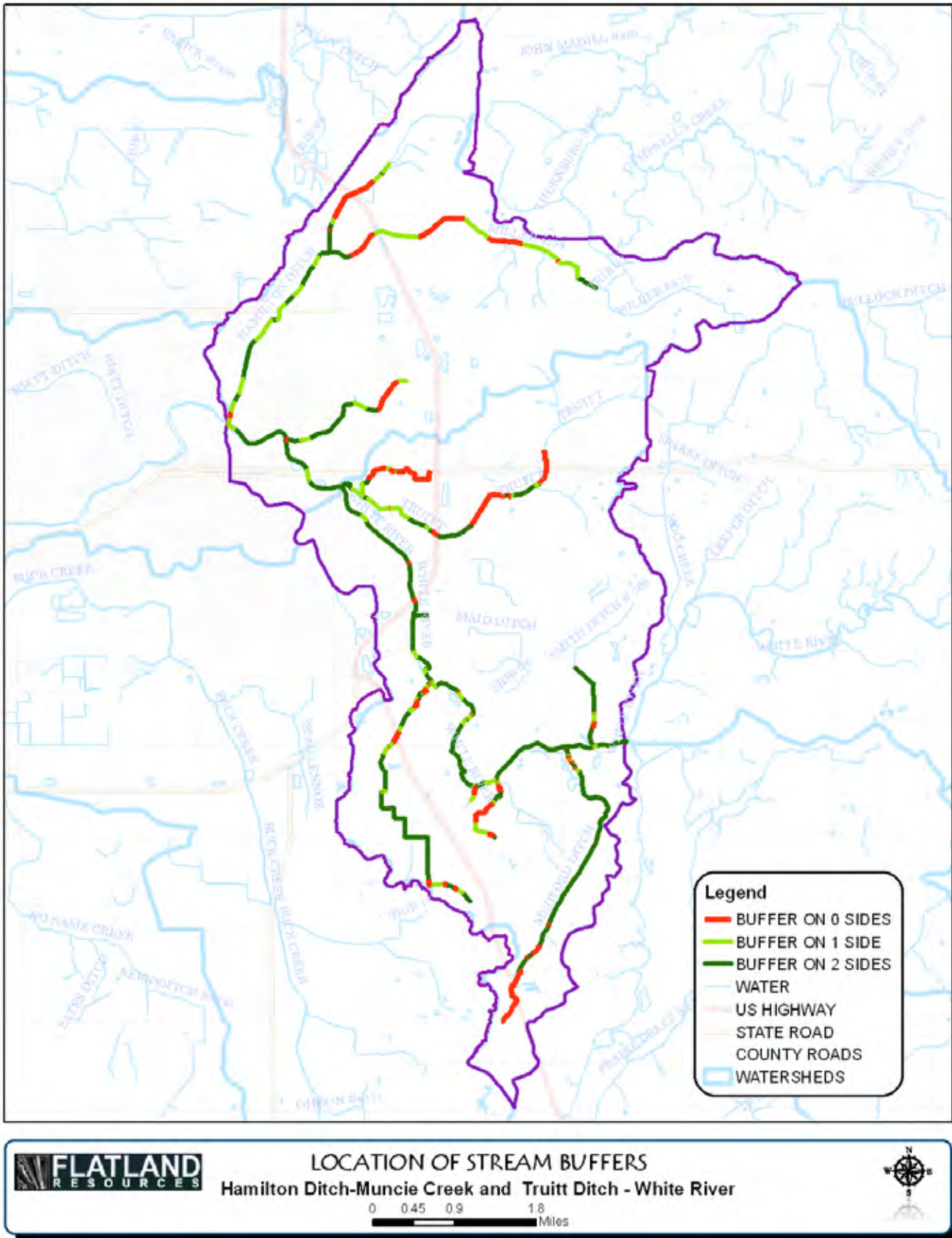


**MAP. 4.4** WRWP Aerial Survey

TABLE 4.8: Nutrient Sources
Source
Sheetflow
SUPPORT
<p>Aerial orthophotograph and windshield surveys show agricultural fields that do not use conservation tillage, lack BMPs (such as grass waterways and filter strips), and have rill erosion and gully formation. The proximity of ditches and field tiles to agricultural fields can provide pollutants with direct access to the watershed's waterways. More in-depth understanding of conservation practices of agricultural producers would aid in making this document more comprehensive. With this in mind, it is suggested that in the future, a survey is mailed out to producers in the watersheds to get a comprehensive inventory of all conservation initiatives used by the producers.</p> <p>Concern from the steering committee was raised over the lack of vegetation on the banks leading to erosion and poor quality of habitat. Preliminary monitoring show that fish (IBI) and macroinvertebrate (mibi) samples are in the fair range, while habitat ratings are on the poor range for both Hamilton Ditch - Muncie Creek and Truitt Ditch-White River Subwatersheds.</p> <p>There has been no watershed wide study of the locations of tile inverts. The ones that have been identified incorporate zero invert or outfall BMPs. There has been no best management practice recommendation for the percentage of storm water that should be managed on site – so there is no way to quantify the lack of filtering and on site infiltration other than the aerial surveys.</p>

TABLE 4.9: Nutrient Sources
Source
Streambanks
SUPPORT
<p>According to the EPA Region 5 model for estimating load reductions for agricultural and urban BMPs, an eroded 500 foot section of bank that is 10 feet high, with silt loam soils, would contribute over 4500 tons of sediment for every three inches of erosion. Assuming a concentration of nitrogen in the soil of 0.1% and phosphorus of 0.05%, this is equivalent to over two tons of phosphorus and almost 5 tons of nitrogen that would also be polluting the waterway with the sediment.</p> <p>Aerial surveys of the waterways show a lack of an overstory throughout much of their length. The removal of overstory, shrub, and herbaceous vegetation and replacing it with cool season grasses is a common practice of the management of legal drains. The presence of trees and shrubs that shade the water aids in keeping water temperatures low, allowing for higher levels of dissolved oxygen. The removal of the native herbaceous layer and the subsequent replacement with cool season grass reduces the biodiversity of the riparian area. Additional areas that lack certain agricultural BMPs were examined through the aerial survey using orthophotographs. In addition to the aerial survey parameters discussed earlier, the Subwatersheds were examined looking for lengths of streams without filter strips and areas where grass waterways were needed. Truitt Ditch-White River Subwatersheds had approximately 3,150 feet of ditch bank that was in need of filter strips and 12,000 feet of gully formations that should be planted as grass waterways. Hamilton Ditch - Muncie Creek Subwatershed had approximately 5,400 feet of bank that was in need of filter strips, and 610 feet of gully formations that should be planted as grass waterways.</p>





**MAP. 4.5** Streambank Buffer Survey

# Sources: E. coli

## WMP - CHAPTER 4 - PART 1 - SECTION 1 - SUBSECTION 5



IMG. 4.4 E. coli

### **E. coli levels exceed the water quality standard**

Bacterial Pollutants enter water through run-off and include E. Coli and other fecal coliforms and pathogens. E. Coli is the major species in the fecal coliforms group. Historic water quality data shows high levels of pathogens present in waterways, regularly exceeding the state standard of 235 cfu/100mL in both watersheds.

Through our WQ studies, it was determined that E. coli is the worst impairment - by more than a 1000% - in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds (and in the state of Indiana). However, it is difficult as a NPS Watershed Group to justify addressing E. Coli as a priority. According to 319/Muncie Bureau of Water Quality studies, the primary source of E. coli in Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds is human waste (from CSOs and failing septic systems). These are point source pollutants and out of the scope of the WRWP. The WRWP advocates that any substantial county-wide efforts should focus solely on those human sources of e. coli - because of their point source, this mitigation/ correction will ultimately come from sources of funding other than the IDEM 319 funding.

We acknowledge that the second major source of E. coli to our rivers is failing CFO waste management systems and poorly timed manure applications. Both of these activities are highly regulated /permitted by the state of Indiana. So long as they are adequately functioning they don't pose a great threat to the Subwatershed areas. We have found in our studies that - despite the presence of CFOs upstream of the city of Muncie, E. coli levels are higher within City limits. That being said, any efforts to reduce E. coli in the realm of NPS it will be considered by the WRWP .

Similar to nutrient applications, we can't necessarily quantify which farms are applying manure as part of their ongoing farm operations but we do know which areas are not adequately filtering manure during a rain event. See lack of Buffers/Vegetation Maps (Map 4.6). Although not a E. coli source , lack of buffering is enabling manure application sources to enter the water systems.

A final source of E. coli is livestock that have access to streams. No formal study has been done by the WRWP to determine livestock access in Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. However, exclusion fencing BMPs will be considered for a cost-share project despite its low priority compared to other aforementioned E. coli sources (i.e. CSOs, failing Septics).

### **Nonpoint Sources: Waste**

E. coli and other fecal coliforms are bacteria that, when present in water bodies, indicates human or animal waste contamination. E. Coli commonly enters water bodies through storm water run-off from failed, failing, or illegally hooked up septic systems, animal feed operations, farms, and sewage discharge. These sources can only be considered a threat if they are located directly adjacent to a waterway, or if there is a method for direct movement of the waste into the waterway, such as a pipe or swale. Wastes also include domestic pets and wildlife sources but this is scattered throughout the watershed. Pathogens may be coming from many sources including septic systems, combined sewer outfalls, pet waste and wildlife waste.

### **Pet Waste**

The nutrients that are associated with domestic pet waste can be a contributor of pollution to our streams and rivers as noted in the TMDL for E. coli bacteria for the West Fork White River from Muncie to the Hamilton-Marion County Line. This is especially true in urban areas where people walk and house their animals and do not pick up their wastes. (Steering Committee members have confirmed this source Muncie Urban Areas). There is no way to accurately quantify the amount or areas where this is the biggest problem. Wastes from domestic pets were identified in the TMDL for E. coli bacteria for the West Fork white River from Muncie to the Hamilton-Marion County Line. Domestic pet sources, no matter the scale, have the potential to increase the amount of E. coli entering water bodies. Wastes left in areas where storm water flows have the potential to be picked up and moved into storm water conveyances, finally end up in the waterbodies.

### **Animal Wastes from Agricultural Sources**

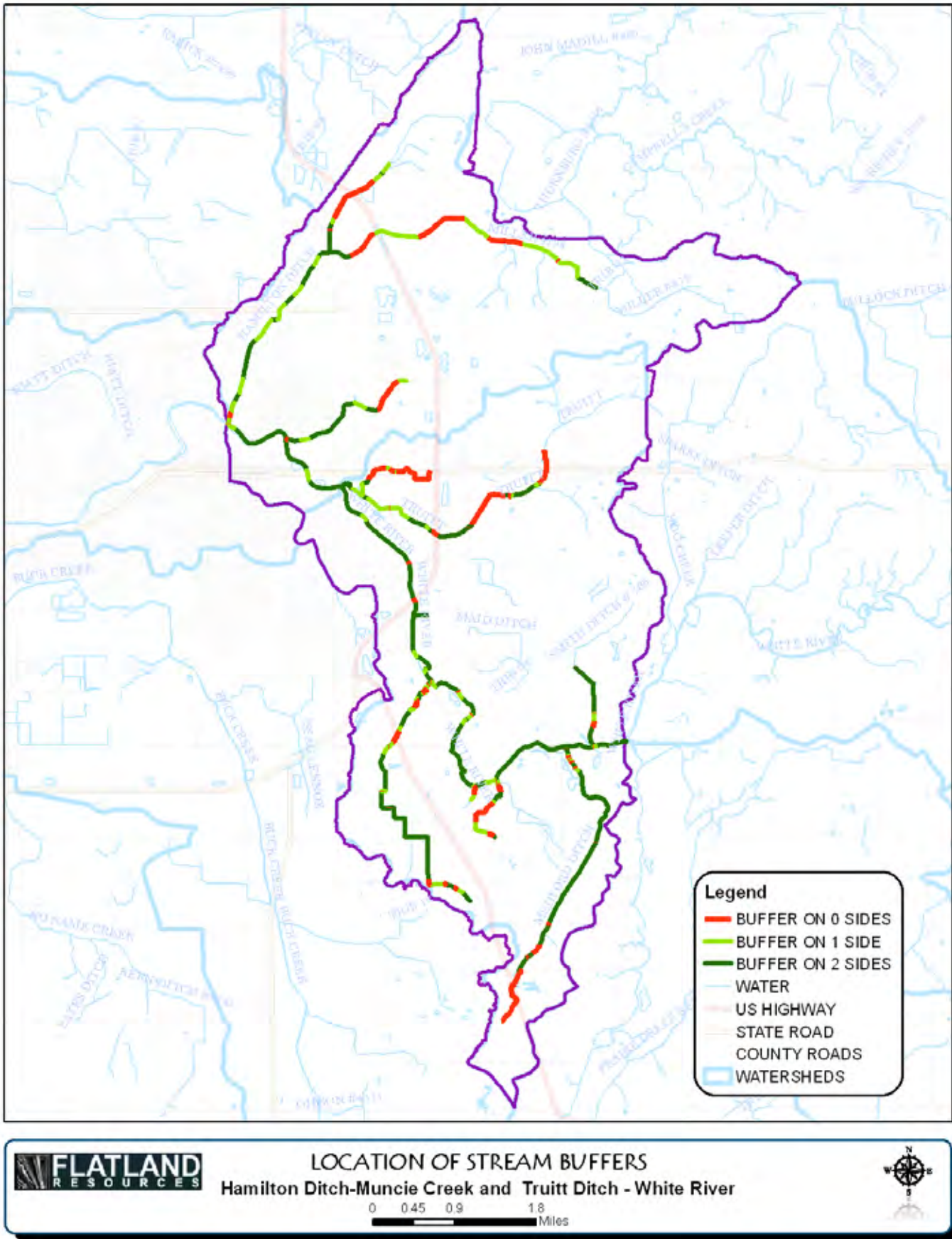
Animal waste improperly used on agricultural lands can be a major contributor to pathogen pollution in watersheds. The surveys of the watershed were ineffective at determining where these applications are occurring (other than agricultural steering committee members sharing informally that it is happening). Manure in applications before rain events can result in the movement of the wastes into the waterway through runoff. It is suggested that in the future, this data be uncovered using social survey techniques.

### **Animal Wastes from Wildlife Sources**

The TMDL for E. coli bacteria for the West Fork white River from Muncie to the Hamilton-Marion County Line explains that wildlife is a potential nonpoint source of pathogen pollution. E. coli coliforms per acre were estimated based on animal per acre assumptions. While this is based on the entire Upper West Fork White River Watershed, we can use it as a guide for our watersheds. Their estimate for geese, deer and raccoon contribution is  $7.21 \times 10^7$  bacteria cells per acre per year. (Tetra Tech 2004)

TABLE 4.10: E. coli Sources
Source
Sheetflow
SUPPORT
<p>Best Management Practices can reduce the frequency and amount of the E. coli that enters the waterway.</p> <p>The removal of overstory, shrub, and herbaceous vegetation and replacing it with cool season grasses is a common practice of the management of legal drains. The presence of trees and shrubs that shade the water aids in keeping water temperatures low, allowing for higher levels of dissolved oxygen. The removal of the native herbaceous layer and the subsequent replacement with cool season grass reduces the biodiversity of the riparian area.</p> <p>A visual assessment of the streams show that over 80% of the main stem of Truitt Ditch - White River and 90% of the main stem of Hamilton Ditch - Muncie Creek have had their native riparian vegetation removed and replaced with either cool season grasses, crops, or invasive species. The only water body that has relatively good shading and a riparian corridor lush with habitat is the White River.</p> <p>Additional areas that lack certain agricultural BMPs were examined through the aerial survey using orthophotographs. In addition to the aerial survey parameters discussed earlier, the watersheds were examined looking for lengths of streams without filter strips and areas where grass waterways were needed.</p> <p>Truitt Ditch-White River Subwatershed had approximately 3,150 feet of ditch bank that was in need of filter strips and 12,000 feet of gully formations that should be planted as grass waterways. Hamilton Ditch - Muncie Creek Subwatershed had approximately 5,400 feet of bank that was in need of filterstrips, and 610 feet of gully formations that should be planted as grass waterways.</p>





**MAP. 4.6** Streambank Buffer Survey

# LOADS, GOALS, CRITICAL AREAS

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 5





# Critical Area Determination

## WMP - CHAPTER 5 - PART 1 - SECTION 1 - SUBSECTION 1

We have completed the following steps in the Management Planning Process:

- (a) Collected, through the Inventory and Analysis process, WQ data and land use information,
- (b) Used the catalogue of information as a means confirming or disproving community concerns,
- (c) We have taken those community concerns and have linked them to a key concerns table which has identified aquatic life concerns, human health concerns and socioeconomic concerns,
- (d) We have processed those concerns through a framework in which we have linked initial concerns to the actual NPS source that is causing stress on the beneficial uses of water,
- (e) We have ranked the stressors based on their exceedance of state and federal WQ standards and guidance,
- (f) and we have taken individual NPS stressors and sought to identify where they are actually coming from ( i.e. sourcing into the subwatersheds).

Having brought the plan through this process, the next step is to develop an method for developing and selecting eligible projects. As discussed in Chapter 4, critical areas have been determined by analyzing basin exceedance levels (And ranking basins based on their relative contribution). As mentioned, these basins will be the focus basins for all WRWP implementation activities in Hamilton Ditch-Muncie Creek and Truitt- Ditch White River Subwatersheds. Cost-share funding available through the IDEM Section 319 program can only be spent in these basins. Eligible applicants must have BMPs selected to match the pollutant critical areas designation.

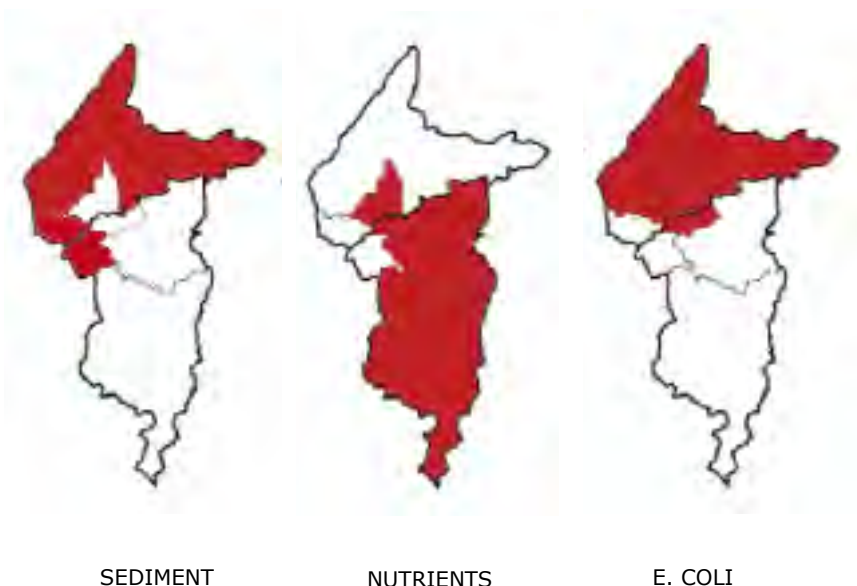
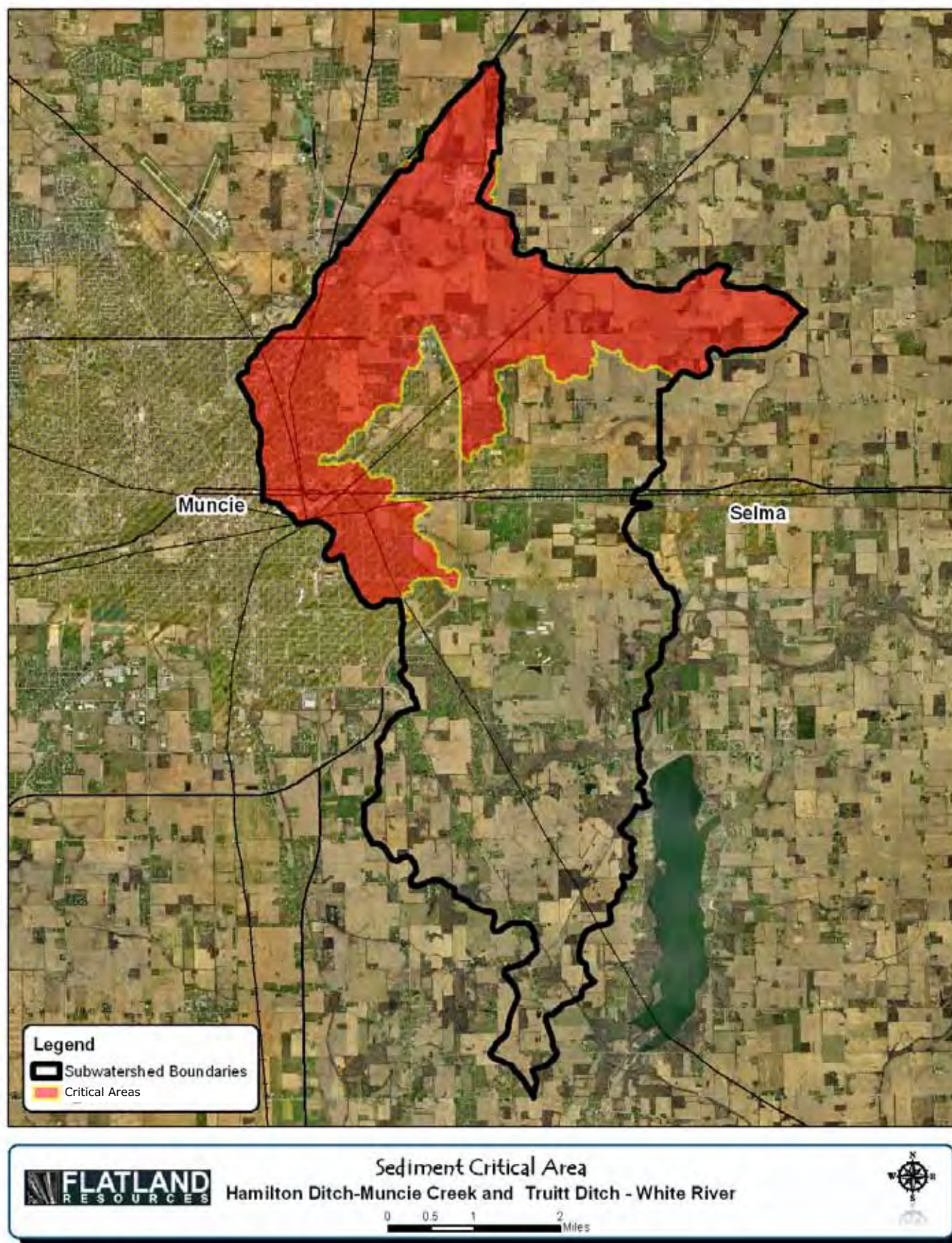
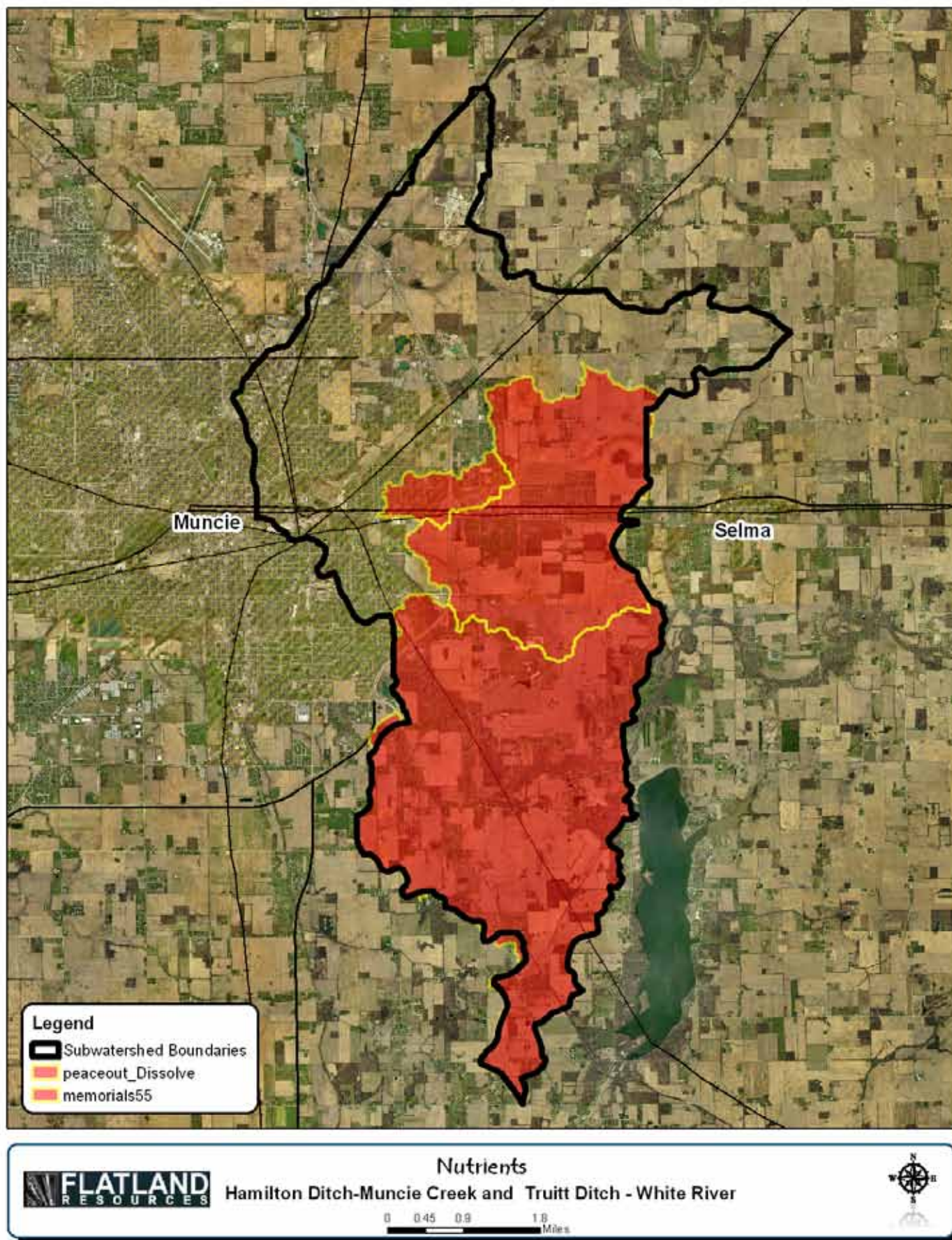


TABLE 5.1: Percentage above state water quality standard					
	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek	70%	115%	159%	101%	481%
Holt Ditch	77%	47%	174%	82%	1597%
Unnamed Tributary	108%	45%	282%	69%	2548%
Truitt Ditch	87%	108%	234%	70%	224%
Memorial	30%	176%	194%	93%	203%



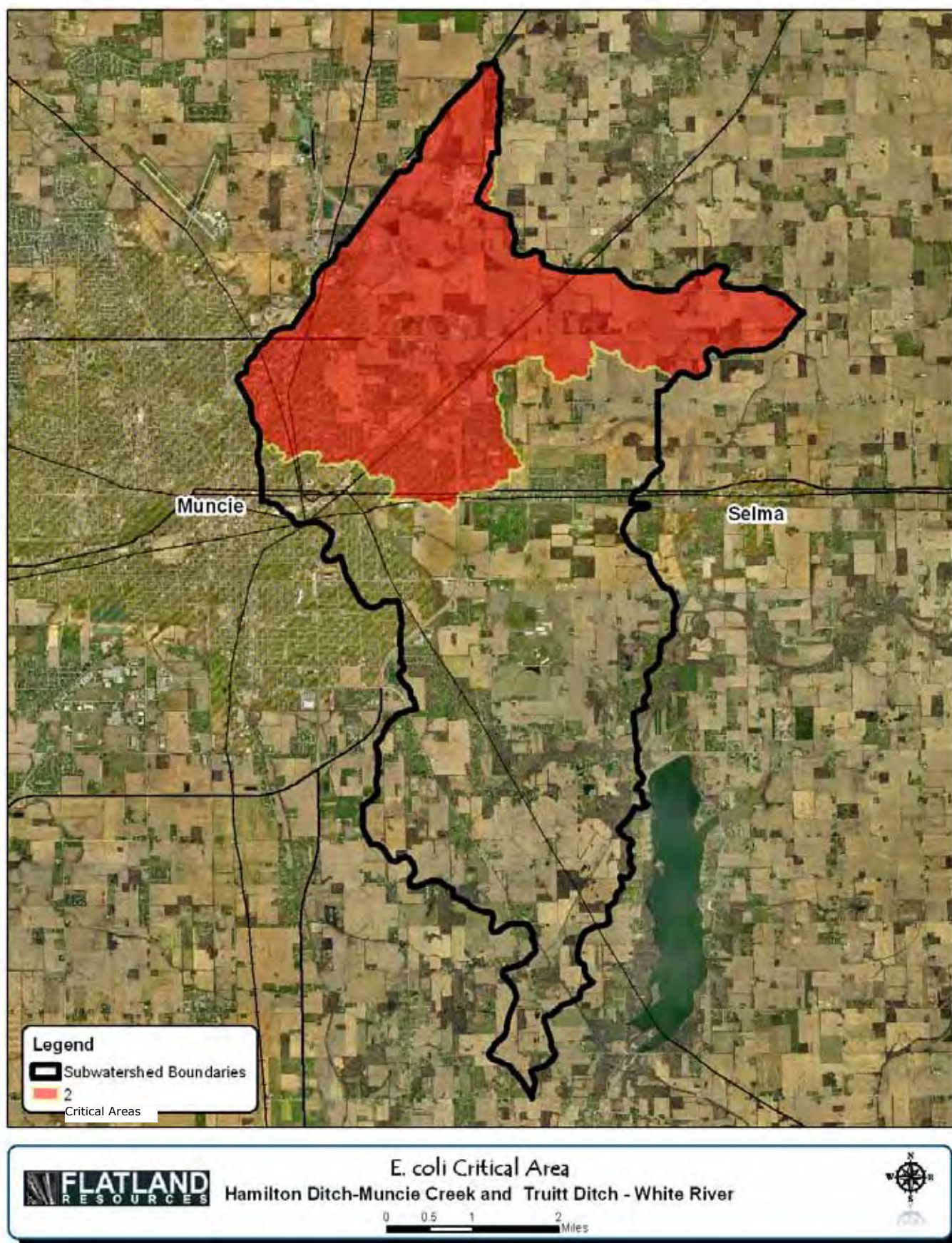
**MAP. 5.1** Sediment Critical Area





MAP. 5.2 Nutrient Critical Area





MAP. 5.3 E. coli Critical Area

# Project Selection Process

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 5

In addition to the critical area determinations, the WRWP seeks to combine information gained from our inventory and analysis and source identification processes into a project selection method. These core ideas are represented as tiers/stages in the flow chart shown in Chart 5.1. It should be emphasized that this prioritization of projects is not mandated but is created to serve as guidance for the WRWP cost-share steering committee.

### Tier one projects

Based on our source identification studies, we concluded that within the Critical Areas boundaries, specific sites may be functioning as gateways for water quality stressors to enter the waterways. These “gateways” are weak points in water filtration, sediment stabilization and nutrient uptake/buffering. Projects that seek to “fill these gaps” will be given priority if they address the weak points identified in Map 5.4.

### Tier two projects

Based on ongoing WRWP water quality studies\* we have created a framework for priority BMP implementation (Table 5.2). As the second tier of the critical areas action plan, projects that seek to stabilize streambanks, increase urban onsite infiltration, and/or contribute to urban reduction of E. coli, will be given priority over all of projects (save tier one).

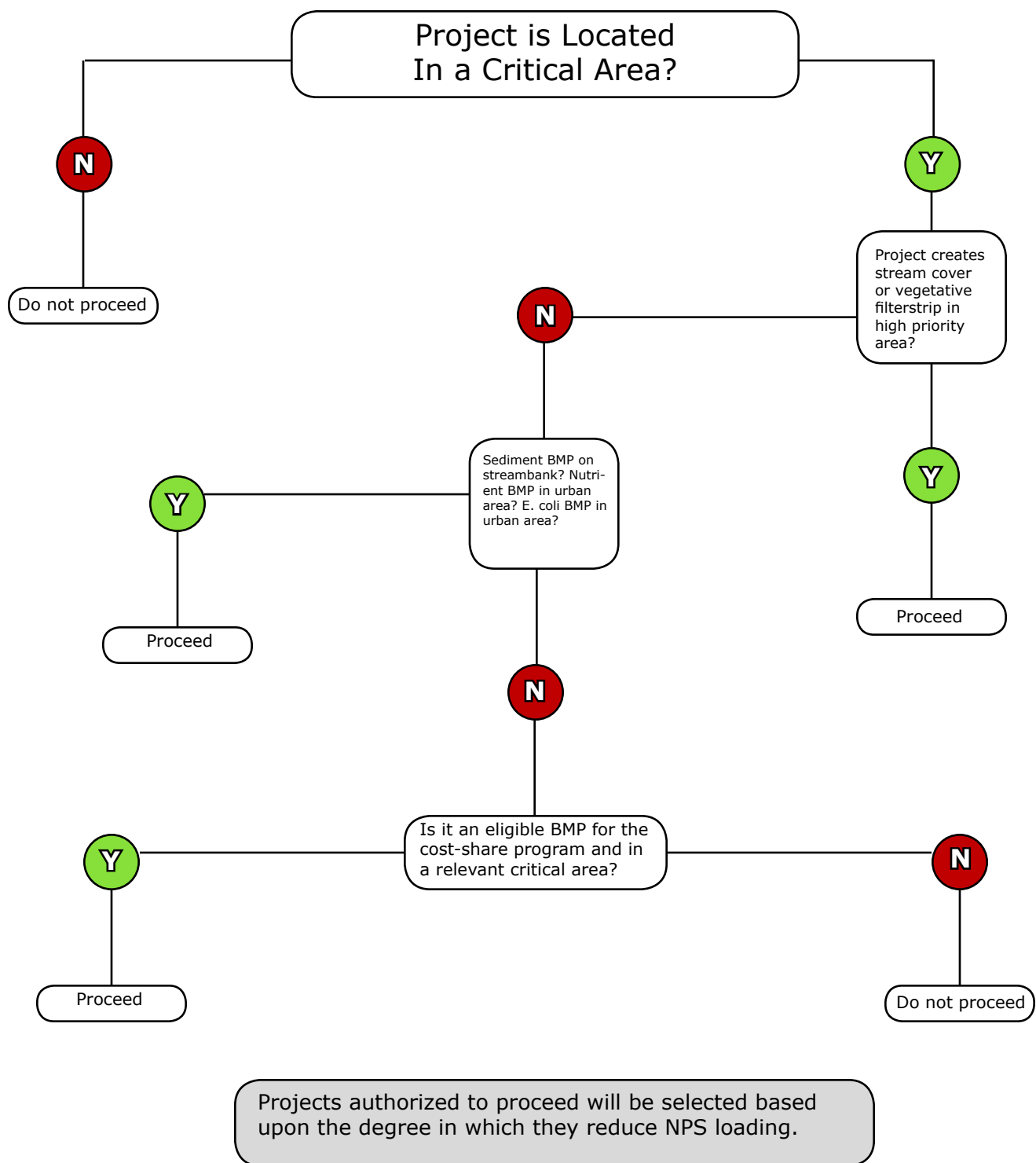
TABLE 5.2: Priority Areas for Nonpoint Source Reduction			
	AGRICULTURAL	STREAM BANKS	URBAN
SEDIMENT	MODERATE	HIGHEST SOURCE	MODERATE
NUTRIENTS	HIGH	MODERATE	HIGHEST SOURCE
PATHOGENS	HIGH	LOW	HIGHEST SOURCE

\* Rationale for Sediment comes from Buck Creek Critical Area Study and preliminary water quality studies performed on Muncie Creek, Rationale for nutrients come from Mainstem White River Studies completed in this WMP, and the rationale for pathogens comes from Mainstem White River studies completed in this WMP.

### Tier three projects

As a third tier project, applicants can apply to implement any BMP that is in our cost-share program at any location that would be beneficial to reducing NPS in the Subwatersheds. A full list of eligible BMPs are located in Chapter 7 along with a table that emphasizes key WRWP identified BMPs (per basin location). This table should be used by applicants as a guidance for competitive Tier three applications. However, the WRWP believes that any effort made to reduce NPS pollution is important. We will work with applicants to ensure applications are competitive and we are willing to compromise if valid arguments are made for BMP selection and location (so long as project is in critical areas). New BMPs will be added to the list if valid need arises.





# Competing Projects

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 3

As a final, and trumping criterion, projects must demonstrate significant reduction in NPS pollutant loadings. All projects that meet limitations and reduce NPS pollution greater than others will gain preference.

As part of this process (and the process to document effective implementation and effective results) we have – in Table 5.3 and Table 5.4 -developed reduction goals (decrease loading by 75%) and the estimated loading reduction needed to bring all Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Streams to target loads. This “reduction needed” is based on current load calculations (Table 5.5 and Table 5.6) and reduction goals (Table 5.7). Applicants must be aware that demonstrating quantifiable pollutant reduction is a critical factor in project development and BMP selections. A table is provided in Chapter 6 Table 6.2 to give insight into BMPs load reduction estimations, but serves only as an initial estimation. Independent BMP loading reduction research is required for all cost-share applications.

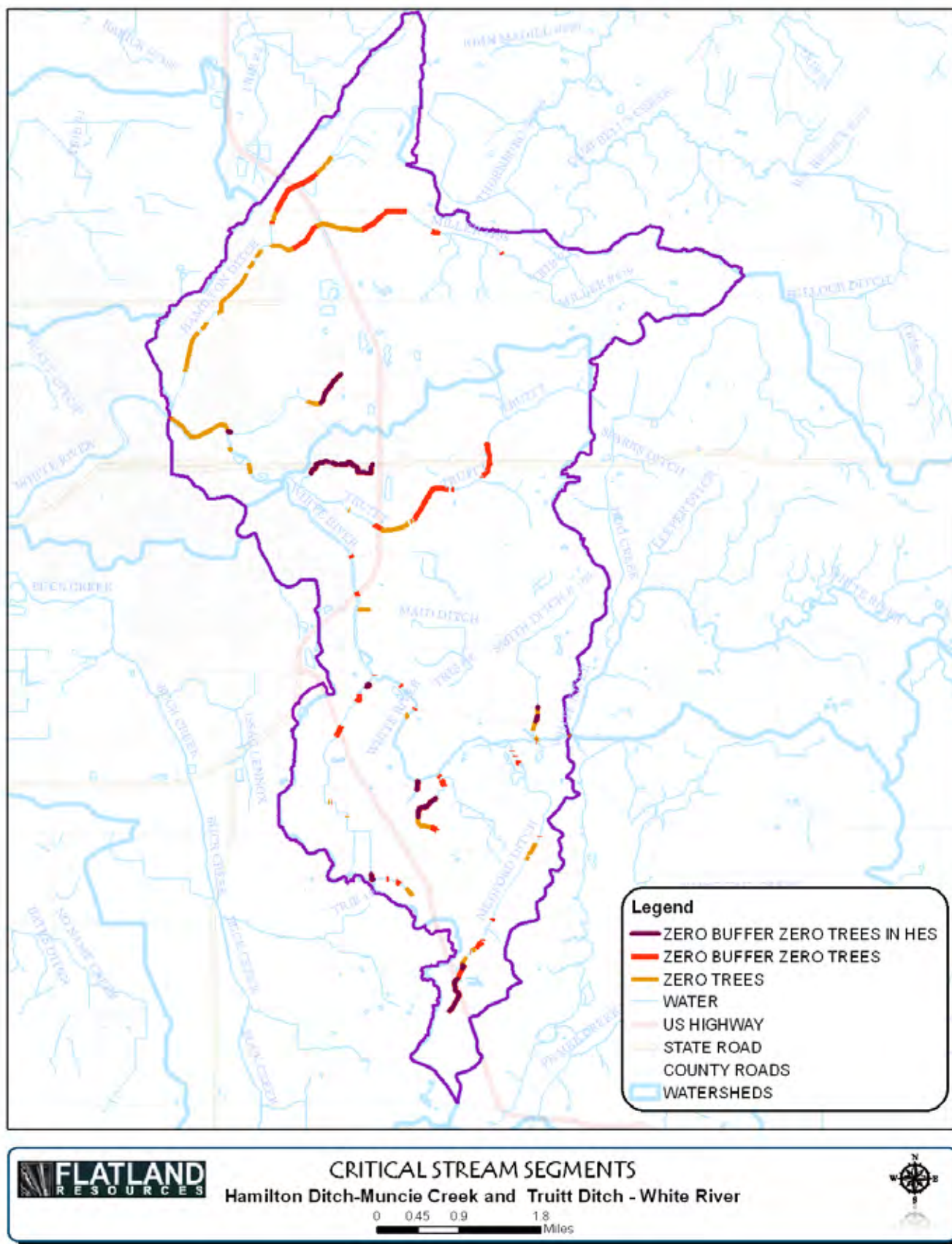
Each individual project must advance overall sub watershed reduction goals. Each cost-share project will be used as a means of tracking effectiveness to reach WRWP reduction goals. Finally, aside from reduction estimations, installed projects will be analyzed by the Bureau of Water quality as a means of determining indicators of goals achievement. Again, projects will be ultimately selected based on its capacity to reduce non point sources (comparative to other applicants).

TABLE 5.3: Target Load Reductions (75% decrease) Hamilton Ditch - Muncie Creek

Parameter	Units	Current Loads	Target Load (goal: decrease 75%)	Reduction Needed
Ammonia as N	Lbs/year	463.299	115.82475	347.47425
E. coli (M.F.)	cfu/year	1.92E+13	4.796E+12	1.4388E+13
Total Suspended Solids	Tons/year	54.989	13.74725	41.24175

TABLE 5.4: Target Load Reductions (75% decrease) Truitt Ditch - White River

Parameter	Units	Current Loads	Target Load (goal: decrease 75%)	Reduction Needed
Ammonia as N	Lbs/year	127.6	31.9	95.7
E. coli (M.F.)	cfu/year	1.45E+12	3.6125E+11	1.08375E+12
Nitrate+Nitrite as N	Lbs/year	885.4	221.35	664.05
Phosphorus as P	Lbs/year	76.1	19.025	57.075



**MAP. 5.4** Critical Stream Segments

# Load Calculations

## WMP - CHAPTER 5 - PART 1 - SECTION 1 - SUBSECTION 4

### CALCULATE LOADS

Current loads for each pollutant identified as a problem's cause.

Parameter	Units	Muncie Creek Baseline	Percent Increase of Historic Data	Adjusted Loads
Ammonia as N	Lbs/year	282.915	63.76	463.299
E. coli by Membrane Filtration	cfu/year	1.0008E+13	91.68	1.9184E+13
Nitrate+Nitrite as N	Lbs/year	808.262	512.44	4950.110
Phosphorus as P	Lbs/year	87.172	485.71	510.574
Total Suspended Solids	Tons/year	21.655	153.93	54.989
Atrazine	Lbs/year	0.896	NA	NA

Parameter	Units	Truitt Ditch Baseline	Percent Increase of Historic Data	Adjusted Loads
Ammonia as N	Lbs/year	40.126	218.0	127.6
E. coli by Membrane Filtration	cfu/year	3.178E+12	-54.5	1.445E+12
Nitrate+Nitrite as N	Lbs/year	228.191	288.0	885.4
Phosphorus as P	Lbs/year	27.113	180.8	76.1
Total Suspended Solids	Tons/year	3.028	218.4	9.6
Atrazine	Lbs/year	109.948	NA	NA

Baseline monitoring occurred weekly for ten consecutive weeks from 8/26/2009 to 11/12/2009. The historic data, taken over a three year period from 2006 to 2008, shows higher average concentrations for almost all of the water quality parameters than the baseline data that was sampled in 2009 (Table 5.5 and Table 5.6). For example, the total suspended solids historic levels for Truitt Ditch are 218% higher than the baseline data. Since the number of samples is higher for the historic water quality data, this is more likely the more accurate measurement of water quality. Since the baseline data is to be used to generate the loading rates for each water quality parameter, it must be taken into consideration that the data is lower than the three-year averages obtained from the historical data.<sup>1</sup>

In order to calculate loads from the more accurate historical data, the percent difference between the historical and baseline data averages was used. As shown earlier, for almost every parameter, the historical data showed higher levels of pollutants. For instance, historic Ammonia levels from the Truitt Ditch sampling point are 218% higher than the baseline data. This increase was then applied to the average ammonia loading rate from the baseline data to generate an adjusted loading rate based on the historic data. Since the historic data contains more samples taken during a longer sampling period than the baseline data, this can give a more accurate picture of the pollutant loading rates from this waterbody. One flaw with this method is that it still does not factor into account high flow periods. This can be addressed as more water quality data is collected.<sup>2</sup>

<sup>1</sup> Tom Reeve, White River Watershed Project

<sup>2</sup> Tom Reeve, White River Watershed Project

# Reduction Goals

## WMP - CHAPTER 5 - PART 1 - SECTION 1 - SUBSECTION 5

### SET GOALS

Water Quality improvements or protection goal statements based on the calculated loads.

TABLE 5.7: Reduction Goals	
CAUSE	Goal(s)
TSS levels exceed the target set by this project	<b>Muncie Creek</b> - Excess TSS has been identified as a problem. We want to reduce the watershed's TSS load from 54.9 tons a year to 13.75 tons per year (a 75% reduction) within 20 years.
E. coli levels exceed the water quality standard	<p><b>Muncie Creek</b> - Excess E. coli has been identified as a problem. We want to reduce the watershed's E. coli load from 1.92E+13 cfu a year to 1.4388E+13cfu per year (a 75% reduction) within 20 years.</p> <p><b>Truitt Ditch</b> - Excess E. coli has been identified as a problem. We want to reduce the watershed's E. coli load from 1.45E+12 cfu a year to 3.6125E+11 cfu per year (a 75% reduction) within 20 years.</p>
Nutrient levels exceed the target set by this project	<p><b>Muncie Creek</b> - Excess ammonia has been identified as a problem. We want to reduce the watershed's ammonia load from 460 lbs a year to 115 lbs per year (a 75% reduction) within 20 years.</p> <p><b>Truitt Ditch</b> - Excess ammonia has been identified as a problem. We want to reduce the watershed's ammonia load from 127.6 lbs a year to 31.9 lbs per year (a 75% reduction) within 20 years.</p> <p><b>Truitt Ditch</b> - Excess Nitrates has been identified as a problem. We want to reduce the watershed's Nitrate load from 885.4 lbs a year to 221.4 lbs per year (a 75% reduction) within 20 years.</p> <p><b>Truitt Ditch</b> - Excess Phosphorus has been identified as a problem. We want to reduce the watershed's Phosphorus load from 76.1 lbs a year to 19 lbs per year (a 75% reduction) within 20 years</p>

# Tracking Effectiveness

## WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 6

The success of the previously listed implementation actions shall be monitored using a variety of methods, dictated by the specific action being measured.

### **Cost-share Program**

Tracking participation (applications) by landowner, acreage, and type of practice shall be used to measure implementation of water quality improvement projects. Protocol for long term reporting of the status of such practices shall be developed by the DCSWCD and shall be a stipulation of participation in the WRWP cost-share program. These applications and potential locations will be reported in at the completion of each subsequent phases.

### **Outreach and Education**

Tracking of participation in conferences, workshops, tours, public meetings and presentations shall be used to measure the effectiveness of the outreach and education actions implemented. Protocol for follow-up from participants of specific workshops and conferences shall be developed as part of those programs and presented at time of participation.

# Indicators

## WMP - CHAPTER 7 - PART 1 - SECTION 1 - SUBSECTION 7

The load reductions calculated for each cost-share project will be used as indicators for measured reductions in order to determine if progress is being made toward achieving Subwatershed wide goal. In addition, quarterly water quality data will be used as indicators to show progress toward attaining reduction goals. The environmental indicator will be water quality testing conducted in conjunction with WMP monitoring and reported at the completion of each subsequent phases.

### **Monitoring**

Monitoring is both a goal (E. coli source identification) and a method of measuring success. Therefore, the success of the monitoring program will be measured by the continuation of a modified monitoring program (that includes the inclusion of a Prairie Creek lake study, and measures the affects of BMP installations). This program will include the monitoring of TSS, nitrate, orthophosphate, E. coli, biology and stream habitat. Details of these programs shall be determined prior to their implementation, with the appropriate QAPP revisions submitted and approved. Data collected through this program shall be used to examine improvements in water quality and primary method of reduction success.





# STRATEGIES AND BMPs

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 6



# Strategies

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 1

Based on identified stakeholder concerns, water quality data, and potential sources of pollution, goal statements were developed for each problem. Implementation of policies, programs, and practices will improve water quality and watershed conditions within the studied Subwatersheds.

The goal statements indicate the ultimate goal for a specific project. In some cases this goal may not be maintainable in the short term; therefore there is also a list of short term objectives included with each goal (see action register). Short term implies efforts will begin implementation in the years 0-5 and long term implies years 6-20. The goal statements themselves are typically the long term goal. It should be noted that some objectives may relate to several goal statements, they are listed in each applicable category.<sup>1</sup>

The goals detailed in the Action Register(s) represent both the ultimate goal of reaching target pollutant concentrations identified by the monitoring committee and the realistic potential for reaching a target goal. Some strategies identified for individual goals may be applicable to other goals, and in such cases, these strategies are listed under each goal.

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<sup>1</sup> Wabash River (Region of the Great Bend) WMP

# Strategies: E. Coli

## WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 2

**Muncie Creek** - Excess E. coli has been identified as a problem. We want to reduce the watershed's E. coli load from  $1.92\text{E}+13$  cfu a year to  $1.4388\text{E}+13$ cfu per year (a 75% reduction) within 20 years.

**Truitt Ditch** - Excess E. coli has been identified as a problem. We want to reduce the watershed's E. coli load from  $1.45\text{E}+12$  cfu a year to  $3.6125\text{E}+11$  cfu per year (a 75% reduction) within 20 years.

### Short-Term Objectives/Actions:

1. Educate about proper pet-waste management
2. Reduce E. coli levels from livestock with access to streams: Identify partners in the agricultural community and communicate livestock restriction methods. Provide alternate watering systems and fence livestock from access through permanent or rotational grazing options.

### Long Term Objectives:

1. Reduce agricultural sources of E. coli.  
Work alongside the agricultural community to educate and promote nutrient management plans, livestock exclusion, and other BMPs aimed at reducing the amounts of E. coli in the waterways.
2. Reduce the occurrence of CSO overflows.  
Work with the Muncie Sanitary District and residents to increase pre-stormwater conveyance capacity, increase discharge time, disconnect combined sewers, and reduce household water usage.
3. Educate and promote the repair of failing or failed septic systems.  
Educate and work with the community to identify, and prevent failing or failed septic system

# Strategies: Nutrients

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 3

**Muncie Creek** - Excess ammonia has been identified as a problem. We want to reduce the watershed's ammonia load from 460 lbs a year to 115 lbs per year (a 75% reduction) within 20 years.

**Truitt Ditch** - Excess ammonia has been identified as a problem. We want to reduce the watershed's ammonia load from 127.6 lbs a year to 31.9 lbs per year (a 75% reduction) within 20 years.

**Truitt Ditch** - Excess Nitrates has been identified as a problem. We want to reduce the watershed's Nitrate load from 885.4 lbs a year to 221.4 lbs per year (a 75% reduction) within 20 years.

**Truitt Ditch** - Excess Phosphorus has been identified as a problem. We want to reduce the watershed's Phosphorus load from 76.1 lbs a year to 19 lbs per year (a 75% reduction) within 20 years

### **Short-Term Objectives/Actions:**

1. Implement BMPs and LID to address stormwater runoff in urban areas

Identify potential project partners and BMP/LID sites. Provide cost-share and technical expertise with the implementation of LID and other BMPs including bioretention (including rain gardens), green roofs, porous pavement, rain barrels, and vegetated swales.

2. Demonstrate innovative BMP/LID techniques in target watersheds.

Identify potential project partners and BMP/LID sites. Install demonstration projects, including planter boxes, subsurface infiltration (dry wells, basins, berms, beds, trenches), and wetland detention basins.

3. Implement BMPs to address stormwater runoff in agricultural areas

Work with the agricultural community to promote federal cost-share programs for BMPs. Educate this community on all the options for agricultural conservation to increase enrolment in these programs (EPA 319, EQIP, CRP, CREP, WRP, etc.).

4. Educate and encourage the public to install native landscaping, rain gardens, rain barrels, and to control exotic species.

Develop, publish, and distribute outreach materials. Showcase demonstration projects already installed in county. Conduct workshops and other outreach events.

5. Educate the public on proper lawn chemical management

Develop, publish, and distribute outreach materials. Implement and showcase demonstration projects. Conduct workshops and other outreach events.



# Strategies: Sediment

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 4

**Muncie Creek** - Excess TSS has been identified as a problem. We want to reduce the watershed's TSS load from 54.9 tons a year to 13.75 tons per year (a 75% reduction) within 20 years.

### Short-Term Objectives/Actions:

1. Implement BMPs and LID to address stormwater runoff in urban areas

Identify potential project partners and BMP/LID sites. Provide cost-share and technical expertise with the implementation of LID and other BMPs including bioretention (including rain gardens), green roofs, porous pavement, rain barrels, and vegetated swales.

2. Demonstrate innovative BMP/LID techniques in target watersheds.

Identify potential project partners and BMP/LID sites. Install demonstration projects, including planter boxes, subsurface infiltration (dry wells, basins, berms, beds, trenches), and wetland detention basins.

3. Implement BMPs to address stormwater runoff in agricultural areas

Work with the agricultural community to promote federal cost-share programs for BMPs. Educate this community on all the options for agricultural conservation to increase enrolment in these programs (EPA 319, EQIP, CRP, CREP, WRP, etc.).

4. Promote and implement natural streambank restoration projects that reduce sediment and nutrient pollution.

Develop, publish, and distribute outreach materials. Implement and showcase demonstration projects. Identify potential partners and restoration sites. Provide cost-share and technical expertise for the implementation of wetland restoration, two-stage ditches, streambank stabilization, and daylighting.

5. Promote, educate, and implement the use of natural channel design in stream restoration that reduces sediment and nutrient pollution.

Develop, publish, and distribute outreach materials on natural channel design restoration methods, including the Rosgen Method, BEHI rating, and the NRCS Engineering Handbook Chapter 16 Streambank and Shoreline Protection. Implement and showcase demonstration projects. Identify potential partners and restoration sites. Provide cost-share and technical expertise for the implantation of stream restoration projects.

# BMPs Measures to Apply

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 5

The watershed restoration and management techniques described in this section, when applied, can help achieve the watershed goals and objectives to decrease the concentrations of sediment and nutrient loads identified in this WMP. The Steering Committee adopted the list of BMPs based on the previous cost-share program and relevant impairments within the watershed and the measures that would improve the water quality within the watershed.

The selected measures and BMPs for improvement are categorized as Agricultural/Rural and Urban BMPs as well as Basin-wide Measures. These BMPs are structural BMPs only and do not include non structural BMPs.

The following BMP summaries are typical BMPs and are provided as a reference and generally describe each measure and its design components; it is not meant to be all inclusive list but only a guide. To choose an appropriate BMP, it is essential to determine in advance the objectives to be met by the BMP and to calculate the cost and related effectiveness of alternative BMPs. Once a BMP has been selected, expertise is needed to insure that the BMP is properly installed, monitored, and maintained over time.

### **Agricultural Best Management Practices**

Agricultural Best Management Practices are implemented on agricultural lands, typically row crop agricultural lands, in order to protect water resources and aquatic habitat while improving land resources and quality. These practices control nonpoint source pollutants and reduce their loading to the White River by minimizing the volume of available pollutants. Potential agricultural Best Management Practices designed to control and trap agricultural nonpoint sources of pollution are listed on the following pages.

### **Urban Best Management Practices**

Development and the spread of impervious surfaces are occurring in the watershed. As impervious surfaces continue to spread throughout the watershed, the volume and velocity of storm water entering the White River will also increase. The best way to mitigate storm water impacts is to infiltrate, store, and treat storm water on site before it can run off into the White River. Urban best management practices designed to complete these actions are listed on the following pages.

TABLE 6.1: Critical Areas		
CRITICAL AREA	REASON FOR BEING CRITICAL	BMP OR MEASURE
Muncie Creek Basin	TSS levels exceed the target set by this project	Conservation Plan Development Grade Stabilization Structure Check Dams- Natural Implementation Grassed Waterway No-till Equipment Modifications Strip cropping Vegetated Stream bank Stabilization Water and Sediment Control Basins 2-Stage Ditches Flow Splitters Level Spreader Storm water Pond Riser Modification Swales/Vegetated Swales Water Retention Ponds retrofits Wetland Creation/Restoration
(1) Unnamed Tributary Basin (2) Truitt Ditch Basin (3) Holt Ditch Basin (4) Memorial Basin (5) Muncie Creek Basin	Nutrient levels exceed the target set by this project	Nutrient Management Plan Filter Strips and Riparian Zones Check Dams- Natural Implementation Grassed Waterway Water and Sediment Control Basins Bioretention/Rain Gardens low Splitters Level Spreader Storm water Pond Riser Modification Swales/Vegetated Swales Water Retention Ponds retrofits Wetland Creation/Restoration
(1) Unnamed Tributary Basin (2) Holt Ditch Basin (3) Muncie Creek Basin	E. coli levels exceed the water quality standard	Livestock Exclusion
(1) Unnamed Tributary Basin (2) Truitt Ditch Basin (3) Holt Ditch Basin (4) Memorial Basin (5) Muncie Creek Basin	Low amount of urban BMPs per square foot of impervious surface	Curb Cuts/ Curbless Design Drivable Grass Green Roofs Low Impact Development Permeable/Porous Pavement Rain Barrels Sand Filters Tree Box Filters

# Ag BMPs Measures to Apply

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 6

### **Comprehensive Nutrient Management Plan (Nutrients & Pathogens)** **Indiana NRCS FOTG Nutrient Management (590)**

A nutrient management plan aids in applying the correct amount and form of plant nutrients for optimum yield and minimum impact on water quality. Soil tests are performed, yield goals are determined, past applications are considered, and short and long-term goals are set for nutrient application. This process can be applied in a variety of methods. Whether they are broadcast, starter, surface band, or injection, they aid in providing the proper application of the nutrient in spring or fall to the fields. In the spring, nitrogen testing is appropriate for corn when it is 6-12 inches tall. In the fall, refrain from applying commercial Nitrogen except when associated with Phosphorus application. Avoid applying manure on frozen or snow-covered ground as this causes extreme nutrient run-off. By applying the proper nutrient at the proper time through the proper method prevents over application of commercial fertilizers and animal manure that could infiltrate the water supply. Retesting soils, monitoring fields, and analyzing nutrient applications along with establishing a maintenance program provides quality care of the land, water supply, and ensures quality yield.

### **Conservation Plan Development (Sediment & Nutrients)**

Indiana NRCS CPA-52 Conservation Planning Form

Conservation Plan Development is a process that outlines management decisions and conservation practices that are currently in use or planned for an area. This plan discusses long and short term goals and objectives, collects information and data regarding nutrient and pest management, soil, water, and other resources, it identifies problems and potential solutions, and develops an implementation and maintenance plan. A Conservation Plan creates the best decisions and actions for the land and the landowner.

### **Filter Strips (Sediment & Nutrients)**

Indiana NRCS FOTG Filter Strip (393)

Strips of grass, trees and/or shrubs or filter strips, filter and slow runoff and remove contaminants before they reach water bodies or sources. The vegetation collects sediment, chemicals, and nutrients. These sources are absorbed so they cannot enter the water bodies. In addition, these strips provide habitat for a variety of birds and animals, removes row crop operations further from the water body to reduce added risk, and reduce soil erosion. Filter strips are most effective on slopes of 5% or less. If the strip is steeper, it should also be wider. A minimum of 15 foot wide strips should be used for cropland and minimum 50 foot wide for forestland. These strips become less effective during frozen conditions. Controlled grazing can occur as long as it is monitored.

### **Grade Stabilization Structure (Sediment & Nutrients)**

Grade Stabilization Structure (410)

An earthen, wooden, concrete, or other structure built across a drainageway aides in grade stabilization to prevent gully erosion and reducing water flow. These structures drop water from one stabilized grade to another by providing a water outlet and improving water quality. This prevents nutrients and sediment from contaminating a potential water source created by an embankment or field. Ensure that all permits are obtained and construction specifications considered before construction. Remove all trees and shrubs within 30 feet of the structure and any debris approximately 50 feet downstream from the outlet during construction.

### **Check Dams- Natural Implementation (Nutrients & Pathogens)**

There are many different techniques to make check dams using natural materials. These techniques are fast, and given local supplies, relatively inexpensive. Some of the natural methods are coir fascines, wattle fences, straw bale, Sediment STOP, and Nilex GeoRidge. Coir fascines are formed by taking willow branches and laying them in a long pile that is generally the length of the channel. The pile should be 18-30" in height. Tie the bundle along its entire length, compacting the bundle as you go. Place this in a pre-dug channel approximately 3-6" deep. Stake the fascines using twine or wire to prevent them from floating away. Place soil or sphagnum moss on top of the bundles to allow the willow branches to grow. Wattle fences are formed by pounding the stems of dogwood or some other wood approximately 8" apart. Take long branches of dogwood or willow and weave them through the stakes like a basket. Make sure to push the branches into a tight bundle. A second technique is to make two rows of stakes and weave a basket with an opening in the middle. This can be filled with more sticks, creating thicker check dam. Wattle fences are an effective and economical alternative to silt fence or straw bales. Fertile topsoil, organic matter, and native seeds are then trapped behind the wattle to provide a stable medium for germination and increase stability. Straw bale check dams are simply created by placing straw bales in a row in the channel. Stake them down using hardwood stakes. This is a fast but effective method if stabilization is required in a short period of time. Sediment STOP is a specially designed straw mat that is rolled and staked in place. Sediment STOP is composed of a straw and coconut fiber matrix reinforced with 100% biodegradable netting. It is water permeable and has greater filtration capabilities than other check dam techniques. This creates a highly-effective, temporary, three-dimensional, sediment-filtration structure. Nilex GeoRidge is a permeable ditch berm designed for erosion and sediment control. By acting as an energy dissipater, GeoRidge reduces flow velocities and provides a smoother, less damaging release of water. All of these natural techniques and others are effective in creating check dams and other erosion controls for storm water.

### **Grassed Waterway (Sediment & Nutrients)**

Indiana NRCS FOTG Grasses Waterway (412)

A grassed waterway is a natural way to prevent gullies from forming. By analyzing the existing natural drainageways, the waterway should be graded and shaped to form a smooth, bowl-shaped channel that is deep and wide enough to carry the peak runoff from a 10-year frequency, 24-hour storm. The NRCS design charts can aid in determining these measurements. After the channel is complete, plant sod-forming grass ¼ to ½ inches deep in a figure eight pattern to avoid erosion. An outlet can then be installed at the base of the drainageway to prevent a new gully from forming. This grass covered strip provides stabilization to prevent erosion, may act as a filter for runoff, and could provide cover for small animals. To maintain this waterway, avoid using it as a roadway for machinery, and fertilize and mow as needed (wait until after July 15 to mow so birds have had a chance to leave nests).

### **Livestock Exclusion (Nutrients & Pathogens)**

Indiana NRCS FOTG Fence (382)

Providing fencing and other natural barriers around water bodies ensures that animal contamination does not run-off into these sources or fields. If livestock need to cross streams, provide a controlled stream crossing. The stream bottom should be covered with coarse gravel to provide animals with firm footing, while discouraging them from congregating or wallowing in the stream. In high sensitive areas, high tensile fence, solar-powered electric fences, or woven fence can be inexpensive alternatives to keep livestock from streams or to allow them a limited number of access points.

### **No-till Equipment Modifications (Sediment & Nutrients)**

Indiana NRCS FOTG Residue and Tillage Management- No Till/Strip Till/Direct Seed (329)

Modifications to farm equipment can be added to aid in no-till practices. Leaving last year's crop residue on the surface before planting operations provides cover for the soil at a critical time of the year. Equipment modifications can vary and include no-till, mulch till and ridge till. These techniques prevent soil erosion, protect water quality, improve soil tilth, add organic matter to the soil, and reduce compaction with fewer tillage trips.

### **Strip cropping (Sediment & Nutrients)**

Indiana NRCS FOTG Stripcropping (585)

Crops are arranged so that a strip of meadow or small grain such as oats, grass or legumes, is alternated with a strip of row crop such as corn or soybeans to create strip cropping. These strips should be nearly the same width. These alternative strips slow runoff, increase infiltration, trap sediment and provide surface cover. Ridges formed by contoured rows slow water flow which reduces erosion. Rotating these crops allows nutrients to be recharged by other legumes or grains and can reduce fertilizer costs. In addition, grass and legumes should serve as the field borders to help establish waterways. Slopes must be considered to accommodate equipment width and to maintain proper stripcropping width.

### **Vegetated Stream bank Stabilization (Bioengineering) (Sediment & Nutrients)**

Indiana NRCS FOTG Stream bank and Shoreline Protection (580)

Grass, riprap, gabions, and other methods are installed along the edges of a stream to buffer the banks from heavy stream flow and reduce erosion. A buffer zone of at least 15-25 feet of vegetation along the stream bank filters runoff and may also absorb excess nutrients and chemicals. Remove brush that adversely affects the desired vegetation of the bank. Fencing may be added to prevent cattle from trampling banks, destroying vegetation and stirring up sediment.

### **Water and Sediment Control Basins (Sediment & Nutrients)**

Indiana NRCS FOTG Water and Sediment Control Basins (638)

A short earthen dam built across a drainageway (where a terrace is impractical), though it usually is part of a terrace system that directs runoff is a control basin. This basin traps sediment and water running off farmland above the structure preventing it from reaching farmland below to reduce erosion and improve water quality. The area draining into the basin should not exceed 50 acres. The basin should be large enough to control a 10-year storm and ensure there is a tile or infiltration outlet for potential overflow. Fill material should contain little to no debris and contain the correct moisture content for adequate compaction. Seeding the embankment to maintain vegetative cover, reduce erosion, and provide cover for wildlife provides for a strong control basin.

### **2-Stage Ditches (Sediment & Nutrients)**

NRCS' Stream Restoration Design Manual, Chapter 1- & Journal of Soil and Water Conservation 62(4) 277-296

A two stage ditch has two main channels, a larger shelf system and a small deeper channel. This system more closely resembles and functions as a natural stream system and maximizes potential contact with the streambed and floodplain. Two stage ditches accommodate larger flows of water than most drainage channels. This aids in water's contact with the bottom sediments where nutrients can be captured, exchanged, and controlled. This provides a healthier stream environment. By providing the initial channel with the 'built-in' floodplain it is able to contain nutrients, control runoff, and prevent erosion.





# Urban BMPs Measures to Apply

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 7

### **2-Stage Ditches (Sediment & Nutrients)**

NRCS' Stream Restoration Design Manual, Chapter 1- & Journal of Soil and Water Conservation 62(4) 277-296 Two stage ditches accommodate larger flows of water than most drainage channels. A two stage ditch has two main channels, a larger shelf system and a small deeper channel. This system more closely resembles and functions as a natural stream system and maximizes potential contact with the streambed and floodplain. This aids in water's contact with the bottom sediments where nutrients can be captured, exchanged, and controlled. This provides a healthier stream environment. By providing the initial channel with the 'built-in' floodplain it is able to contain nutrients, control runoff, and prevent erosion.

### **Bioretention/Rain Gardens(Sediment & Nutrients)**

LID Manual for Michigan & City of Philadelphia, Storm Water Manual  
Bioretention or Rain Garden systems use surface storage, vegetation, a select growing medium, flow controls, and other components. This design can vary in size from a planter box to an acre or more and replicate natural hydrologic processes. They improve water quality and reduce water quantity. The ponding depth for water varies from 6 inches to 2 feet and the soil depth should be between 2 and 3 feet. The side slopes should not exceed a 2:1 maximum ratio. Rain gardens require minimum maintenance after initial establishment.

### **Curb Cuts/ Curbless Design (Sediment & Nutrients)**

City of Philadelphia, Storm Water Manual  
Curbless design or curb cuts allow storm water to flow directly from an impervious source to a pervious surface. This type of design discourages concentration of flow and reduces the energy of storm water entering a management facility. These systems are often used with bioretention islands or roadside swales. Curb cuts or openings provide an alternative inlet control to complete curbless design. Pavement edges should be slightly higher than the elevation of the vegetated swale and openings should be at least 12-18 inches wide. Small rocks or stones should be used at the inlet of the curb openings to provide erosion protection. Filtering of water, control of quantity, and reduction of erosion from impervious surfaces are accomplished with curbless designs.

### **Drivable Grass (Sediment & Nutrients)**

Plantable Concrete Systems  
Drivable grass and other forms of grass paving offer infiltration while maintaining heavy loads. Drivable grass is an alternative to porous pavement. Drivable grass has up to a concrete compressive strength of 5000 psi and also responds more favorably to freeze/thaw cycles. Insects and micro-organisms within the grass aid in breaking down pollutants from runoff and slow runoff by creating ground water recharge and erosion by providing on site infiltration. It provides more durability and less construction and disturbance of the subsoil. These systems can also reduce urban heat island effects.

### **Storm Water Pond Riser Modification (Sediment & Nutrients)**

City of Philadelphia, Storm Water Manual  
Pond riser techniques aid in controlling flow, especially outflow, and maintain a healthy water level for a pond. These can be in the form of pipes, concrete box structures, or natural or constructed weir structures. These efforts help preserve and maintain the ecological integrity of the pond, encourage sediment removal, help maintain positive nutrient levels, and decrease erosion especially during high outflows.

### **Filter Strips (Sediment & Nutrients)**

Indiana NRCS FOTG Filter Strip (393)

Filter strips are vegetated sections of land designed to slow runoff. They may use any type of vegetation from grassy meadow to small forest cover. Filter strips are fairly level in surface and are used for a natural buffer and facilitates the removal of pollutants like sediment, organic materials, and trace metals. They are ideal for low to medium density residential areas where they can access, filter, and slow roof top and lawn runoff. Slopes no more than 15% are ideal. Filter strips require periodic repair, regarding, and sediment removal to prevent channelization. They encourage urban wildlife habitat, increase groundwater recharge, and provide buffer, stabilization, and erosion control for water bodies.

### **Flow Splitters (Sediment & Nutrients)**

City of Philadelphia, Storm Water Manual & Storm water Management Manual for Western Washington

A flow splitter is a structure constructed to control runoff by providing diversion directions of various flow rates. This system is most commonly used to divert large flows of storm water away from sensitive areas or monitor flow rates, many times to a wetland. By reducing the flow into these sensitive areas, the area will still receive water, but because of the decrease in flow, erosion and excess sediment discharge is avoided. Flow splitters can be constructed with concrete, metal, or treated lumber and create a weir and plumbing system that directs water flow.

### **Green Roofs (Sediment & Nutrients)**

LID Manual for Michigan & City of Philadelphia, Storm Water Manual

Green roofs consist of a layer of vegetation that covers a conventional roof. The system is composed of multiple layers including the roof structure, waterproofing, a drainage layer, filter fabric, engineered planting media, and plants. Vegetated roofs improve water quality, reduce water runoff, extend roof life, reduce heating and cooling costs, improve air quality by filtering dust particles, and reduce the urban heat island effect. Green roofs can vary from 3 inches of depth to 2 feet.

### **Level Spreader (Sediment & Nutrients)**

LID Manual for Michigan, Designing Level Spreaders to Treat Storm Water Runoff & City of Philadelphia, Storm Water Manual

Level spreaders are inlet controls that are design to uniformly distribute concentrated flow over a large area. There are many types of level spreaders that can be selected based on the peak rate of inflow, the duration of use, and the site conditions. These controls reduce concentrated flow and erosion. Types of level spreaders include a rock lined channel, concrete troughs and half pipes and treated lumber. Concentrated flow enters the spreader at a single point, the flow is slowed and energy dissipated. The water flow is distributed throughout a long linear shallow trench or behind a low berm and is uniformly distributed along the entire length.

### **Tree Box Filters (Sediment & Nutrients)**

VA Demonstration Project & LID Manual for Michigan

Tree box filters retain storm water runoff and reduce impervious cover. There are typically two types: flow-through and contained. Flow-through tree box filters are designed to retain and slowly release water. They have or are placed on an impervious surface. Contained tree box filters slow storm water runoff and drain through their base or overflow structures to surrounding soils.

### **Low Impact Development (Sediment & Nutrients)**

Must be designed by professional engineer

Low Impact Development strategies offer environmentally sound technology and more economically sustainable approaches to addressing the adverse impacts of urbanization. Key components of any LID strategies are conservation, small-scale controls, directing runoff to natural areas, customized site design and maintenance, pollution prevention, and education that can enhance the local environment, protect public health, and improve community livability. LID strategies are economically viable; while initial costs may be higher, lower operation and maintenance costs offset this difference.

### **Permeable/Porous Pavement (Sediment & Nutrients)**

LID Manual for Michigan, IDEM Storm Water Quality Manual & City of Philadelphia Storm Water Manual

Porous/Permeable Pavement is an alternative to conventional pavement where runoff is diverted through a porous layer and into a subsurface infiltration bed. This stored runoff then gradually infiltrates into the subsoil. These pavement systems have high removal rates for sediment, nutrients, organic matter, and trace metals. These systems also increase storm water quality and divert the quantity. Porous/permeable pavement is ideal for soils with high infiltration rate and a slope that is less than five percent. This pavement can only be used for lower traffic areas such as parking lots, sidewalks, and access roads. The pavement must be maintained and kept from clogging due to debris and snow removal techniques such as salt or sand.

### **Rain Barrels (Sediment & Nutrients)**

City of Philadelphia, Storm Water Manual

Rain barrels, cisterns, or tanks are structures designed to intercept and store runoff from rooftops. These systems can be above or below the ground and can be drained by gravity or be pumped. The stored water may be slowly released to a pervious area or used for irrigation. This water can even be filtered, treated, tested, and reused for non-portable water uses indoors such as washing machines or toilets.

### **Sand Filters (Sediment & Nutrients)**

LID Manual for Michigan, City of Philadelphia, Storm Water Manual & Storm water Management Manual for Western Washington

Sand filters provide the first barrier for storm water run-off. Water is diverted into a self-contained bed of sand. The runoff is strained through the sand, collected in underground pipes, and returned back to the water body. Two systems can be used, "unconfined" sand-filled trench with a perforated underdrain or "confined" where the sand is contained in a concrete vault with a drain at the bottom of the vault. Typical drainage areas vary from one to five acres and can be easily adapted to parking lots. Sand or peat sand filters have high removal of sediment and trace metals, and moderate removal for nutrients, BOD and fecal coliform. Sand filters must be maintained by removing excess debris and trash.

### **Stream Restoration/Daylighting (Sediment & Nutrients)**

Engineer Designed

Streams are ecosystems, not merely infrastructure. Ensuring streams are restored and maintained is essential for water quality, runoff management, recreational and educational opportunities, and habitat. Daylighting is one of the most extreme forms of stream restoration. Stream daylighting is the act of removing streams from underground pipes and culverts, and restoring some of the form and function of historic streams. This effort re-establishes a waterway in its old channel where feasible, or in a new channel. These efforts aid in preserving or restoring the ecological integrity of watersheds as a whole, and even can encourage new wetlands, ponds or estuaries.

### **Subsurface Infiltration Beds (Sediment & Nutrients)**

LID Manual for Michigan & City of Philadelphia, Storm Water Manual

Subsurface infiltration bed systems are designed to provide temporary below grade storage infiltration of storm water as it infiltrates into the ground. These systems are typically stone-filled beds beneath landscaped or paved surfaces. Storm water flows into the subsurface system, collects within the aggregate void space, and slowly infiltrates into surrounding soils. Overflow for larger storms must be considered, usually with an overflow pipe system.

### **Swales/Vegetated Swales (Sediment & Nutrients)**

City of Philadelphia, Storm Water Manual

Swales or vegetated swales are open channels that direct, store, reduce peak flows, increase travel time and friction, treat, and filter water. A swale provides some infiltration and water quality treatment, though check dams and vegetation increase these capabilities. Vegetation increases friction of the water and stabilizes soil. Check dams often increase storage, dissipate energy, and control erosion. Typical swales are 2-8 feet at the base whose side slopes are at a 2:1 ratio.

### **Vegetated Stream bank Stabilization (Bioengineering) (Sediment & Nutrients)**

Indiana NRCS FOTG Stream bank and Shoreline Protection (580)

Vegetated Stream bank Stabilization, sometimes called bioengineering or soil bioengineering, describes varied methods of establishing vegetative cover by embedding a combination of live, dormant and/or decaying plant materials into banks and shorelines. Sediment removal is the most important function of stream bank stabilization, though it also aids in erosion control and overland runoff.

### **Water Retention Ponds retrofits (Sediment and Nutrients)**

City of Philadelphia, Storm Water Manual

Water retention pond retrofits are just one tool to restoring watersheds. These retrofits are a series of structural (usually storm water) practices designed to mitigate erosive flows, reduce pollutants in storm water runoff, and promote conditions for improved aquatic habitat. Retrofit processes begin with an analysis of the existing hydraulic characteristics of the facility or area and evaluating new options. These tools aid in storing additional storm water, directing flowpaths, inflows and outflows, and providing additional filtering and improving overall habitat. Most retrofits provide 80-90% pollutant removal.

### **Wetland Creation/Restoration (Sediment & Nutrients)**

Indiana NRCS FOTG Wetland Creation (658) & Wetland Restoration (657), State of Pennsylvania Storm water BMP Manual, & Storm water Management Manual for Western Washington, Volume 5

Wetlands are shallow pools that create growing conditions suitable for the growth of marsh plants. Wetlands are designed to maximize pollutant removal through wetland uptake, retention, and settling. These areas aid in wildlife and waterfowl habitat. The creation and restoration of wetlands provide an essential key to the health of the ecosystem.

# BMPs Load Reductions

## WMP - CHAPTER 6 - PART 1 - SECTION 1 - SUBSECTION 8

Load reduction calculations were estimated for nitrogen, phosphorus and sediment based on the potential best management practices to be implemented within the watershed. The percent reductions for each BMP were based on EPA's National Management Measures to Control Nonpoint Source Pollution from Agriculture, and STEPL. The load reduction expected for each BMP:

TABLE 6.2: BMP Load Reductions			
BMP OR MEASURE	LOAD REDUCTION FOR SINGLE BMP		
	SEDIMENT	PHOSPHORUS	NITROGEN
No-till Equipment Modifications	12 tons/ yr	60 lbs yr	120 lbs yr
Vegetated Stream bank Stabilization	4 tons yr	9 lbs yr	8 lbs yr
Filter Strips and Riparian Zones	2 tons	60 lbs yr	120 lbs yr
Wetland Creation/Restoration	na	na	na
Livestock Exclusion	2 tons	60 lbs yr	120 lbs yr
Rain Barrels	na	na	na

The BMPs listed are typical BMPs and are provided as a reference, it is not meant to be an all inclusive list but only a guide. The reductions only apply to the drainage area that is directly tributary to the implemented BMP. Therefore, when looking at overall reductions in a given Subwatershed, an aggregate for all BMPs implemented with each associated tributary area will be need to be evaluated.

The actual efficiency of each BMP is based on several variables making it difficult to accurately determine the number required to equal the reduction goals (e.g. the location in the watershed, tributary area, soils, etc). Therefore, specific locations and types of BMPs should be carefully planned out in coordination with the landowners and applicable local, state and federal agencies and with the load reduction needs of the Subwatershed in mind.<sup>1</sup>

<sup>1</sup> Tom Reeve, White River Watershed Project





# ACTION REGISTER AND SCHEDULE

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 7



# Action Register

## WMP - CHAPTER 7 - PART 1 - SECTION 1 - SUBSECTION 1

The action register is a method of displaying each goals' schedules objectives and milestones, estimated financial costs, and possible partners.

The success of a watershed management plan can be measured by how readily it is used by its intended audience and how well it is implemented. This plan is very ambitious and continued implementation of the plan will require an even greater degree of cooperation and coordination among partners and funding for projects. It will be the decision of the Steering Committee to prioritize the implementation projects for the watershed which will also guide the decision of which funding opportunity to choose (as described in the Incentives/Cost Share Opportunities section of this WMP).

The action register is a tool used to easily identify each objective, milestone, estimated cost, and possible partners for easier implementation of the plan. The action register is divided based on the previously identified problem and goal categories. The problem and goal statements are also repeated in these sections for quick reference. It should be noted that some objectives may relate to several problem/goal statements, they are listed in each applicable category.



TABLE 7.1: Action Register for TSS Goal

Excess TSS has been identified as a problem:

Goal:

We want to reduce the watershed's TSS load from 54.9 tons a year to 13.75 tons per year (a 75% reduction) within 20 years.

Source	Objective	Target audience	Milestone	
STREAM BANKS: DUE TO POOR VEGETATION STRUCTURAL INTEGRITY	Vegetated Stream bank Stabilization	Farmers and Rural/Urban Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
STREAM BANKS: DUE TO NEAR BANK SHEER STRESS CHANNELIZATION	Natural Chanel Design	Farmers and Rural/Urban Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
STREAM BANKS: DAMMING	Remove Dams	City of Muncie	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
STREAM BANK: DITCH FEATURES	2-stage ditch	Farmers and Rural/Urban Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
SHEET FLOW: LACK OF TILE, DITCH INVERT BMPs	No-till Equipment Modifications	Farmers	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
SHEET FLOW: LACK OF FILTERING AND ON SITE INFILTRATION	Filter Strips and Riparian Zones	Farmers and Rural Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
SHEET FLOW: LACK OF GROUND COVER	Covercrops	Farmers	Identify five partners by 2020. Install 10 BMPs by 2020.	



	Cost	Possible Partner (PP)	Technical Assistance (TA)
	Greater than \$50,000	IDEM, BBF, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Greater than \$100,000	IDEM, MSD, IDEM, BBF, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Greater than \$50,000	IDEM, MSD, IDNR	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Greater than \$25,000	IDEM, MSD, IDNR, DCSWCD, BSU, NRCS, FSA, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Greater than \$15,000	IDEM, NRCS, FSA, property owners	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Greater than \$15,000	IDEM, SWCD, BSU, NRCS, FSA, property owners,	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Greater than \$15,000	IDEM, DCSWCD, BSU, NRCS, FSA, property owners.	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants

TABLE 7.2: Action Register for nutrients Goal

Excess nutrients has been identified as a problem:

Goal(s):

Muncie Creek - Excess ammonia has been identified as a problem. We want to reduce the watershed's ammonia load from 460 lbs a year to 115 lbs per year (a 75% reduction) within 20 years.

Truitt Ditch - Excess ammonia has been identified as a problem. We want to reduce the watershed's ammonia load from 127.6 lbs a year to 31.9 lbs per year (a 75% reduction) within 20 years.

Truitt Ditch - Excess Nitrates has been identified as a problem. We want to reduce the watershed's Nitrate load from 885.4 lbs a year to 221.4 lbs per year (a 75% reduction) within 20 years.

Truitt Ditch - Excess Phosphorus has been identified as a problem. We want to reduce the watershed's Phosphorus load from 76.1 lbs a year to 19 lbs per year (a 75% reduction) within 20 years

Source	Objective	Target audience	Milestone	
STREAM BANKS: DUE TO POOR VEGETATION/STRUCTURAL INTEGRITY	Vegetated Stream bank Stabilization	Farmers and Rural/Urban Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
STREAM BANKS: DUE TO NEAR BANK SHEER STRESS CHANNELIZATION	Natural Chanel Design	Farmers and Rural/Urban Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
STREAM BANKS: DAMMING	Remove Dams	City of Muncie	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
STREAM BANK: DITCH FEATURES	Natural Chanel Design	Farmers and Rural/Urban Land Owners	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
SHEET FLOW: LACK OF GROUND COVER	No-till Equipment Modifications	Farmers	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
SHEET FLOW: LACK OF TILE, DITCH INVERT BMPs	Invert BMPs	Farmers	Identify 2-5 potential projects by 2013. Install BMPs by 2020.	
SHEET FLOW: LACK OF FILTERING AND ON SITE INFILTRATION	Wetland Creation/Restoration	Farmers and Rural Land Owners	Identify five partners by 2020. Install 10 BMPs by 2020.	

Cost	Possible Partner (PP)	Technical Assistance (TA)	
Greater than \$50,000	IDEM, BBF, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	
Greater than \$100,000	IDEM, MSD, IDEM, BBF, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	
Greater than \$50,000	IDEM, MSD, DNR	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	
Greater than \$25,000	IDEM, MSD, IDNR, DCSWCD, BSU, NRCS, FSA, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	
Greater than \$15,000	IDEM, NRCS, FSA, property owners	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	
Greater than \$15,000	IDEM, SWCD, BSU, NRCS, FSA, property owners, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	
Greater than \$100,000	IDEM, MSD, IDNR, DCSWCD, BSU, NRCS, FSA, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants	

TABLE 7.3: Action Register for pathogens Goal

Excess E. coli has been identified as a problem:

Goal(s):

Muncie Creek - Excess E. coli has been identified as a problem. We want to reduce the watershed's E. coli load from 1.92E+13 cfu a year to 1.4388E+13cfu per year (a 75% reduction) within 20 years.

Truitt Ditch - Excess E. coli has been identified as a problem. We want to reduce the watershed's E. coli load from 1.45E+12 cfu a year to 3.6125E+11 cfu per year (a 75% reduction) within 20 years.

Source	Objective	Target audience	Milestone	
Pet Waste	Education	Urban Residents	Develop campaign by 2013 and begin implementation.	
Animal Wastes from Agricultural Sources	Livestock Exclusion	Farmers and Rural Land Owners	Identify five partners by 2013. Install 10 BMPs by 2020.	

	Cost	Possible Partner (PP)	Technical Assistance (TA)
	Greater than \$4,000	IDEM, MSD	USFWS, IDEM, IDNR, NRCS, DC-SWCD, EPA, Consultants
	Greater than \$15,000	IDEM, DCSWCD, BSU, NRCS, FSA, property owners	USFWS, IDEM, IDNR, NRCS, DC-SWCD, EPA, Consultants

TABLE 7.4: Action Register for Education Goal

Lack of public education has been identified as a problem:

Goal:

Truitt Ditch and Muncie Creek - Lack of public education has been identified as a problem. We want to increase the amount of educational opportunities to one a month over next funding cycle.

Source	Objective	Target audience	Milestone	
Illegal Dumping of Trash/Waste	Create a water quality education program	Urban and Rural Residents	Develop campaign by 2013 and begin implementation.	
Lack of BMP Implementation	Educate about BMPs	Urban and Rural Residents	Develop campaign by 2013 and begin implementation.	

TABLE 7.5: Action Register for urban areas Goal

Low amount of urban BMPs per square foot of impervious surface has been identified as a problem:

Goal:

Truitt Ditch and Muncie Creek - Low amount of urban BMPs per square foot of impervious surface has been identified as a problem. We want to increase the amount of BMPs per impervious surface by 10% over the next 20 years.

Source	Objective	Target audience	Milestone	
Lack of system priority in land owners and regulators	Implement BMPs and LID to address storm water runoff in urban areas	Urban Residents	Identify five partners by 2013. Install 3 BMPs by 2020.	
Lack of system priority in land owners and regulators	Demonstrate innovative BMP/LID techniques in target watersheds.	Urban Residents	Identify five partners by 2013. Install 4 BMPs by 2020.	



	Cost	Possible Partner (PP)	Technical Assistance (TA)
	less than \$5,000	IDEM, MSD, IDNR, DCSWCD, BSU, NRCS, FSA, property owners,	USFWS, IDEM, IDNR, NRCS, DC-SWCD, EPA, Consultants
	less than \$5,000	IDEM, MSD, IDNR, DCSWCD, BSU, NRCS, FSA, property owners,	USFWS, IDEM, IDNR, NRCS, DC-SWCD, EPA, Consultants

	Cost	Possible Partner (PP)	Technical Assistance (TA)
	Greater than \$100,000	IDEM, MSD, IDNR, DC-SWCD, BSU, NRCS, FSA, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants
	Less than \$10,000	IDEM, MSD, IDNR, DC-SWCD, BSU, NRCS, FSA, property owners, County Surveyor, Drainage Board	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants

# APPENDIX

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER WMP  
CHAPTER 8



# Cost-Share Opportunities

## MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

Landowners in Delaware County are eligible to participate in many different cost-share programs. The most commonly awarded programs are CRP, CREP, EQIP, WHIP, and CFWP. While the WRWP cost-share program is separate from these sources of funding, there are opportunities for partnership and pooling of resources. Before the WRWP awards grants out of the 319 funding, we often check to see if some of these other programs might be available for higher amounts of funding and for longer time periods. The WRWP will assist citizens in learning more about cost-share options – both through the WRWP or through the below programs.

### **Conservation Reserve Program**

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

### **Conservation Reserve Enhancement Program**

The Conservation Reserve Enhancement Program (CREP) is a federal-state natural resources conservation program that addresses agricultural-related environmental concerns at the state and national level. CREP participants receive financial incentives to voluntarily enroll in the Conservation Reserve Program (CRP) in contracts of 14 to 15 years. Participants remove cropland from agricultural production and convert the land to native grasses, trees and other vegetation. The Indiana CREP is a partnership between USDA and the state of Indiana. The program targets the enrollment of 26,250 acres of land in the Highland-Pigeon, Lower East Fork White, Lower Wabash, Lower White, Middle Wabash-Busseron, Middle Wabash-Deer, Middle Wabash-Little Vermillion, Tippecanoe, Upper East Fork White, Upper Wabash, Upper White watersheds where sediments, nutrients, pesticides and herbicides run off from agricultural land. What are the potential benefits of the Indiana CREP? The program will improve water quality by creating buffers and wetlands that will reduce agricultural runoff into the targeted watersheds. Installing buffer practices and wetlands will enhance habitat for wildlife, including State and Federally-listed threatened and endangered species. The program will also reduce nonpoint source nutrient losses.

### **Farmable Wetlands Program**

The Farmable Wetlands Program (FWP) reduces downstream flood damage, improves surface and groundwater quality, and recharges groundwater supplies by restoring wetlands.

### **Grassland Reserve Program (GRP)**

The Grassland Reserve Program (GRP) helps landowners restore and protect grassland, rangeland, pastureland, and shrubland and provides assistance for rehabilitating grasslands.

### **Environmental Quality Incentives Program (EQIP)**

The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program that helps agricultural producers in a manner that promotes agricultural production and environmental quality as compatible goals. Through EQIP, farmers and ranchers receive financial and technical assistance to implement structural and management conservation practices that optimize environmental benefits on working agricultural land. EQIP is re-authorized through the Food, Conservation, and Energy Act of 2008 (2008 Farm Bill).

### **Wildlife Habitat Incentive Program (WHIP)**

The Wildlife Habitat Incentive Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land. Through WHIP USDA's Natural Resources Conservation Service provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP agreements between NRCS and the participant generally last from 5 to 10 years from the date the agreement is signed. WHIP has proven to be a highly effective and widely accepted program across the country. By targeting wildlife habitat projects on all lands and aquatic areas, WHIP provides assistance to conservation minded landowners that are unable to meet the specific eligibility requirements of other USDA conservation programs.

### **Indiana Classified Forest and Wildlands program**

The Classified Forest and Wildlands Program encourages timber production, watershed protection, and wildlife habitat management on private lands in Indiana. Program landowners receive a property tax reduction in return for following a professionally written management plan. In addition to the tax incentive, landowners receive free technical assistance from DNR foresters and wildlife biologists, priority for cost share to offset the cost of doing management, and the ability to "green" certify their forests. The minimum requirement for program enrollment is 10 acres of forest, wetland, shrubland, and/or grassland. Enrolling your forests or grasslands (has to be at least a 10 acre parcel) will drop your property taxes to \$1 per acre. Managed harvesting of timber is still allowed in this program.

### **Emergency Conservation Program**

Get back on your feet after a natural disaster. USDA Farm Service Agency's (FSA) Emergency Conservation Program (ECP) provides emergency funding and technical assistance for farmers and ranchers to rehabilitate farmland damaged by natural disasters and for carrying out emergency water conservation measures in periods of severe drought.

### **Emergency Forest Restoration Program**

Emergency Forest Restoration Program (EFRP), will make payments available to nonindustrial private forest (NIPF) land owners who are approved for program participation in order to carry out emergency measures to restore land damaged by a natural disaster.

### **Source Water Protection Program**

Source water is surface and ground water that is consumed by rural residents. The Source Water Protection Program is designed to help prevent source water pollution through voluntary practices installed by producers at local levels.

# Cost-Share Opportunities

## MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

### **Conservation Tillage Program**

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 more demanding than no-till soybean. The no-till drill facilitated a no-till soybean production boom.

### **Farm and Ranch Lands Protection Program (FRPP)**

The goal of the Farm and Ranch Lands Protection Program (FRPP) is to protect prime or unique farmland, statewide and locally important soils, or historic and archaeological resources on farmland and ranch land from conversion to non-agricultural uses. The program preserves valuable farmland for future generations, protecting agricultural land use and related conservation values of the land. This goal is achieved by working cooperatively with State, Tribal, and local government entities and non-governmental organizations. FRPP provides matched funds to help eligible entities purchase development rights to keep productive farmland and ranch land in agricultural uses. USDA provides up to 50 percent of the easement fair market value. To qualify, farmland must: be part of a pending offer from a State, tribe, or local farmland protection program; be privately owned; be large enough to sustain agricultural production; be accessible to markets for what the land produces; have adequate infrastructure and agricultural support services; and have surrounding parcels of land that can support long-term agricultural production.

### **Grassland Reserve Program (GRP)**

The Grassland Reserve Program (GRP) offers landowners the opportunity to protect, restore, and enhance grassland including rangeland, pastureland, shrubland and certain other lands on their property. USDA's Natural Resources Conservation Service and Farm Service Agency administer this program. This voluntary program helps protect valuable grasslands from conversion to cropland or other uses and helps ensure that grasslands are available to future generations. Participants voluntarily limit future development and cropping uses of the land, while retaining the right to conduct common grazing practices and operations related to the production of forage and seeding, subject to certain restrictions during nesting seasons of bird species that are in significant decline or are protected under Federal or State law. A grazing management plan is required for participants.



### **Healthy Forests Reserve Program (HFRP)**

The purpose of the Healthy Forests Reserve Program (HFRP) is to assist landowners, on a voluntary basis, in restoring, enhancing and protecting forestland resources on private lands through easements, 30-year contracts and 10-year cost-share agreements. The objectives of HFRP are to: Promote the recovery of endangered and threatened species under the Endangered Species Act (ESA); improve plant and animal biodiversity; and enhance carbon sequestration.

### **Indiana Wetlands Reserve Program (WRP)**

The Wetlands Reserve Program (WRP) is the Nation's premier wetlands restoration program. It is a voluntary program that offers landowners the means and the opportunity to protect, restore, and enhance wetlands on their property. The USDA Natural Resources Conservation Service (NRCS) manages the program as well as provides technical and financial support to help landowners that participate in WRP. Program objectives are: 1) to purchase conservation easements from, or enter into cost-share agreements with willing owners of eligible land, 2) help eligible landowners, protect, restore, and enhance the original hydrology, native vegetation, and natural topography of eligible lands, 3) restore and protect the functions and values of wetlands in the agricultural landscape, 4) help achieve the national goal of no net loss of wetlands, and to improve the general environment of the country. The emphasis of the WRP program is to protect, restore and enhance the functions and values of wetland ecosystems to attain: 1) first and foremost, habitat for migratory birds and wetland dependent wildlife, including threatened and endangered species; 2) protection and improvement of water quality; 3) lessen water flows due to flooding; 4) recharge of ground water; 5) protection and enhancement of open space and aesthetic quality; 6) protection of native flora and fauna contributing to the Nation's natural heritage; and 7) contribute to educational and scholarship.

### **Conservation Planning**

A Conservation Plan is a written record of your management decisions and the conservation practices and systems you plan to use and maintain on your farm. Carrying out your Plan will achieve the goals of protecting the environment on and off your farm. After soil, water, air, plant, and animal resources on your property are inventoried and evaluated, the NRCS Planner will review several alternatives for you to consider. The alternatives you decide are recorded in the Conservation Plan, which becomes your roadmap for better management of your natural resources. Conservation Plans are now required in Indiana for the Environmental Quality Incentives Program (EQIP) and the Wildlife Habitat Incentives Program (WHIP).

# Cost-Share Opportunities

## MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

### **Emergency Watershed Protection**

The purpose of the Emergency Watershed Protection (EWP) program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention. This safeguards lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed. The program objective is to assist sponsors and individuals in implementing emergency measures to relieve imminent hazards to life and property created by a natural disaster. Activities include providing financial and technical assistance to remove debris from streams, protect destabilized stream banks, establish cover on critically eroding lands, repairing conservation practices, and the purchase of flood plain easements. NRCS may bear up to 75 percent of the construction cost of emergency measures. The remaining 25 percent must come from local sources and can be in the form of cash or in-kind services. Sponsors are responsible for providing land rights to do repair work and securing the necessary permits. Sponsors are also responsible for furnishing the local cost share and for accomplishing the installation of work. The work can be done either through federal or local contracts. A case by case investigation of the needed work is made by NRCS. All projects undertaken must be sponsored by a political subdivision of the State, such as a city, county, general improvement district, or conservation district.

### **Floodplain Easement Program (FPE)**

The Floodplain Easement Program (FPE) is a voluntary program that offers landowners the means and the opportunity to protect, restore and enhance lands subject to repeated flooding and flood damage. The Floodplain Easement is funded through the Emergency Watershed Protection Program. The USDA Natural Resources Conservation Service (NRCS) manages the program and provides technical and financial support to help landowners that participate in FPE. The objective of the FPE program is to assist in relieving imminent hazards to life and property from floods and the products of erosion created by natural disasters that are causing a sudden impairment of a watershed. The FPE Program is not intended to deny any party access to the traditional eligible EWP practices, but rather to provide a more permanent solution to repetitive disaster assistance payments and achieve greater environmental benefits where the situation warrants and the affected Landowner is willing to participate in the easement approach. The benefits of FPE include; 1) reduction of the public risk of flood damages including public risk to downstream or adjacent lands, 2) protection of lives and property from floods, 2) reduction in soil erosion through restoration, protection and/or enhancement of the floodplain, 3) elimination of future disaster payments, 4) restoration, protection, management, maintenance and enhancement of the functions of wetlands, riparian areas, and other lands, and 5) conservation of natural values including fish and wildlife habitat, water quality improvement, flood water retention, groundwater recharge, open space, aesthetics, and environmental education.

### **Conservation of Private Grazing Land**

The Conservation of Private Grazing Land (CPGL) program will ensure that technical, educational, and related assistance is provided to those who own private grazing lands. It is not a cost share program. This technical assistance will offer opportunities for: better grazing land management; protecting soil from erosive wind and water; using more energy-efficient ways to produce food and fiber; conserving water; providing habitat for wildlife; sustaining forage and grazing plants; using plants to sequester greenhouse gases and increase soil organic matter; and using grazing lands as a source of biomass energy and raw materials for industrial products. The CPGL program was authorized by the conservation provisions of the Federal Agricultural Improvement and Reform Act (1996 Farm Bill). The intent of this provision is to provide accelerated technical assistance to owners and managers of grazing land. The purpose is to provide a coordinated technical program to conserve and enhance grazing land resources and provide related benefits. Currently, funds have not been appropriated for this program. When producers need assistance with grazing land, local NRCS staffs will contact the designated Grassland Conservationist for assistance.

### **Conservation Technical Assistance**

The Conservation Technical Assistance (CTA) program provides voluntary conservation technical assistance to landowners, communities, tribes, units of state and local government, and other Federal agencies in planning and implementing conservation systems. This assistance is for planning and implementing conservation practices that address natural resource issues. It helps people voluntarily conserve, improve, and sustain natural resources. Objectives of the program are to: Assist individual land users, communities, conservation districts, and other units of State and local government and Federal agencies to meet their goals for resource stewardship and assist individuals to comply with State and local requirements. Natural Resources Conservation Service (NRCS) assistance to individuals is provided through conservation districts in accordance with the memorandum of understanding signed by the Secretary of Agriculture, the governor of the state, and the conservation district. Assistance is provided to land users voluntarily applying conservation and to those who must comply with local or State laws and regulations assisting agricultural producers to comply with the highly erodible land (HEL) and wetland (Swamp buster) provisions of the 1985 Food Security Act as amended by the Food, Agriculture, Conservation and Trade Act of 1990 (16 U.S.C. 3801 et. seq.) and the Federal Agricultural Improvement and Reform Act of 1996 and wetlands requirements of Section 404 of the Clean Water Act. NRCS makes HEL and wetland determinations and helps land users develop and implement conservation plans to comply with the law. Provide technical assistance to participants in USDA cost-share and conservation incentive programs. (Assistance is funded on a reimbursable basis from the CCC.) Collect, analyze, interpret, display, and disseminate information about the condition and trends of the Nation's soil and other natural resources so that people can make good decisions about resource use and about public policies for resource conservation. Develop effective science-based technologies for natural resource assessment, management, and conservation. Technical assistance is for planning and implementing natural resource solutions to reduce erosion, improve soil health, improve water quantity and quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range health, reduce upstream flooding, improve woodlands, and address other natural resource issues.

# Cost-Share Opportunities

## MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

### **Grazing Lands Conservation Initiative Program**

The Grazing Lands Conservation Initiative (GLCI) is a nationwide collaborative process of individuals and organizations working together to maintain and improve the management, productivity, and health of the Nation's privately owned grazing land. GLCI was developed to provide for a coordinated effort to identify priority issues, find solutions, and affect change on private grazing land. There is a National GLCI Steering Committee and many state committees throughout the country. Coalitions, made up of individuals and organizations, represent the grass root concerns that impact private grazing land. Concerns are expressed to the public and agency officials in an attempt to address the issues impacting private grazing land. GLCI seeks to strengthen partnerships, promote voluntary assistance and participation, respects private property rights, encourages diversification to achieve multiple benefits, and emphasize training, education, and increased public awareness. Through GLCI efforts, Congress has identified funds in the NRCS budget to be used directly for technical assistance and public awareness activities to support conservation activities on private grazing lands. This assistance will provide owners and managers of private grazing land information to make management decisions and use the latest and best technology that will conserve and enhance private grazing land resources.

### **Conservation Stewardship Program (CSP)**

The Conservation Stewardship Program (CSP) is a voluntary program that encourages agricultural producers to improve conservation systems by improving, maintaining, and managing existing conservation activities and undertaking additional conservation activities. The Natural Resources Conservation Service administers this program and provides financial and technical assistance to eligible producers. CSP is available on Tribal and private agricultural lands and non-industrial private forestland (NIPF) on a continuous application basis. CSP offers financial assistance to eligible participants through two possible types of payments: annual payment for installing and adopting additional activities, and improving, maintaining, and managing existing activities. Conservation Activity List – 2009 (posted on Indiana SharePoint) Conservation Activity List – 2010 (PDF; 39 KB) — Document requires Acrobat Reader Conservation Activity List – 2011 Payments will be made for conservation performance payments points estimated for each agricultural operation by the Conservation Measurement Tool (CMT). Conservation performance points are unique for each agricultural operation and will be based on existing and proposed conservation activities. Contracts cover the eligible land in the entire agricultural operation and last for five years. For all contracts entered into, CSP payments to a person or legal entity may not exceed \$40,000 in any fiscal year, and \$200,000 during any five-year period. Each CSP contract will be limited to \$200,000 over the term of the initial contract period.

### **Agricultural Water Enhancement Program (AWEP) via EQIP**

The Agricultural Water Enhancement Program (AWEP) is a voluntary conservation initiative that provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface and ground water and improving water quality. As part of the Environmental Quality Incentives Program (EQIP), AWEP operates through program contracts with producers to plan and implement conservation practices in project areas established through partnership agreements. The Secretary of Agriculture has delegated the authority for AWEP to the Chief of NRCS. Under AWEP, the Natural Resources Conservation Service (NRCS) enters into partnership agreements with eligible entities and organizations that want to promote ground and surface water conservation or improve water quality on agricultural lands. After the Chief has announced approved AWEP project areas, eligible agricultural producers may submit a program application.

# Partnerships

## MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

Partnerships to help achieve the objectives of the Watershed Management Plan: three sub-committees have been formed to spearhead and guide the activities necessary. The sub-committees will work to develop beneficial partnerships with other local and regional groups. Existing partners are described in Chapter 1.

# FOOTNOTES

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# DEFINITIONS

## MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

**Algae:** Any of various primitive, chiefly aquatic, one-or multi-celled, nonflowering plants that lack true stems, roots, and leaves, but usually contain chlorophyll. Algae convert carbon dioxide and inorganic nutrients such as nitrogen and phosphorus into organic matter through photosynthesis and form the basis of the marine food chain. Common algae include dinoflagellates, diatoms, seaweeds, and kelp.

**Algal bloom:** A condition which occurs when excessive nutrient levels and other physical and chemical conditions facilitate rapid growth of algae. Algal blooms may cause changes in water color. The decay of the algal bloom may reduce dissolved oxygen levels in the water.

**Ammonia (NH<sub>3</sub>+):** A colorless gas with a pungent odor. It is easily liquefied and solidified and is very soluble in water. Large quantities of ammonia are used in the production of nitric acid, urea and nitrogen compounds. Since ammonia is a decomposition product from urea and protein, it is found in domestic wastewater. Aquatic life and fish also contribute to ammonia levels in streams. NH<sub>3</sub> is the principal form of toxic ammonia.

**Aquifer:** An underground layer of rock or soil containing ground water.

**Atrazine:** An herbicide (trade name Aatrex) widely used for control of broadleaf and grassy weeds in corn.

**Benthic:** Living in or on the bottom of a body of water.

**Benthos:** Collectively, all organisms living in, on, or near the bottom substrate in aquatic habitats (examples are oysters, clams, burrowing worms).

**Best management practices (BMPs):** Management practices (such as nutrient management) or structural practices (such as terraces) designed to reduce the quantities of pollutants-- such as sediment, nitrogen, phosphorus, and animal wastes -- that are washed by rain and snow melt from farms into nearby receiving waters, such as lakes, creeks, streams, rivers, estuaries, and ground water.

**Biochemical Oxygen Demand (BOD):** The quantity of largely organic, materials present in a water sample as measured by a specific test. Although BOD is not a specific compound, it is defined as a conventional pollutant under the federal Clean Water Act.

**Buffer strip:** A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.

**Coldwater fish:** Fish such as trout and salmon; preferred water temperature ranges between 7-18 degrees C (45-65 degrees F); coolwater fish, such as striped bass, northern pike, and walleye, have a range between that of coldwater and warmwater fish.

**Combined sewer system:** A wastewater collection and treatment system where domestic and industrial wastewater is combined with storm runoff. Although such a system does provide treatment of stormwater, in practice, the systems may not be able to handle major storm flows. As a result, untreated discharges from combined sewer overflows may occur.

**Combined Sewer Overflow (CSO):** A pipe that discharges water during storms from a sewer system that carries both sanitary wastewater and stormwater. The overflow occurs because the system does not have the capacity to transport, store, or treat the increased flow caused by stormwater runoff.

**Community water system:** A public water system that has at least 15 service connections for year-round residents or that serves at least 25 year-round residents.

**Conservation tillage:** Any tillage and planting system that maintains at least 30% of the soil surface covered by residue after planting for the purpose of reducing soil erosion by water.

**Contour:** An imaginary line on the surface of the earth connecting points of the same elevation. A line drawn on a map connecting points of the same elevation

**Critical habitat:** Areas which are essential to the conservation of an officially-listed endangered or threatened species and which may require special management considerations or protection.

**Detention:** The process of collecting and holding back stormwater for delayed release to receiving waters.

**Diazinon:** marketed mostly for household use but is also used in agricultural applications. Spectracide and Bug-B-Gon are popular household pesticides that contain diazinon.

**Discharge permit:** Legal contract negotiated between federal and state regulators and an industry or sewage treatment plant that sets limits on many water pollutants or polluting effects from the discharges of its pipes to public waters.

**Dissolved Oxygen (DO):** The amount of oxygen present in the water column. DO refers to the volume of oxygen that is contained in water. Oxygen enters the water by photosynthesis of aquatic biota and by the transfer of oxygen across the air-water interface. The amount of oxygen that can be held by the water depends on the water temperature, salinity, and pressure.

**Drainage area:** An area of land that drains to one point; watershed.

**Escherichia coli (E. coli):** is a type of bacteria normally found in the intestines of people and animals. Although most strains of E. coli are harmless, some can cause illness or even death.

**Ecological integrity:** A measure of the health of the entire area or community based on how much of the original physical, biological, and chemical components of the area remain intact.

**Ecoregion:** A physical region that is defined by its ecology, which includes meteorological factors, elevation, plant and animal speciation, landscape position, and soils.

**Ecosystem:** Interrelated and interdependent parts of a biological system.

**Erosion:** Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

**Eutrophic:** Usually refers to a nutrient-enriched, highly productive body of water.

**Eutrophication:** A process by which a water body becomes rich in dissolved nutrients, often leading to algal blooms, low dissolved oxygen, and changes in community composition. Eutrophication occurs naturally, but can be accelerated by human activities that increase nutrient inputs to the water body.

**Fecal coliform:** Bacteria from the colons of warm-blooded animals which are released in fecal material. Specifically, this group comprises all of the aerobic and facultative anaerobic, gram-negative, non-spore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35 degrees Celsius.

**Geographic Information Systems (GIS):** Computer programs linking features commonly seen on maps (such as roads, town boundaries, water bodies) with related information not usually presented on maps, such as type of road surface, population, type of agriculture, type of vegetation, or water quality information. A GIS is a unique information system in which individual observations can be spatially referenced to each other.

**Ground water:** The water that occurs beneath the earth's surface between saturated soil and rock and that supplies wells and springs.

**Habitat:** A specific area in which a particular type of plant or animal lives.

**Hectare:** An area with 10,000 square meters or 2.47 acres.

**Herbicide:** A substance used to destroy or inhibit the growth of vegetation.

**Hydrocarbons:** Any of a vast family of compounds originating in materials containing carbon and hydrogen in various combinations. Some may be carcinogenic; others are active participants in photochemical processes in combination with oxides of nitrogen.

**Hydrologic Soil Groups:** groups of soils that, when saturated, have the same runoff potential under similar storm and ground cover conditions. The soil properties that affect the runoff potential are those that influence the minimum rate of infiltration in a bare soil after prolonged wetting and when the soil is not frozen. These properties include the depth to a seasonal high water table, the infiltration rate, permeability after prolonged wetting, and the depth to a very slowly permeable layer. The influences of ground cover and slope are treated independently and are not taken into account in hydrologic soil groups. The four hydrologic soil groups are A, B, C and D (SSURGO, 1999).

**Impervious surface:** A surface such as pavement that cannot be easily penetrated by water

**Index of Biological Integrity (IBI):** composed of several metrics that are combined to produce a total score. The sum of the metric scores is the IBI score. The scores range from 12 (worst) to 60 (best). The metrics include total number of fish, community function or feeding types, tolerant species, intolerant species, presence of hybrids, reproductive function, and abnormalities. The IBI is positively correlated with habitat quality as measured by the QHEI.

**Intermittent stream:** A watercourse that flows only at certain times of the year, conveying water from springs or surface sources; also, a watercourse that does not flow continuously, when water losses from evaporation or seepage exceed available stream flow.

**K factor:** Indicates the susceptibility of a soil to sheet and rill erosion by water; a factor used in the Universal Soil Loss Equation and the Revised Soil Loss Equation to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year (SSURGO, 1999).

**Lake:** A man-made impoundment or natural body of freshwater of considerable size, whose open-water and deep-bottom zones (no light penetration to bottom) are large compared to the shallow-water (shoreline) zone, which has light penetration to its bottom.

**Land use:** The types of activities on a given area (agriculture, residences, industries, etc.). Certain types of pollution problems are often associated with particular land uses, such as sedimentation from construction activities.

**Leachate:** Water or other liquid that has washed (leached) from a solid material, such as a layer of soil or debris. Leachate may contain contaminants such as organics or mineral salts. Rainwater that percolates through a sanitary landfill and picks up contaminants is called the leachate from the landfill.

**Lentic:** Still or standing (water).

**Loading:** The influx of pollutants to a selected water body.

**Lotic:** Flowing (water).

**Macroinvertebrate:** Invertebrates visible to the naked eye, such as insect larvae and crayfish.

**Mitigation:** Actions taken with the goal of reducing the negative impacts of a particular land use or activity.

**Monitor:** To systematically and repeatedly measure conditions in order to track changes.

**Nitrate:** A form of nitrogen which is readily available to plants as a nutrient. Generally, nitrate is the primary inorganic form of nitrogen in aquatic systems. Bacteria in water quickly convert nitrites [NO<sub>2</sub>-] to nitrates [NO<sub>3</sub>-] and in the process deplete oxygen supply.

**Nitrogen (N):** Nitrogen an abundant element found in air, water, and soil. About 80 percent of the air we breathe is nitrogen. It is found in the cells of all living things and is a major component of proteins. Inorganic nitrogen may exist in the free state as a gas, N<sub>2</sub>, or as nitrate NO<sub>3</sub>, nitrite NO<sub>2</sub> or ammonia NH<sub>3</sub>. Organic nitrogen is found in proteins, and is continually recycled by plants and animals. Nitrogen-containing compounds act as nutrients in streams, rivers, and reservoirs.

**Nitrification:** The oxidation of ammonia to nitrate and nitrite, yielding energy for decomposing organisms.

**Non-Point Source Pollution (NPSP):** Pollution originating from runoff from diffuse areas (land surface or atmosphere) having no well-defined source

**No-till:** The practice of leaving the soil undisturbed from harvest to planting except for nutrient injection. Planting or drilling is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, or in-row chisels. Weed control is accomplished primarily with herbicides.

**Nutrients:** Chemicals that are needed by plants and animals for growth (e.g., nitrogen, phosphorus). In water resources, if other physical and chemical conditions are optimal, excessive amounts of nutrients can lead to degradation of water quality by promoting excessive growth, accumulation, and subsequent decay of plants, especially algae. Some nutrients can be toxic to animals at high concentrations.

**Nutrient management:** A BMP designed to minimize the contamination of surface and ground water by limiting the amount of nutrients (usually nitrogen) applied to the soil to no more than the crop is expected to use. This may involve changing fertilizer application techniques, placement, rate, or timing. The term fertilizer includes both commercial fertilizers and manure.

**Orthophosphate:** Orthophosphate is an inorganic form of phosphorus found in natural waters and readily available to plants. Organic forms of phosphorus found in natural waters are not plant available.

**Parts per million (ppm):** A unit of measurement; the number of parts of a substance in a million parts of another substance. Can be expressed as mass or volume. For example, 10 ppm nitrate in water means 10 parts of nitrate in a million parts of water or 10 milligrams of nitrate in one liter of water.

**Pesticide:** Any substance that is intended to prevent, destroy, repel, or mitigate any pest.

**pH:** The negative log of the hydrogen ion concentration ( $-\log_{10} [H^+]$ ); a measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The scale is 0-14.

**Phosphorus:** An element essential to the growth and development of plants, but which, in excess, can cause unhealthy conditions that threaten aquatic animals in surface waters.

**Pollutant:** A contaminant that adversely alters the physical, chemical, or biological properties of the environment. The term includes nutrients, sediment, pathogens, toxic metals, carcinogens, oxygen-demanding materials, and all other harmful substances. With reference to nonpoint sources, the term is sometimes used to apply to contaminants released in low concentrations from many activities which collectively degrade water quality. As defined in the federal Clean Water Act, pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water.

**Point source:** Any confined and discrete conveyance from which pollutants are or may be discharged. These include pipes, ditches, channels, tunnels, conduits, wells, containers, and concentrated animal feeding operations.



**Qualitative Habitat Evaluation Index (QHEI):** composed of several metrics that describe physical attributes of physical habitat that may be important in explaining species presence or absence and composition of fish communities in a stream. QHEI represents a measure of stream geography. The interrelated metrics include stream cover, channel morphology, riparian and bank condition, substrate, pool and riffle quality, and gradient. The QHEI is a score of the combination of these metrics, in which 100 is the best possible score. These attributes have shown to be correlated with stream fish communities

**Reservoir:** A constructed impoundment or natural body of freshwater of considerable size, whose open-water and deep-bottom zones (no light penetration to bottom) are large compared to the shallow-water (shoreline) zone, which has light penetration to its bottom.

**Ridge-till:** The leaving of the soil undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners. Residue is left on the surface between ridges. Weed control is accomplished with herbicides and/or cultivation. Ridges are rebuilt during cultivation.

**Riffle:** Area of a stream or river characterized by a rocky substrate and turbulent, fast-moving, shallow water.

**Riparian:** Relating to the bank or shoreline of a body of water.

**Runoff:** Water that is not absorbed by soil and drains off the land into bodies of water, either in surface or subsurface flows.

**Sediment:** Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water.

**Sedimentation:** Deposition of sediment.

**Soil Component Name:** The name of the component (series, taxonomic unit, or miscellaneous area) of the soil map unit.

**Soil Drainage Classes:** Classes identifying the natural drainage condition of the soil and refers to the frequency and duration of periods when the soil is free of saturation; classes include excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained (SSURGO, 1999).

**Soil Map Unit:** Represents an area dominated by one major kind soil or an area dominated by several kinds of soil; identified and named according to the taxonomic classification of the dominant soil or soils (SSURGO, 1999).

**Soil Textural Triangle:** Soil textures are identified by the USDA textural triangle (loam, clay, etc.); the orientation of the each axis of the triangle indicate how to read the triangle to determine the textural class name.

**Soil Texture:** The relative proportion of the various soil separates (sand, silt, and clay) that make up the soil texture classes as defined by the soil textural triangle (Singer and Munns, 2002).

**Storm drain:** A system of gutters, pipes, or ditches used to carry stormwater from surrounding lands to streams or lakes. In practice storm drains carry a variety of substances such as sediments, metals, bacteria, oil, and antifreeze which enter the system through runoff, deliberate dumping, or spills. This term also refers to the end of the pipe where the stormwater is discharged.

**Stormwater:** Rainwater that runs off the land, usually paved or compacted surfaces in urban or suburban areas, and is often routed into drain systems in order to prevent flooding.

**Stratification:** Division of an aquatic community into distinguishable layers on the basis of temperature.

**Stream:** A watercourse that flows at all times, receiving water from groundwater and/or surface water supplies, such as other streams or rivers. The terms “river” and “stream” are often used interchangeably, depending on the size of the water body and the region in which it is located.

**Substrate:** The surface with which an organism is associated; often refers to lake or stream beds.

**Subwatershed:** A drainage area within a watershed.

**Suspended solids:** Organic and inorganic particles, such as solids from wastewater, sand, clay, and mud, that are suspended and carried in water

**Sustainable use:** Conserved use of a resource such that it may be used in the present and by future generations.

**T factor:** An estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period, the rate is expressed in tons per acre per year (SSURGO, 1999).

**Total Suspended Solids (TSS):** The weight of particles that are suspended in water. Suspended solids in water reduce light penetration in the water column, can clog the gills of fish and invertebrates, and are often associated with toxic contaminants because organics and metals tend to bind to particles. Differentiated from Total dissolved solids by a standardized filtration process, the dissolved portion passing through the filter.

**Toxic:** Poisonous, carcinogenic, or otherwise directly harmful to life.

**Transport:** The movement of a soil particle, nutrient, or pesticide from its original position. This movement may occur in water or air currents. Nutrients and pesticides can be attached to soil particles or dissolved in water as they move.

**Tributary:** A stream or river that flows into a larger stream or river.

**Turbidity:** A measure of the amount of light intercepted by a given volume of water due to the presence of suspended and dissolved matter and microscopic biota. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity are harmful to aquatic life.

**Universal Soil Loss Equation (USLE):** An empirical erosion model designed to compute long-term average soil losses from sheet and rill erosion under specified conditions.

**Warmwater fish:** Prefer water temperatures ranging between 18-29 degrees C (65-85 degrees F); includes fish such as smallmouth bass, largemouth bass, and bluegill.

**Water table:** The depth or level below which the ground is saturated with water.

**Watershed:** The area of land from which rainfall (and/or snow melt) drains into a single point. Watersheds are also sometimes referred to as drainage basins or drainage areas. Ridges of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed