VFC Index - Watershed (Plan)

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

Watershed Management Plan

MUNCIE CREEK - HAMILTON DITCH AND TRUITT DITCH-WHITE RIVER

The White River Watershed Project has received funding from the Indiana Department of Environmental Management (Office of Water Quality, Watershed Planning and Restoration Section) for developing a Watershed Management Plan for the Muncie Creek-Hamilton Ditch (HUC 12-Digit Number: 051202010111) and Truitt Ditch-White River (HUC 12-Digit Number: 051202010110) Subwatersheds. Each HUC12 watershed is located at the headwaters of the HUC10 Muncie Creek Watershed, which forms the headwaters of the Upper White River Watershed.

The Muncie Creek-Hamilton Ditch and Truitt Ditch-White River Watershed Management Plan (WMP) is intended to guide the protection and enhancement of the environment while balancing the different land uses and demands of the community on the landscape.

The Plan will address items such as:
- Education and Outreach;
- Increasing preservation, restoration, and protection;
- Increasing cooperation, coordination, and collaboration with stakeholders;
- Maintaining a solid organization to implement the guidelines of the plan.

The WMP follows the Indiana Department of Environmental Management (IDEM) requirements for watershed management plans, including sections on:
- Watershed Inventory
- Problems and Causes
- Sources and Loads
- Setting Goals and Identifying Critical Areas
- Action Register and Schedule
- Tracking Effectiveness

The WMP is intended to be comprehensive, identifying problem areas and suggesting improvement measures for water quality concerns. The Subwatersheds have various issues and concerns that need to be addressed. In order to comprehensively address some of these issues, the group will work with local stakeholders, organized as a steering committee (See Section: Organization of the WRWP) to pursue Best Management Practices that will result in the improvement of water quality within the Subwatersheds. Because of the size of the task at hand, this plan will also be used as a platform to pursue additional grants and funding for implementation of the many different measures recommended in the plan.

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WATERSHED COMMUNITY INITIATIVE

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CHAPTER 1

Mission and Vision of the WRWP

WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 1

A watershed is the area of land where water drains to a single point. All precipitation that enters a watershed will move across the landscape via overland flow, eventually making its way into a variety of detention basins or river systems (e.g. lakes, rivers, groundwater, wetlands or other water bodies). We all live, work, and play in a watershed. Watersheds provide water for drinking, irrigation, agriculture, industry, boating, fishing, and swimming, and is home to a vast array of plants and animals. A healthy watershed is vital for a healthy environment, a healthy economy, and overall high quality of life. However, all the behavior and technologies we use (new buildings, land care maintenance, agriculture) have externalities that can have a negative impact on water quality.

Understanding watershed dynamics is important because they aid in tracking sources of Nonpoint Source Pollution. Storm water runoff is the major medium of these types of pollutants and storm water drainage occurs within watershed boundaries. Once we begin to understand individual watershed dynamics, we can begin to understand sources of Nonpoint Source Pollution (NPS) and recommend alternative practices commonly referred to as Best Management Practices (BMPs).

BMPs are classified into structural and non-structural (behavioral) categories. This document primarily focuses on structural BMPs as methods for mitigating land-based water quality issues. While non-structural BMP education is a crucial element in the WRWP education program, this plan serves as a guidance document in selecting and implementing structural BMPs in the Delaware County community. A list of recommended BMPs (to be funded through the WRWP cost share program) can be found in subsequent chapters.

Mission and Vision Statements

The purpose of the White River Watershed Project is to advocate Best Management Practices (BMPs) through education, demonstration and financial incentive. It is important that we implement both structural and non-structural BMPs when feasible in order to reduce negative environmental impacts, which can inhibit nature’s ability to produce natural goods by endangering the health of ecosystems. By managing and improving the portion of the White River Watershed (in Delaware County), we can do our part to improve water quality in the entire White River Basin.

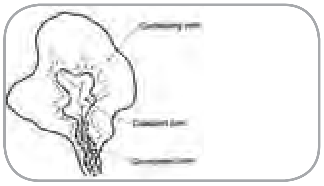
It is the mission of the WRWP to create a better awareness of water quality issues in Delaware County and to work with local landowners to develop BMPs for their properties and landholdings. The WRWP is able to exist because of its wide range of community partners and numerous volunteers and participants that share their time and expertise.

Mission: The White River Watershed Project is a citizen partnership dedicated to developing watershed management plans to improve water quality.

Vision: Our vision is that the White River will improve the quality of life of our community by safely serving its various needs, while supporting wildlife diversity.

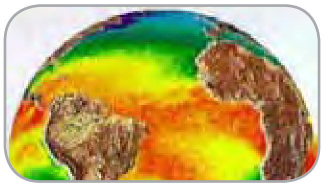
STATEMENT OF VALUES

The driving force behind the WRWP is its steering committee, which assists in identifying public concerns and Best Management Practices that are fit to solve those concerns. How these problems are identified and solved are based on the values which are held by the committee and watershed user groups. Our process of site analysis, selecting performance goals, and BMPs usually begins with the definition of these values, attitudes, and policies while understanding that people have different values in each Subwatershed or WMP area. The following values are present in our analysis of Watershed Data and subsequent recommendations.



Img. 1.1

Collection Zones
Collection Zones are the most critical areas for restoration, on site infiltration, and filtering of NPS pollutants.



Img. 1.2

Climate Change
Climate Change may lead to temperature extremes (droughts and floods) and increases in peak flow and shrink-swell dynamics.

Img. 1.3

Sediment Loss
Sediment loss is the most critical contributor to pollution, according to the Muncie Bureau of Water Quality and Hoosier River Watch.

Img. 1.4

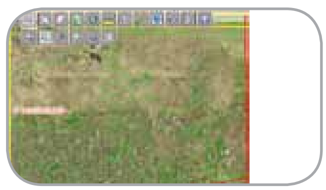
Natural Hydrology
Stream bioengineering and biomimicry should influence design when selecting appropriate BMPs.

Img. 1.5

Creation of Habitat
Habitat is the most effective and self-sustaining water quality Best Management Practice.

Img. 1.6

Chemical Testing
Chemical Testing is important especially when combined with biological studies.



Img. 1.7

Basin planning
Basin level planning is crucial to understanding true site scale NPS pollutant sources.

Img. 1.8

Preservation
Preservation of natural resources, e.g. forests and riparian habitat (QHEI), enables functioning ecosystem services.

Values Summary

The consistent parallel in each of our values is the trust that natural systems hold the key to most of our water quality problems. Underlining this connection is a philosophy that ecosystems are capable of processing pollutants if managed properly. If we can seek to preserve existing habitat, recreate it when possible, utilize its ability to treat water, and confirm its success through biological testing we can begin to set in place the long range vision for this project.

A Public Process

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

This plan was created by members of the White River Watershed Project (WRWP), a group of Delaware County stakeholders overseen by the Delaware County Soil and Water Conservation District (DCSWCD). The White River Watershed Project is a community-driven, voluntary effort to cleanup and reduce non-point source water pollution for a better quality of life in Delaware County.

The plan was created based on the premise that Watershed Planning is a critical and needed service to Delaware County. The process began with initial information gathered on the current conditions of Delaware County Subwatersheds and the eventual selection of Truitt Ditch-White River and Hamilton Ditch-Muncie Creek for the Watershed Management Planning process.

This plan outlines the initial local water quality issues and concerns gathered through public meetings, provides step-by-step methods for addressing each concern, and steers the reader toward sources that can help them implement the listed BMP suggestions. This management plan shall serve as a guide for local citizens from all sectors of the community in pursuit of Water Quality improvement.

Public Input Process

Public participation is crucial for a legitimate WMP planning process and sets the foundation for sustained community engagement. The committee consisted of representatives of over twenty different groups. Most importantly, the Muncie Bureau of Water Quality (responsible for water quality data collection and biological data analysis), Ball State University (assisted with data collection and interpretation of findings), and the Delaware County GIS Department and the Delaware-Muncie Metropolitan Plan Commission (responsible for Land Use Data creation and analysis). Other contributors range from Muncie citizens, experts, organizations, and community leaders organized through committees. These committees function as the primary method of ascertaining public concern.

The Watershed Coordinator crafted the plan with assistance from members of the general public organized through committees; therefore, this plan can be considered a product and result of a combined effort between the White River Watershed Project advisory board, subcommittees, and ultimately - Delaware County Citizens.

The Steering and Watershed Committees worked together to confirm local water quality issues and recommend strategies for voluntary action, while the DCSWCD Board reviewed all recommendations and granted final plan approval for submission to IDEM. The Technical Committees made the final plan possible by providing detailed baseline information needed to make appropriate watershed management recommendations.

The steering committee was directly involved in all aspects of the development of the plan, including input at public meetings, steering committee meetings, and completion of windshield surveys.

Initial concerns raised by the group will be explored throughout this WMP planning process. These concerns must by quantified using science and prioritized based on need and the values of the organization.

Public Meetings

There are many different methods of gaining public input – many of which have been outlined as a function of the WRWP Education and Outreach committee. The foundation of this plan was public meetings. These meetings are effective due to the presence of many participants focused on the process/strategy of Watershed Planning. Public input is essential for the sustainability and success of the watershed improvement effort. Stakeholder and public input was sought and included during all aspects of the planning process. This local input was essential for developing a plan that would have broad appeal throughout the watershed and be supported by the many different stakeholders.

Therefore, development of the White River Watershed Project Management Plan was achieved through the use of public meetings held throughout the life of the project. These included single committee sessions to large multi-committee and general public participation meetings. Each of the committees played a key role in the development of this plan.

Public meetings orchestrated by the WRWP follow a typical pattern of (1) presentation on the history and context of the WRWP (2) explanation of the watershed boundaries to be studied (3) brief discussion of the water quality issues in the community (4) discussion of concerns (5) overview of behavioral BMPs and how to get involved in future volunteer efforts.

The core public meeting for plan development was held on Monday April 27, 2009 at 6:30 pm at Minnetrista Cultural Center. 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.

The White River Watershed Project maintains a comprehensive list of water quality concerns. Most of these concerns are not specific to any particular Subwatershed. This comprehensive list can be found in Chapter 2 - Part 3 - Section 2. During the April 27, 2009 meeting, participants affirmed the existing (general) concerns and discussed issues specific to the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. A overview of these specific concerns can be found on the following pages.

Public Input Meeting(s)

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

Below is a list of concerns raised by the public for the Truitt Ditch-White River and the Hamilton Ditch-Muncie Creek watersheds during primary input meetings. Public Input Participants affirmed the existing (general) concerns held commonly by the White River Watershed Project. A comprehensive list of all concerns considered can be found in Chapter 2 Section 3 Subsection 3.

Runoff from Urban Areas
The participants noted that excessive urban runoff is present in all urbanized areas. This is often transferred through the storm water system to outfalls in the river. While there is concern over the runoff from all urbanized areas, concern over specific locations was raised by some of the participants. These locations are:

Nutrient rich runoff from Sports Complex,
Nutrient rich runoff from fertilizers used by the Delaware Country Club,
Memorial Drive ramps to IN-67, located adjacent to Truitt Ditch,
Runoff from the former Indiana Steel and Wire Company buildings,
Runoff from various parking lots sitting adjacent to Muncie Creek,
Storm water issues in Whitely area (high gradient, impermeable surfaces, etc.).

Runoff from urban areas was identified as one of the major concerns to the public. In these watersheds, additional concern over the direct runoff from recreation areas was brought up, specifically the Delaware Country Club. The main stem of Truitt Ditch runs through the Club and there are few to no filter strips present. This provides nutrients applied to the turf grass direct access to the stream.

Agricultural Conservation
Small or nonexistent buffer strips on Truitt Ditch and feeder ditches,
Lack of no-till/grassed waterways throughout both watersheds.

The lack of agricultural Best Management Practices in the Truitt Ditch watershed was brought up in the public meeting. The NRCS will be involved in identifying the areas where these practices are needed.

Ditch/Stream Erosion
General erosion of the streams and ditches was brought up as a major concern by the participants. They then identified areas in the two watersheds where this is a known problem. The following locations were identified:

Erosion of main stem of Truitt Ditch through Delaware Country Club,
Erosion on Smith Ditch, very visible from Inlow Springs Road,
Erosion of White River behind houses on Burlington drive,
Ditch erosion on Elwood Reese Ditch west of Burlington drive,
Erosion of White River banks near SR 32.

Channelized Ditches Eroding in Muncie Creek Watershed
The erosion of waterways was also identified by the public as an issue of major concern. There are two types of erosion; natural and human induced. In areas with little topography, such as Delaware County, erosion is usually the result of straightening, channelization, log jams, or other changes to the hydrology of the water body. Many of these concerns can be addressed in this plan.

Failed or Failing Septic Systems/E. coli Concerns
A concern over failing or failed septic systems in the watershed was brought up during the public meeting. It is suspected that failed or illegally hooked up septic systems are polluting the water bodies in this watershed.

Illegal Dumping Areas
Illegal and legal dumping areas, both past and present, were a concern to the public. These activities denote a general lack of education and awareness over pollution issues. There is a dumping area south of Delaware Country Club with unknown contents.

Various Illicit Dumping Areas
Former buried landfill in headwaters of Muncie Creek,
Auto salvage yards directly adjacent to Muncie Creek.

Areas where dumping has occurred, especially those directly adjacent to ditches and streams, were identified as concerns by the public. Runoff from these areas can carry pollution directly into the water bodies. This is especially true of auto salvage yards and other places where hydrocarbons can leak out of junked cars.

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

Red-tail Conservancy
The Red-tail Conservancy preserves, protects, and restores natural areas and farm land in East Central Indiana while increasing awareness of our natural heritage. This not-for-profit land trust focuses on five counties to provide land conservation options to individual landowners. They also partner with local governments in restoration projects while providing land stewardship activities and education for these communities. Since 1999, the Red-tail Conservancy has protected nearly 2000 acres of natural areas and farm land and is committed to greater conservation efforts in the future.

Delaware County Office of Geographic Information
The Delaware County Office of Geographic Information manages the county's Geographic Information System (GIS). Their goals are to: maintain and update the county's GIS information databases; deliver this data to the public, private sectors, and government agencies; and provide consulting and application development for projects in the area. This data and assistance aids in making informed decisions and creating effective developments.

Upper White River Watershed Alliance
The Upper White River Watershed Alliance (UWRWA) is a 16-county organization of local governments, industries, utilities, universities, and agricultural and regional communities that improve and protect the water quality of watershed basins in the larger Upper White River Region. This organization works to better understand regional water quality patterns and target areas for restoration or protection. The UWRWA synthesizes existing data to better understand some of the social drivers affecting large-scale land use change. This alliance works together to protect vital water resources and pool their financial and technical resources.

The Muncie Sanitary District: (Bureau of Water Quality)
The Muncie Sanitary District: Bureau of Water Quality's vision is to become the principal regional watershed leader by creating resources and educational partnerships that promote, protect, and enhance the biological, chemical, and physical integrity of the White River ecosystem.

Delaware County Department of Storm water Management
The Delaware County Department of Storm water Management's vision is to create resources and educational programs that promote, protect, and enhance the biological, chemical, and physical integrity of the White River ecosystem by maintaining and promoting proper storm water techniques.

Ball Brothers Foundation
The Ball Brothers Foundation is an independent, private, philanthropic organization that is dedicated to improving the quality of life by building communities. This organization funds and supports these efforts through thorough examination and action. The Foundation applauds efforts to educate and participate in sound conservation practices, data gathering, and supporting of agricultural processes and other land usages that work in balance with a healthy economy and environment.

Cardinal Greenways
Cardinal Greenways is a private, not-for-profit organization that encompasses the Cardinal Greenway, White River Greenway, Historic Wysor Street Depot and Cardinal Equestrian Trail. The Cardinal Greenway portion is the longest rail-trail in Indiana and spans almost 60 miles from Marion through Muncie to Richmond in East Central Indiana.

The Delaware County Health Department
The Delaware County Health Department is organized for the purpose of health promotion and communicable disease prevention for the entire Delaware County community. Risk reduction and public health awareness are directed toward individuals, of all ages, to achieve optimal health. The department will facilitate programs that educate, enforce and provide services for the promotion and maintenance of a healthy environment in Delaware County.

Delaware County Soil and Water Conservation District
The Delaware County Soil & Water Conservation District provides information about soil, water, and related natural resource conservation; identifies and prioritizes local soil and water resource concerns; and connects land users to sources of educational, technical and financial assistance to implement conservation practices and technologies.

Prairie Creek: Reservoir & Park
Prairie Creek Reservoir is a man-made reservoir that provides resources for Delaware County through water, recreation, habitat, and education. The reservoir is owned by the Indiana-American Water Company, and the lands around it are managed by the City of Muncie Parks and Recreation Department. The reservoir is a secondary drinking water supply for the City of Muncie; during periods of low-flow, water is released from the reservoir into the White River, Muncie's primary water supply.

Ball State Natural Resources Club
The Natural Resources Club participates in activities to improve the environment. Their efforts in the past have included: reservoir clean-up and water quality improvement, streambed restoration and stabilization, wetland restoration and delineation, rain barrel workshop, educational programs, and much more.

Ball State Department of Natural Resources and Environmental Management
The Department of Natural Resources and Environmental Management at Ball State University promotes the educational, professional, and social interest of being stewards of the land.

Ball State Department of Biology
The Department of Biology at Ball State University promotes exploration, research, and study of nature and life.

Ball State Landscape Architecture Department
The Department of Landscape Architecture at Ball State University promotes the creation, design, and maintenance of the natural and built environment by creating safe, functional, and sustainable places for everyday life.

Ball State Geological Sciences Department
The Geological Sciences Department at Ball State University promotes the study of the composition of earth, and how best to find, use, and protect its mineral, energy, and water resources.

Delaware-Muncie Metropolitan Plan Commission (DMMPC)
The Delaware-Muncie Metropolitan Plan Commission (DMMPC) plans and approves the structure and infrastructure of the City of Muncie and the unincorporated Delaware County. This organization is responsible for all transportation planning activities.

Partners (cont.)

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

Minnetrista Cultural Center
Minnetrista Cultural Center is a 40-acre, regional museum campus located along the White River in Delaware County. Their mission is to create awareness, understanding and appreciation of the natural and cultural heritage of East Central Indiana. Minnetrista serves the eight counties of East Central Indiana and beyond. Annual admissions and program participation averages 40,000 visitors, including 11,000 secondary school students. Minnetrista's wide reach into the regional community, their expertise in educational outreach, and strategic focus on eco-friendly initiatives makes them an organization focused on land and water management and stewardship, history, art, and education.

Randolph County Soil & Water Conservation District
The Randolph County Soil & Water Conservation District provides information about soil, water, and related natural resource conservation; identifies and prioritizes local soil and water resource concerns; and connects land users to sources of educational, technical and financial assistance to implement conservation practices and technologies.

Area Planning Commission of Randolph County
The Area Planning Commission oversees planning and zoning for the county and issuing Improvement Location Permits for new construction.

Purdue University Cooperative Extension Service: Randolph County
The Cooperative Extension Service is one of the nation's largest providers of scientific research-based information and education. It provides a network of colleges, universities, and the U.S. Department of Agriculture, serving communities and counties across America. Local Extension Services provide information about agriculture and natural resources, consumer and family sciences, economic and community development, and 4-H Youth programs for their particular county.

NRCS- Conservation Implementation Team and District Conservationist
The Natural Resources Conservation Service (NRCS) is dedicated to conserving natural resources on private lands. It was originally established by Congress in 1935 as the Soil Conservation Service and has expanded to become a conservation leader for all natural resources; ensuring private lands are conserved, restored, and more resilient to environmental challenges. NRCS works with private landowners through conservation planning and assistance designed to benefit the soil, water, air, plants, and animals that result in productive lands and healthy ecosystems.

Winchester Wastewater Treatment Plant
The Winchester Wastewater Treatment Plant promotes clean and efficient sanitary and storm sewers. The WWTP maintains 10 lift stations and is a 100% separate sanitary sewer system. The Plant uses a Class III conventional activated sludge treatment process.

Farmland Conservation Club
The Farmland Conservation Club participates and promotes activities that will improve the environment. The Club's mission is to promote healthy environments through preservation, conservation, and educational efforts. They seek to raise environmental awareness and concern about the local environment.

TABLE 1.1: WRWP Partners and their presence on sub-committees	
Organization(s) Represented	Sub-Committee
Red-tail Conservancy	Cost Share Sub-committee
Delaware County Office of Geographic Information	Watershed Management Planning Sub-committee
Upper White River Watershed Alliance	Outreach/Education Sub-committee
The Muncie Sanitary District: (Bureau of Water Quality)	Watershed Management Planning Sub-committee
Delaware County Department of Storm water Management	Outreach/Education Sub-committee
Ball Brothers Foundation	Cost Share Sub-committee
Cardinal Greenways	Cost Share Sub-committee
The Delaware County Health Department	Watershed Management Planning Sub-committee
Delaware County Soil and Water Conservation District	Watershed Management Planning Sub-committee
Prairie Creek: Reservoir & Park	Outreach/Education Sub-committee
Ball State Natural Resources Club	Outreach/Education Sub-committee
Ball State Department of Natural Resources and Environmental Management	Watershed Management Planning Sub-committee
Ball State Department of Biology	Outreach/Education Sub-committee
Ball State Landscape Architecture Department	Watershed Management Planning Sub-committee
Ball State Geological Sciences Department	Watershed Management Planning Sub-committee
Delaware-Muncie Metropolitan Plan Commission (DMMPC)	Watershed Management Planning Sub-committee
Minnetrista Cultural Center	Outreach/Education Sub-committee
Randolph County Soil & Water Conservation District	Watershed Management Planning Sub-committee
Area Planning Commission of Randolph County	Watershed Management Planning Sub-committee
Purdue University Cooperative Extension Service: Randolph County	Watershed Management Planning Sub-committee
NRCS- Conservation Implementation Team and District Conservationist	Watershed Management Planning Sub-committee
Winchester Wastewater Treatment Plant	Watershed Management Planning Sub-committee
Farmland Conservation Club	Outreach/Education Sub-committee

History of the WRWP

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

Context

The Clean Water Act was a landmark piece of legislation that triggered a Nation-wide effort to address water pollution issues in the United States. Early application of the legislation was directed at point source pollution. Point source pollutants enter a stream directly from a pipe – most commonly from industrial processes. Amendments to the legislation added means and methods to address nonpoint water pollution, which is more diffuse and thus harder to track. Nonpoint water pollutions enter streams from storm water runoff. Out of these amendments came the 319 program, which funds states to solve nonpoint water pollution issues at the local level.

One way the State of Indiana has chosen to approach the nonpoint problem is by creating a grant program to cost-share on best management practices (The 319 Program). The WRWP administers this grant money to Delaware County. In order to most effectively distribute grant monies, WRWP has developed a management plan that identifies critical areas in the county that are in the greatest need for grant funding.

History

Impetus for the White River Watershed Project came from combined community concerns regarding local water quality, identified through a series of public meetings held in 2000 and 2001 by the Delaware County Soil and Water Conservation District. Representatives from Ball State University, local, state, and federal government, local community foundations, the agricultural community, and other local citizens met over a one year period to discuss options for addressing those concerns. Their final recommendation was to conduct a study of local watersheds and develop a community-driven, voluntary plan for protecting and improving local water quality.

From this, the White River Watershed Project (WRWP) was formed. The lead organization became the Delaware County Soil and Water Conservation District (DCSWCD) following the acquisition of an EPA Section 319 Grant in 2001. This initial three-year grant was awarded for the purpose of creating a watershed management plan that addresses local non-point source water pollution issues in the original three priority Subwatersheds. Those Subwatersheds, chosen by the community, are: Killbuck/Mud Creek, Buck Creek, and Prairie Creek Subwatersheds.

The original White River Watershed Project (WRWP) Watershed Management Plan (WMP) (developed in the first phase of the WRWP), covered three 12-digit HUC watersheds within the Upper West Fork White River Watershed in Delaware County, Indiana. The initial effort in creating this plan happened from 2001-2004. The second phase began in 2005 and was focused on implementing the recommendations from the WMP. Currently the WRWP is in its third phase of implementation, focused upon (1) updating the existing Watershed Management Plans, (2) continued implementation of the WMP, and (3) expansion into more urban locations. This management plan is a product of efforts to expand Watershed Planning into urban locations.

Updating the existing Watershed Management Plan affects the White River Watershed Project's efforts to reduce non-point source pollution. These include: updates to the 303 (d) List of Impaired Waters, the change of the EPA's use of 14 digit HUC watershed boundaries to 12 digit HUC watershed boundaries (of which only the Macedonia Creek-Buck Creek Watershed had any changes), and modifications to critical areas based on the results of the monitoring that took place during Phase Two of the WRWP.

The WRWP/Ball State Partnership
WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 7

The White River Watershed Project (WRWP) continues its ten year history in reducing non-point source pollution in Delaware County because we believe in the foundational principals of our cause: that a healthy environment is the true foundation of any healthy economic system and that proper stewardship of the natural world is the first step in the proper stewardship of our economic order.

Our objectives are to continue supplying the community with solid water quality science and land use impact analysis, provide future generations the ability to make objective land use decisions, and continuing the great environmental accomplishments we have made as a society in the past 40 years (since the Clean Water Act) - in industry, agronomy, and our household economies.

Watershed Planning, nation-wide and locally, has lead to many positive outcomes. None of the local discoveries could have been found without partnerships with various citizen groups, local foundations, and community partners in water quality including the Bureau of Water Quality, Delaware-Muncie Metropolitan Plan Commission (DMMPC), Ball Brothers Foundation, Community Foundation, and the Minnetrista Cultural Center.

Among our largest collaborators, Ball State University has consistently played a crucial role in helping us accomplish our goals by assisting in numerous and diverse ways. Faculty and students in the university's Department of Natural Resources and Environmental Management have aided our education outreach activities over the years, while also developing water quality studies in partnership with the Muncie Bureau of Water Quality.

That research, under the guidance of Dr. Hugh Brown and Dr. Jarka Popovicova, has led to a host of ecologically sound planning and environmental management strategies at Prairie Creek Reservoir. It has been a force in initiating the formulation of a long-term management plan and zoning for the reservoir, currently being implemented by Superintendant Bob Patterson.

Additional Ball State water quality research has demonstrated a reduction of E. coli contamination in the Killbuck-Mud Creek sub-watershed as the result of the 2001 Royerton Sewer project in northern Delaware County. Although there were many residential and commercial hardships in completing that project, the E. coli reduction is one positive outcome that will yield benefits to residents of the area for generations to come.

Innovative regional planning/land use classes in the Department of Landscape Architecture and Department of Geography, meanwhile, continue to use watersheds as the basis for developing theoretical land use plans that are mindful of ecological issues and concerns. The students in these projects have helped to clarify and identify key ecological resources in our community and their fresh eyes and energy have repeatedly confirmed and strengthened the values for which the WRWP and many Delaware County citizens have long stood.

Ball State Partnership (cont.)

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

GIS students in the Department of Geography, under the guidance of Dr. Matt Wilson (and Kyle Johnson of the Delaware county GIS), have aided the WRWP in the development of this WMP by discovering primary sources of sediment contribution in our stream and rivers. Their research has helped to dispel commonly held notions that farm fields are the number one contributor of sediment to our rivers, and have quantified that key "hotspots" along de-vegetated stream banks can contribute up to 400 times more sediment than farm fields that are managed with contemporary conservation methods such as no-till, filter strips, grass waterways, and cover crops. Together with land use planners at the WRWP, students will be able to use this data to illustrate the historical decrease of sediment discharge of farm fields over the past 30 years as a result of these changes in land management practices.

The University has helped to offset costs through partnership and capacity building. The new techniques and technologies developed by Ball State students and faculty aid in making watershed planning ever more efficient and cost-effective. They keep our project young, relevant, and able to respond to a rapidly changing technical world. At the same time, the partnership provides students with Immersive Learning experiences, which is core to the Ball State mission.

Community partnerships such as these demonstrate the value of community groups coming together, and are celebrated state-wide as a precedent for other communities to follow. We are grateful for a vibrant volunteer community that is willing to work together on important issues that otherwise may remain unsolved or unaddressed. There is much work to be done to protect and enhance the lands on which we live, work, and play. Initiatives to learn more about human impact on the environment -- good or bad -- are not likely to cease in the foreseeable future, and great broad-based partners, like Ball State University, provide the WWRP a positive town-grown relationship.

Organization of the WRWP
WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 9

The DCSWCD Board of Supervisors (grant holders) understood early on the importance of having broad community involvement in all aspects of the WRWP. An effective WMP is dependent on legitimate and quantifiable concerns from a wide range of citizens and professionals. The primary method of gaining this input is through public meetings (see below), but the sustained method of reporting data is through the committee structure of the organization. Without community involvement, chances of gaining broad-based community support would be slim and the successful implementation of the management plan would be in jeopardy. The following detailed description of the WRWP's organization reflects this deep commitment.

WRWP Structure
Below is the WRWP structure, listing each committee, their responsibilities, and their community representation. Some members have changed throughout the process, therefore this list represents all current and former participants.

Delaware County Soil and Water Conservation District Board of Supervisors
The DCSWCD is the legal grant holder and provides funding for the full-time Watershed Coordinator. The board is responsible for final approval on financial transactions, contracts, grant requests, and the final plan. The DCSWCD Board is represented by the agricultural community and local businesses (associate supervisors: Ball State University, Indiana Farm Bureau, agricultural community). This group provides invaluable insight and vision for the long-term success of the WRWP.

WRWP Steering Committee
The steering committee represents core individuals and organizations interested in County-Wide water quality issues. The Committee's responsibilities include overall project direction, major financial and contractual transaction recommendations to DCSWCD Board of Supervisors, and co-development of the management plan. The committee meets quarterly with monthly sub-committee meetings. Individuals involved represent the city of Muncie and other towns in Delaware County, and when possible include: neighborhood associations, environmental groups, natural resource and engineering professionals, industrial and educational entities, agricultural community, rural residential community, and the urban community.

Role of the Watershed Coordinator
The central role of the Watershed Coordinator is to bring together the vast community representation, which serve as the backbone of the White River Watershed Project, as represented above. The Coordinator provides the primary project management, working as translator of ideas and information into a common language for all to work with. Responsibilities include daily and overall project management, committee and general volunteer coordination, public outreach and education, financial management (including invoicing and bookkeeping), and writing of grants, reports, public relations documents and the Watershed Management Plan(s).

TABLE 1.2: Primary Responsibilities of WRWP sub-committees

Sub-committee(s)	**Responsibilities**
Watershed Planning Sub-committee	Public Input, Monitoring Analysis, GIS
Outreach/Education Sub-committee	Education/promotional Activities
Cost Share Sub-committee	Cost-share Assistance

Watershed Planning Sub-committee

WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 10

The Watershed Planning Committee: ensures that local issues and concerns are addressed throughout the project; solicits interest and support for the project in their communities; assists with local land use identification; co-organizes local events and outreach activities; co-developes the management plan; and provides a representative to serve on the steering committee. The Watershed Committee includes: watershed citizens; the urban, rural residential and agricultural community, business owners, local governments, and educators and school administrators (primary, secondary and university).

Monitoring Analysis
Water quality monitoring is a crucial part of the watershed planning effort, providing quantitative studies to confirm public concerns about pollutants present in water resources. This quantitative data aids in the delineation of critical areas. The monitoring assists in sample site identification, historic water quality data identification, and data review and recommendation development. In Phase III, the Bureau of Water Quality has been responsible for identifying sites and monitoring on behalf of the organization. The committee has the responsibilities of continued implementation of the monitoring program, creation of the QAPP (quality assurance project plan for WRWP monitoring program), coordination of GIS based land use analysis, and the study and interpretation of monitoring program results.

GIS (Geographic Information System)Analysis
Responsibilities: creation and analysis of land use information using GIS technology; co development of GIS based land use analysis; development and maintenance of project web site; and outline development for GIS interactive web site. The GIS Committee is represented by: The Delaware County GIS Department, Muncie-Delaware Metropolitan Planning Commission, Ball State University (Geography), and the Bureau of Water Quality (city government).

TABLE 1.3: WMP Committee Chairperson

Sub-committee	Sub-committee Chairperson
Watershed Management Planning Sub-committee	Amanda Arnold

Outreach/ Education Sub-committee

WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 11

The Education and Outreach Sub-committee is tasked with the execution of education programs that seek to: make citizens more aware of the WRWP's impacts in the community, engage the community for greater input into the WMP planning process, educate about the importance of non-structural BMPs (3) educate and demonstrate the implementation of structural BMPs, and promote the local cost-share programs available to the community. Responsibilities: co-creation of quarterly newsletter; creation and/or acquisition of outreach and education materials; development of outreach and education strategy; identification of target audiences; assist watershed committees with their outreach and education efforts.

Presentations on the Context and History of the WRWP
Sub-committee Members will work to develop a speaking engagement schedule for the calendar year. Engagements involve regional organizations and groups that have an interest in public service – especially those related to soil and water conservation. It should be emphasized that we do not limit our presentation to conservation groups. We speak with any community organization that is willing (within reason). The committee develops a list of WRWP steering committee members that are willing to speak at these events and provides them with materials and training to speak effectively.

Presence at Local "Trade show" Events
Sub-committee Members will work to develop a trade show event schedule for the calendar year. These events are primarily in Delaware County – and other opportunities are considered when they arise. The committee develops a "traveling display booth" that can easily be setup and broken down with minimal physical demands. The committee makes arrangements for the WRWP to be present at these events and arranges for these events to be staffed by WRWP steering committee members.

Public Input Meetings
Public input meetings are an important part of the Watershed Planning Process. Ascertaining the concerns of the community gives us leads for pursuing formal scientific studies of these issues and helps to broaden our understanding of larger watershed dynamics.

Educational Presentations
The core of the WRWP educational program is the Earth Team Service learning curriculum that spans 12 months and features storm water education. Each month, participants learn about a best management practice related to storm water management and tour structural BMPs. These individual presentations can also be given to local groups and at community events when desired.

Demonstration Project Tours (and Other Relevant Tours)
The Sub-committee develops a tour schedule for the calendar year. The purpose of these tours is to get interested Community Members into the field to observe previously installed Demonstration Projects and other cost-share BMPs (those that have landowner permissions).

Cost Share Promotion
We will meet with small groups of people interested in how our cost-share program can financially aid in the implementation of best management practices.

The WRWP Website
The WRWP Website aims to: channel public input into the WMP planning process, communicate elements of the WMP in accessible format, improve education and awareness of watershed issues and behavioral best management practices, and provide information for the various cost-share programs in the county. Event calendars also communicate happenings in the WMP process. The web site can be found at http://www.whiteriverwatershedproject.org

Quarterly E-mail Newsletters / Reports / Presentations
At each quarter, monthly project reports are sent to IDEM. These reports are presented to community stakeholders primarily through quarterly meetings (Power Point presentations), web site content development, and when appropriate, newsletters.

Promotional Materials
Promotional materials are created as needed to supplement all other educational efforts. Some of these materials include: cut-sheets for context and history presentation, methods to input community concerns, supplements to educational presentations, and descriptions of

TABLE 1.4: Education and Outreach Committee Chairperson	
Sub-committee	Sub-committee Chairperson
Education and Outreach Sub-committee	Colby Gray

Cost-share Sub-committee
WMP - CHAPTER 1 - PART 1 - SECTION 1 - SUBSECTION 12

Cost Share Sub-committee
The WRWP assists community members in learning more about local cost-share options – either through the WRWP or through other local programs. 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 cost-share sub-committee is primarily responsible for the implementation of cost-share promotion and strategic cost-share planning.

TABLE 1.5: Cost-share Implementation Committee Chairperson	
Sub-committee	Sub-committee Chairperson
Cost Share Sub-committee	Lorey Stinton

WATERSHED INVENTORY

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

WATERSHED INVENTORY PART ONE

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

Nonpoint Source Control Program

WMP - CHAPTER 2 - PART 1 - SECTION 0 - SUBSECTION 1

This watershed management plan is a product of the IDEM Clean Water Act Section 319 nonpoint source control program and is made possible by the various assistance given to the WRWP in collaboration with the program. The NPS program conducts training and provides technical assistance on watershed management planning and implementation and has produced valuable resources for watershed planning, such as the Indiana Watershed Planning Guide, the Indiana Water Quality Atlas (IWQA), and a community of Indiana Water Quality Groups engaged in the Watershed Management process. IDEM also employs five Watershed Specialists (WSS) who assist the NPS/TMDL Section in promoting the watershed approach by working with local watershed groups. [1]

Environmental problems often cut across political jurisdictions. Consequently, environmental mitigation and protection require a comprehensive and collaborative approach that works with a multitude of programs and agencies. IDEM is at the center of this collaborative effort. The watershed approach provides a framework for coordinating between multiple programs and leveraging limited resources. This approach focuses on water quality in a geographic area delineated by a watershed.[2]

Nonpoint source (NPS) pollution in Indiana is addressed in many ways by a number of agencies and organizations statewide. In partnership with other agencies, the IDEM Nonpoint Source Control Program leads efforts to restore waters of the state that do not meet Indiana Water Quality Standards and, consequently, are on Indiana's 303(d) List of Impaired Waters. [3]

In addition to providing tools to assist watershed management efforts, the NPS program has adopted a targeted approach to improving water quality in the state by focusing IDEM's Section 319 funds on impaired waters.

Thus, the White River Watershed Project is funded for the purposes of alleviating nonpoint source pollutant pressures on streams that do not meet current Water Quality Standards. In turn, the White River Watershed Project conducts its own water quality monitoring program which aids IDEM to a refined understanding of water quality at the watershed level. (The WRWP monitoring program is conducted by the Muncie Bureau of Water Quality). Under grant agreements, projects funded by IDEM routinely submit this data to the NPS program.

In many ways the White River Watershed Project is a local catalyst for IDEM statewide goals and objectives and concurrently, (data collected by the White River Watershed) informs IDEM's strategic water quality improvement prgram. In this way, the White River Watershed Project and IDEM are a partnership in state-wide water quality improvement.

1 Indiana's 2008 Integrated Water Monitoring and Assessment Report
2 Indiana Nonpoint Source Management Plan
3 Indiana's 2008 Integrated Water Monitoring and Assessment Report

TABLE 2.1: IDEM Assessment of Indiana Streams by Designated Usage: 305B Report, 2008				
Designated Use	Support	Non Support	Assessed	Not Assessed
Rivers (miles)				
Aquatic Life Use	13, 913	3,622	17,535	14,606
Fishable Uses	1,044	3,402	4,435	27,705
Drinking Water Supply	--	1	1	101
Recreational Use (Human Health)	3,700	8,374	12,073	20,100
Lakes and Reservoirs (acres)				
Aquatic Life Use	3,690	6,625	10,315	21,826
Fishable Uses	7,820	63,663	71,483	5,084
Drinking Water Supply	230	16,385	22,905	12,926
Recreational Use (Human Health)	21,922	983	22,905	104,662
Recreational Use (Aesthetics)	29,035	8,006	37,041	90,526
SOURCE: Indiana's 2008 Integrated Water Monitoring and Assessment Report				

The state mandated beneficial uses of water is one of the primary legislative methods for ensuring stream health above water quality standards.

Beneficial Uses at Core of Approach
Indiana's water quality standards (WQS) provide the basis for IDEM's CWA Section 305(b) water quality assessments which functions to designate the beneficial uses that Indiana waters must support. [1] Of the beneficial uses designated in the State's WQS, 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. [2]

Although there are additional uses designated in Indiana's WQS, 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 for these four uses, other uses such as agricultural and industrial uses are supported.[3]

The beneficial uses metric is used as a framework for this Watershed Plan Development. It provides a method for classifying concerns in the community and for creating an action plan for project implementation.

Therefore, this plan should be considered an effort to improve our streams and rivers for the purposes of human recreation and aquatic life.

1 Indiana's 2008 Integrated Water Monitoring and Assessment Report
2 Indiana's 2008 Integrated Water Monitoring and Assessment Report
3 Indiana's 2008 Integrated Water Monitoring and Assessment Report

Watersheds[1]

WMP - CHAPTER 2 - PART 1 - SECTION 0 - SUBSECTION 2

The watershed is the total area of land that drains into a particular water body (wetland, stream, river, lake, or sea). Land uses and runoff in a watershed determine the quality of surface water in smaller streams and waterways. They can then influence the water quality of larger streams. For example, point source discharges, urban runoff, runoff from landfills and runoff from agricultural areas may contain sediments, organic material, nutrients, toxic substances, bacteria or other contaminants. When these substances are present in significant concentrations, they may interfere with some stream uses.

Approximately one percent of a watershed is stream channels. The smallest channels in a watershed have no tributaries and are called first-order streams. When two first-order streams join, they form a second-order stream. When two second-order streams join, a third order stream is formed, and so on. First and second order channels are often small, steep or intermittent. Stream orders that are six or greater constitute large rivers.

The stream channel is formed by runoff from the watershed as it flows across the surface of the ground following the path of least resistance. The shape of the channel and velocity of flow are determined by the terrain, unless changes have been made by man. When the terrain is steep, the swiftly moving water may cut a deep stream channel and keep the streambed free of sediments. In flatter areas, the stream may be shallow and meandering, with a substrate comprised largely of fine sediments.

Hydrologic Unit Code (HUC) Areas are “watershed address”. Delineated by the U.S. Geological Survey, hydrologic units represent the geographic boundaries of water as it flows across the landscape.

Not every HUC is a “watershed” in the pure sense, since longer streams are divided along their length. Each HUC has an associated 8-digit number or code. This number is representative of the size of the basin. Larger basins are represented by smaller numbers. The first six numbers of two or more watersheds near each other will be equal if they are in the same larger watershed.

Water within watersheds beginning with “04” flow into Lake Michigan or Lake Erie and are part of the Great Lakes Watershed. The “07”s flow west into the Illinois River before entering the Mississippi River. Water from the “05” watersheds flows into the Wabash or Ohio Rivers before also joining the Mississippi River and discharging into the Gulf of Mexico. The Mississippi River watershed is the largest in the USA .

Indiana is divided into 39 watersheds at the 8-digit level. Each of these watersheds can also be divided into smaller sub-watersheds which are represented by 11-digit numbers, and even smaller units with 14-digit numbers.

The State of Indiana has a surface area of approximately 36,532 square miles. There are about 90,000 miles of rivers, streams, ditches and drainage ways in Indiana. In addition, there are approximately 35,673 miles of surface waterways in Indiana greater than one mile in length.

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1 Hoosier Riverwatch - Volunteer Stream Monitoring Training Manual

MAP 2.1: HUC8 Watersheds of Indiana, Hoosier Riverwatch - Volunteer Stream Monitoring Training Manual

SECTION ONE - LOCATION

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

Watershed Location

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

Indiana is located on the eastern edge of the North American great interior plains. The North - South continental divide traverses through northern Indiana, draining watersheds into the Great Lakes basin and the Mississippi River and Ohio River systems. Surface water in the northern one-quarter of the state flows north into the Great Lakes and then through the St. Lawrence River to the Atlantic Ocean. The southern three-quarters of the state drains into the Ohio River or Illinois River and flows into the Mississippi River then south to the Gulf of Mexico.[1] There are 35,673 miles of Indiana rivers, streams, ditches and drainage ways listed at the 1:100,000 scale in USEPA River Reach File 3 (RF3).[2]

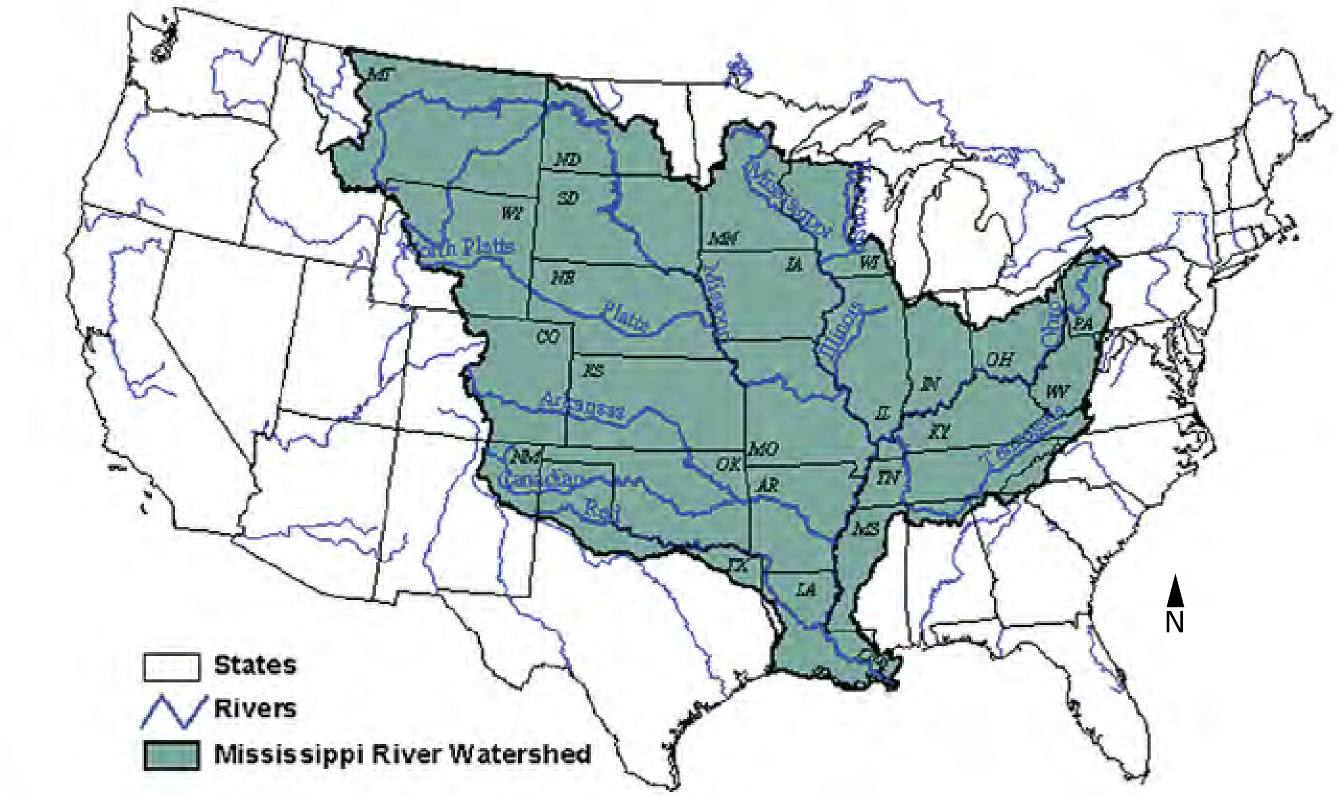
TABLE 2.2: Characteristics of Water bodies in Indiana

Description	Value	Units
Indiana population	6,080,485	
Indiana surface area	36,291	sq. mi.
Total miles of rivers and streams	35,673	miles
Number of publicly-owned lakes/ reservoirs/ ponds	575+	
Publicly-owned lakes/ reservoirs/ ponds	106,205	acres
Great Lakes	154,240	acres
Great Lakes shoreline	59	miles
Fresh water wetlands	813,000	acres

SOURCE: Indiana's 2008 Integrated Water Monitoring and Assessment Report

The White River flows in two forks across most of Central and Southern Indiana, creating the largest watershed contained entirely within the state, draining all or part of nearly half the counties. The White River Basin encompasses 11,350 square miles, starting in Randolph County (where the West Fork of the White River begins in an agricultural field), and ending in Gibson County (where the White River drains into the Wabash River). [3] There is approximately 1.6 million people living in the Upper White River Watershed and 1.8 million acres (approximately 1 acre per person).

1 Indiana Nonpoint Source Management Plan
2 Indiana's 2008 Integrated Water Monitoring and Assessment Report
3 U.S. Geological Survey



MAP 2.2: Mississippi River Watershed Basin, Hoosier Riverwatch - Volunteer Stream Monitoring Training Manual

MAP. 2.3: White River Basin, Indiana, wikipedia

INVENTORY

Watershed Location

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

West Fork of the White River Basin (051202)
"The West Fork of the White River begins near Winchester in Randolph county, Indiana and flows through 11 counties where it is joined by the East Fork of the White River near Petersburg. It drains portions of Randolph, Henry, Delaware, Madison, Hancock, Brown, Monroe, Owen, Greene, Martin, Daviess, Knox, Clay, Pike, Gibson, Clinton, Vigo, Tipton, Boone, Hendricks, Putnam, Morgan, Johnson, Hamilton, Marion, and Sullivan counties. The main stem of the White River then flows about 48 miles and joins the Wabash River. In total, the West Fork flows about 356 river miles and drains 5,600 square miles of land in Indiana. Land use in the watershed is predominately agriculture (primarily corn and soybean production), which represents approximately 76 percent of the total land cover." [1]

The West Fork of the White River, from Farmland, IN to its confluence with the Wabash River, is on the Outstanding Rivers List for Indiana, as having outstanding ecological, recreational, or scenic importance. [2]Indianapolis is the state capital and largest city in this watershed (largest population area), with Muncie and Anderson following as the next largest cities.

1 Hoosier Riverwatch - Volunteer Stream Monitoring Training Manual
2 Indiana Nonpoint Source Management Plan

MAP. 2.4 Upper White River Watershed, West Fork White River

Watershed Location

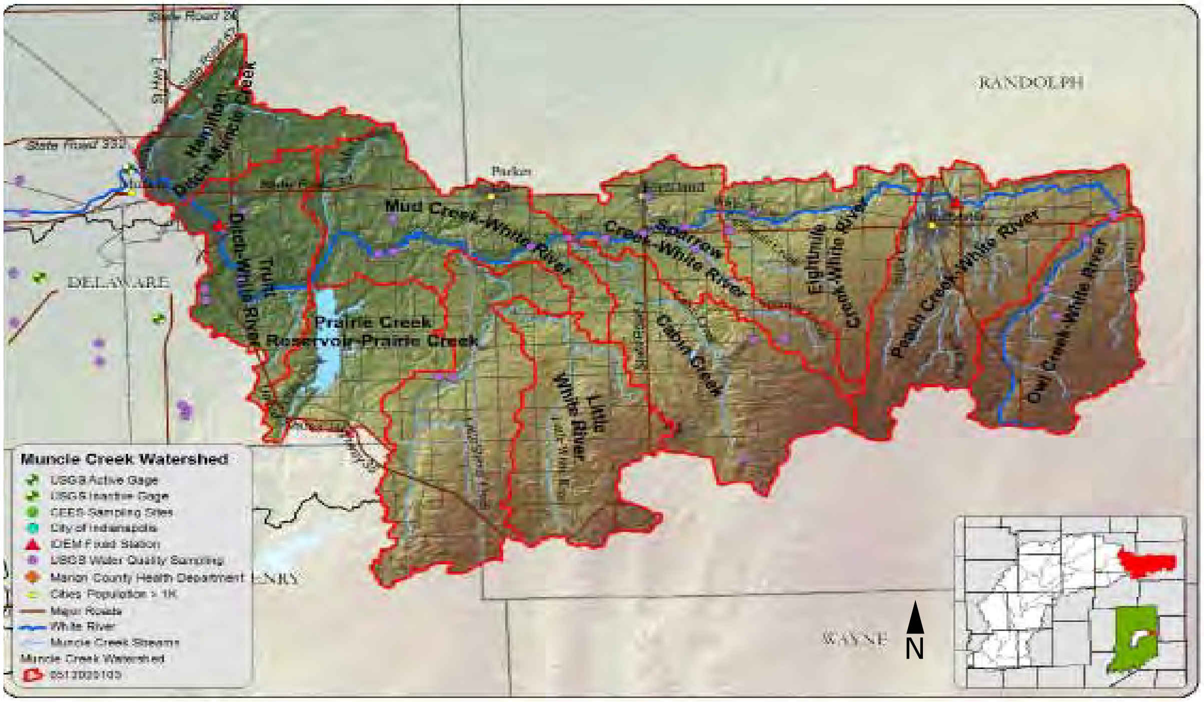
WMP - CHAPTER 2 - PART 1 - SECTION 1 - SUBSECTION 3

The Upper White River Watershed (Muncie Creek) (05120201)
"The headwaters of the West Fork White River (WFWR) can be found near Winchester, Indiana, moving westward through Muncie, draining approximately 384 square miles at the Madison County/Delaware County line (Hoggat 1975). The land along the river in Delaware County is primarily used for agriculture (corn, soybeans, and livestock), but also includes the urban area of Muncie."[1]

"Muncie is a heavily industrialized community that has included electroplating firms, a secondary lead smelter, foundries, heat treatment operations, galvanizing operations, and tool and die shops (although there has been a reduction of industry in the last 20 years)."[2] It is the first industrial city in the White River Watershed drainage basin. The HUC 10 watershed cover parts of Delaware County and Randolph county.

This management plan analyzes two Subwatersheds in the Muncie Creek HUC12 Watershed; Hamilton Ditch - Muncie Creek and Truitt-Ditch White River. For a list of all Subwatersheds in the Muncie Creek HUC10 Watershed see Table 2.3.

1 BWQ Macroinvertebrate (Aquatic Insect) And Mussel Community Report 2010
2 BWQ Macroinvertebrate (Aquatic Insect) And Mussel Community Report 2010



MAP. 2.5 Muncie Creek HUC10 Basin, http://www.cees.iupui.edu/

TABLE 2.3: Subwatersheds in Muncie Creek HUC10 Basin, indianamap.org

HU_12_NAME	HUC_12	ACRES	Sq Mi.	Counties
Peach Creek-White River	51202010102	19001	30	Henry
Eightmile Creek-White River	51202010103	13117	20	Henry
Cabin Creek	51202010104	16573	26	Henry
Sparrow Creek-White River	51202010105	11385	18	Henry
Little White River	51202010106	14609	23	Henry
Little Stoney Creek-Stoney Creek	51202010107	18771	29	Delaware, Randolph, Henry
Prairie Creek Reservoir-Prairie Creek	51202010108	10853	17	Delaware
Mud Creek-White River	51202010109	15745	25	Delaware, Randolph
Truitt Ditch-White River	51202010110	11781	18	Delaware
Hamilton Ditch-Muncie Creek	51202010111	8602	13	Delaware
Owl Creek-White River	51202010101	13456	21	Henry

SOURCE: ArcGIS, Indianamap.org

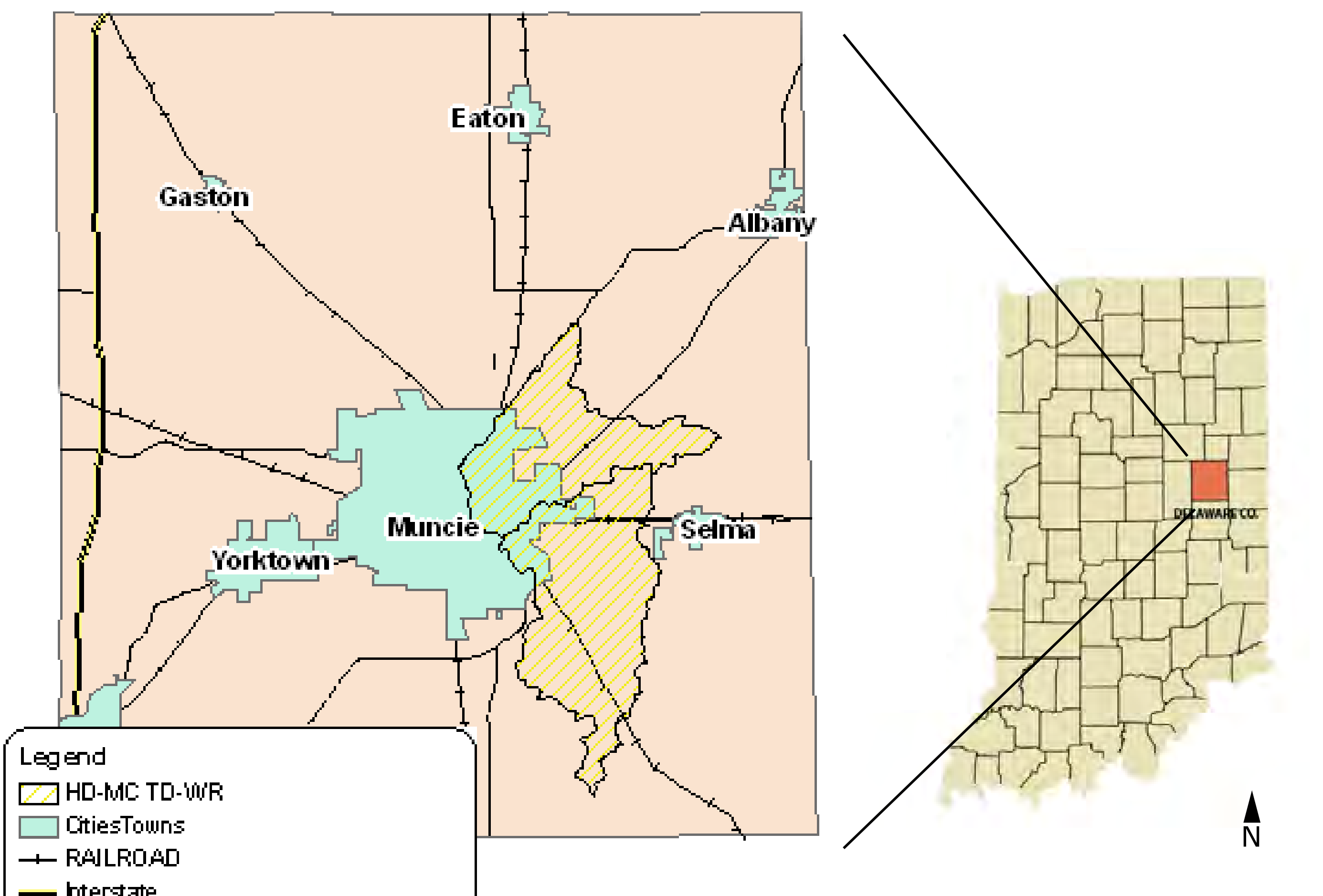
Watershed Location
WMP - CHAPTER 2 - PART 1 - SECTION 1 - SUBSECTION 4

Hamilton Ditch- Muncie Creek (051202010111) and Truitt Ditch- White River (051202010110) are at the confluence of the Muncie Creek HUC10 Watershed. Both are located in Delaware County, Indiana (MAP 2.6).

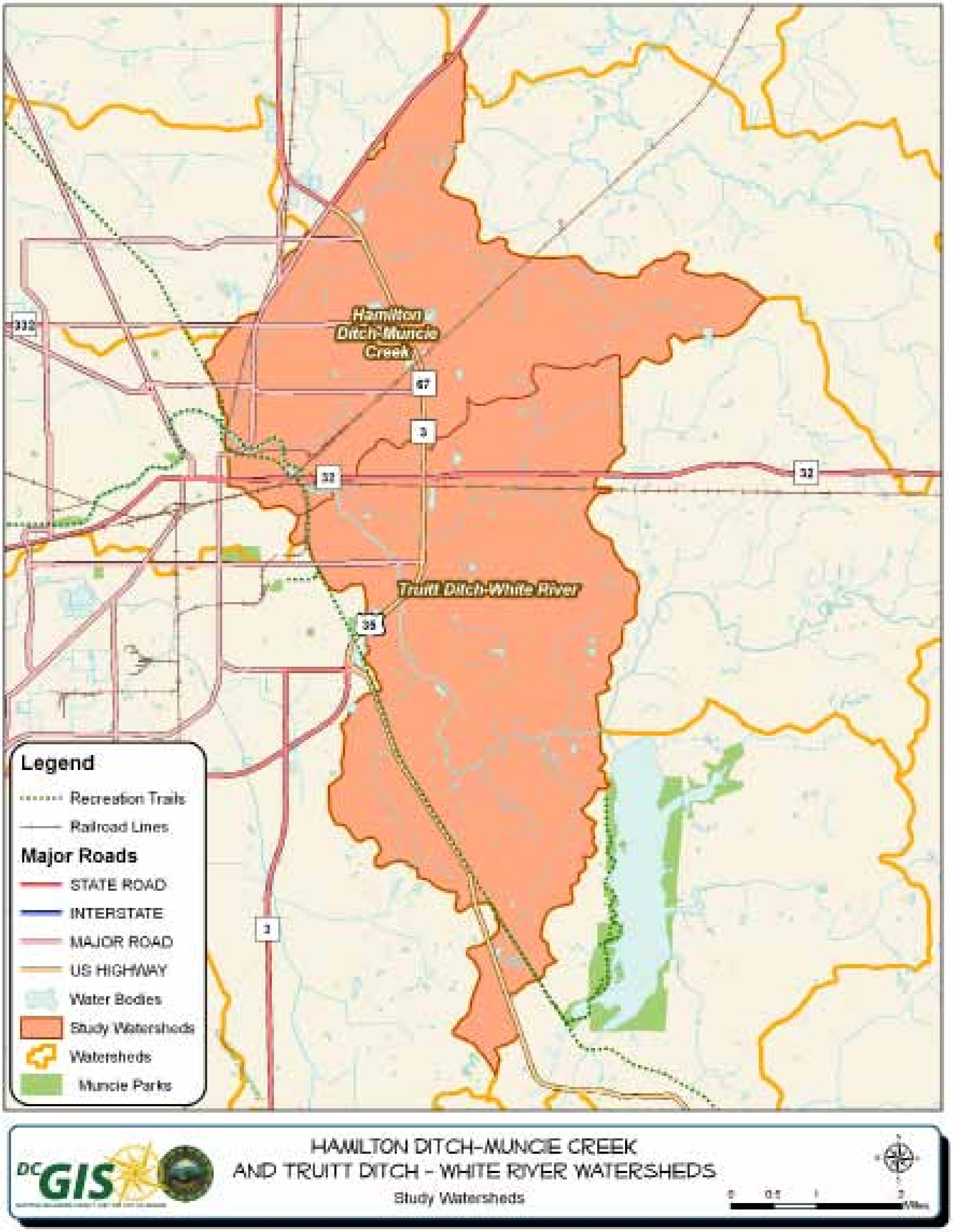
Delaware County is located in East Central Indiana. The Counties primary river, the White River, serves as the spine for the County's major city, Muncie. The main stem of the West Fork of the White River flows through both watersheds. The White River has approximately seven miles of its length in these two Subwatersheds. The second largest stream is Muncie Creek which extends six miles.

The Truitt Ditch-White River Subwatershed begins directly to the east of Muncie, and continues to the south (MAP 2.7, 2.9). It is 11,781 acres in size. The Hamilton Ditch-Muncie Creek Subwatershed is located to the northeast of the city of Muncie (MAP 2.7, 2.8). It is 8,602 acres in size. Both contain a mixture of urban, suburban, and rural areas.

CITIES AND TOWNS IN DELAWARE COUNTY INDIANA



MAP. 2.6 Delaware County, Indiana, wikipedia



MAP. 2.7 Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Watersheds

INVENTORY

MAP. 2.8 Hamilton Ditch - Muncie Creek Subwatershed

MAP. 2.9 Truitt Ditch - White River Subwatershed

Watershed Location

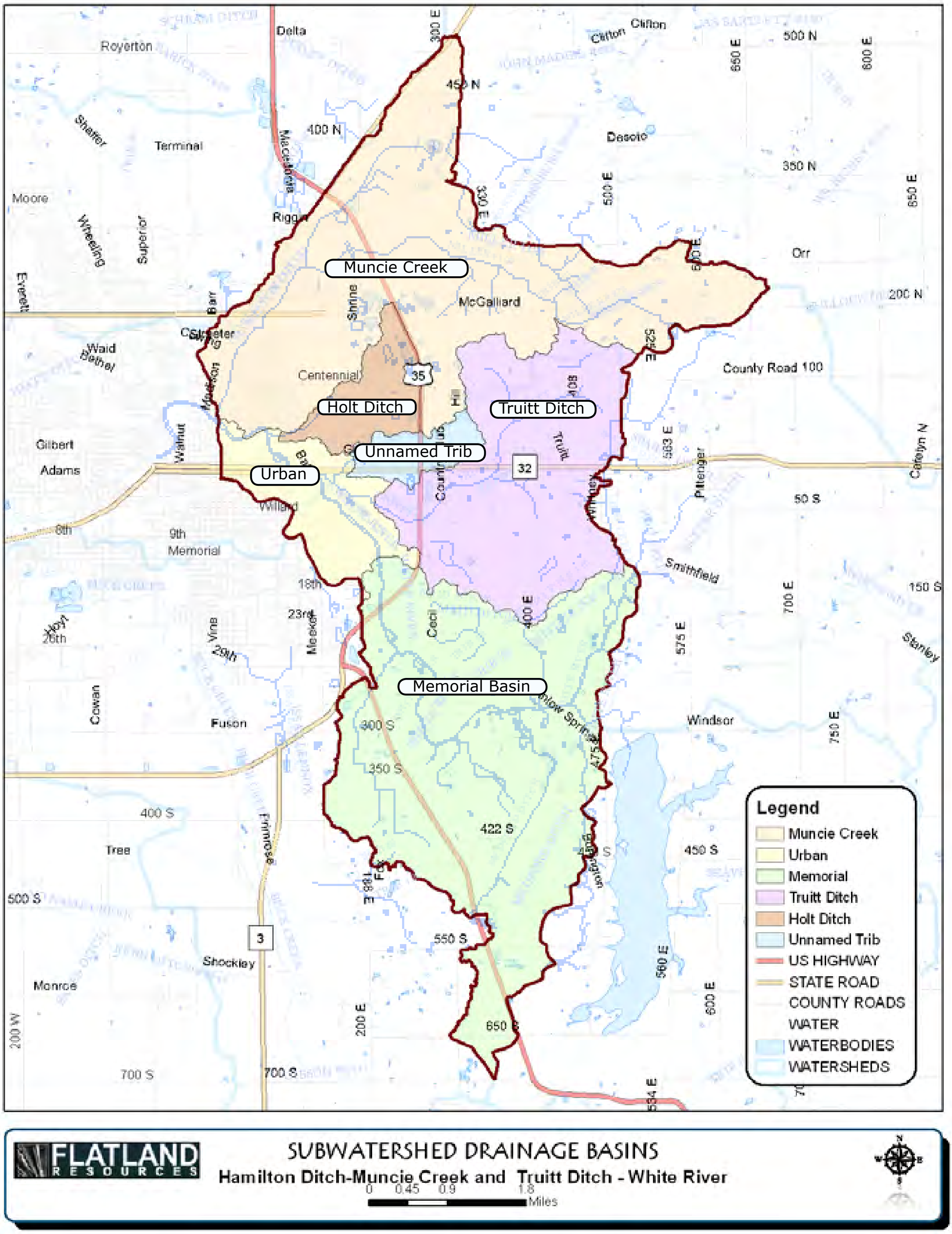
WMP - CHAPTER 2 - PART 1 - SECTION 1 - SUBSECTION 5

Primary Subwatershed Drainage Basins

Table 2.4 outlines the drainage basins that will be studied in response to water quality sampling point locations and data generated by the Muncie Bureau of Water Quality. These drainage basin delineations will serve as study areas for critical area determinations. Each of the following sub basins are described in greater details in section 2[1]

TABLE 2.4: Primary Drainage Basins in Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds		
	Acres	Stream Mi.
Total Combined Subwatersheds	19654	31
Walnut Basin	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
Memorial Basin	7184	11
SOURCE: ArcGIS, Indianamap.org		

1 Data Generated by ArcGIS



MAP. 2.10 Primary Drainage Basins in studied Subwatersheds

SECTION TWO - NATURAL FEATURES

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

Natural History

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

The Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds are located in the Central Till Plain Natural Region. The Tipton till plain (a sub unit of the Central Till Plain) is characterized by (1) a mix of poorly drained soils which support a variety of oaks, maples, ash, elm, and sycamore and (2) better drained soils home to hickory, tulip tree, white ash, sugar maple, and beech. Within the till plain, depressions are often wet and mesic forests, which contain highly diverse communities.

Sediments borne by ice sheets were deposited as till (an unsorted mixture of sand, silt, clay and boulders) when the glaciers advanced into Indiana and as outwash sand and gravel when the ice melted . Thick accumulations of till and outwash filled the bedrock valleys and covered the bedrock hills of northern Indiana to produce the flat to gently rolling landscape thought of by many as monotonous.[1]

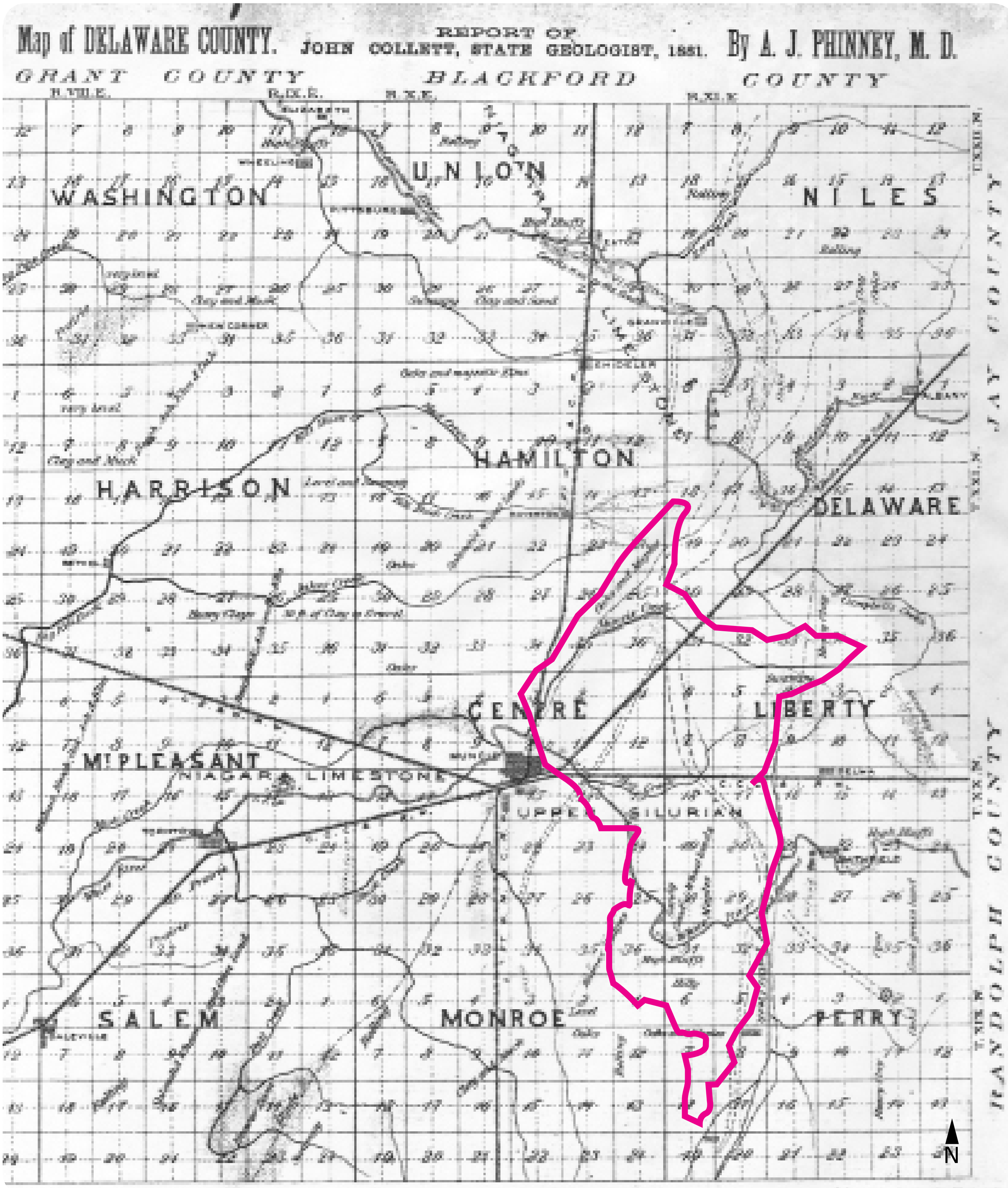
The surface of this region is flat to gently rolling and was shaped by the Wisconsinan Glaciers. The moraines that were left behind after glaciation are of two types: ground moraines and recessional moraines. The ground moraines are generally flatter and less sloped. The recessional moraines are more convexly shaped and have steep slopes.[2]

Pre-settlement, the area was predominately forest, with beech forests and oak sugar maple forests being the major type on the drier areas and beech and elm-ash swamp forests dominating the wetter areas. Small sections of prairie were located throughout the area, where conditions allowed. Typically, wetland areas would have been located in the headwaters of streams, as is apparent from the color of the soils as seen through contemporary aerial photography. [3]

Most of the early settlers in Delaware County came from Virginia, Pennsylvania, and Kentucky. The Delaware and Miami Indians, who were living in the area when the settlers arrived, remained until 1818. Muncie, the county seat, was named for the chief of the Delaware tribe. The first permanent settlement in Delaware County was established in 1820. The earliest settlers located along the West Fork of the White River near the present sites of Muncie, New Burlington, and Smithfield. [4]

By 1909 a tremendous landscape transformation had occurred. DeHart (1909) lamented the loss of forests throughout the region as more settlers arrived. He described Indiana as becoming a “treeless state” where native timber stands were removed for farming purposes. He wrote “with more timber our streams would again flow with more water; our climate would be better, crops would be better and prosperity would be insured to those that come after us.”[5]

1 Landscapes of Indiana, Indiana Geological Survey.
2 Soil Survey of Delaware County Indiana. US Department of Agriculture
3 Wabash River (Region of the Great Bend) WMP
4 Wabash River (Region of the Great Bend) WMP
5 Past and Present of Tippecanoe County Indiana



MAP. 2.11 Historic Map of Delaware County

INVENTORY

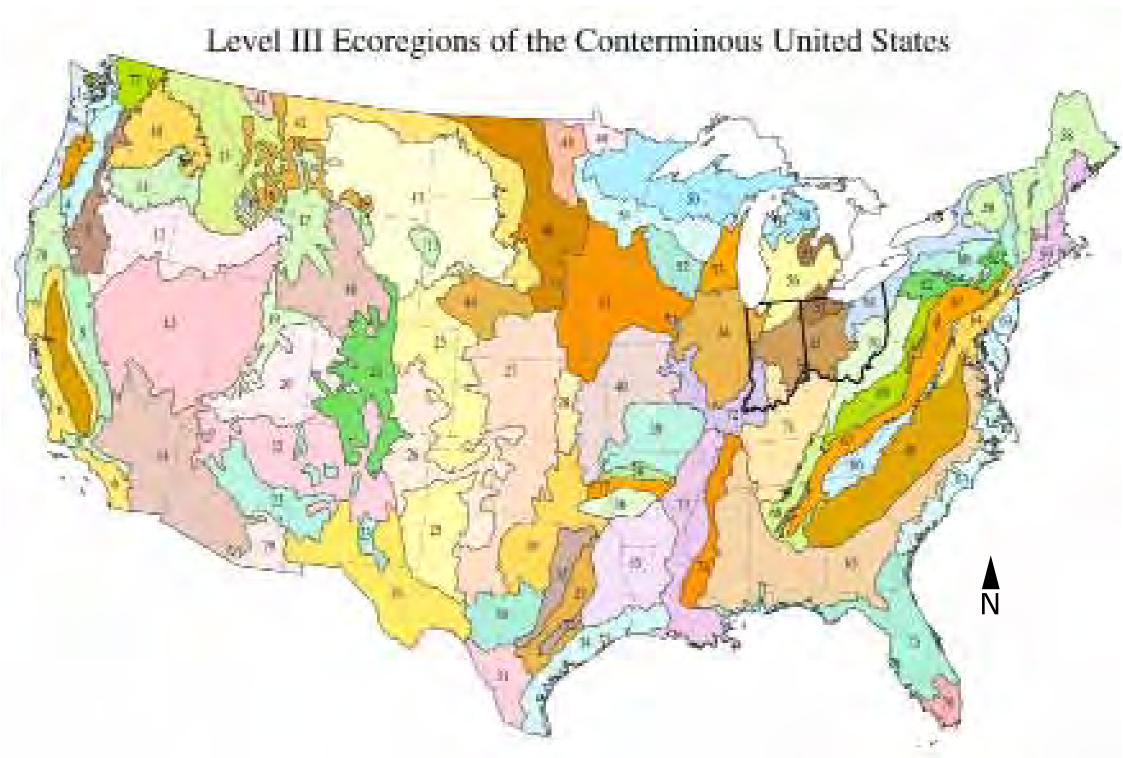
Ecoregions

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

Ecoregions
Underlying site-specific habitat variability is the broader effect of ecoregion differences. Geology, climate, geographic location, and soils all factor into shaping the native flora and fauna which occurs in a particular area.[1] Categorization of these floral and faunal communities has been completed by a number of ecologists since the earliest efforts by Coulter in 1886. Since this time, Petty and Jackson (1966) identified regional communities; Homoya et al. (1985) classified Indiana into natural regions, while Omernik and Gallant (1988) categorized Indiana into Ecoregions.[2]

Ecoregions are those areas with generally similar ecosystems. Ecoregions have four levels of classification, from Level I to Level IV, with Level I encompassing the broadest description and Level IV being the most specific.

Delaware County and all of the Upper West Fork White River lie within the Eastern Corn Belt Plains, a Level III ecoregion delineation (MAP 2.12). This ecoregion is characterized by rolling hills and end moraines. Extensive glacial deposits left over from the Wisconsonian age cover the area. Within the Level IV delineation, three separate Ecoregions can be found in Delaware County (MAP 2.14) and the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds (MAP 2.13).



MAP. 2.12 Level III Ecoregions, USA, epa.gov

1 Soil Survey of Delaware County Indiana. US Department of Agriculture
2 Wabash River (Region of the Great Bend) WMP

MAP. 2.13 Subwatershed Ecoregions

INVENTORY

Ecoregions

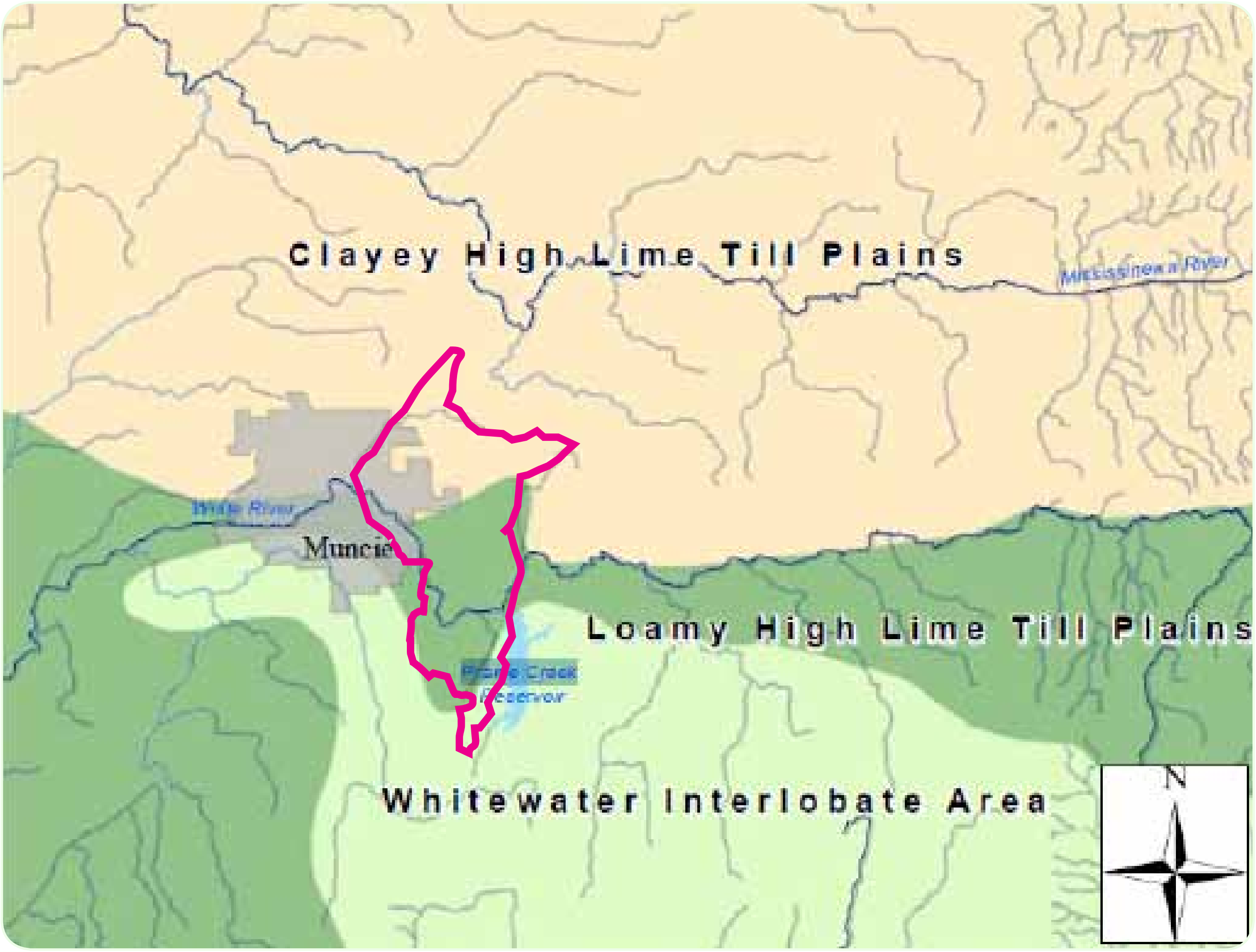
WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 3

Clayey High Lime Till Plains (CHLTP)
North of White River is the Clayey High Lime Till Plains (CHLTP), distinguished by turbid, low gradient streams that cross less productive, poorly-drained soils. Within Delaware and Randolph County, this ecoregion includes the Mississinewa River watershed and many smaller tributaries of White River. (55a), The Clayey Lime Till Plains ecoregion is transitional between the Loamy High lime Till Plains (55b) and the Maumee Lake Plains (57a); soils are less productive and more artificially drained than Ecoregion 55b and supported fewer swampy areas than Ecoregion 57a. Corn, soybean, wheat, and livestock farming are dominant and have replaced the original beech forests and scattered elm-ash swamp forest. No exceptional fish communities exist in the turbid, low gradient streams of Ecoregion 55a."[1]

Loamy High Lime Till Plains (LHLTP)
Through the middle of the county and bordering nearly the entire length of White River is the Loamy High Lime Till Plains (LHLTP). Soils here are typically better drained than those of the previous ecoregion and have slightly higher gradients. 55b, "The Loamy, High Lime Till Plains ecoregion contains soils that developed from loamy, limy, glacial deposits of Wisconsinan age; these soils typically have better natural drainage than those of Ecoregion 55a and have more natural fertility than those of Ecoregion 55d. Beech forests, oak-sugar maple forest, and elm-ash swamp forests grew on the nearly level terrain; today, corn, soybean, and livestock production is widespread."[2]

Whitewater Interlobate Area (WIA)
Further south encompassing most of Buck Creek and the Prairie Creek Subwatershed is the Whitewater Interlobate Area (WIA). The coarse bottomed streams in this region have moderate gradients and are supported by abundant ground water supplies leading to noticeably cooler water temperatures. The cooler temperatures have a discernable effect on the composition of fish communities in this ecoregion and on IBI scores. 55f, The redside dace, northern stud fish, and banded sculpin occur; they are absent or uncommon in Ecoregion 55b. Unique Ozarkian invertebrates also occur in Ecoregion 55f. Dolomitic drift and meltwater deposits are characteristic and overlie limestone, calcareous shale, and dolomitic mudstone."[3]

1 Ecoregions of Indiana and Ohio
2 Ecoregions of Indiana and Ohio
3 Ecoregions of Indiana and Ohio



MAP. 2.14 Ecoregions of Delaware County. BWQ

INVENTORY

Ecoregions & World Biomes

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

"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 anthropocentric 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. The unique thermal regime of the WIA has led to a fish community that includes mottled sculpin, two species of dace, and native lampreys." [1]

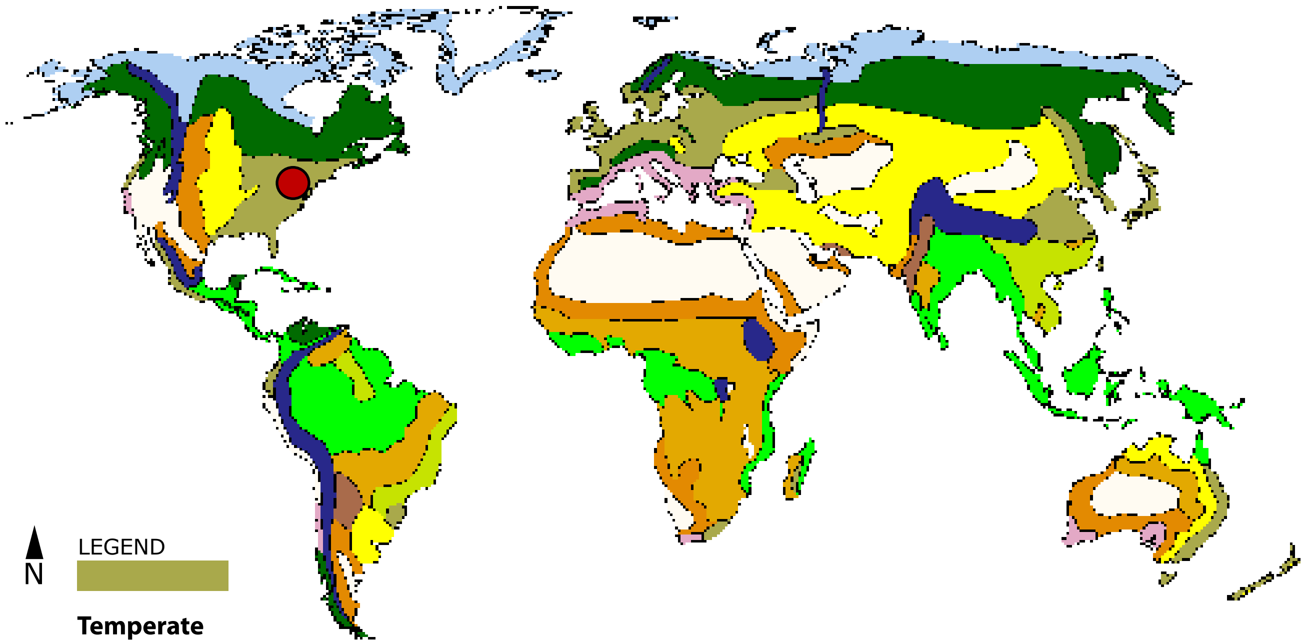
"When attempting to compare fish communities from these three Ecoregions it is important to take into consideration the unique characteristics that are beyond the control of managers and inherently promote different fish communities."[2]

Biomes are large geographical areas that are distinguished by different plant and animal groups within the area. The plants and animals have developed certain characteristics based on the climate and geography of the biome. In order for biomes to survive, a healthy relationship must exist between the living and its environment. [3]

The biome that describes the location of the White River Watershed is the temperate deciduous forest. (MAP 2.16) This biome is also found in the eastern half of North America, southwest Russia, Japan, Eastern China, New Zealand, southeast Australia, and the southern tip of South America. (MAP 2.15) The average temperature of the biome is 60 degrees Fahrenheit and it typically receives 30 – 60 inches of rain per year. [4]

The temperate deciduous forest has four distinct seasons – spring, summer, autumn and winter. The biome is considered deciduous because the plant leaves turn colors in the autumn, fall off in the winter and grow back in the spring. The common trees that are found in the biome are: beech, oak, ash, lime, and northern arrowhead. Five planting zones with distinct plants are found within the biome. They are: Tree stratum zone, small tree and sapling zone, shrub zone, herb zone and ground zone.[5]

1 Muncie Sanitary District's Fish Community Report
2 Muncie Sanitary District's Fish Community Report
3 Blue Planet Biomes
4 Natureworks
5 Blue Planet Biomes



LEGEND

Temperate forest

N

MAP. 2.15 Site Location in Relationship to World Biome, BSU

MAP. 2.16 Site Location in Relationship to Temperate Forest, BSU

The Temperate Deciduous Biome in the United States is one of the largest biomes.

This project recommendations have potential application to sites in the eastern part of the country.

LEGEND

Temperate forest

N

INVENTORY

Climate

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 5

Normatively, the State of Indiana has a temperate climate with warm summers and cool or cold winters. The dynamic of this climate affects many aspects of natural system history, land use, and water resources planning.

Temperature

Delaware County has average temperatures ranging from 34°F to 72°F, with an average temperature of 51.4°F (Table 2.5). This averaging is a result of the climatic forces that result in distinct seasons Spring, Summer, Fall and Winter. Table 2.6 shows probable dates of the first freeze in fall and the last freeze in spring, which are the most significant periods of transition during these climatic extremes. High temperatures measure approximately 85°F in July and August, while low temperatures measure near freezing (31°F) in January. In winter, the average temperature is 27.7 °F and the average daily minimum temperature is 20.0 °F. In summer, the average temperature is 72.8°F and the average daily maximum temperature is 83.1 °F. [1]

Precipitation

Average annual rainfall is 40 inches. According to the US Department of Agriculture, "Thunderstorms occur on about 43 days each year, and most occur between May and August." The average seasonal snowfall is 26.7 inches. On an average, 31 days per year have at least 1 inch of snow on the ground. The heaviest 1-day snowfall on record was 12.5 inches recorded on December 20, 1973. [2] (Table 2.7)

Humidity, Sun, Wind

"The average relative humidity in mid-afternoon is about 61°F. Humidity is higher at night, and the average at dawn is about 83°F. The sun shines 67 percent during daylight hours in summer and 43 percent in winter. The prevailing wind is from the southwest, except from January to March, when it is from the northwest. Average wind speed is highest, between 11 and 12 miles per hour, from January to April". [3]

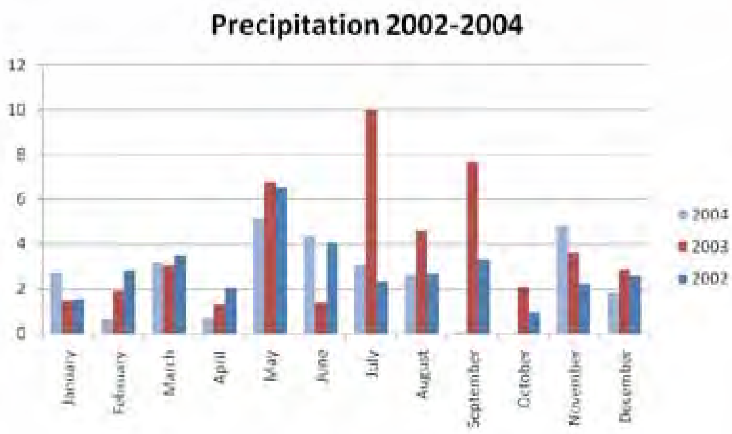
1 Soil Survey of Delaware County Indiana. US Department of Agriculture
2 Soil Survey of Delaware County Indiana. US Department of Agriculture
3 Soil Survey of Delaware County Indiana. US Department of Agriculture

TABLE 2.5: Temperature Recorded in the period 1961 to 1990 at Muncie Ball State University							
				2 year in 10 will have:			
	Average Daily Maximum	Average Daily Minimum	Average	Max temp higher than	Minimum temp higher than	Average number of growing degree days	Average
Month							
January	32.2	16.8	24.5	61	-14	14	2.01
February	36.1	19.8	28	64	-8	25	2.1
March	48.4	30.5	39.4	77	5	132	3.33
April	61.6	40.7	51.2	84	20	345	3.5
May	72.1	51.1	61.6	90	30	669	3.86
June	81.3	60.8	71	95	43	926	3.62
July	85.1	64.6	74.8	97	40	1070	3.24
August	83	62.2	72.6	94	45	1003	3.49
September	76.9	55.3	66.1	92	35	779	3.19
October	64.7	43.5	54.1	85	24	432	2.68
November	50.6	34.3	42.5	74	13	160	3.18
December	37.9	23.3	30.6	64	-7	35	3.47
Yearly							
Average	60.8	41.9	51.4				
Extreme	102	-24		100	-16		
Total						5,590	37.67

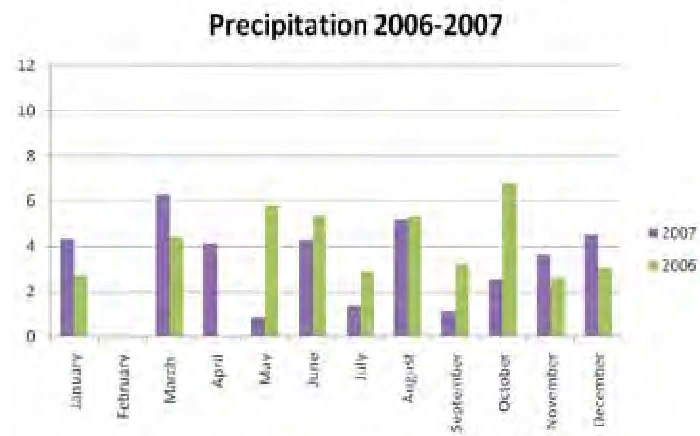
SOURCE: Soil Survey of Delaware County Indiana. US Department of Agriculture

TABLE 2.6: Freeze Dates in the Spring and Fall Recorded in the period 1961 to 1990 at Muncie Ball State University			
Probability	Temperature		
	24 F or lower	28 F or lower	32 F or lower
Last freezing temperature in spring:			
1 year in 10 later than	Apr. 15	Apr. 24	May 9
2 year in 10 later than	Apr. 9	Apr. 19	May 5
5 year in 10 later than	Mar 30	Apr. 9	Apr. 26
First freezing temperature in the fall:			
1 year in 10 earlier than	Oct. 24	Oct. 12	Sept. 26
2 year in 10 earlier than	Oct. 29	Oct. 17	Oct. 2
5 year in 10 earlier than	Nov. 9	Oct. 27	Oct. 12

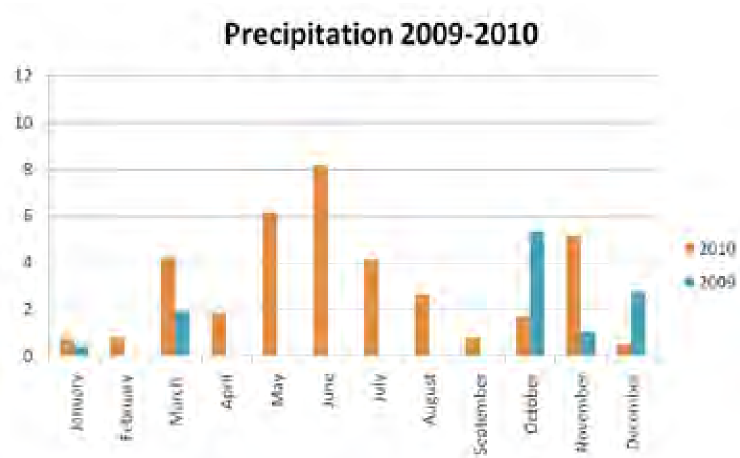
SOURCE: Soil Survey of Delaware County Indiana. US Department of Agriculture



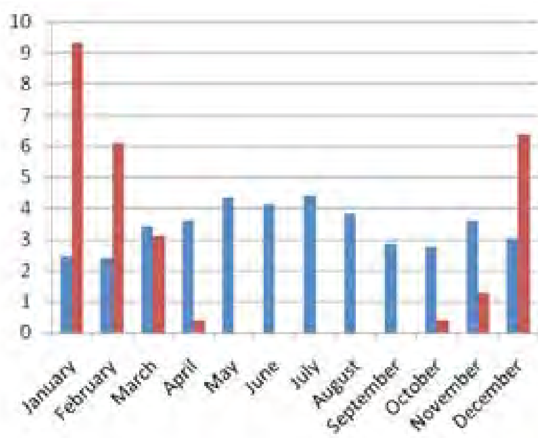
CHA. 2.1 Delaware County Precipitation 2002-2004



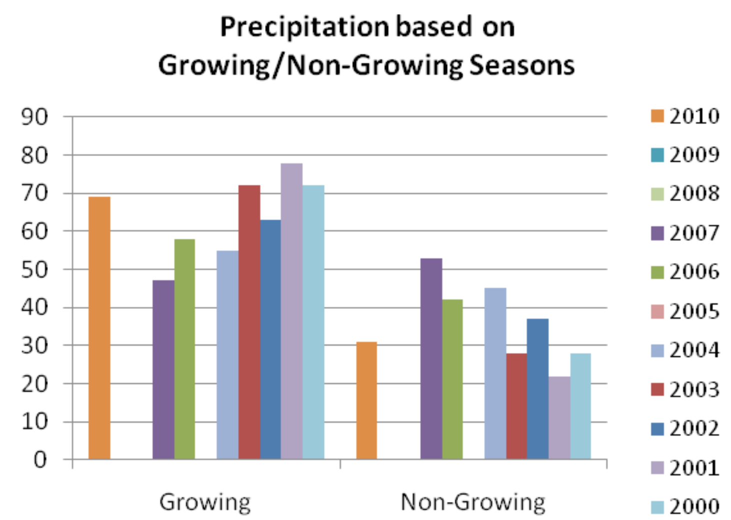
CHA. 2.4 Delaware County Precipitation 2006-2007



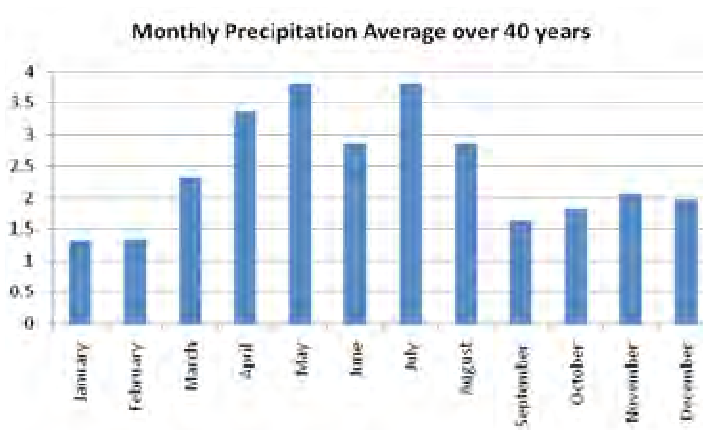
CHA. 2.2 Delaware County Precipitation 2009-2010



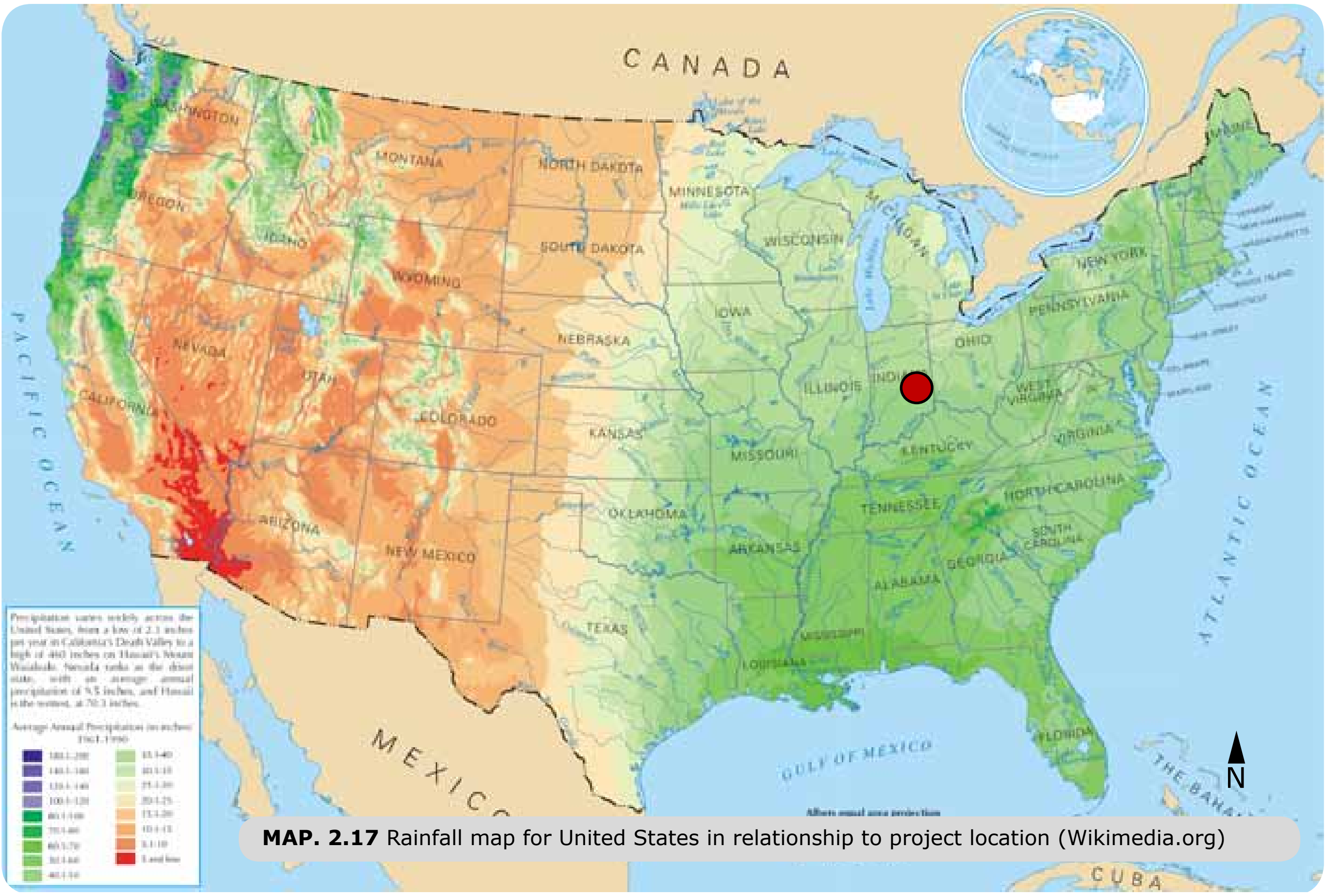
CHA. 2.5 Delaware County, Snowfall (red) Rain (blue)



CHA. 2.3 Delaware County Precipitation 2000-2010



CHA. 2.6 Delaware County Precipitation 40 year Monthly Avg.



MAP. 2.17 Rainfall map for United States in relationship to project location (Wikimedia.org)

TABLE 2.7: Snowfall precipitation Recorded in the period 1961 to 1990 at Muncie Ball State University, Soil Survey of Delaware County Indiana. US Department of Agriculture				
	2 years in 10 will have			
	Less than	More than	Average number of days with 0.10 in or more	Average snowfall
Month				
January	0.96	2.92	5	7.1
February	0.85	3.15	5	6.9
March	2	4.53	7	3.7
April	2.32	4.57	7	0.4
May	2.36	5.2	7	0
June	1.9	5.12	6	0
July	1.89	4.45	6	0
August	1.74	5.02	5	0
September	1.02	4.97	5	0
October	1.58	3.84	6	0.3
November	1.38	4.71	6	1.9
December	2.06	4.73	7	6.4
Total	25.57	45.48	72	26.7

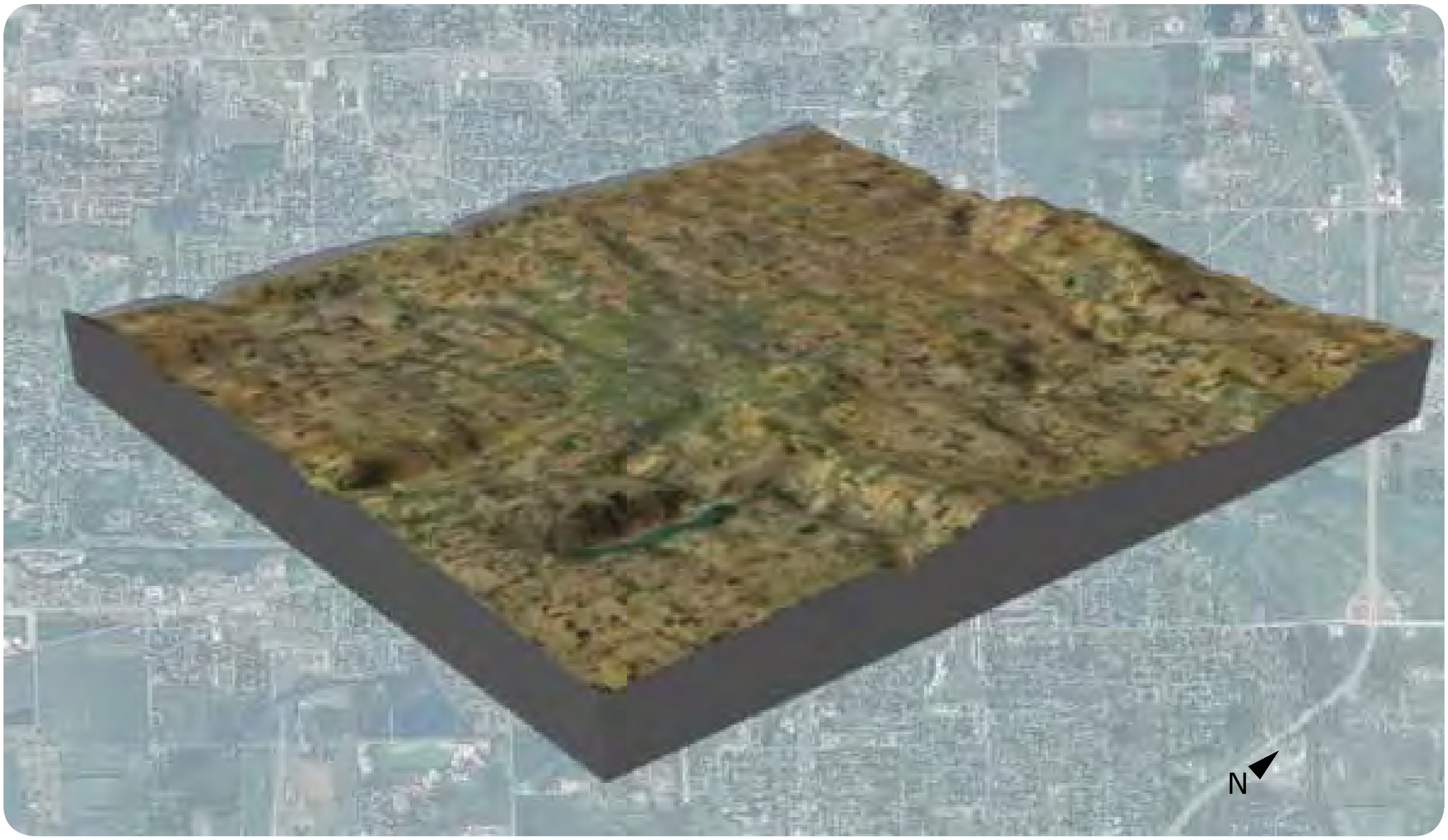
SOURCE: Soil Survey of Delaware County Indiana. US Department of Agriculture

Topography

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 6

The topography, surface geology, soil development, and bedrock geology in Muncie Creek- Hamilton Ditch and Truitt Ditch-White River Subwatersheds were directly influenced by the advance and retreat of the Saginaw-Huron, Michigan, and Erie lobes of ice during the Wisconsinan Glaciation. The two watersheds are located within the boundaries of the Wisconsinan glacial deposits. [1]

The lowest elevation in the county is 830 feet along the Mississinewa River on the northern edge of the county. The highest elevation in the county is 1,100 feet in the southeast corner of the county on the Knightstown Moraine. The relatively flat topography is interrupted both by a series of parallel end moraines or hills and by the White River.[2]



DIA. 2.1 Axonometric diagram of Delaware County landform (Kevin Henn)

1 Soil Survey of Delaware County Indiana. US Department of Agriculture
2 Soil Survey of Delaware County Indiana. US Department of Agriculture

MAP. 2.18 Digital Elevation Model

INVENTORY

Geological Bedrock

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 7

The bedrock of both watersheds was formed during the Silurian Period (~440-410 mya). This bedrock consists of limestones and dolostones with fossils throughout.[1] Bedrock deposits are from the Devonian and Mississippian ages and generally consist of shale, siltstone, and limestone (Rosenshein, 1958). There are many sand and gravel resources located in this watershed. The distance to the bedrock varies from 0 to 250 feet.[2]

Landforms

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 8

The till plain in Delaware County is divided into two distinct landforms, ground moraines and recessional moraines. The ground moraines have rather broad, flat surfaces with swell-and-swale topography and scattered closed depressions. The largest ground moraine in the county lies in the watershed between the West Fork of the White River and the Mississinewa River.

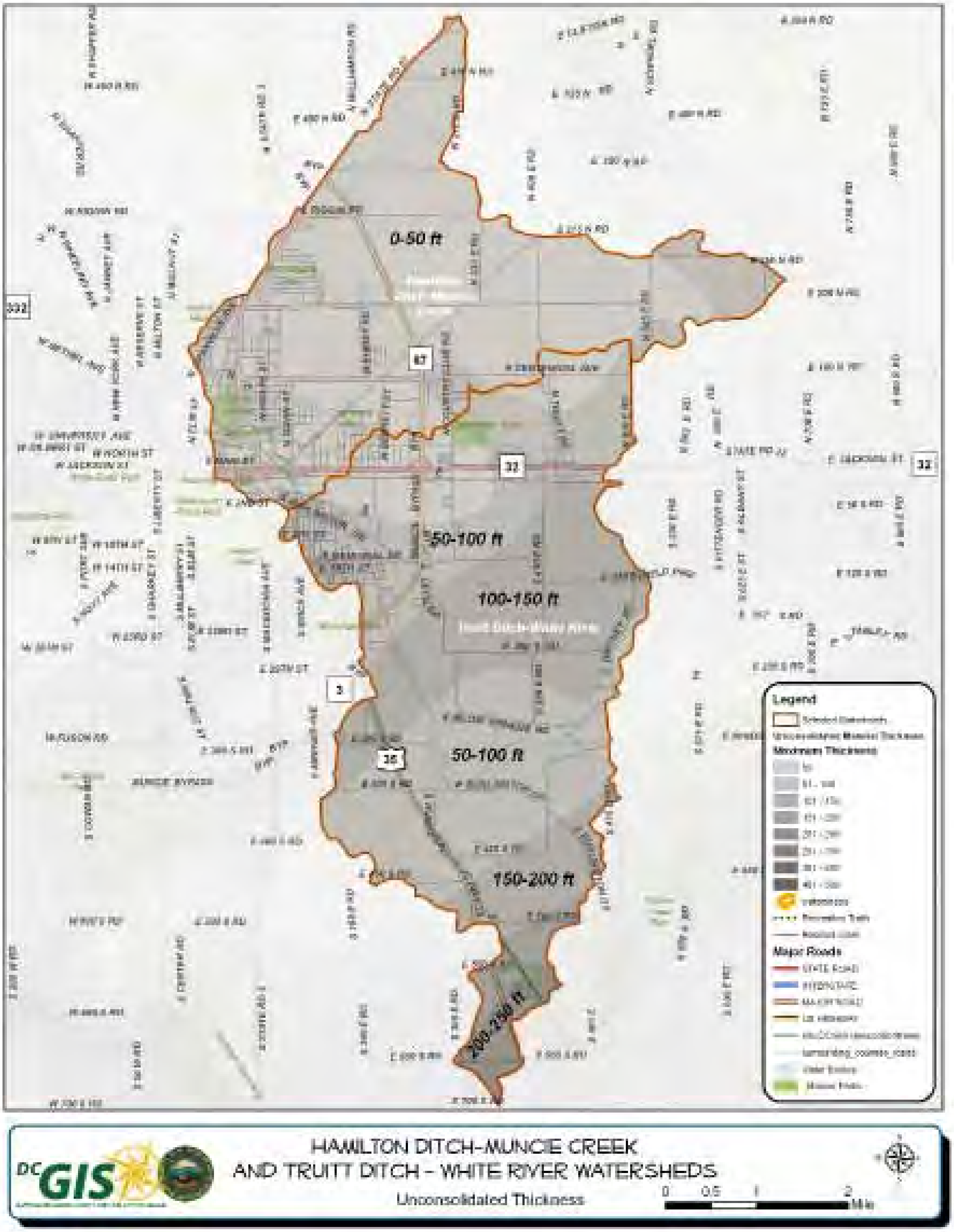
The recessional moraines are a series of rolling, mostly convex ridges that are narrower and more sloping than the ground moraines. The rolling slopes in the southeastern part of the county are part of the Knightstown Moraine (Wayne, 1965). Several kames in the county rise above the till plain like an inverted bowl. These eskers and kames are underlain by sand and gravel and are commonly mined.[3]

In the Hamilton Ditch - Muncie Creek watershed, there are numerous eskers present as a result of the glacial period. The depth of unconsolidated material ranges from 0 to 100 feet. [4]

The Truitt Ditch-White River watershed is located on the boundary between the Tipton Till Plain and the Bluffton till Plain section of the Central Till Plain. Its shrink-swell characteristics are moderate throughout, with an unconsolidated thickness of 0 to 250 feet.

An abrupt ridge system rising above the till plain northeast of Muncie is known as the Muncie Esker, a portion of the Muncie Esker runs through the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. This esker was also left by the retreating glaciers of the Wisconsinan Ice Age. [5]

1 Indiana Geological Survey
2 Indiana Geologic Survey, ARCIMS Downloader
3 Soil Survey of Delaware County Indiana. US Department of Agriculture
4 Soil Survey of Delaware County Indiana. US Department of Agriculture
5 Soil Survey of Delaware County Indiana. US Department of Agriculture



MAP. 2.19 Unconsolidated Thickness

INVENTORY

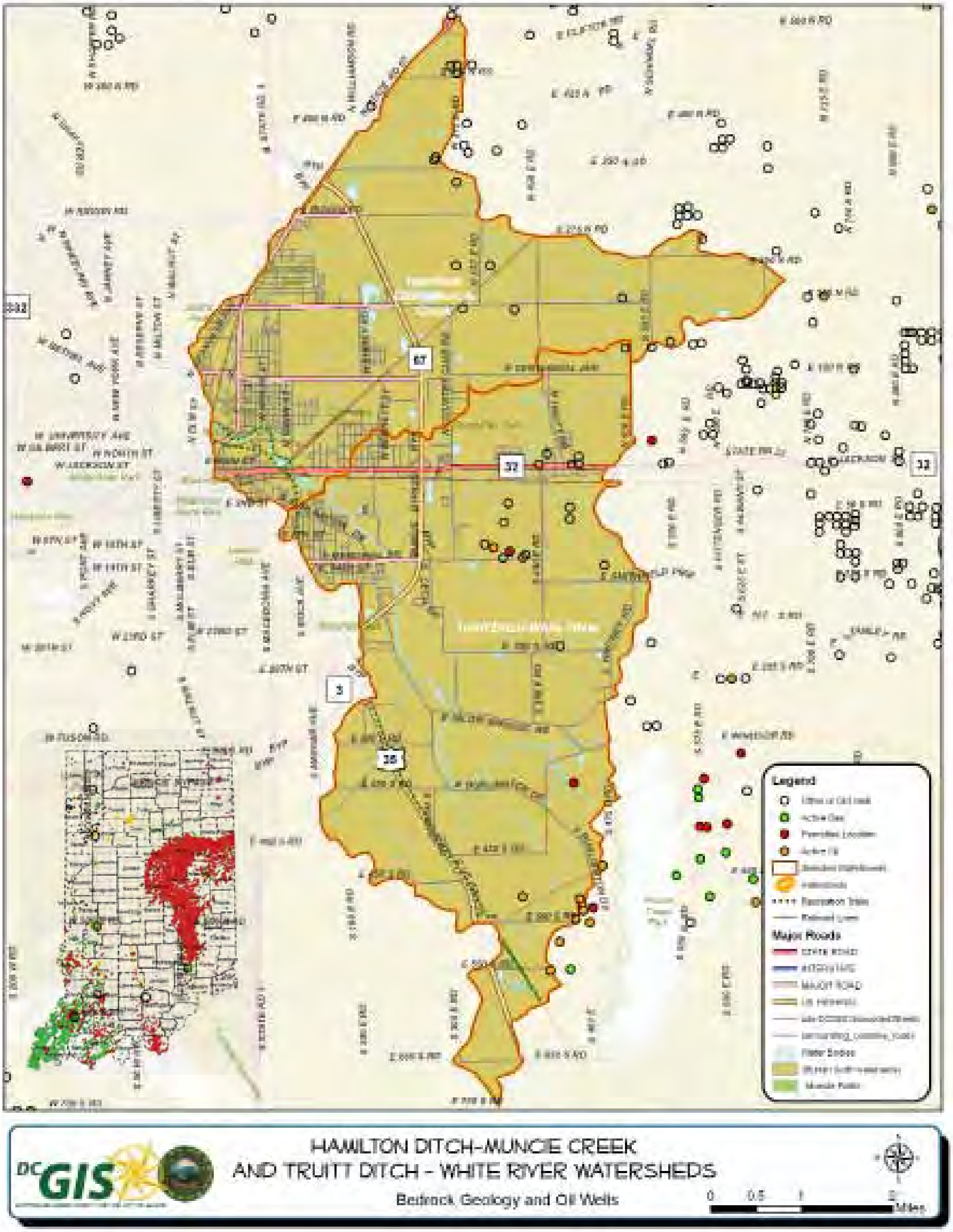
Petroleum

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 9

Trenton Field:
In 1876, natural gas was found near Eaton, Delaware County, Indiana. The gas was not used until the 1880s. Trenton Field was the first giant oil field in the United States. It produced 100 million total barrels. By 1910, 90% of the gas was used; mostly due to the wastefulness and unregulated drilling practices of the field. The oil boom in Delaware Co. is the reason why the county became industrious attracting people like the Ball Brothers. [1]

Hamilton Ditch - Muncie Creek and Truitt - Ditch White River are both located within the Trenton Petroleum Field and there are numerous oil and gas wells present. New and recent drilling has started in the Prairie Creek - Perry Township area. The status of both old (retired) and new wells and their inherent risks and unknown at this time.

1 Indiana Geological Survey



MAP. 2.20 Bedrock Geology and Oil Wells

Biological Indicators

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 10

"Biological indicators provide many benefits to a water quality program. Biological communities reflect the cumulative impacts of the watershed condition. The most obvious biological indicator related to water quality is stream biology. 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." [1]

The Muncie Bureau of Water Quality assists the White River Watershed Project by assessing the fish and macroinvertabrate communities within the WFWR and its tributaries within Delaware County for the purposes of: evaluating the health of these aquatic communities, supplementing chemical assessments by evaluating overall water quality, and reporting the results to the WRWP in a manner that is useful to both the public and professionals.

"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), while 7% were 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." [2]

Aside from instream biology, individuals are concerned about lack of knowledge of local wildlife populations and the impact that changing land uses could have on these populations. Additionally, pathogen inputs from wildlife are also a concern.

The Indiana Department of Natural Resources (IDNR) is tasked with managing wildlife populations throughout the state. The most recent survey of wildlife populations occurred in 2005. Deer and squirrels are the most common wildlife present within the region.

According to IDNR, many wild animals in Indiana have become displaced as the result of urban growth and removal of their habitat. While some species may move to other areas where natural habitat exists, some species actually thrive in urban settings. Species such as raccoons, opossums, Canadian geese and even red foxes are becoming more common in urban areas and are frequently seen by people. However, these animals can also cause problems when they use a person's attic for shelter, destroy shingles and soffits, utilize lawns as homes, and eat their garbage. [3]

Wildlife is an indicator of a healthy and 'complete ecosystem.' At the core of any thriving ecosystem is a water system that is supportive of all dimensions of the wildlife food chain. Therefore, the hope of the White River Watershed Project is that water quality improvement at the in stream level will concurrently work to help improve the presence of historic wildlife in the area.

1 Muncie Sanitary District's Fish Community Report
2 Muncie Sanitary District's Fish Community Report
3 Geist Reservoir/Upper Fall Creek WMP

INVENTORY

Endangered Species

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 11

According to the Indiana Department of Natural Resources, Division of Nature Preserves, there are 31 species that are endangered, threatened, or rare in Delaware County (Table 2.8). The state of Indiana uses the following definitions for classification of species:

Endangered: Any species whose prospects for survival or recruitment with the state are in immediate jeopardy and are in danger of disappearing from the state. This includes all species classified as endangered by the federal government which occur in Indiana. Plants currently known to occur on five or fewer sites in the state are considered endangered.[1]

Threatened: Any species likely to become endangered within the foreseeable future. This includes all species classified as threatened by the federal government which occur in Indiana. Plants currently known to occur on six to ten sites in the state are considered threatened.[2]

Rare: Plants and insects currently known to occur on from eleven to twenty sites.[3]

This includes 9 species of mollusks, 5 reptiles, 6 birds, 3 mammals, and 8 plants. Of these, four are federally listed as endangered: the Indiana Bat (Myotis sodalist), the Northern Riffleshell Rangiana (Epioblasma torulosa), the Clubshell (Pleurobema clava), and the Running Buffalo Clover (Trifolium stoloniferum).

1 Indiana County Endangered, Threatened and Rare Species List
2 Indiana County Endangered, Threatened and Rare Species List
3 Indiana County Endangered, Threatened and Rare Species List

TABLE 2.8: Delaware County Endangered Species

Species Name	Common Name	Federal	State	GRANK	SRANK
Mollusk: Bivalvia (Mussels)					
Alasmidonta viridis	Slippershell Mussel			G4G5	S2
Epioblasma turulosa rangiana	Northern Riffleshell	LE	SE	G2T2	S1
Lampsilis fasciola	Wavyrayed Lampmussel		SSC	G4	S2
Pleurobema clava	Clubshell	LE	SE	G2	S1
Pleurobema cordatum	Ohio Pigtoe		SSC	G3	S2
Ptychobranchus fasciolaris	Kidneyshell		SSC	G4G5	S2
Toxolasma lividus	Purple Lilliput		SSC	G2	S2
Toxolasma parvum	Lilliput			G5	S2
Villosa fabalis	Rayed Bean	C	SSC	G1G2	S1
Reptile					
Clemmys guttata	Spotted Turtle		SE	G5	S2
Clonophis kirtlandii	Kirtland's Snake		SE	G2	S2
Emydoidea blandingii	Blanding's Turtle		SE	G4	S2
Sistrurus catenatus catenatus	Eastern Massasauga	C	SE	G3G4	S2
Thamnophis butleri	Butler's Gartner Snake		SE	G4	S1
Bird					
Ardea herodias	Great Blue Heron			G5	S4B
Botaurus lentiginosus	American Bittern		SE	G4	S2B
Lanius ludovicianus	Loggerhead Shrike	NS	SE	G4	S3B
Nyctanassa violacea	Yellow-crowned Night-heron		SE	G5	S2B
Nycticorax nycticorax	Black-crowned Night-heron		SE	G5	S1B
Rallus eleganus	King Rail		SE	G4	S1B
Mammal					
Lynx rufus	Bobcat	NS		G5	S1
Myotis sodalis	Indiana Bat or Social Myotis	LE	SE	G2	S1
Taxidea taxus	American Badger			G5	S2
Vascular Plant					
Carex alopecoidea	Foxtail Sedge		SE	G5	S1
Glyceria borealis	Small Floating Manna-grass		SE	G5	S1
Matteuccia struthiopteris	Ostrich Fern		S	G5	S2
Silene regia	Royal Catchfly		ST	G3	S2
Trichostema dichotomum	Forked Bluecurl		SR	G5	S2
Trifolium stoloniferum	Running Buffalo Clover	LE	SE	G3	S1
Valerianella chenopodiifolia	Goose-foot Corn-salad		SE	G5	S1
Wisteria macrostachya	Kentucky Wisteria		SR	G5	S2
Forest - flatwoods central till plain	Central Till Plain Flatwoods		SG	G3	S2

SOURCE: Indiana County Endangered, Threatened and Rare Species List

INVENTORY

Exotic and Invasive Species

WMP - CHAPTER 2 - PART 1 - SECTION 2 - SUBSECTION 12

Exotic and invasive species are prevalent throughout the state of Indiana. Their presence throughout the watershed and their potential impacts on high quality natural communities and regional species are of concern to stakeholders.

Individuals are especially concerned about the prevalence of garlic mustard, Norway Maple, honeysuckle species, and invasive fish species such as carp on the White River. Honeysuckle, in particular, have been documented to increase surface erosion due to shade suppression of understory species.

Exotic species are defined as non-native species, while invasive species are those species whose introduction can cause environmental or economic harm and/or harm to human health. Thousands of dollars are spent annually controlling exotic and/or invasive species populations within both publicly-owned natural areas and on privately-owned land. The threat of exotic and invasive species is continuously evolving. [1]

Invasive plant species are a threat to natural areas. They displace native plants, eliminate food and cover for wildlife, and threaten rare plant and animal species. Many agencies and organizations have joined together to form the Invasive Plant Species Assessment Working Group (IPSAWG) to assess which plant species threaten natural areas in Indiana and develop recommendations regarding the use of that specific plant species. The IPSAWG's goal is for all partner agencies and organizations to utilize the species assessment when recommending or selling plants. [2]

In 2007, the State of Indiana established a task force to (1) study the economic and environmental impacts of invasive species in Indiana and (2) provide findings and recommendations on strategies for prevention, early detection, control and management of invasive species to minimize these impacts. [3]

1 Wabash River (Region of the Great Bend) WMP
2 Wabash River (Region of the Great Bend) WMP
3 Indiana DNR (http://www.in.gov/dnr/files/is_Task_force_list.pdf)

Nuisance Wildlife

WMP - CHAPTER 2 - PART 1 - SECTION 1 - SUBSECTION 13

Canada geese are a particular problem within the watershed, specifically for areas along the White River Liner Park System. As stated by the DNR, many people enjoy seeing Canada geese, but problems can occur when too many geese concentrate in one area. [1]

The Starpress, the local Muncie newspaper, has recently written op-ed pieces questioning the impacts that nuisance wildlife has on the community and overall health of streams. Canada geese can contribute to excessive fecal matter to streams (three geese equal the daily waste equivalent of one human) and their presence is an indicator of mismanaged stream habitat.

Typically, developers and landowners unknowingly cause the problem by creating ideal goose habitat. Geese are grazers and feed extensively on fresh, short, green grass. A permanent body of water adjacent to their feeding area will create the ideal stable environment for geese to set up residence, multiply and concentrate. Geese, including their young, also have a strong tendency to return to the same area year after year.[2]

The problem is further exacerbated when well-intentioned people purposefully feed geese. Artificial feeding of geese tends to concentrate larger numbers of geese in areas that under normal conditions would only support a few geese. Artificial feeding can also disrupt normal migration patterns and hold geese in areas longer than what would be normal. With an abundant source of artificial food available, geese can devote more time to locating nesting sites and mating. Artificial feeding can also concentrate geese on adjacent properties where their presence may not be welcomed, resulting in neighbor/neighborhood conflicts. [3]

Congregating geese can cause a number of problems. Damage to landscaping can be significant and expensive to repair or replace, while large amounts of excrement can render swimming areas, parks, golf courses, lawns, docks, and patios unfit for human use. Since geese are active grazers, they are particularly attracted to lawns and ponds located near apartment complexes, houses, office areas and golf courses. Geese can rapidly denude lawns, turning them into barren, dirt areas. Most of the problems in metropolitan areas occur from March through June during the nesting season. Breeding pairs begin nesting in late February and March. Egg-laying begins soon after nest construction is complete. [4]

1 Geist Reservoir/Upper Fall Creek WMP
2 Geist Reservoir/Upper Fall Creek WMP
3 Geist Reservoir/Upper Fall Creek WMP
4 Geist Reservoir/Upper Fall Creek WMP

SECTION THREE - SOIL CHARACTERISTICS

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

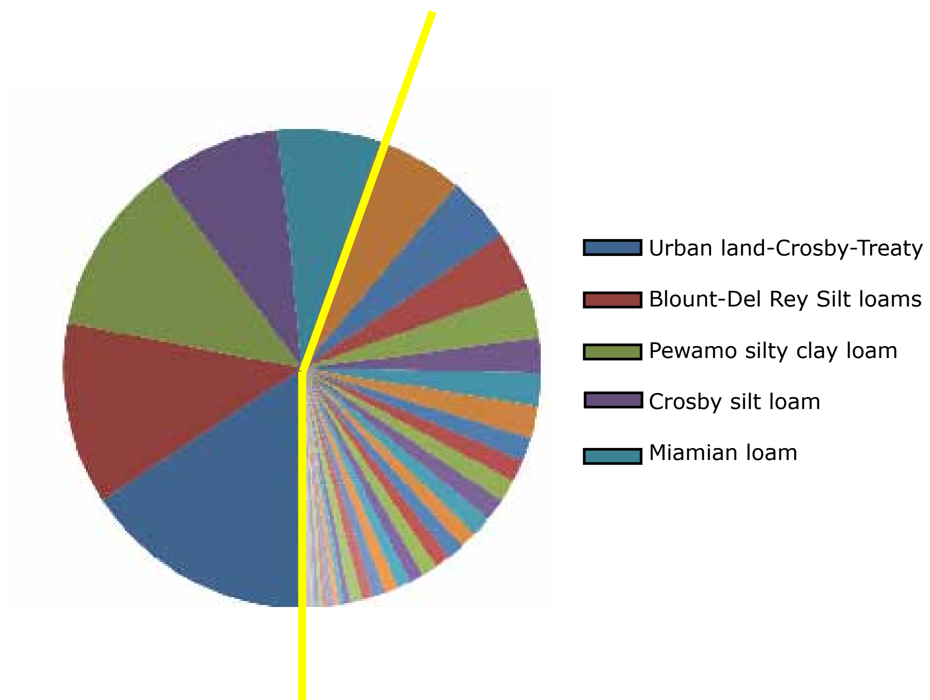
Soil Characteristics

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

There are hundreds of different soil types located within the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. These soil types are delineated into soil associations by their unique characteristics such as slope, drainage, and water. A soil association is a geographic area consisting of landscapes on which soils are formed. Soil associations are groups of soil types that generally share one or more common characteristics, such as parent material or drainage capability. The watershed is covered by 44 core soil types with six associations individually accounting for 55% of the total watershed area. The Urban-Crosby, Blount, Pewamo, Crosby, and Miamian soils associations make up the largest percentage of the watersheds. These soil types will be referenced as the Dominant Soil Associations. These main soil types have limited use for septic systems, due to a higher percentage of septic failure in areas with these soil types. The Treaty soil type is the only soil that is considered hydric (see hydric). Some specific soil characteristics of interest, including hydric soils, highly erodible soils, and septic limitations are detailed in later sections.[1]

These soil associations provide general characteristics for the specific soil association, and can be used for conceptual locations of best management practices. Information pertaining to the clay content, permeability and even groundwater characteristics are helpful when identifying locations that are feasible for infiltration practices or other best management practices to improve the water quality within the watershed. It should be noted that soil tests in these specific areas should be performed for more project specific detailed information.

The data source for the Soil Association Map is from the Department of Agriculture Soil Associations in Indiana GIS shape file with a published date of December 2002.



CHA. 2.7 Dominant Soil Associations

1 Web Soil Survey

Dominant Soil Associations
WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 2

Urban land-Crosby-Treaty complex
These soils accompany 3205.919 acres, with 16% predominantly urban. Urban soil types are those that have undergone major alterations from human activity. They are typically covered with parking lots and buildings. These soils take on the characteristics of their parent soil, but modification from humans has a major affect on their characteristics, which varies from site to site (USDA, 2004). Urban soils are somewhat poorly drained, but may be prime farmland if drained.[1]

Blount-Del Rey silt loams
Both of these soils are prime farmland if drained, and both are very limited in their septic use. The Blount types are somewhat poorly drained, non hydric, and are subject to slight erosion. Similar soils: Soils that have less than 35 percent clay in the subsoil, Soils in which the depth to dense till is more than 48 inches and in areas of the Blount soil; soils that have stratified outwash deposits in the profile. Dissimilar soils: the poorly drained Pewamo soils in open depressions; the very poorly drained Milford-till substratum-soils in closed depressions; the moderately well drained, moderately eroded glynwood soils on microhighs which are somewhat poorly drained and prime farmland if drained.[2]

Pewamo silty clay loam
Pewamo soils are good as farmland if drained, and are very limited in their septic use. The Pewamo types are poorly drained, hydric, and also suffer from slight erosion. Similar soils: soils that have a surface layer that is less than 10 inches thick and soils that have 8 to 15 inches of lighter colored overwash. Dissimilar soils: the somewhat poorly drained Blount and Del Rey soils on summits); the very poorly drained Millgrove soils in microlows of open depressions; the poorly drained Pella soils in closed depressions, The very poorly drained Milford, till substratum, soils in closed depressions; the very poorly drained Muskego-undrained- soils in closed depressions; and areas of undrained mineral soils in closed depressions, mostly in woodlands.[3]

Crosby silt loam
Similar soils: soils that have less than 35 percent clay in the argillic horizon; soils in which the depth to dense till is more than 40 inches; and soils that have layers of outwash or lacustrine, deposits overlying the till. Dissimilar soils: the moderately well drained Williamstown soils on microhighs on summits; the somewhat poorly drained Del Rey soils in microlows on summits; the poorly drained Treaty soils in open depressions; and the moderately well drained Miamian soils on gently sloping shoulders (Soil Survey of Delaware County Indiana. US Department of Agriculture).[4]

Miamian loam
Similar soils: soils that have less than 35 percent clay in the subsoil; soils that have 12 to 36 inches of outwash overlying the till; soils in which the depth to dense till is more than 40 inches. Dissimilar soils: the well drained Belmore soils on gently sloping shoulders; the well drained Mount Pleasant soils on gently sloping shoulders; the somewhat poorly drained Crosby soils on nearly level summits; and the moderately well drained, severely eroded Losantville soils on backslopes. (USGS)

1 Web Soil Survey
2 Web Soil Survey
3 Web Soil Survey
4 Web Soil Survey

INVENTORY

Dominant Soil Associations

WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 4

According to the USGS soil survey, there are over forty-four soils types in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. Of these types, eight constitute 69% of the Subwatersheds. These eight types are represented in Table 2.9 and represented collectively as yellow in MAP 2.21. All other soils types are represented collectively as purple and presented on the following page in Table 2.10.

Soils are also represented in MAP 2.22 according to their NRCS Hydrologic Soil Groups Classification. These classifications are based on the soil's runoff potential and are grouped as A, B, C and D. A's generally have the smallest runoff potential and Ds the greatest.

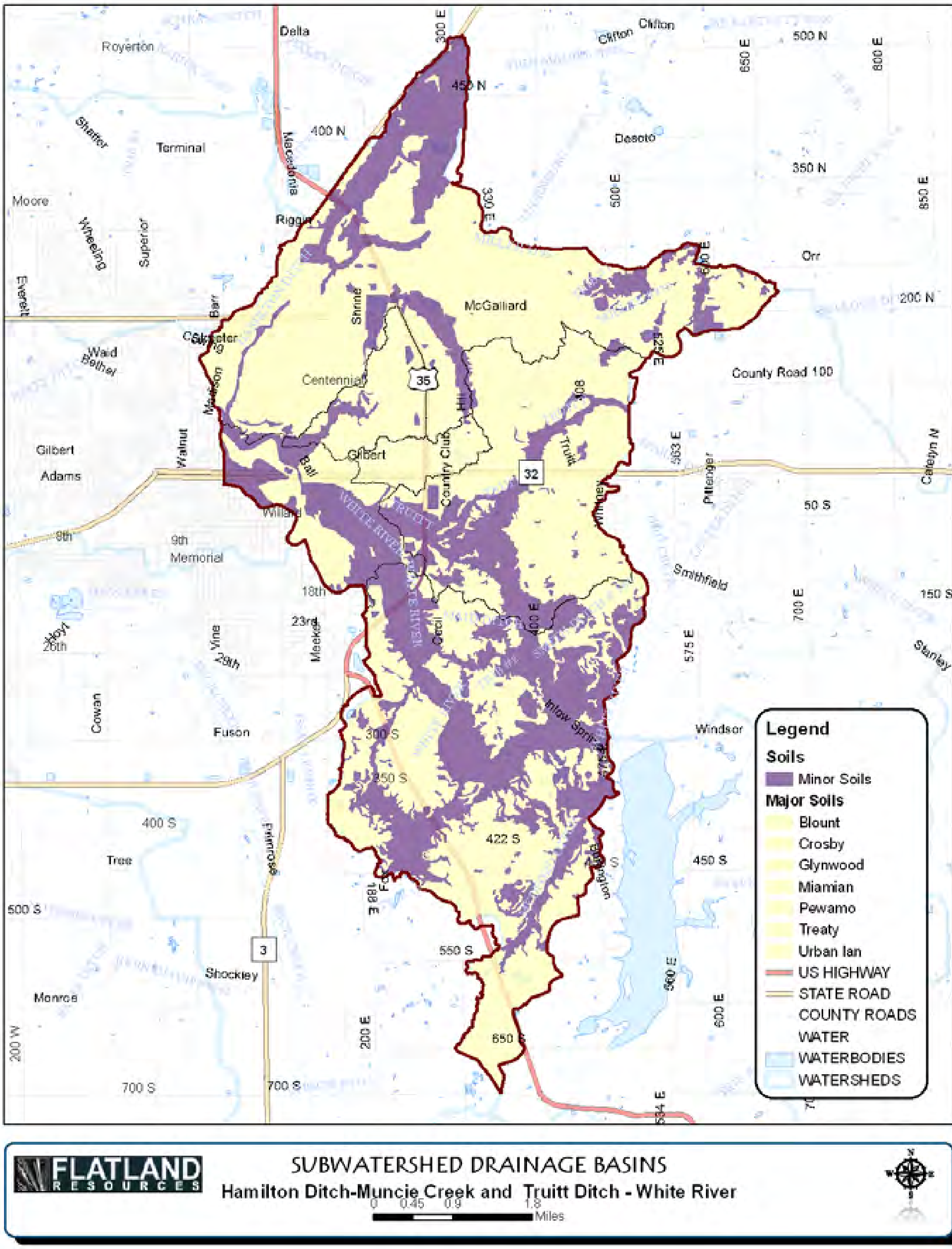
> "Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
>
> Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
>
> Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
>
> Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material."[1]

TABLE 2.9: Dominant Soil Associations

Abbrv.	Soil Name	Acres	%
UccA	Urban land-Crosby-Treaty complex, 0 to 2 percent slopes	3205.919	16%
BmlA	Blount-Del Rey silt loams, 0 to 1 percent slopes	2509.408	12%
PkkA	Pewamo silty clay loam, 0 to 1 percent slopes	2410.159	12%
CudA	Crosby silt loam, 0 to 2 percent slopes	1728.012	8%
MoeB2	Miamian loam, 1 to 5 percent slopes, eroded	1424.959	7%
GlrB2	Glynwood silt loam, 1 to 4 percent slopes, eroded	1185.787	6%
ThrA	Treaty silty clay loam, 0 to 1 percent slopes	910.9704	4%
BltA	Blount silt loam, 0 to 2 percent slopes	801.3442	4%

SOURCE: Web Soil Survey

1 Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55.

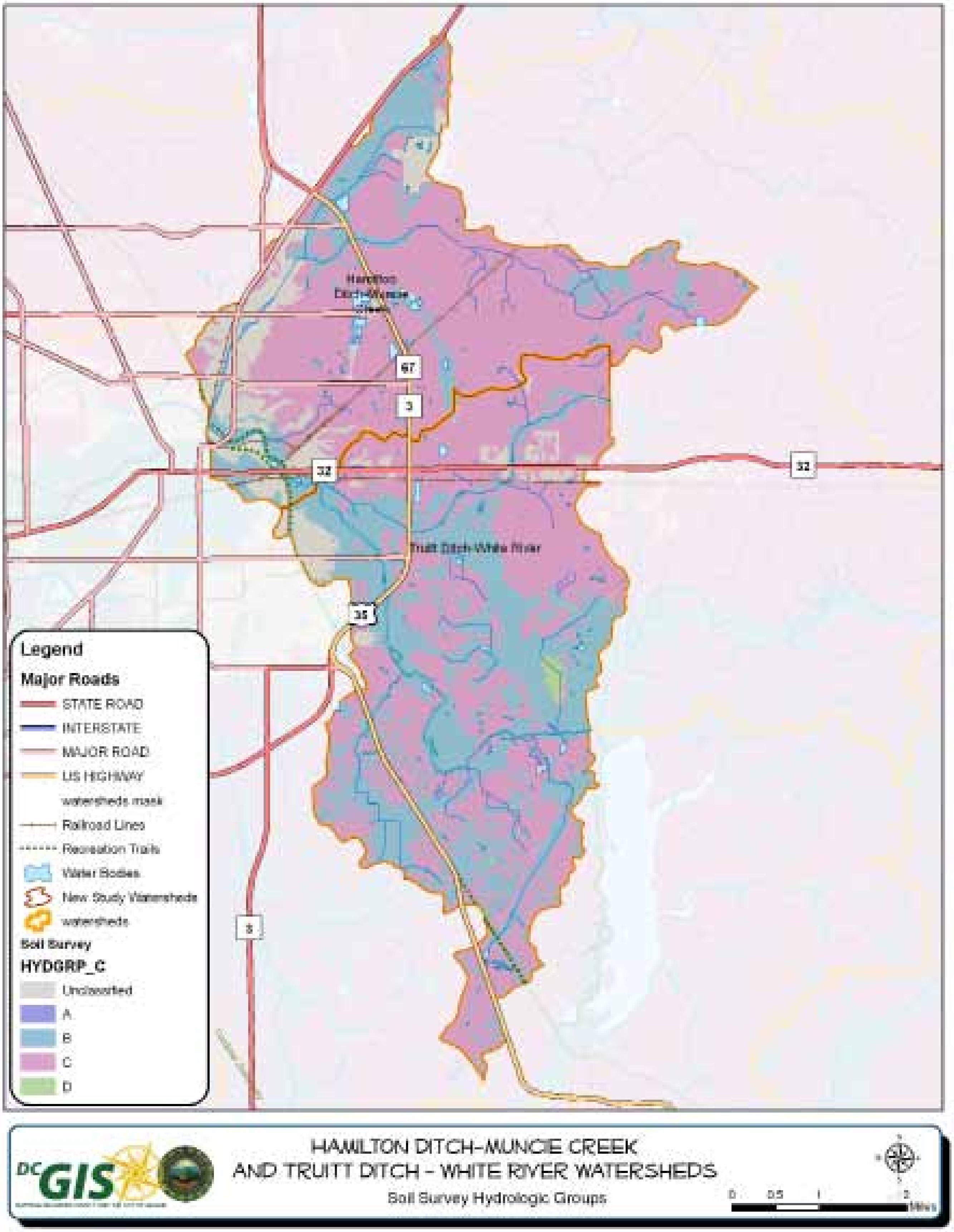


MAP. 2.21 Dominant Soil Associations

INVENTORY

TABLE 2.10: Inventory of Minor Soil Groups			
Abbrv.	Soil Name	Acres	%
MryA	Millgrove silty clay loam, 0 to 1 percent slopes	693.0557	3%
ReyA	Rensselaer loam, 0 to 1 percent slopes	471.4656	2%
FgoB2	Fox-Muncie complex, 2 to 6 percent slopes, eroded	455.7407	2%
MecA	Martinsville loam, 0 to 2 percent slopes	452.2533	2%
BdlC2	Belmore loam, 6 to 12 percent slopes, eroded	317.5489	2%
MphA	Milford silty clay loam, stratified sandy substratum, 0 to 1 percent slopes	310.0925	2%
Uam	Udorthents, loamy	303.6377	1%
DdxA	Digby-Haney silt loams, 0 to 1 percent slopes	302.8224	1%
MvxA	Mountpleasant silt loam, 0 to 2 percent slopes	275.7508	1%
FexB2	Fox loam, 2 to 6 percent slopes, eroded	243.4605	1%
PgaA	Pella silty clay loam, 0 to 1 percent slopes	227.1152	1%
ObxA	Ockley silt loam, 0 to 2 percent slopes	215.8506	1%
SnlA	Southwest silt loam, 0 to 1 percent slopes	215.5479	1%
W	Water	196.5221	1%
GlnAH	Gessie-Eel silt loams, 0 to 1 percent slopes, frequently flooded, brief duration	184.3782	1%
LshC3	Losantville clay loam, 5 to 10 percent slopes, severely eroded	183.6972	1%
RrwB	Rawson loam, 1 to 5 percent slopes	165.4414	1%
SmsAH	Sloan silt loam, 0 to 1 percent slopes, frequently flooded, brief duration	162.7757	1%
Pmg	Pits, gravel	157.6533	1%
RroAH	Ross-Lash loams, 0 to 1 percent slopes, frequently flooded, brief duration	91.00208	0%
HtbAu	Houghton muck, undrained, 0 to 1 percent slopes	75.23479	0%
MvbC3	Morley-Mississinewa clay loams, 5 to 10 percent slopes, severely eroded	74.22328	0%
CdgC3	Casco sandy clay loam, 6 to 15 percent slopes, severely eroded	71.00009	0%
SgmAH	Shoals silt loam, 0 to 1 percent slopes, frequently flooded, brief duration	68.21214	0%
LneAW	Lickcreek silt loam, 0 to 3 percent slopes, occasionally flooded, very brief duration	58.80764	0%
LdfAH	Lash loam, 0 to 1 percent slopes, frequently flooded, brief duration	55.29421	0%
SvsE2	Strawn-Belmore loams, 15 to 30 percent slopes, eroded	36.78916	0%
EdxB2	Eldean silt loam, 2 to 6- percent slopes, eroded	27.59103	0%
BdsAN	Benadum silt loam, drained, 0 to 1 percent slopes	23.01658	0%
Pml	Pml—Pits, quarry	21.04004	0%
MorA	Milford mucky silty clay, pothole, 0 to 1 percent slopes	14.92274	0%
LshD3	LshD3—Losantville clay loam, 10 to 15 percent slopes, severely eroded	14.15701	0%
MumC2	Morley silt loam, 5 to 10 percent slopes, eroded	13.2358	0%
GlyB3	Glynwood-Mississinewa clay loams, 2 to 6 percent slopes, severely eroded	12.93883	0%
BdhAH	Bellcreek silty clay loam, 0 to 1 percent slopes, frequently flooded, brief duration	6.123329	0%
MwzAU	Muskego muck, undrained, 0 to 1 percent slopes	1.919829	0%

SOURCE: Web Soil Survey



MAP. 2.22 Hydric Soil Groups

INVENTORY

Highly Erodible Soils

WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 5

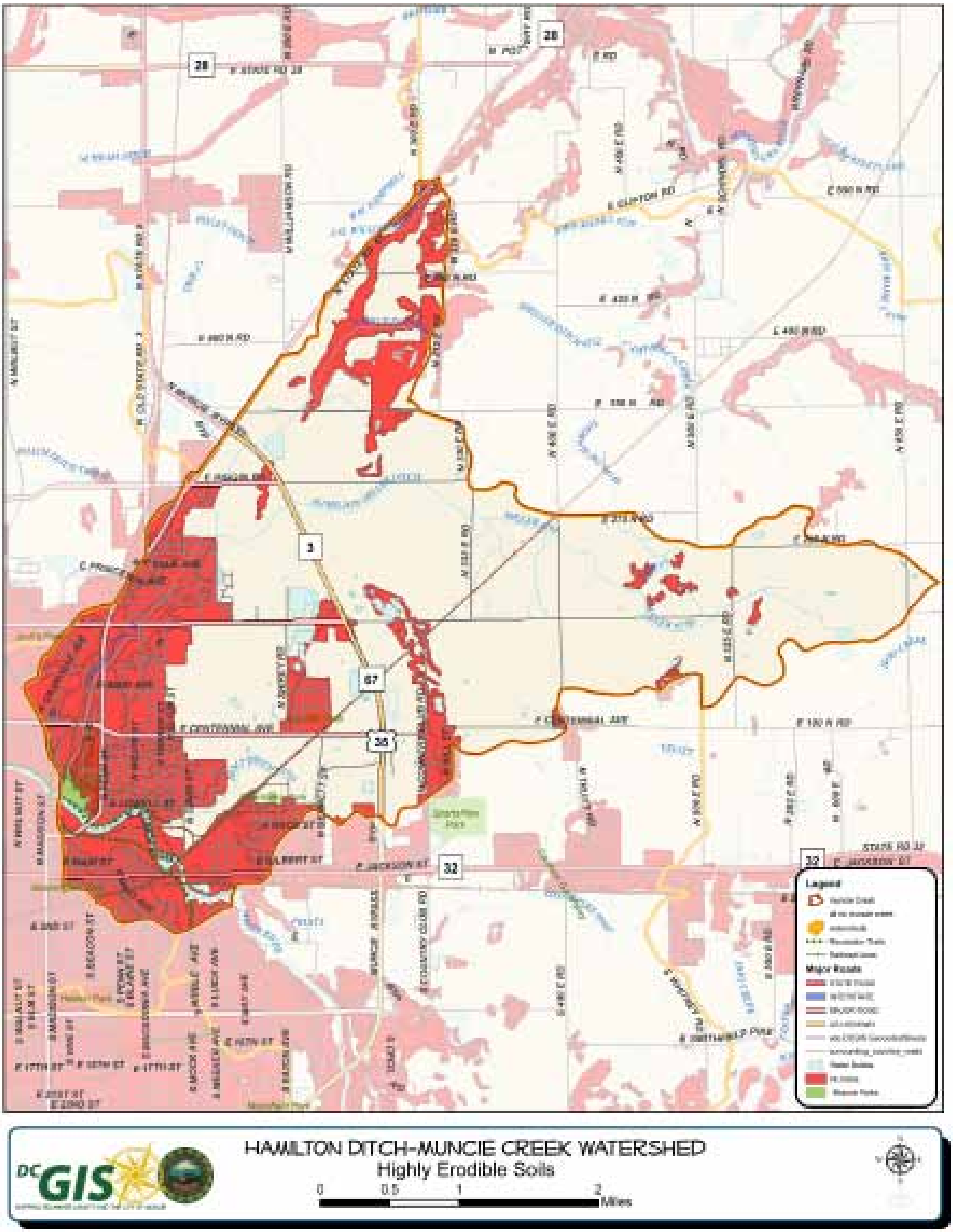
Soils that are transported through storm water runoff across the landscape have negative impacts on ecosystems and result in degraded water quality, limited recreational use, and impaired aquatic habitat and health. Soils carry attached nutrients, pesticides, and herbicides. These can result in impaired water quality by increasing plant and algae growth, killing aquatic life, or damaging water quality. [1]

The NRCS uses soil texture and slope to classify soils into those that are considered highly erodible, potentially highly eroded, and non-erodible. The classification is based on an erodibility index which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss or tolerance value (T value). The T value is the maximum annual rate of erosion that occurs for a particular soil type without causing a decline in long-term productivity. Potentially highly erodible soil determinations are based on the slope steepness and length in addition to the erodibility index value.[2]

The actual potential for these soils to erode is based on the slope steepness and length of slope; erodibility can only be determined through field investigations.

The United States Department of Agriculture (USDA) and the National Resources Conservation Service (NRCS) have begun to update the 1985 survey of soil types. However, due to a policy decision, the Highly Erodible Soils data has not been updated. This has led WRWP planners to incorporate the old HES data into the new soil units through the GIS data. As such, these do not constitute official HEL (HES) determinations for Farm Bill Programs.

1 Tom Reeve, White River Watershed Project, White River Watershed Project
2 Tom Reeve, White River Watershed Project, White River Watershed Project



MAP. 2.23 Highly Erodible Soils

Highly Erodible Soils (cont.)

WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 6

Erosion is a natural process within stream ecosystems; however, excessive erosion negatively impacts the health of the watershed. Erosion throughout the watershed increases sedimentation of the streambeds, which impacts the quality of habitat for fish and other organisms. As water flows over land and enters the stream it carries pollutants and other nutrients that are attached to the sediment. Sediment suspended in the water blocks light needed by plants for photosynthesis and clogs respiratory surfaces of aquatic organisms. [1]

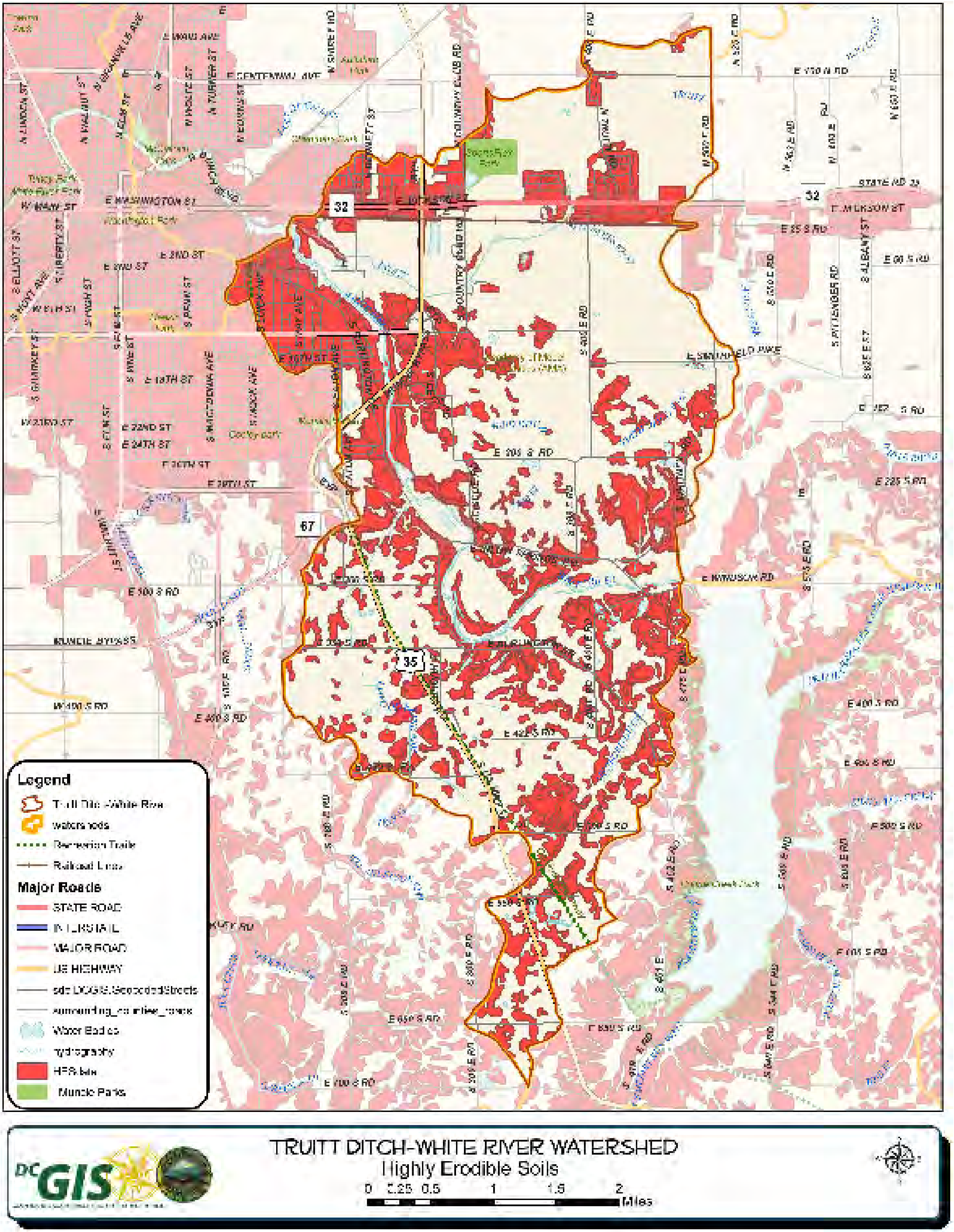
Therefore, erosion also impacts water quality as it increases nutrients and decreases water clarity. Highly erodible land (HEL) and potentially highly erodible soils in the Subwatersheds are mapped in MAP 2.23 and MAP 2.24. [2]

Highly erodible soils are also especially susceptible to the eroding forces of wind and water. Wind erosion is common in flat areas where vegetation is sparse or where soil is loose, dry, and finely granulated. Wind erosion damages land and natural vegetation by removing productive top soil from one place and depositing it in another. [3]

In areas with highly erodible soils, special care must be taken to insure that land use practices do not result in severe wind or water erosion. Although natural erosion cannot be prevented, the effects of runoff can be moderated so that it does not diminish the health of the watershed. There are no specific requirements for developments within highly erodible soils. However, IDEM's Rule 5 regulates storm water discharges during construction where temporary best management practices are required (until construction activities are completed and the site has been stabilized) as to not impact receiving waters with sediment.[4] Additionally, no-till practices (and other BMPs) in the agricultural community has been documented to reduce sheetflow and rill erosion.

Of a total of 8,602 acres in the Hamilton Ditch-Muncie Creek watershed, 2,393 of them (27.8%) have highly erodible soils (MAP 2.23). Of a total of 11,781 acres in the Truitt Ditch-White River watershed, 3,662 of them (31.0%) have highly erodible soils (MAP 2.24). Depending on the type of land use associated with these areas, varying NPS water pollution issues can become issues of concern.

1 Geist Reservoir/Upper Fall Creek WMP
2 Geist Reservoir/Upper Fall Creek WMP
3 Geist Reservoir/Upper Fall Creek WMP
4 Geist Reservoir/Upper Fall Creek WMP



MAP. 2.24 Highly Erodible Soils

Hydric Soils

WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 7

Hydric soils are soils that, due to prolonged hydration, change on a chemical-biological level through natural processes. Once a soil takes on hydric characteristics, it retains those characteristics even after the soil is drained. [1] The changes in the soils are not easily reversed when drained and therefore typically can be identified as hydric soils post drained. A majority of hydric soils found in the watershed are located along river corridors in the non urban areas. Because these soils are considered to have developed under wetland conditions, they are a good indicator of historic wetland locations.[2]

Legal drains (controlled by the County drainage board), agricultural tilling (controlled by Producers) and urban stormwater systems have drained wetlands and continue to keep wetlands drained.

Hydric soils that have been converted to other uses should be capable of being restored to wetlands. However, a large majority of the soils in the watershed have been drained for either agricultural production or urban development. Removing the subsurface drainage systems would allow for restoration of these wetland areas. [3]

The three essential characteristics of wetlands are hydrophytic vegetation, hydric soils, and wetland hydrology. Criteria for each of the characteristics must be met for areas to be identified as wetlands. Undrained hydric soils that have natural vegetation should support a dominant population of ecological wetland plant species. [4]

Of the 8,602 acres in Muncie Creek Watershed, 2,512 acres are considered to contain hydric soils (29.0%). In general, hydric soils in the Muncie Creek Watershed surround the waterways (MAP 2.25). Aerial orthophotographs show large areas of hydric soils in the upper reaches of the watershed as evidenced by the presence of darker than normal soils. These findings are typical of the area; Delaware County has a large number of agricultural areas that have high water tables, and shows evidence of being a wetland in the past.[5]

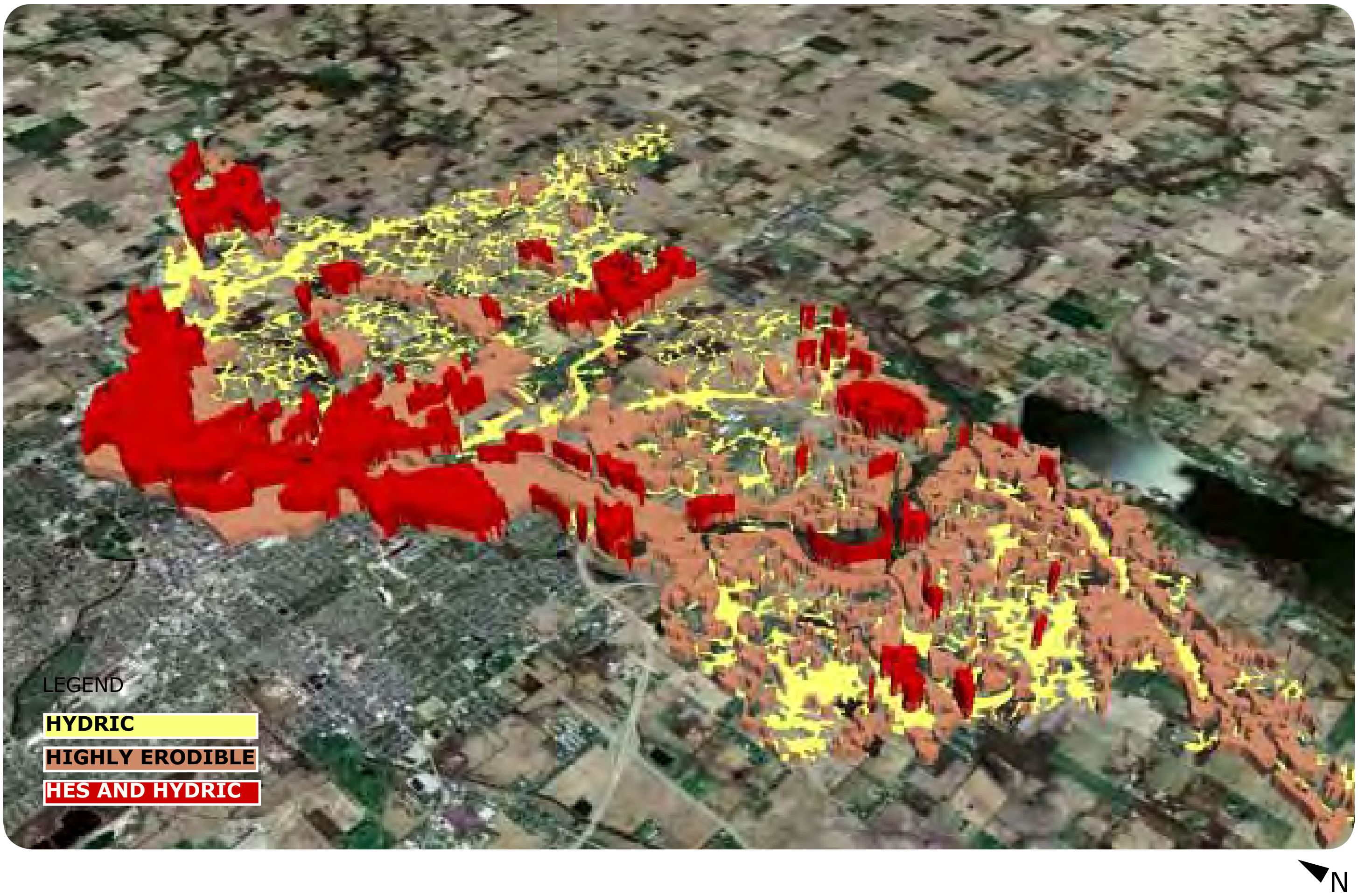
Out of the 11,781 acres in Truitt Ditch Watershed, 3,011 acres are considered to have hydric soils (25.6%). In general, hydric soils in the Truitt Ditch watershed follow the paths of the existing waterways (MAP 2.26). Additionally, there is a major section of hydric soils in the northern part of the watershed that appears to follow the original path of what is now called Truitt Ditch. Aerial views of the area show soils in a drained agricultural field that is dark in color. Additional areas of hydric soils are located in the southern portion of the watershed.[6]

1 Geist Reservoir/Upper Fall Creek WMP
2 Tom Reeve, White River Watershed Project
3 Geist Reservoir/Upper Fall Creek WMP
4 Geist Reservoir/Upper Fall Creek WMP
5 Tom Reeve, White River Watershed Project
6 Tom Reeve, White River Watershed Project

MAP. 2.25 Hydric Soils

HES and Hydric Soils

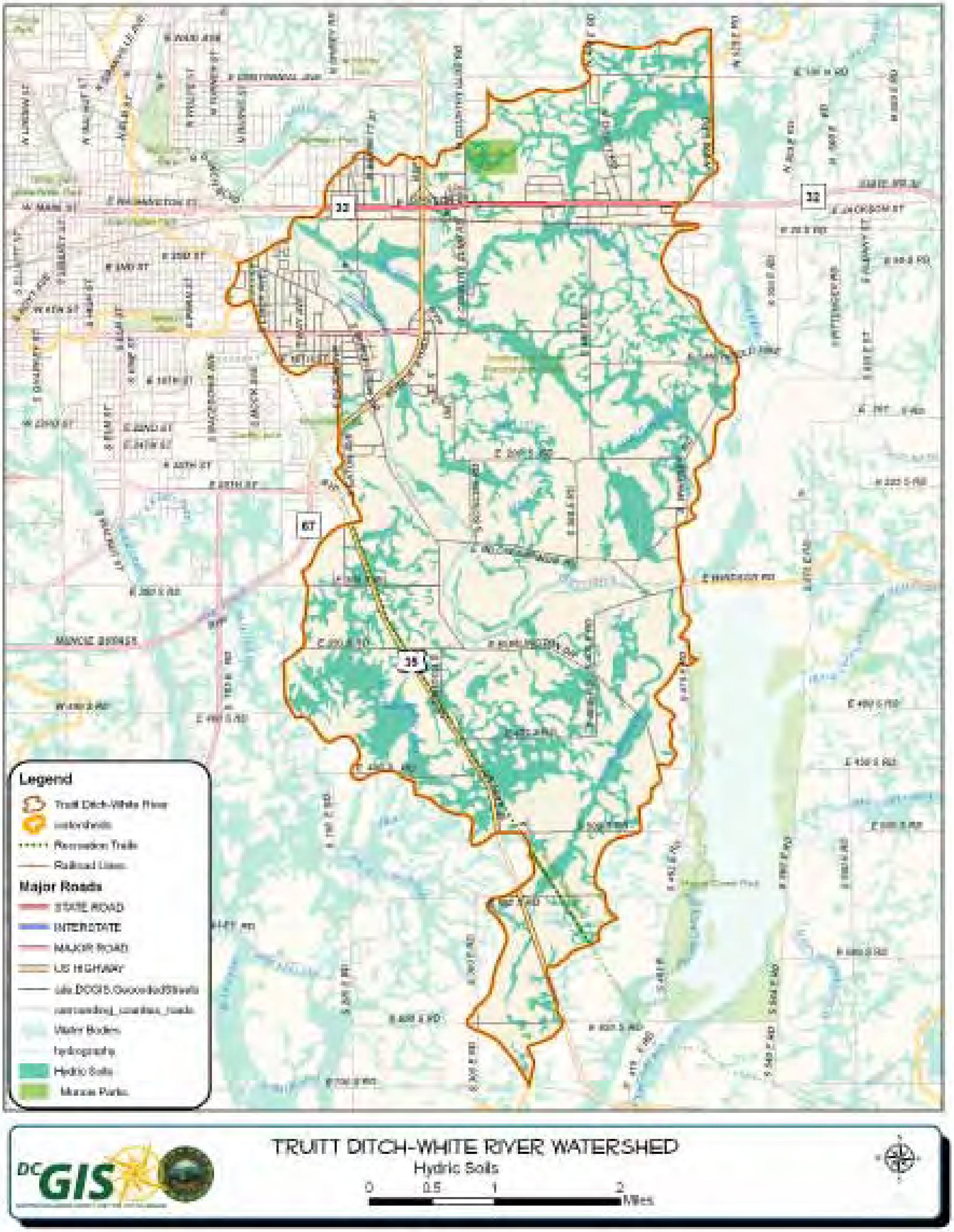
WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 8



DIA. 2.2 HES and Hydric Soil Relationship (see description below)

The White River Watershed Project stakeholders are concerned about both Hydric and Highly Erodible Soils. The above diagram compares the location of Highly Erodible Soils (salmon) and Hydric soils (yellow). The red areas designate soils that are considered both hydric and highly erodible. These types of comparisons aid the WRWP in determining critical areas for sediment.

Since hydric soils are typically soil types that were once wetlands (and sometimes also riparian zones) they are important to preserve and restore when feasible (i.e. when both environmental and agronomy needs are met). Restored wetlands along riparian zones help prevent the flow of HES soil from agricultural and urban land into river systems.



MAP. 2.26 Hydric Soils

Waste Water Treatment

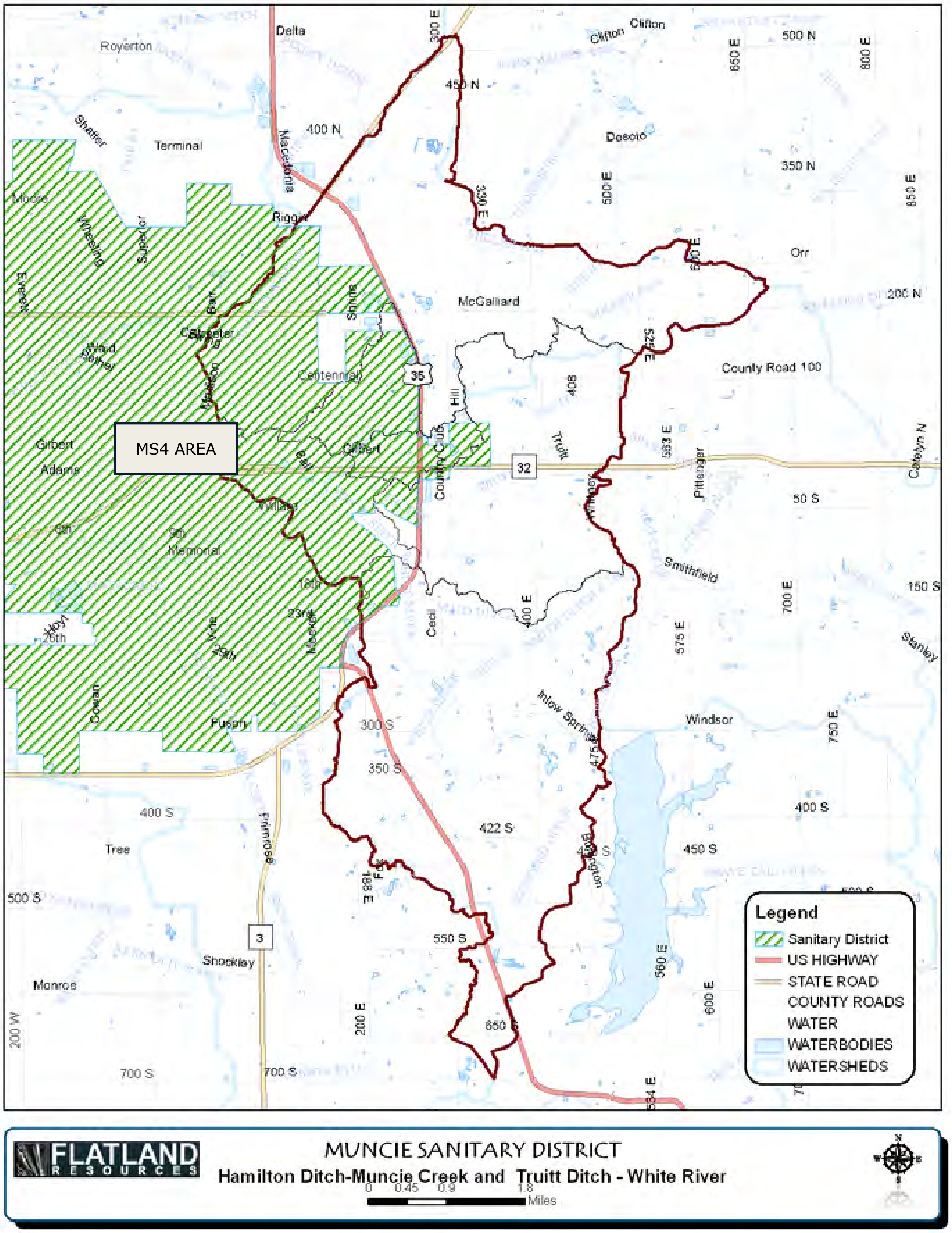
WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 9

"The Muncie Sanitary District owns and operates a 24 MGD activated sludge water pollution control facility. The facility treats domestic, commercial & industrial wastewater to reduce biochemical oxygen demand (BOD), total suspended solids (TSS), nitrogen ammonia and E. coli prior to discharge into the receiving stream, the West Fork of the White River." [1]

"The main discharge outfall to the receiving stream is designated as outfall #21A. A secondary outfall used during excessive river levels or during maintenance to the tertiary facility is designated as outfall #30A. Treatment includes screening, grit removal, primary settling, aerobic activated sludge nitrification, final clarification/settling, & final tertiary filtration through mono media filters. Disinfection with gaseous chlorine and dechlorination with sulphur dioxide follows final filtration from April to November. In addition to the processes described above, sludge dewatering takes place with belt presses following anaerobic digestion/sludge stabilization. Ultimate sludge disposal is completed by transporting the dewatered sludge to a sanitary landfill." [2]

IMG. 2.1 Muncie Water Pollution Control Facility, MWPCF

1 Muncie Water Pollution Control Facility
2 Muncie Water Pollution Control Facility



MAP. 2.27 MS4 Relationship to Subwatersheds

Unsewered Areas
WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 10

Throughout Indiana, households depend upon septic tank absorption fields to treat wastewater. Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. The only part that is evaluated is soil depths between 24 and 60 inches.

Septic waste treatment systems require soil characteristics and geology that allow gradual seepage of wastewater into the surrounding soils. (The key chemical processes governing the movement of particles from the effluent through the soil are ion exchange, adsorption, and chemical precipitation.[1]) Seasonal high water tables, shallow compact till and coarse soils present limitations for septic systems. While system design (i.e. perimeter drains, mound systems or pressure distribution) can often overcome these limitations sometimes, the soil characteristics prove to be unsuitable for any type of traditional septic system. Heavy clay soils require larger (and therefore more expensive) absorption fields; sandier, well-drained soils are often suitable for smaller, more affordable gravity-flow trench systems. [2]

Several unsewered areas were identified within the watershed. These areas generally consist of relatively concentrated housing units outside of the sanitary district boundaries. School buildings should be particularly observed, due to a high density of usage at these facilities throughout the year. There are many pollutants that enter the water system as the result of failed septic systems:

Nitrogen: The organic form of nitrogen is converted to the ammonium form due to anaerobic conditions in the septic tank.

Chlorides: Chlorides are very common and are naturally present in surface and groundwater, and are also found in wastewaters.

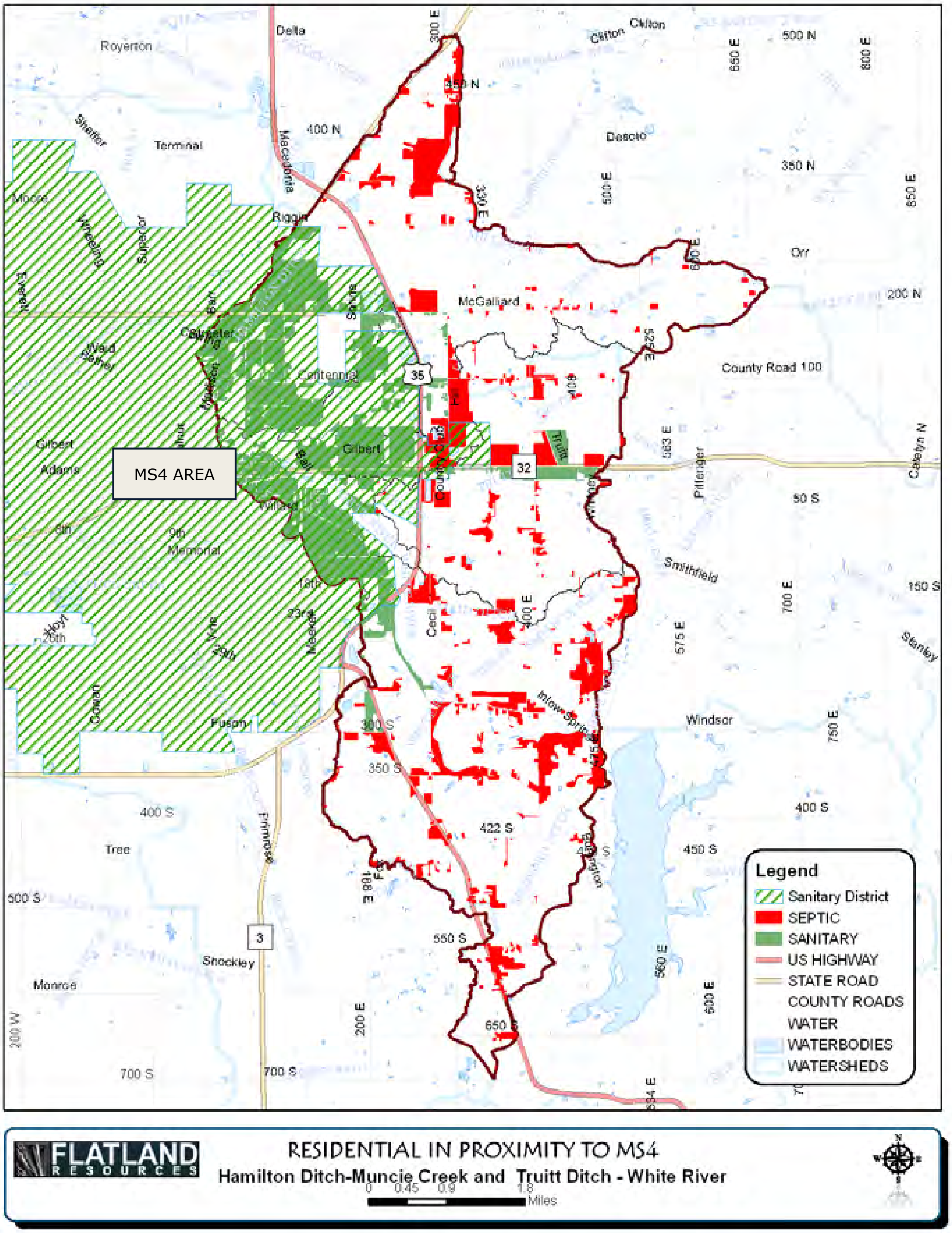
Phosphorus: Most of the influent phosphorus in the organic and phosphate forms are converted to soluble orthophosphate by the anaerobic process occurring in the septic tank. Usually phosphorus does not reach the groundwater because it is strongly retained in soils.

Metals: Metals in the effluents from septic tank systems may be responsible for the contamination of shallow water supply sources, especially where there is a high groundwater table.

Microorganisms: Microorganisms do not usually contaminate groundwater sources. The main limitation to movement of microbes through the soil is the physical filtration of bacteria and other microbes. This factor usually limits the travel distances. Soil conditions with limited nutrients and antagonistic organisms' secretions also determine the travel distances.

Septage: Septage is the mixture of sludge, fatty materials, and wastewater present in septic tanks. The septage is periodically pumped out by licensed companies. The concentrations of possible pollutants is high in septage. Septage has also been found to harbor disease-causing organisms. [3]

1 The Elkhart River Watershed Management Plan
2 Tom Reeve, White River Watershed Project,
3 Virginia Tech Department of Enviornmental Engineering



MAP. 2.28 Residential (red) not on Sanitary

Septic Tank Suitability

WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 11

Seven soil characteristics are utilized to determine suitability for on-site septic treatment including: position in the landscape, soil texture, slope, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table. Septic tanks require soil characteristics that allow for gradual movement of wastewater from the surface into the groundwater. High water tables, shallow soils, compact till, and coarse soils all limit soil's abilities in their use as septic tank absorption fields. Specific system modifications are necessary to adequately address soil limitation. However, in some cases, soils are too poor for treatment and therefore prove inadequate for use in septic tank absorption fields. [1]

Soil ratings are determined by the NRCS. The ratings are both verbal and numerical. Each soil series is placed in one of three categories: severely limited, moderately limited, and slightly limited.

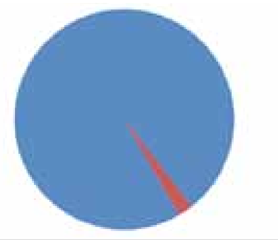
Severe limitations delineate areas whose soil properties present serious restrictions to the successful operation of a septic tank tile disposal field. Using soils with a severe limitation increases the probability of the system's failure and increases the costs of installation and maintenance.

Areas designated as having moderate limitations have soil qualities which present some drawbacks to the successful operation of a septic system. Correcting these restrictions will increase the system's installation and maintenance costs[2].

Slight limitations delineate locations whose soil properties present no known complications to the successful operation of a septic tank tile disposal field. Use of soils that are rated moderately or severely limited generally require special design, planning, and/or maintenance to overcome limitations and ensure proper function. [3]

Severely limited soils cover a majority of the watershed. In total, nearly 19,500 acres (of 20,000 acres) of the watershed is covered by soils that are considered severely limited for use in septic tank absorption fields. 500 acres are moderately to slightly limited (Chart 2.8).

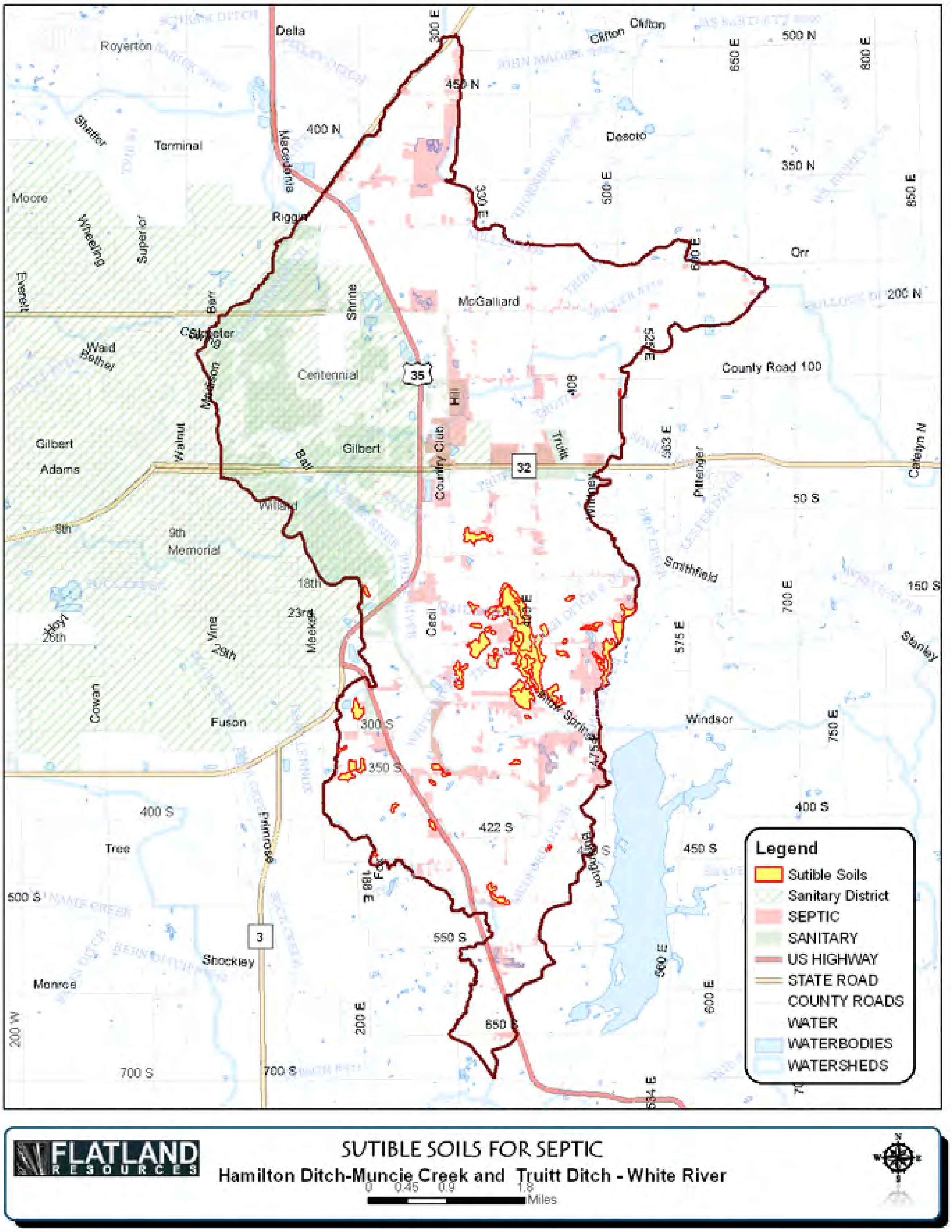
CHA. 2.8 Percent of suitable soils



CHA. 2.9 <5% of Septic tanks on Suitable soils

TABLE 2.11: Acres of Soils Suitable for septic system (MecA only soils suitable according to USGS soil mapper)		
Soil Type	Name	Acres
All Soil Types	Varies	19,924
MecA	Martinsville loam, 0 to 2 percent slopes	452
SOURCE: ArcGIS Indianamap.org		

1 Wabash River (Region of the Great Bend) WMP
2 The valleys of the East Branch of LeBoeuf Creek
3 Wabash River (Region of the Great Bend) WMP



MAP. 2.29 Soils suitable for septic absorption fields

Septic Tank Failure

WMP - CHAPTER 2 - PART 1 - SECTION 3 - SUBSECTION 12

Because so little of the Subwatersheds are suitable for septic systems, watershed stakeholders are concerned. They are especially concerned about the perceived lack of maintenance associated with septic tanks, the use of soils that are not suited for septic treatment, and the presence of straight pipe systems within the watershed.

"The septic disposal system is considered failing when the system exhibits one or more of the following: the system refuses to accept sewage at the rate of design application thereby interfering with the normal use of plumbing fixtures; effluent discharge exceeds the absorptive capacity of the soil, resulting in ponding, seepage, or other discharge of the effluent to the ground surface or to surface waters; effluent is discharged from the system causing contamination of a potable water supply, ground water, or surface water." [1]

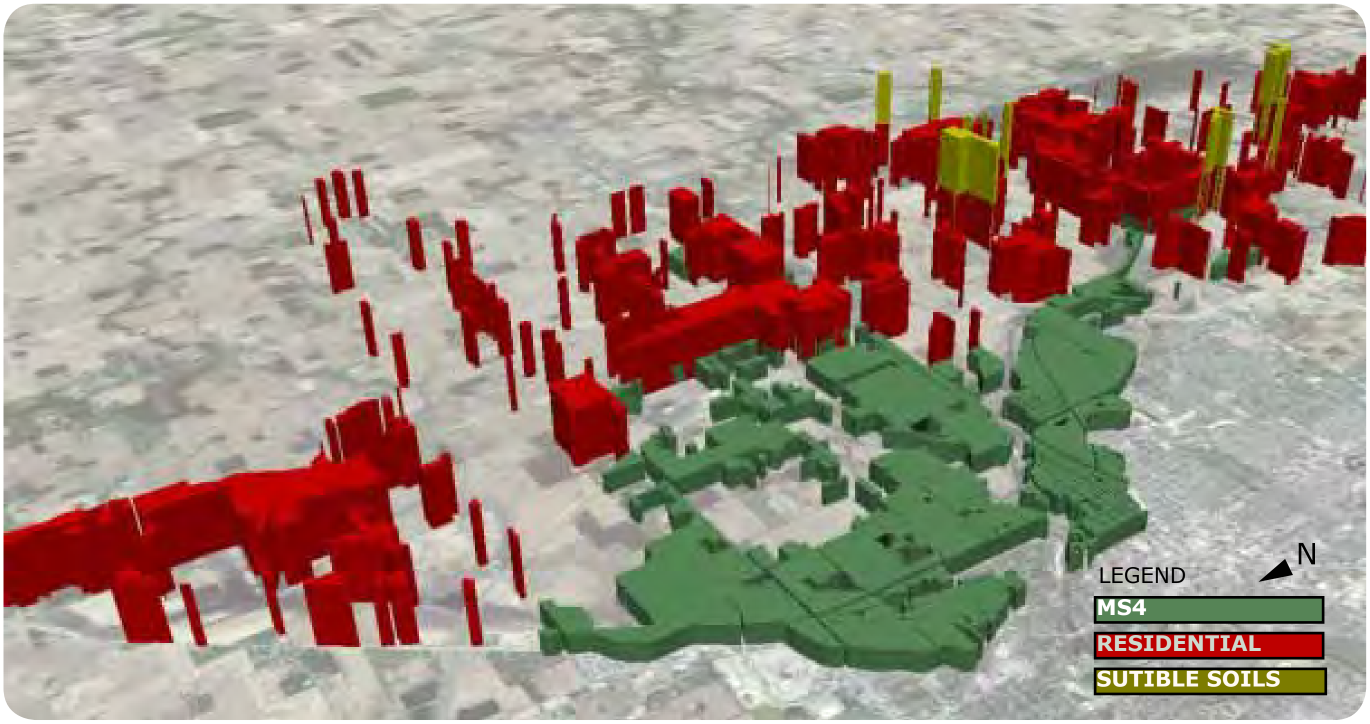
"Prior to 1990, residential homes on 10 acres or more of land --and at least 1,000 feet from a neighboring residence --did not have to comply with any septic system regulations. A new septic code in 1990 fixed this loophole but many of these homes still do not have functioning septic systems. The septic effluent from many of these older homes discharges into field tiles and eventually flows to open ditches. Unfortunately, the high cost of septic repair (typically from $5,000 to $15,000) has been an impediment to modernization." [2]

Current regulations address these issues and require that individual septic systems be examined for functionality. It is estimated that 76,650 gallons of untreated wastewater is expelled in the state of Indiana annually. The true impact of these systems on the water quality in the Subwatersheds cannot be determined without a complete survey of systems [3] as individual septic sites must be evaluated on a case-by-case basis to determine septic system suitability.

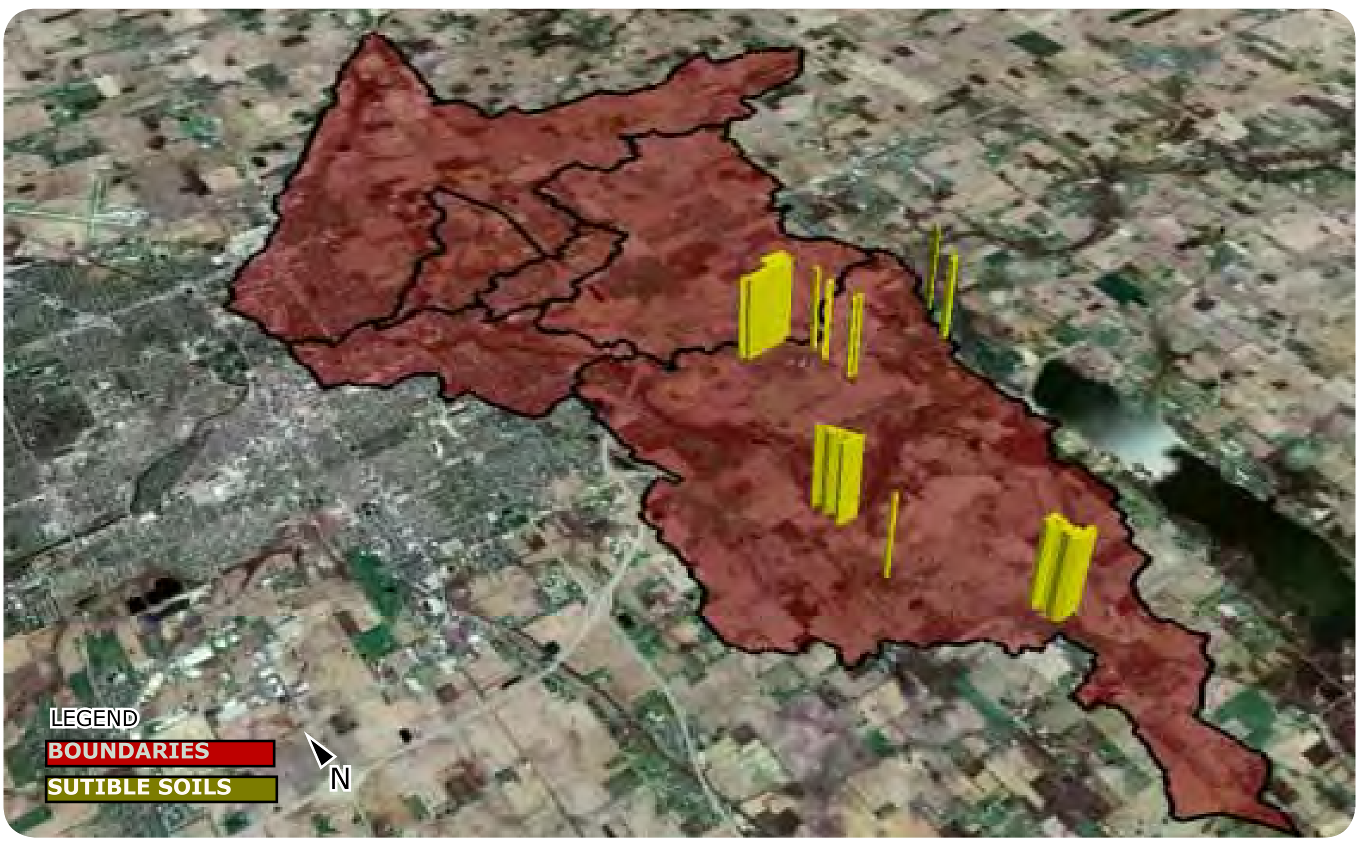
Additionally, newly constructed systems cannot be placed within the 100-year floodplain and systems installed at existing homes must be placed above the 100-year flood elevation. However, many residences grandfathered into this code throughout the state have not upgraded or installed fully functioning systems (Krenz and Lee, 2005). In these cases, septic effluent discharges into field tiles or open ditches and waterways and will likely continue to do so due to the high cost of repairing or modernizing systems.

Diagram (DIA) 2.3 shows the location of urban/residential areas (red) in proximity to suitable soils (yellow) and the Muncie Sanitary System (green) in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. Diagram 2.4 shows the location of suitable soils relative to the entire subwatershed(s) area.

1 Residential Onsite Swwage Systems, RULE 410 IAC 6-8
2 Geist Reservoir/Upper Fall Creek WMP
3 Kangen Water



DIA. 2.3 Septic Suitability Diagram (Red - on septic; Green - on sanitary - Yellow - suitable soils for septic)



DIA. 2.4 Diagram of Suitable Soil Types (yellow)

SECTION FOUR - HYDROLOGY

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

Hydrology and Drainage

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

The Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds contain more than 30 miles of streams, legal drains, and tile drains. The White River and major tributaries are used for boating, fishing, and full-body contact recreation.

The West Fork of the White River, and its largest tributaries—Prairie, Buck, Mud, and Bell Creeks—drain two-thirds of the county. Glaciation formed a number of eskers, kames, outwash plains, and glacial drainage channels within the till plain. Outwash plains and glacial drainage channels commonly bracket the rivers and their tributaries or, in places, are associated with eskers. In places, relief from the flood plain to the crest of the adjacent moraine is 40 to 50 feet. Some of the eskers are 30 to 40 feet above the adjacent till plain.[1]

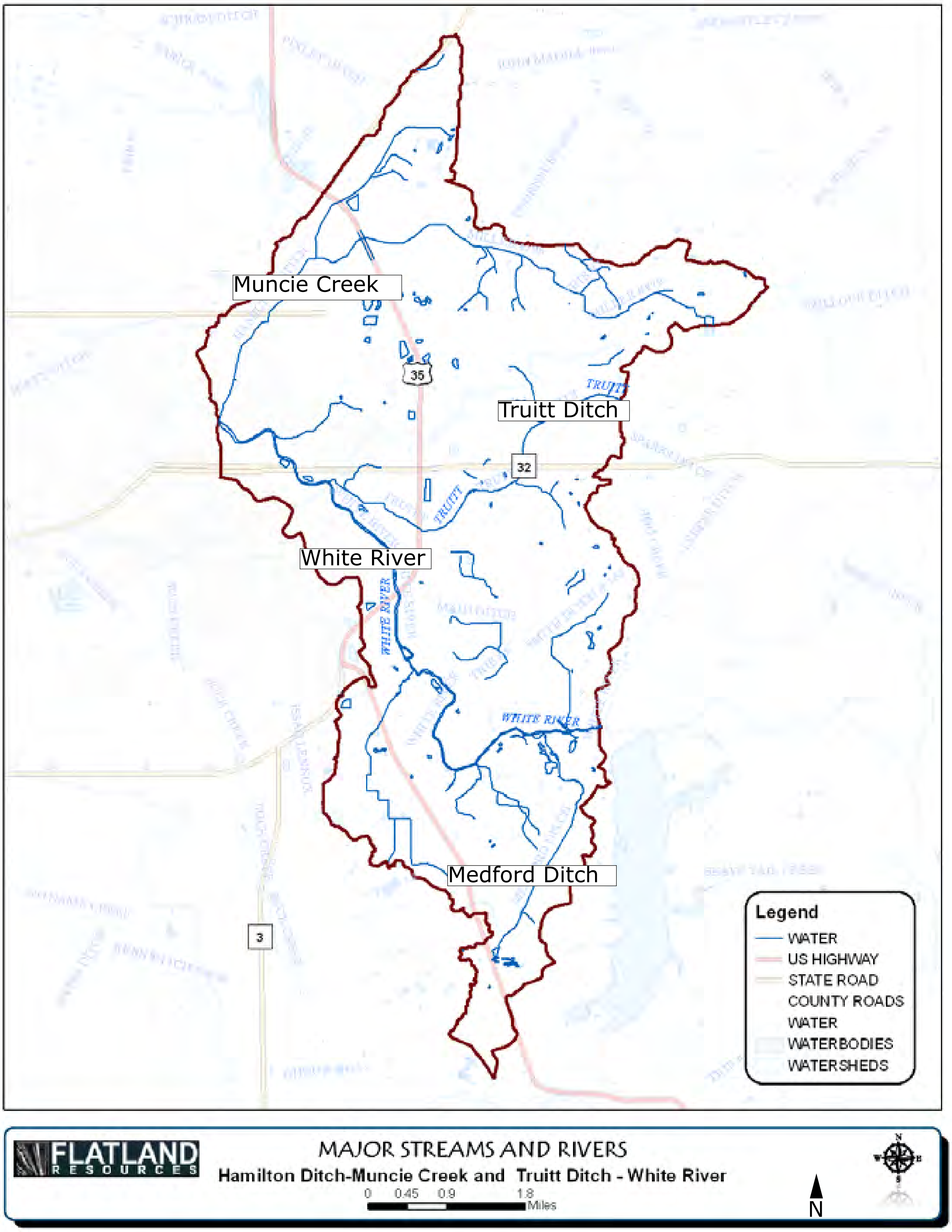
The main waterbodies in the Truitt Ditch-White River Watershed are the White River in the center, Truitt Ditch to the north (joining the White River at the mouth of the watershed), and Medford Ditch in the south. Both Truitt Ditch and the White River are naturally occurring channels. Both of their natural courses have been modified by human activity to either increase drainage or allow for development. The modifications to the White River have been less severe than those of Truitt Ditch, mostly occurring in the areas around Burlington Drive and the southeast end of Muncie. These changes have altered the floodplain, causing areas of erosion. Truitt Ditch has been highly modified to allow for drainage. The channel flow has been straightened and the cross section of the channel has been modified to such a degree that erosion occurs frequently. [2]

The modified (incised) cross-sectional area of most ditches and waterways has eliminated the streams access to the floodplain and the point of incipient flooding (anything above bankful, i.e. ordinary high water mark.) As a result, any flood-stage activity increases the velocity of water because the volume of water is confined or trapped. Velocity is also increased by straightening the stream meander outside of natural meander wave-length patterns. This increases the stream gradient and velocity. Increased velocity, plus high volumes in confined spaces, increases flood frequencies (without floodplain access) and the collective result is a high frequency of localized bank failures. White River Watershed Project research on Buck Creek (neighboring stream) shows that the sediment source is greater from in-channel sources (e.g. streambanks) than sheet flow from farm fields.

The main bodies of the Hamilton Ditch-Muncie Creek Watershed are the White River in the southern portion and Muncie Creek that flows from the north east and joins with the White River at the mouth of the watershed (MAP 2.30). Both Muncie Creek and the White River are naturally occurring channels. Both of their natural courses have also been modified by human activity to either increase drainage, allow for development, or as flood control measures. Muncie Creek has also undergone major channelization and straightening to allow for human activities such as agriculture and housing development. As a result, degradation and aggradation occurs as the channel tries to re-engineer itself to the appropriate sinuosity and grade.

Watershed streams, legal drains, floodplains, wetlands, storm drains, groundwater, subsurface conveyances, and manmade drainage channels all contribute to the watershed's hydrology. Each component moves water into, out of, or through the system.

1 Soil Survey of Delaware County Indiana. US Department of Agriculture
2 Tom Reeve, White River Watershed Project



MAP. 2.30 Major Subwatershed Hydrology

Mainstem

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

The most significant water feature in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds is the White River, which flows from east to west across the southern third of the County, thereby draining most of the County. The River bisects the City of Muncie, then continues along the north side of Yorktown, then curves south to form the north boundary of Daleville before exiting the County. Buck Creek, Bell Creek, Muncie Creek, and York-Priaire Creek are major tributaries that flow into the White River in Delaware County. The amount of floodplain surrounding the river is fairly limited within the City of Muncie, with the exception of the River's eastern entrance. [1]

"As a whole, Delaware County encompasses nearly 250 miles of streams which provide habitat for 65 species of fish, 13 species of mussels, and numerous birds and mammals. These public waterways offer recreational opportunities such as fishing, canoeing, and swimming to Delaware County residents. Additionally, the White River provides a source of drinking water for Muncie residents as well as residents of downstream cities such as Anderson and Indianapolis." [2]

"Prior to passage of the Clean Water Act (CWA) and its amendments in the early 1970s, the White River was the receiving stream for several point source stressors such as: wastewater treatment facilities, combined sewer overflows (CSOs), battery and transmission plants, and tool and die shops. These point sources were unregulated and led to massive amounts of pollutants entering the river, severely degrading water quality. Toxic pollutants that hindered all but the most tolerant species included ammonia, cyanide, lead, zinc, and chromium (Craddock 1975). In addition to these point source pollutants, nonpoint source pollutants were also contributing to the degraded water quality. Originating from agriculture and urbanization, runoff including sediment, fertilizers, insecticides, and herbicides were some of the top sources of impairments. Currently agriculture and hydromodification such as dredging, channelization, and impoundments by dams are listed as the source for over 60% of the reported impaired rivers and streams in the U.S. (U.S. EPA 2009)."[3] Due to a large amount of bedrock in Muncie streams, dredging for flood control is a common practice.

Outstanding Rivers

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 3

"The state of Indiana determines "outstanding rivers". The West Fork White River is considered an Outstanding River. Outstanding rivers or streams are those that are of particular environmental or aesthetic interest and qualify under one or more of 22 categories (NRC, 2007). The three categories upon which the West Fork White River qualifies are as follows: Category 5) Nationwide Rivers Inventory Rivers: The 1,524 river segments identified by the National Park Service in its 1982 "Nationwide Rivers Inventory" as qualified for consideration for inclusion in the National Wild and Scenic Rivers System. Category 11) State Heritage Program Sites: Rivers identified by state natural heritage programs or similar state programs as having outstanding ecological importance. Category 13) Canoe Trails: State-designated canoe/boating routes."[4]

1 Tom Reeve, White River Watershed Project
2 BWQ Annual Fish Community Report
3 BWQ Annual Fish Community Report
4 Outstanding Rivers List for Indiana

IMG. 2.2 Historic White River at West Side Park, Thomas Keesling.

TABLE 2.12: White River as Outstanding River Metric			
River	Location	Significance	Counties
West Fork White River	Farmland to confluence with Wabash River	5, 11, 13	Daviess, Delaware, Gibson, Knox, Greene, Hamilton, Madison, Marion, Morgan, Owen, Randolph

SOURCE: Outstanding Rivers List for Indiana

INVENTORY

Tributaries

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

Importance of Tributary Development

"Over the last thirty-five years, fish communities within White River in Muncie have dramatically improved. However, future improvements may depend on our ability to affect change in the tributaries which supply its water. In addition to efficiently conveying water, tributaries simultaneously transport myriad nonpoint pollutants such as silt, fertilizers, pesticides, etc. which are discharged directly into White River.

In Delaware County, these small streams account for more than 80% of the county's stream miles and are capable of having a significant impact on the water quality of White River. For example, effects of agricultural related run-off and stream bank erosion were found in the number of sucker species metric of the IBI. Often, the use of streams as drainage ditches is viewed as directly cimpacting the ability to support ecological integrity. However, simple methods exist that can cause dramatic improvements on water quality while still preserving the primary function of the stream.[1]

County-wide, headwater sites that typically receive good ratings, such as those along Stoney Creek, are bordered by wooded riparian zones, while those that typically receive poor ratings, such as those on Killbuck Creek and Mud Creek, are not.

Streams bordered by a woody buffer strip 10 m wide may reduce the phosphorous load by 95% (Vought et al. 1995). Simpler vegetated borders such as filter strips and grassed waterways also provide significant benefits to water quality. These BMPs trap soil that would otherwise suffocate aquatic life and protect the natural structure and function of fish habitats. In addition to benefiting water quality, they can also increase farming profits by diverting efforts away from the naturally low-yield areas of buffer zones. Filter strips also supply increased access to fields, more forage for cattle, and improved aesthetics." [2]

There are five major tributaries in the Subwatershed Management Areas

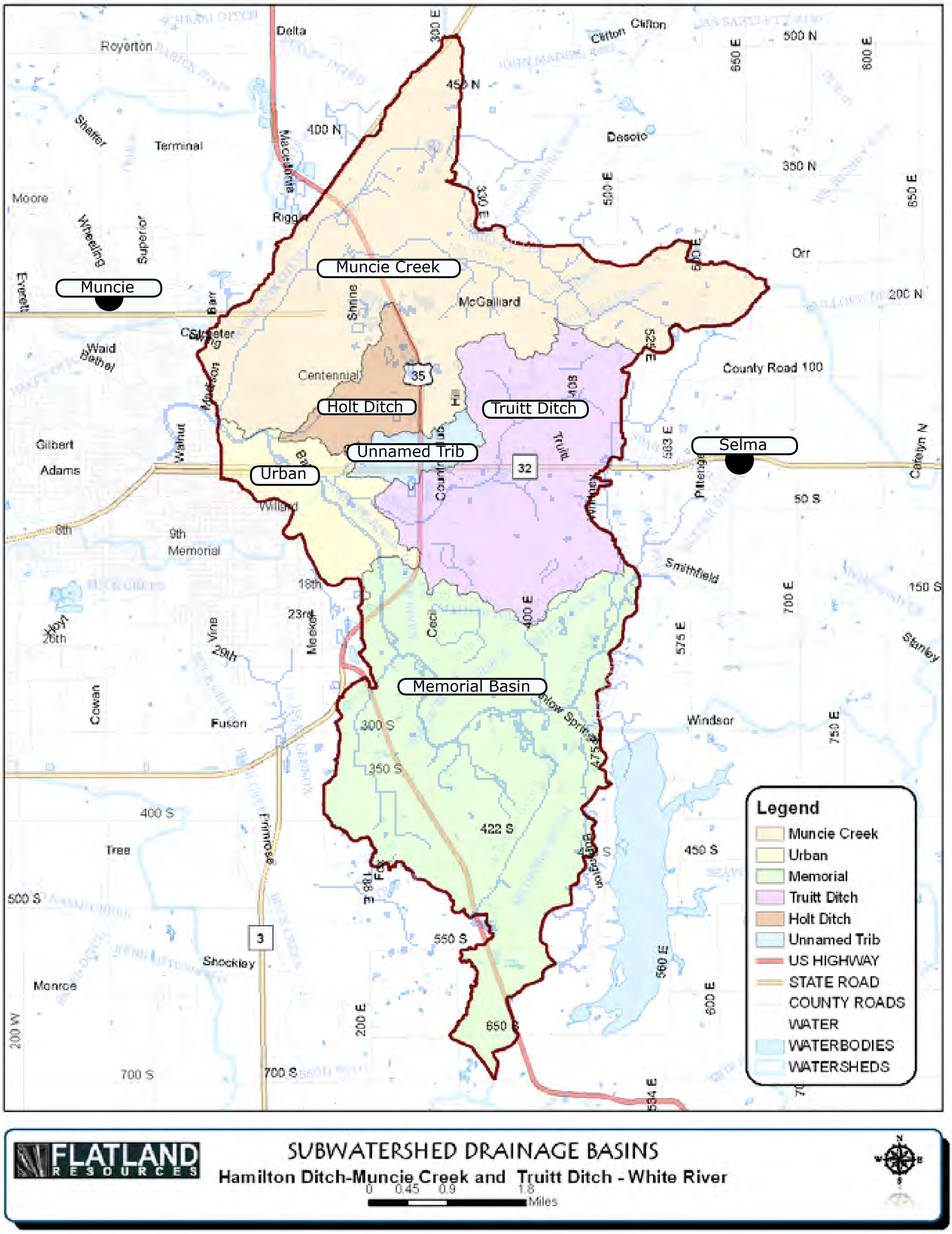
TABLE 2.13: Major tributaries in the Subwatershed Management Areas

GIS ID NUMBER	NAME
435642	Hamilton Ditch
438961	Medford Drain
439879	Muncie Creek
441546	Prairie Creek
444933	Truitt Ditch
SOURCE: ArcGIS Indianamap.org	

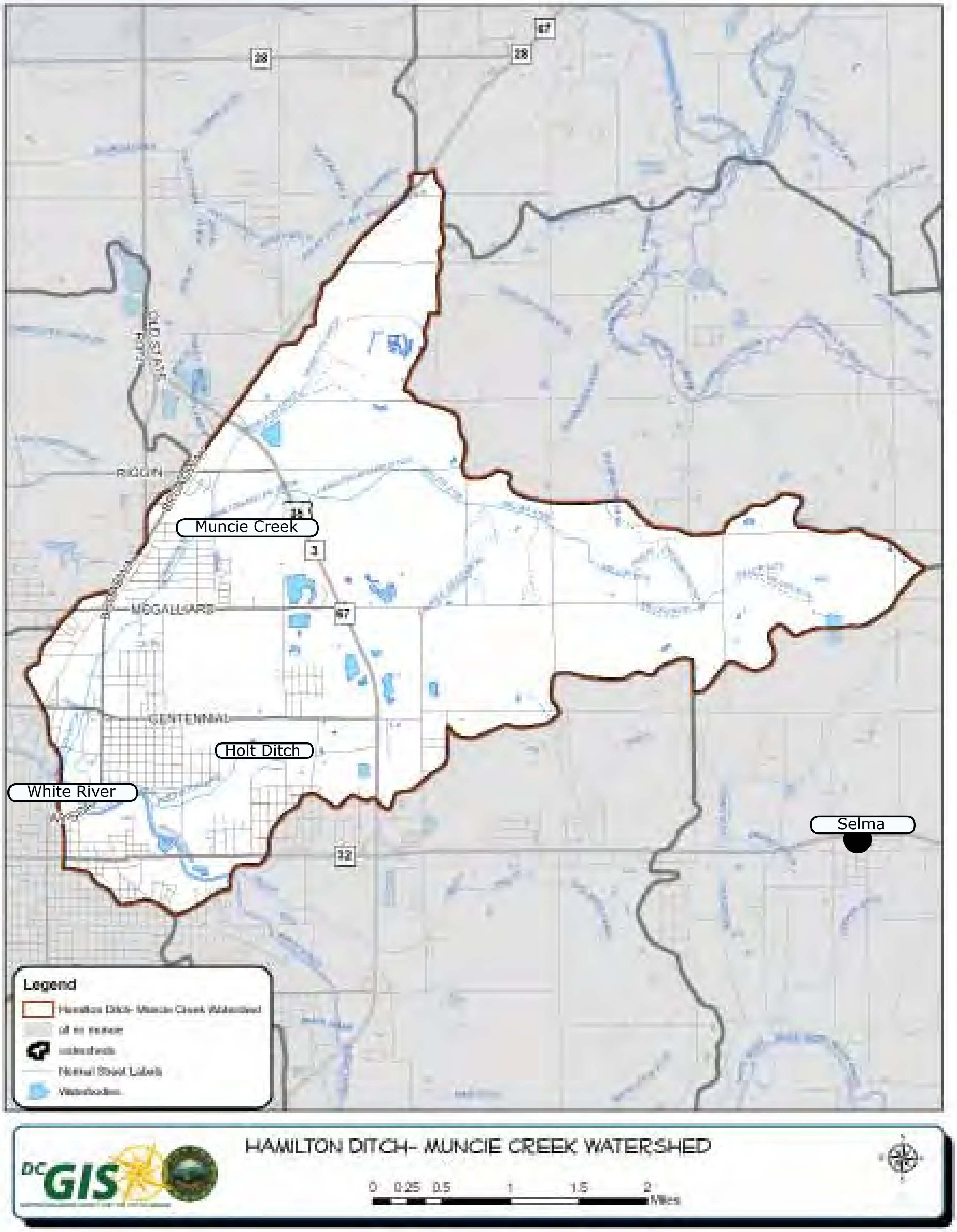
Tributary to White River Comparison

"In contrast to White River, tributaries within Delaware County have consistently poor biological integrity ratings. Often, small streams and creeks are not maintained with consideration to water quality and aquatic life. Channelized, dredged, and denuded of riparian vegetation, they have been engineered for the sole purpose of rapidly draining water. Fish communities within these types of streams are dominated by pollution tolerant species. Under these conditions, biological integrity is often irretrievable (Yoder et al. 2000)."[3]

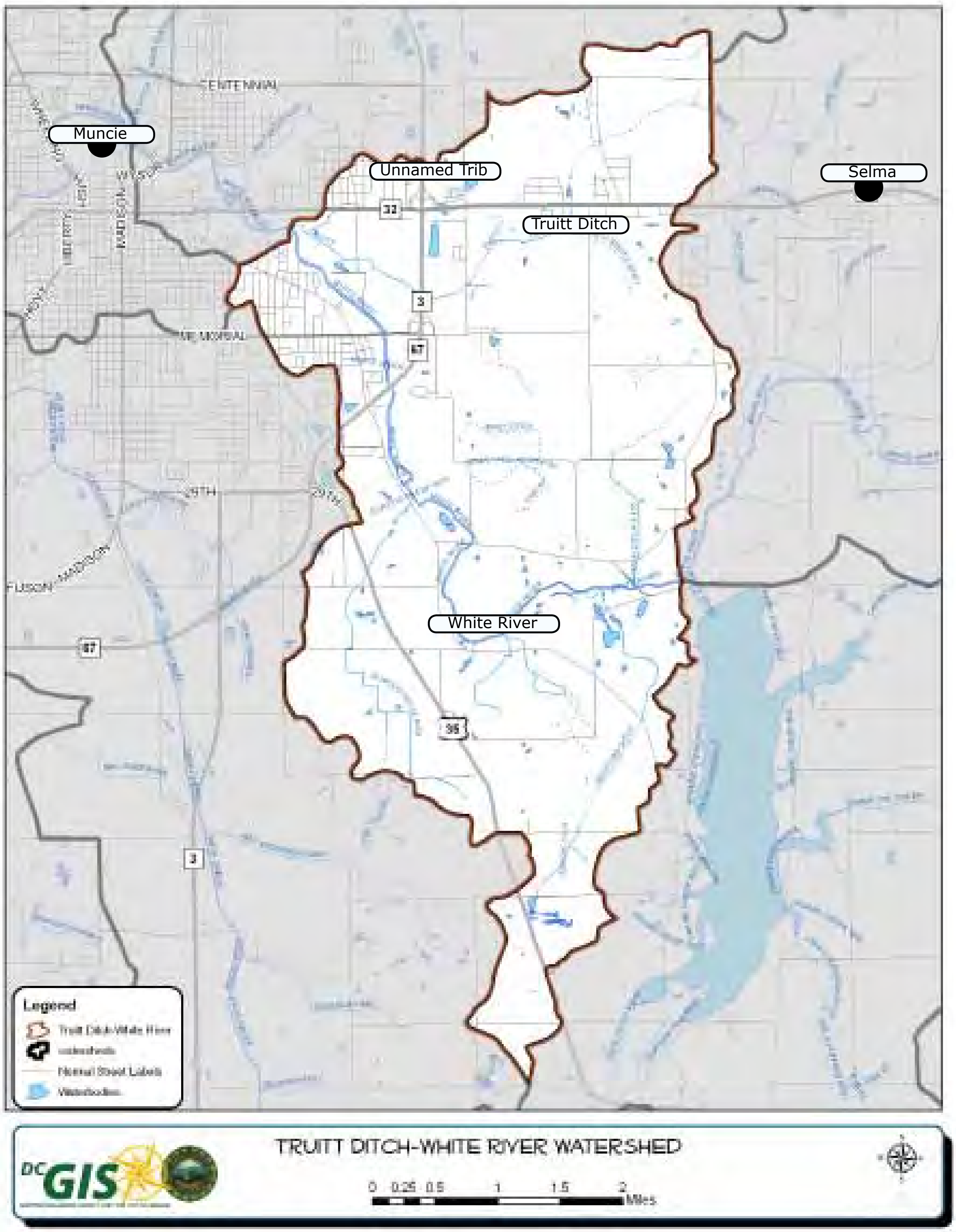
1 BWQ Annual Fish Community Report
2 BWQ Annual Fish Community Report
3 BWQ Annual Fish Community Report



MAP. 2.31 Major Rivers in Subwatersheds



MAP. 2.32 Hamilton Ditch - Muncie Creek Hydrology



MAP. 2.33 Truitt Ditch - White River Hydrology

INVENTORY

Floodplains

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 5

Flooding is a common hazard that can affect a local area or an entire river basin. Increased imperviousness, encroachment on the floodplain, deforestation, stream obstruction, tiling, or failure of a flood control structure are all mechanisms by which flooding occurs. Impacts of flooding include property and inventory damage, utility damage and service disruption, bridge or road impasses, stream bank erosion and riparian vegetation loss, water quality degradation, and channel or riparian area modification. [1]

In addition to storm water runoff, flooding can negatively affect water quality as large volumes of water transport contaminants into water bodies and also overload storm and wastewater systems. Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground and ultimately increases during periods of flooding. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, and streams.[2]

Floodplains are lands adjacent to streams, rivers, and other waterbodies that provide temporary storage for water. These systems act as nurseries for wildlife, offer green space for humans and wildlife, improve water quality, and buffer the waterbody from adjacent land uses. [3]

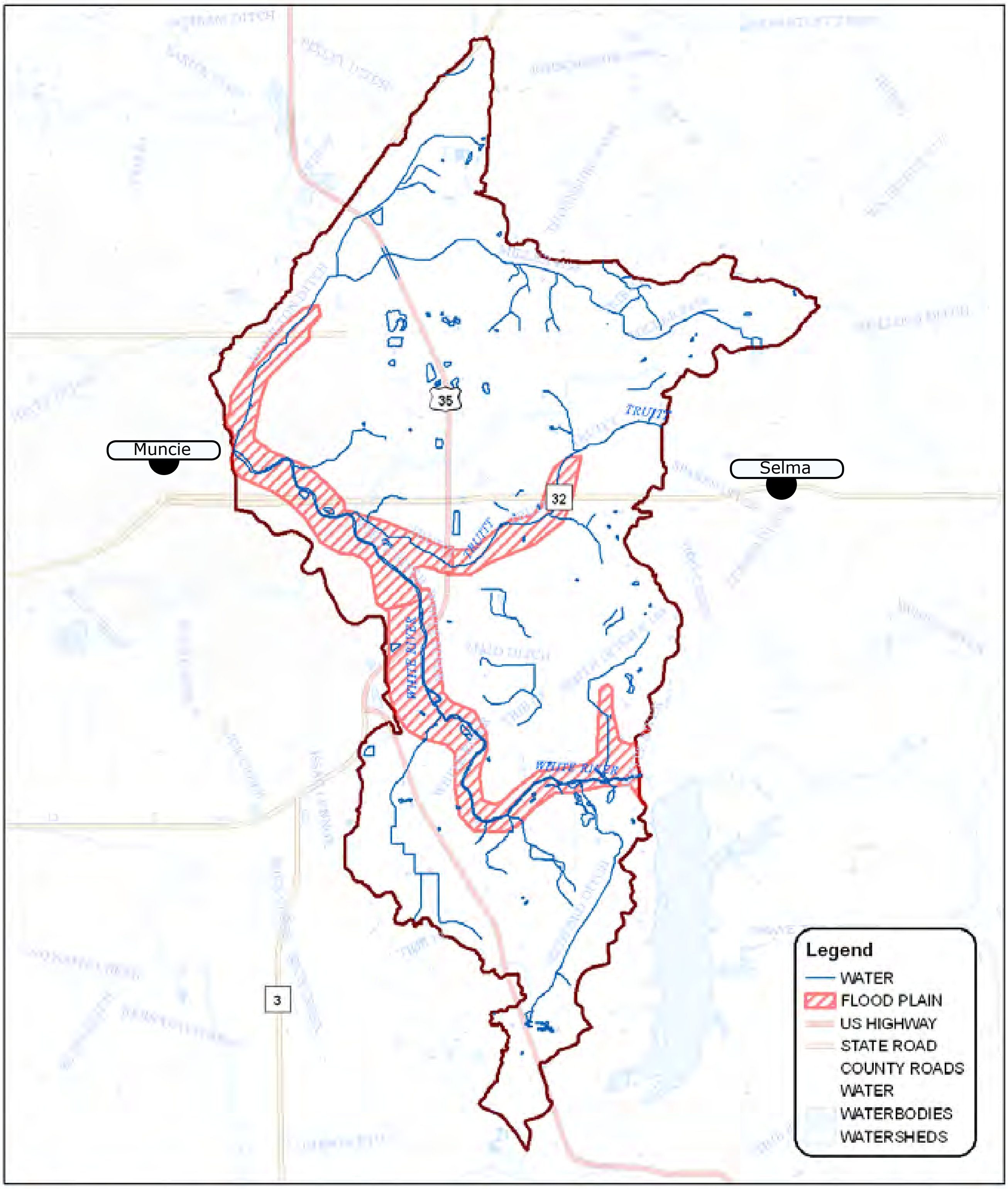
Approximately 6.8% (1295 acres) is cultivated and 890 acres is of urban land use within Subwatershed 100-year floodplains. In some cases, the rivers and streams have steep escarpments along their edges. Relatively small flood plains and terraces commonly alternate on opposite sides of the rivers.

These natural features pose the largest single constraint upon land use in the County. Development in waterways is generally impossible. Floodplain development should be carefully limited and controlled, due to the risk of property damage to the development itself, as well as the potential changes to the floodplain that may result in injury to properties downstream. Upon visual observation, much of the undeveloped acreage in the County is located in floodplain areas.[4]

Waterways and associative floodplains should also be viewed as assets. They perform an important function by draining areas of storm water and runoff. Floodplains attenuate energy resulting in sediment “drops” at the flood stage. Channeled systems can’t properly deposit sediment at flood stage forcing sediment to be flushed downstream until it finds floodplain (or if the channel creates new floodplains). Additionally, these waterway and floodplains serve as habitats for wildlife and need to be maintained as such.

Significant floodplain access occurs near Selma and between Yorktown and Daleville.

1 Tom Reeve, White River Watershed Project
2 Geist Reservoir/Upper Fall Creek WMP
3 Tom Reeve, White River Watershed Project
4 Wabash River (Region of the Great Bend) WMP



FLATLAND RESOURCES

MAJOR FLOODPLAINS

Hamilton Ditch-Muncie Creek and Truitt Ditch - White River

0 0.45 0.9 1.8 Miles

MAP. 2.34 GIS Based Subwatershed Floodplains (GIS)

INVENTORY

Floodplains

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 6

The Federal Emergency Management Agency (FEMA) has developed Flood Insurance Rate Maps (FIRMs) for many parts of the country in order for individuals and governments to assess the risk of flooding in specific areas. These maps also indicate what insurance rates property owners may need to pay to develop property in these areas.

Identifying the location of floodplain areas within the Subwatersheds allows for targeted areas for floodplain management and/or restoration. Floodplain management is the operation of a community program of corrective and preventative measures for reducing flood damage. These measures take a variety of forms and generally include requirements for zoning and special-purpose floodplain ordinances. [1]

Developments within flood prone areas (regulated by local, state and federal agencies) is dependant on permitting. The probability of permit approval further depends on the floodplain boundaries depicted on the FEMA FIRM and its corresponding floodplain designation (Zone A, AE, X).

Zone A (MAP 2.35) is defined as an area inundated by 100-year flooding for which no base flood elevation (BFE) has been determined. In this zone there is a 1% chance of annual flooding, and a 26% chance that the area will be inundated at sometime during the life of a 30-year mortgage.

Zone AE (MAP 2.35) is defined as an area inundated by 100-year flooding for which a BFE has been determined. Chance of flooding in Zone AE is the same as in Zone A. However, Zone A floodplain boundaries are based off of approximate methods, and Zone AE floodplain boundaries are based off of detailed hydrologic and hydraulic analyses (thus establishing BFEs), making the delineation more accurate.

Zone X (MAP 2.35) is defined as an area that is either determined to be outside the 100-year floodplain but within the 500-year floodplain (0.2% chance of annual flooding), or to have a 1% chance of sheet flow flooding where the average depths are less then 1 foot. These areas are considered to have a moderate or minimal risk of flooding, and the purchase of flood insurance is available but not required. [2]

Rainfall data is used to create these maps based on National Weather Service cooperative network. Teams of Soil Survey of Delaware County Indiana. US Department of Agriculture hydrographers have traveled to 40 streamflow-gaging stations to keep station instruments operating and to verify streamflow data needed for National Weather Service (NWS) flood forecasts. Soil Survey of Delaware County Indiana. US Department of Agriculture personnel have worked closely with Federal, state, and local agencies during the flood to provide flood information for emergency managers, the media, and the public. [3]

1 Geist Reservoir/Upper Fall Creek WMP
2 Geist Reservoir/Upper Fall Creek WMP
3 Geist Reservoir/Upper Fall Creek WMP

MAP. 2.35 Subwatershed Floodplains, note levee system in city limits; See photos of red dots on next page, DCGIS

Riparian Zones / Floodplains

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 7

Riparian zones are responsible for trapping sediment, filtering water, maintaining banks and shorelines, reducing impacts of flooding, recharging local groundwater reserves, and enhancing biodiversity and habitat. Eighty percent of terrestrial species within the western US depend on riparian vegetation for food, habitat or mitigation. Riparian zones slow the flow of the water down affecting the sedimentation rates. Human manipulation can accelerate the sedimentation rate from 500 years to 20-30 year periods.

TABLE 2.14: Type of Land Use in Subwatershed Floodways

Watershed Name	Truitt Ditch - White River		Hamilton Ditch - Muncie Creek	
GAP Land Use	Area (Ha.)	30 meter Buffer	Area (Ha.)	30 meter Buffer
Ag: Pasture	6	7%	12	17%
Ag: Row Crop	25	29%	30	43%
Ag: Wet Areas	0	0%	0	0%
Deciduous Forest	17	20%	2	3%
Evergreen Forest	13	14%	0	0%
Open Water	0	0%	0	0%
Palustrine Forest	11	13%	3	5%
Palustrine Herbaceous	9	11%	6	9%
Palustrine Sparsely Veg.	1	1%	0	0%
Palustrine Deciduous	0	0%	0	0%
Shrubland	1	1%	0	0%
Urban: High Density	0	0%	4	6%
Urban: Low Density	0	0%	11	16%
Woodland	3	4%	0	1%
Total Riparian Area	88		70	
Total Watershed Area	4,769		3,480	

SOURCE: ArcGIS Indianamap.org

GIS Derived Statistics
Table contains information derived from GIS maps created in ArcView. Summary statistics are listed by storm water watersheds and include land use information from Indiana's GAP data program.

Levee System

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 8

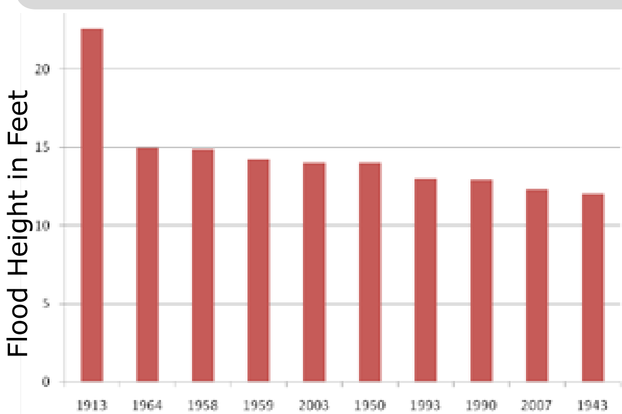
A Section of the Muncie Creek-Hamilton Ditch Subwatershed includes portion of the Muncie Levee System. The flood control levees were created by the United State Army Corps of Engineers over a period of time spanning from 1913-1960. The Levee System was created in response to catastrophic flooding during the turn of the century and built in conjunction with WPA and CCC programs with pressures from the local Business Community.

IMG. 2.3 Photo 1 Levee System at McKinnley Neighborhood

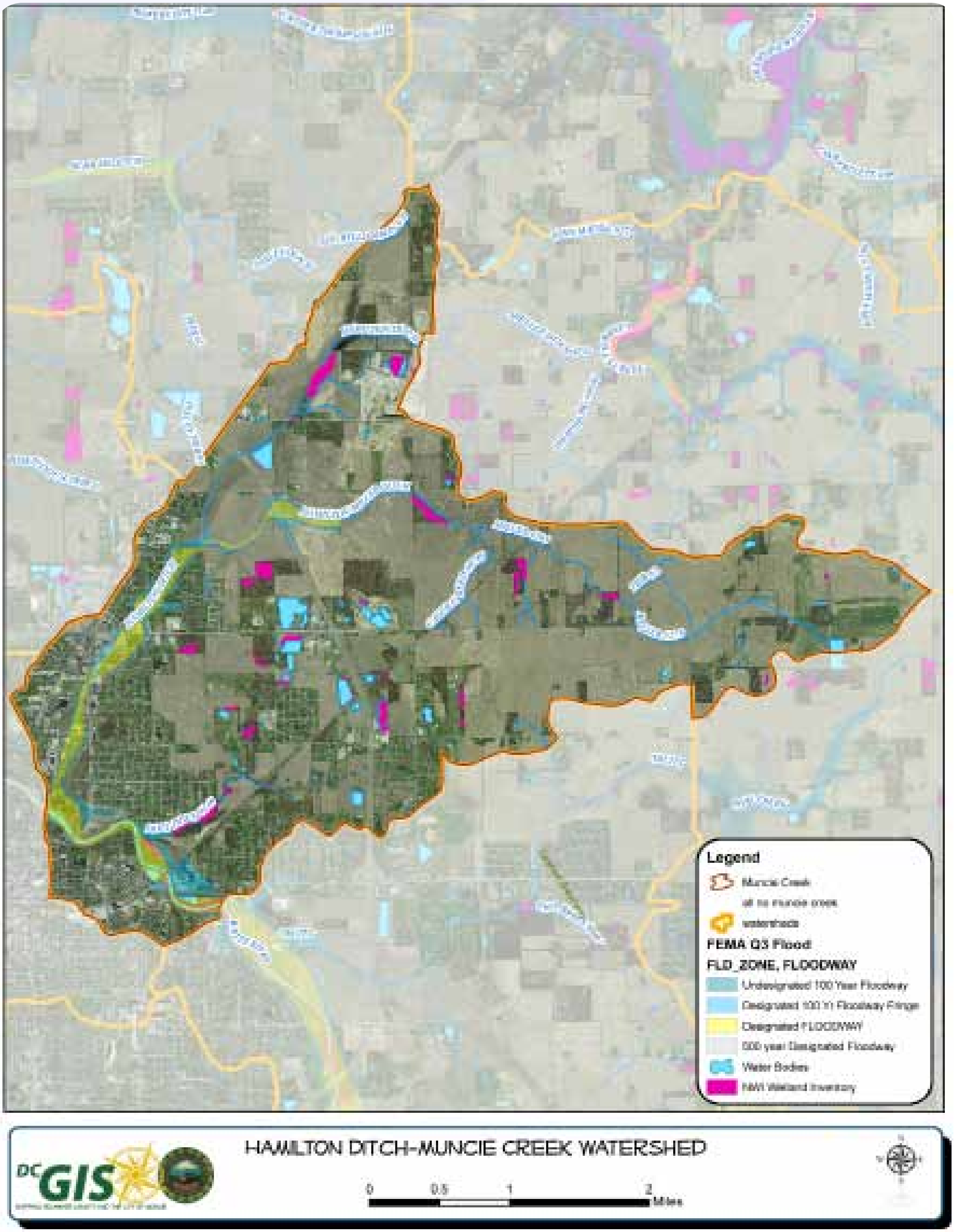
IMG. 2.5 Photo 4 Levee System at Daily Apartments

IMG. 2.4 Photo 3 Levee System at Cardinal Greenways

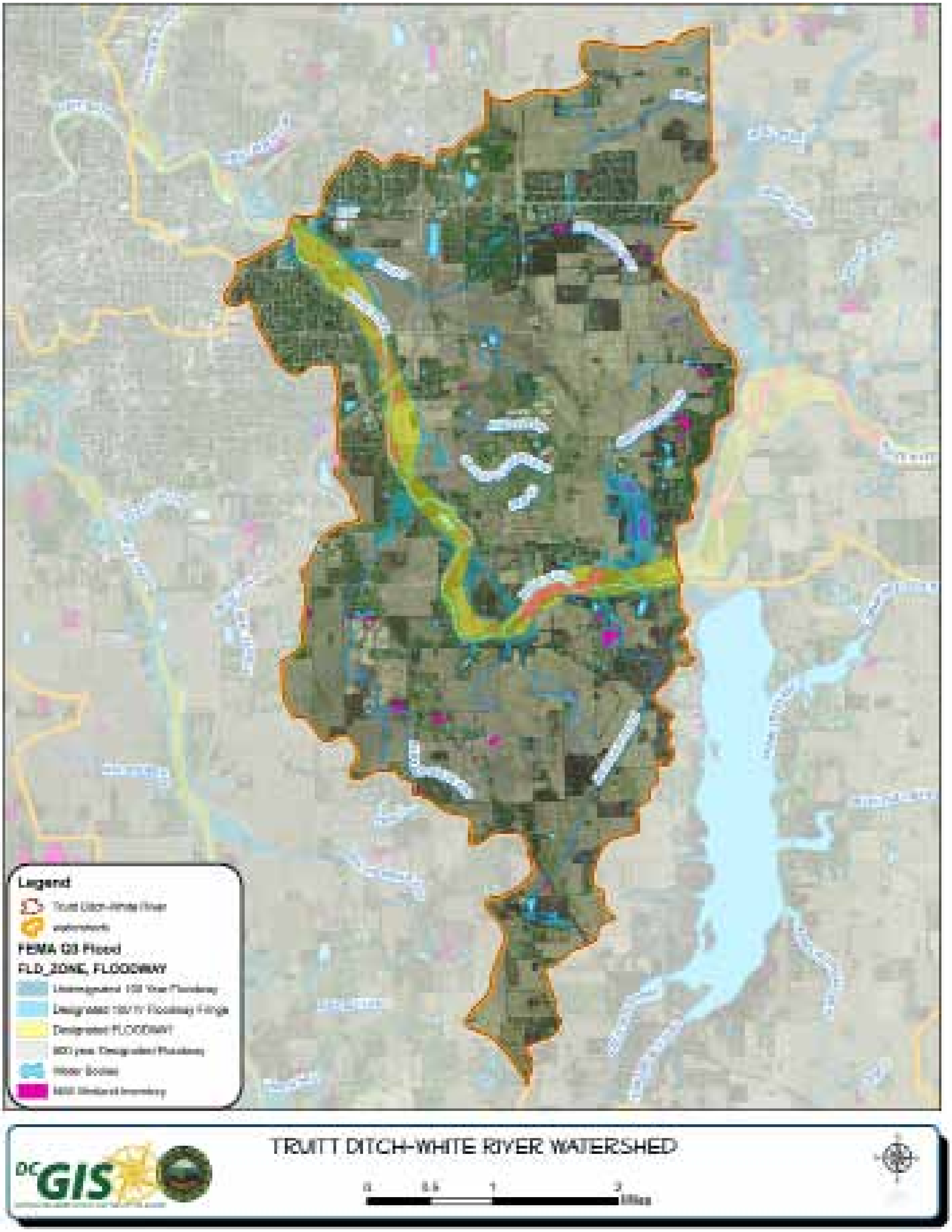
IMG. 2.6 Photo 4 Levee System at Craddock Wetlands



CHA. 2.10 Major Floods in the City of Muncie



MAP. 2.36 Hamilton Ditch - Muncie Creek Floodway



MAP. 2.37 Truitt Ditch - White River Floodway

INVENTORY

Waterbodies

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 9

Several small ponds and reservoirs are located in the Muncie Creek - Hamilton Ditch and Truitt Ditch - White River Subwatersheds. However, none of these waterbodies are significant in either size or usability and are therefore not discussed in further detail. Ponds and reservoirs located within Delaware County are typically used for shoreline and small boat fishing, full-body contact recreation, and aesthetic enjoyment. [1] They are concerns as they are potential nutrients sinks, but we do not have quantifiable data to support those concerns that this time.

One prominent water feature in Delaware County is the Prairie Creek Reservoir, a man-made lake located in the southeast corner of the County. The outlet for this Reservoir drains into the Truitt Ditch-White River Subwatershed. In addition to serving as a drinking water resource, the Reservoir also has recreational value. Although floodplain is evident in the White River, which runs near the Reservoir, little floodplain is evident at the Reservoir itself. [2]

Individuals are concerned about consuming fish from regional waterbodies and the possible health risks associated with full-body contact with many of the regional waterbodies. No beaches are located within the watershed. However, access to the waterbodies is possible via public access or public parks located adjacent to waterbodies. Informal swimming areas may be located in the watershed, but these sites were not identified by stakeholders.[3]

DIA. 2.5 Diagram of Waterbodies in Subwatersheds

1 Tom Reeve, White River Watershed Project
2 Tom Reeve, White River Watershed Project
3 Tom Reeve, White River Watershed Project

Wetland Importance

WMP - CHAPTER 1 - PART 1 - SECTION 4 - SUBSECTION 10

Wetlands provide numerous valuable functions that are necessary for the health of a watershed and waterbodies. Wetlands play critical roles in protecting water quality, moderating water quantity, and providing habitats. Wetland vegetation adjacent to waterways stabilize shorelines and stream banks, prevents erosion, and limits sediment transport to waterbodies.[1]

In addition, wetlands have the ability to increase storm water detention capacity, increase storm water attenuation, and moderate low flows. These benefits help to reduce flooding and reduce erosion. Wetlands also facilitate groundwater recharge by allowing water to seep slowly into the ground, thus replenishing underlying aquifers. This groundwater recharge is also valuable to wildlife during the summer months when precipitation is low and the base flow of the river draws on the surrounding groundwater table. [2]

Although wetlands occupy a small percentage of the surrounding landscape, these areas typically contain large percentages of wildlife and produce more flora and fauna per acre than any other ecosystem. As a result of this high diversity, wetlands provide many recreational opportunities, such as fishing, hunting, boating, hiking and bird watching.

However, wetlands within the Subwatersheds have experienced degradation as a result of urbanization and development (as has most Indiana Wetlands). Development projects that have wetlands present or adjacent to the property must apply for and receive Section 404 (of the Clean Water Act) permits to fill and develop wetlands. This practice permits the reduction of wetland acreage in the watershed. [3]

Isolated and adjacent wetlands are regulated through IDEM and the Army Corps of Engineers (ACOE), respectively. Although wetlands are typically avoided during the development phase, permits have been given to fill wetlands that cannot be avoided. Some isolated wetlands are being converted to detention/retention basins in new residential developments. Regulatory agencies may require on-site mitigation, including the creation of wetlands and natural areas on the same piece of land where wetland impacts occur. Some development projects that impact wetlands are allowed to mitigate for wetland impacts at an approved off-site wetland mitigation bank facility. In this case, the wetland impacts are offset through the purchase of wetland mitigation credits at an approved wetland mitigation bank.

For Indiana Department of Transportation (INDOT) projects in general, the Federal and State requirement is to mitigate for impacts to wetlands associated with roadway improvements within the same watershed. Stream enhancement and stream mitigation are some of the options that INDOT utilizes to offset wetland/stream impacts.[4]

1 Geist Reservoir/Upper Fall Creek WMP
2 Geist Reservoir/Upper Fall Creek WMP
3 Geist Reservoir/Upper Fall Creek WMP
4 Geist Reservoir/Upper Fall Creek WMP

Wetlands

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 11

Approximately 25% of Indiana was covered by wetlands prior to European settlement (IDEM, 2007). Overall, 85% of wetlands have been lost resulting in Indiana ranking fourth in the nation in terms of percentage of wetland loss. Wetland classifications are based on attributes which can be measured and when combined, help to define the nature of a specific wetland and distinguish it from others. According to the National Wetland Inventory, there are three wetland classifications within the Subwatersheds including lacustrine, palustrine, and riverine.[1]

Lacustrine Wetlands: As defined by the U.S Fish and Wildlife Service, lacustrine wetlands are associated with lakes and are characterized by a lack of trees and a dominance of emergent and submersed aquatic vegetation. Lacustrine wetlands typically extend from the shoreline to depths of 6.5 feet or until emergent vegetation no longer persists. Lacustrine wetlands are important in removing sediment and nutrients as well as providing habitat for fish and macroinvertebrates which are a vital food source within a lake ecosystem. The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 20 acres.[2]

Palustrine Wetlands: Palustrine wetlands are related to marshes, swamps and bogs. Palustrine habitats are wetlands dominated by trees, shrubs, persistent emergents, and emergent mosses or lichens. Palustrine habitats have structural features that provide feeding, breeding, nesting, over wintering and migration habitat for Wildlife in addition to their natural filtration properties. [34]

Riverine Wetlands: Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Riverine wetlands are directly affected by streamflow including overbank and backwater conditions. Riverine wetlands are very important in sediment retention as well as pollutant removal. [5]

Currently, Hamilton Ditch - Muncie Creek and Truitt Ditch - White River contain approximately 400 acres of wetlands. In total, wetlands cover approximately 9% of the Subwatersheds. There are 5,525 acres of hydric soils and when hydric soil coverage is used as an estimate of historic wetland coverage, it becomes apparent that the Subwatersheds were once 36% wetland. This theoretically represents nearly 5,125 acres of wetland loss within the Subwatershed(s) area.

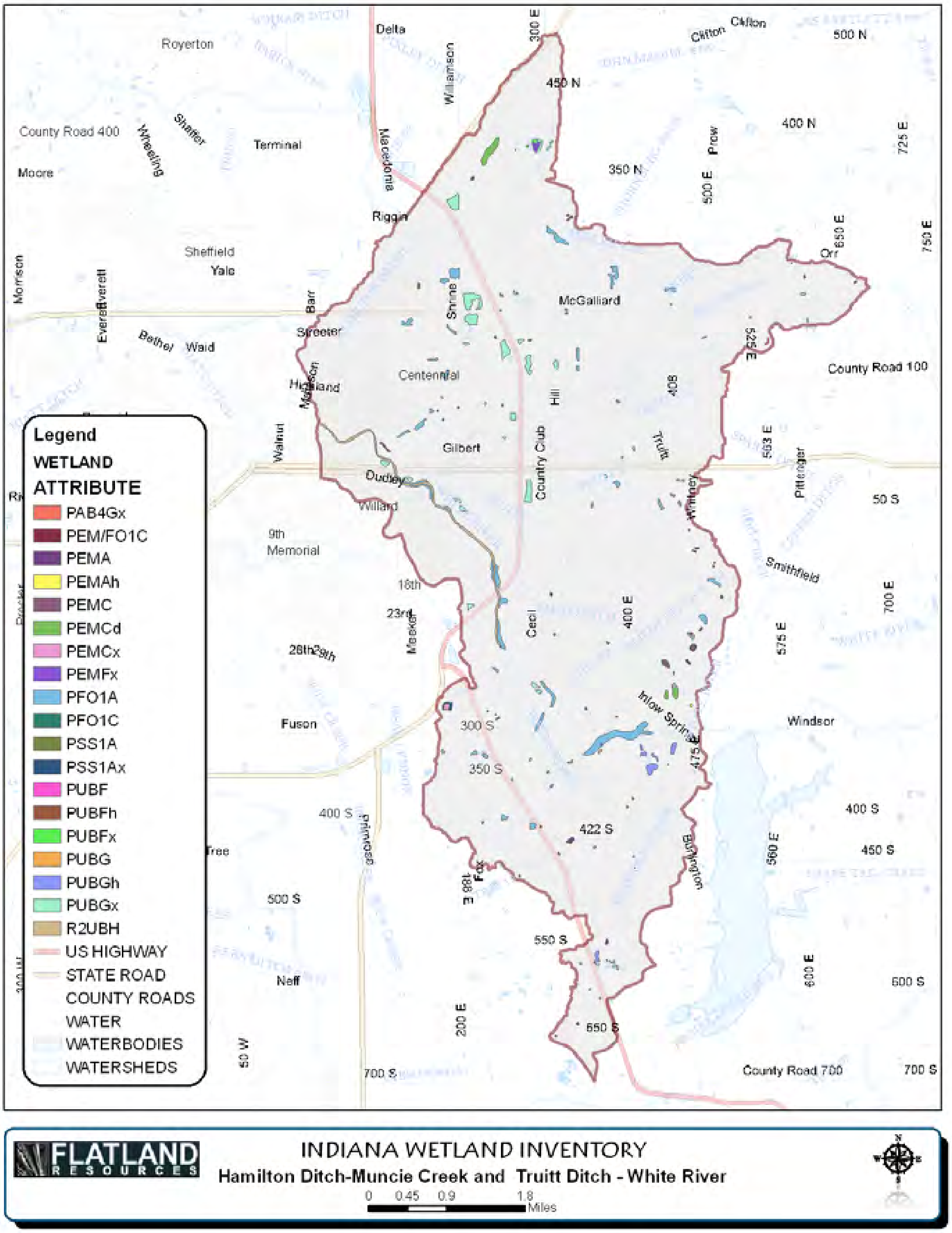
MAP. 2.38 Major Wetland Destruction by State

TABLE 2.15: State Ranking by Percentage of Wetland Destruction

Arkansas	72%	Maryland	73%
California	91%	Mississippi	59%
Connecticut	74%	Missouri	87%
Delaware	54%	Nevada	52%
Idaho	56%	New York	60%
Illinois	85%	Ohio	90%
Indiana	87%	Oklahoma	67%
Iowa	89%	Pennsylvania	56%
Kentucky	81%	Tennessee	59%

SOURCE: EPA

1 Tom Reeve, White River Watershed Project
2 U.S Fish and Wildlife Service
3 U.S Fish and Wildlife Service
4 U.S Fish and Wildlife Service
5 U.S Fish and Wildlife Service



MAP. 2.39 FWS Wetland Mapper (pink watershed boundary)

Wetlands Assessment

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 12

IDEM administers the Clean Water Act (CWA) Section 401 Water Quality Certification (WQC) Program. IDEM regulates the placement of fill materials, excavation (in certain cases), and mechanical clearing of wetlands and other waterbodies. IDEM draws its authority from the federal CWA, state law and rules for state regulated wetlands, and from Indiana's Water Quality Standards. IDEM regulates some activities in wetlands in conjunction with the ACOE. Any person who wishes to place fill materials, excavate or dredge, or mechanically clear (use heavy equipment) within a jurisdictional wetland, lake, river, or stream must first apply to the ACOE for a CWA Section 404 permit. If the ACOE decides a permit is needed, then the person must also obtain a CWA Section 401 water quality certification from IDEM. Placement of fill into nonjurisdictional wetlands is regulated by Indiana's Wetlands Activity Permits rule and by state law. Under CWA Section 401, IDEM reviews the proposed activity to determine if it will comply with Indiana's WQS. The applicant may be required to avoid impacts, minimize impacts, or mitigate for impacts to wetlands and other waters. IDEM will deny water quality certification if the activity will cause adverse impacts to water quality. No project may proceed until it has received a certification from IDEM. A key goal of the program is to ensure that all activities regulated by IDEM meet the no net loss of wetlands policy. Table 2.16 provides information regarding historical and present estimates of wetland resources in Indiana.[1]

TABLE 2.16: Percentage of Existing Wetlands in Indiana compared to 1700 estimate

Statistic	Amount
Total surface area of the state of Indiana	23,310,000 acres
Estimate of wetland acreage in Indiana circa 1700	5,600,000 acres
Wetland acreage in Indiana circa 1986 (National Wetland Inventory)	813,000 acres
Percent of surface area of Indiana covered by wetlands circa 1700	24.1%
Percent of surface area of Indiana covered by wetlands circa 1986	3.5%
Percent of total area of wetlands that are wholly or partially contained within managed lands (state, local, federal and private areas)	14%
Percent of Indiana's total wetlands that are 0.25 acres or less in size	11.6%
Percent of Indiana's total wetlands that are 0.50 acres or less in size	29.5%
Percent of Indiana's total wetlands that are 1.00 acres or less in size	46.9%
Percent of Indiana's total wetlands that are 5.00 acres or less in size	80.2%

SOURCE: IDEM: Indiana's Wetland Resources

1 IDEM: Indiana's Wetland Resources

Integrity and Extent of Wetland Resources

Wetlands occur in and provide benefits to every county in Indiana. The lack of quantitative information on some aspects of Indiana's wetland resources is a major obstacle to improving wetland conservation efforts. The most extensive database of wetland resources in Indiana is the National Wetlands Inventory developed by the USFWS. Indiana's National Wetlands Inventory maps were produced primarily from interpretation of high-altitude color infrared aerial photographs (scale of 1:58,000) taken of Indiana during spring and fall 1980-87. The maps indicate wetlands type, using the Cowardin et al. classification scheme. Very narrow wetlands in river corridors and wetlands under cultivation at the time of mapping are generally not depicted. Forested wetlands are poorly described. IDEM entered into a partnership with Ducks Unlimited to update the palustrine wetlands mapped in Indiana. This effort was scheduled for completion in 2009 and will become an update to the National Wetland Inventory.[2]

The IDNR conducted the most recent and complete analysis of this database in 1991. According to the report, Indiana had approximately 813,000 acres of wetland habitat in the mid-1980s when the data were collected (Table 2.17). Wetland loss or gain since then is not known at this time (Rolley 1991). [3]

TABLE 2.17: Historic Wetland Resources in Indiana

Wetland Type (Cowardin Classification)	Extent as of mid-1980s (acres)
Palustrine scrub/shrub (PSS)	42,000
Palustrine forested (PFO)	504,000
Palustrine emergent (PEMB)	55,000
Palustrine emergent seasonally flooded (PEMC)	68,000
Palustrine emergent semi-permanently flooded (PEMF)	21,000
Palustrine open water (POW)	99,000
Lacustrine limnetic open water (L10W)	141,000
Riverine (R)	53,000
Total wetland resources	813,000 (Historic: 5,600,000)

SOURCE: IDEM: Indiana's Wetland Resources

2 IDEM: Indiana's Wetland Resources
3 IDEM: Indiana's Wetland Resources

INVENTORY

Hydromodification - Dams

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 13

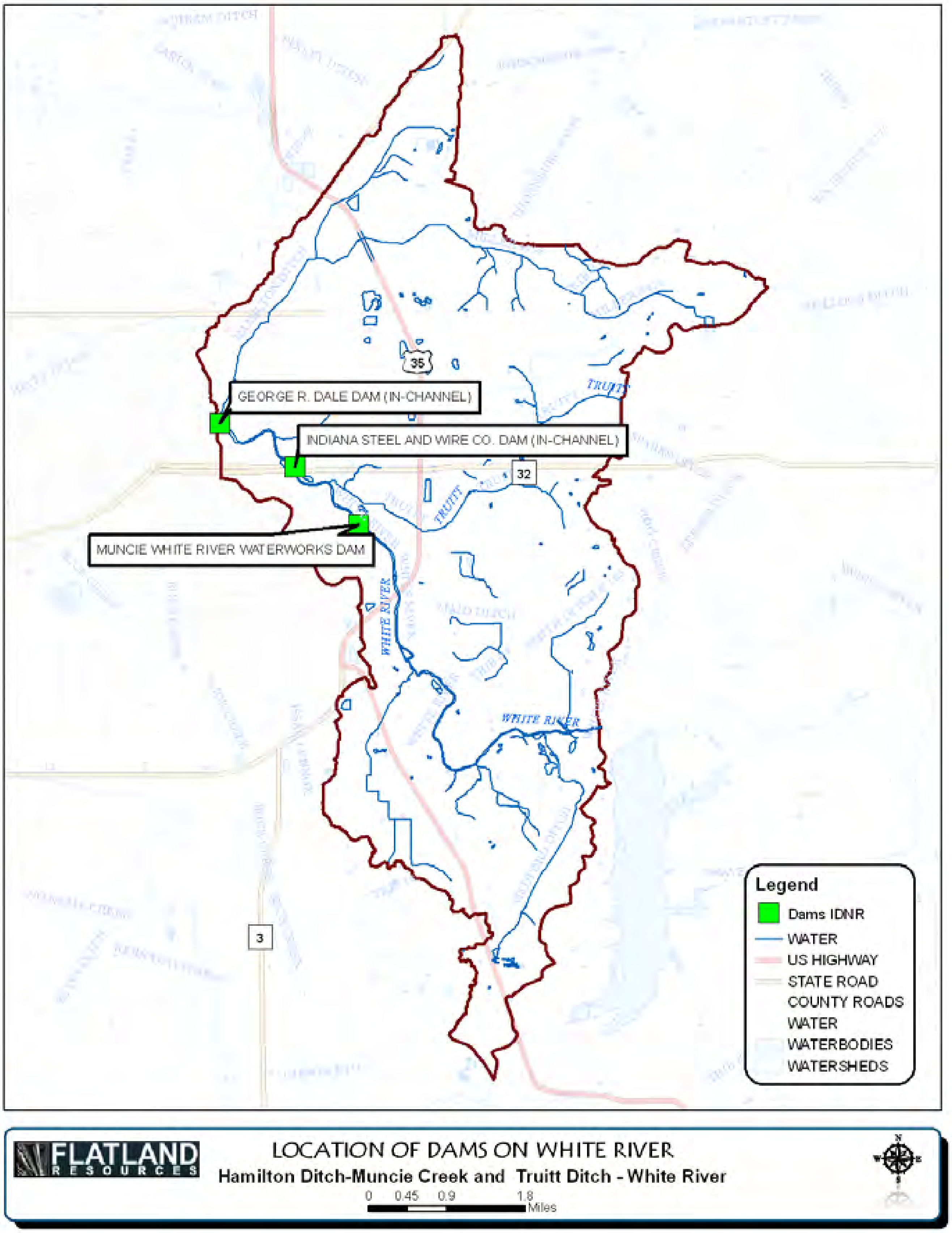
Dams are an ecological impairment because they create long pools of water that are low in dissolved oxygen (DO), high in nutrients such as nitrogen (and can inhibit breakdown of background pollutants such as ammonia (Baxter 1977)), and very monotonous in terms of habitat conditions for fish and other aquatic organisms. They are also a safety hazard because of the turbulent flow conditions at the base of the dams.[1] Their presence blocks fish passage and creates lentic habitats unsuitable for rheophilic (river dependent) species (Beasley & Hightower 2000).[2]

"Fish need cold, clean water rich in oxygen, but the shallow reservoirs behind the dams can potentially warm to temperatures lethal to organisms and are low in oxygen. Overheated and oxygen deficient waters provide prime conditions for toxic algae to bloom in the reservoirs behind the dams at levels thousands of times higher than what the World Health Organization says is safe for recreation. The algae secrets a toxin that is known to can cause liver damage and promote tumor growth."[3]

There are three dams in the Muncie Creek- Hamilton Ditch and Truitt Ditch-White River Subwatersheds.[4] Although the presence of dams or impoundments typically have noticeable negative effects on water quality (Santucci et al. 2005); all dams located along White River maintain uncommonly high IBI scores. In spite of the chemical and physical challenges, integrity of fish communities above Muncie's dams currently remain strong.

TABLE 2.18: Name and Location of Dams in Subwatersheds				
DAM NAME	STATE_ID	COUNTY_NAM	EASTING	NORTHING
MUNCIE WHITE RIVER WATERWORKS DAM	18-3	Delaware	640503	4449462
INDIANA STEEL AND WIRE CO. DAM (IN-CHANNEL)	18-6	Delaware	639311	4450519
GEORGE R. DALE DAM (IN-CHANNEL)	18-5	Delaware	637903	4451296
SOURCE: ArcGIS Indianamap.org				

1 Friends of Alum Creek and Tributaries
2 BWQ Annual Fish Community Report
3 Klamath Restoration Agreements
4 Data Generated by ArcGIS



MAP. 2.40 Location of Dams in Subwatersheds

Hydromodification - Drains

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 14

Regulated drains consist of creeks, ditches, tiles (underground pipe systems), and other structures intended to move run-off water. Regulated drains are under the jurisdiction of the local county drainage board and/or the County Surveyor's office . Regulated drains are common throughout the watershed and are mainly tiles and open ditches.[1] Regulated drains are typically maintained by the County Surveyors office. This maintenance includes dredging with large construction equipment, removal of debris, and management of vegetation both within the regulated drains and within the riparian zone associated with the drains. As these waterbodies are subject to periodic cleaning, it is important to work with the county surveyor to establish priorities for these waterbodies in terms of water quality improvement and erosion control. [2]

Muncie has approximately 389,700 ft of ditches within the MS4 boundary. The precise footage is unavailable, but it is continually updated by the Muncie Sanitary District and maps are available at the Engineering Department. It should be noted that legal drains are maintained by the county surveyor's office. However, some of the legal drains within the watershed have neither a maintenance fund nor a maintenance schedule.

There has been extensive underground tiling and above ground ditching within the watershed. This reduces the amount of water that infiltrates the ground and causes a flush of water during rain events. Many of the above ground ditches have structural problems, such as abutments and impoundments. These problems cause erosion and deposition throughout the channels.

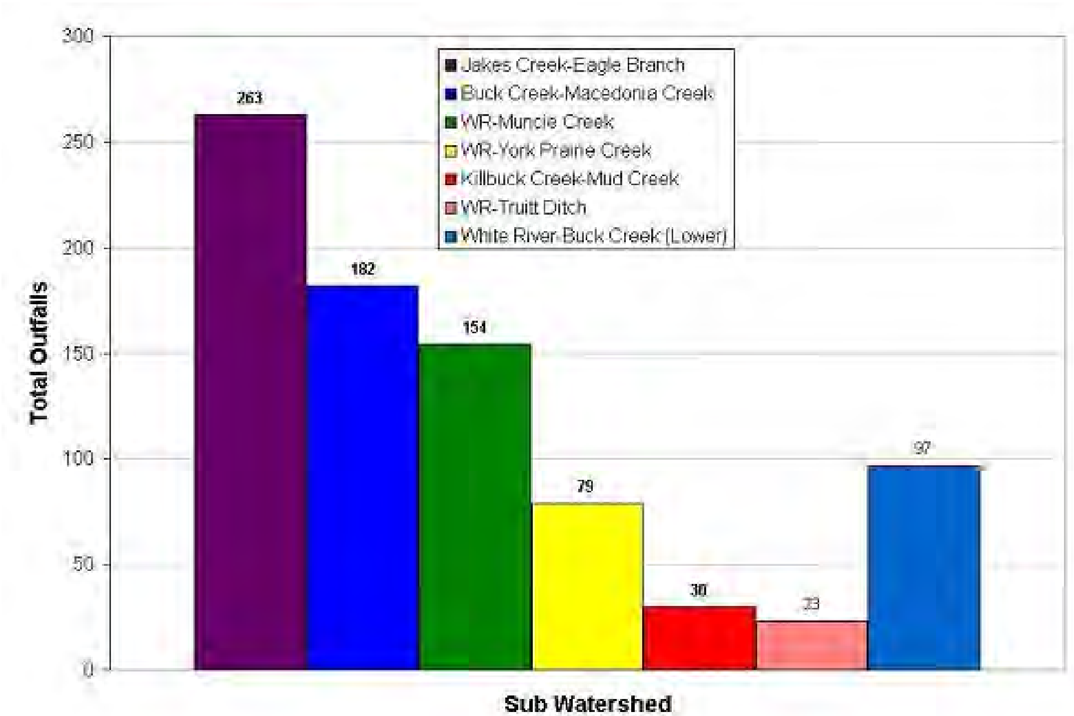
Due to the nature of the drainage systems in the county that do not fall under the jurisdiction of the County Surveyor (and Drainage Board) or INDOT, identification has proven to be difficult. The County is diligently working to gather 100% of the information, however, some of the surveyor's maps are on linen from the late 1800's and determining the age of developments or ownership has been difficult. [3]

Based on the unpredictable maintenance schedule of regulated drains within the watershed, it is difficult to assign a priority rating to these areas for potential improvement of wildlife habitat, water quality improvement measures, and erosion control measures within the Subwatersheds. However, the selected BMPs and Action Registers include measures and implementation projects that may be applicable to regulated drains. Coordination with the County Surveyors Office will be necessary during the implementation project evaluation phase. [4]

Potential limitations were considered by the steering committee with regard to prioritizing specific projects and priorities for Subwatersheds that contain high densities of legal drains. The remaining waters are streams that are not maintained and remain in their natural state.[5] BMPs within regulated drains in the watershed should be evaluated prior to implementation. If regulated drains are considered for BMP measures (Le. two-stage ditches, stabilization, etc), the Steering Committee should coordinate with the local County Surveyor's office. [6]

1 Geist Reservoir/Upper Fall Creek WMP
2 Wabash River (Region of the Great Bend) WMP
3 Tom Reeve, White River Watershed Project
4 Wabash River (Region of the Great Bend) WMP
5 Tom Reeve, White River Watershed Project
6 Geist Reservoir/Upper Fall Creek WMP

Many outfall pipes, in Muncie city limits, have been identified by the Muncie Bureau of Water Quality surveillance team. Common types of pipe materials identified are: corrugated metal pipe, corrugated plastic pipe, polyvinyl chloride, reinforced concrete pipe, and steel pipe. Table 2.19 shows the number of outfalls located in Muncie Creek - Hamilton Ditch and Truitt Ditch - White River Subwatersheds and Chart 2.11 compares these subwatersheds to others in the county. The location of these outfalls can be found on Map 2.41 on the following pages.



CHA. 2.11 Relation of out falls between major Subwatersheds in City Limits, BWQ

TABLE 2.19: Total Outfalls in Hamilton Ditch-Muncie Creek and Truitt Ditch-White River Subwatersheds (Muncie)

Subwatershed	Stream	Total Outfalls	Stream Miles	Density (out-falls/mile)
WR-Muncie Creek		154	5.95	25.88
	White River	33	1.7	19.41
	Holt Ditch	14	1.6	8.75
	Muncie Creek	93	2.28	40.79
	Hamilton Ditch	14	0.37	37.84
WR-Truitt Ditch		23	3.08	7.47
	White River	20	1.8	11.11
	Truitt Ditch	2	1.24	1.61
	32 Ditch	1	0.04	25.00
Total		835	32.44	25.73982737

SOURCE: Muncie Bureau of Water Quality Website

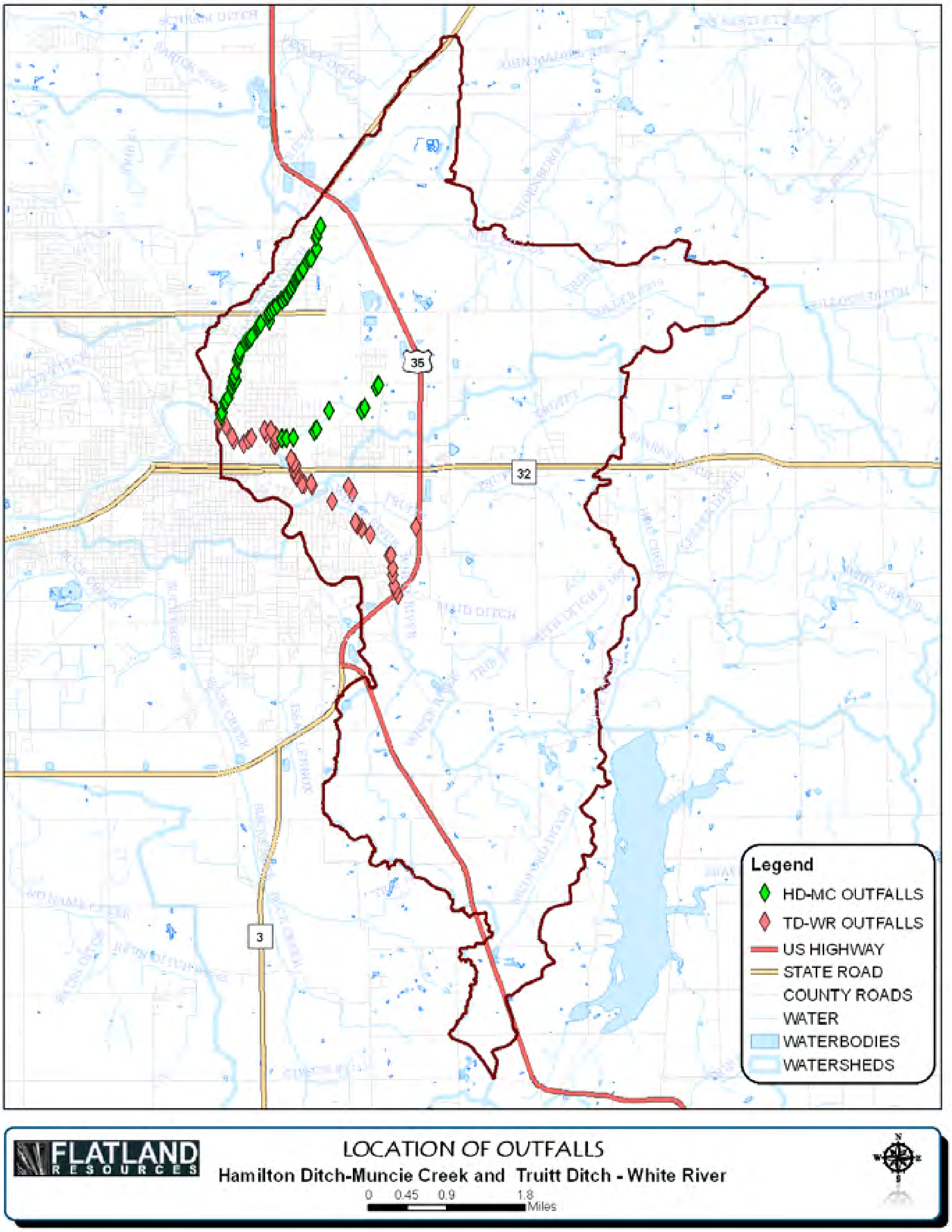
INVENTORY

Hydromodification - Logjams

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 15

A major log jam over one acre in size was removed in 2008 from the White River in the Truitt Ditch - White River Subwatershed. This log jam had been building in size for over 5 years. The backup of water and alteration in the flow of the river had caused the river to alter its course during high water events. This led to an increase in erosion in the area surrounding the jam. After removal, the eroded channel was restored to proper sinuosity and width using natural channel design to reduce the possibility of future erosion. Channel obstructions are a significant cause of erosion but not the sole source source of sediment.

IMG. 2.7 Burlington Log Jam



MAP. 2.41 Location of Outfalls in Subwatersheds

Hydromodification - Stormsewers
WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 16

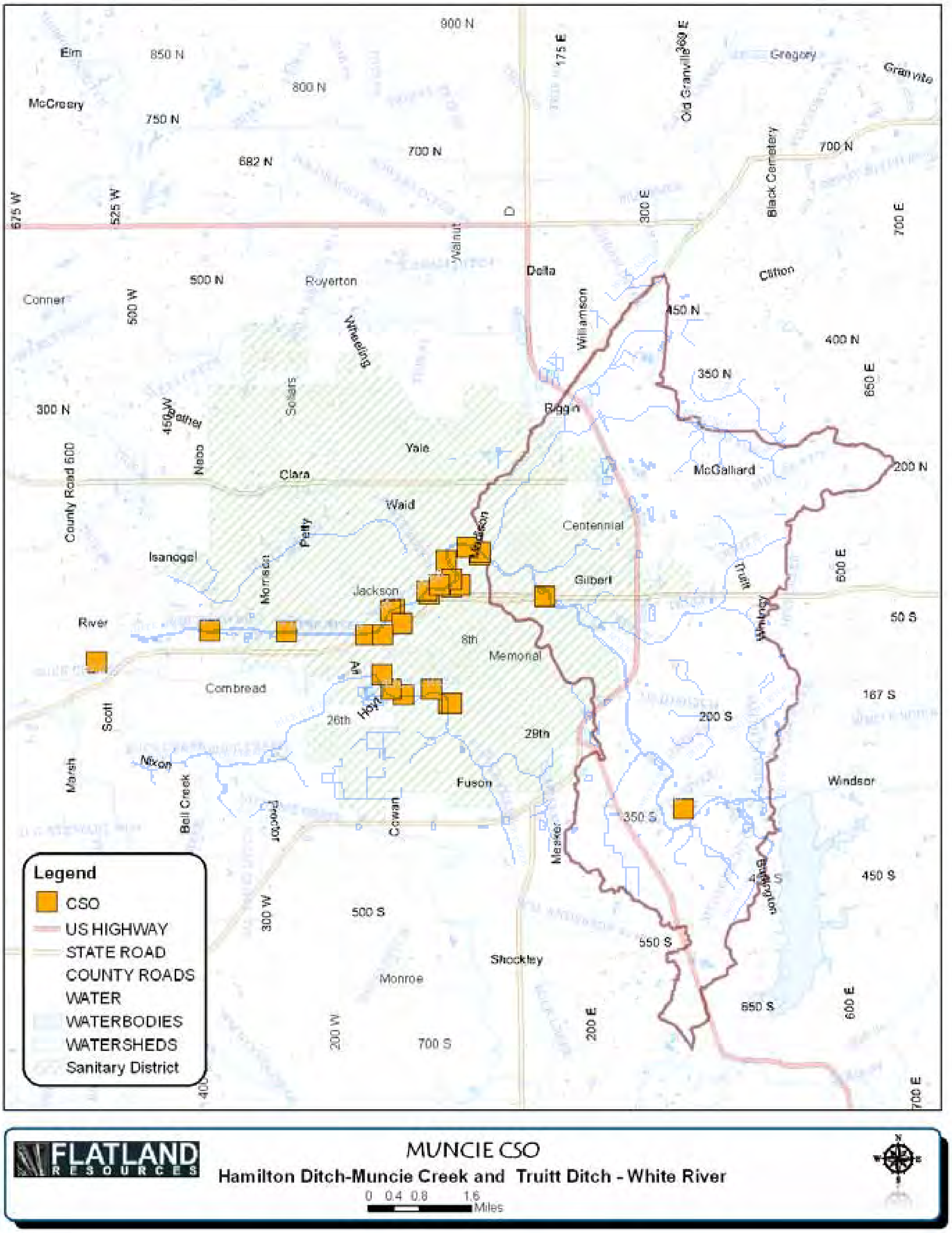
Under natural conditions, the majority of precipitation is allowed to infiltrate the soil and recharge groundwater resources. The volume of infiltration and groundwater recharge diminishes as development increases. To handle the large volume of precipitation falling in urban areas, storm water systems have been constructed. Storm drain systems are present in most urban areas throughout the watershed. In total, more than 800 miles of storm drain pipe are present within the watershed. The MS4 boundary is the service area of the Muncie Sanitary District, which includes most of the corporate boundary of the City of Muncie. The Muncie MS4 has approximately 617,800 ft of storm sewers.[1]

The Muncie Sanitary District has 100% of its storm sewer system and outfalls mapped in GIS and AutoCAD (MAP 2.41). Delaware County has 100% of its outfalls mapped in GIS and approximately 95% of its storm sewer system mapped. [2] Once systems that do fall under the jurisdiction of the County Surveyor and private have been identified, the county mapping will be complete.[3]

Evidence for Muncie's vast combined storm water/sewage system is the spike of Phosphorus that discharges from the WPCF. Although the WPCF estimates reducing Phosphorus by 10%, the WPCF is not designed to remove Phosphorus. The fact that there is such a high amount of Phosphorus discharging from the WPCF makes shareholders assume that the storm water runoff entering the combined system is high in Phosphorus from urban lawn care practices (and other sources).

Combined Sewer Overflows
When it rains, the sewer system can't handle the large volume of sewage and storm water. Instead of allowing water to back up into people's basements during a rainstorm, the combined sewer system allows the polluted water to be discharged directly into the White River. This discharge into the river is known as a combined sewer overflow or CSO.[4]

1 Tom Reeve, White River Watershed Project
2 Tom Reeve, White River Watershed Project
3 Tom Reeve, White River Watershed Project
4 The Rouge River Project



MAP. 2.42 Location of CSOs in Muncie City Limits, MSD

TABLE 2.20: MUNCIE SANITARY DISTRICT SUMMARY OF CSO DISCHARGE MONITORING REPORTS (2002 - 2004)						
	2002		2003		2004	
	37.2-in. Rainfall		45.1-in. Rainfall		30.0-in. Rainfall	
	Discharge Days	Discharge Duration (HRS)	Discharge Days	Discharge Duration (HRS)	Discharge Days	Discharge Duration (HRS)
CSO 026	9	133	34	454	24	349
CSO 025	No Data	No Data	No Data	No Data	No Data	No Data
CSO 024	1	11	6	66	6	80
CSO 023	No Data	No Data	No Data	No Data	No Data	No Data
CSO 022	No Data	No Data	4	44	4	51
CSO 018	13	195	55	940	50	693
CSO 262	No Data	No Data	No Data	No Data	No Data	No Data
CSO 027	4	47	14	197	5	66
CSO 015	20	283	52	834	42	645
CSO 013	1	16	7	98	10	126
CSO 012	1	15	10	142	4	51
CSO 031	No Data	No Data	5	67	2	24
CSO 009	9	143	9	143	12	146
CSO 028	2	18	12	161	13	152
CSO 034	No Data	No Data	No Data	No Data	No Data	No Data
CSO 007	No Data	No Data	6	69	4	46
CSO 004	3	28	3	28	4	46
CSO 033	No Data	No Data	5	72	2	24
CSO 002	2	23	2	23	2	24
CSO 001	7	102	7	102	4	40

SOURCE: MUNCIE SANITARY DISTRICT SUMMARY OF CSO DISCHARGE MONITORING REPORTS

Long Range Control Plan

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 17

Muncie's Long Term Control Plan (LTCP) specifies a 96% reduction in CSO discharge and the eventual elimination of combined sewers.[1] There is no CSO data for the two CSOs in the Hamilton Ditch - Muncie Creek Subwatershed or the singular CSO in the Truitt-Ditch White River Subwatershed (See MAP 2.42). The remaining CSO locations discharge to the White River and Buck Creek. This data is included to demonstrate the tremendous impact CSOs have on water quality in Delaware County. The relationship between CSOs and E. coli levels will be discussed in later sections of the WMP.

1 Data from the Muncie Water Pollution Control Facility

MUNCIE SANITARY DISTRICT SUMMARY OF CSO DISCHARGE MONITORING REPORTS (2005 - 2008)							
2005		2006		2007		2008	
39.7-in. Rainfall		44.7-in. Rainfall		38-in. Rainfall		39.31-in. Rainfall	
Discharge Days	Discharge Duration (HRS)	Discharge Days	Discharge Duration (HRS)	Discharge Days	Discharge Duration (HRS)	Discharge Days	Discharge Duration (HRS)
33	519	37	508	13	206	19	542
9	141	4	43	0	0	1	23
11	197	7	93	4	48	5	107
11	199	3	44	0	0	1	23
9	167	7	91	11	236	42	391
37	649	71	1099	74	1743	33	2119
No Data	No Data	10	151	14	232	13	266
11	170	10	142	15	174	26	136
42	657	34	481	38	424	55	861
15	207	6	71	2	26	0	0
8	116	No Data	No Data	6	73	1	24
2	26	2	25	0	0	0	0
9	117	8	90	2	24	3	71
13	168	7	90	8	168	2	52
No Data	No Data	No Data	No Data	0	0	0	0
4	46	No Data	No Data	0	0	1	28
6	106	8	112	5	68	4	93
No Data	No Data	No Data	No Data	2	24	0	0
6	94	4	52	0	0	1	23
8	114	15	209	6	128	3	76

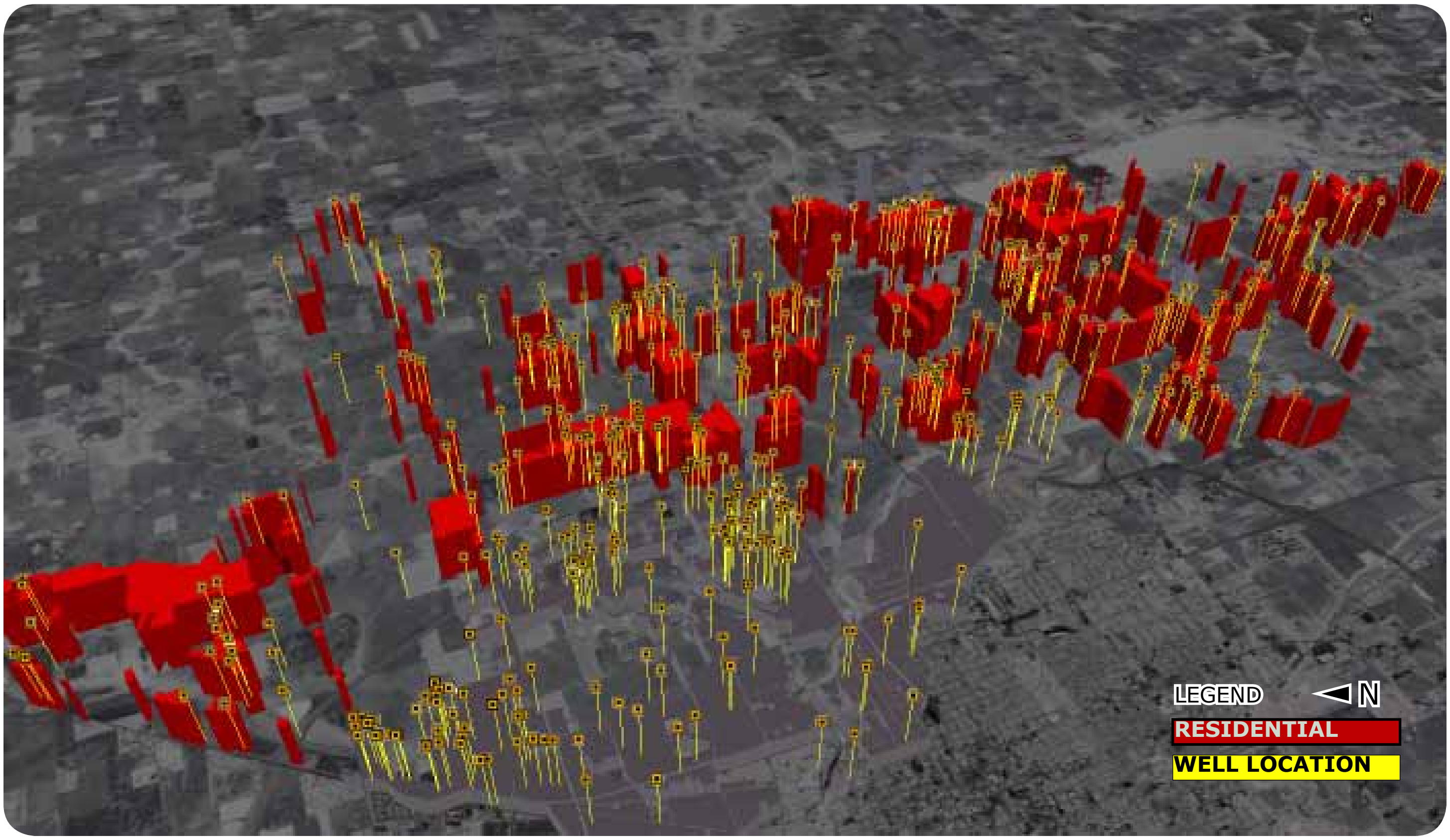
SOURCE: MUNCIE SANITARY DISTRICT SUMMARY OF CSO DISCHARGE MONITORING REPORTS

Water Supply

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 18

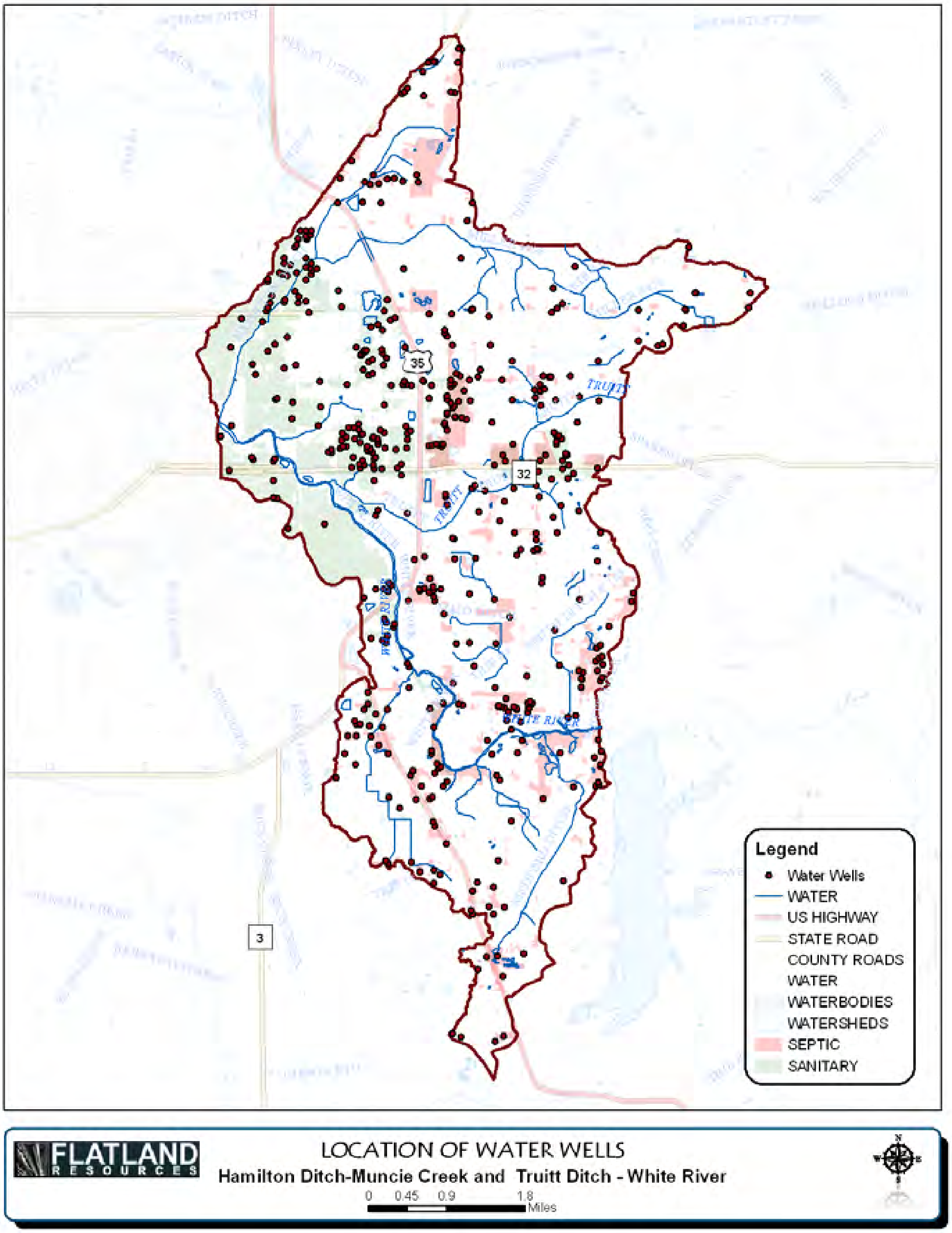
The primary supply for the city is derived from the White River, supplemented by discharge from Prairie Creek Reservoir during periods of low flow. The City of Muncie utilizes ground water as an auxiliary water supply. Delaware County does not have any rural water systems, thus wells are used in much of the rural community. There are 610 wells in Muncie Creek - Hamilton Ditch and Truitt Ditch-White River Subwatersheds (See Map 2.43 and Diagram 2.6). [1] The quality of the ground water is strongly affected by the glacial deposits and the underlying bedrock. The availability of ground water is generally good in Delaware County, and wells produce as much as 200 to 400 gallons per minute. For the most part, the primary aquifers are seams of sand and gravel within the glacial till and glacial outwash deposits of sand and gravel.[2]

Recharge of local aquifers occurs in the same manner as do many of the other aquifers in the state, namely by the downward percolation of local rainfall through the soil horizon and underlying formations. However, localized significant rainstorms can produce relatively quick response to recharge, especially if adjacent areas did not receive the rainfall. Care must be taken to ensure the quality of the water from alluvial and surficial aquifer source waters. Potential pollution from construction, sewage outfall, illegal dumping, agriculture, and storm water runoff must be avoided or controlled due to the recharge of these aquifers from runoff and river water.[3]



DIA. 2.6 Location of Water Wells adjacent to residential septic tanks on unsuitable soils.

1 Soil Survey of Delaware County Indiana. US Department of Agriculture
2 Soil Survey of Delaware County Indiana. US Department of Agriculture
3 Soil Survey of Delaware County Indiana. US Department of Agriculture



MAP. 2.43 Location of Waterwells in Subwatersheds

Wellhead Protection Areas

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 19

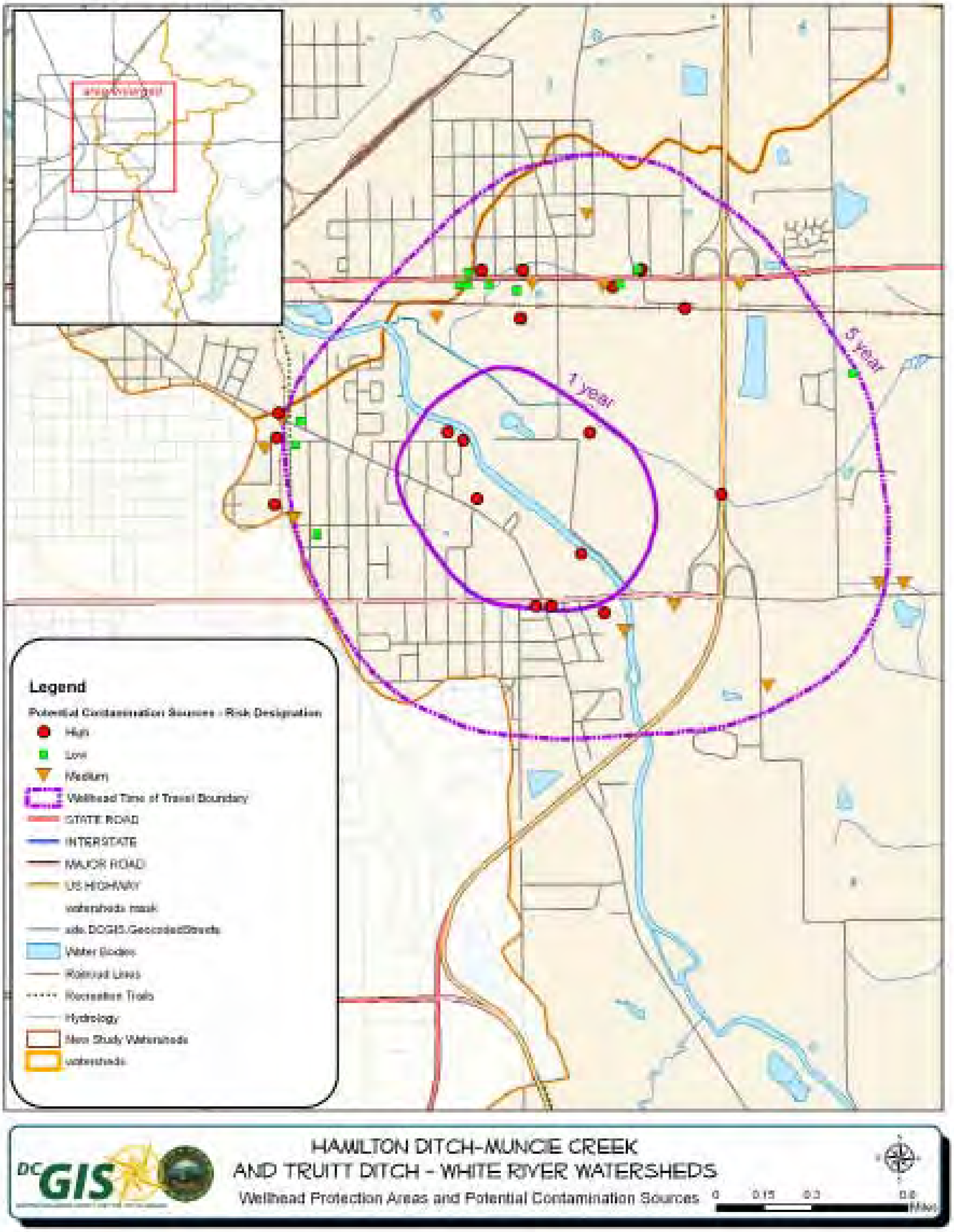
The IDEM Ground Water Section administers the Wellhead Protection Program, a strategy to protect ground water drinking supplies from pollution. The Safe Drinking Water Act and the Indiana Wellhead Protection Rule (327 IAC 8.4-1) mandates a wellhead program for all Community Public Water Systems. The Wellhead Protection Programs consist of two phases. Phase I involves the delineation of a Wellhead Protection Area (WHPA), identifying potential sources of contamination, and creating management and contingency plans for the WHPA. Phase II involves the implementation of the plan created in Phase I, and communities are required to report to IDEM how they have protected ground water resources. [1]

Information pertaining to wellhead protection and its delineations/restrictions will be important during the implementation phases of the plan. Approved Wellhead Protection Areas are no longer available on-line due to recent legislation classifying this type of information as confidential. [2]

Indiana America Water Company Inc. is the utility providing water to Muncie. As a community water source, they are required by IDEM to have a plan in order to protect the groundwater supply from pollution. The plan is regularly reviewed and updated with input from a local Wellhead Protection Plan committee. Committee members include personnel from the Indiana-American Water Co., the Delaware County Health Department, the East-Central Indiana Soil Waste District, Storm water Management, the Delaware-Muncie Metropolitan Plan Commission, and local emergency service providers.[3]

The plan includes identifying potential contaminant sources within the wellhead protection areas. The Wellhead Protection Areas are the delineated areas where a spill would take one year to reach the wellheads and the areas in where a spill would take five years to reach the wellheads (MAP 2.44). If a spill occurs in these areas, procedures have been established to minimize the spill's impact upon the local water supply. Another important component to the plan is educating the public about what groundwater is and practices to protect it from pollution. Recently the plan has helped identify Indiana American Water in Muncie's community as a Hoosier Water Guardian.[4]

1 Tom Reeve, White River Watershed Project
2 Tom Reeve, White River Watershed Project
3 Tom Reeve, White River Watershed Project
4 Tom Reeve, White River Watershed Project



MAP. 2.44 Wellhead Protection Zone in Subwatersheds

INVENTORY

Ground Water Assessment

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 20

Ground water is an important resource for Indiana citizens, agriculture, and industry. The majority of the state's population use ground water for drinking water and other household uses.

During the growing season, ground water is withdrawn at an average rate of 282.9 million gallons per day (mgd) for crop and turf irrigation (based on a 90-day season). Industry withdraws an average 98.6 mgd of ground water, and 31.3 mgd is used for energy production (Ralph Spaeth, Indiana Department of Natural Resources, written communication, 2000). Since December 2000, no statewide ground water monitoring studies have been conducted due to budgetary and staffing constraints. However, a statewide ground water monitoring network is scheduled to begin spring of 2008.[1]

Some of the major contaminant sources impacting Indiana ground water as of 1998 are listed below and in Table 2.21 and 2.22. All pollutant sources are a potential threat to ground water. However, the degree to which the source is a threat to ground water depends on several factors, the most significant being hydrogeologic sensitivity. Other major risk factors include location of the contaminant source relative to drinking water sources, toxicity of the contaminant, and the size of the population at risk.[2]

1 Indiana Integrated Water Monitoring and Assessment Report
2 Indiana Integrated Water Monitoring and Assessment Report

Nitrate

Nitrate is a potential contaminant from the following high priority sources: commercial fertilizer applications, concentrated animal feeding operations (CAFOs), and septic systems. Nitrate, a highly mobile and soluble contaminant, is the most frequently detected ground water contaminant in rural areas. However, determining the source of nitrates detected in ground water can be difficult and costly. For the 1999 and 2000 crop production season, 537 million tons and 970 million tons, respectively, of commercial fertilizer containing nitrogen were sold in Indiana for application on some 12 million acres of cropland, most of which was applied to nearly 6 million acres of corn (Indiana Agricultural Statistics Service 1999-2000). Unlike pesticides, the purchase and application of commercial fertilizer is not regulated by the Office of the Indiana State Chemist. When applied at the proper rate and time, commercial fertilizer poses little threat of contamination to ground water. Purdue University Cooperative Extension Service staff, United States U.S. Department of Agriculture Natural Resources Conservation Service (USDA-NRCS) staff and private consultants assist crop producers in developing nutrient management plans that focus on meeting crop nutrient needs based on realistic goals.[3]

Confined feeding operations

Confined feeding operations and larger concentrated animal feeding operations exist throughout Indiana as an integral component of Indiana's agricultural economy. In 2001, the Indiana WPCB adopted new confined feeding operation (CFO) regulations (327 IAC 16), as required by IC 13-18-10, that provides design, construction and operational performance standards for all state-regulated CFOs. This is not to be confused with the NPDES permit program that regulates CAFOs. The WPCB adopted new NPDES regulations for CAFOs in January of 2004. These regulations mirror the federal regulations for animal feeding operations and include the recent amendments to the federal regulations. The NPDES regulations for the issuance of individual NPDES permits for CAFOs are found at 327 IAC 5-4-3 and the regulations for the issuance of NPDES general permits for CAFOs are found at 327 AIC 15-15-5. Additionally, the USDA-NRCS also works closely with livestock producers who request financial and technical assistance for building livestock waste storage facilities and to install or implement conservation practices that serve to reduce soil erosion and nutrient loss. The primary concerns associated with CAFOs are the proper storage and land application of the large volumes of ammonia-containing manure produced by these operations. The ammonia form of nitrogen is converted to nitrate through biological processes in the soil. Consequently, the rate of manure application to farmland is a major concern when the application provides more nitrogen than a crop will use, allowing excess nitrogen to move into underlying aquifers. The new regulations also address the need to consider the phosphorous content of manure in determining the agronomic rates for land application.[4]

Septic Systems

Properly constructed and maintained septic systems provide satisfactory on-site treatment of domestic wastewater in rural and unsewered suburban areas of Indiana. However, improperly constructed or poorly maintained septic systems, as well as systems operating in areas of high seasonal water tables or other ground water sensitive areas, are also of concern as a source of nitrate contamination to ground water.[5]

Landfills

3 Indiana Integrated Water Monitoring and Assessment Report
4 Indiana Integrated Water Monitoring and Assessment Report
5 Indiana Integrated Water Monitoring and Assessment Report

Landfills and underground storage tanks are a high priority ground water contamination concern, largely due to practices or activities that occurred prior to construction standards and legislation established for the protection of ground water. Landfills constructed after 1988 have been required to adhere to stringent construction standards. Since 1988, underground storage tank registration, upgrading, closure activity and site assessment have been closely reviewed by the IDEM Underground Storage Tank (UST) Section. In accordance with federal and state mandates, underground storage tanks installed prior to December 22, 1988, were to be either properly protected against spills, overflows and corrosion, or properly closed. Class V underground injection wells (UIWs) are widespread throughout the state and occur in high concentration in several areas, including some where ground water is highly sensitive to contamination. Class V wells release a wide variety of contaminants into or above aquifers supplying drinking water. The large number and diversity of Class V wells combined with lack of information regarding effects of these wells on ground water pose a significant potential threat to ground water. Indiana Class V wells are regulated by the USEPA. The USEPA targeted those Class V wells that pose the greatest environmental risk and in 2000 implemented more intensive regulations and enforcement for large capacity cesspools and motor vehicle waste disposal wells. [6]

Industrial facilities

Several cases of ground water contamination due to industrial facilities or their ancillary operations have been documented in Indiana. Although many contamination events occurred prior to the development of regulations for the storage and handling of industrial materials, ground water contamination still occurs as a result of either accidents or intentional dumping of waste. In 1998, Indiana's Secondary Containment of Above Ground Storage Tanks Containing Hazardous Materials Rule (327 IAC 2-10) was adopted. This rule requires that new facilities provide secondary containment for storage of 660 gallons or more of hazardous wastes if the facility is located outside an approved delineated wellhead protection area. The rule is more protective if the facility is located within an approved delineated wellhead protection and requires secondary containment if 275 gallons or more of hazardous materials are stored there. The secondary containment rule, along with outreach and education programs, have alleviated a number of problems. However, these activities continue to be a potential source of contamination to ground water in Indiana.[7]

Salt

The storage and extensive use of salt as a deicing agent during the winter months has an impact on ground water. Ground water contamination from road salt has been documented in Indiana. Efforts are being made by the Indiana Department of Transportation (INDOT) to build salt storage facilities in areas where ground water is not sensitive to contamination and to upgrade existing facilities to protect ground water. Currently all INDOT salt storage facilities are covered by domes or canopies, and several new facilities were built to contain all surface runoff on-site to reduce ground water contamination. In addition, road salt usage and application rates have been significantly reduced from past years through computerized weather forecasting and roadway temperature sensors. [8]

Spills

Ground water contamination as a result of spills can be avoided or minimized if spills are properly handled and cleaned up. Unreported spills may contribute to ground water contamination. Spill handling and clean up, when not properly executed, create a concern for ground water contamination. Indiana's Spills; Reporting, Containment and Response Rule (327 IAC 2-6.1) ensures that spills are reported, properly handled and cleaned up.[9]

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6 Indiana Integrated Water Monitoring and Assessment Report
7 Indiana Integrated Water Monitoring and Assessment Report
8 Indiana Integrated Water Monitoring and Assessment Report
9 Indiana Integrated Water Monitoring and Assessment Report

TABLE 2.21: Contaminant Priority Rankings for Muncie Creek - Hamilton Ditch and Truitt Ditch-White River (adopted from USEPA)			
	Highest Priority	Risk Factors	Type of Contaminant
Agricultural chemical facilities		A,C,H,I	5
Commercial fertilizer applications	X	A, C, D, E	5
Confined animal feeding operations	X	A, D, E	5, 9
Irrigation practices		A,C,H,I	1,2,5,8,9
Manure applications	X	A,C,H,I	5, 9
Pesticide applications		A,C,H,I	1,2
Land application		A,C,H,I	5,9
Domestic and industrial residual applications		A,C,H,I	5,9
Material stockpiles		A,C,H,I	5,9
Storage tanks (above ground)		A,C,H,I	
Storage tanks (underground)	X	A, B, C, D, E, F	2, 3, 4
Surface impoundments	X	A, C, D, E, F	1, 2, 3, 4, 5, 6, 7, 9
Waste piles		A,C,H,I	5,9
Landfills (constructed prior to 1989)	X	A, B, C, D, E, F	1, 2, 3, 4, 5, 6, 7, 8, 9
Septic systems	X	A, C, D, E, F, G	1, 2, 3, 4, 5, 7, 9
Shallow (Class V) injection wells	X	A, B, C, D, E, I	1, 2, 3, 4, 5,7,9
Hazardous waste generators		A	
Hazardous waste sites		A	
Industrial facilities	X	A, B, C, D, E, F	1, 2, 3, 4, 5, 7, 8, 9
Liquid transport pipelines (including sewer)		A	8
Materials spills (including during transport)	X	A, B, C, D, E, F	1, 2, 3, 4, 5, 7, 8, 9
Material transfer operations		A	
Small-scale manufacturing and repair shops		A, I	8
Mining and mine drainage		A	7,8
Salt storage (state and nonstate facilities) and road salting	X	A, C, D, E, F	6
Urban runoff		A, C, H, I	1, 2, 4, 5, 7, 8, 9

SOURCE: USEPA

Factors considered in selecting the contaminant source: (A) human health and/or environmental risk (toxicity); (B) size of the population at risk; (C) location of source relative to drinking water source; (D) number and/or size of contaminant sources; (E) hydrogeologic sensitivity; (F) documented state findings, other findings; (G) high to very high priority in localized areas, but not over majority of Indiana; (H) geographic distribution/occurrence; (I) lack of information

Classes of contaminants associated with contamination source: (1) Inorganic pesticides; (2) Organic pesticides; (3) Halogenated solvents; (4) Petroleum compounds; (5) Nitrate; (6) Salinity/ brine; (7) Metals; (8) Radionuclides; (9) Bacteria, Protozoa and Viruses[1]

1 Indiana Integrated Water Monitoring and Assessment Report

INVENTORY

Hazardous Waste and Superfund

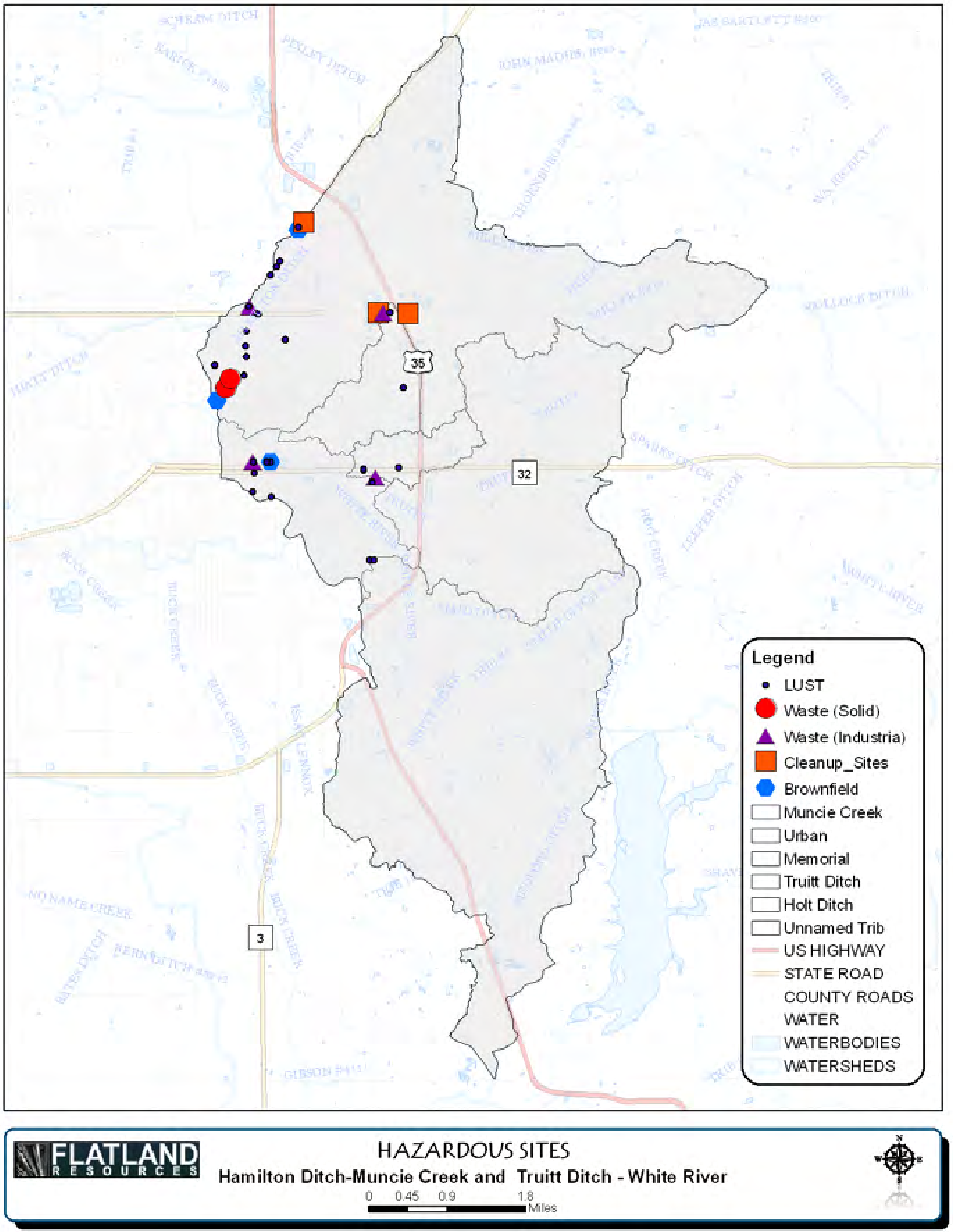
WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 23

There are about 4000 Leaking Underground Storage Tanks (LUST) sites in the state of these over eighty require attention in Delaware County. A list of Active LUST Sites in Delaware County was extracted from the state database.[1]

Underground storage tanks are typically found at gas or service stations, dry cleaners, airport or truck refueling facilities, and in homes or businesses where heating oil was stored. Gasoline, diesel fuel, hydraulic fuel, jet fuel, oil, and perchloroethylene (dry cleaning), are some of the contaminants that leak from older tanks.

A fuel additive called MTBE, methyl tertiary-butyl ether, is also a source of concern. "In December 1997, EPA issued a drinking water advisory that states concentrations of MTBE, in the range of 20 to 40 ppb of water or below will probably not cause unpleasant taste and odor for most people, recognizing that human sensitivity to taste and odor varies widely. The advisory is a guidance document that recommends keeping concentrations below that range." The EPA recommends but does not require drinking water be tested for MTBE.[2]

1 Data Generated by ArcGIS
2 Data Generated by ArcGIS



MAP. 2.45 Location of Hazardous, Waste, Lust and Superfund Sites

Hazardous Waste and Superfund

WMP - CHAPTER 2 - PART 1 - SECTION 4 - SUBSECTION 24

There are two permitted solid waste sites in the Muncie Creek - Hamilton Ditch Subwatershed: Muncie Sanitation District (811 East Centennial Avenue) and the East Central Recycling Transfer Station (701 East Centennial Avenue). There are currently no permitted hazardous waste disposal facilities in the county.[1]

However, at least two hazardous waste sites have been formally identified in Delaware County by IDEM and are described in the 2002 Commissioners Bulletin: The Albany Sludge Pit (located on Hwy 67SW in Albany) and Stout Storage Battery (located at 2505 W 8th Street in Muncie). The sludge pit served as an uncontrolled dumpsite and sewage release site. Lead, PCBs and solvents have been detected in the soil and groundwater. Action has begun to contain the problem and a three-year study ending in 2003 has been implemented to monitor progress. The old lead battery site has been cleaned and is considered safe for residential or commercial use. [2]

The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) tracks EPA's hazardous waste sites that have the potential for releasing hazardous substances into the environment. They list the following current hazardous waste sites in Delaware County.[3]

The Agency for Toxic Substances and Disease Registry identifies incidences at the following hazardous sites: Baker Garage, 1996, the Battery Case Dump, in 1991, Franks Foundry Corp. in 1996 and 2000; the Lennington and Thornburgh Sludge Dumps, 1990 and 1991; the Memorial Drive Dump in 1997. The Lennington Area Dump is located at Eaton Avenue and SR 35S in Muncie. The CDC toxic substances report for this site in 1990, indicated private groundwater contamination: 35mg lead (MCL 0.05mg); iron 7mg, sodium 180mg. The Thornburgh Sludge Dump located at SR and CR 700N in Albany has been cleaned after the EPA found lead contamination in 1991. The site continues to be monitored. [4]

1 BioMuncie.org
2 IDEM, 2002
3 EPA CERCLIS Database
4 Agency for Toxic Substances and Disease Registry

TABLE 2.22: Location of Waste, Cleanup and Brownfeild sites		
Waste_Solid_Active_Permitted		
Name	Location	Zip
East Central Recycling Transfer Station	701 East Centennial Avenue	47303
MUNCIE-TRANSFER-ST	300 North High Street	47305
Waste_Industrial_IDEM		
Name	Location	Zip
JEFFERSON SMURFIT CORP (U.S.)	301 S BUTTERFIELD RD	47303
CITY MACHINE TOOL & DIE CO	1302 E WASHINGTON ST	47305
PRECISION TRANSMISSION	3700 E MCGALLIARD RD	47303
SEARS SVC	3501 GRANVILLE AVE	47303
Cleanup_Sites_IDEM		
Name	Location	Zip
Norrick Petroleum	NA	NA
Fred Ginther Property	NA	NA
Union Chapel Ministries	NA	NA
Brownfields		
Name	Location	Zip
CARDINAL GREENWAY	NA	NA
Muncie Recycling Center	NA	NA
Feeney Farm	4500 N. Broadway	47303
Munsyana Homes Pub. Hse. Copl	NA	NA

SOURCE: ArcGIS Indianamap.org

SECTION FIVE - LAND USE

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

Historic Land Use

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 1

Prior to pioneer settlement, the county was covered primarily in natural forests, beech and oak-sugar maple complexes on more well drained soils and elm-ash complexes in swampy areas of the county (Ecoregions of Indiana, USEPA). According to the 1849 Delaware County Retrospect, "The face of the county is mostly level or gently undulating, even the rivers and creeks not having any considerable bluffs or hills in their vicinity. In the southwest, southeast, and northwest parts of the county and near the center, there are prairies mostly small and not exceeding one-twelfth of the county. They are usually called wet prairies. The principal growth of timber is oak, hickory, poplar, beech, walnut, sugar, linn, etc., with undergrowth of hazel, dogwood, spice, and prickly ash; but the oak land is more extensive than the beech.". [1]

Delaware County was organized in 1826, named after the largest division of the Delaware Native American tribe that made its home here. That tribe was the Delaware Indians, an Eastern tribe that settled in east central Indiana during the 1770's. The Delaware Indians established several towns along the White River, among these Munseytown, near present day Muncie. In 1818, under the Treaty of St. Mary's Ohio, the Delawares ceded their holdings in Indiana to the United States government and moved westward. In 1820, Delaware County was opened for settlement. [2]

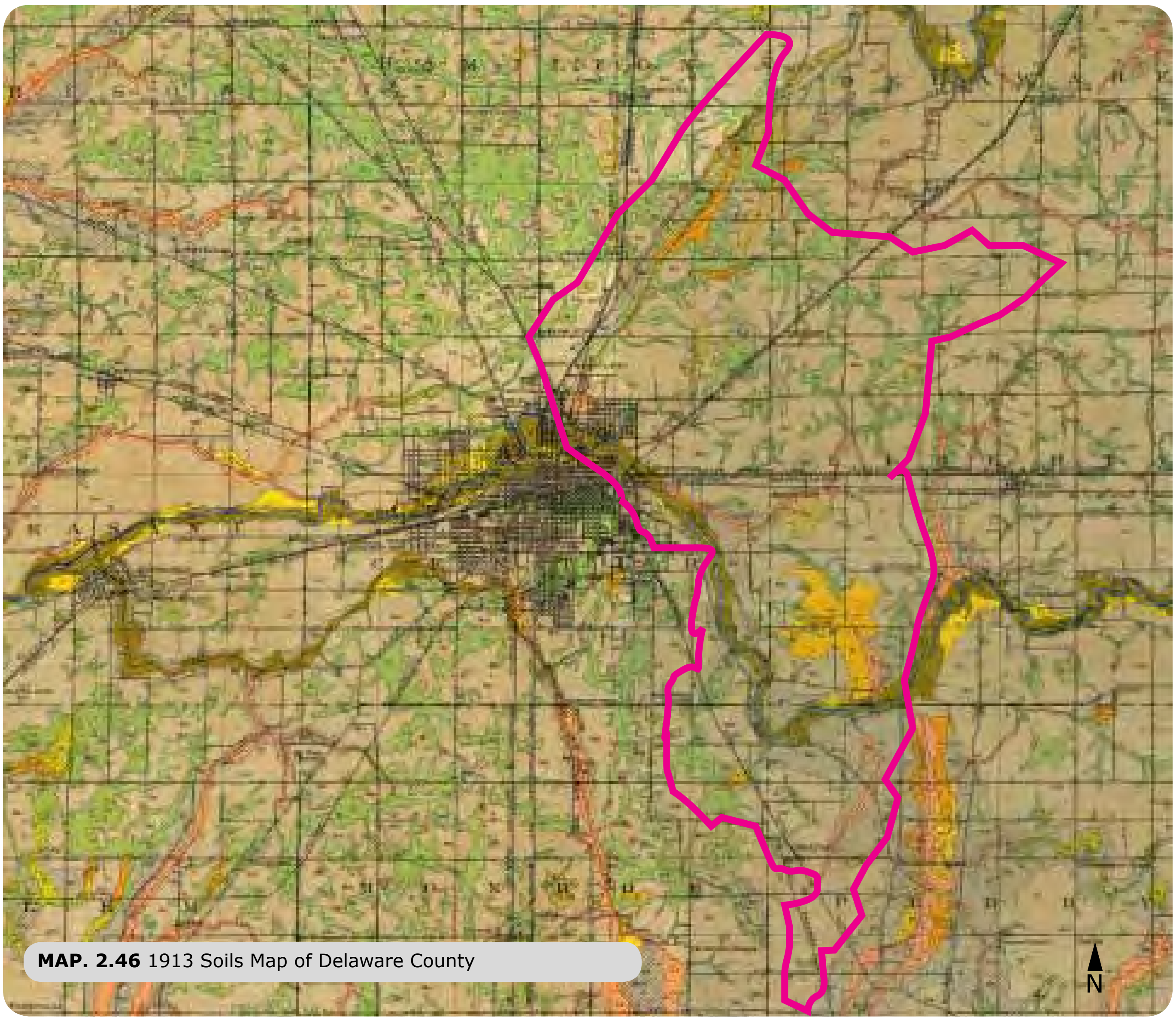
Munseytown became the county seat in 1827 (over Granville and Smithfield, both on like waterways). Muncie was incorporated in 1854 and became a city in 1865. "Most of the County's small towns were laid out along railroad lines. These included Desoto, Cowan, Oakville, and Royerton. Delaware County's population almost doubled to 23,000 between the years 1860-1880. During these years, Muncie began to evolve into an industrial city. By 1880, Muncie had forty factories, manufacturing products ranging from washing machines to roller skates. During the next few years, more than a dozen new industries opened. In 1888, five brothers from Buffalo, New York moved to Muncie after their glass factory had burned. Ball Brothers became one of the largest employers in Muncie and their Ball jars and other glass products were shipped throughout the country." [3]

"During the 1890's, additional businesses located in Muncie including Midland Steel, Indiana Iron Works, and the Muncie Wheel Company. By 1900 the Union Traction Company had opened an interurban line between Muncie and Anderson. The interurban passed through many of the smaller towns and cities. The opportunity to easily and inexpensively travel to a larger city to make purchases and conduct business decreased the economic importance of smaller towns. This became more evident when the interurban extended its service to Indianapolis early in the century. In 1917, the Ball Brothers bought what had previously been the Eastern Indiana Normal University and offered the property to the State. The school opened as a teachers college in 1918". [4]

The college is now known as Ball State University." Waterways and wagon paths were supplemented with railroads (8 lines laid between 1901 and 1948) and public roads. Enhanced connections between cities and towns were developed through a system of county roads, turnpikes and, eventually, a state highway system. The final connectors came with the completion of I-69 and the expansion of Johnson Field into the Delaware County airport, which ties the Delaware-Muncie area into a nationwide arena and a global economy. [5]

1 Indiana County History Preservation Society
2 Delaware County INGenWeb Project
3 2030 Delaware-Muncie Transportation Plan Update
4 Center Township Trustee's Office
5 2030 Delaware-Muncie Transportation Plan Update

Muncie was transformed from an agricultural trading center into an industrial community (glass, rubber, metals) with the discovery of natural gas in 1886. Depletion of the gas supply was followed by a growing automobile industry. The glass industry, via the Ball family, fostered a small community college, Normal City, which grew into Ball State Teachers College (with a 1944 enrollment of 1,346) and became Ball State University in 1965 with enrollment steadily increasing until the mid 1990's to a current range of some 19,000 students, which has risen and fallen near that level for ten years. [6]



MAP. 2.46 1913 Soils Map of Delaware County

6 2030 Delaware-Muncie Transportation Plan Update.pdf

Current Land Use

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 2

The Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds consist of approximately 20,383 acres of mixed land use, according to the 2001 National Land Cover Data (NLCD) published by the Soil Survey of Delaware County Indiana US Department of Agriculture (MAP 2.47, 2.48). The NLCD 2001 includes nineteen land classifications ranging from cultivated crops to high intensity developed land. These aerial images were compared to the NLCD 2001 in order to determine if any changes in land use had occurred. Based on the 2008 aerial, minor changes in land use when looking at the overall watershed (less than .1%) were seen in comparison to the 2001 information. [1]

The watershed has historically been dominated by agricultural land that comprises approximately 60% of its area. Additionally, forests and wetlands comprise only 30% (open water, forest, shrub/scrub, grassland herbaceous, woody wetlands and emergent herbaceous), and urban and residential lands comprise 10% of the watershed.

As urban areas continue to develop within the watershed, the agencies with regulatory authority should pay careful attention to the characteristics of the existing areas and require (as much as the law allows) that developments incorporate best management practices (including avoidance of significant natural areas, buffers, etc.) within their projects. [2]

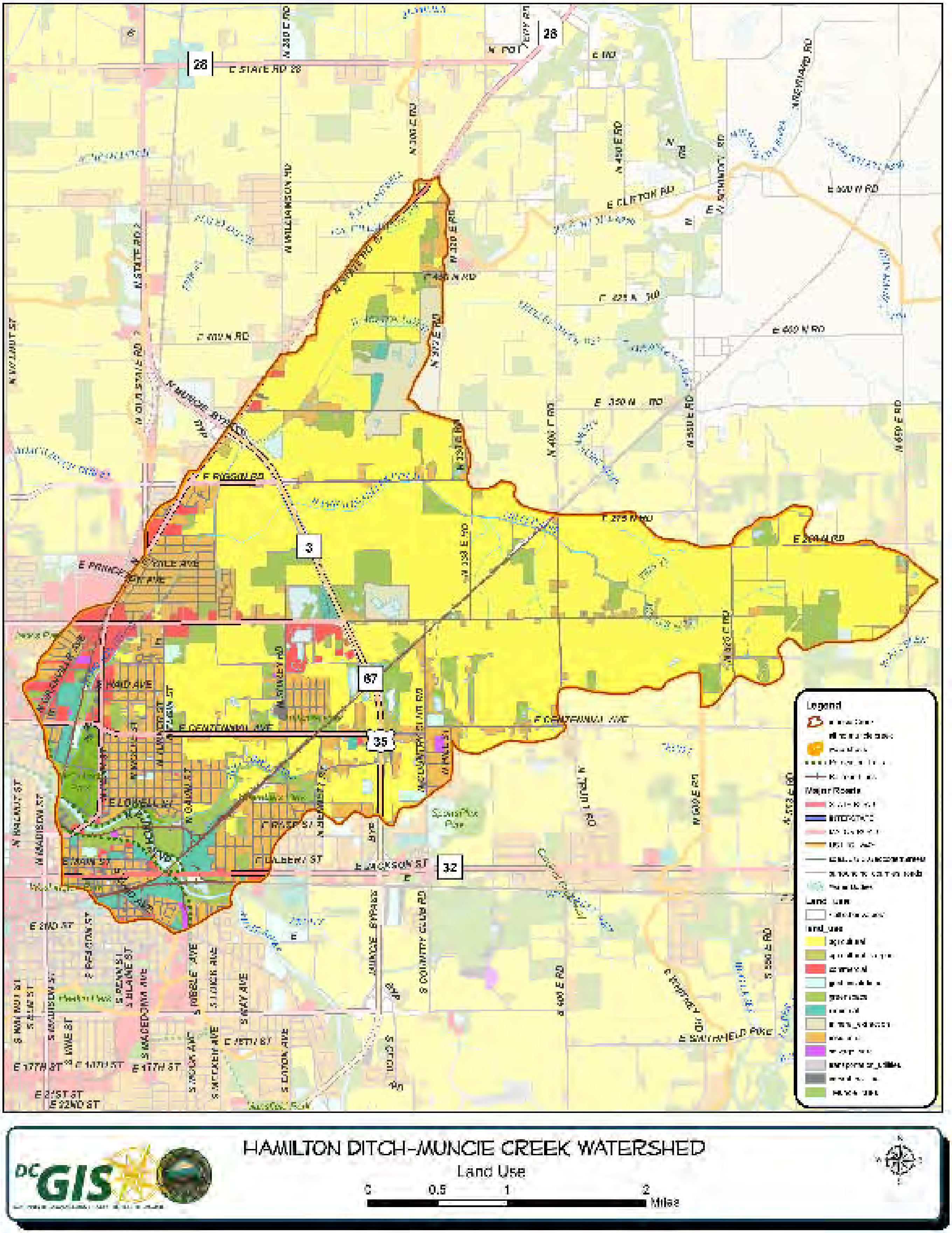
Of the total 11,781 acres in the Truitt Ditch-White River watershed, a large section of the watershed, over 1000 acres, is owned by the Academy of Model Aeronautics and is the site of their National Model Aviation Museum. The museum includes a large cool-season grass field that is surrounded by agriculture fields. Other large landowners include the County Commissioners of Delaware County, Cardinal Greenways Inc., and the Delaware Country Club Golf Course. In total 2.24% of the land is owned by public entities, and the rest, 97.76% is privately held.

Of the total 8,602 acres in the Hamilton Ditch-Muncie Creek watershed, the major landowners in this watershed include the City of Muncie, Irving Materials, Inc., and Muncie Community Schools. Three parks are located in this watershed: McCullough Park, the John M. Craddock Wetland Nature Preserve, and the Hughes Nature Preserve. A portion of the White River Greenway is also located in this watershed. In total, 2.17% of the land is owned by public entities, and the rest, 97.83% is privately held.[3]

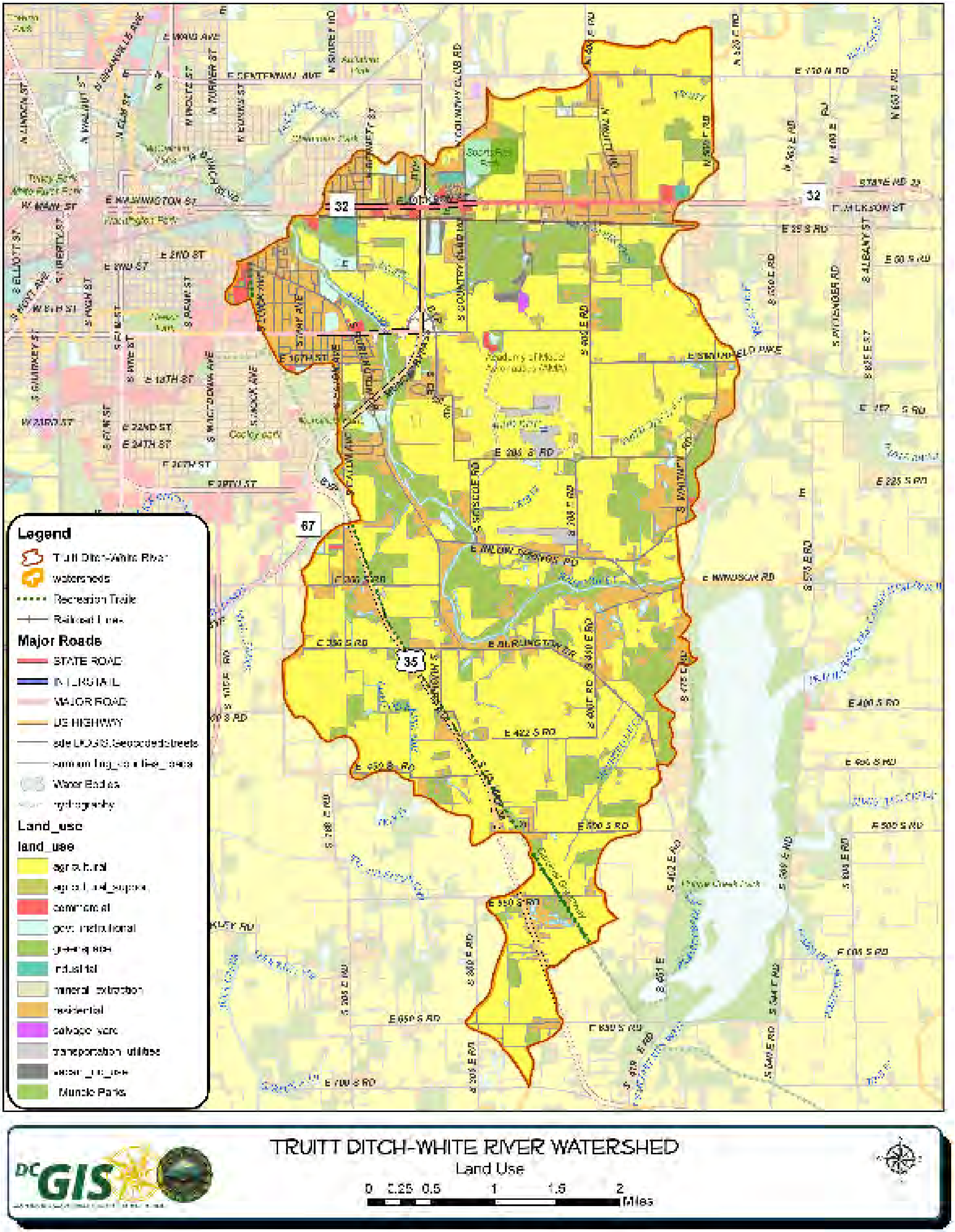
Water quality is greatly influenced by land use both past and present. Different land uses contribute different contaminants to surface waters. As water flows across agricultural lands it can pick up pesticides, fertilizers, nutrients, sediment, pathogens, and manure. However, when water flows across parking lots or from roof tops it not only picks up motor oil, grease, transmission fluid, sediment, and nutrients, but it reaches a waterbody faster than water flowing over natural or agricultural land. This is due to the inability of surface water to reach groundwater where hard surfaces exist. A review of the land types present in the watershed will provide an idea of the types of restoration that could occur within the watershed and also a basis for the past uses of the land. [4]

1 Tom Reeve, White River Watershed Project
2 Tom Reeve, White River Watershed Project
3 Tom Reeve, White River Watershed Project
4 Tom Reeve, White River Watershed Project

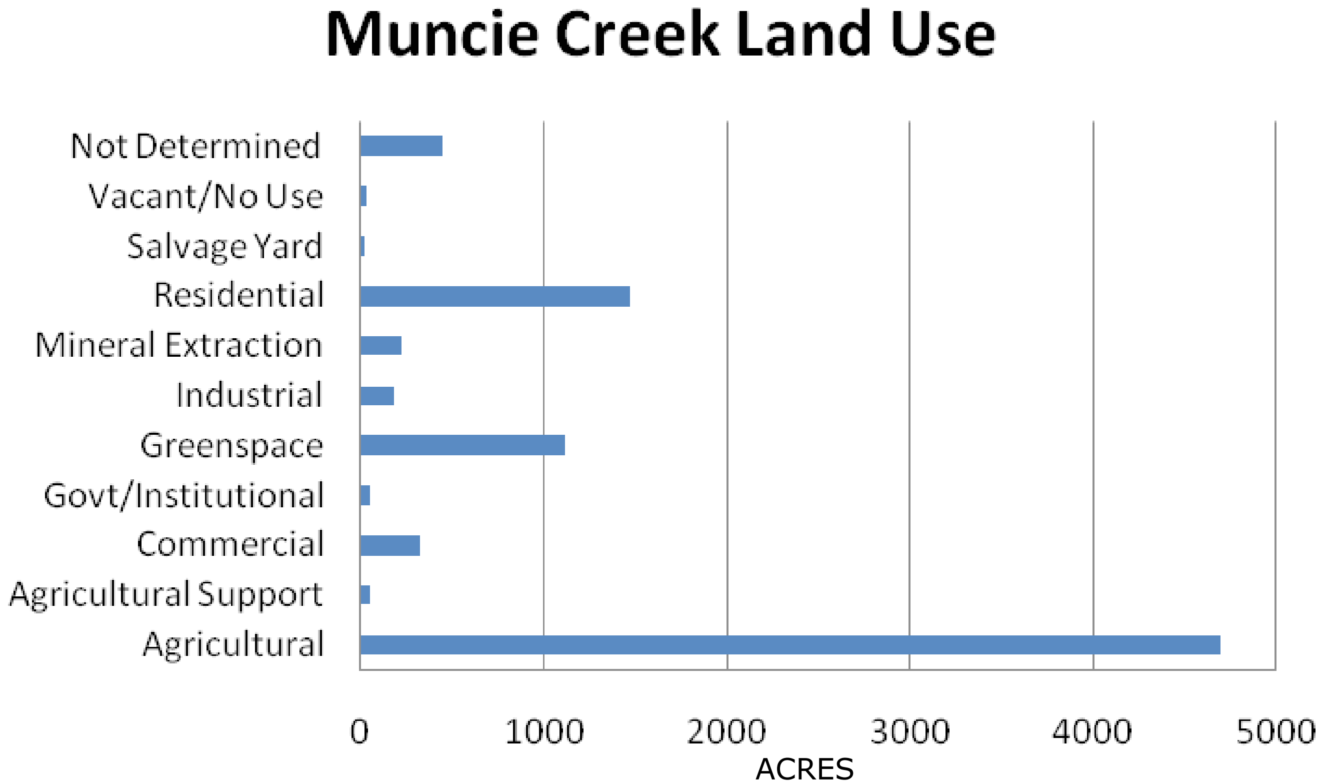
INVENTORY



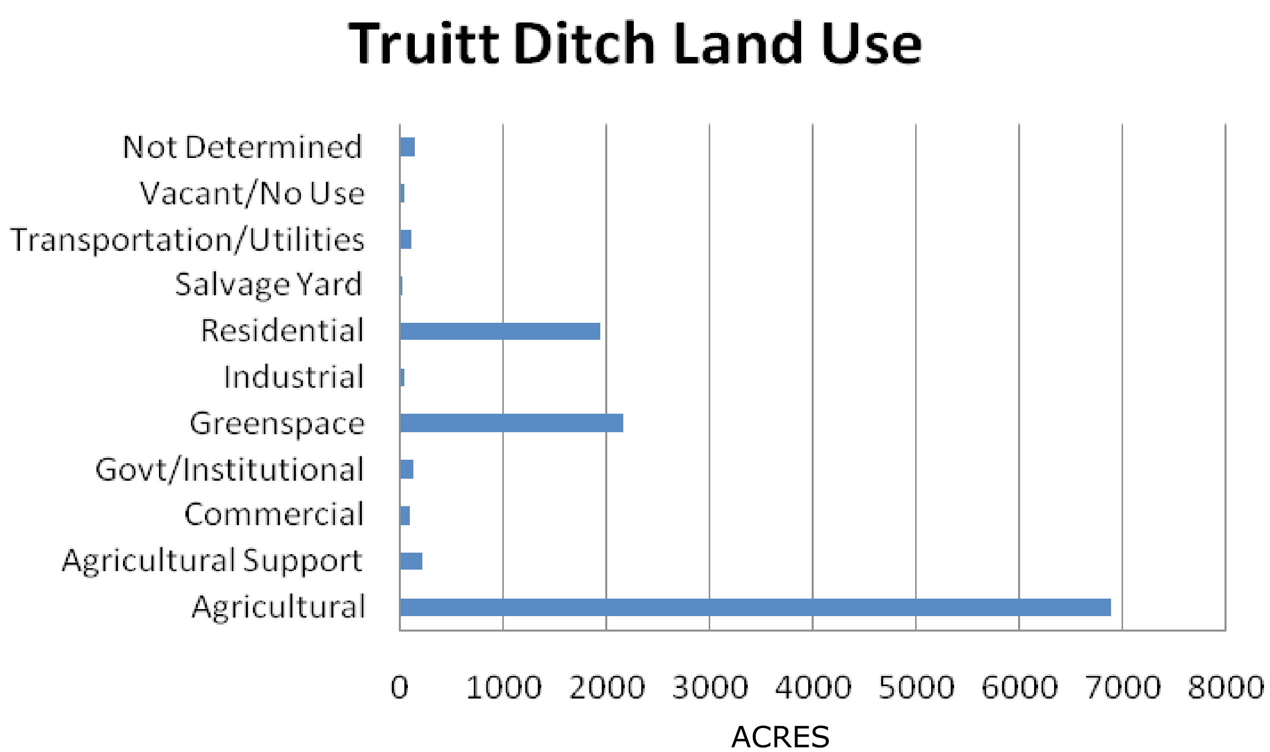
MAP. 2.47 Hamilton Ditch - Muncie Creek Land Use



MAP. 2.48 Truitt Ditch-White River Land Use



CHA. 2.12 Hamilton Ditch-Muncie Creek Land Use



CHA. 2.13 Truitt Ditch-White River Land Use

Below is a summary of the types of land use for the Muncie Creek Watershed according to a 2008 aerial orthophotograph (Table 2.23) and a map of the land use data (MAP 2.47). The specific data about land use and its relationship to water quality will be discussed later in this management plan.

TABLE 2.23: Hamilton Ditch-Muncie Creek Land Use

Land Use	Acres	Percentage
Agricultural	4697.19	54.61
Agricultural Support	49.14	0.57
Commercial	321.77	3.74
Govt/Institutional	52.5	0.61
Greenspace	1113.07	12.94
Industrial	180.98	2.10
Mineral Extraction	219.7	2.55
Residential	1470.91	17.10
Salvage Yard	19.66	0.23
Vacant/No Use	30.99	0.36
Not Determined	446.09	5.19
Total	8155.91	100.00

SOURCE: ArcGIS Indianamap.org

Below is a summary of the types of land use for the Truitt Ditch Watershed according to a 2008 aerial orthophotograph (Table 2.24) and a map of the land use data (MAP 2.48). The specific data about land use and its relationship to water quality will be discussed later in this management plan.

TABLE 2.24: Truitt Ditch-White River Land Use

Land Use	Acres	Percentage
Agricultural	6884.39	58.44
Agricultural Support	217.06	1.84
Commercial	101.39	0.86
Govt/Institutional	121.4	1.03
Greenspace	2152.03	18.27
Industrial	47.74	0.41
Residential	1937.91	16.45
Salvage Yard	8.82	0.07
Transportation/Utilities	116.94	0.99
Vacant/No Use	39.76	0.34
Not Determined	153.56	1.30
Total	11627.44	100.00

SOURCE: ArcGIS Indianamap.org

Urban Land Use

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 4

Urban land uses cover an additional 10% of the watersheds. These land uses include low, medium, and high density residential and commercial development and urban grass lands. Many urban land use issues are of concern to stakeholders including: the prevalence of impervious surfaces, which contribute to both the increasingly flashy nature of the White River and sediment transportation to watershed waterbodies; continued urban development and conversion of lands from agricultural to urban uses without restoration of forested and wetland land uses; use of septic systems in areas which are unsuited for high-density residential development and where sewer systems are not yet present; and the presence of chemical inputs from previous industrial development and uses.

A majority of the urban land is located within the citiy of Muncie and this is the boundary for the municipal separate storm sewer system (MS4). The MS4 boundary is designated by IDEM.

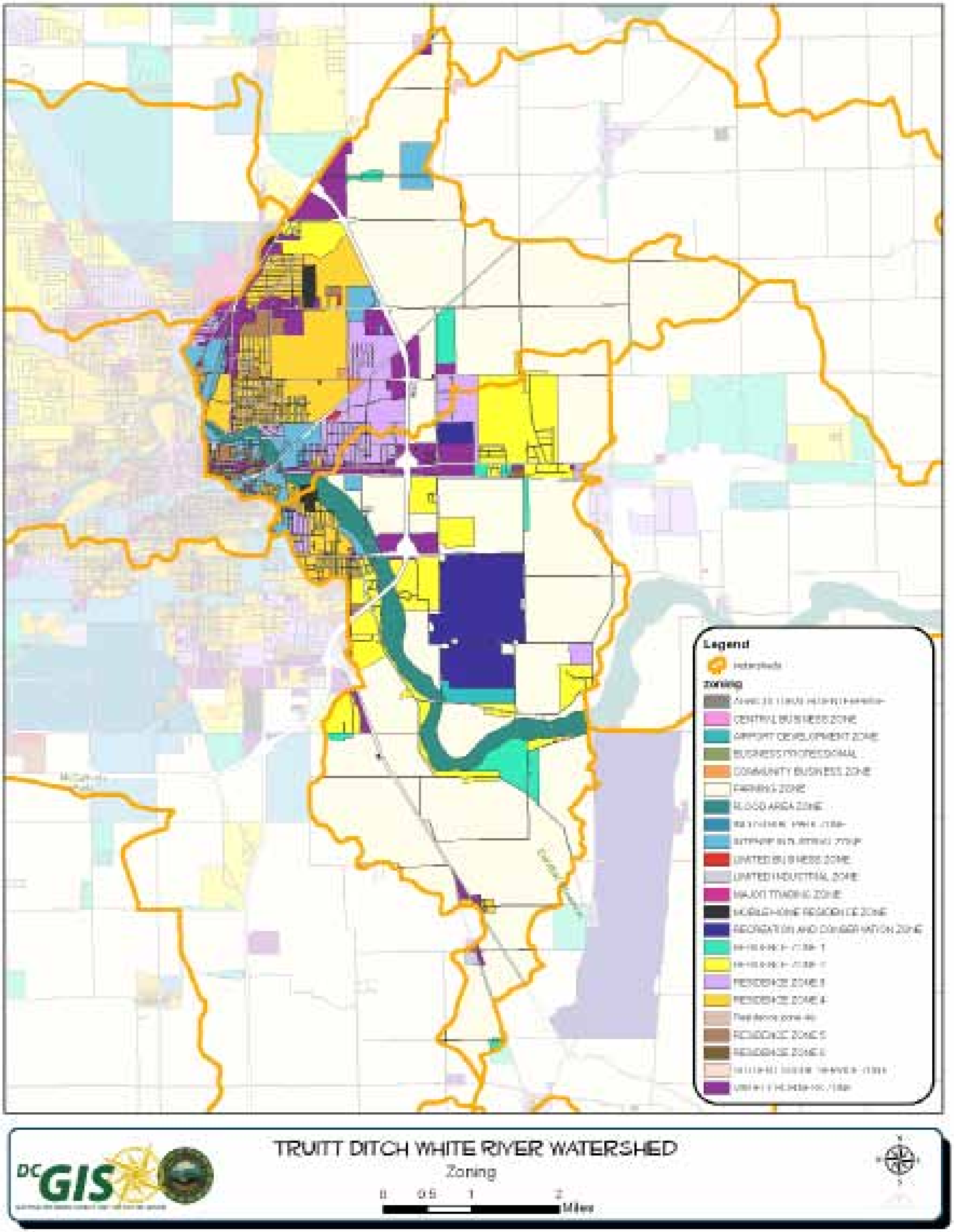
Muncie, the county seat of Delaware County, has many different industries. Some of the smaller companies produce component parts or provide services to the larger industries. The main industries are plants that treat metal, produce alloys, and provide metal products, factories that manufacture automotive equipment and tool-and-die equipment, and firms that provide a variety of goods and services, including trucking, foods, and other retail products.[1]

Delaware County is served by several State highways, U.S. Highway 35, and Interstate Highway 69. Muncie is located about 50 miles northeast of Indianapolis, Indiana, and is within 5 to 10 miles of Interstate 69. Delaware County is served by three railroad lines. Small airlines provide commuter service to the Muncie airport. Grain markets consist mainly of local elevators in the county and surrounding counties. From these elevators, grain is shipped by truck or railroad to larger terminals. Glacial outwash deposits provide a good source of sand and gravel.[2]

Several commercial gravel pits are in operation. Quarries produce crushed and agricultural limestone used in concrete, farming, road construction, and building construction. Organic soils provide a source of muck and peat. The larger deposits are found in the northwest quadrant of the county. A few commercial operations mine muck and peat in the county.[3]

IMG. 2.8 Aerial View of the City of Muncie

1 Soil Survey of Delaware County Indiana. US Department of Agriculture soil survey
2 Soil Survey of Delaware County Indiana. US Department of Agriculture soil survey
3 Soil Survey of Delaware County Indiana. US Department of Agriculture soil survey



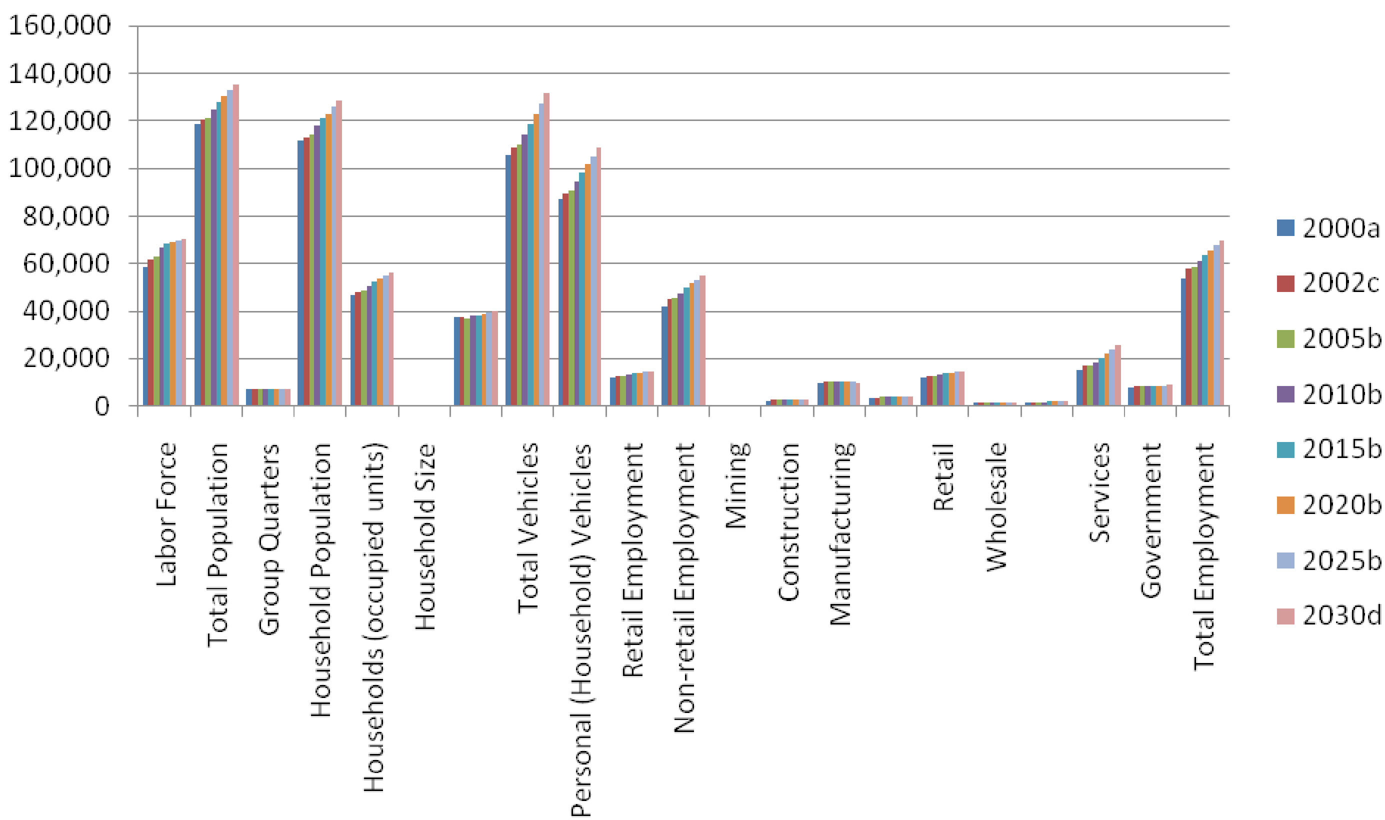
MAP. 2.49 Hamilton Ditch - Muncie Creek Zoning

INVENTORY

Economy

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 5

As with many communities, the economic base of the Delaware-Muncie area used to be characterized by a small number of large manufacturing firms and the provision of professional services. The manufacturing base included Ball Brothers, Borg-Warner, Westinghouse, Owens-Illinois, General Motors, and Dayton-Walther - all of which have are now gone. Ball State University and Ball Memorial Hospital continue to represent a majority of the professional services industry. Diversification and new recruitment, including manufacturing concerns, and retention/ growth of the service industry have helped to maintain some stability for the local economy. Employment trends have continued along patterns established over the last few decades in line with national trends toward a tertiary economy. East Central Indiana has shown more job and population loss than most areas of the state; however, the IU Business Research Center does show projections that, over the next 20 years, Delaware County will maintain stability and some growth. [1]



CHA. 2.14 Delaware County Employment Characteristics and Projections

1 2030 Delaware-Muncie Transportation Plan Update

TABLE 2.25: Delaware County Employment Characteristics and Projections								
	2000a	2002c	2005b	2010b	2015b	2020b	2025b	2030d
Labor Force	58,710	61,540	62,990	66,530	68,379	69,110	69,745	70,390
Total Population	118,749	120,227	120,984	124,691	128,161	130,237	132,855	135,525
Group Quarters	6,933	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Household Population	111,836	113,227	113,984	117,691	121,161	123,237	125,855	128,523
Households (occupied units)	47,131	47,978	48,504	50,511	52,451	53,581	54,959	56,371
Household Size	2.37	2.36	2.35	2.33	2.31	2.30	2.29	2.28
Median Household Income (Yr 2000 dollars)	$37,401	$37,328	$37,218	$37,884	$38,042	$38,765	$39,344	$39,930
Total Vehicles	105,436	108,645	109,684	114,031	118,378	122,724	127,071	131,569
Personal (Household) Vehicles	87,286	89,818	90,803	94,401	98,000	101,598	105,197	108,921
Retail Employment	11,943	12,751	12,890	13,444	13,907	14,136	14,360	14,587
Non-retail Employment	41,789	45,161	45,656	47,611	49,702	51,472	53,231	55,128
Mining	34	29	26	22	21	20	19	18
Construction	2,375	2,616	2,638	2,725	2,778	2,795	2,811	2,827
Manufacturing	9,569	10,142	10,170	10,284	10,298	10,194	10,081	9,969
Transportation /Communications Public Utilities	3,279	3,781	3,827	4,009	4,136	4,191	4,244	4,297
Retail	11,943	12,751	12,890	13,444	13,907	14,136	14,360	14,587
Wholesale	1,507	1,507	1,507	1,507	1,507	1,507	1,507	1,507
Finance / Insurance /Real Estate	1,846	1,903	1,913	1,954	1,991	2,007	2,024	2,041
Services	15,073	16,818	17,167	18,562	20,307	22,052	23,796	25,678
Government	8,126	8,373	8,408	8,548	8,665	8,707	8,749	8,791
Total Employment	53,732	57,920	58,546	61,055	63,610	65,609	67,591	69,715

SOURCE: 2030 Delaware-Muncie Transportation Plan Update

Population Forecast Control Totals
Sources: (a) Indiana Department of Workforce Development for labor force and "wage and salary" employment; U.S. Bureau of the Census for 1990-2000 population and housing; and Indiana Business Research Center for median household income and motor vehicle registration with the State of Indiana Bureau of Motor Vehicles. (b) Bernardin-Lochmueller & Associates for Projections (c) DMMPC projections using March 2002 Indiana employment figures and BLA figures. (d) DMMPC projections using BLA figures. 1

1 2030 Delaware-Muncie Transportation Plan Update

Population

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 6

Population trends can be monitored per watershed, though watershed boundaries do not align with townships or census tracts. Despite these challenges, it is important to understand overall population trends within the watershed or the vicinity.

Delaware County has shown a slow decline in population since 1980, as seen below. The population in 2009 was 115,192 with 77% located in the urban areas and 23% in rural areas. The population density of Delaware County is 293 people per square mile (395.6 sq miles in the county). [1]

Muncie-Delaware County area is currently experiencing declines from the nationwide recession. For the most part, the rate of growth has slowed significantly. County planners project that population decline in the Muncie-Delaware County area will slowly begin to reverse over the next 20 years. [2]

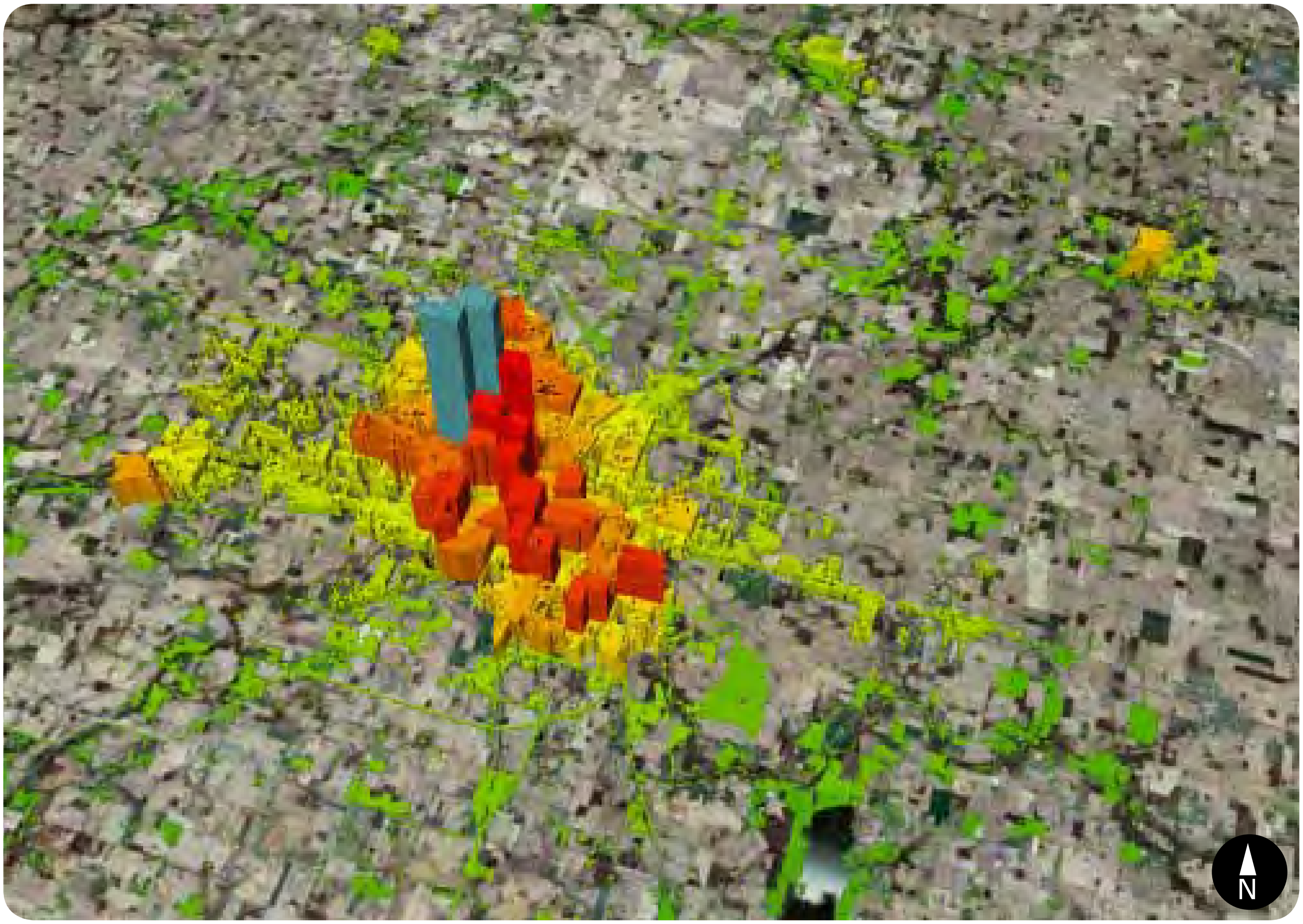
According to a data collected by the Muncie Parks and Recreation Department and the US Census Bureau, the population outside of Muncie has increased at a larger rate as the city has decreased in population. [3]

TABLE 2.26: Census QuickFacts

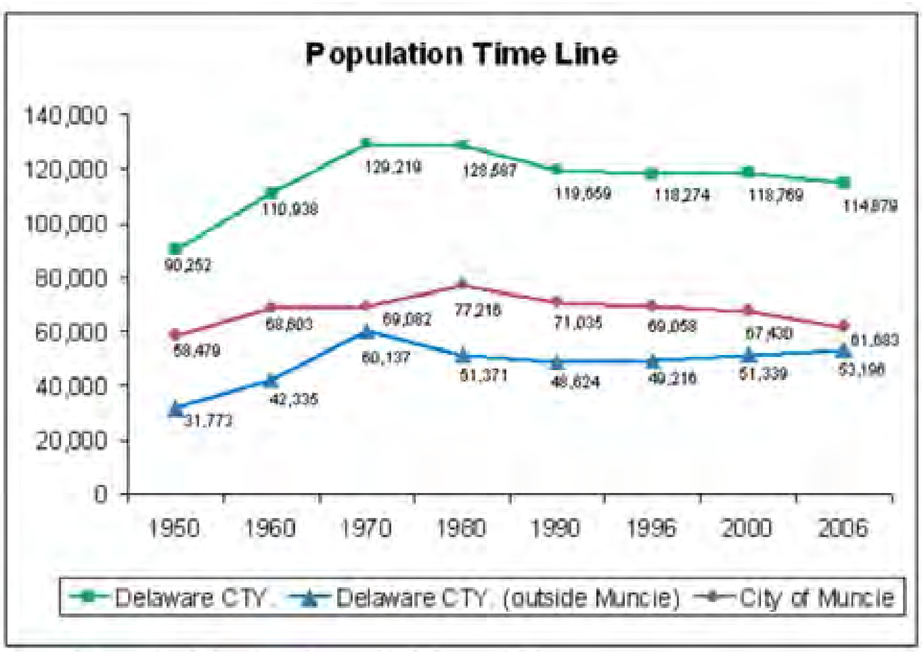
Population, 2009 estimate	115,192
Population, percent change, April 1, 2000 to July 1, 2009	-3.0%
Population estimates base (April 1) 2000	118,769

SOURCE: Census QuickFacts

1 CityData.com
2 2030 Delaware-Muncie Transportation Plan Update
3 U.S. Census Bureau



DIA. 2.7 Diagram of Population Concentration



CHA. 2.15 Muncie-Delaware County Population Timeline, US Bureau of Censu

INVENTORY

Pop. /Economic Projections
WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 7

Population projections for Delaware County in 2035 show a low of 109,081, a medium of 119,497 and a high of 132,754. The high range is reflected in the 2005-2030 Model used in the Regional Planning department. However, with the slowing of permits by more than half and the state of the recovering economy, the medium population projections were used in other regional planning documents. [1]

Therefore, using this estimate, the 2030 population will have recovered to approximate the 2000 population.[2] As the growth in jobs exceeds the growth in population and labor force over the same twenty-five year period, Delaware County will become an even greater net importer of labor with the number of jobs (including farms and proprietorships) exceeding the available labor force in the county.[3]

For the year 2020, the Delaware County forecast of 130,237 persons was considerably higher than most recent forecast of 117,344 persons by the Indiana State Data Center and the Woods & Poole Economics forecast of 118,430 persons, but comparable to the 1970 Census count of 129,129 persons and the 1980 Census count of 128,597 persons.[4]

Using the population projection and assuming a stable population in group quarters, 54,959 households were projected for the year 2025 for Delaware County resulting in a net increase of 7,828 households over the year 2000 count of 47,131 households. [5]

This reflects a future reduction in the gap between the household size in the United States and Indiana versus Delaware County. In the year 2000, the household size was 2.37 persons per household for Delaware County compared to 2.59 persons per household in the United States and 2.53 persons per household in Indiana. [6]

1 2030 Delaware-Muncie Transportation Plan Update
2 2030 Delaware-Muncie Transportation Plan Update
3 2030 Delaware-Muncie Transportation Plan Update
4 2030 Delaware-Muncie Transportation Plan Update
5 2030 Delaware-Muncie Transportation Plan Update
6 2030 Delaware-Muncie Transportation Plan Update

TABLE 2.27: Population and Employment Forecast for Delaware County			
Component	Year 2000	Change from 2000 to 2025	Year 2025
Population	118,769	14,080	132,849
Group Quarters Population	6,933	67	7,000
Household Population	111,836	14,013	125,849
Households	47,131	7,828	54,959
Grades K to 12 School Enrollment	18,615	1,396	20,011
College & University Enrollment	20,346	0	20,346
Total Enrollment	38,961	1,396	40,357
Farm Employment	307	0	307
Mining Employment	9	0	9
Construction Employment	2,586	475	3,061
Manufacturing Employment	10,281	573	10,854
Transportation, Communication & Public Utilities Employment	1,739	512	2,251
Wholesale Employment	1,891	0	1,891
Retail Employment	13,841	2,801	16,642
Finance, Insurance & Real Estate Employment	2,794	269	3,063
Services Employment	27,991	11,411	39,402
Government Employment	1,068	82	1,150
Total Employment in Year 2025	62,507	16,123	78,630

SOURCE: 2030 Delaware-Muncie Transportation Plan Update

INVENTORY

Land Use Demand Model
WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 8

As emphasized by the regional planning office, there is an undeniable interrelationship between transportation, land use, demographics and socioeconomic factors. Policies, decisions and actions undertaken within one arena will affect the others. With a strong economy, existing businesses will expand and new business will locate in an area (after consideration of feasibility factors such as capacity of transportation facilities, utilities, labor force, etc.). This, in turn, provides new employment opportunities and these new employees will create a demand for housing and other urban amenities and services.

Increased amenities (social, recreational, environmental) and services (roads, transit, utilities) increase the attractiveness of an area and its potential for obtaining more new business, and the cycle continues.

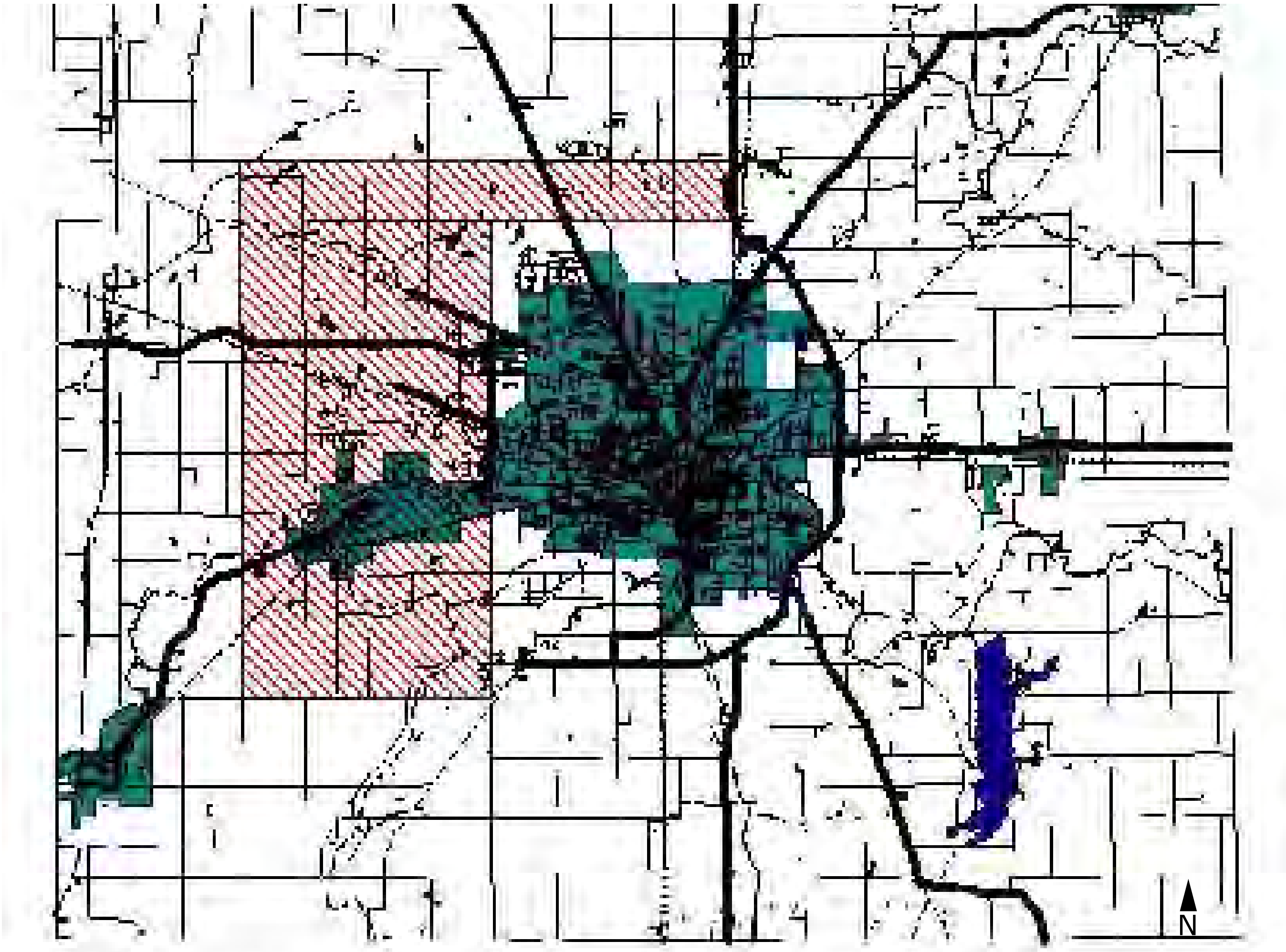
Therefore it is important to document the projections used in other regional planning documents to prepare for development pressures that are projected to occur and have watershed management strategies for these developments. (MAP 2.50)

County wide control totals of socioeconomic variables were forecasted in five-year increments from 2000 to the year 2025 in order to serve as a basis for developing projections for the individual 514 Travel Analysis Zones (TAZs), which represented all general locations connected by traffic. BLA developed a base year traffic model for 2000 and a future year traffic model for 2025. [1]

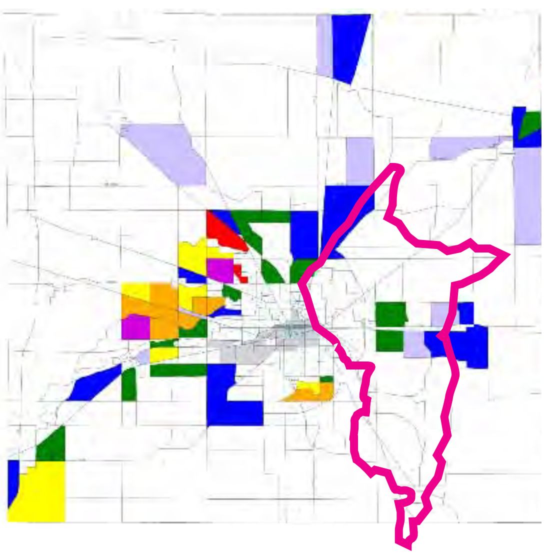
The forecasts used in developing the Delaware County Travel Model were cross-checked by utilizing building permit data. Permit location patterns were consistent with the Travel Model forecasts which emphasize growth to the west and northwest of the City of Muncie. Business loss has occurred within the City of Muncie. However, new business attraction in the last 5 years has occurred in the 3 industrial park areas –the Airpark on the north side, the Industrial Centre on the southwest side and the Park One center at I-69 and SR 332. [2]

The cross-checked building permit data forecasts indicated an increase of 1,373 new dwelling units from 2000-2005 (MAP 2.53). With approximately 20 permits per year for the small towns, a five year period would add 100 new units. Also, a fourplex development in the county was undercounted by 60 units and a city apartment project for 52 units was counted as one commercial permit. The 5 year total of 1323 is within 4% of the forecast.[3]

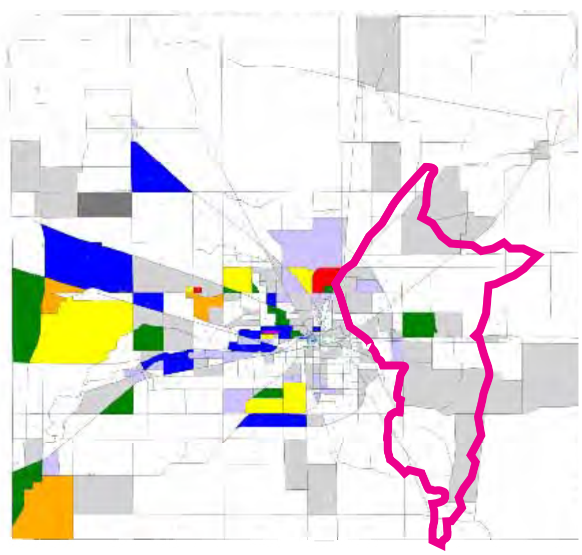
1 2030 Delaware-Muncie Transportation Plan Update
2 2030 Delaware-Muncie Transportation Plan Update
3 2030 Delaware-Muncie Transportation Plan Update



MAP. 2.50 Forecasted Land Use Development (hashed)



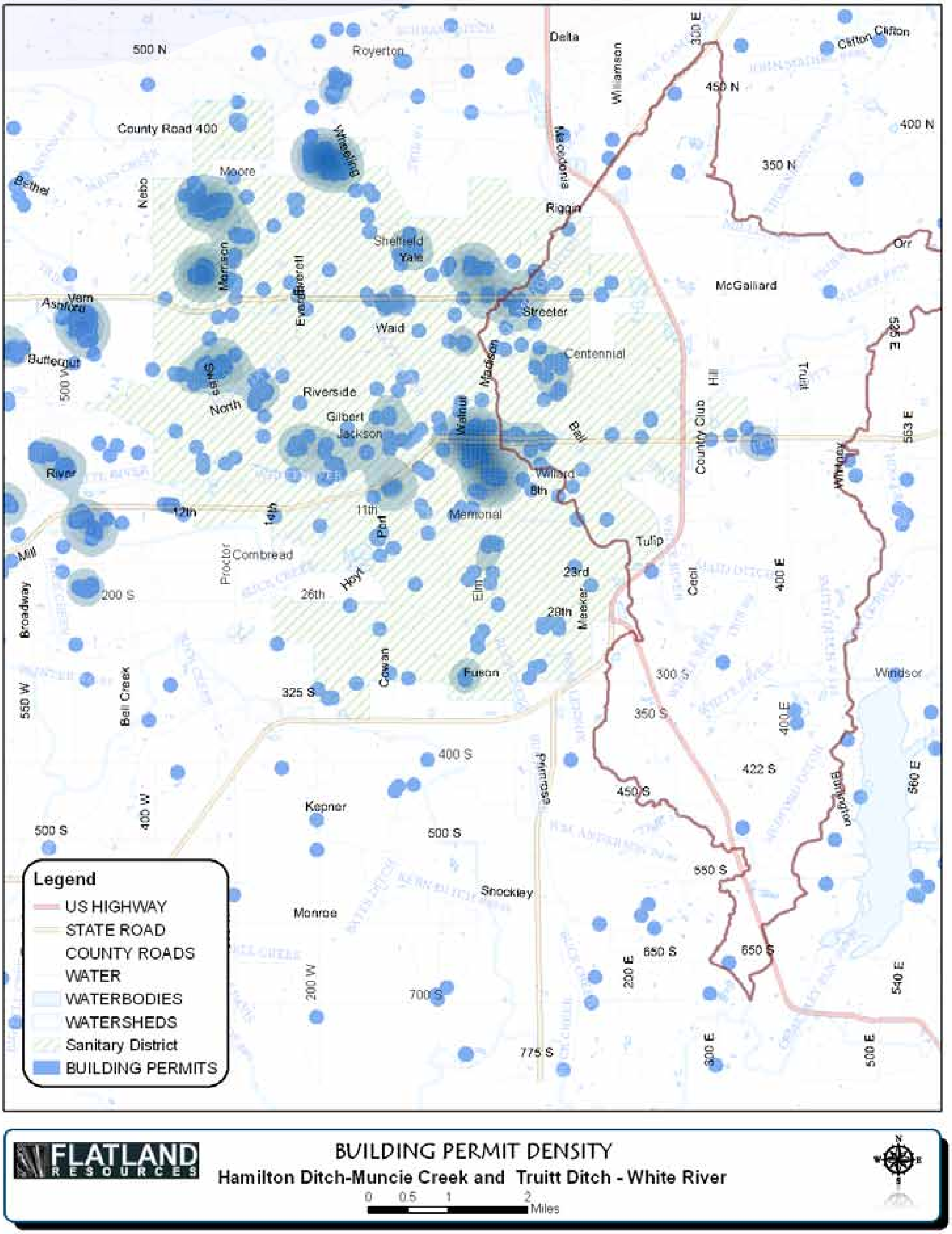
MAP. 2.51 Forecasted Residential Changes



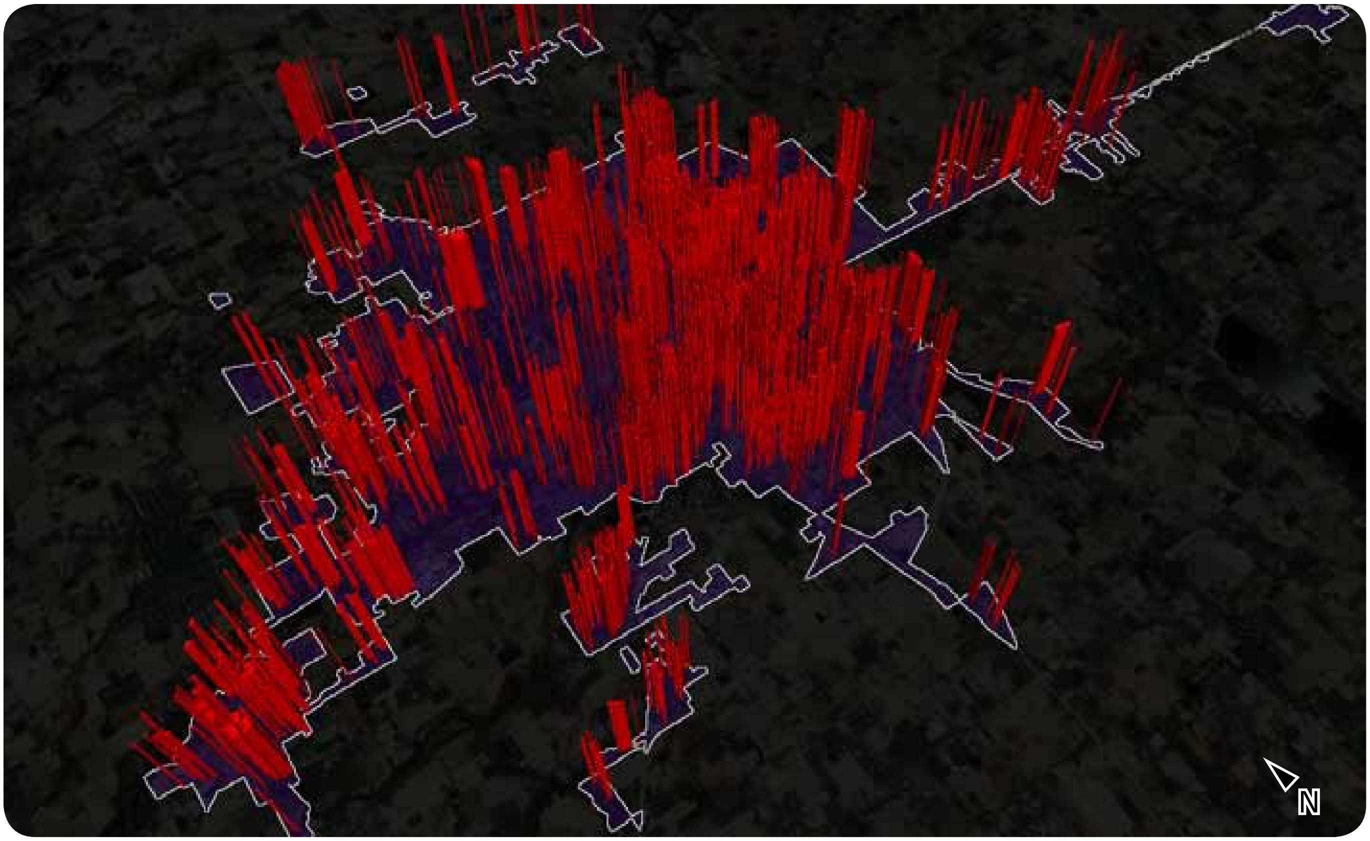
MAP. 2.52 Forecasted Commercial Changes

SOURCE: 2030 Delaware-Muncie Transportation Plan Update

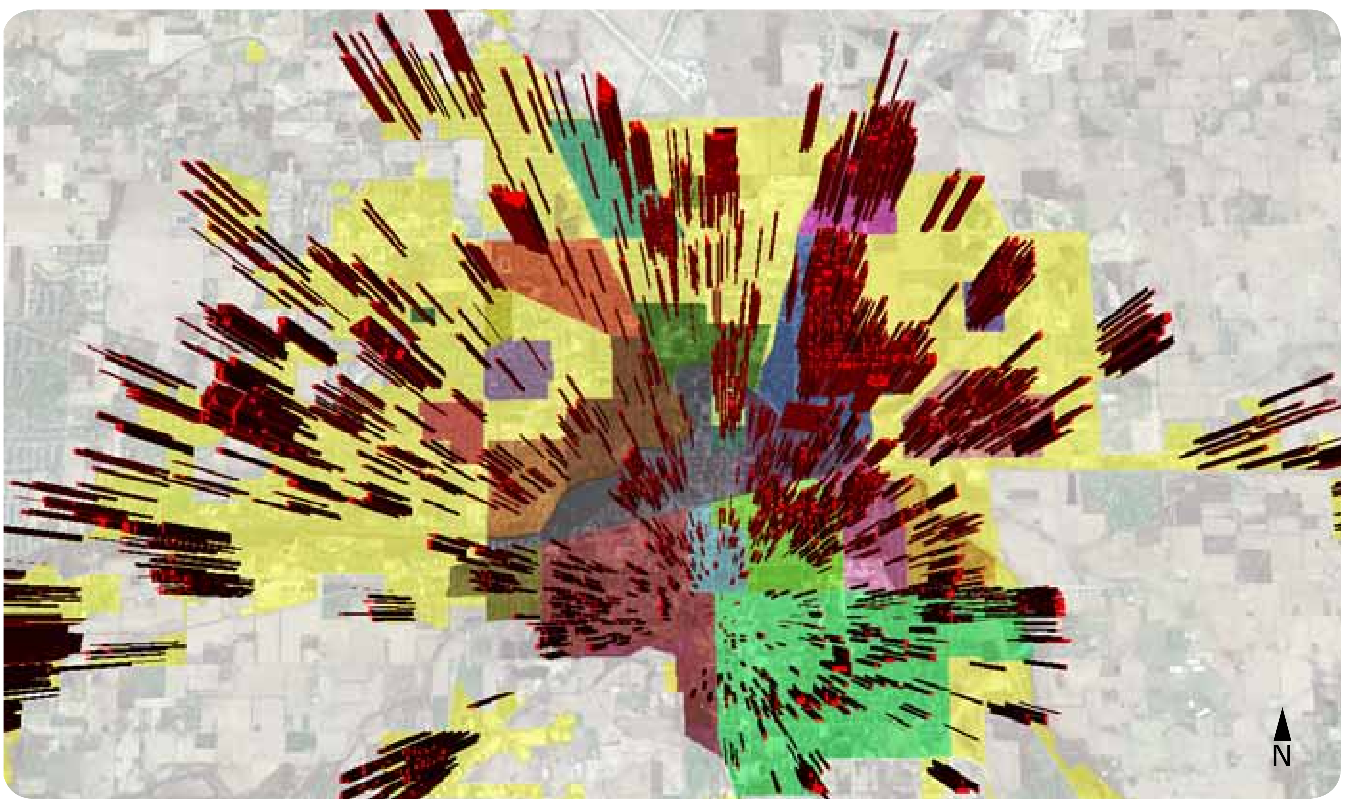
INVENTORY



MAP. 2.53 Concentration of Building Permits in Delaware County



DIA.2.8 Location of Vacancy in City of Muncie



DIA.2.9 Location of Vacancy in City of Muncie Relative to Historic Neighborhoods

INVENTORY

Impervious Surface

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 9

Impervious surfaces are hard surfaces which limit surface water from infiltrating into the land surface to become groundwater, thereby creating high overland flow rates. Hard surfaces include concrete, asphalt, compacted soils, rooftops, and buildings or structures. In developed areas like the City of Muncie, land which was once permeable has been covered by hard, impervious surfaces. This causes rain that once absorbed into the surface to runoff of rooftops and over pavement entering the White River with not only higher velocity but also higher quantities of pollutants. [1]

Overall, much of the watershed is covered by low levels of impervious surfaces; however, high impervious densities are present in Muncie with lower densities occurring within smaller towns and along roads throughout the watershed.

Studies indicate that stream ecology degradation begins with only 10% impervious cover in a watershed. Higher impervious surface coverage results in further impairments including water quality problems, increased bacteria concentrations, higher levels of toxic chemicals, high temperatures, and lower dissolved oxygen concentrations. Areas of high impervious surface density (>10%) within the watershed should be considered as a factor during implementation.[2]

The impervious cover in the Truitt Ditch - White River Subwatershed is 1022.4 acres or 11.89 % of the watershed area under the current conditions.[3]

The impervious cover in the Muncie Creek - Hamilton Ditch Subwatershed is 806.4 acres or 6.84 % of the watershed area under the current conditions.[4]

1 Tom Reeve, White River Watershed Project
2 Wabash River (Region of the Great Bend) WMP
3 Data Generated by ArcGIS
4 Data Generated by ArcGIS

DIA. 2.10 Normative Urban Core in City of Muncie

DIA. 2.11 Dominant Peri-urban land use configuration in city of Muncie

Impervious Surface (cont.)

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 9

TABLE 2.28: Impervious Surface per Land Use Type Muncie Creek - Hamilton Ditch and Truitt Ditch-White River	
Acres	Landuse
219	Agriculture
316.5	Commercial
33.1	Forest
28.2	Grass/pasture
1,136.3	Residential
95.7	Industrial
1,828.8	Total impervious acres
20,367.5	Total acres

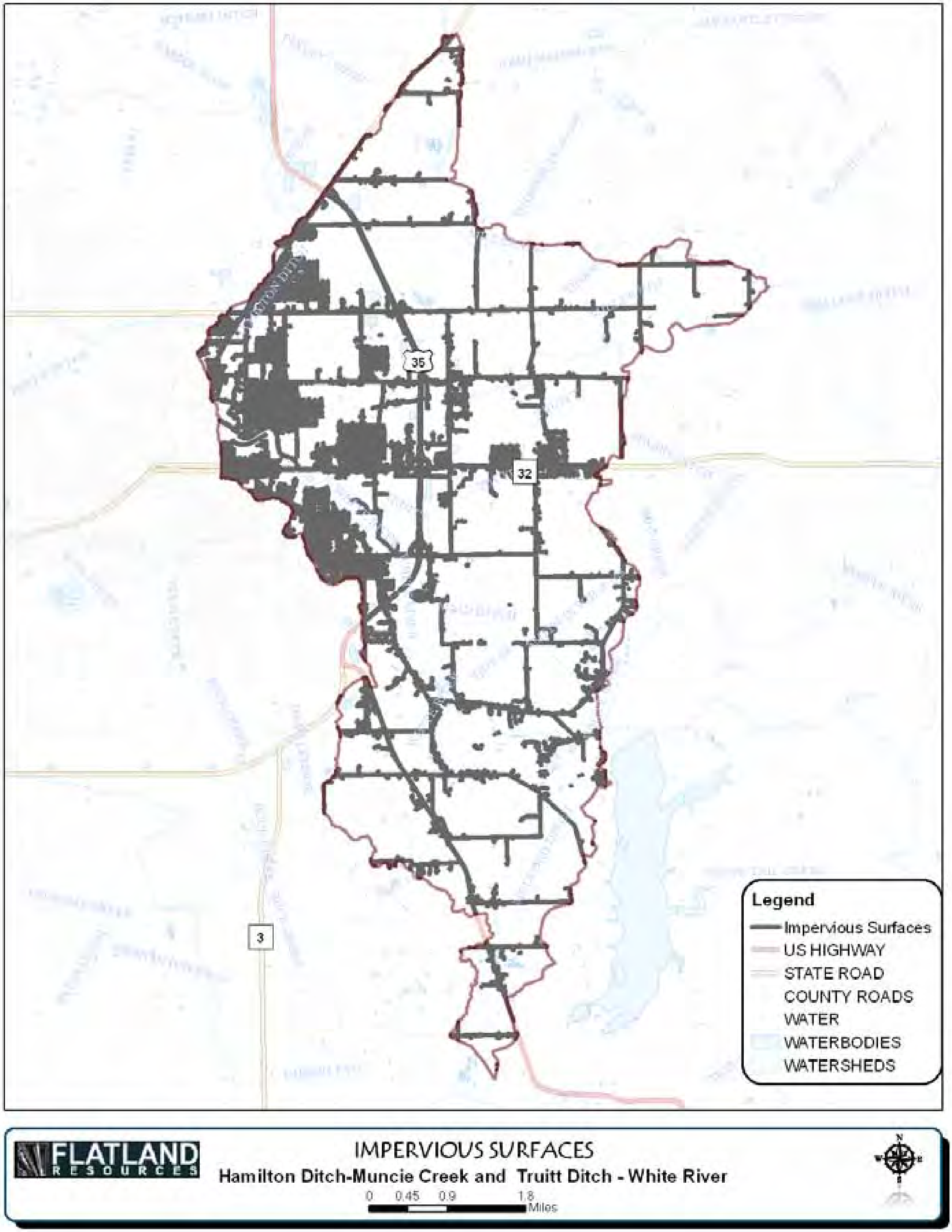
SOURCE: ArcGIS Indianamap.org

TABLE 2.29: Comparison of Impervious Surface to Wetlands					
	Truitt Ditch-White River			Muncie Creek - Hamilton Ditch	
Total Impervious Cover	1022.4	11.89%		806.4	6.84%
Total Wetland	96	2.02%		98	2.81%

SOURCE: ArcGIS Indianamap.org

GIS Derived Statistics
Tables contain information derived from GIS maps created in ArcView. Summary statistics are listed by storm water watersheds and include land use information from Indiana's GAP data program.[1]

1 Data Generated by ArcGIS



MAP. 2.54 Impervious Surfaces in Subwatershed Areas

Natural Land Uses

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 10

Natural land uses including forest, wetlands, and open water cover 30% of the watershed. Individuals are concerned that too much forested land is being lost within the watershed and would like to see reforestation prioritized. Forest cover occurs adjacent to waterbodies throughout the watershed in non-contiguous tracts. However, large lengths of the watershed streams no longer contain intact riparian buffers. Specific areas of concern will be discussed in further detail in subsequent sections.

A number of recreational opportunities are present throughout the Subwatershed areas. Recreational facilities and parks serve as an opportunity for the public to enjoy the natural landscape within their community as well as learn about valuable natural resources.

Recreational opportunities in the watersheds include city parks, nature preserves, and recreational facilities including: McCulloch Park, Buley Center Park, Riverview Park, Aultshire Park, and the John M Craddock Wetland Nature Preserve. The Muncie Parks and Recreation Department oversees the management of these parks with the exception of The John M Craddock Wetland Nature Preserve.

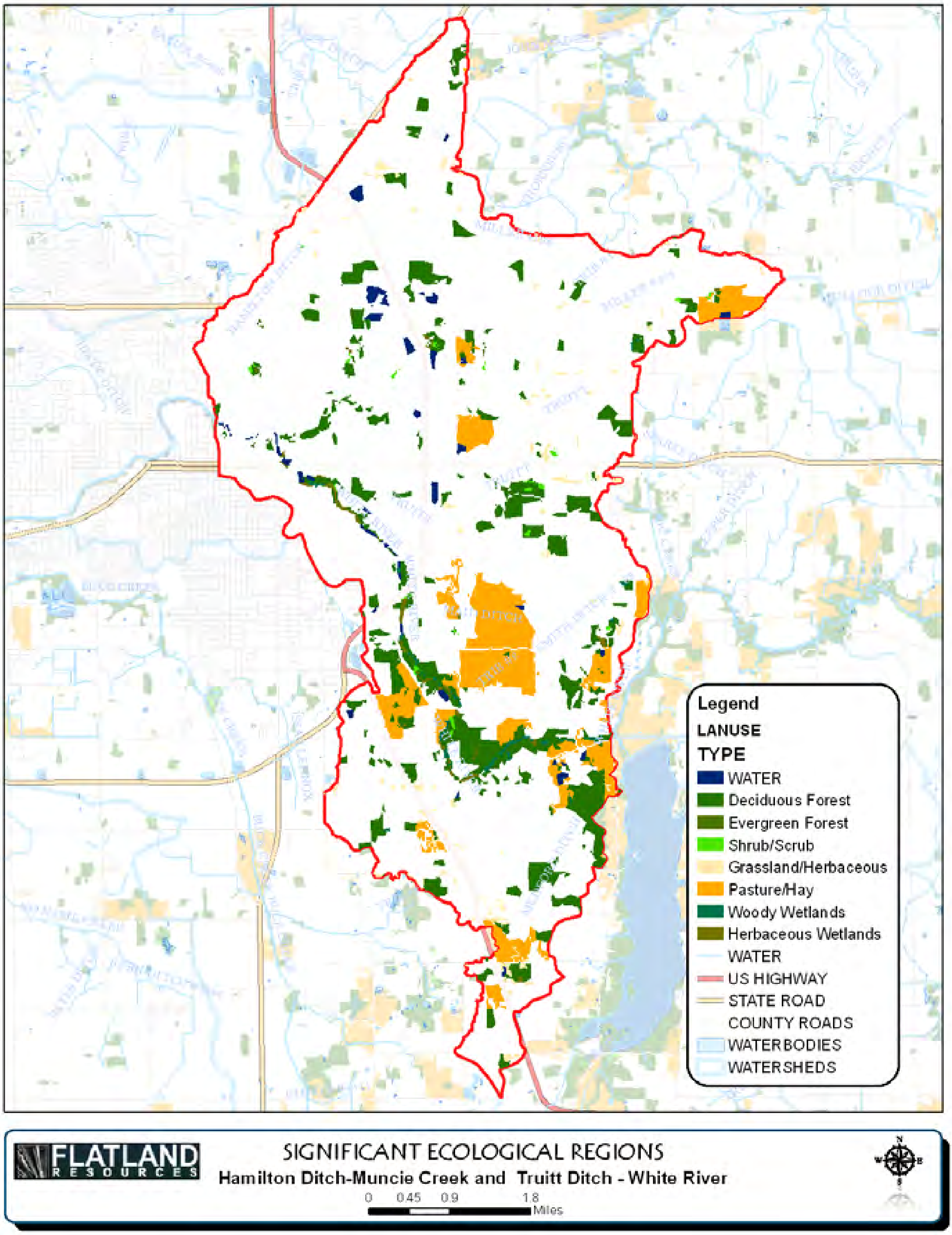
County-wide Park System and Public Space Deficiency
Couty-wide, the Muncie Park System includes 23 parks including the largest natural resource in Delaware County, Prairie Creek Park and Reservoir.

Parks are classified by the National Recreation and Park Association (NRPA) to understand level of service (LOS), recreational opportunities, and local population. Below are the classifications of Muncie Parks: Prairie Creek Reservoir, 750 acres, is considered Delaware County's only regional park. [1]

(a) Two parks met the NRPA's standard for Large Urban Parks (McCullough and Heekin Parks).
(b) Two parks were classified as large neighborhood parks (Thomas and Ball Corporation Parks).
(c) One recreational facility, the 750- acre Prairie Creek Reservoir, meets the NRPA's definition of a regional park. The LOS for this park The NRPA LOS standard for this type of park is 5.0 to 10.0 acres per 1,000 persons. Accounting for Delaware County's population, the LOS for regional parks comes out to 6.3 acres per 1,000 population, which is within the LOS range set by NRPA.
(d) Three parks (Heekin, McCulloch, and White River Parks) meet the NRPA's definition of community parks. Another two parks (Tuhey and Westside) are on the margin between neighborhood-level and community-level parks. These five parks have a combined area of about 245 acres. If we define "community" as Adequate park and recreation facilities are critical quality of life features in any community. Delaware County, then the LOS is about 2.1 acres per 1,000 population. This LOS does not measure up to NRPA's recommended LOS of 5.0 to 8.0 acres per 1,000 population. It is also noteworthy that the existing community park space is concentrated in the City of Muncie, with no community parks space immediately available to County residents.[2]

The remaining 18 parks qualify as either mini- or neighborhood-level parks, with a total area of 59.2 acres. Since all of these parks are located within the City of Muncie, and are oriented to Muncie neighborhoods, we can assume that the serviced population is constituted entirely of Muncie residents. The combined LOS for these parks is 1.33 acres per 1,000 residents, which is within the

1 Muncie-Delaware County Comprehensive Plan
2 Muncie-Delaware County Comprehensive Plan



MAP. 2.55 Significant Ecological Regions

Natural Land Uses (cont.)

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 11

NRPA recommended LOS of 1.25 to 2.5 acres per 1,000 residents. No formal recreation space is tallied within the County, although this analysis does not include informal passive recreation space that may be available in such places as schoolyards.[3] Overall, the total amount of "close-to-home" recreational space (consisting of community-, neighborhood-, and mini-park facilities) available to Muncie citizens is about 3.4 acres per 1,000 persons, which is well below the NRPA's recommended LOS of 6.25 to 10.5 acres per 1,000 persons. This is primarily due to a lack of community park space. [4]

In the County, which does not have the benefit of neighborhood- or mini-parks, the total "close-to-home" recreational space consists entirely of community parks, at a LOS of 2.1 acres per 1,000 population (While Delaware County Townships do manage some park space there is no county-wide parks system). Again, this is well below the NRPA's total recommended LOS of 6.25 to 10.5 acres per 1,000 persons. More community park space and substantial implementation of neighborhood- or minipark space may be required to rectify these deficiencies.[5]

Due to this county wide deficiency in public space, the steering committee expressed an interest in exploring opportunities to develop park space in conjunction with environmental restoration activities. The John M Craddock Wetland Nature Preserve serves as a case study for this type of development. MAP 2.55 provides a framework for restoration efforts/locations.

Cardinal Greenway / White River Greenway

The Cardinal Greenway is part of the organized Rails-to-Trails movement and Indiana's longest rail trail on a former CSX (railroad)line. Both the Cardinal and White River Greenway trails have asphalt surfaces and can accommodate multiple users. All rest areas and trail heads are handicapped accessible. In addition to Muncie's park system, a major portion of the Cardinal Greenway is in the watershed. This 60-plus mile trail extends continuously from Gaston to Richmond in the south and sees over 250,000 visitors annually. It provides an important link for the community providing access to recreation throughout the area.[6]

Prairie Creek Park and Reservoir

Although Prairie Creek Reservoir is not in the studied subwatershed, it discharges directly into the headwaters of the Truitt Ditch-White River Subwatershed. The reservoir is currently being used as an environmental education site by the Muncie Stormwater Department and the White River Watershed Project Education and Outreach Sub-committee. As a regional destination, it will undoubtedly have a crucial role to play in Muncie Creek - Hamilton Ditch and Truitt Ditch-White River community based education. The future of Prairie Creek Park and Reservoir is of great importance to WRWP steering committee. It is also a serious responsibility. To ensure that this unique community resource continues to be available for human enjoyment and use by future generations it is important to plan ahead. The Prairie Creek Master Plan has been a joint effort between the Delaware-Muncie Metropolitan Plan commission and the Delaware County Soil and Water Conservation District with input from multiple government and private stakeholders, along with the public. The plan elaborates upon key elements set forth in the Comprehensive Plan and has been mindful of the need to protect private property rights.[7]

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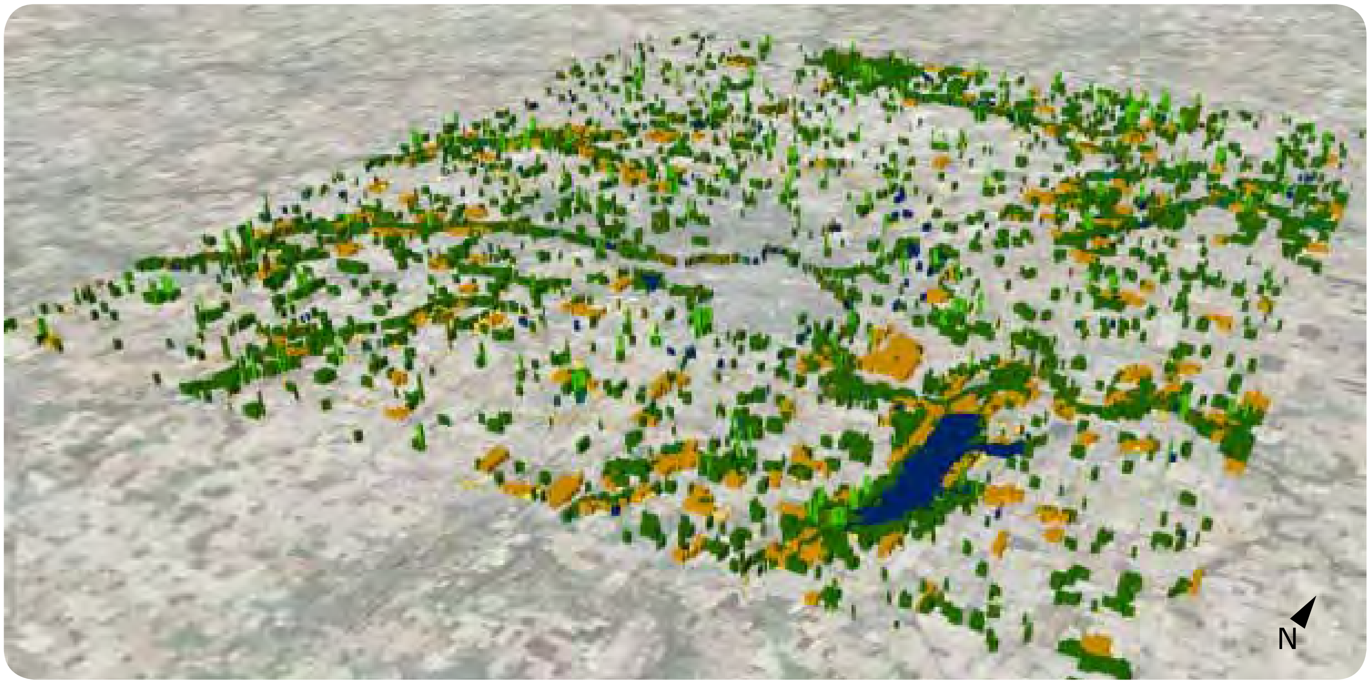
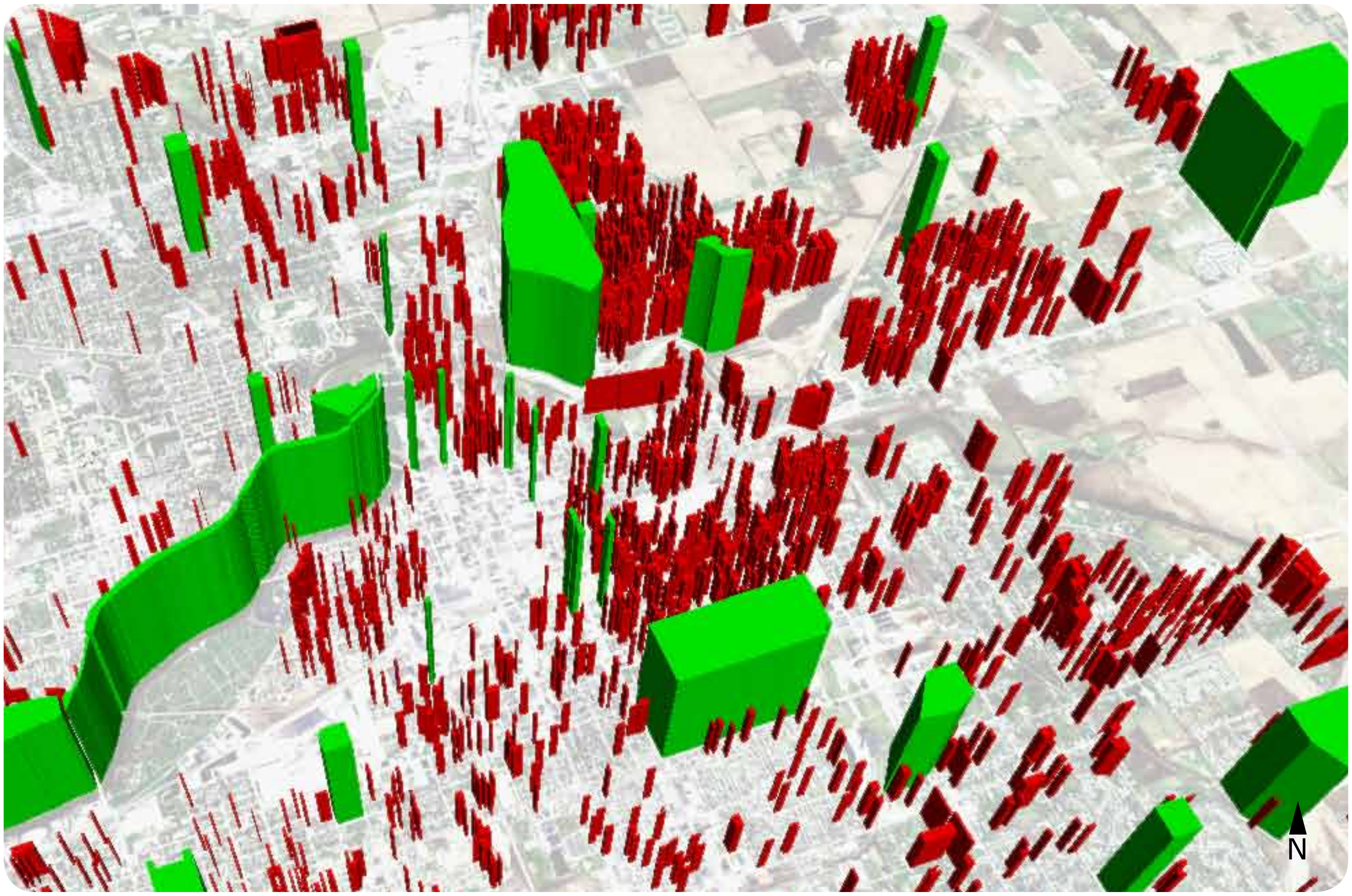
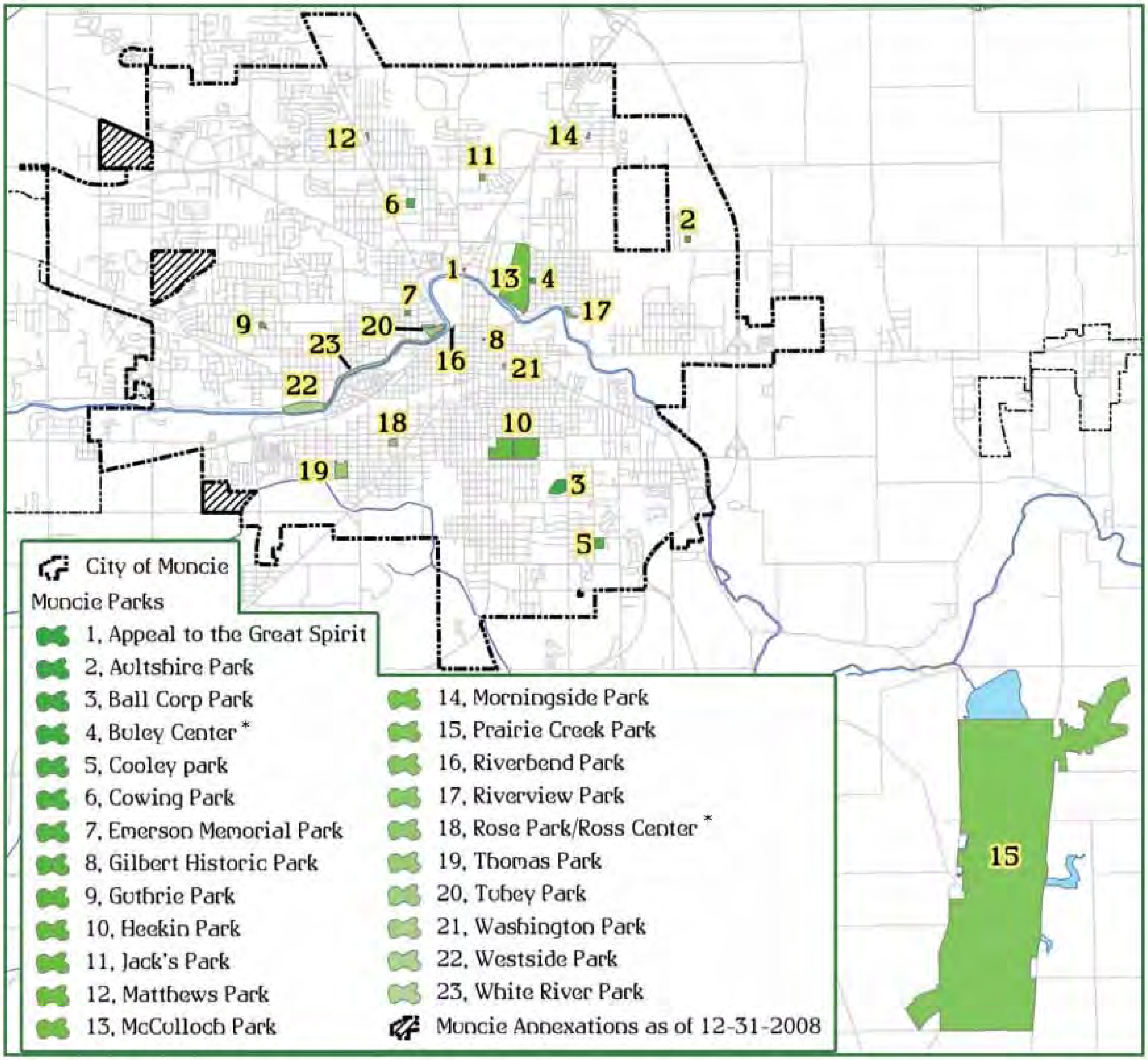
3 Muncie-Delaware County Comprehensive Plan
4 Muncie-Delaware County Comprehensive Plan
5 Muncie's 5 Year Parks and Recreation Master Plan 2009
6 Muncie's 5 Year Parks and Recreation Master Plan 2009
7 Muncie's 5 Year Parks and Recreation Master Plan 2009



DIA. 2.12 Diagram of Forest (green) and Openspace (yellow) land use in Delaware County



DIA. 2.13 Relationship of Muncie Parks System (green) to Vacancy (red)



MAP. 2.56 Locations of Muncie Parks

SOURCE: Muncie's 5 Year Parks and Recreation Master Plan 2009

Park Classifications			
Muncie Parks, Owned Properties			
Park Type	NRPA Size Criteria	Local Classifications	# of parks
Mini Park	up to 1 acre		5
Small Neighborhood Parks		1 - 5 acres	7
Neighborhood Parks	5 - 10 acres		2
Large Neighborhood Parks		10 - 20 acres	1
Linear Parks			1
Small Community Parks		20 - 30 acres	1
Community Parks	30 - 50 acres		0
Large Urban Parks	50 - 75+ acres		2
			19
Muncie Parks, Leased Properties			
Small Neighborhood Parks		1 - 5 acres	2
Large Neighobrhood Parks		10-20 acres	1
Regional Parks	200+ acres*		1
			23

* - defined by the NRPA in 1983 but not updated in the 1996 guidelines

TABLE. 2.30 Muncie Parks Classifications

INVENTORY

Agricultural Land Uses

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 12

According to the 2007 Census of Agriculture, 635 farms were in Delaware County in 1997 (USDA). They incorporated 173,443 acres of land. About 5,307 acres was used for hay and pasture, and a total of 5,587 acres was forested. Cash grain is the major farming enterprise in the county. Corn and soybeans are the main grains grown as cash crops. About 61,100 and 96,500 acres, respectively, were planted.[1]

These concerns are especially important as according to the 2001 land classification effort, nearly 60% of the watershed is used for agricultural purposes. According to USDA data from 2004, cultivated areas cover approximately 55% of the watershed with a majority of cultivation occurring in densities of 75% or greater. Of the areas that are cultivated, corn and soybeans dominate crop production (MAP 2.57). [2]

Delaware County ranks in the top 20 statewide for corn and soybean production. Most farms within the watershed undergo a corn-soybean rotation with some including a corn-soybean-wheat rotation. According to the 2009 survey, conservation tillage practices within the county are on par or a little below the median for the state of Indiana.[3]

Small grains made up about 2,100 of the acres. In 2002, specialized crops, such as tomatoes for processing, peppers, pumpkins, apples, turf grass, and nursery crops, were raised on small acreages. Hogs and beef cattle are the main livestock raised in Delaware County (Table 2.31). A few dairy operations are in the county, and some sheep and chickens are raised. Also, a significant number of horses and other equines are raised in the county.[4] Due to the difficulty in estimating animal farms from aerial photography, the amount of farm animals in the individual Subwatersheds is undetermined at this time.

Individuals are concerned about the impact of agricultural practices on water quality. Specifically, the volume of exposed soil entering adjacent waterbodies, the prevalence of tiled fields and thus the transport of chemicals into waterbodies, the use of agricultural chemicals, and the volume of manure applied via small animal farms and through confined animal feeding operations are concerning to local residents. Each of these issues will be discussed in further detail below. In total, corn production accounted for 32% of land cover in 2006, while soybeans accounted for 28% of land cover. Non-agricultural uses, such as woodland and urban areas, covered an additional 28% of the watershed. Grasses and clover, small grains, alfalfa, winter wheat, and other crops covered the remaining crop production lands.[5]

1 USDA data from 2004
2 USDA data from 2004
3 USDA data from 2004
4 USDA data from 2004
5 USDA data from 2004

TABLE 2.31: Agricultural Land Use in Delaware County and Subwatershed Estimates based on farm acreage.

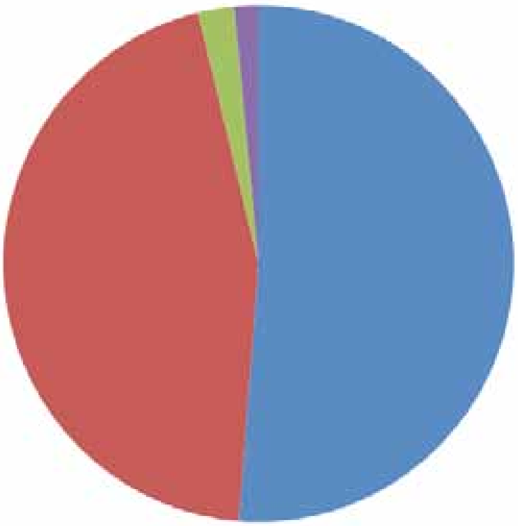
	Delaware Co.	Munce Creek - Hamilton Ditch	Truitt Ditch-White River
Number of Farms	659	20	30
Land in Farms (acres)	154,470	4,742	6,974
Total Acres	253,382	8,602	11,781
Average Size of Farm (acres)	234	234	234
Market Value of Products Sold	68,608,000	2,109,770	3,102,812
Crop Sales	60,539,000	1,793,304	2,637,390
Livestock Sales	8,069,000	316,465	465,422
Average Total Sales Per Farm	104,109	104,109	104,109
Government Payments	2,670,000	82,105	120,751
Average Per Farm Receiving Payments	6,934	4,052	4,052

SOURCE: USDA data from 2004 (grey columns interpolated from GIS acreage)

TABLE 2.32: Dominant Agricultural Land use in Delaware County and Subwatershed Estimates

Category	Delaware Co.	Munce Creek - Hamilton Ditch	Truitt Ditch-White River
Total Acres	253,382	8,602	11,781
Soybeans	81,087	2,753	3,770
Corn	70,673	2,399	3,286
Pasture/Hay	28,270	960	1,314
Deciduous Forest	23,815	808	1,107
Developed/Open Space	22,025	748	1,024
Developed/Low Intensity	11,724	398	545
Grassland Herbaceous	4,337	147	202
Developed/Medium Intensity	3,025	103	141
Open Water	2,660	90	124
Developed/High Intensity	1,428	48	66
Winter Wheat	1,426	48	66
Grass/Pasture/Non-Ag	981	33	46
Alfalfa	455	15	21
Other Hays	366	12	17
Tomatoes	208	7	10
Popcorn or Ornamental Corn	204	7	9
Herbaceous Wetlands	202	7	9
Winter Wheat/Soybeans	120	4	6
Barren	107	4	5
Dry Beans	90	3	4
Woody Wetlands	76	3	4
Oats	41	1	2
Shrubland	36	1	2
Evergreen Forest	15	1	1
Fallow/Idle Cropland	6	0	0
Seed/Sod Grass	6	0	0

SOURCE: ArcGIS

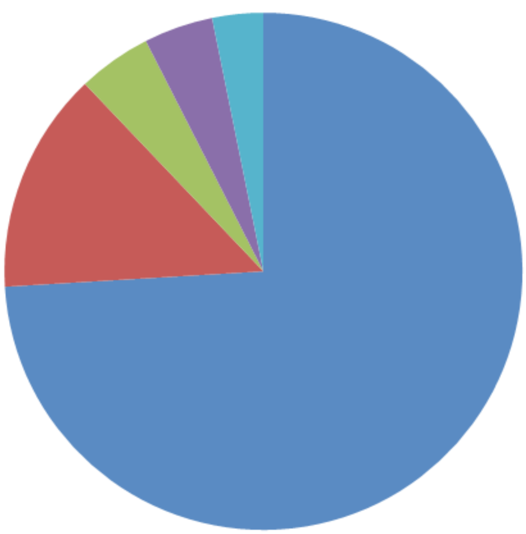


CHA. 2.16 Corn and Soybean Dominant

TABLE 2.33: Crop Items

	Delaware Co.	Munce Creek - Hamilton Ditch	Truitt Ditch-White River
Total Acerage	253,382	8,602	11,781
Corn for grain	70,502	2,393	3,278
Soybeans for beans	61,828	2,099	2,875
Forage	3,158	107	147
Wheat for grain, all	2,097	71	98
Total	137,585	4,671	6,397

SOURCE: USDA data from 2004

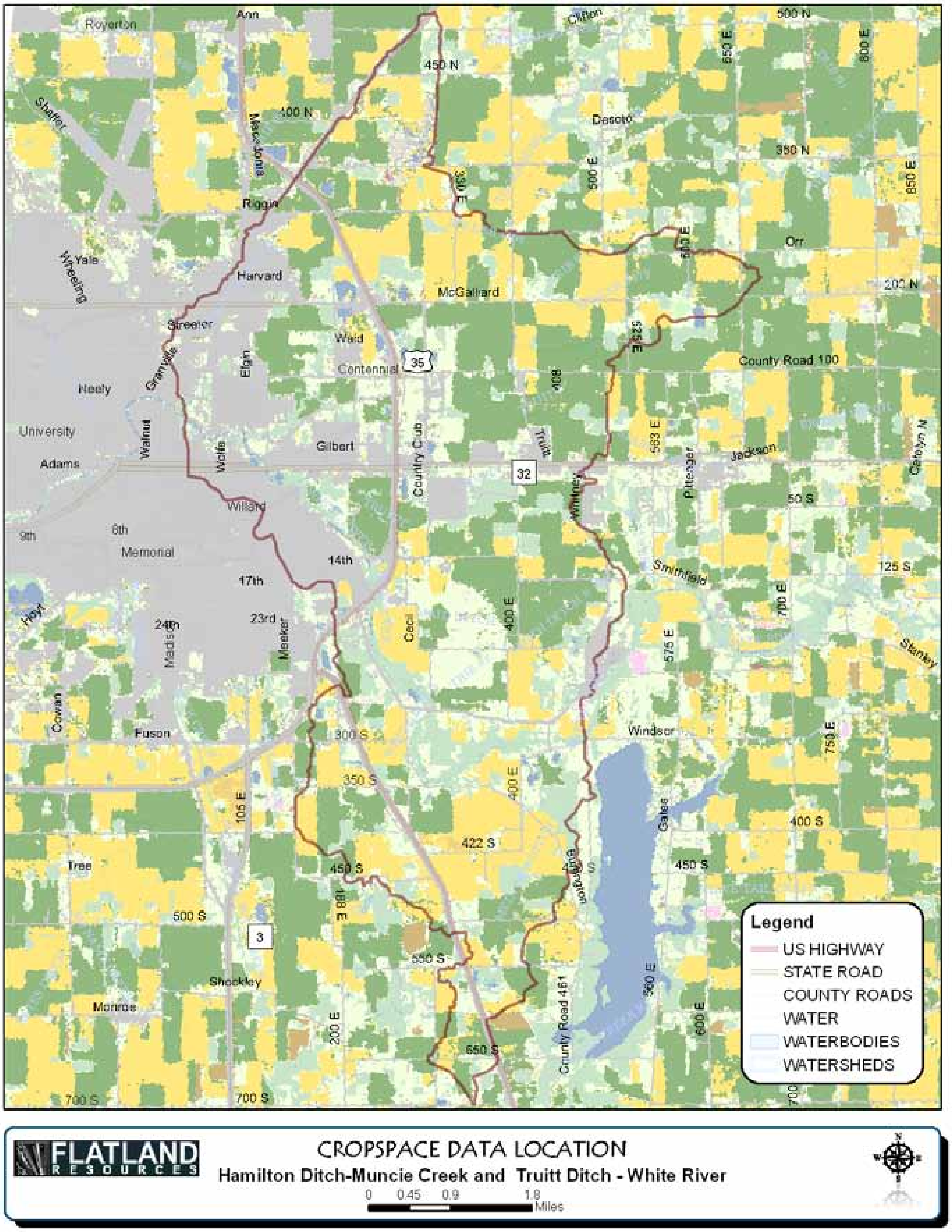


CHA. 2.17 Hogs and pigs Dominant

TABLE 2.34: Delaware County Livestock Inventory (Estimation)

	Delaware Co.	Munce Creek - Hamilton Ditch	Truitt Ditch-White River
Total Acerage	253,382	8,602	11,781
Hogs and pigs	15,453	525	718
Cattle and calves	2,891	98	134
Layers	959	33	45
Horses and ponies	901	31	42
Sheep and lambs	664	23	31

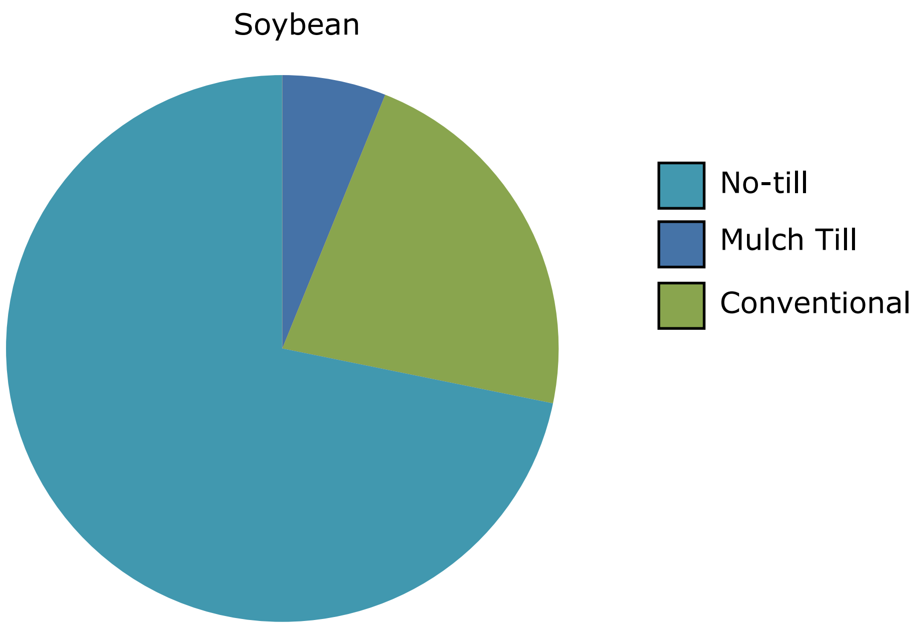
SOURCE: USDA data from 2004

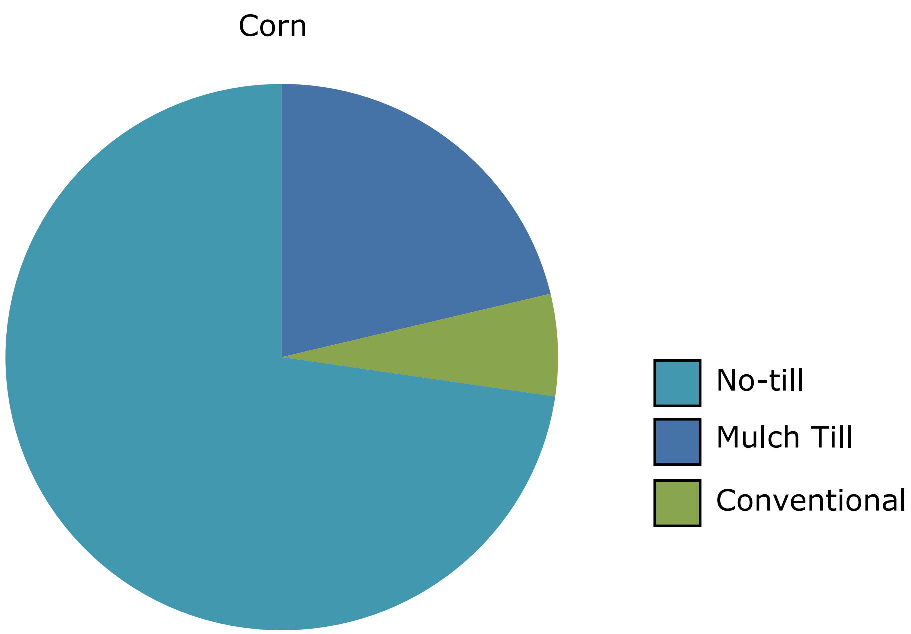


MAP. 2.57 Typical Soybean (green) and Corn (yellow) Field Locations in Subwatershds

SOURCE: USDA, NASS

Agricultural No-till
WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 13





CHA. 2.18 Delaware Corn and Soybean Tillage Practices

SOURCE: USDA

TABLE 2.35: Soybean and Corn Ranked by No-till Percentage

		total	conventional till		mulch till		no-till	
		acres	Acres	%	Acres	%	Acres	%
Bean	Delaware County	84,000	5,100	6%	18,600	22%	60,300	72%
	Muncie Creek - Hamilton Ditch	2,099	126	6%	462	22%	1,511	72%
	Truitt Ditch- White River	2,875	173	6%	633	22%	2,070	72%
Corn	Delaware County	66,300	14,100	21%	4,000	6%	48,200	72%
	Muncie Creek - Hamilton Ditch	2,393	502.53	21%	143.58	6%	1722.96	72%
	Truitt Ditch- White River	3,278	688.38	21%	196.68	6%	2360.16	72%

SOURCE: USDA data from 2004

TABLE 2.36: Total Diesel Fuel Cost Estimate (in dollars per year) based on $4.00/gallon

Delaware County					
Crop	Acres	Conventional	Mulch-Till	Ridge-Till	No-Till
Corn	70,502	$1,598,985	$950,367	$865,765	$486,464
Soybeans	61,828	$1,402,259	$833,441	$759,248	$426,613
Muncie Creek - Hamilton Ditch					
Crop	Acres	Conventional	Mulch-Till	Ridge-Till	No-Till
Corn	2,393	$54,273	$32,258	$29,386	$16,512
Soybeans	2,099	$47,605	$28,294	$25,776	$14,483
Truitt Ditch- White River					
Crop	Acres	Conventional	Mulch-Till	Ridge-Till	No-Till
Corn	3,278	$74,345	$44,187	$40,254	$22,618
Soybeans	2,875	$65,198	$38,751	$35,301	$19,835
Total Fuel Cost (Subwatersheds)		$241,421	$143,490	$130,717	$73,448
Potential Cost Savings vs Conventional			$97,931	$110,705	$167,973

SOURCE: USDA data from 2004

INVENTORY

Agricultural Chemical Usage

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 14

Agricultural herbicides, pesticides, and fertilizers are commonly applied to row crops in Indiana. These chemicals can be carried into adjacent waterbodies through surface runoff and through tile drainage. This is especially an issue if a storm occurs prior to the chemicals being broken down and used by the crops.

Data for chemical usage on an individual county or watershed level is not currently collected. Rather, data is collected for the state as a whole in two forms. First, the National Agricultural Statistics Survey (NASS) collects information on chemical usage, number of applications per year, type of chemical applied, number of applications per year, and the application rate. These data were last collected in 2006 (NASS, 2006). Additionally, NASS collects farmland data for the number of acres in agricultural production by type (i.e. corn, soybeans, grains) every five years. This data was last collected in 2007 (NASS, 2007). The acreage of cropland in the watershed was estimated above using 2005 cropland cover data. [1]

Purposes of Herbicides:
Alachlor – Annual grasses and broadleaf weeds in corn and soybean fields.
Atrazine – Pre and post emergent broadleaf weeds and grass.
Metolachlor – Broadleaf weed control in corn.
Glysophate – Non-selective herbicide; commonly known as Round-up.
Potash – Potassium carbonate. Used in fertilizers. Improves water retention, yield, nutrient value, color, texture, taste and disease resistance in crops.

TABLE 2.37: Soybean: Fertilizer Primary Nutrient Applications

Nutrient	lbs/acre/yr
Nitrogen	16
Phosphate	44
Potash	96

SOURCE: USDA data from 2004

TABLE 2.38: Corn: Fertilizer Primary Nutrient Applications

Nutrient	lbs/acre/yr
Nitrogen	67
Phosphate	56
Potash	111
Sulfur	10

SOURCE: USDA data from 2004

1 National Agricultural Statistics Service

TABLE 2.39: Soybean: Agricultural Chemical Applications	
Herbicides	lbs/acre/yr
2,4-D, 2-EHE	0.585
2,4-D, dimeth. salt	0.525
Chlorimuron-ethyl	0.017
Glyphosate	1.374
Glyphosate iso. salt	1.3974
Imazaquin	0.072
Imazethapyr	0.061
Metribuzin	0.253

SOURCE: USDA data from 2004

TABLE 2.40: Corn: Agricultural Chemical Applications *	
Herbicides	lbs/acre/application
2,4-D, 2-EHE	0.428
Acetochlor	1.823
Atrazine	1.094
Clopyralid	0.136
Dicamba, Dimet. salt	0.121
Dicamba, Sodium salt	0.106
Diflufenzopyr-sodium	0.042
Flufenacet	0.463
Flumetsulam	0.044
Foramsulfuron	0.028
Glyphosate iso. salt	0.867
Imazapyr	0.014
Imazethapyr	0.042
Isoxaflutole	0.049
Mesotrione	0.128
Nicosulfuron	0.02
Primisulfuron	0.027
Prosulfuron	0.009
Rimsulfuron	0.017
S-Metolachlor	1.234
Simazine	1.236
Insecticides	
Chlorpyrifos	1.336
Cyfluthrin	0.006
Tebupirimphos	0.113
Tefluthrin	0.107

Indiana - Soybeans: Fertilizer Primary Nutrient Applications, Program States and Total, 2006

SOURCE: USDA data from 2004

INVENTORY

Growing Season

WMP - CHAPTER 1 - PART 1 - SECTION 5 - SUBSECTION 15

The average annual total precipitation is about 37.67 inches. Of this, 20.1 inches, or about 53 percent, usually falls in May through October. The growing season for most crops falls within this period. The heaviest 1-day rainfall during the period of record was 4.74 inches at Muncie on June 18, 1992.[1]

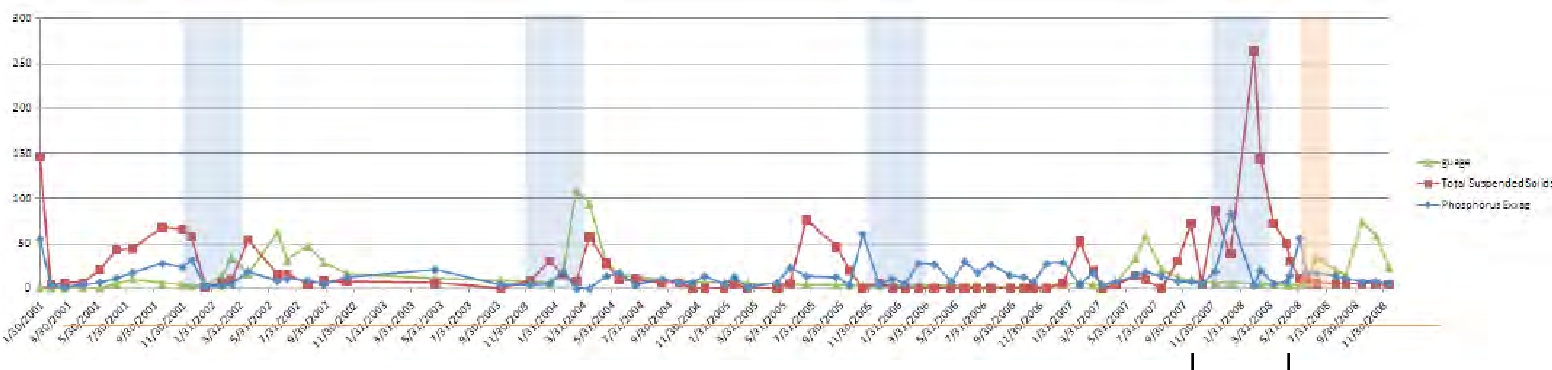
Growing degree days are shown in Table 2.41. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (40 degrees F). The normal monthly accumulation is used to schedule single or successive planting of a crop between the last freeze in spring and the first freeze in fall.[2]

TABLE 2.41: Daily Minimum Temperature During Growing Season

Probability	Higher than 24 F	Higher than 28 F	Higher than 32 F
	Days	Days	Days
9 years in 10	203	177	149
8 years in 10	210	185	156
5 years in 10	224	200	169
2 years in 10	238	215	181
1 years in 10	245	223	188

SOURCE: Soil Survey of Delaware County Indiana. US Department of Agriculture

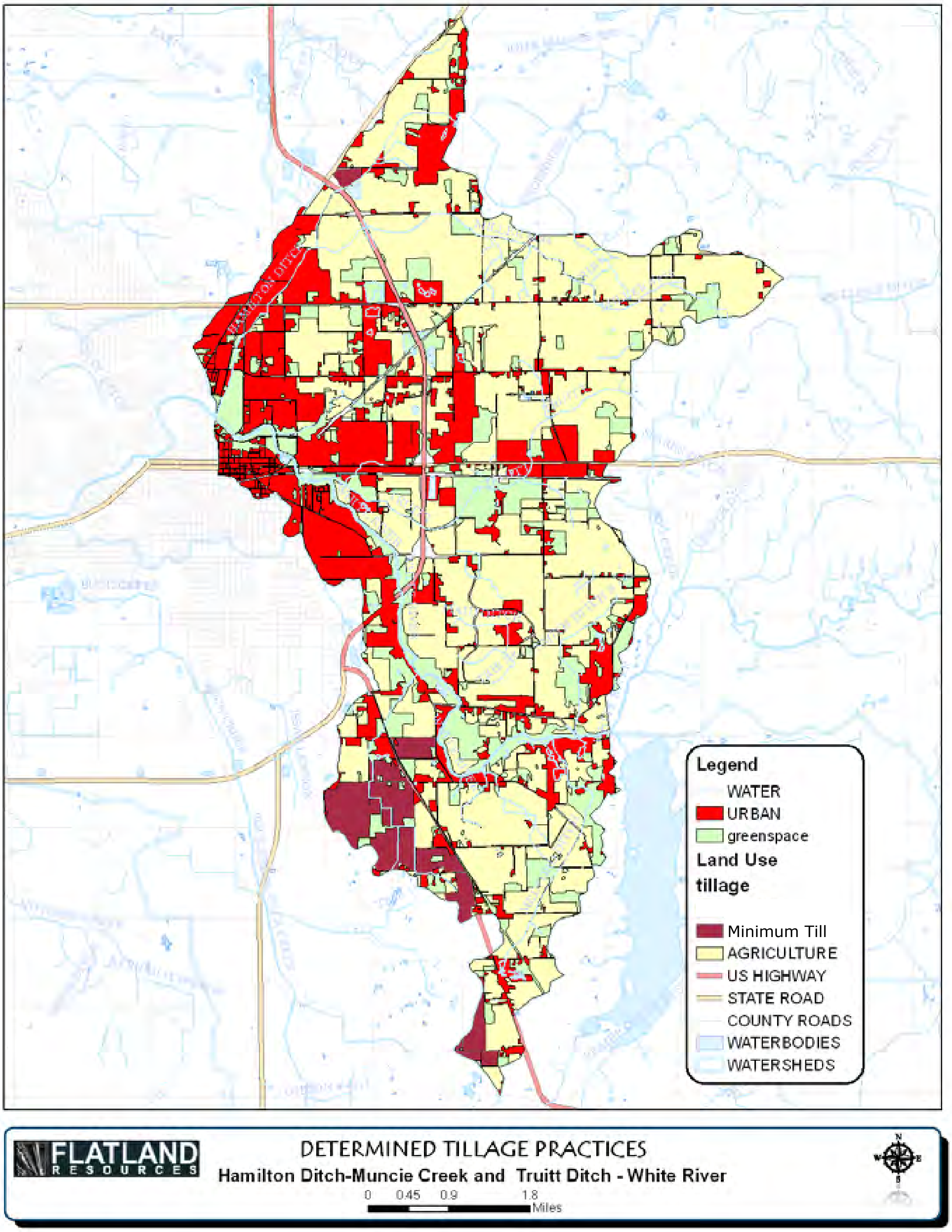
Spikes in TSS and Phosphorus can be observed in WQ sampling data (over 10 year monitoring period) during non growing seasons. Chart 2.19 highlights winter months in light blue. A sediment spike is observed in 2008 as a result in a significant logjam.



CHA. 2.19 TSS and Phosphorus Spikes During Nongrowing Seasons

Sediment Spike in 2008 occurred as a result of a logjam

1 Soil Survey of Delaware County Indiana. US Department of Agriculture
2 Soil Survey of Delaware County Indiana. US Department of Agriculture



MAP. 2.58 No-till locations.

CAFOS

WMP - CHAPTER 2 - PART 1 - SECTION 5 - SUBSECTION 16

Confined Feeding Operations and Hobby Farms
A mixture of small, unregulated (hobby farms) and larger, regulated livestock operations (confined feeding operations) are located within Delaware and Randolph Counties (feeding into the Subwatersheds). Small farms are referred to as hobby farms and are unregulated, while larger farms that house animals for longer than 45 days per year are regulated by the IDEM. These regulations are based on the number and type of animals present. IDEM requires permit applications which document animal housing, manure storage and disposal, and nutrient management plans for farms that maintain 300 or more cows, 600 or more hogs, or 30,000 or more fowl. These facilities are considered confined feeding operations (CFO). There are 19 active confined feeding operations and 420 hobby farms located in the watershed. None of the CFOs are large enough to be classified as a concentrated animal feeding operation (CAFO). [1]

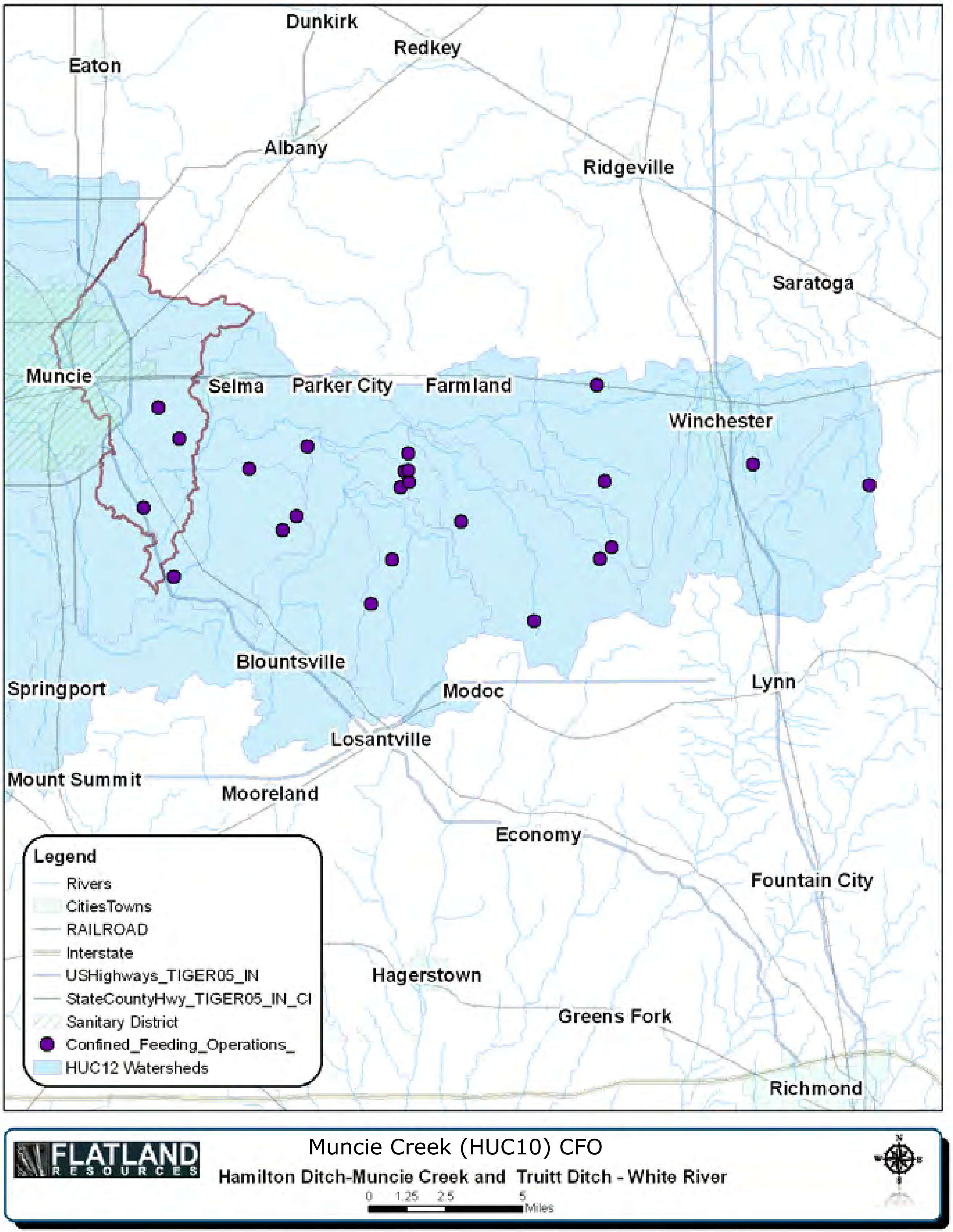
CAFOs are defined by the number of animals housed on-site as follows:
1,000 beef cattle; 1,000 veal calves; 700 mature dairy cattle; 2,500 swine if >55 pounds; 10,000 swine if <55 pounds; 500 horses; 10,000 sheep; 55,000 turkeys; 125,000 chickens (dry system); 30,000 chickens (liquid system); 82,000 layers (dry system); 30,000 ducks (dry)[2]

Confined Feeding Operation (CFO):
Confined feeding operation for purposes of the Delaware County Ordinance means:
1) any confined feeding of: a. at least three hundred (300) cattle; b. at least six hundred (600) swine or sheep; or c. at least thirty thousand (30,000) fowl.
2) any animal feeding operation electing to be subject to state law; or
3) any animal feeding operation that is causing a violation of: a. water pollution control laws; b. any rules of the water pollution control board; or c. state statute (IC 13-18-10).

The term CFO is intended to include all of the production area involved in the operation. Two or more operations under common ownership are considered to be a single operation for purposes of determining the number of animals at an operation if they adjoin each other or if they use a common area or system for the disposal of waste. [State definition 327 IAC 16-2-5][3]

Concentrated Animal Feeding Operation (CAFO):
An AFO that is one of the following: a large CAFO, a medium CAFO, or designated as a CAFO by the Indiana Department of Environmental Management. Two or more AFOs under common ownership are considered to be a single AFO for the purposes of determining the number of animals at an operation, if the AFOs adjoin each other or if the AFOs use a common area or system for land application of manure, litter or process wastewater. [State definition 327 IAC 5-4-3][4]

1 Muncie Free Press
2 Muncie Free Press
3 Muncie Free Press
4 Muncie Free Press



MAP. 2.59 CFOs in Subwatersheds and Muncie Creek HUC10 Drainage basin

SECTION SIX - OTHER PLANNING EFFORTS IN WATERSHEDS

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

Planning Efforts in Watersheds

WMP - CHAPTER 2 - PART 1 - SECTION 6 - SUBSECTION 1

Planning efforts have occurred at a variety of scales in Delaware County since 2000. These efforts have been focused on developing, maintaining, and improving local resources, stimulating the economy, improving quality of life, and planning for the future. Various groups have been involved in this process and there has been public participation with every project, at all levels. Large scale planning has occurred within the City and the County with the development of the Muncie-Delaware Comprehensive, Muncie Action, Transportation, Muncie-Delaware Public Transit-Human Services Coordination, Delaware-Muncie Transportation Improvement, and Muncie Delaware County Economic Development Alliance Vision Plans. These have been a wide scale effort to understand development and create a cohesive vision. As these county/citywide plans have developed there has been an intense focus on parks, recreation, and natural resources through the White River Watershed Project, The City of Muncie 5 Year Parks and Recreation, and Prairie Creek Master Plans. All of these plans have created a centered focused vision for Muncie and Delaware County for the next 5-20 years.

TABLE 2.42: Inventory of Muncie-Delaware County Planning
Muncie-Delaware County Comprehensive Plan: 2000
White River Watershed Project: 2001
Prairie Creek Master Plan 2007
The City of Muncie 5 Year Parks and Recreation Master Plan 2009
Muncie Action Plan 2010
Muncie Delaware County Economic Development Alliance Vision 2011
2005-2030 Transportation Plan
Muncie Delaware County Public Transit - Human Services Coordination Plan
Delaware-Muncie Transportation Improvement Plan

Muncie-Delaware County Comprehensive Plan: 2000[1]
Communities plan so that they can better manage their future and provide a high quality of life to their residents. By carefully planning land uses and public investments, public services can be more efficiently provided, scarce land resources can be put to their highest uses, and public resources can be effectively targeted to pervasive problems. This Comprehensive Plan Update focuses on seven key plan elements. These plan elements are equal in importance to one another, and include:

- Alleviating and preventing problems created by urban sprawl, through several means. These means may include focusing new developing around the existing "service area villages" of Eaton, Gaston, Albany, Selma, Yorktown and Daleville, as well as encouraging infill development and defining an effective growth boundary for the City of Muncie.

- Preserving agricultural land, by focusing new development around existing development. An investigation of the feasibility of changing lot size for residential uses in agricultural areas should be conducted. The agricultural land committee that was formed during the Comprehensive Planning process should be retained, and continue to discuss and implement agricultural preservation items.

- Redevelopment and revitalization of existing urban areas and neighborhoods within the City of Muncie, including the Central Business District.

- Implementing key thoroughfare improvements, including the completion of the western portion of the Muncie Bypass loop.

- Encouraging economic development through the provision of new Class A industrial and office space, and taking advantage of the proximity of the community to the Indianapolis metropolitan area via I-69.

- Preserving and protecting the natural environment, and maximizing the recreational value of natural areas for all citizens, through constraining development to non-environmentally sensitive areas, expanding the greenway system, and encouraging, where feasible, clustered development that preserves open space. Such techniques to preserve and protect the natural environment shall also be cognizant of the importance of private property rights.

- Enhancing the attractiveness of the community through enhanced design standards for major gateway corridors, and implementing improvements to major gateways, such as SR 332 and the Muncie Bypass. Such activities will reinforce a positive city/county image, promote better quality design, and serve as a guide for the enhancement of existing properties.

1 Muncie-Delaware County Comprehensive Plan: 2000

White River Watershed Project: 2001[2]

The purpose of the White River Watershed Project is to advocate Best Management Practices (BMPs) through education, demonstration and financial incentive. BMPs are both behavioral and structural. Behavioral BMPs include day to day decision making such as conserving water, proper disposal of waste, and other conservation methods - while structural BMPs include modifications to the landscape or machinery. It is important that we implement both types of BMPs when feasible in order to reduce negative environmental impacts, which inhibits nature's ability to produce natural goods, and endangers the health of entire ecosystems.

The Clean Water Act was a landmark piece of legislation that initiated a Nation-wide effort to address water pollution issues in the United States. Early application of the legislation was directed at point source pollution. Point source pollutants enter a stream directly from a pipe – most commonly from industrial processes. Amendments to the legislation added means and methods to address nonpoint water pollution which is harder to track as it is more diffuse. Nonpoint water pollutants enter streams from storm water runoff. Out of these amendments came the 319 program which funds states to solve nonpoint water pollution issues at the local level.

One way the State of Indiana has chosen to approach the nonpoint problem is creating a grant program to cost-share on best management practices. The WRWP administers this grant money for Delaware County. In order to most effectively distribute grant monies, WRWP has developed a management plan that identifies critical areas in the county that are in the greatest need for grant funding. It is the mission of the WRWP to create a better awareness of water quality issues in Delaware County and to work with local landowners to develop best management practices for their properties and landholdings.The WRWP is able to exist because of its wide range of community partners and numerous volunteers and participants that share their time and expertise.

2 White River Watershed Project: 2001

Prairie Creek Master Plan 2007[3]

Although Prairie Creek Reservoir is not in the studied subwatershed, it discharges directly into the headwaters of the Truitt Ditch-White River Subwatershed. The reservoir is currently being used as an environmental education site by the Muncie Stormwater Department and the White River Watershed Project Education and Outreach Sub-committee. As a regional destination, it will undoubtedly have a crucial role to play in Muncie Creek - Hamilton Ditch and Truitt Ditch-White River community based education.

The future of Prairie Creek Park and Reservoir is of great importance to the citizens of Muncie and Delaware County. It is also a serious responsibility. To ensure that this unique community resource continues to be available for human enjoyment and use by future generations, it is important to plan ahead. This plan is a guide for public policy, actions, and investments. The plan is not limited in scope to government, but includes many suggestions that can only be implemented by other organizations, private individuals, and community groups including those not-for-profits.

The Prairie Creek Master Plan has been a joint effort between the Delaware-Muncie Metropolitan Plan commission and the Delaware County Soil and Water Conservation District with input from multiple government and private stakeholders, and the public. The plan elaborates upon key elements set forth in the Comprehensive Plan and has been mindful of the need to protect private property rights. It should be interpreted as a dynamic document frequently updated to incorporate the ongoing changes both at Prairie Creek and in the community at large.

Key elements in the Prairie Creek Master Plan:

- Protecting the future of the park and reservoir as community assets entails extending the city's lease with IAWC beyond 2010 termination of the current lease and purchasing the land if it becomes available for sale. These measures are essential to ensure that both public access to the area and its ecological health continues.

- Water quality in the watershed is a fundamental concern. Conservation measures must be extended to limit pollution. The impact of development must be mitigated through regulations and creative design. On-site wastewater disposal systems are one source of pollution that needs to be addressed immediately. Measures to reduce sedimentation and accompanying nutrient and pesticide loading in the reservoir should continue and expand.

- Enhance the value of the park and reservoir as an economic, aesthetic (quality of life) and recreational asset for our community. The reservoir and park have regional appeal that should be capitalized on through planning and marketing of special events. The park facilities are in need of an upgrade and should receive priority funding.

- Implementation of this plan should involve public education, amending, ordinances, the forming of public and private partnerships and the cooperation of all involved entities.

The citizens of Muncie and Delaware County enjoy the benefits of Prairie Creek Reservoir and have acknowledged it as one of the important factors contributing to the quality of life in our community. The success of this plan will depend on the support it receives from a coordinated effort between all stakeholders and the greater community.

3 Prairie Creek Master Plan 2007

The City of Muncie 5 Year Parks and Recreation Master Plan 2009[4]
Parks, Open Space, Trails, Greenways and Recreational Programming offer many beneficial amenities to a community. These amenities include:

Quality of Life Benefits

- Makes neighborhoods more attractive places to live
- Strengthens community pride
- Improves physical health – opportunities for exercise and recreation
- Improves mental health
- Can reduce violence and crime Economic Benefits
- Attracts and retains businesses
- Attracts home buyers (when parks are within 2000 feet of the home)
- Attracts retirees
- Reduced costs for public services
- Provides "free" natural services like flood control & filtration of pollutants
- Higher assessments, thus higher property tax revenue for local government (when parks are within 2000 feet of the home)
- Increased tourism

Environmental Benefits

- Offer natural environmental protection
- Improved water quality – absorbs storm runoff, reduces runoff and filters out sediment, nutrients, pathogens, pesticides, metals and other contaminants
- Reduce air pollution – natural air filters
- Moderates temperatures – reduces heat island effects
- Energy conservation (within the parks these are applicable for cabins and offices)
- Tree cover can reduce building energy use in the summer by providing shade
- Trees also contribute to reduced winter energy use by providing a wind block
- Habitat
- Increased natural areas provides for habitat diversity
- Contributes to connecting natural areas which provide for healthier wildlife

According to the 2007 U.S. Census population estimates, Muncie is the 8th largest second class city in Indiana. Muncie spends less on its park system and employs one of the lowest amount of full time employees than all other second class cities benchmarked. While Muncie provides an average number of parks, the amount of acres dedicated to parkland in the City is the least amount offered per resident. For decades, Muncie's park system has not offered any recreational programming, aged park equipment has needed updating, and no new parks of significant size have been established. One of the best ways for Muncie to improve its overall character is to enhance its park system. A preeminent park system will set Muncie apart from other cities in the State. This would enhance the livability of the community for residents and the marketability of Muncie for prospective businesses.

4 The City of Muncie 5 Year Parks and Recreation Master Plan 2009

Muncie Action Plan 2010[5]

The Muncie Action Plan provides a pathway to the future of the city of Muncie. The plan utilizes the ideas and input of more than 2,000 residents- an unprecedented coming together of the community. The Plan includes long-term goals and measurable action steps that will accomplish a realistic vision and uphold the values identified by our community.

Recommendations from the community, accompanied by extensive factual analysis of trends and conditions, form the basis of the Plan. The Plan is divided into five initiative areas, each with specific action steps designed to realize the vision of a stronger, better Muncie. The Plan will be used by the community as public and private decisions are made concerning development, redevelopment, capital improvements, and other matters affecting the well being of the community. The Plan will be used as the Delaware-Muncie Metropolitan Plan Commission begins working on a Comprehensive Plan update. It will be used by Community Development as it prioritizes projects and funding.

Five Initiatives:

1. Linking Learning, Health, and Prosperity
2. Fostering Collaboration
3. Strengthening Pride and Image
4. Creating Attractive and Desirable Places
5. Managing Community Resources

The Plan encourages cooperation and neighborhood development. It recognizes that the whole community is responsible for education, community image and identity, economic development and for the effective use of community resources. To our knowledge it is the first city-wide strategic plan and has had unprecedented success in involving the whole community.

The Plan strongly recommends an integrated approach to land use and reuse so that decisions are not made in isolation; rather, each decision should consider its impact on other areas (neighborhoods, pedestrian movement, educating the public) and be examined through the lens of the Plan's goals, principles, and action steps.

The effectiveness of the Plan will be measured in the success of its implementation. 47 actions were recommended within the five initiatives, and implementation and planning structures were developed.

5 Muncie Action Plan 2010

Muncie Delaware County Economic Development Alliance Vision 2011[6]

Vision 2011 is an updated master plan for the Muncie Delaware County Economic Development Alliance vision 2006. A new five-year economic development effort was formed after careful analysis of the results, failures, and outcomes of the 2006 Plan. The 2011 goals were focused around seeking to improve wages, increasing the number of high skill, high pay and advancement jobs, and work to develop a community that is attractive to knowledge based businesses, which in turn will enhance the overall quality of life for the city. Vision 2011 is the most aggressive and comprehensive program that the community has undertaken.

The overarching goals are the following with these initiatives:

• By working with existing businesses to improve the performance of mainstay industries.

- -Expansion and Retention of Existing Businesses
- -Downtown Development
- -Strengthen Workforce Education

•By accelerating the attraction and/or development of frontier industries and high growth, high pay companies.

- -New Business Attraction and Tax Base Expansion
- -Marketing and Recruitment of Tech/Knowledge-based Businesses and Retention of Tech/ Knowledge Based Workers
- -Promote Agri-business as a Method to Help Diversify the Local Economic Base and Provide New Opportunities for the Region's Farming Industry

• By forming strong alliances with our business, government, labor, medical and education partners, we will surpass the competition by executing seamless, collaborative initiatives in economic development.

- -Marketing and Recruitment of Tech/Knowledge-based Businesses and Retention of Tech/ Knowledge Based Workers
- -Marketing and Promotion of the Medical Community as the Destination Point for Healthcare in East Central Indiana

• By encouraging everyone involved to stay the course even when the economy slows down over the short term.

- -Coordinate Community and Regional Resources to Generate Economic Growth
- -Promote a Positive "Quality of Life" Image of Muncie-Delaware both Internally and Externally

This new long-term vision calls for Muncie and Delaware County to be one of the best small cities in the Midwest while achieving national recognition in four areas of excellence: free enterprise, smart government, superior education, and quality of life.

6 Muncie Delaware County Economic Development Alliance Vision 2011

Delaware-Muncie Transportation Improvement Plan
This project is a transportation study and network analysis for future transportation improvements designed to enhance travel movements in the development growth areas of Delaware County (including Muncie and Yorktown). The main purpose of the study is to determine the best combination of improvements to deal with congested traffic resulting from growth toward the north and the west edges of Muncie, Indiana. A second purpose of the study is to compare the impact of extending the Muncie Bypass around the north and west side of Muncie to the impact of a variety of alternative improvements.

To ensure that the annual development of the DMTIP is consistent with the ends to which the Delaware-Muncie area aspires, a set of transportation goals and objectives was adopted by the DMTIP Coordinating Committee. The goals and objectives are intended to help establish policy guidelines for planning implementation and identify specific community needs as a focal point for project selection.

The goals and objectives adopted by the committee were developed and approved as a part of the 2009-2030 Delaware-Muncie Transportation Plan:

- Ensure the continued provision of bus service throughout the City of Muncie including purchase of replacement transit vehicles.

-Provide a safe, well-maintained, functional multi-modal transportation system that is compatible with planned community growth and minimizes traffic congestion.

-Develop cost-effective, environmentally sound plans, programs, standards, and enforcement procedures for the maintenance and extension of public and private facilities.

-Promote the development of land, parking facilities and effective movement of people and goods within the Central Business District (also known as City Center), while improving the aesthetic character and environmental quality of downtown Muncie.

-Promote the community's ability to improve the surface transportation system by means of an improved economic base resulting from orderly economic development encompassing all industries (ousing, retail, manufacturing and tourism)

SECTION SEVEN - SUMMARY

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

Inventory Summary
WMP - CHAPTER 2 - PART 1 - SECTION 7 - SUBSECTION 1

By Amy Latomme, White River Watershed Project

A healthy environment is the foundation of any healthy economic system; the proper stewardship of the natural world is the first step in the proper stewardship of the economic order. This foundational belief is the driving force behind the continuation and adaptation of the White River Watershed Management Plan.

The White River Watershed Project started in 2000 because of concerns for local water quality. The project acquired a three year grant that enabled the committee to form the White River Watershed Management Plan for three sub-watersheds. By updating the existing plan to include two more sub-watersheds, the plan will be comprehensive and will result in the finding of more point and non-point source pollutants of the White River and its tributaries.

The objectives for the White River Watershed Management Plan are to 1) supply the community with water quality science and land use impact analysis, 2) provide future generations the ability to make objective land use decisions, and 3) foster the ability to continue the great environmental accomplishments made by the society in industry, agronomy and household economies that have occurred in the last forty years.

The mission for the White River Watershed Management Plan is to advocate Best Management Practices (BMPs) through education, demonstration and financial incentive. It is important for all types of BMPs to be implemented when feasible. BMPs reduce the negative environmental impacts that inhibit nature's ability to produce natural goods and that endanger the health of the entire ecosystem. BMPs will ultimately improve the quality of the White River which will in turn improve the quality of life surrounding the White River whether that is human, plant or animal life.

The plan has been created by members of the White River Watershed Project, a group of stakeholders from Delaware County who oversee the Delaware County Soil and Water Conservation District. The project is a community-driven, voluntary effort to clean-up and reduce non-point source water pollution within the county. The Red-tail Conservatory, the Delaware County Office of Geographic Information, the Muncie Sanitary District, the Ball Brothers Foundation, Ball State University and Minnetrista Cultural Center are just a few of the partners that aided in the development of the plan because of their concern for the White River Watershed.

During its development, the plan received public input at several meetings. At these meetings, the public raised concerns about the quality of the White River. Some of these concerns included: run-off from urban areas and from the sports complex; ditch and stream erosion; channelized ditches within the watershed; failed or failing septic systems; and illegal and legal dumping. The public was also informed about the project through educational outreach, newsletters and promotional material.

The White River Watershed Natural History

A watershed is the total area of land that drains into a particular body of what whether that be a wetland, stream, river, lake or sea. Each watershed is assigned an address referred to as a Hydrologic Unit Code Area (HUC). Each HUC has an 8-digit code; that represents its location in the United States. Indiana is divided into 39 watersheds at the 8-digit code level. Watersheds can be divided even further into 11, 12 and 14 digit codes. The Muncie Creek-Hamilton ditch and the Truitt Ditch-

White River are 12 digit sub-watersheds and are the specific watersheds being used for this update of the White River Watershed Management Plan.

The White River Watershed is located in the Tipton Till plain in East Central Indiana. This plain was formed from glacial deposits of sand and gravel that filled in bedrock valleys. The result of the deposits is the flat monotonous landscape that is central Indiana. The watershed, geologically, is made up of moraines and eskers, as well as bedrock. The landforms dictate the natural flow of the streams and rivers within the watershed.

Within the Tipton Till plain, the soils are generally classified by poorly drained or better draining soils. Using the USDA classification of soils, most of the soils within the sub-watersheds are silt loam. Also, almost 30% of the soils within the sub-watersheds are classified as highly erodible. The soil eroded by wind and storm water carries with it nutrients, herbicides and pesticides. The soil travels directly into the streams affecting the water quality. The poor water quality increases plant and algae growth, kills aquatic life and increases the sedimentation of the streambeds.

Another general soil classification is a hydric soil. Hydric soils are typically found along river corridors and are good indications of historic wetland conditions. Around 27% of the soils in the sub-watersheds are considered hydric.

Floodplains are the land adjacent to streams, rivers and other water bodies that provide temporary storage of water. Approximately 6.8% of the urban and cultivated land of the sub-watershed lies within the 100-year floodplain. Flooding occurs when there is encroachment on the floodplain, deforestation, stream obstruction, tiling, or the failure of the flood control structure. Flooding can cause property and inventory damage, utility damage and service disruption, bridge or road impasses, stream bank erosion, vegetation loss, and water quality degradation. To avoid the damages and impacts of flooding, floodplains should not be built in or disturbed. The majority of undeveloped land in Delaware County is within the floodplain of the White River.

To help alleviate the impact of potential flooding of the White River and other rivers across the country, the Army Corps of Engineers designed and developed the flood control levee system that was built during 1913-1960. The Muncie Levee System within the Muncie Creek –Hamilton Ditch sub-watershed is part of the Army Corps of Engineers' efforts.

Pre-settlement vegetation within the sub-watersheds was mostly forest consisting of oak, maple, ash, elm, sycamore, hickory, and beech trees. There were also a few prairies and wetlands.

White River Watershed Cultural History

Most of the early settlers to Delaware County came from Virginia, Pennsylvania and Kentucky. The Delaware and Miami Indians lived in the area and remained until 1818. Muncie was named after the chief of the Delaware Indian tribe. The first permanent settlement in Delaware County was established in 1820 located along the West Fork of the White River near present day Muncie, New Burlington and Smithfield.

Most of the county's towns were laid out along railroad lines making it convenient for trade. Muncie, then Munseytown, became the county seat in 1827. Between 1860 and 1880, the population of Muncie nearly doubled. In 1876, natural gas was discovered near Eaton in Delaware County, this area would become known as Trenton Field. The natural gas was almost forgotten about until it was discovered in neighboring Ohio around the 1880s.

The availability of the gas attracted many businessmen and industries to the region, including the Ball Brothers. By 1880, Muncie had forty factories manufacturing products ranging from washing machines to roller skates. Unfortunately, by 1910, 90% of the gas had been used due to wastefulness and unregulated drilling practices.

As the glass industry continued to grow, the Ball Brothers and their families became a respected and influential part of Delaware County. In 1917, the Ball Brothers purchased what would become Ball State University. The university attracts around 19,000 students from around the world.

With the globalization of the manufacturing business, many of manufacturers have moved away from Muncie, leaving the economy of the town depleted. Ball State University and Ball Memorial Hospital are the leading employers of the county. Projections for the next twenty years show that Delaware County will maintain stability and steady growth.

White River

The White River is the primary supply of water for Muncie and Delaware County. During periods of low flow the water supply is supplemented by Prairie Creek Reservoir. In the rural parts of the county, wells are used. Due to the glacial deposits and bedrock, the availability of ground water is good, producing 200 to 400 gallons per minute.

The White River is used for boating, fishing and full-body contact recreation. The West Fork of the White River and its major tributaries drains two-thirds of the county. The Truitt Ditch, a main tributary to the White River, joins the White River at the mouth of the Truitt-Ditch White River watershed. Both are naturally occurring channels, although both have been modified by humans to either increase drainage or allow development. Because of the modifications, both have frequent cases of erosion.

Muncie Creek, within the Muncie Creek –Hamilton Ditch Subwatershed, is also a naturally occurring channel that has also undergone channelization and straightening to allow for agriculture and housing development. As a result the channel tries to reengineer itself back to a more natural and appropriate grade and flow.

Before the Clean Water Act was implemented in the 1970s, the White River received several point source pollutants from sources such as, waste water treatment facilities, combined sewer outflows, battery and transmission plants, and tool and die shops. Non-point source pollutants also contributed to the degradation of the water quality of the White River. Some of these include urbanism, agriculture, runoff, fertilizers, insecticides, and herbicides. Most of these non-point sources still exist.

Pitfalls within the Watershed

Impervious surfaces limit surface water from infiltrating the land to become groundwater. Studies show that stream ecology degradation begins with only 10% impervious cover within a watershed. This results in water quality problems, increased bacteria concentrations, higher levels of toxic chemicals, and higher temperatures. The combined impervious surface total for both sub-watersheds is 18% coverage.

Although there are great recreational amenities within the county including the Cardinal and White River Greenways and Prairie Creek Reservoir, the amount of recreational space per person that is recommended by the National Recreation and Park Association is half the amount it should be. This number needs to be increased and can be increased by community involvement.

Most of the soil erosion and the stream sedimentation problems are blamed on agricultural fields not using BMPs. Some sedimentation comes from agriculture surface erosion, however most comes from the erosion of stream banks due to human manipulation (straightening and channelization) of the channel's natural course. Farmers should be more concerned about containing the herbicide and pesticide chemicals as well as manure applications that get washed into the river during storm events.

Unfortunately, over 85% of the wetlands in Indiana have been lost due to land development. In the Muncie Creek - Hamilton Ditch and Truitt Ditch - White River Subwatersheds an estimated 25% has been removed. There are now laws that require the replacement of a wetland within the same watershed if the wetland was drained for development. Although not the ideal solution, the obligation to replace beneficial wetland ecosystems will benefit the watershed. Restoring these areas back to their historic condition would prevent the further flow of highly erodible soils into the river systems.

Conclusion

Since 2000, many efforts have been made to improve the quality of the White River and its associated Watersheds. Because of the White River Watershed Management Plan, planning efforts involving Muncie and Delaware County have focused on the improvement of parks, recreation and natural resources. These plans need to be implemented to ensure the protection of the White River and its surroundings.

The White River Watershed Project exists because of the wide range of community partners and the numerous volunteers who share their time and expertise improving the quality of the White River for themselves and for future generations.

WATERSHED INVENTORY PART TWO

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

SECTION ONE - HISTORICAL WATER QUALITY DATA

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

IDEM Integrated Water Monitoring

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

Integrated Water Monitoring Assessment

The Indiana Department of Environmental Management (IDEM) is the primary agency tasked with monitoring surface water quality within the state of Indiana.

Every two years, the Indiana Department of Environmental Management submits an Integrated Monitoring report to the Environmental Protection Agency on the state of Indiana's waters. The most recent report was delivered to the United States Environmental Protection Agency (USEPA) in 2008 (IDEM, 2008).

USEPA emphasizes a probabilistic monitoring approach in order to help states meet the Clean Water Act section 305(b) goal of comprehensively monitoring all waters of the state. IDEM's probabilistic monitoring program provides IDEM with the ability to make statistical inferences regarding the extent to which waters of the state, as a whole, support or do not support designated uses based on data collected randomly throughout the state. [1]

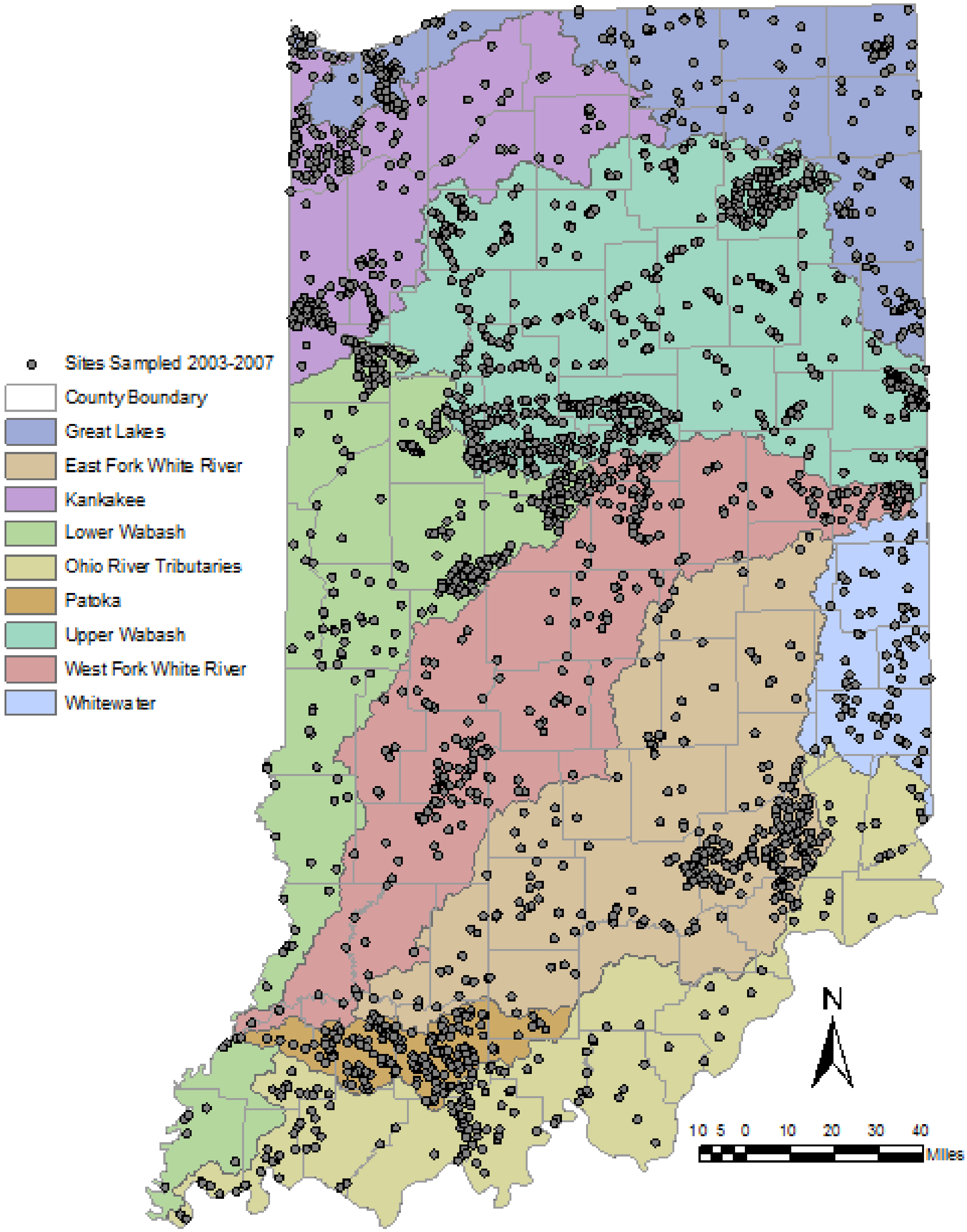
Sources of Data Include:[2]

- Fixed Station Monitoring Program, which provides chemistry data;
- Watershed Monitoring Program, which provides fish and benthic aquatic macroinvertebrate community data (IBI and mIBI) along with habitat evaluations, water chemistry data including information on nutrients, Chlorophyll a data, and E. coli data;
- Source ID Program, which provides chemistry data;
- Stressor ID Program, which provides fish community (IBI) data and habitat evaluations along with chemistry data collected at the same sites;
- Fish Tissue Contaminant Program, which provides fish tissue data;
- Special Studies Program which provides a variety of information for selected locations.

Indiana's list of impaired streams continues to grow as a function of probabilistic monitoring required to meet Clean Water Act monitoring goals. IDEM seeks to continue probabilistic monitoring in order to determine overall trends in water quality throughout the state and over time and to provide additional data with which to assess previously unassessed waters.[3]

IDEM's water quality monitoring also employs a watershed approach. The statewide rotating basin approach to watershed monitoring was adopted in 1996. The rotating basin plan makes it possible to update water quality assessments on a five-year cycle for monitored watersheds throughout the state and ensures that the information available for planning and watershed management activities is no more than five years old. MAP 2.60 shows the monitoring locations for all of IDEM's sampling programs and illustrates the sampling density achieved through IDEM's water quality monitoring strategy over the past five years (2003-2007).[4]

1 SWQMS and fact sheets with detailed descriptions of the monitoring programs are available on the IDEM Web site.
2 Indiana Integrated Water Monitoring and Assessment Report
3 Indiana Integrated Water Monitoring and Assessment Report
4 Indiana Integrated Water Monitoring and Assessment Report



MAP. 2.60 Location of IDEM Sampling Sites

SOURCE: Indiana Integrated Water Monitoring and Assessment Report

INVENTORY

Integrated Water Monitoring

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

The data collected in IDEM's WQ program enables the state to assess and report on how well the waters of Indiana support the "beneficial uses" designated in Indiana's water quality standards. This assessment is called the 305(b) report which uses the data from the waterbodies sampled for water quality and determines where "beneficial uses" are adversely effected.

Indiana's beneficial uses are defined in Indiana Code 14-25-7-2 as "The use of water for any useful and productive purpose." The term includes the following uses:[1] (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

To complete this report, the 305(b) coordinator reviews all data collected by IDEM and selected high-quality data collected by other organizations on a waterbody basis. Each assessed waterbody is then assigned a water quality rating based on its ability to meet Indiana's water quality standards (WQS). WQS are set at a level to protect Indiana waters' designated uses of swimmable, fishable, and drinkable. Waterbodies that do not meet their designated uses are proposed for listing on the impaired waterbodies list (303(d)), which is discussed in more detail below.[2]

IDEM completed its first comprehensive aquatic life use support assessments for the entire state in 2002 and will report similar information for recreational uses in 2010. The 2002 report was the state's first baseline report on water quality, which was revised in 2004 and 2006. The 2008 report provides the most recent comprehensive report on Indiana water quality to date.[3] MAP 2.61 Designates the location of IDEM Sampling points in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds as part of the 2002 and 2008 305(b) reports.

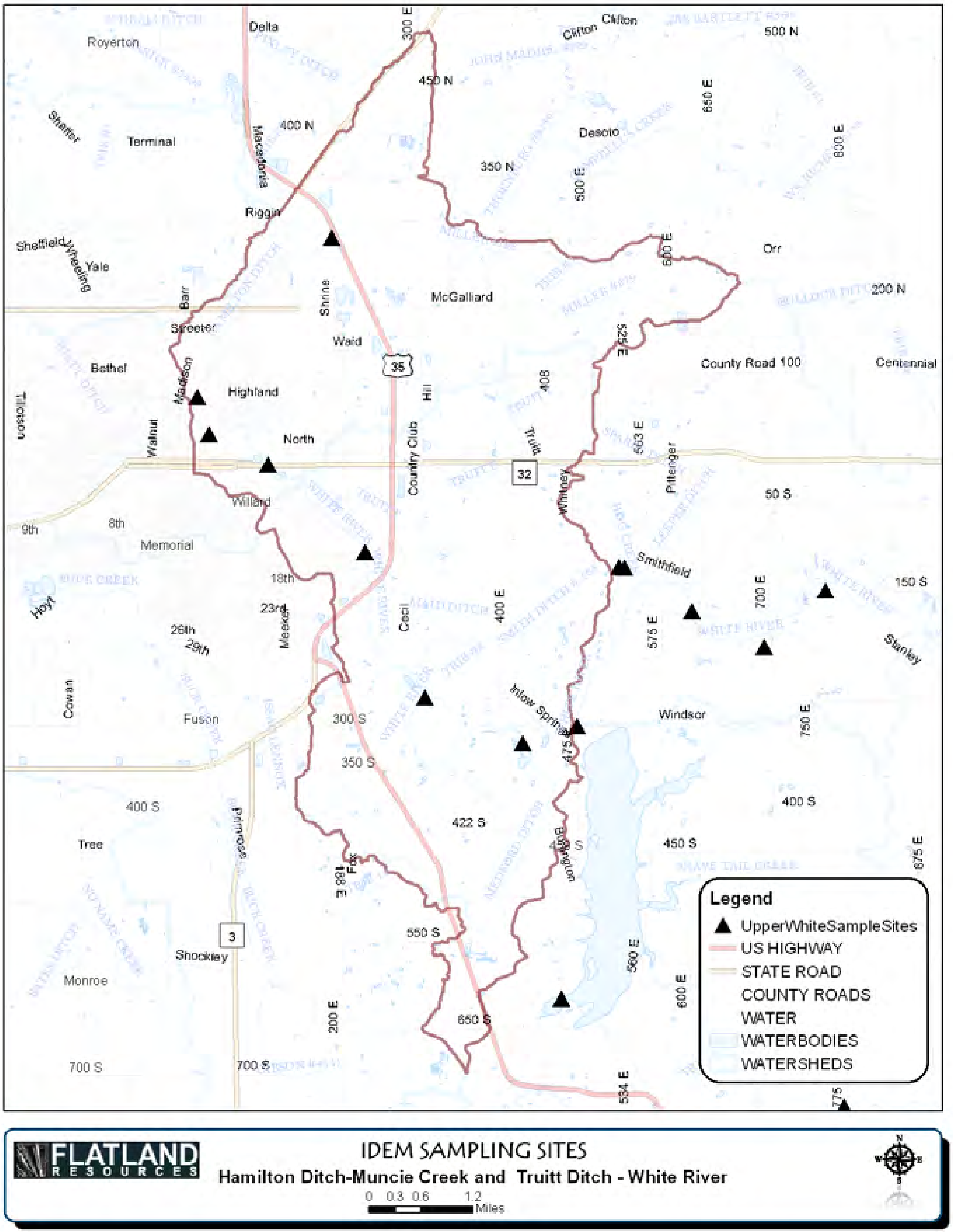
Approximately 79 percent of the 17,535 stream miles assessed Statewide for aquatic life use were found to be fully supporting. Approximately 30 percent of the 12,073 stream miles assessed Statewide support full body contact recreational use. [4] During the analysis, it was determined that pathogens are the top cause of stream impairments, affecting over 8,000 miles of streams. Polychlorinated biphenyl (PCB) found in fish tissue impacts over 3,000 miles while mercury impairments impact nearly 2,000 miles of streams. [5] Over 2,000 stream miles also have biological communities with measurable adverse response to pollutants. [6]

TABLE 2.43: Designated Beneficial Use of Water State of Indiana

Designated Beneficial Use	Total Miles Designated	Miles Assessed	Percent Assessed	Miles Fully Supporting	Miles Not Supporting
Aquatic Life Use	32,141	17,535	54.6	13,913	3,622
Fishable Uses	32,170	4,465	13.9	1,044	3,420
Drinking Water Supply	102	1	1.0	0	1
Rec / Human Health	32,173	12,073	37.5	3,700	8,374

SOURCE: Indiana Integrated Water Monitoring and Assessment Report

1 IC-14-25-7-2 2009
2 Indiana Integrated Water Monitoring and Assessment Report
3 Indiana Integrated Water Monitoring and Assessment Report
4 Indiana Integrated Water Monitoring and Assessment Report
5 Indiana Integrated Water Monitoring and Assessment Report
6 Indiana Integrated Water Monitoring and Assessment Report



IDEM SAMPLING SITES

Hamilton Ditch-Muncie Creek and Truitt Ditch - White River

MAP. 2.61 IDEM Sampling Sites Points

INVENTORY

Integrated Water Monitoring
WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 3

Two water bodies in the Truitt Ditch-White River watershed were examined during the 2008 305(b) monitoring: the main stem of Truitt Ditch, along with some tributaries, and the White River. For three categories; recreation use, fishing use, and aquatic life use, there was insufficient data available to make a use support determination (Category 3).

The main stem of the White River was impaired for recreation use by the presence of E. coli (Category 5A), and a Total Maximum Daily Load determination is needed. It was also impaired for fishable use by the presence of PCBs found in fish tissue (Category 5B) and a TMDL is needed. Aquatic life use was placed in Category 2, which means that there is insufficient data to determine if all the uses are being met and further data would be required.

Two waterbodies in the Hamilton Ditch-Muncie Creek watershed were examined during the 2008 305(b) monitoring: the main stem of Muncie Creek and some of its tributaries, as well as the White River. Muncie Creek is impaired for recreational use due to E. coli levels and a TMDL has been approved in 2004 (Category 5A).

There was insufficient data to determine whether Muncie Creek was impaired for fishing (Category 3), and the data indicates that some, but not all designated uses are supported for aquatic life (Category 2).

The main stem of the White River was impaired for all use categories. Recreation use was threatened, but it was determined that a TMDL is not needed (Category 4A). Additionally fishable use was threatened by the presence of PCBs in fish tissue and a TMDL is needed (Category 5B). Finally, aquatic life use is impaired in this stretch of the White River due to impaired biotic communities. It was determined that a TMDL is needed for this parameter (Category 5A).[1]

TABLE 2.44: Designated Use Categories

Category 1	Attaining the water quality standard and other applicable criteria for all designated uses and no use is threatened.
Category 2	Attaining some of the designated uses; no use is threatened; and insufficient data and information are available to determine if the remaining uses are attained or threatened.
Category 3	Insufficient data and information is available to determine if any designated use is attained.
Category 4	Impaired or threatened for one or more designated uses, but does not require the development of a total maximum daily load (TMDL).
Category 5	The water quality standards or other applicable criteria are not attained. The waters are impaired or threatened for one or more designated uses by a pollutant(s), and require a TMDL.

SOURCE: Indiana Integrated Water Monitoring and Assessment Report

1 Indiana Integrated Water Monitoring and Assessment Report

TABLE 2.45: Indiana Integrated Water Monitoring ASSESSMENT UNIT NAME	RECREATIONAL USE	FISHABLE USE	DRINKING WATER USE	AQUATIC LIFE USE	ECOLI	IBC	PCBs in FISH TISSUE	NUMBER OF IMPAIRMENTS
STONEY CREEK AND OTHER TRIBUTARYS	5A	3		3	X			1
WHITE RIVER	5A	5B		2	X		X	2
MUD CREEK AND OTHER TRIBUTARIES	5A	3		2	X			1
WHITE RIVER	5A	5B		2	X		X	2
ARBOGAST DITCH	3	3		5A				
PRAIRIE CREEK-CUNNINGHAM/CARMICHAEL DITCHES	2	3		2				
TRUITT DITCH AND OTHER TRIBUTARYS	3	3		3				
WHITE RIVER	5A	5B		2	X		X	2
MUNCIE CREEK - OTHER TRIBUTARIES	5A	3		2	X			1
WHITE RIVER	4A	5B		5A		X	X	2
Buck Creek	5A	3		5A	X	X		2
BELL CREEK-BETHEL BROOK	5A	3		2	X			1
BELL CREEK-WILLIAMS DITCH	5A	3		2	X			1
BELL CREEK-NO NAME CREEK	5A	3		2	X			1
WHITE RIVER	4A	5B		5A			X	1
BUCK CREEK	5A	5B		5A	X		X	2
YORK PRAIRIE CREEK AND OTHER TRIBUTARYS	5A	3		3	X			1
WHITE RIVER	4A	5B		5A			X	1
KILLBUCK CREEK	5A	3		2	X			1
MUD CREEK	2	3		3				
KILLBUCK CREEK-THRUSTON DITCH	5A	3		2	X			1
JAKES CREEK-EAGLE BRANCH	5A	2		2	X			1
KILLBUCK CREEK-PLEASANT RUN CREEK	5A	2		2	X			1
KILLBUCK CREEK	5A	5B		2	X		X	2
PIPE CREEK-YEAGER FINLEY MENARD DITCH	5A	3		2	X			1
BURLINGTON LAKE	3	3		3				
EMERALD LAKE	3	3		3				
JIM LAKE	3	3		3				
PHILLIPS QUARRY LAKE	3	3		3				
PRAIRIE CREEK RESERVOIR	3	3	3	3				

Impaired Waterbodies 303(d)

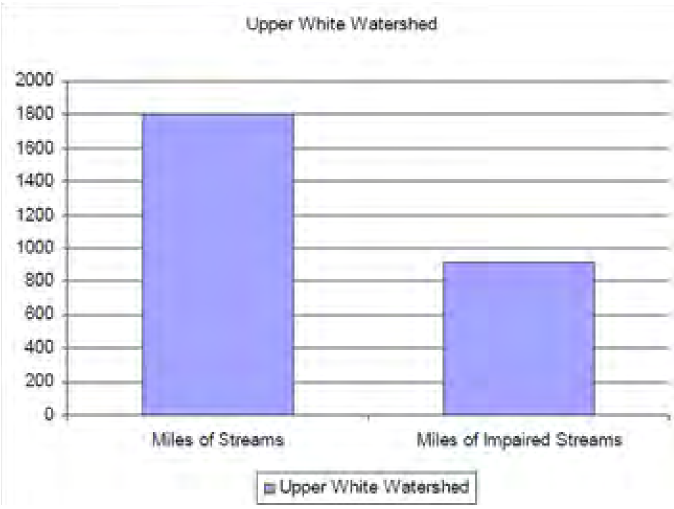
WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 4

A part of the 305(b) report is the 303(d) list. This list is used to identify impairments in waterbodies for which a total maximum daily load (TMDL) is needed.[1]

The impaired waterbodies list is prepared biannually (as a component of the IR) by the Indiana Department of Environmental Management. Waterbodies are included on the list if they do not meet the state's water quality standards. Waterbodies are relisted on the impaired waterbodies list once a Total Maximum Daily Load (TMDL) has been written or the waterbody or the waterbody again meets the state standards.[2]

There are currently 28 stream segments listed as not meeting the state water quality standards within the West Fork Drainage Basin Delaware County (Table 2.46). 10 of these listings are on streams present in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. These segments are part of the United State Environmental Protection Agency's approved list of water quality limited segments still requiring Total Maximum Daily Load calculations (Approved May 21, 2008). The segments that are a part of this management plan are listed in bold. In Delaware County, the waters are impaired due to the presence of mercury or PCBs, or both in the edible tissue of fish collected at levels exceeding Indiana's human health criteria for these contaminants." [3]

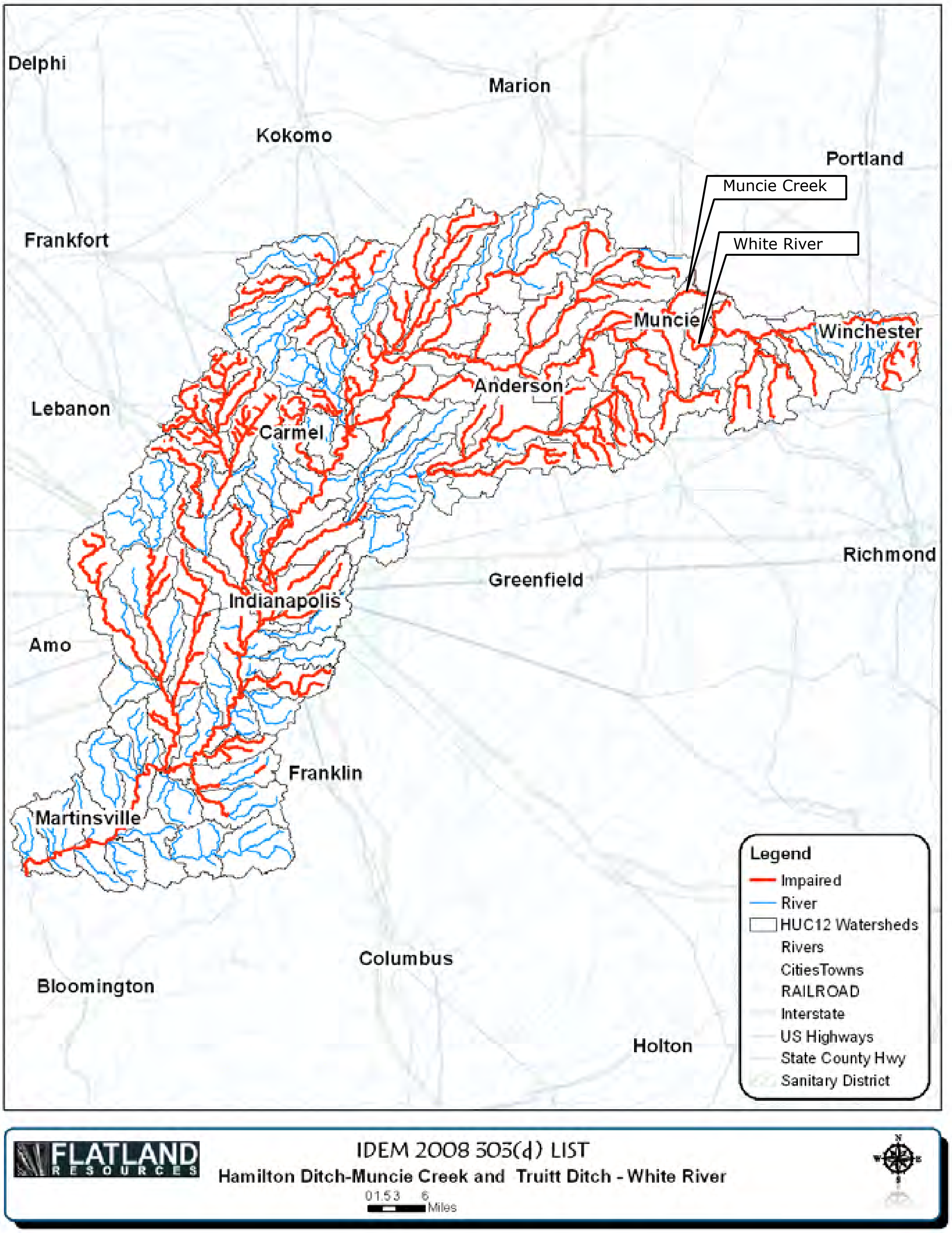
State wide, leading problems in Indiana's waters include E. coli impaired biotic communities, and fish consumption advisories.



CHA. 2.20 Miles of Impaired Stream in Upper White River Watershed

SOURCE: Rapid Watershed Assessment Upper White Watershed

1 Indiana Integrated Water Monitoring and Assessment Report
2 DNR Division of Forestry
3 IDEM, 2009



MAP. 2.62 2008 IDEM Impaired Streams in Upper White River Watershed

INVENTORY

Impaired Waterbodies 303(d) List For W

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 5

TABLE 2.46: 303 (d) List for West Form White River				
MAJOR BASIN	14-DIGIT HUC	COUNTY	ASSESSMENT UNIT ID	
WEST FORK WHITE	512020102003 0	DELAWARE CO	INW0123_00	
WEST FORK WHITE	5120201020050	DELAWARE CO	INW0125_00	
WEST FORK WHITE	5120201020040	DELAWARE CO	INW0124_00	
WEST FORK WHITE	5120201020020	DELAWARE CO	INW0122_T1011	
WEST FORK WHITE	5120201020020	DELAWARE CO	INW0122_T1011	
WEST FORK WHITE	5120201020060	DELAWARE CO	INW0126_T1012	
WEST FORK WHITE	5120201020060	DELAWARE CO	INW0126_T1012	
WEST FORK WHITE	5120201040030	DELAWARE CO	INW0143_00	
WEST FORK WHITE	5120201040010	DELAWARE CO	INW0141_00	
WEST FORK WHITE	5120201040050	DELAWARE CO	INW0145_00	
WEST FORK WHITE	5120201040050	DELAWARE CO	INW0145_00	
WEST FORK WHITE	5120201040040	DELAWARE CO	INW0144_00	
WEST FORK WHITE	5120201040020	DELAWARE CO	INW0142_00	
WEST FORK WHITE	5120201010100	DELAWARE CO	INW011A_00	
WEST FORK WHITE	5120201010130	DELAWARE CO	INW011D_00	
WEST FORK WHITE	5120201050010	DELAWARE CO	INW0151_00	
WEST FORK WHITE	5120201010090	DELAWARE CO	INW0119_00	
WEST FORK WHITE	5120201010090	DELAWARE CO	INW0119_T1006	
WEST FORK WHITE	5120201010090	DELAWARE CO	INW0119_T1006	
WEST FORK WHITE	5120201010100	DELAWARE CO	INW011A_T1007	
WEST FORK WHITE	5120201010100	DELAWARE CO	INW011A_T1007	
WEST FORK WHITE	5120201010120	DELAWARE CO	INW011C_T1008	
WEST FORK WHITE	5120201010120	DELAWARE CO	INW011C_T1008	
WEST FORK WHITE	5120201010130	DELAWARE CO	INW011D_T1009	
WEST FORK WHITE	5120201010130	DELAWARE CO	INW011D_T1009	
WEST FORK WHITE	5120201020060	DELAWARE CO	INW0126_T1010	
WEST FORK WHITE	5120201030010	DELAWARE CO	INW0131_T1013	
WEST FORK WHITE	5120201030010	DELAWARE CO	INW0131_00	
SOURCE: Indiana Integrated Water Monitoring and Assessment Report				

/est Fork White River

	ASSESSMENT UNIT NAME	CAUSE OF IMPAIRMENT	IRCAT
	BELL CREEK-BETHEL BROOK	E. COLI	5A
	BELL CREEK-NO NAME CREEK	E. COLI	5A
	BELL CREEK-WILLIAMS DITCH	E. COLI	5A
	BUCK CREEK	E. COLI	5A
	BUCK CREEK	Impaired Biotic Communities	5A
	BUCK CREEK	E. COLI	5A
	BUCK CREEK	PCBs in Fish Tissue	5B
	JAKES CREEK-EAGLE BRANCH	E. COLI	5A
	KILLBUCK CREEK	E. COLI	5A
	KILLBUCK CREEK	E. COLI	5A
	KILLBUCK CREEK	PCBs in Fish Tissue	5B
	KILLBUCK CREEK-PLEASANT RUN CREEK	E. COLI	5A
	KILLBUCK CREEK-THRUSTON DITCH	E. COLI	5A
	MUD CREEK AND OTHER TRIBUTARIES	E. COLI	5A
	MUNCIE CREEK - OTHER TRIBUTARIES	E. COLI	5A
	PIPE CREEK-YEAGER FINLEY MENARD DITCH	E. COLI	5A
	STONEY CREEK AND OTHER TRIBUTARIES	E. COLI	5A
	WHITE RIVER	E. COLI	5A
	WHITE RIVER	PCBs in Fish Tissue	5B
	WHITE RIVER	E. COLI	5A
	WHITE RIVER	PCBs in Fish Tissue	5B
	WHITE RIVER	E. COLI	5A
	WHITE RIVER	PCBs in Fish Tissue	5B
	WHITE RIVER	Impaired Biotic Communities	5A
	WHITE RIVER	PCBs in Fish Tissue	5B
	WHITE RIVER	PCBs in Fish Tissue	5B
	WHITE RIVER	PCBs in Fish Tissue	5B
	YORK PRAIRIE CREEK AND OTHER TRIBUTARIES	E. COLI	5A

INVENTORY

TMDL Studies

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 6

Total Maximum Daily Load is the amount of a pollutant that a water body can receive and still meet water quality standards. It is calculated by combining a sum of allowable loads from point sources and nonpoint sources plus a margin of safety. The TMDL study seeks to identify sources of water quality impairments and estimate needed reductions.

TMDLs aid watershed groups in the determination of sources for the purposes of effective watershed planning. TMDLs provide an overview of the watershed condition and provide guidance on how to correct problems. TMDLs are also required by the Clean Water Act.

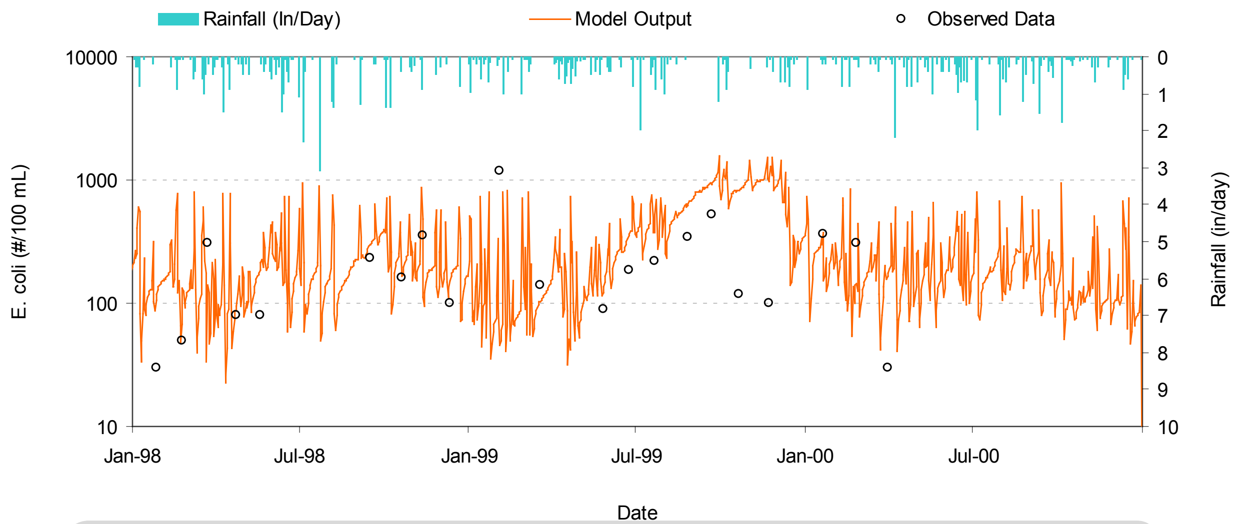
IDEM's TMDL program focuses almost exclusively on nonpoint source related impairments and has developed 559 TMDLs to date. There are another 548 TMDLs either in progress or planned for 2008. Indiana's early TMDLs were developed primarily through the use of third party contractors. IDEM's TMDL program now develops most of its TMDLs in-house. In addition to being more cost-effective, agency development of TMDLs provides the opportunity for more effective coordination with IDEM's NPS program and other relevant water quality programs. IDEM is continuing to develop TMDLs focused on E. coli impairments as well as TMDLs for other NPS related issues such as impaired biotic communities and nutrient impairments. [1]

IDEM's TMDL program has been awarded considerable funding from USEPA through contractor support grants to develop additional TMDLs. IDEM's TMDL program has collaborated with both Illinois and Michigan on TMDL development for interstate waters and leads the nation in the development of TMDLs for impairments in waters that cross state lines.[2]

IDEM's TMDL Program works closely with the NPS program and IDEM's Watershed Specialists to develop TMDL reports that can be effectively used by local watershed groups and stakeholders to facilitate the restoration of impaired waters. The TMDL program also coordinates with local governmental agencies and stakeholders within the TMDL area. This coordination provides numerous opportunities for local participation in the TMDL process, which leads to positive changes in the watershed. Since 2004, the coordinated efforts of the NPS/TMDL Section and IDEM's WSS have resulted in the formation of ten new watershed groups and new grant -funded projects for planning and restoration activities in impaired watersheds. [3]

There have been no TMDL studies completed in the Hamilton Ditch-Muncie Creek or Truitt Ditch-White River Subwatersheds at the time of this plan development, although there is currently being one developed by IDEM.

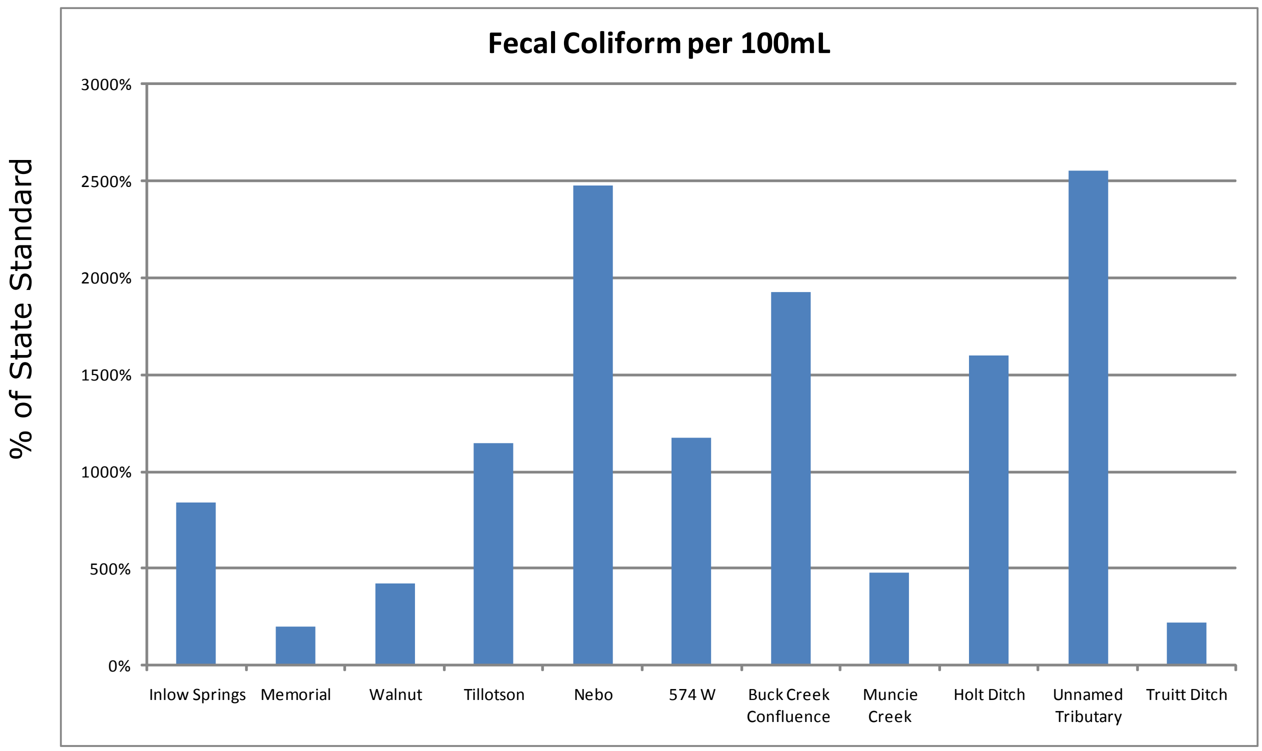
1 Indiana Integrated Water Monitoring and Assessment Report
2 Indiana Integrated Water Monitoring and Assessment Report
3 Indiana Integrated Water Monitoring and Assessment Report



CHA. 2.21 TMDL E. coli East Edge of Muncie

SOURCE: IDEM TMDL West Fork White River

Comparison of modeled to observed predicted E. coli at station WWU010-0001 (east edge of Muncie) for the period January 1, 1998, to December 31, 2000.



CHA. 2.22 Comparison of E. coli readings at 319 Water sampling Points

INVENTORY

Chemistry | IDEM Data

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 7

Although the leading metric for the 303(D) and subsequent TMDL listing (in the West Fork White River) is limited to Mercury, E. coli., Impaired Biotic Communities, PCBs found in fish Tissue, Cyanide, Algae, Dissolved Oxygen, and Taste and Odor, IDEM collects data on over 50 other contaminates. This data, despite the inherent limits of probabilistic monitoring, is available for analysis through IDEM data resources website.

In 2010, GRW Engineers did an analysis of IDEM water quality sampling on behalf of the Muncie Storm Water Utility (MS4) as part of the submission requirements for the NPDES (National Pollutant Discharge Elimination System) Phase II. This research included data for six HUC 12 Subwatersheds located in Muncie MS4 jurisdiction: Buck Creek-Macedonia Creek watershed, the Jakes Creek-Eagle Branch watershed, the White River-Truitt Ditch watershed, the White River-Buck Creek (lower) watershed, the White River-Muncie Creek watershed and the White River-York Prairie Creek watershed in the Muncie area. (MAP 2.63)

Because the data analysis included the Truitt Ditch-White River watershed and the Hamilton Ditch - Muncie Creek watershed, it is included in this WMP. The complete report can be found on the Muncie Sanitary District Website. Raw data for the studied Subwatersheds is available from the Indiana Department of Environmental Management upon request.

GRW looked at close to 40 water quality metrics in the broader Muncie area and provided an overview of what their inherent risks are, rated/analyzed them based on how much they exceeded their state limits, indicated how consistently they were above the state standards (per sample), and indicated whether they are issues to be concerned about (i.e. require mitigation). GRW's analysis of water quality parameters is included in the following pages. Table 2.48 provides a summary and indicates where data suggested issues of concern for the Truitt Ditch-White River watershed and the Hamilton Ditch - Muncie Creek watersheds.

Description of IDEM Water Quality Data Sets (GRW)
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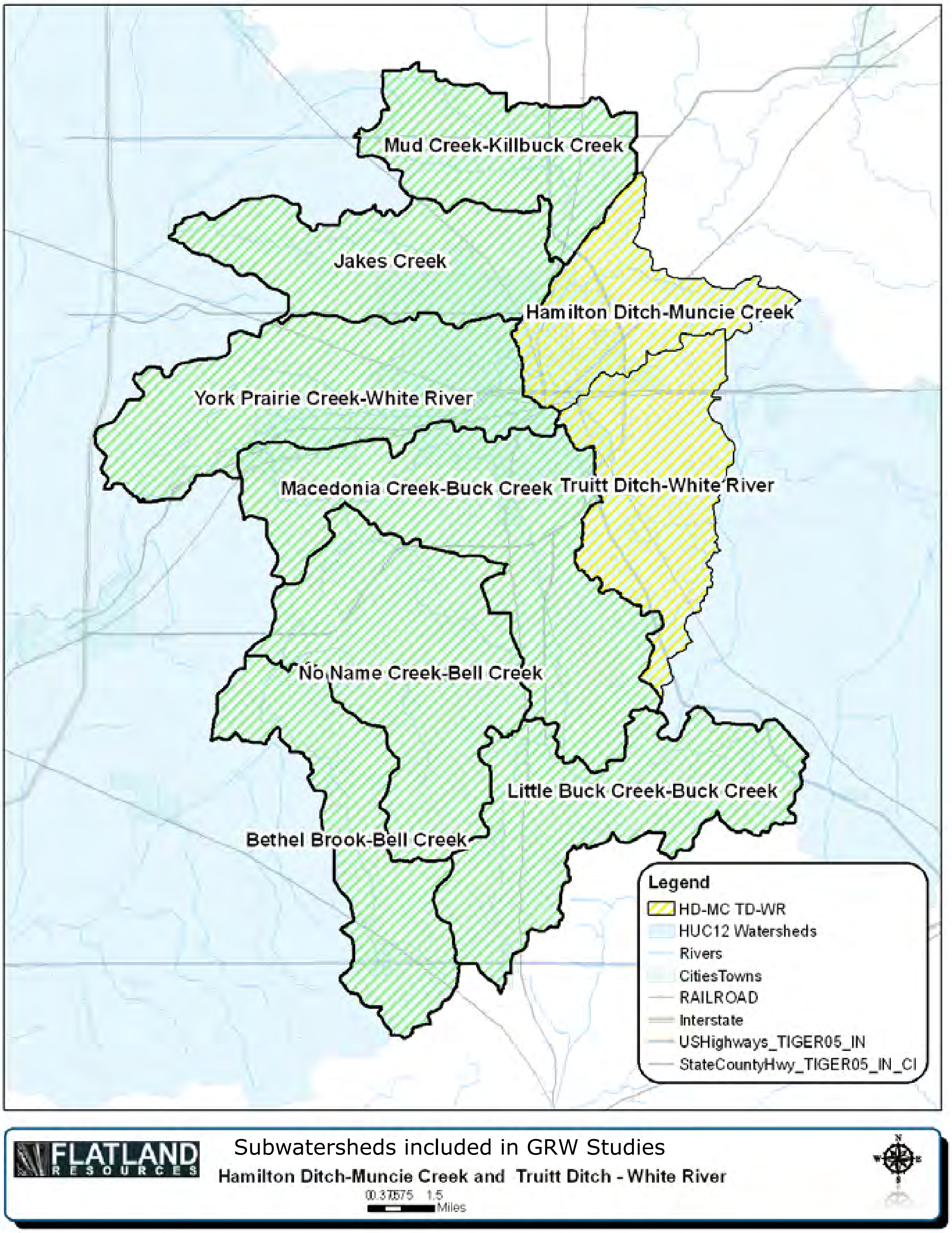

MAP. 2.63 Location of GRW Subwatershed Studies

Dissolved Oxygen (DO)
"This is one of the most important measures of water quality. For recreational purposes, it has significant effects on odor and color of the body of water. DO helps to reduce certain contaminants in the water. Bacteria uses oxygen to decompose organic material in addition to converting some more toxic chemicals to more stable less toxic forms. IDEM has set a minimum five-day level of 5 mg/L and no less than 4 mg/L at any one time in a freshwater stream for healthy organism life.
The data displayed acceptable values for DO over the 11-year period. However, three sampling points were below the minimum acceptable limit in that period. In the White River-Truitt Ditch watershed the level declined to 2.0 mg/L. The level also declined twice in the White River-Buck Creek (lower) watershed. These levels were 0.7 and 3.8 mg/L. While all three points are significantly low levels of DO, they did not remain low. The reading of 0.7 mg/L may be a monitor malfunction. There is no reason to be concerned with these results."

pH
"The pH is a measure on a logarithmic scale ranging from 0 to 14 where the lower range numbers are associated with acidic solutions and the higher range numbers with basic solutions. Consequently the closer to the number 7 the results are, the more neutral the solution. For natural waters the pH value should be between 6 and 9, according to IDEM, however, daily fluctuations can occur. Daily fluctuations in pH are acceptable and can result in a daily reading exceeding 9.
These increases in pH readings rarely remain high and are likely to be associated with photosynthetic activity. The values for the watersheds were well within the acceptable range."

Saturation Percent
"The saturation percent is the calculation of the DO concentration relative to the capacity in a body of water. The main factors affecting it are the water temperature, salinity, and partial pressure. There are no set standards for this parameter, but it should stay as close to 100% as possible. If the percent saturation falls to a detrimental level, the result would show up in the DO available.
Muncie's data showed reasonable values for this parameter. The saturation percent ranged from 57 % to 117 % with the majority of the data points falling in the 90th percentile."

Specific Conductance
"Specific conductance is the ability of water to conduct electricity. The IDEM standard for specific conductance for water to be used for agricultural, domestic and industrial uses is 1200 micromhos per centimeter. However, when used as a water quality parameter for surface water for recreational purposes, it is most often used in estimating total dissolved solids. The majority of the watersheds were within the threshold for this parameter. However, both the White River-Buck Creek (lower) watershed and the White River-York Prairie Creek watershed had some falling values. 13% of the data retrieved from the Buck Creek (lower) watershed was higher than the standard. This is a relatively small percentage and is not large enough to cause concern. The York Prairie Creek watershed however, was significantly failing. 42% of the data was above the standard. The value for total dissolved solids is within range for this watershed, so wheather or not this parameter needs further attention depends on whether or not there is an intake near the failing area."

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Turbidity

"Turbidity is the measure of the clarity of water. An increase in turbidity is due to suspended impurities such as clay, silts, and soil particles. An increase can hinder the microorganisms from acting as disinfectants in surface waters. The acceptable range for turbidity varies between a "clear" lake at 25 units to a muddy unaesthetic body of water at 100 units. The Muncie watersheds only had 5% of its data point in the 100 units or above range. All the fixed monitoring stations reported relatively low numbers throughout the data with a few spikes. If these spikes were associated with a large rain event, then the waterways in the Muncie watershed would be considered "flashing water" (the data was not compared to major rain events during this study). "Flashing water" is a waterway that, due to a rain event and the terrain, has more soil particles released from the streambed. There are no significant problems with this situation. It should be noted that one of Muncie's meters in each watershed had significant malfunctions throughout the data retrieval period."

Temperature

"An increase in temperature of a body of water can increase the oxygen required for life while at the same time decrease the DO available. If changed at a rapid rate this could have detrimental effects on the aquatic life, however, since the levels of DO are within the required limits it is safe to extrapolate that the temperature is within a safe zone. The main factor related to temperature is the rate of change. For every 10 degrees Celsius increase the metabolic rate increases by a factor of two. The IDEM standard states that the water temperature should not exceed 32.2 degrees Celsius at any given time, and that the maximum rate of temperature increase should be no more rapid than 2.8 degrees Celsius at any given time. This statement is from the IDEM standards and is incomplete. There is not a reference as to the unit of time. This parameter should not be a concern."

Alkalinity

"Alkalinity is the ability of water to absorb hydrogen ions without having a change in pH. It is what helps to keep the pH stable when water conditions change. In surface water, the alkalinity is mainly affected by the presence of bicarbonates. There is not a standard alkalinity value. The value is a result of the geological formations of the area. This value can vary drastically from city to city. Areas of Indiana and Kentucky are prone to having high values of alkalinity; this is due to the large quantity of limestone in the area. Even taking this into consideration, the average values for the area studied are relatively average for the nation. The data for this parameter revealed relatively low levels of alkalinity.
This parameter should not be a concern."

Chlorides

"Chlorides in large quantities contribute highly to the hardness of water. They also reduce the quality of taste in the drinking water supply. The IDEM standard for chlorides is less than 250 mg/L. Muncie's watershed data for this parameter was significantly under the standard. The highest reading was 134 mg/L in the White River-Buck-Creek (lower) watershed.
This parameter should not be a concern."

Biochemical Oxygen Demand (BOD5)
"The BOD5 is the measure of the amount of oxygen consumed in five days by microorganisms during biodegradation. According to NPDES, the standard for effluent from a sanitary sewer treatment facility is 20-50 mg/L with the average below 30 mg/L. The data from Muncie's water quality study is not at an effluent point, but instead at some point downstream of the mixing station. Therefore, the measured values should be considerably lower than expected values near the effluent. For the two watersheds monitored, White River-Truitt Ditch and White River-Buck Creek (lower), values were between 1.0-6.7 mg/L. The measured values were below the effluent standard, however, there is no standard for the values downstream of the mixing zone. Therefore, the results are inconclusive."

Chemical Oxygen Demand (COD)
"COD is the measure of the oxygen needed to oxidize chemical waste. There is not a standard set for this parameter; however, the values should be higher than the biochemical oxygen demand (BOD5). The measured values for COD are higher than those identified for BOD5, and they are also in a reasonable range. This parameter should not be a concern."

Fluoride
"Fluoride is not to exceed 2.0 mg/L according to IDEM in any waterway in Indiana. Fluoride is added to many cities water supply for the benefit of protecting the consumer's teeth. This is only being done to an amount of 1.0 mg/L. In large quantities if ingested fluoride can cause brittleness of bones. The measured values in the watersheds in Muncie stayed within the standard. This parameter should not be a concern."

Coliforms
"The number of coliform bacteria found in a sample of water can be significant. This number indicates the potential for disease causing species being in the sample. The lower the number of coliform bacteria, the lower the potential for pathogenic organisms. The IDEM standard limit for the coliform bacteria group is 5,000 MPN or MF per 100 mL on a monthly average and no more than 20% of the data samples can be above 5,000, and there has to be less than 20,000 MPN or MF per 100mL in 5% of the data collected. The data reading for the Muncie watershed read greater than 2,419 per 100 mL. This data are inconclusive."

Hardness
"Hardness is a measure of the concentration of ions of calcium and magnesium, and is a major cause of staining plumbing fixtures. These properties should not be present in significant quantities in natural waters. Four additional elements contribute to the hardness of water. They are iron, manganese, strontium, and aluminum. It is considered to be excessive if the value is greater than 500 mg/L as Calcium carbonate ($CaCO_3$) and is preferred to be around 150 mg/L as $CaCO_3$. In excessive amounts, hardness can cause skin irritation. These can vary and depend highly on the type of soil that is in the area. The highest measured value for $CaCO_3$ in Muncie's watersheds was 470 mg/L as $CaCO_3$ in the White River-Buck Creek (lower). This is not an issue for storm water discharge."

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Nitrogen
"Nitrate-N + Nitrite-N has an IDEM standard of 10 mg/L. Nitrate and nitrite are harmful if consumed in large quantities. They can function as a hemoglobin inhibitor. The measured values for the watershed do stay significantly low for all data points. In fact, there was not a single data point that crossed the maximum acceptable level. Ammonia nitrogen has been known to have adverse affects on aquatic life at chronic levels as low as 0.1 mg/L, however the EPA standard is 3.5 mg/L. Again, all the data points were significantly lower than the standard. This parameter should not be a concern."

Sulfates
"Sulfates in large quantities contribute highly to the hardness of water. They may have a laxative effect if found in high concentrations in a drinking water supply. The IDEM standard is 250 mg/L. Muncie's sulfate reading displayed several incidences where sulfates were considerably above the standard. 11% of the readings were above the threshold, and the highest reading was 723 mg/L. All of the points that were outside of the standard were in the White River-Buck Creek (lower) watershed. Some of the readings were significantly elevated. The reason for this could need to be investigated."

Phosphorus
"Nutrients are considered pollutants when the concentrations reach a level that is conducive for excessive algal growth. Excessive algae are undesirable for surface water for three main reasons. It adds to the turbidity of water, causes a foul smell, and reduces the DO levels in water. Nitrogen, carbon, and phosphorus are the three most contributing nutrients for algae growth. In the Muncie watersheds, phosphorus is the limiting nutrient. Most state regulations require phosphorus-limiting streams to have a maximum of 1.0 mg/L of phosphorus. Common contributors of phosphorus are detergents, clay type soils, human waste and agricultural runoff. 8% of the data points from the White River-Buck Creek (lower) measured outside of the threshold and the highest value was 2.0 mg/L. Such as small percentage is insignificant, and the rest of the watershed in this area are within the threshold."

Surfactants
"Surfactants are man made synthetic organic chemicals often used in large quantities in detergents or result from the natural decay of organic substances found in a stream. These substances can cause a foamy layer on the surface of water. For the most part, this foam layer is not hazardous, but rather unattractive for recreational uses. There is no set standard for the concentration of surfactants for surface water."

Total Organic Carbon (TOC)
"TOC is the measure of the total organic material in a water supply source from natural and human activities. According to the EPA, in surface water the number should be no higher than 5 mg/L. All of the watersheds in this area had a few points that were slightly high, however, no one watershed had a significant amount of points above the threshold. This parameter should not be a concern."

Total Dissolved Solids and Suspended Solids

"Total dissolved solids (TDS) are the amount of solids that pass through a 1.2-micrometer filter, while the term suspended solids refers to the amount of substance retained on said filter. In high concentrations, dissolved solids can reduce the serviceable water for agriculture, domestic, and industrial uses. The TDS threshold for drinking water is 500 mg/L and the majority of data points fell around this range. However, the IDEM requirement for fresh water streams is 750 mg/L assuming that the water will be used for more than just recreation. For water used solely for recreational purposes, there is no existing standard. 11% of the TDS measured values were above the standard of 750 mg/L, with the highest value being 1450 mg/L. All of the failing data points were retrieved from the White River-Buck Creek (lower) watershed. Some of the suspended solids data were rather high as well, and there appeared to be a correlation between suspended solids and the TDS level. . 21% of the tests for suspended solids were above the allowable 30 mg/L as stated in the NPDES for effluents. These points were taken from the White River-Buck Creek watershed and the White River-Truitt Ditch watershed. The samples were taken from a location downstream from the mixing point. Therefore, they should have significantly lower values than the NPDES requirements for effluent discharge."

Total Kjeldahl Nitrogen (TKN)

"TKN consists of ammonia plus organic nitrogen. According to NPDES, the standard for effluent from a sanitary sewer treatment facility is 20-50 mg/L with the average less than 30 mg/L. The data that is contained in Muncie's water quality study is not at an effluent point, but instead at some point downstream from the mixing station. Therefore, the measured values should be considerably lower than the actual values at the effluent. The measured values for the Muncie watersheds' were between 0.2-5.4 mg/L. Yorktown's watersheds measured between 0.3-5.4 mg/L. The values were below the effluent standard, however, there is no standard for the values downstream of the mixing zone. Therefore, the results are inconclusive."

Phenolics

"Phenol is an aromatic organic compound commonly used in disinfectants. The EPA standard limit for this material is 5 micrograms per liter. The majority of the results resulted in less than 5 micrograms per liter detected, however, three measurments were slightly above that. They ranged from 6-8 micrograms per liter. These points were located in the White River-Truitt Ditch and the White River-Buck Creek (lower) watersheds. If this chemical is found in excessive quantities, it can cause fish flesh tainting in the streams. There is no reason to be concerned with the concentration of this chemical."

Pyrene

"Pyrene and its derivatives are used commercially to make dyes and dye precursors. The EPA standard limit for this material is 0.21 mg/L. The majority of the results resulted in less than 0.00001 mg/L detected, however, one reading was above that. That result read 0.0002 mg/L in the White River-Buck Creek (lower) watershed. This is still significantly below the standard. There is no reason to be concerned with the concentration of this chemical."

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Cyanide
"The IDEM standard for cyanide is 0.0052 mg/L for human health and 0.022 mg/L for aquatic life. Muncie's fixed monitoring stations reported more than 90% to be below the detectable value of 0.005 mg/L. And Yorktown reported more than 85% of their fixed monitoring stations to be below this value also. The White River-Truitt Ditch watershed had 4% of its measured values above the human health standard, but no points above the aquatic life standard. The only other watershed that had a significant data was the White River-Buck Creek (lower) watershed. This watershed had 12% of the measured values above the IDEM standard for human health and one value above the standard for aquatic life. However, none of the failing values were significantly above the standard and they did not remain elevated either. This parameter should not be a concern."

E. Coli
"E. coli is used as an indicator organism that suggests the presence of sewage and other pathogenic organisms. Most strains of E. coli are harmless, only one in hundred strains is harmful to humans. E. coli will not survive as long as coliforms will; therefore, if the coliform bacteria level is low it is probably not necessary to test for E. coli. The IDEM standard for full body contact with E. coli is no more than 235 MF per 100 mL in any one sample over a 30-day sampling period. Muncie's watersheds had consistent reading of E. coli that are significantly higher than the standard. The Buck Creek-Macedonia Creek watershed and the Jakes Creek-Eagle Branch watershed had 100% of their data points above the threshold. The White River-Muncie Creek watershed and the White River-Buck Creek (lower) watershed were both in the range of 65% failing readings. The remaining two watersheds, White River-Truitt Ditch and White River-York Prairie Creek had approximately 35% of the values above the threshold. The E. coli reading in this area should be considered as a significant sign of contamination."

Organics
"In the data tables for the types of organic material tested, very few had measured values above the detectable limits. The only chemicals addressed are those that had results above the detectable value."

Metals | IDEM Data

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Antimony
"The IDEM standard is 0.146 mg/L for surface waters. 50% of the measured values were below the detectable value. The highest reading from the fixed monitoring station was 0.011 mg/L in the White River-Buck Creek (lower) watershed. The highest measured value is still below the standard. There is no reason to be concerned with the concentration of this metal."

Arsenic
"Arsenic can cause a variety of problems for human health. It is a known carcinogen and a mutagen. In milder forms it can cause fatigue and dermatitis. The EPA standard is 0.05 mg/L for surface waters. The measured values for Muncie's watersheds are very low for this parameter. The highest value was 0.014 mg/L in Jakes Creek-Eagle Branch watershed. There is no reason to be concerned with the concentration of this metal."

Beryllium
"The EPA standard for domestic water supply is 0.004 mg/L. 93% of the measured values for Muncie's watersheds were less than the detectable value of 0.002mg/L. Therefore, this parameter is insignificant. There is no reason to be concerned with the concentration of this metal."

Cadmium
"Cadmium will concentrate long-term in the liver, kidneys, pancreas, and thyroid. It has also been suspected of causing hypertension. The IDEM standard is 0.01 mg/L for surface waters. 93% of the measured values for Muncie's watersheds were less than the detectable value. There is no reason to be concerned with the concentration of this metal."

Calcium
"Calcium can contribute to blue-green algae growth. There are currently no standards fro calcium from the EPA or IDEM."

Chromium
"Long-term excessive exposure to chromium can cause skin irritation and kidney damage. The IDEM standard is 0.47 mg/L for surface waters. More than 93% of the measured values were below detectable values. There is no reason to be concerned with the concentration of this metal."

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Copper
"Copper in surface water will act as a corrosive agent. The EPA standard is 0.028 mg/L for surface waters. In the Muncie area, 63% of the data points were below the detectable value, yet there were 3 out of the 296 results that were above the threshold. Two points were in the White River-Truitt Ditch watershed and one was in the White River-Buck Creek (lower) watershed. A few points above the threshold over an eleven-year period are not detrimental. For Yorktown, 30% of the data points were below the detectable value, yet there was 1 out of the 144 results that was above the threshold. That point was in the White River-Buck Creek (lower) watershed. One point above the threshold over an eleven-year period is not detrimental. There is no reason to be concerned with the concentration of this metal."

Iron
"Iron in large quantities can cause staining of clothes, boats, etc. It may also contribute to the growth of Crenothrix, autotrophic bacteria. The EPA standard is 0.3 mg/L for surface waters. The data in this watershed were significantly higher than the threshold for the material. Only two watersheds had significant data on this parameter and some of the points were extremely high. The White River-Truitt Ditch watershed had 48% of the data above the threshold and the White River-Buck Creek (lower) watershed had 36% of the data above the threshold value. This metal is found in too high of concentrations and should be investigated. The extreme levels found in this area could be due to a high clay or inorganic content in the soil."

Lead
"Lead can cause long-term brain and kidney damage as well as birth defects if consumed in large quantities. The EPA standard is 0.011 mg/L for surface waters. 83% of Muncie's data was below a detectable value of 0.006 mg/L. However, there were still seven points above the threshold. Five of the points were in the White River-Buck Creek (lower) watershed and the remaining points were in the White River-Truitt Ditch watershed. Over an eleven-year period, seven measured values above the threshold is not detrimental, but should be watched. The concentration of this material is not a major concern, however, it should be closely monitored."

Magnesium
"There are currently no standards fro Magnesium from the EPA or IDEM."

Thallium
"The IDEM standard is 0.048 mg/L for surface waters. Muncie's watershed data was under detectable values. There is no reason to be concerned with the concentration of this metal."

Pesticides | IDEM Data

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The following has been compiled by GRW Engineers as an explanation of the water quality report assembled for the NPDES (National Pollutant Discharge Elimination System) Phase II as it pertains to storm water quality for the Buck Creek-Macedonia Creek watershed, the Jakes Creek-Eagle Branch watershed, the White River-Truitt Ditch watershed, the White River-Buck Creek (lower) watershed, the White River-Muncie Creek watershed and the White River-York Prairie Creek watershed in the Muncie area. The following will describe characteristic of the sampling data as it related to pesticides. It will also provide a comparison of the data versus the standard limits.

Pesticides
The only chemicals addressed are those that had results above the detectable value:

Acetochlor
"Acetochlor has been classified as a probable human carcinogen. It is a herbicide developed by Monsanto Company and Zeneca. There is not a standard for this material. The majority of the data were below the detectable value. Only 19% were above the detectable value, and those values ranged from 0.1-0.8 micrograms per liter. There is no reason to be concerned with the concentration of this chemical."

Alachlor
"The United States Environmental Protection Agency classifies the herbicide as toxicity class III - slightly toxic. It is commonly used for annual grasses and broadleaf weeds in corn and soybean fields. The EPA standard limit for this material is 2 micrograms per liter. The majority of the results stated less than the detectable value, and all the reading were below the standard. If this chemical is found in excessive quantities, it can cause skin and eye irritation and some long-term kidney problems. There is no reason to be concerned with the concentration of this chemical."

Atrazine
"Its use is controversial due to widespread contamination in drinking water and its associations with birth defects and menstrual problems when consumed by humans at concentrations below government standards. Atrazine is used to stop pre- and post-emergence broadleaf and grassy weeds in major crops. The EPA standard for this material is 3.0 micrograms per liter. The majority of the data were below the detectable value. Only 8% of the test results were above the standard, and those values ranged from 3.1-10.0 micrograms per liter. These points were taken from the data in the Buck Creek-Macedonia Creek watershed and the White River Buck Creek (lower) watershed. There is no reason to be concerned with the concentration of this chemical."

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Bromacil
"Bromacil is a commercially available herbicide that is also used as rat poison. The EPA standard limit for this material is 5 mg/L. The majority of the results were less than the detectable value, and all the readings were below the standard. If this chemical is found in excessive quantities, it can cause skin and eye irritation. There is no reason to be concerned with the concentration of this chemical."

Metolachlor
"Evidence of the bioaccumulation of metolachlor in edible species of fish as well as its adverse effect on the growth and development raise concerns on its effects on human health. It is an herbicide commonly used for broadleaf weed control in corn. There is not a standard for this material. The majority of the data were below the detectable value. Only a few were above that, and those values ranged from 0.1-2.7 micrograms per liter. This data is inconclusive."

Metribuzin
"Metribuzin is slightly to moderately toxic to humans by oral, skin or inhalation routes of exposure. It is an herbicide which inhibits photosynthesis. There is not a standard for this material. The majority of the data were below the detectable value. Only a few were above that, and those values ranged from 0.1-0.5 micrograms per liter. This data is inconclusive."

Simazine
"If simazine is found in excessive quantities, it can harmful to the livestock that use the stream for nourishment. The EPA standard limit for this material is 4 micrograms per liter. The majority of the results were less than the detectable value, and all the readings were below the standard. There is no reason to be concerned with the concentration of this chemical."

TABLE 2.47: Chemical Applications for Corn and Soybeans in Delaware County

Corn: Agricultural Chemical Applications *	
	lbs/acre/application
Acetochlor	1.823
Atrazine	1.094
S-Metolachlor	1.234
Simazine	1.236
Soybean: Agricultural Chemical Applications,	
Metribuzin	0.253

SOURCE: USDA 2004

INVENTORY

GRW Engineers Study | IDEM Data

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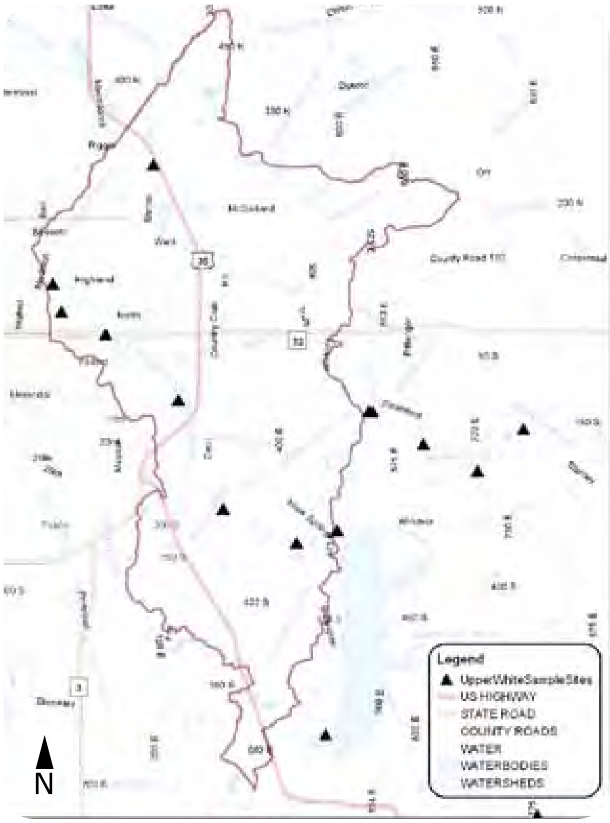

MAP. 2.64 IDEM Sampling Sites

The GRW Study was consistent with IDEM conclusions that E. Coli is the leading cause of water quality impairment in the Truitt Ditch-White River watershed and the Hamilton Ditch - Muncie Creek watershed.

The report also determined that Dissolved Oxygen, BODs, Cyanide, TSS, Pheonilics, Copper, Lead, and Iron were contaminates that exceeded water quality standards at various sampling times but did not indicate that they were issues of concern when averaged.

	Dissolved Oxygen	pH	Saturation Percent	Specific Conductance	Turbidity	Temperature	Alkalinity	Chlorides	Biochemical Oxygen Demand	Fluoride	Coliforms	Cyanide	E. Coli	Hardness	Nitrogen	Sufates	
TABLE 2.48: Summary of GRW Study																	
Hamilton Ditch - Muncie Creek													X				
Truitt Ditch - White River	X								X			X	X				

MAP 2.64 designates the locations of IDEM sampling sites in Truitt Ditch-White River watershed and the Hamilton Ditch - Muncie Creek watershed. Table 2.48 Notes impairments exceeding state Water Quality Standards.

	Phosphorus	Surfactants	Total Organic Carbon	Total Suspended Solids	Total Organic Carbon	Organics	Phenolics	Pyrene	Antimony	Arsenic	Beryllium	Cadmium	Calcium	Chromium	Copper	Iron	Lead	Magnesum	Thallium	Acetochlor	Alachlor	Atrazine	Bromacil	Metolachlor	Metribuzin	Simazine
				X			X								X	X	X									

INVENTORY

Point Sources Overview

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Point source pollution is contamination that enters the environment through any discernible, confined, and discrete conveyance, such as a smokestack, pipe, ditch, tunnel, or conduit. Point source pollution remains a major cause of pollution to both air and water. Point sources are differentiated from non-point sources, which are those that spread out over a large area and have no specific outlet or discharge point. Point source pollution in the United States is regulated by the Environmental Protection Agency (EPA).[1]

"Point source pollution in Indiana is controlled primarily through permits issued by IDEM for discharges to surface water under the NPDES program. Locally, the Muncie Sanitary and Bureau of Water Quality enforces discharge permits as well as additional regulations such as storm water permits and pre-treatment permits. Additional sources of reports/information used to determine our water quality program/ overview include Muncie's Long Term Control Plan for separation of storm water and sewage systems, and contaminants of emerging concern report.

Discharge Permits

The NPDES is a state program issuing permits to regulate industrial waste and discharge into our water bodies. Certain scales of industry are given permits to discharge, but have to conform to state standards and often times have to pretreated the discharge before it enters into our water bodies. All facilities which discharge to waters of the State must apply for and receive a NPDES permit. Unpermitted dischargers and permittees out of compliance with their permit conditions are referred to IDEM's Office of Enforcement for corrective actions, which can include fines." [2] One industrial permit was issued in the studied Subwatersheds and it is located in Hamilton Ditch- Muncie Creek. This site has had zero noncompliance issues during the WMP development period.

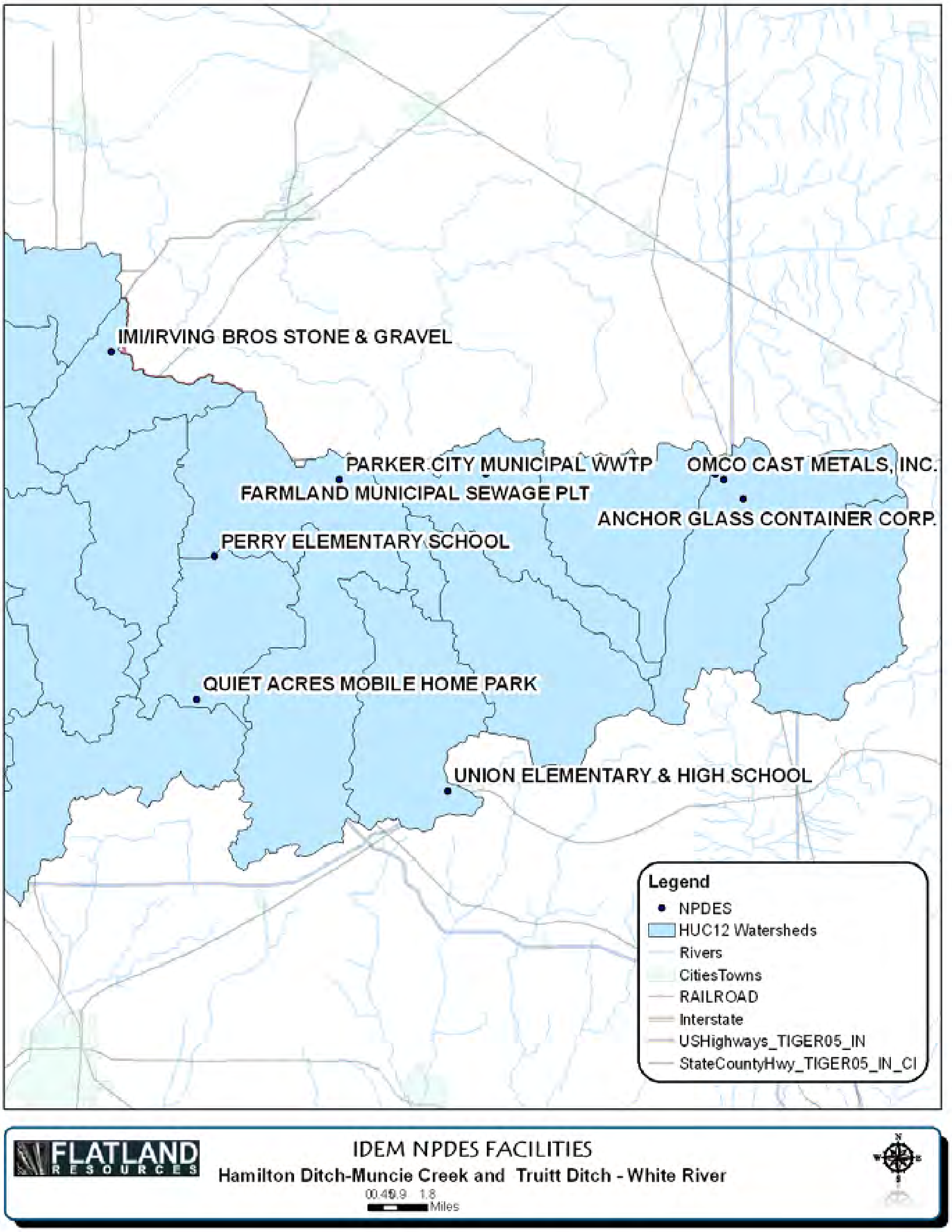
Pre-treatment Permits

"n order to reduce untreated discharges to Indiana's surface waters, industrial wastewater pretreatment permits are issued to industries that discharge to municipal wastewater treatment plants and industries that were delegated to operate their own pretreatment programs. NPDES staff oversees and audits municipal pretreatment programs in 45 municipalities with industrial dischargers.

Point Sources of Emerging Concern

"The Muncie Bureau of Water Quality included a study of contaminants of emerging concerns, in their 2010 annual report. Medications, pharmaceuticals, etc. that are improperly disposed make their way to the WPCF or into our rivers during CSO events. Muncie Bureau of Water Quality sampling at the WPCF and White River indicate that while these contaminants are detectable, they are currently not a levels that are to be of concern. There are no formal studies planned by the Muncie Bureau of Water Quality on these contaminates due to their low level in out waters. The public at large can often times misperceive the data and can become more concerned about the presence of these contaminants than the scientists at the Muncie Bureau of Water Quality." [3]

1 Pollutionissues.com
2 BWQ Annual Pretreatment Report
3 BWQ Annual Pretreatment Report



MAP.2.65 Point Source Discharge Permits in Muncie Creek HUC10 Watershed

INVENTORY

Point Source: Discharge Permits

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 12

The stability of White River is due in large part to the strict permitting efforts of point source outfalls through the National Pollutant Discharge Elimination Systems. Discharges of toxic pollutants is controlled through permit limits for specific chemicals and by whole effluent toxicity limits.

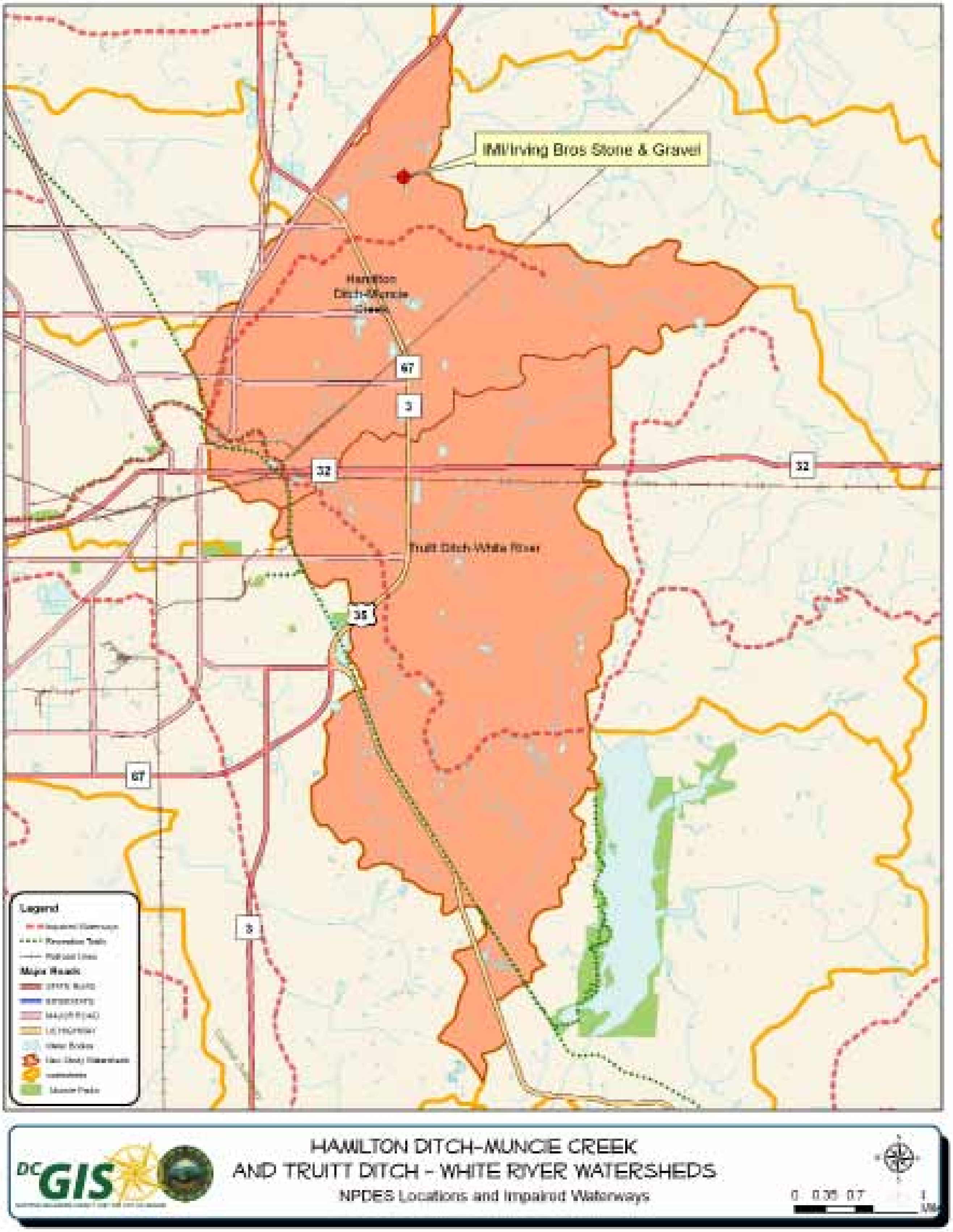
Several facilities which treat wastewater and are permitted to discharge the treated effluent are located within the Muncie Creek HUC 10 watershed and have impacts on the incoming water quality to Hamilton Ditch - Muncie Creek and Truitt Ditch - White River. However, there are no NPDES facilities in the Truitt Ditch-White River watershed and only one facility within the Hamilton Ditch-Muncie Creek watershed (MAP 2.66). The site is a quarry that discharges waste water polluted with the leavings from mining limestone. These pollutants can affect sediment levels and pH. Below is information submitted to the USEPA about the facility and its discharge.[1]

Facility Name: Irving Stone and Gravel Division of IMI
Address: 4312 East County Road 350 North, Muncie, IN 47303
County: Delaware
NPDES: ING490028
Permit Issued Date: JUL-15-2005
Permit Expired Date: JAN-31-2011
SIC Code: 1422 Crushed and Broken Limestone
List of Permitted Discharges

IDEM's NPDES permits are the cornerstone of the point source control program. IDEM actively works to stay in contact with permittees through the inspection program and the permit renewal process. The various permits issued through IDEM's NPDES program are intended to reduce untreated discharges to Indiana surface waters and to ensure that treated discharges do not cause or contribute to impairment of Indiana's surface water resources. [2]

TABLE 2.49: Location of Permitted Point Source Discharge Facility			
IND016541096	IMI/MUNCIE	DELAWARE	W FK WHITE R VIA MUNCIE CR VIA DR.
SOURCE: ArcGIS Indianamap.org			

1 Tom Reeve, White River Watershed Project
2 Indiana Integrated Water Monitoring and Assessment Report



MAP.2.66 Point Source Discharge Permits in Muncie Creek /Truitt Ditch Subwatershed

INVENTORY

Point Source: Pre-treatment Program

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 13

"The BWQ's pretreatment program has been federally mandated through the United States Environmental Protection Agency (EPA) and the Indiana Department of Environmental Management (IDEM) to ensure the safe and effective operation of the Muncie Water Pollution Control Facility (MWPCF) and to protect the quality of the facility's receiving stream. Publicly owned treatment works are designed to remove contaminants and harmful organisms commonly associated with residential wastewater; however, many facilities including the MWPCF also service local industries whose wastewaters may contain uniquely toxic compounds capable of interfering with, passing through, or accumulating in the sewage sludge of the treatment facility. Through the pretreatment program, the Muncie Bureau of Water Quality serves as the Control Authority responsible for ensuring that local industries comply with the regulatory requirements of the EPA, IDEM, and Muncie's local Pretreatment Ordinance." [3]

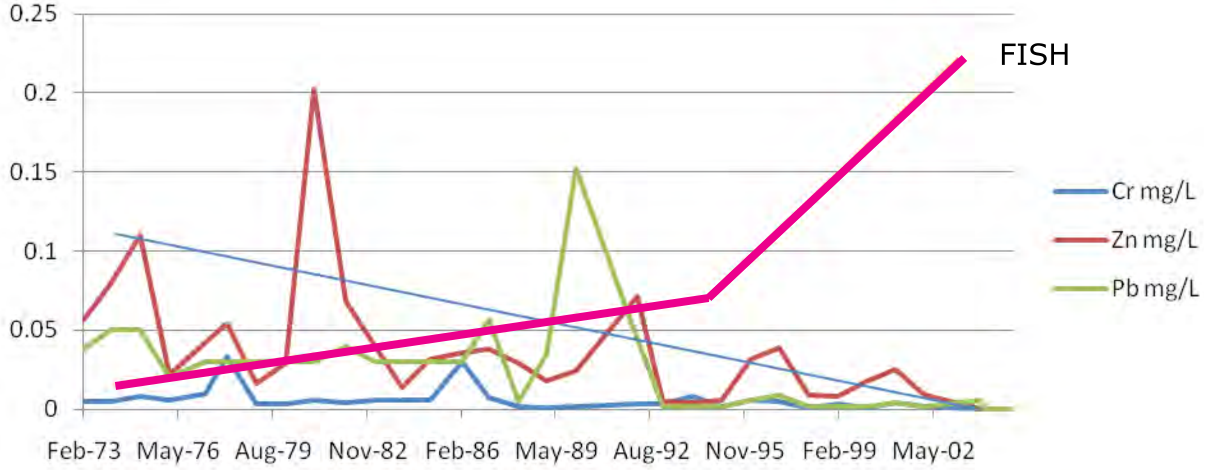
Major responsibilities of the program include:
"(1) permitting industries (2) sampling and analyzing industrial wastewater (3) requiring industries to self-monitor their wastewaters (4) requiring industries to implement spill response plans and pollution prevention (P2) management plans (5) sampling and analyzing the MWPCF's influent, effluent, and biosolids (6) sampling and analyzing the MWPCF's receiving stream (7) Industrial compliance is maintained nearly entirely through cooperation; however, the Bureau has the authority to issue enforcement actions including administrative orders, fines."[4]

"Before the Clean Water Act gave municipalities the legal authority to require pretreatment standards, the Muncie Bureau of Water Quality was already working with local industries to maintain voluntary compliance with its pretreatment standards. Both the City of Muncie and its industries have invested greatly in their pretreatment programs. The industrial community has spent approximately $14.5 million dollars within the Muncie Sanitary District for pretreatment equipment from the time the Muncie Bureau of Water Quality was established in 1972 through 2010. Of the BWQ's $1 million annual budget, approximately 80% is allocated specifically for the industrial pretreatment program. The Muncie Bureau of Water Quality maintains a Pretreatment Coordinator, a Chemistry Section for laboratory analyses, a surveillance Section for collection of water samples, and a Biological Section for assessing the health of aquatic life, each with specific roles related to the pretreatment program."

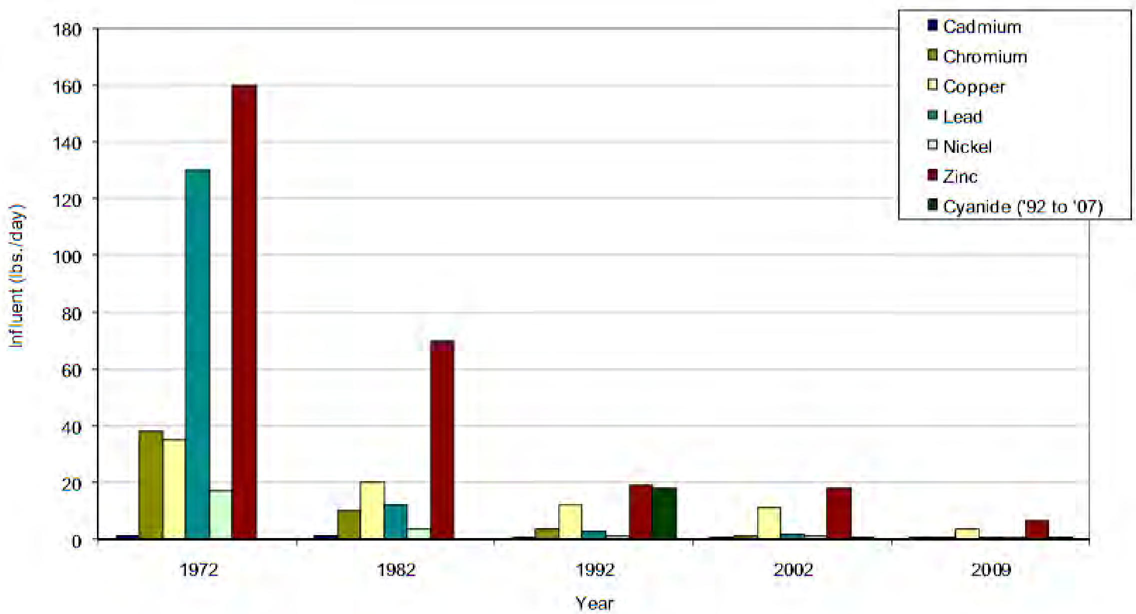
"Even as early in its history as 1982, when many cities were just beginning to establish their own pretreatment programs, the Muncie Bureau of Water Quality was already seeing measurable improvements in the quality of wastewater being collected and discharged by the MWPCF. Some of the changes could only be seen through chemical analyses; the reduction in metal concentrations reaching the MWPCF equates to removing as much as 63 tons of metal every year."[5]

"Some of the changes could be seen in the biology. Since the BWQ's first biological assessments over thirty years ago, the number of fish in White River downstream of the MWPCF has doubled, and sensitive species like the smallmouth bass, longear sunfish, and many freshwater mussels have returned. Some of the changes were easily visible to the naked eye; the White River, which once ran orange and whose stream bottom was once nothing but sludge, is now clear and its substrate once again contains a healthy mixture of gravel and cobble."[6]

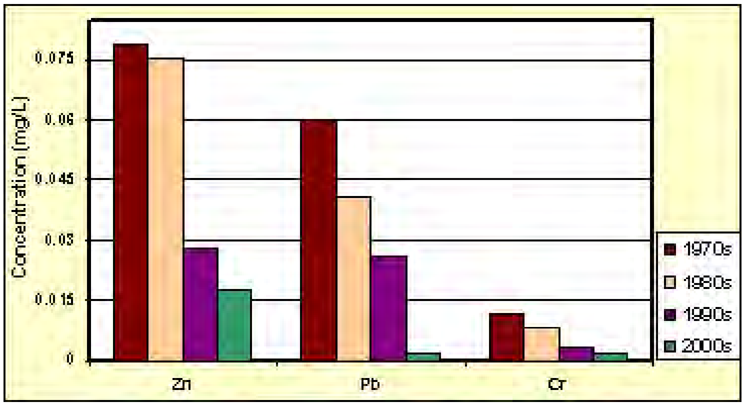
3 BWQ Annual Pretreatment Report
4 BWQ Annual Pretreatment Report
5 BWQ Annual Pretreatment Report
6 BWQ Annual Pretreatment Report



CHA. 2.23 Response of Fish to metals reduction (pink trendline_



CHA. 2.24 Historic Heavy Metals data



CHA. 2.25 Historic Heavy Metals data

Through Industrial Pre-treatment Program the White River has shown extensive reductions in pollutants. Chart 2.23 and 2.24 display changes that have taken place as measured just downstream from Muncie. Zinc (Zn) concentrations have been reduced 77% from the 1970s , while lead (Pb) and chromium (Cr) have seen a 97% and 83% reduction, respectively.

INVENTORY

Point Source: Metals
WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 14

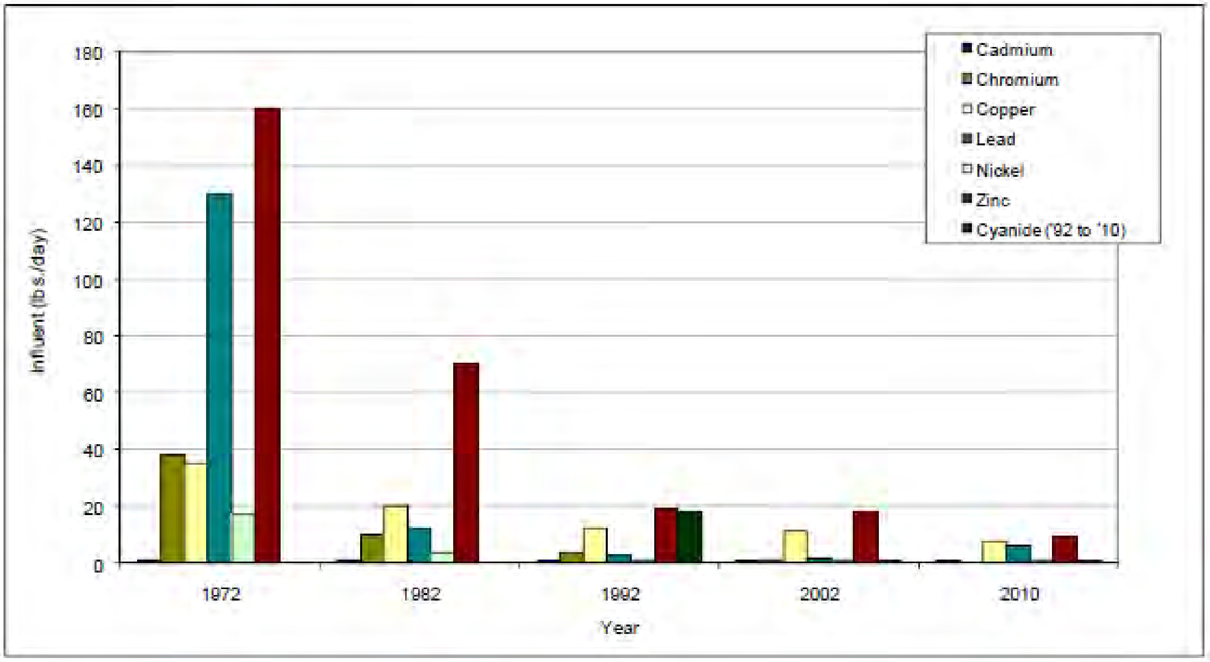
"One means of demonstrating the overall effectiveness of Muncie's Pretreatment Program is to graphically present data associated with industrially related parameters in the Muncie Water Pollution Control Facility's (MWPCF) Influent, Effluent and Biosolids. A major portion of the wastewater entering the MWPCF from our industrial base is from metal finishing processes. Muncie has plating firms, zinc coaters, phosphate coaters, automotive transmission plants, a secondary lead smelter, heat treat operations, hammer shops, tool and die operations and others. For the purposes of comparison, the Bureau uses the Method Detection Limit or Level of Detection (MDL or LOD) as the basis for reporting results at the low end of the analytical curve."[1]

"An example of this would be requiring industries to replace chromium as an anticorrosive agent in cooling towers with a less toxic chemical. The overall effectiveness of a Pretreatment Program can be evaluated by determining the reduction in the regulated parameters from year to year. (Chart 2.26, 2.27) One can see substantial reductions have taken place in the MWPCF Influent, Effluent and Biosolids." [2] (Chart 2.28)

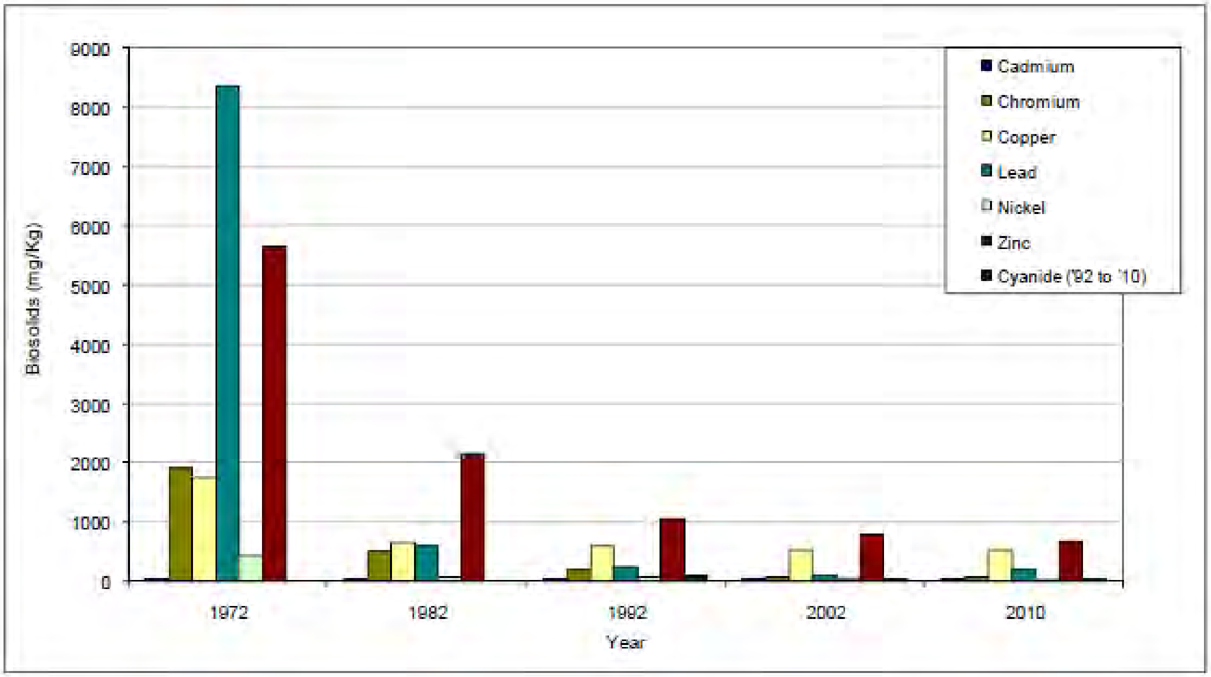
"The graphs for the Influent and Effluent have units of pounds per day. Being directly related to flow measurements, pounds per day allows for a direct yearly comparison even though the flow at the MWPCF fluctuates from year to year. Using pounds per day, the BWQ can document the actual decrease in loadings to the MWPCF and West Fork White River. Biosolids concentrations are graphed using mg/Kg dry weight. Graphing dry weight concentrations for the Biosolids eliminates the percent moisture variable in the biosolid samples."[3]

"Following the creation of the Bureau of Water Quality in 1972, the amount of toxic metals entering the MWPCF has been reduced as a result of the Pretreatment Program by an average of approximately 133,000 pounds (66.5 tons) annually."[4]

1 BWQ Annual Pretreatment Report
2 BWQ Annual Pretreatment Report
3 BWQ Annual Pretreatment Report
4 BWQ Annual Pretreatment Report



CHA. 2.26 Heavy Metals in Influent



CHA. 2.27 Heavy Metals in Biosoilds

Point Source: Toxic Organics

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 15

Toxic Organic Pollutant Monitoring

As part of the monitoring requirements detailed by the BWQs NPDES permit, the BWQ conducts an annual scan for organic pollutants in the influent, effluent, and biosolids of the pollution control facility.

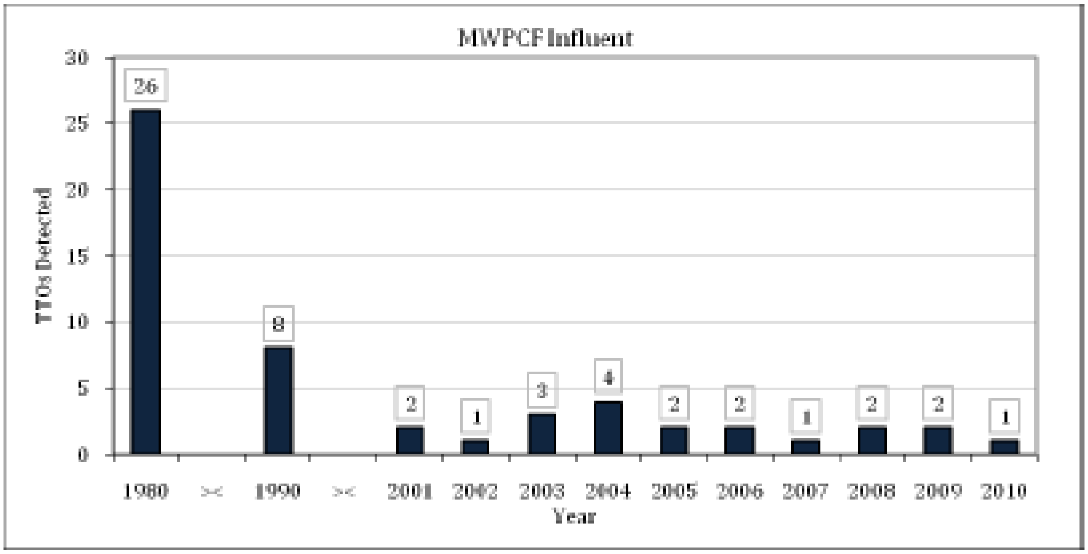
Though the pollution control facility is not specifically designed to remove organic compounds, removal efficiencies appear to be relatively high as most of the compounds found in the influent are absent from the effluent.

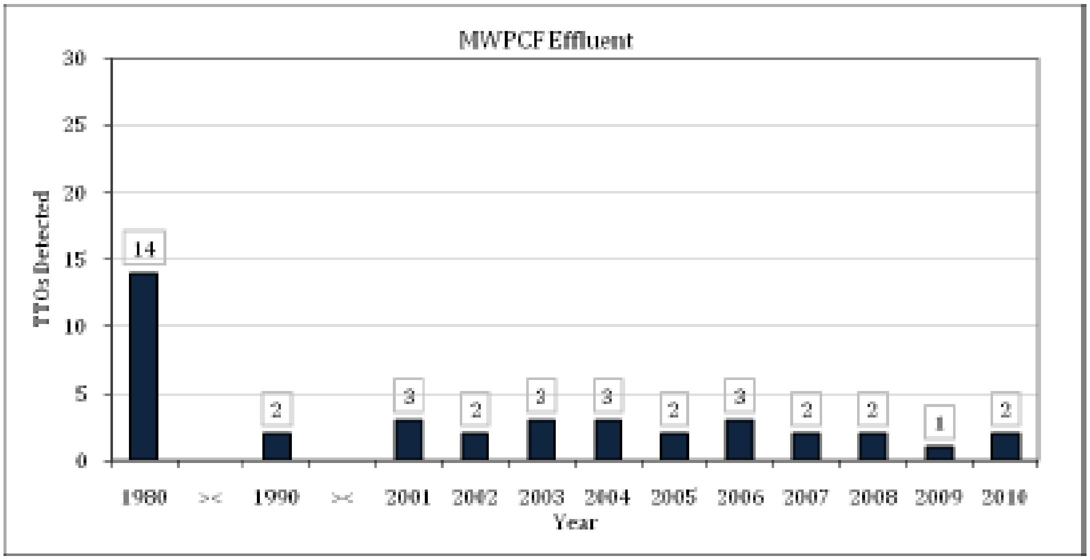
The BWQ has long recognized the potential threat posed by organic pollutants and has continued to surpass the minimum monitoring required by law. This includes annual monitoring of a handful of industries, selected on a rotating basis, to ensure they are effectively prohibiting the discharge of these toxic organics into wastestreams. Periodic sampling of storm water run-off, including run-off from large parking lots, are also included as these are each sources of organic compounds found in the wastewater treatment plant.[1]

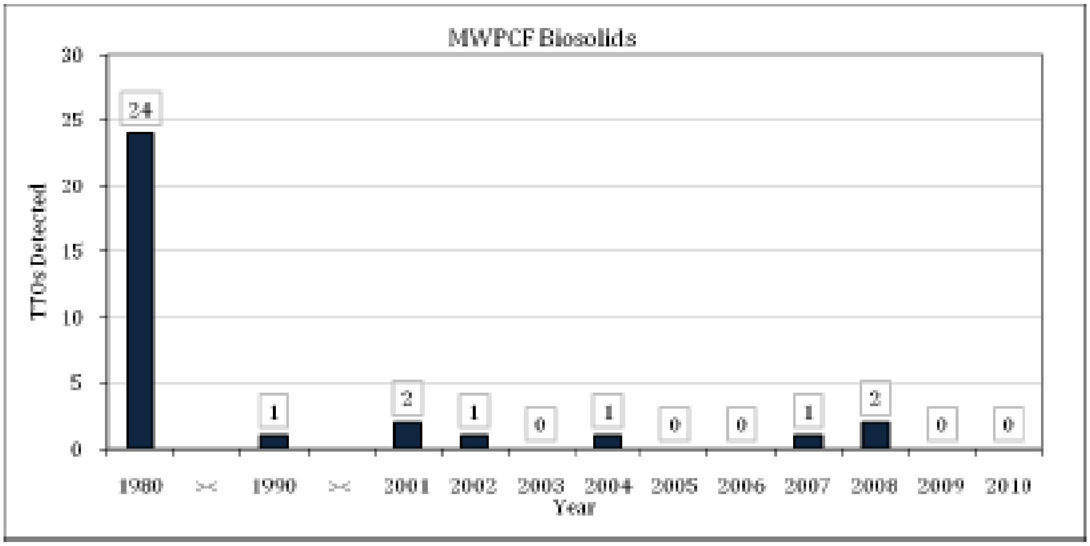
"Finally, samples from the White River are also included in annual organic compound scans to estimate the influence on the receiving stream and to help locate potential sources."[2]

"Commonly detected compounds include chloroform and bromodichloromethane, which are by-products of the chlorination of tap water. In most cases, the concentrations of compounds were below detection limits, but those few that were detected were extremely low in concentration (in the microgram per Liter range)."[3]

1 BWQ Annual Pretreatment Report
2 BWQ Annual Pretreatment Report
3 BWQ Annual Pretreatment Report







CHA. 2.28 Toxic Organic Pollutants in Influent, Effulent and Biosolids at WPCF

INVENTORY

Point Source: Contaminants of Emerging Concern
WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 16

"Public concern regarding endocrine disrupting compounds, specifically those related to pharmaceutical and personal care products, has piqued in recent years. In response, the BWQ has implemented a limited monitoring program aimed at identifying the presence of these substances in local wastewaters and waterways. Table 2.50 lists the compounds which were investigated as well as their concentrations in Muncie's wastewater treatment plant and in the White River throughout Muncie."[1]

"Relatively high concentrations of acetaminophen, caffeine, and ibuprofen were detected in the wastewater influent. However, in spite of the fact that the treatment plant is not specifically designed to remove these types of wastes, the removal efficiency appears remarkably high for those compounds which were more concentrated in the wastewater than they were in the river."[2]

"The small number of samples taken prevents any detailed statistical analysis of loading or removal efficiencies; however, more rigorous sampling seems unwarranted at this time for three main reasons.[3]

(1) These tests are extremely expensive. Analysis of pharmaceuticals requires specialized equipment to detect such small concentrations, and it quickly becomes cost prohibitive to conduct as many samples as would be necessary to illustrate the nuanced variability that we are frequently able to describe with the more conventional pollutants such as ammonia and metals.

(2) The BWQ can already reasonably estimate the presence and concentrations of pharmaceuticals in and around Muncie based on research conducted elsewhere in the country simply based on Muncie's population.

(3) The demonstrated threat from exposure to pharmaceuticals appears to be extremely low. As an example, for someone to consume the equivalent of a one-time dose of Tylenol, he or she would have to drink 300 gallons of water directly from the river every day for the rest of his or her life. Some of the communities in this area do rely upon the White River as a drinking water source, but only following additional treatment. Additional treatment has been shown to further reduce the concentrations of these chemicals.[4]

To be clear, it is not the BWQ's contention that this subject is not important. With so much left unknown about these compounds and their possible interactions in the environment, the BWQ is merely suggesting that efforts be focused less on re-reporting numbers which have very little meaning to the public other than to incite worry.

With this in mind, the Muncie Sanitary District has decided to focus its efforts in two general directions.

1 BWQ Annual Pretreatment Report
2 BWQ Annual Pretreatment Report
3 BWQ Annual Pretreatment Report
4 BWQ Annual Pretreatment Report

(1) Investigating the possible responses of aquatic organisms in the environment.[5] Specifically, the BWQ is working to develop a more practical detection method that is sensitive to a wider array of endocrine disrupting compounds, and one that will simultaneously demonstrate an impact on the environment (as opposed to simply demonstrating presence). The preliminary results of this work are promising. [6] Morphological measurements of a sentinel species of fish have shown small but detectable effects that have been correlated to the presence of estrogenic compounds.

(2) An acknowledgment that the concentrations of these compounds could be reduced, and that there was no reason to wait and see if any of these compounds is someday proven to be harmful to humans or the environment before taking action to reduce their presence in waterways. To this end, the Muncie Sanitary District has been sponsoring "drug drops" where residents can safely dispose of their unused medicines. The district has also developed educational programs directed at the public and local pharmacies to discourage flushing of unwanted medicines; the most controllable means of contamination of waterways."[7]

The White River Watershed Projects intends to follow the BWQ's lead and therefore will not investigate or implement strategies to reduce endocrine disrupting compounds independent of BWQ efforts.

all values in ng/L

Drug Name	Plant Influent	Plant Effluent	Percent Removal	White River Upstream of Muncie	White River Within Muncie	White River Downstream of Muncie	Buck Cr. Upstream of CSOs	Buck Cr. Downstream of CSOs
Acetominophen	39000	5.8	99.99%	4.2	5.4	6.5	41	26
Caffeine	26000	14	99.95%	29	48	54	52	78
Carbamazepine	110	150	0%	1.4	1.6	9.3	1.7	1.7
Cotinine	1300	13	99.00%	4.3	5.1	8.3	5.9	6.5
DEET	1400	150	89.29%	*24	24	33	*24	*24
Ibuprofen	3400	2.7	99.92%	3.1	*1.1	*1.1	13	6.3
Lincomycin	*1.0	*1.0	-	1.1	1.2	1	*1.0	*1.0
Sulfadimethoxine	*1.1	*1.1	-	*1.1	*1.1	*1.1	*1.1	*1.1
Sulfamethazine	*1.1	*1.1	-	*1.1	*1.1	*1.1	*1.1	*1.1
Sulfamethoxazole	810	9.8	98.79%	4.7	5.7	7.1	2.1	2.3
Sulfathiazole	*1.0	*1.0	-	*1.0	*1.0	*1.0	*1.0	*1.0
Triclosan	*4.8	*4.8	-	*4.8	*4.8	*4.8	*4.8	9.2
Trimethoprim	170	*6.6	-	*1.0	*1.1	*1.2	*1.0	1.7
Tylosin	1.8	1.3	27.78%	*1.1	*1.0	*1.0	*1.0	*1.0
Gemfibrozil	650	5.9	99.09%	2	*1.1	1.5	2.5	2.2
Diclofenac	42	*1.0	-	*1.0	*1.0	*1.0	*1.0	*1.0

** below detection limit*

SOURCE: Muncie Bureau of Water Quality

Summary of results of pharmaceutical sampling in the MWPCF and local streams via LCMSMS.

TABLE 2.50: Contaminates of Emerging Concern

5 BWQ Annual Pretreatment Report
6 BWQ Annual Pretreatment Report
7 BWQ Annual Pretreatment Report

INVENTORY

Summary of Existing Data

WMP - CHAPTER 2 - PART 2 - SECTION 1 - SUBSECTION 17

While probabilistic monitoring has value at the macro scale (for determining the overall status of Indiana's waters), at the site specific scale it is incapable for determining site/reach impairments, or in quantifying necessary or needed reductions. The sporadic, inconsistent, and age of this data makes site scale WQ planning with IDEM data problematic.

Despite the wide number of sampling sites in the state of Indiana, and even for Delaware County, there is a inability for IDEM to sufficiently rate the sites based on the four primary desired use characteristics: recreational use, fishable uses, drinking water uses, and aquatic life uses. This is evidenced in the fact most of the streams in the WMP areas cannot be assessed with WQ metric to determine 305(b) ranking due to insufficient data (Category 3).

GRW Engineering looked at all IDEM WQ data collected from 2001-2006. Despite reporting on the conclusions from this data analysis, the incomplete data sets prohibits a sufficient comparative analysis of all streams and tributaries in the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. GRW conclusions are therefore used with caution considering the difficulty of making definitive critical area decisions with the data (due to a lack of Subbasin information). Nonetheless, there are points of note for Dissolved Oxygen, Cynaide, E. Coli, TSS, Phenolics, and Copper.

E. coli is the only WQ impairment that is discovered to be a significant source of contamination in both sets of non point analysis. It is used as a metric for impaired recreational usage on the 305 (b) report, most of the streams on the 303(d) list (West Fork White River) are impaired for E. coli, and these same streams have been designated for the TMDL list. A TMDL is currently being developed for the West Fork White River East of the City of Muncie. WRWP 319 WQ studies (explained in subsequent sections) also confirmed that E. coli is the most pressing water quality impairment in Delaware County rivers and tributaries. The water quality parameters exceeding state water quality standards (according to IDEM data) is indicated in Table 2.51 in relationship to the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds.

Most of the point source studies done in conjunction with treatment identification/treatment programs are at the Muncie Water Pollution Control Facility. The WPCF is located downstream of Hamilton Ditch - Muncie Creek and Truitt Ditch-White River and there are over six Subwatersheds that have urban areas discharging to this system.

Combined sewer/storm water systems are prevalent in the sanitary district. Because both point and non-point sources are entering this sanitary line, it is difficult to discern which contaminants are coming from which source: residential, urban, storm water, etc. Furthermore, because there are no sampling points on the actual storm water network (for the purposes of isolating Hamilton Ditch - Muncie Creek and Truitt Ditch- White River) there is no capacity for separating out all of the Subwatersheds and discerning their relative contribution.

The BWQ's studies have shown a significant decrease in point source WQ pollutants over the last forty years in organic toxins, metals etc. The WRWP is confident that point source reductions will continue under the guidance of the BWQ because of these effective programs despite a lack of data specific to the Hamilton Ditch - Muncie Creek and Truitt Ditch - White River Subwatersheds. Therefore, point sources of pollution will not be addressed going forward in our WMP.

Table 2.51 IDEM Impairment Summary		Dissolved Oxygen	Biochemical Oxygen Demand	Flouride	Coliforms	Cyanide	E. Coli	Total Suspended Solids	Phenolics	Copper	Iron	Lead
Hamilton Ditch - Muncie Creek					X		X					
Truitt Ditch - White River		X	X		X	X	X	X	X	X	X	X

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:

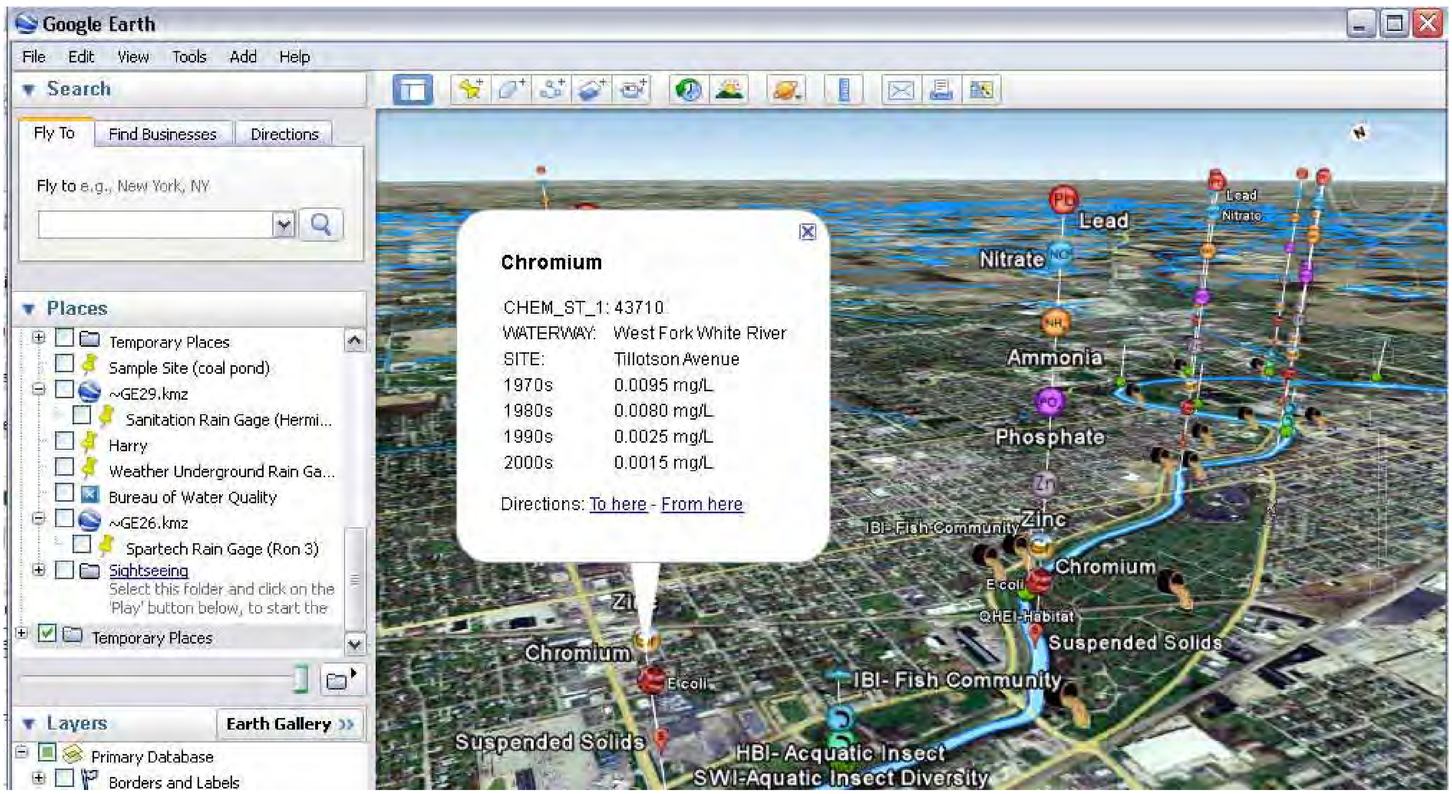
The first (a baseline analysis) consists of comparing Subwatersheds at the HUC12 level i.e. comparing Hamilton Ditch - Muncie Creek and Truitt Ditch - White River to each other to determine the relative water quality issues in the two Subwatersheds. This study looked at sampling points on the main stem 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.

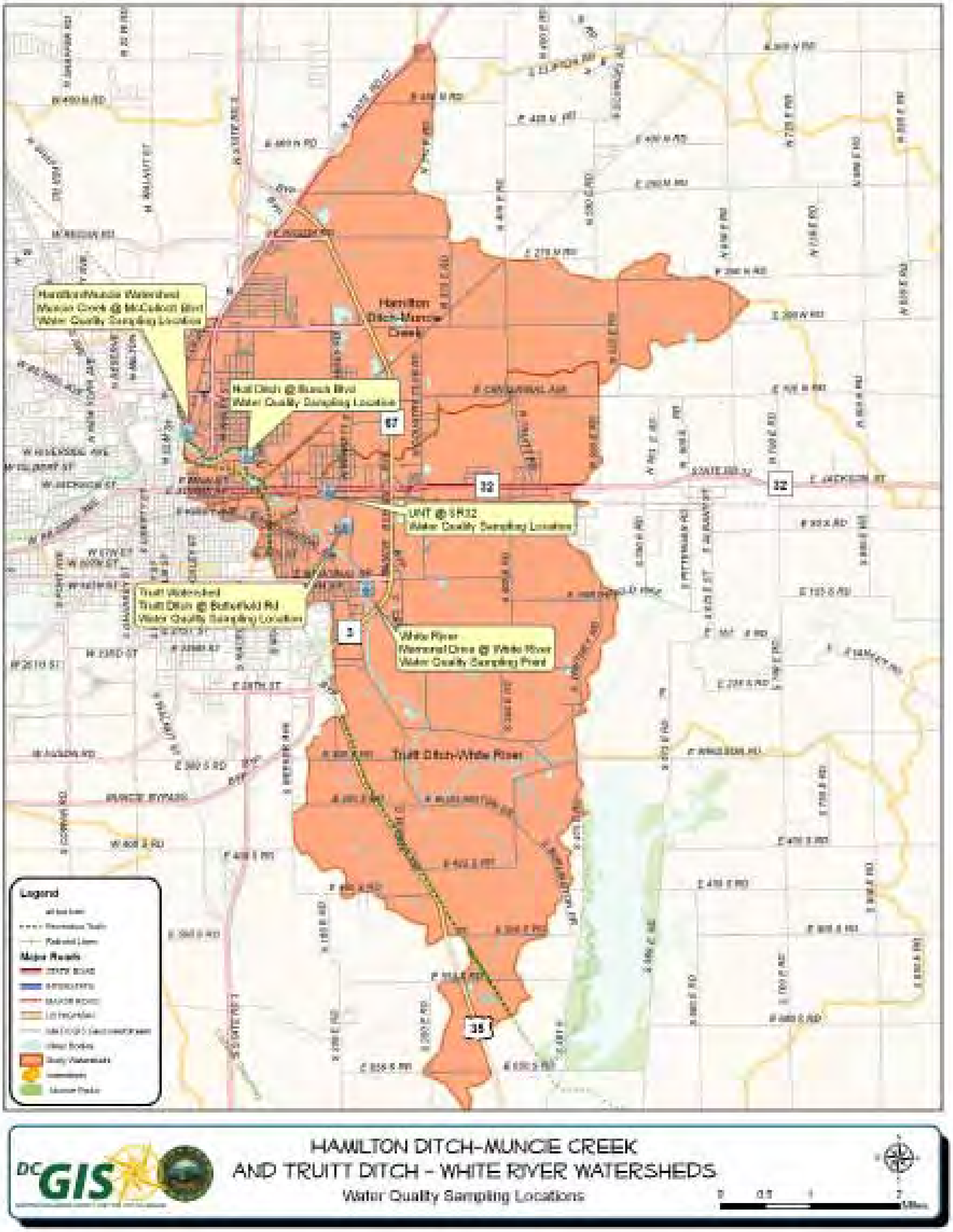
TABLE 2.52: Analytical procedures and methods.		
Parameter	Method	Method Detection Limit
pH	SM 20th, 4500-H+ B	NA
DO	SM 20th, 4500-O G.	0.1 mg/L
Temperature	EPA 170.1	0.1 °C
TSS	SM 20th, 254-O D	4.0/250 mL
Ammonia	SM 20th, 4500-NH3 E	0.05 mg/L
TP-P	SM 20th 4500-P E	0.05 mg/L
(NO3+NO2)-N	EPA 353.2	0.02 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.[1]

1 BWQ Annual Pretreatment Report



MAP.2.67 Water Quality Sampling Locations

Chemical Parameters

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

Ammonia (NH3)

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 NH4 to NH3. Ammonia was analyzed by the Muncie Bureau of Water Quality using method 4500-NH3 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 4500-0 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+ 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 a. 919980 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 purposed 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 purposed 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 temperate 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 Atraznine for drinking water is 3.0ug/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.[1]

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.[2]

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.[3]

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	Varible; 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.

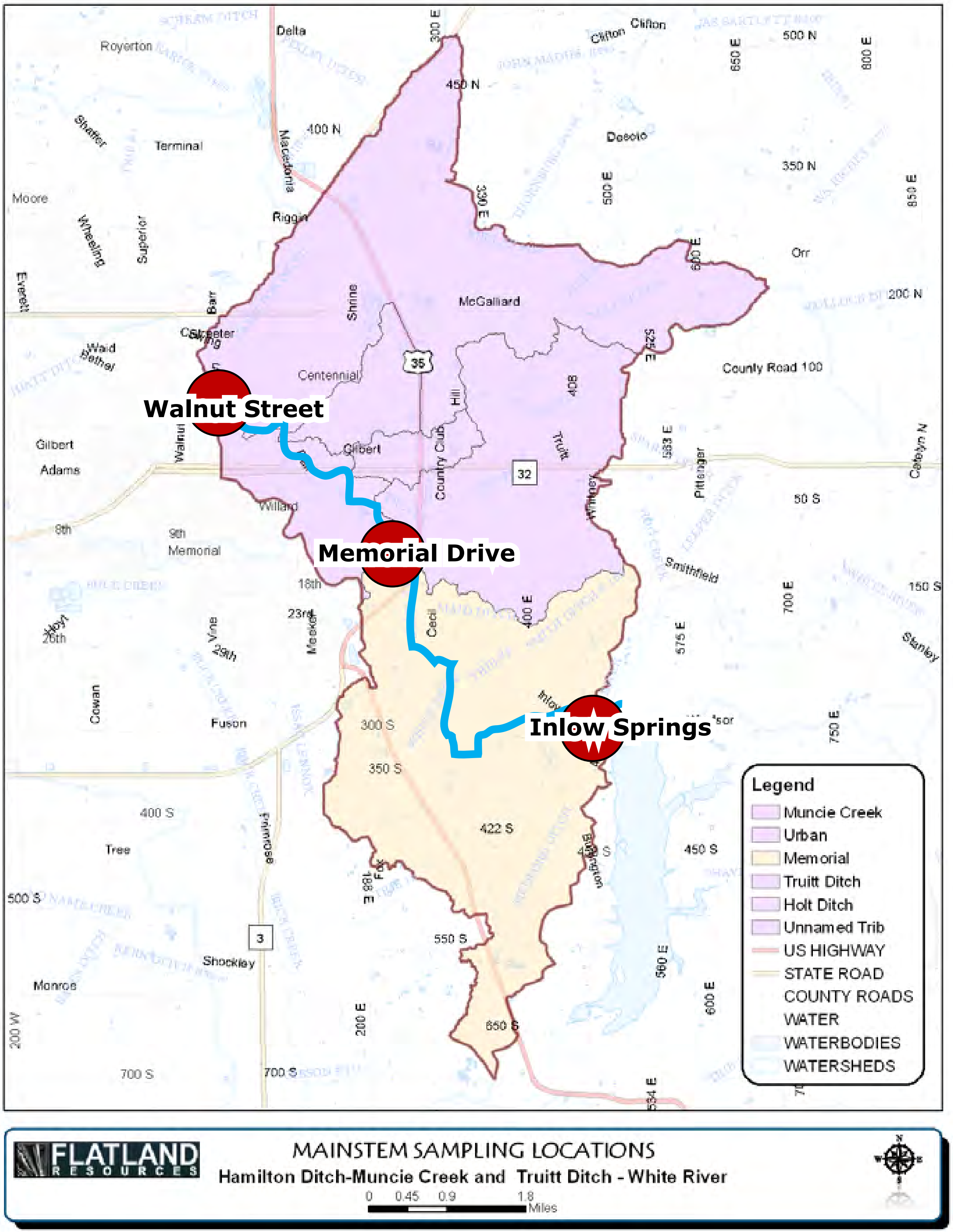
This data was also compared to data collected at Inlow Springs Road (since 2001). This sampling point is at the headwaters of the Subwatersheds. The Inlow Springs sampling site has very limited samples and although included as a point of discussion, will be inconclusive due to limited comparative sampling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

INVENTORY

Walnut Street

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

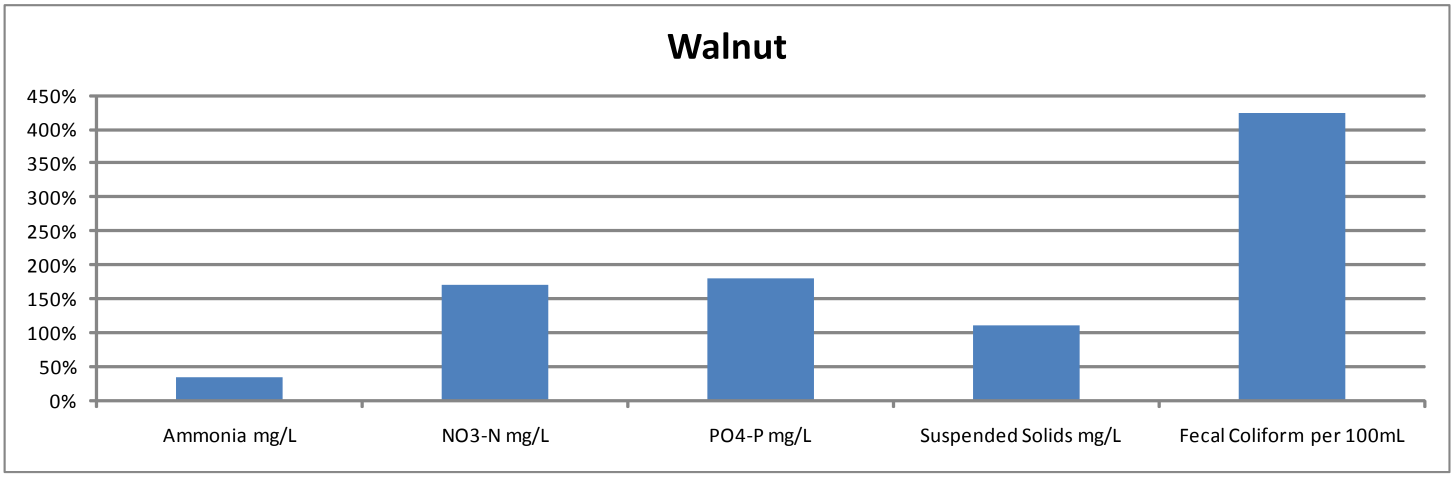
The Walnut Street sampling site is located on the main stem of the White River on the east side of Muncie. It is located at the discharge point of the Muncie Creek-Hamilton Ditch Subwatershed Basin which also flows from the Truitt Ditch-White River Subwatershed.

TABLE 2.54: Walnut Street Nonpoint Source Pollutants

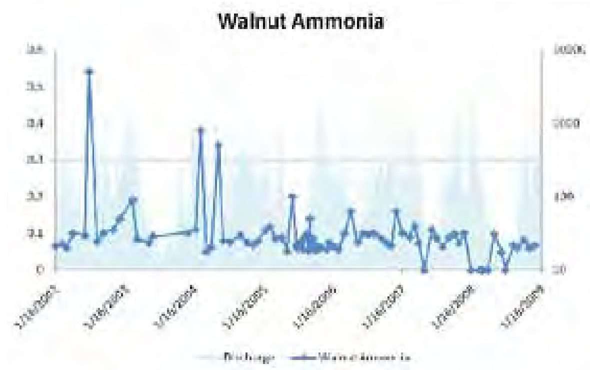
Walnut	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.07	77	0	0%
NO3-N mg/L	1.00	1.70	74	33	45%
PO4-P mg/L	0.08	0.14	77	34	44%
Suspended Solids mg/L	30.00	33.40	77	18	23%
Fecal Coliform per 100mL	235.00	997.62	77	51	66%

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.

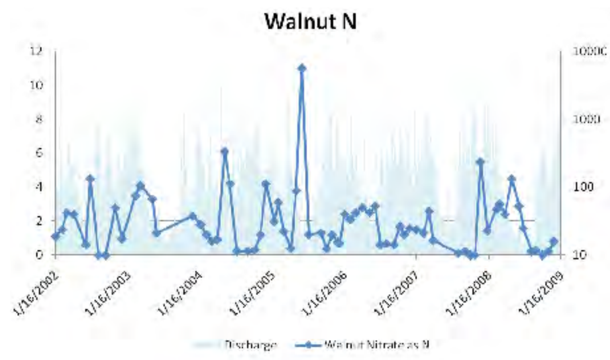
Charts 2.29 - 2.34 graph water quality impairments over a 10 year sampling period for the purposes of comparing current averages and exceedences to historical data. These graphs also include flow gauge data from the Main stem of the White River.



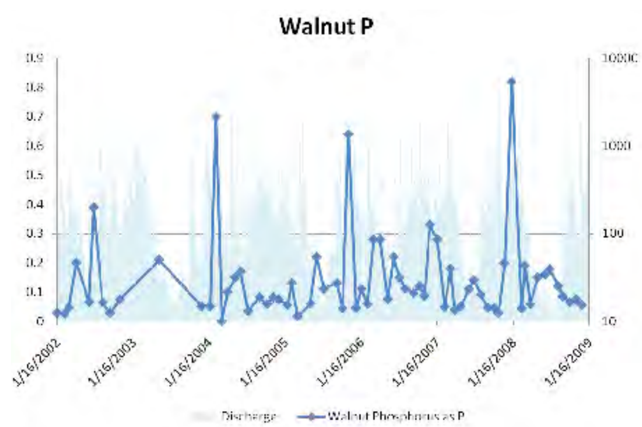
CHA. 2.29 Walnut St. Pollutant by Percentage of Exceedence



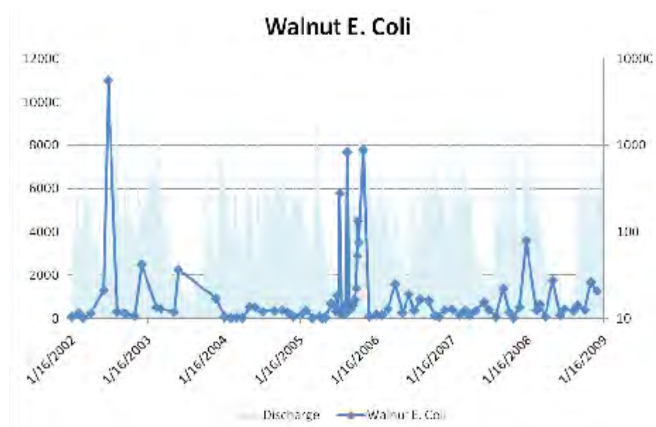
CHA.2.30 Walnut St. Ammonia



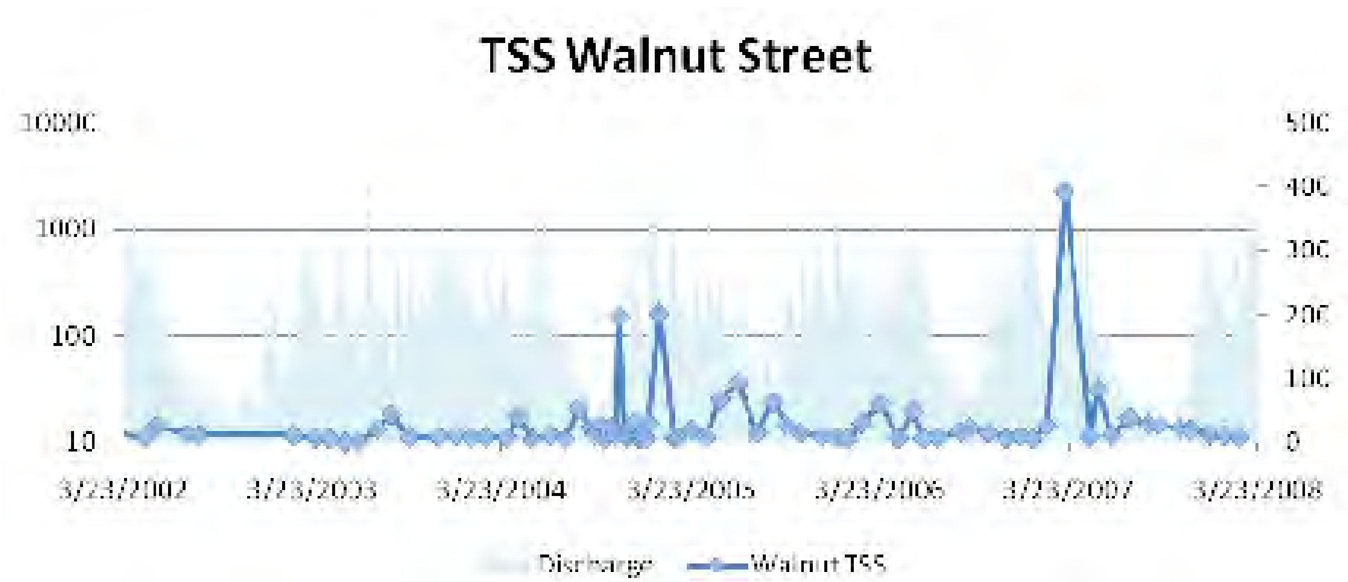
CHA.2.31 Walnut St. Nitrogen



CHA. 2.32 Walnut St. Phosphorus



CHA. 2.33 Walnut St. E. coli



CHA. 2.34 Walnut St. TSS

Memorial Drive

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

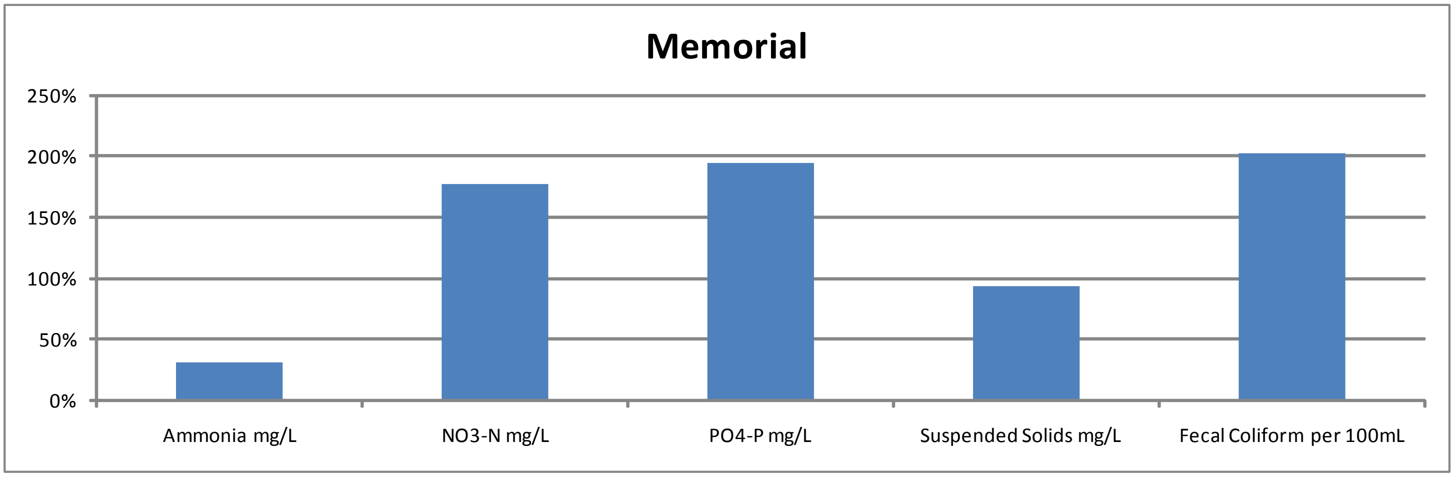
The Memorial Drive sampling site is located on the main stem of the White River on the east side of Muncie. It is located directly upstream of the Indiana American Water Company drinking water facility.

TABLE 2.55: Memorial Drive Nonpoint Source Pollutants

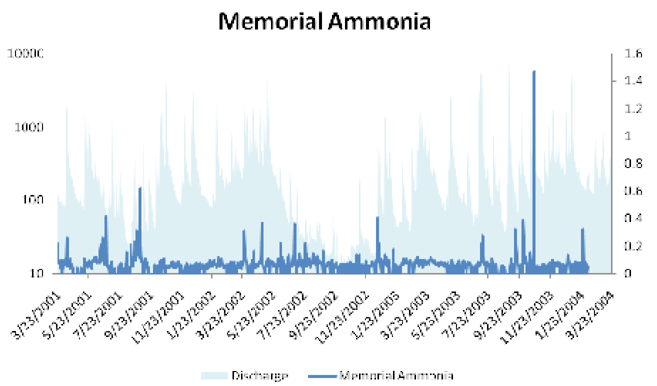
Memorial	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.06	1006	20	2%
NO3-N mg/L	1.00	1.76	184	36	20%
PO4-P mg/L	0.08	0.15	187	41	22%
Suspended Solids mg/L	30.00	27.88	1007	193	19%
Fecal Coliform per 100mL	235.00	476.91	557	209	38%

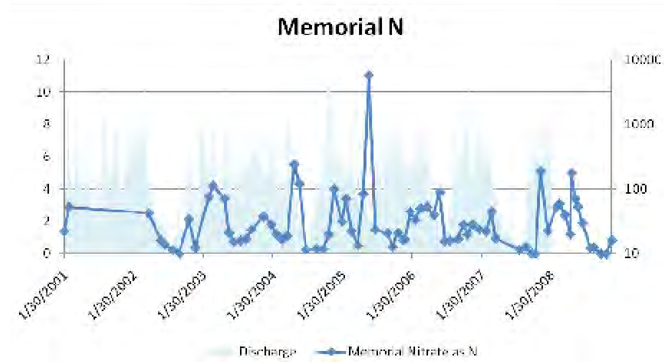
This site had a varying amount of samples per impairment taken over the three year sampling period. The Ammonia as N levels at this site averaged 0.06 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 20 times. Nitrates and 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.



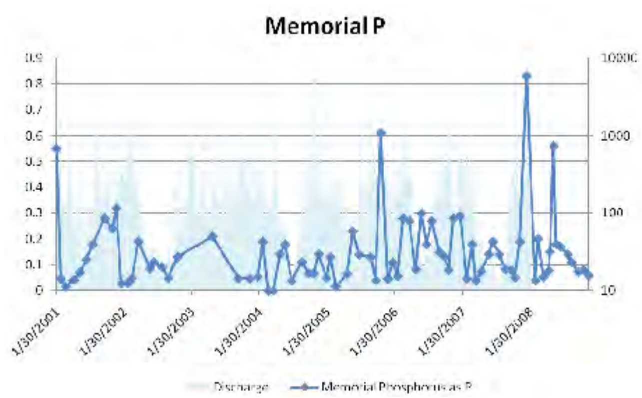
CHA. 2.35 Memorial Drive Pollutant by Percentage of Exceedence

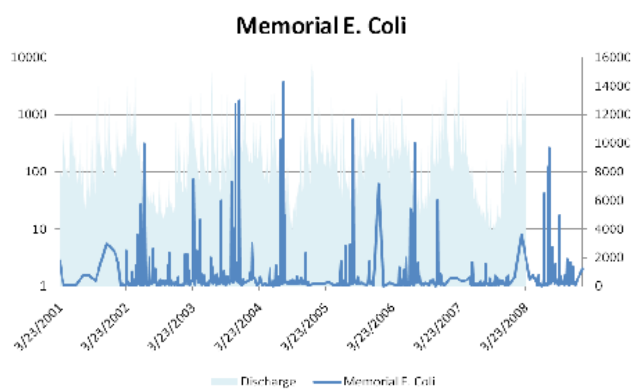




CHA. 2.36 Memorial Drive Ammonia

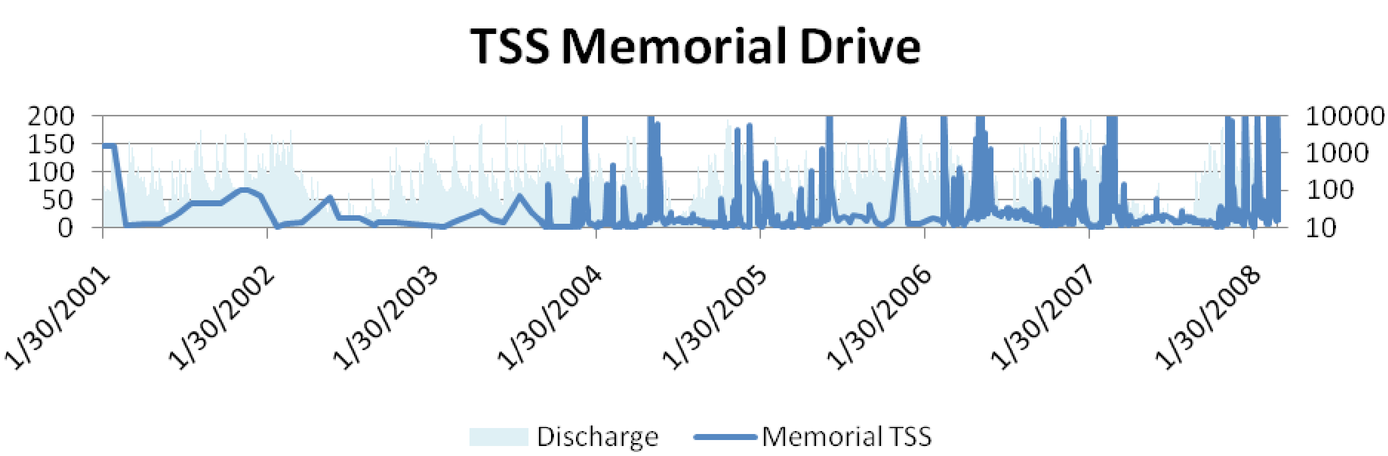
CHA. 2.37 Memorial Drive Nitrogen





CHA.2.38 Memorial Drive Phosphorus

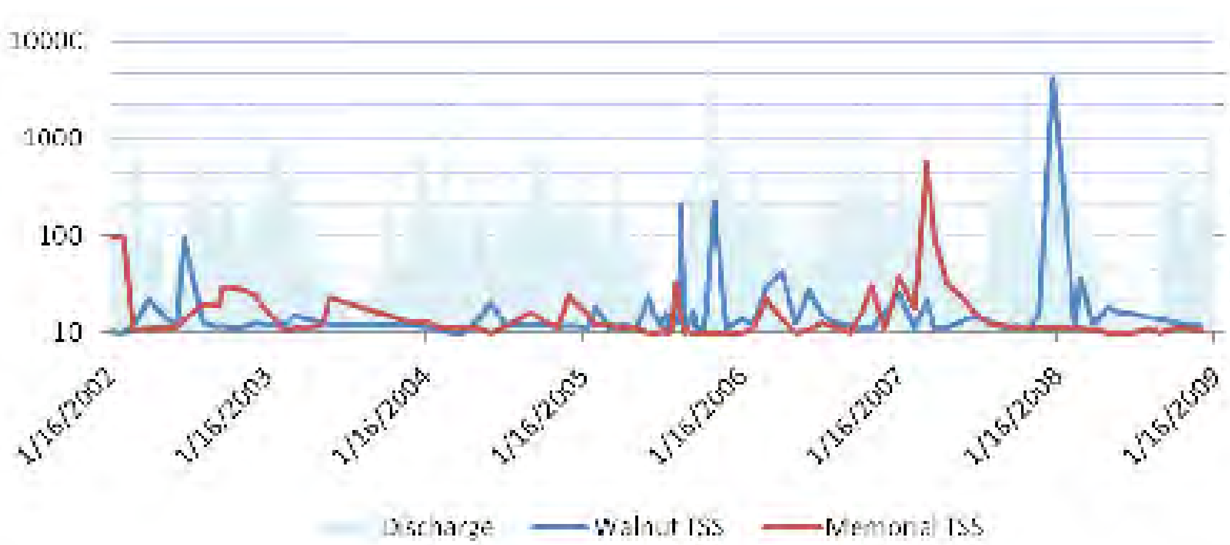
CHA. 2.39 Memorial Drive E. coli



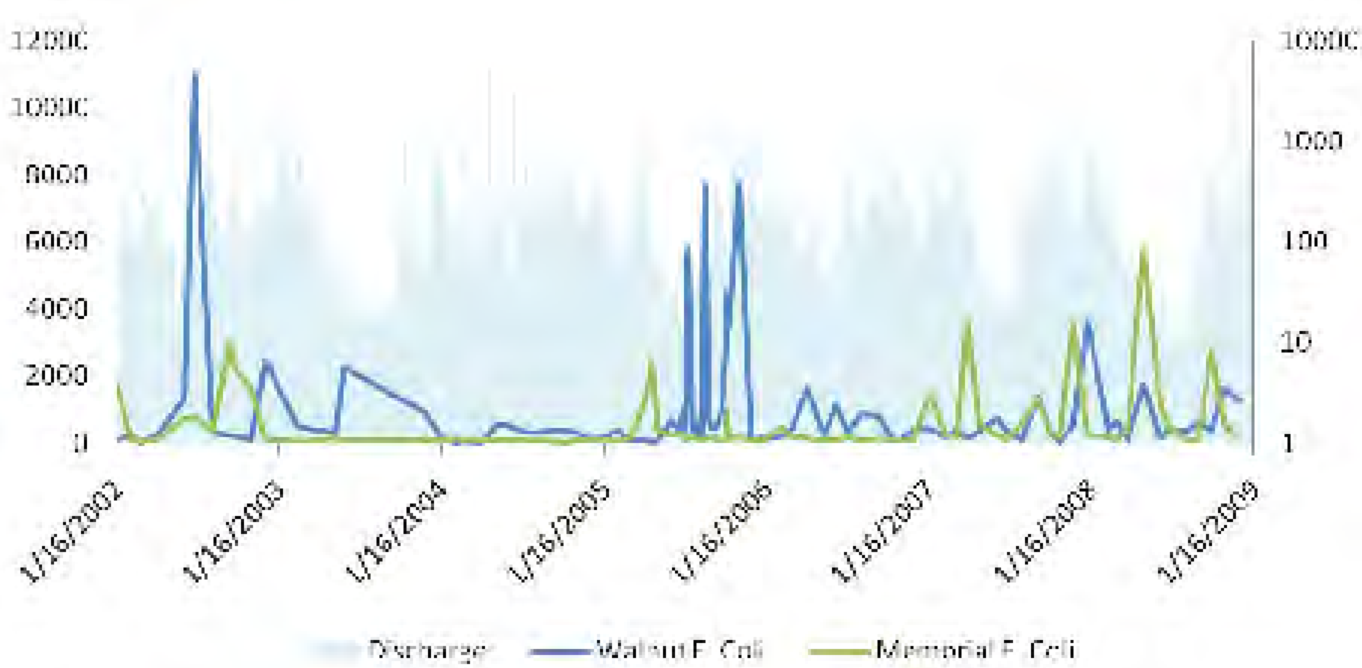
CHA. 2.40 Memorial Drive TSS

INVENTORY

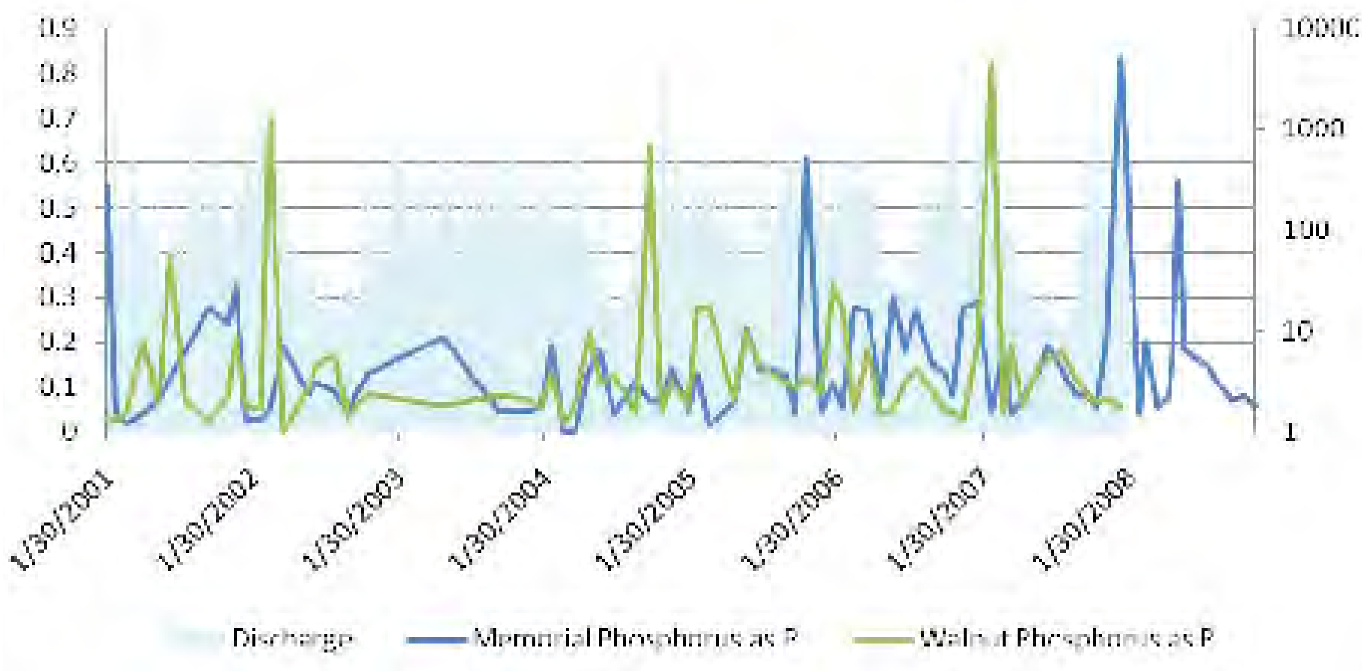
Charts 2.41 - 2.44 graph water quality impairments at the Walnut Street and Memorial Drive Sampling locations (over a 10 year sampling period) for the purposes of comparing current averages and exceedences to historical data as well as the sampling points relative to each other. These graphs also include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



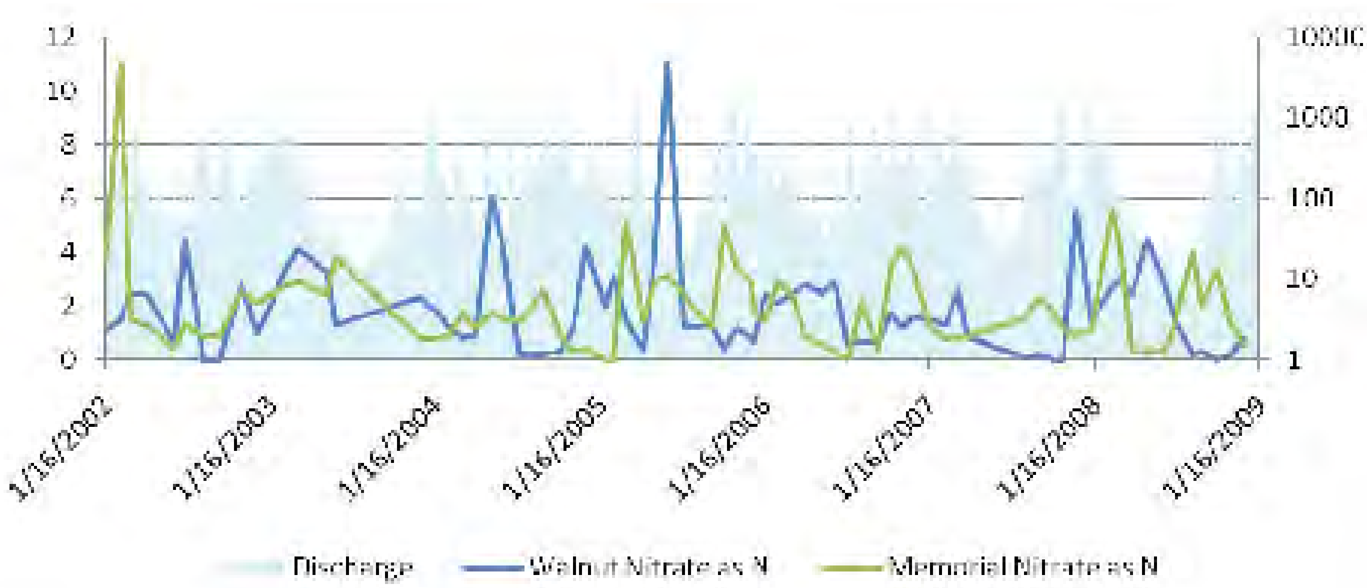
CHA. 2.41 TSS: Comparison of Memorial Drive and Walnut Street



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

INVENTORY

Inlow Springs Road

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

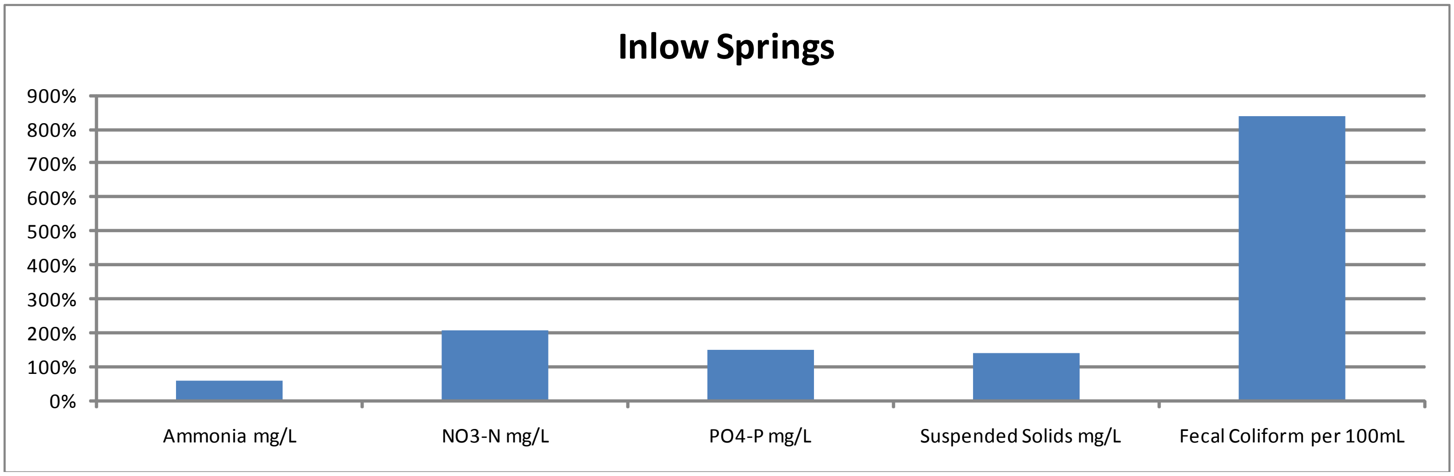
The Inlow Springs Road sampling site is located on the main stem of the White River on the east side of Muncie. It is located at the headwaters of the Truitt-Ditch-White River Subwatershed and flows into the Muncie Creek-Hamilton Ditch Subwatershed Basin.

TABLE 2.56: Inlow Springs Nonpoint Source Pollutants

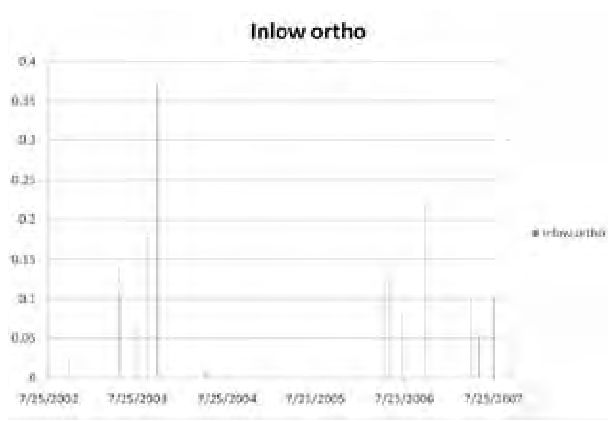
Inlow Springs	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.13	16	2	13%
NO3-N mg/L	1.00	2.06	16	9	56%
PO4-P mg/L	0.08	0.11	16	10	63%
Suspended Solids mg/L	30.00	42.10	16	7	44%
Fecal Coliform per 100mL	235.00	1968.80	20	14	70%

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.

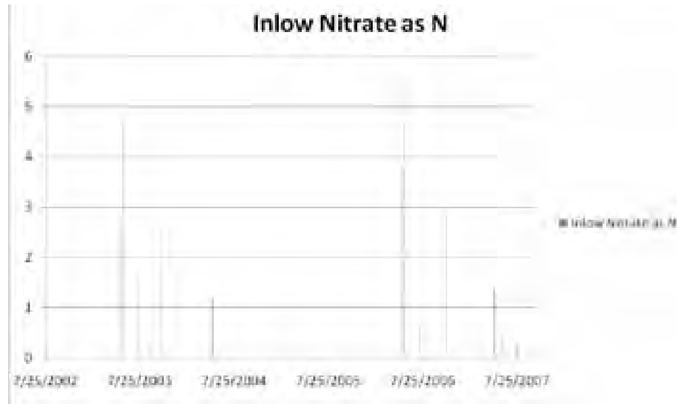
Charts 2.45 - 2.50 graph water quality impairments over a 10 year sampling period for the purposes of comparing current averages and exceedences to historical data. These graphs also include flow gauge data from the Main stem of the White River.



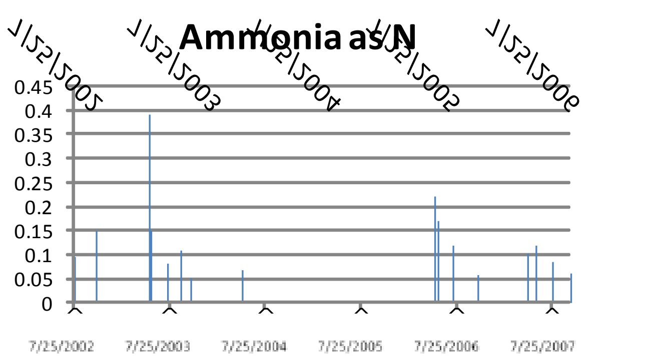
CHA. 2.45 Inlow Springs Pollutant by Percentage of Exceedence



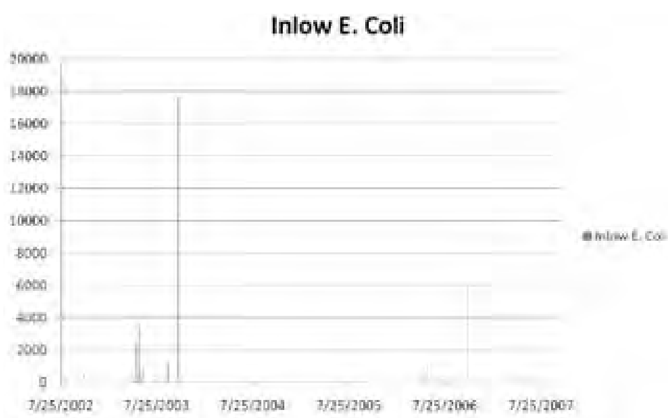
CHA. 2.46 Inlow Springs Orthoposhpates



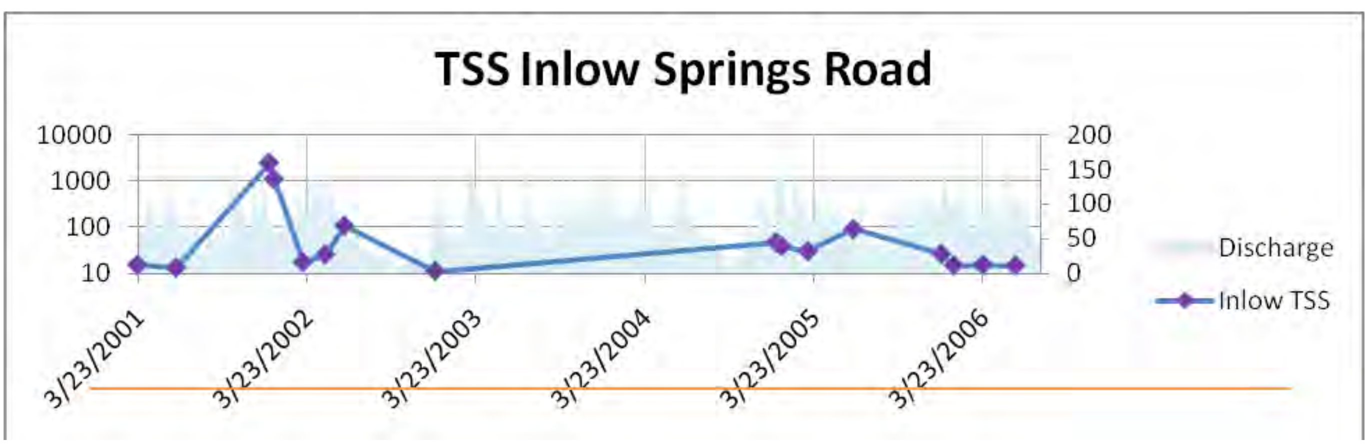
CHA. 2.47 Inlow Springs Nitrogen



CHA. 2.48 Inlow Springs Ammonia



CHA. 2.49 Inlow Springs E. Coli



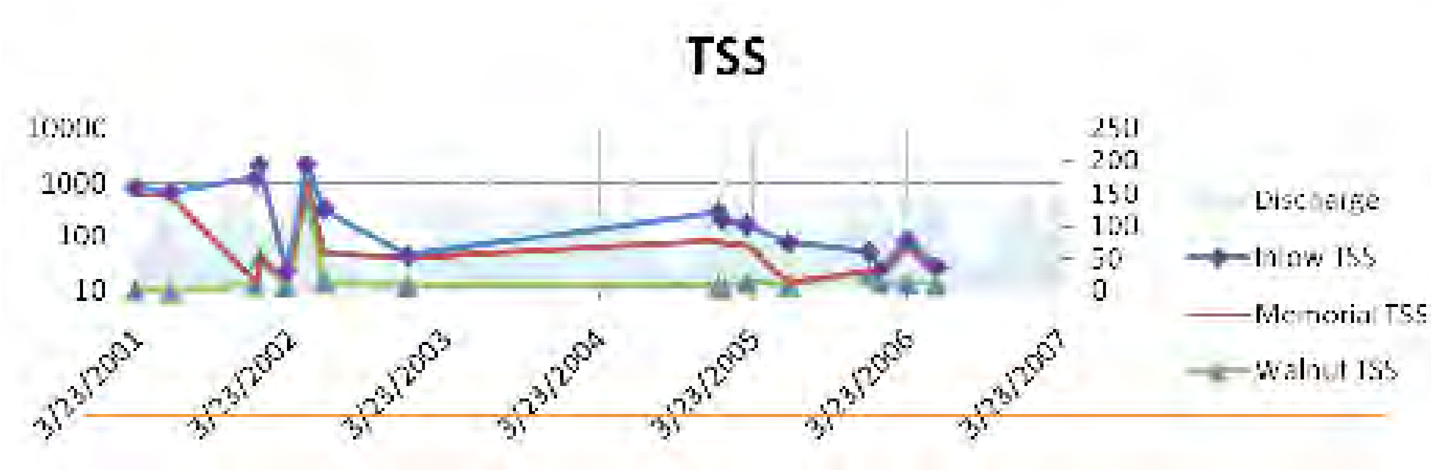
CHA. 2.50 Inlow Springs TSS

INVENTORY

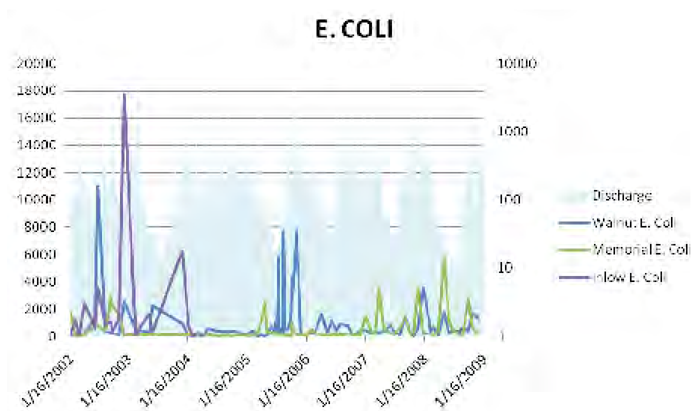
Comparative Studies

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

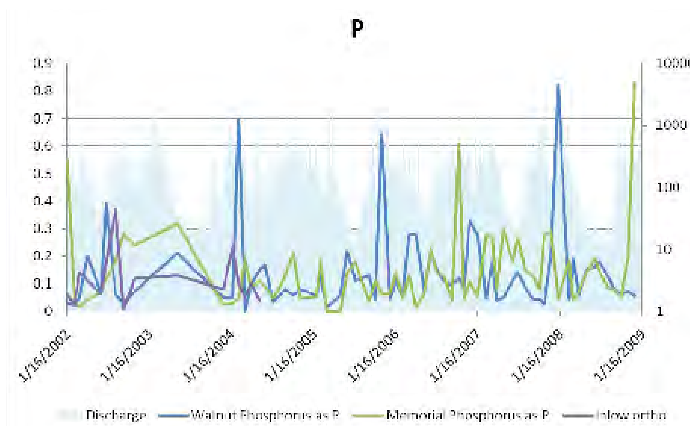
Charts 2.51 - 2.53 graph water quality impairments at the Walnut Street, Memorial Drive, and Inlow Springs sampling locations (over a 10 year sampling period) for the purposes of comparing current averages and exceedences to historical data - as well as the sampling points relative to each other. Nitrogen 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

INVENTORY

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.

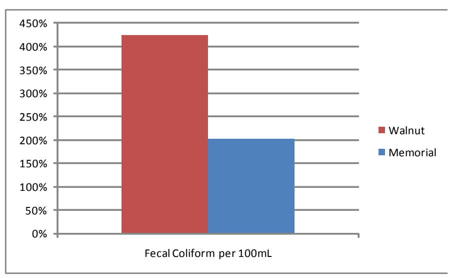
TABLE 2.57: Critical Pollutants on Mainstem Sampling Points

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

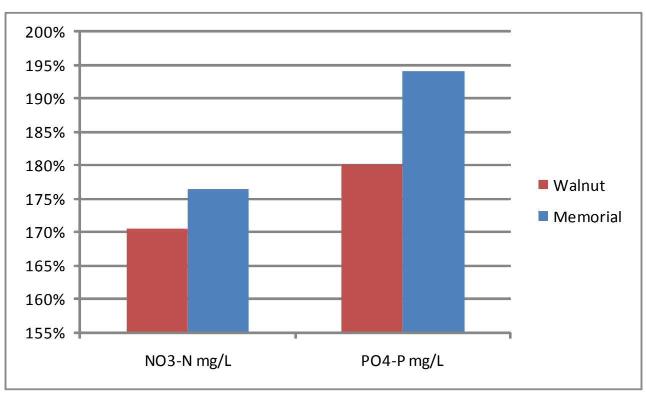
TABLE 2.58: IDEM Impairment Summary	Ammonia	Nitrogen	Phosphorus	Dissolved Oxygen	Biochemical Oxygen Demand	Flouride	Coliforms	Cyanide	E. Coli	Total Suspended Solids	Phenolics	Copper	Iron	Lead
Hamilton Ditch - Muncie Creek		X	X				X		X	X				
Truitt Ditch - White River		X	X	X	X		X	X	X	X	X	X	X	X



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

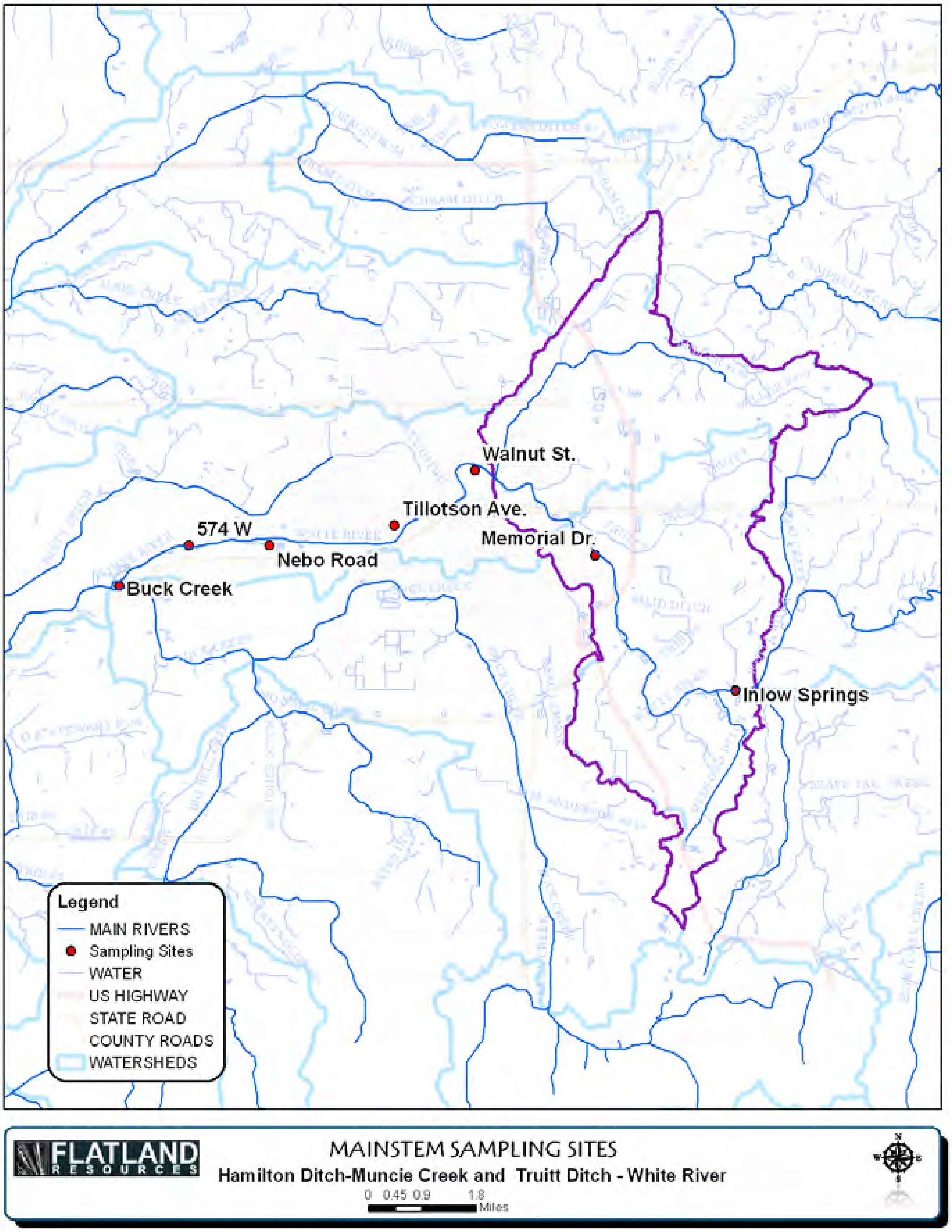
Truitt Ditch- White River is more impaired for Nitrogen and Phosphorus than Muncie Creek - Hamilton Ditch

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

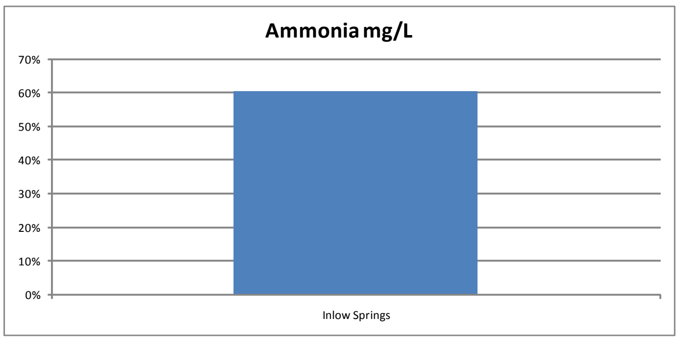
The Inlow Springs Road sampling site is located on the main stem of the White River on the east side of Muncie as seen in Map 2.71. It is located at the headwaters of the Truitt-Ditch-White River Subwatershed. The water tested at this sampling point flows into the Muncie Creek-Hamilton Ditch Subwatershed.

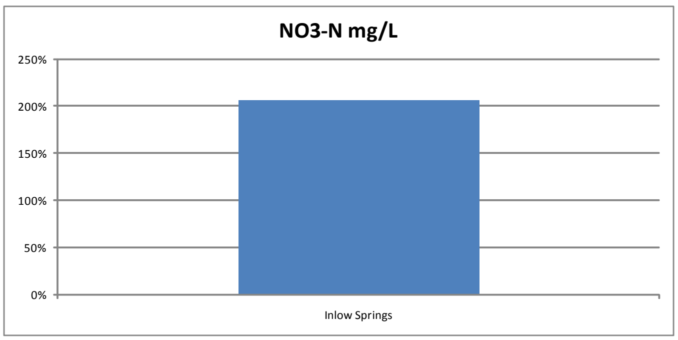
TABLE 2.59: Inlow Springs Nonpoint Source Pollutants

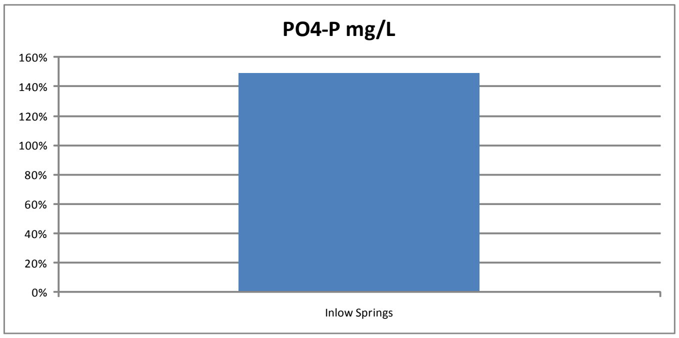
Inlow Springs	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.13	16	2	13%
NO3-N mg/L	1.00	2.06	16	9	56%
PO4-P mg/L	0.08	0.11	16	10	63%
Suspended Solids mg/L	30.00	42.10	16	7	44%
Fecal Coliform per 100mL	235.00	1968.80	20	14	70%

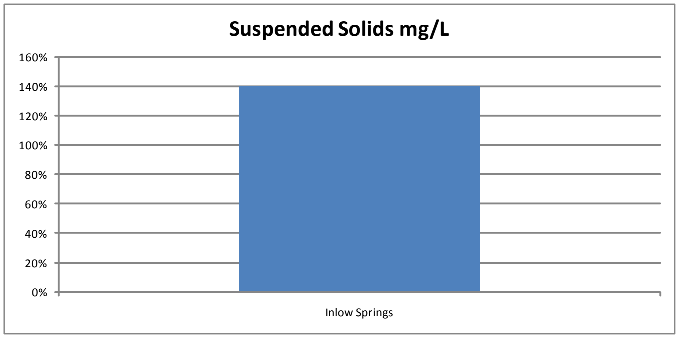
This site had a total of 16 samples taken over the ten year sampling period. The Ammonia as N levels at this site averaged 0.13 mg/L and exceed the limits set by the Indiana Administrative Code (IAC), which varies depending on temperature and pH, a total of 2 times. Nitrates and Nitrite as N levels averaged 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.

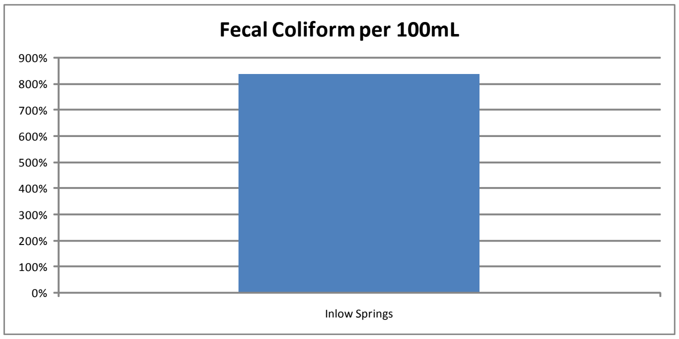
MAP. 2.71 Inlow Springs Sampling Location











CHA. 2.57 Pollutants by Exceedence

INVENTORY

White River | Mainstem Study

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

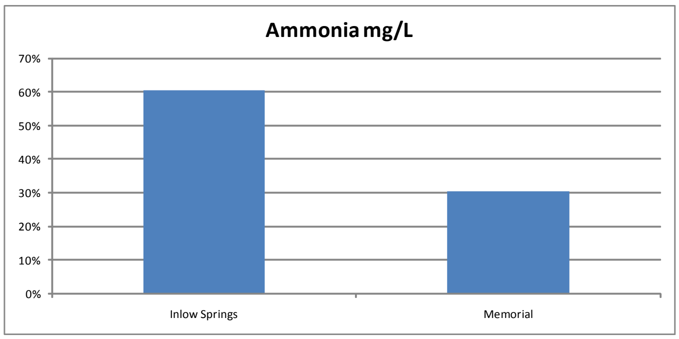
The Memorial Drive sampling site is located on the main stem of the White River on the east side of Muncie as seen in Map 2.72. It is located directly upstream of the Indiana American Water Company drinking water facility.

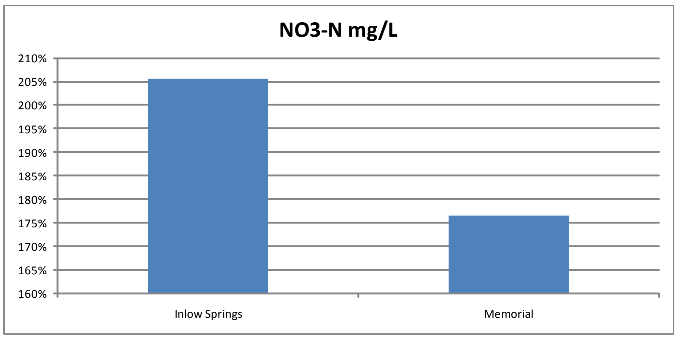
TABLE 2.60: Memorial Drive Nonpoint Source Pollutants

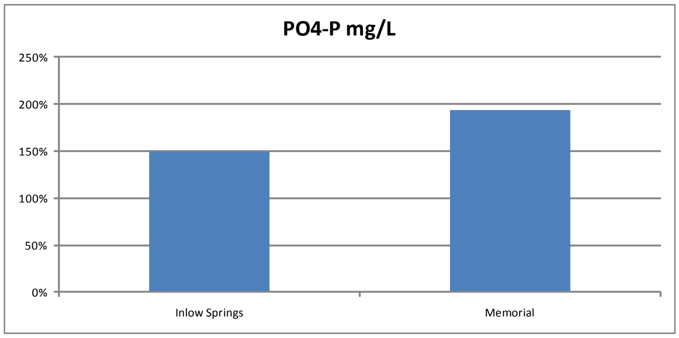
Memorial	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.06	1006	20	2%
NO3-N mg/L	1.00	1.76	184	36	20%
PO4-P mg/L	0.08	0.15	187	41	22%
Suspended Solids mg/L	30.00	27.88	1007	193	19%
Fecal Coliform per 100mL	235.00	476.91	557	209	38%

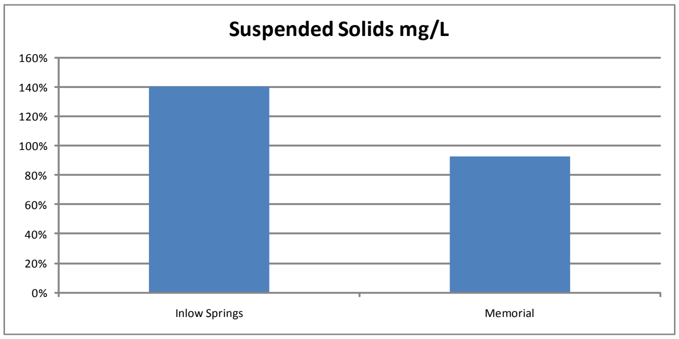
This site had a varying amount of samples per impairment taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.58; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as 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.

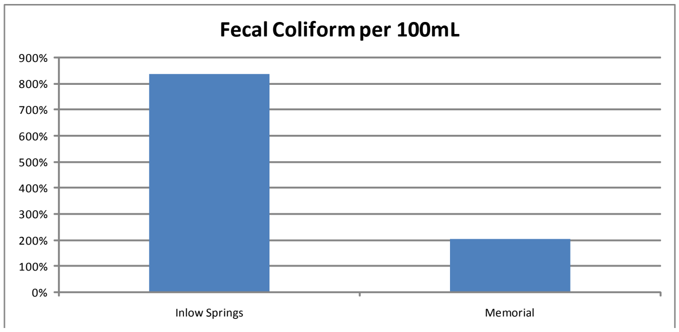
MAP. 2.72 Memorial Drive Sampling Location











CHA. 2.58 Pollutants by Exceedence

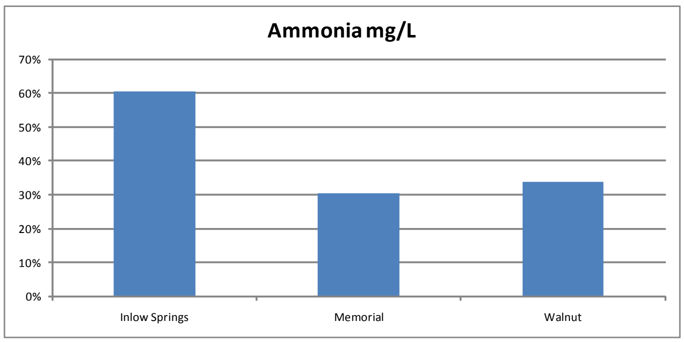
The Walnut Street sampling site is located on the main stem of the White River on the east side of Muncie as seen in Map 2.73. It is located at the discharge point of the Muncie Creek-Hamilton Ditch Subwatershed Basin which also flows from the Truitt Ditch-White River Subwatershed.

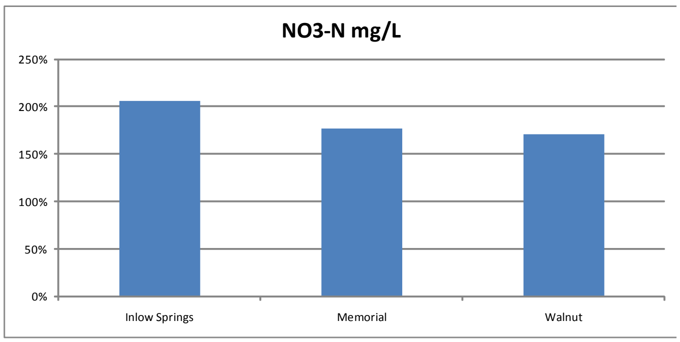
TABLE 2.61: Walnut Street Nonpoint Source Pollutants

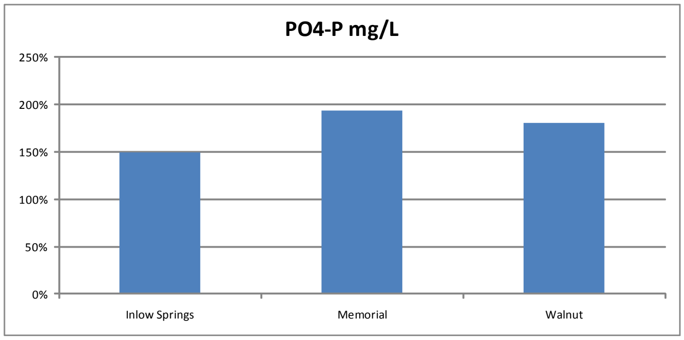
Walnut	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.07	77	0	0%
NO3-N mg/L	1.00	1.70	74	33	45%
PO4-P mg/L	0.08	0.14	77	34	44%
Suspended Solids mg/L	30.00	33.40	77	18	23%
Fecal Coliform per 100mL	235.00	997.62	77	51	66%

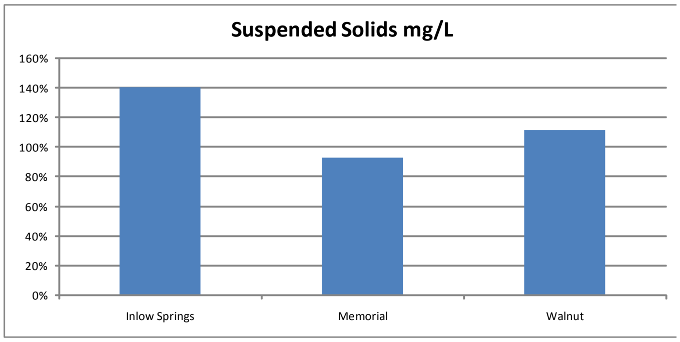
This site had 77 samples taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.59; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 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.

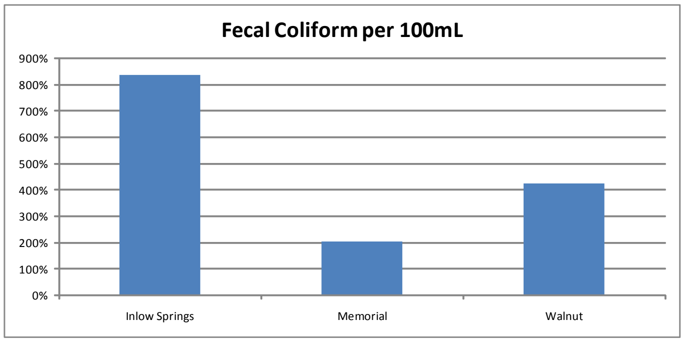
MAP. 2.73 Walnut Street Sampling Location











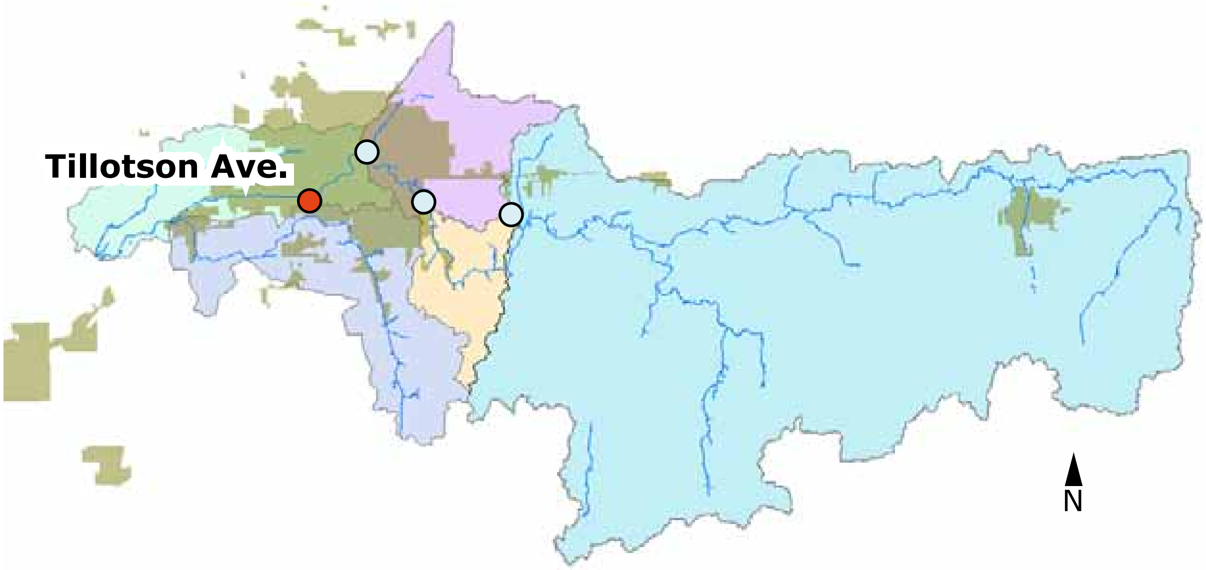
CHA. 2.59 Pollutatns by Exceedence

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.

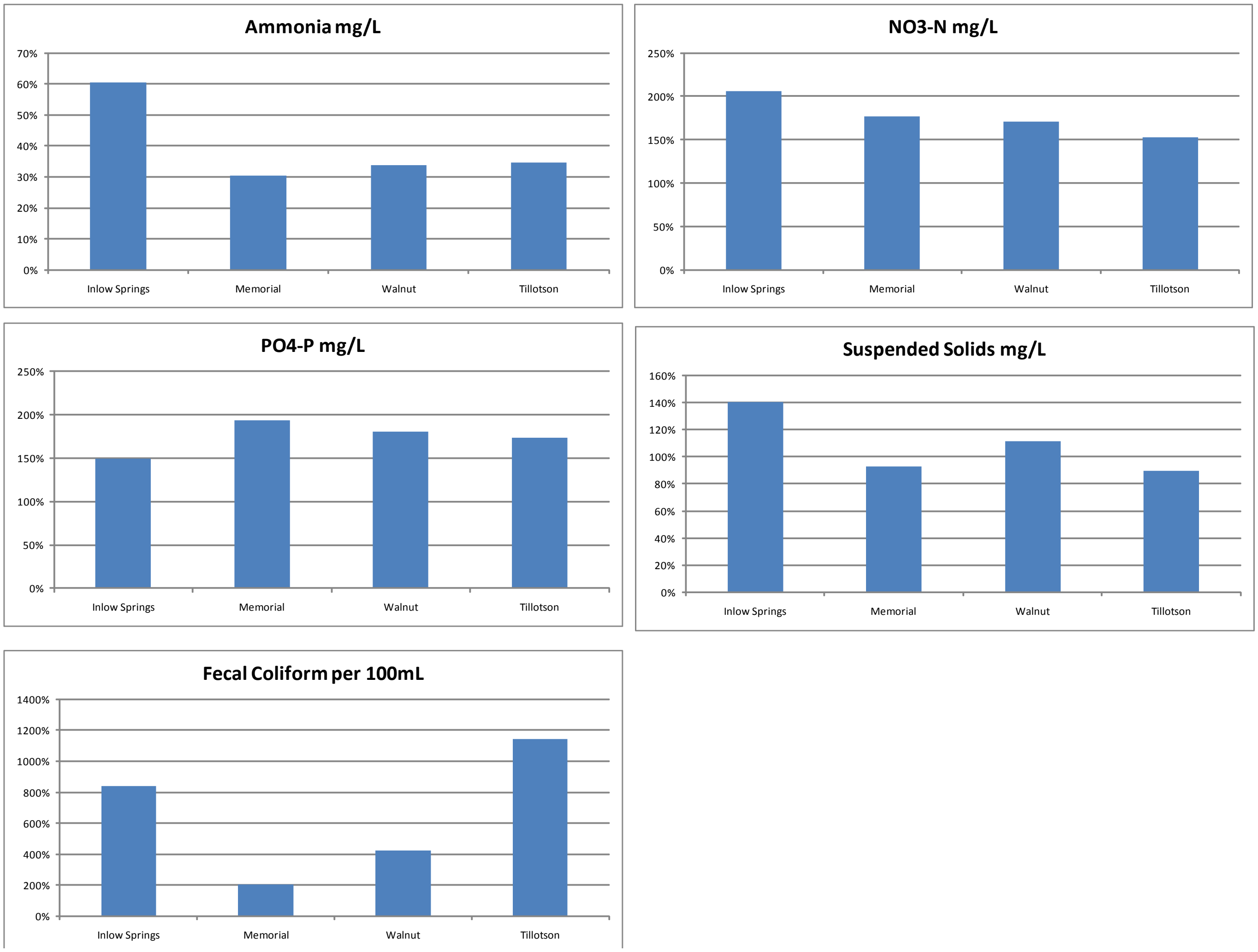
TABLE 2.62: Tilllotson Ave. Nonpoint Source Pollutants

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.

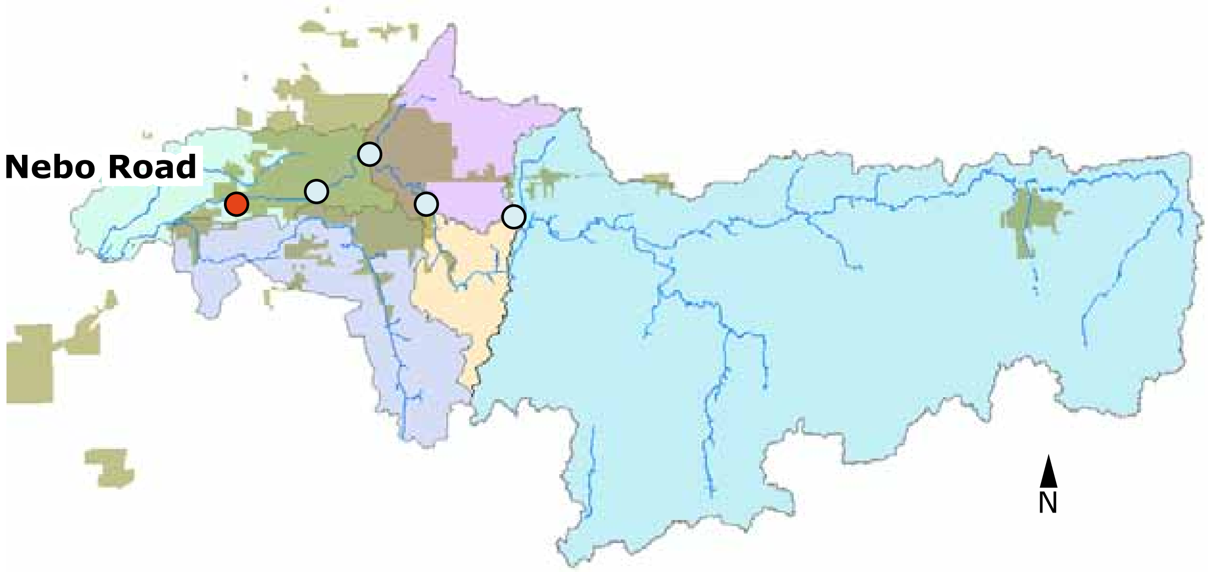
INVENTORY

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.

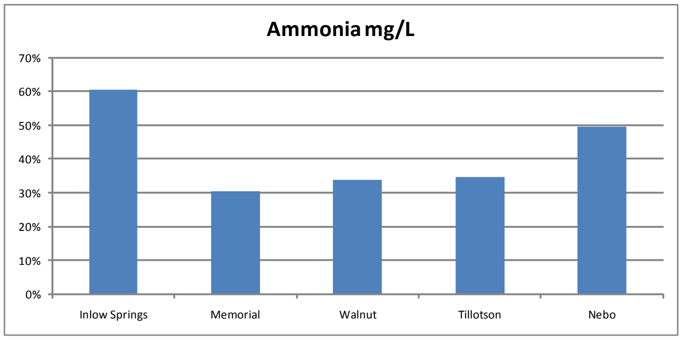
TABLE 2.63: Nebo Road Nonpoint Source Pollutants

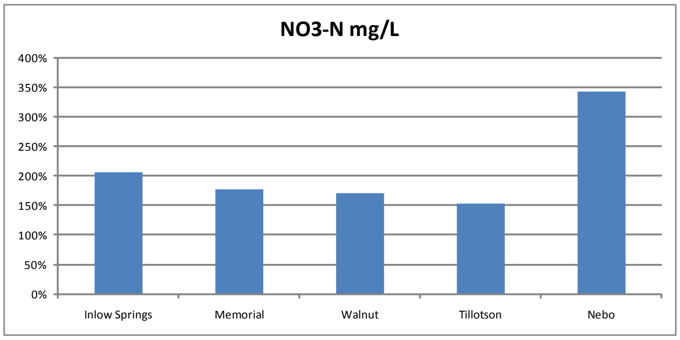
Nebo Road	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.10	86	6	7%
NO3-N mg/L	1.00	3.42	80	59	74%
PO4-P mg/L	0.08	0.60	50	50	100%
Suspended Solids mg/L	30.00	27.69	86	19	22%
Fecal Coliform per 100mL	235.00	5823.72	92	64	70%

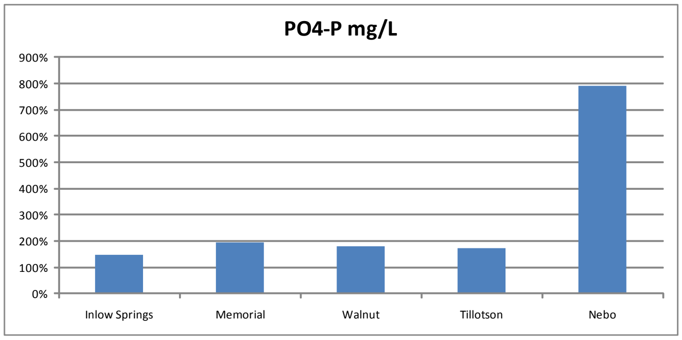
This site had 96 samples taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.61; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 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.

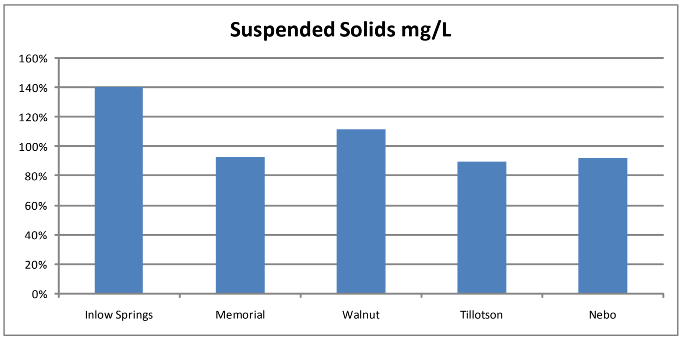


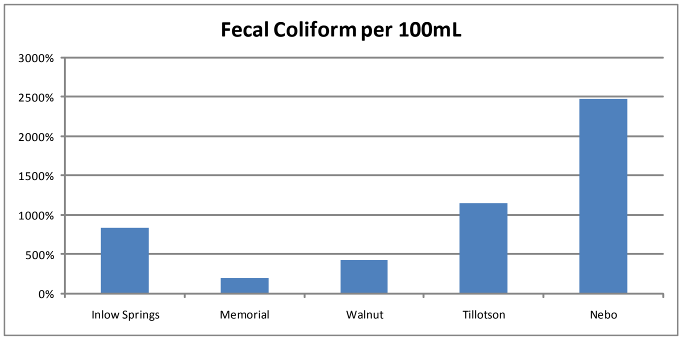
MAP. 2.75 Nebo Road Sampling Location











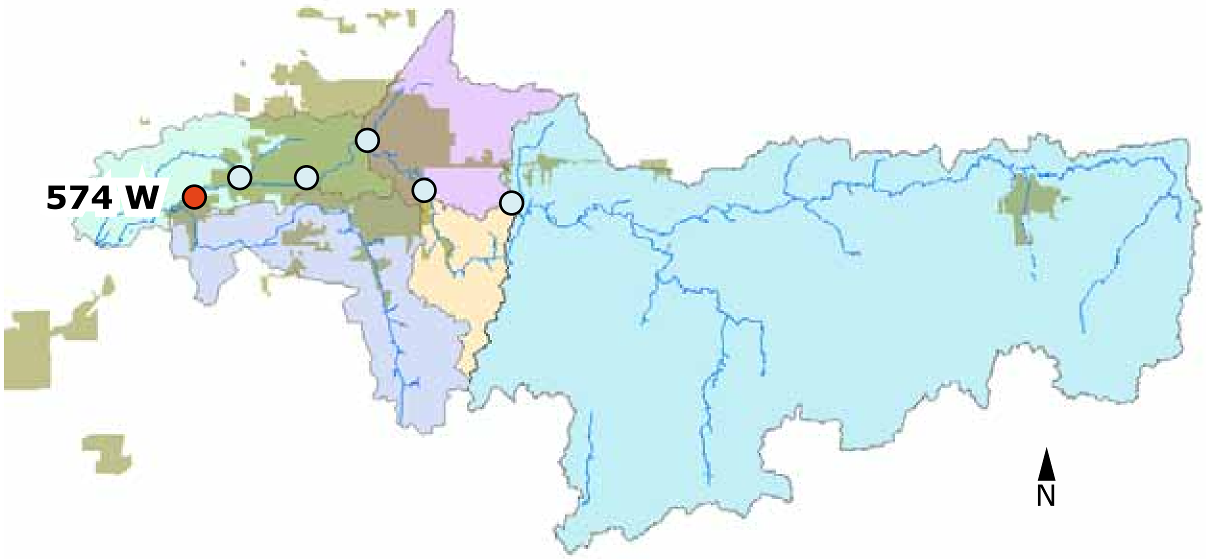
CHA. 2.61 Pollutants by Exceedence; comparison of sampling points.

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.

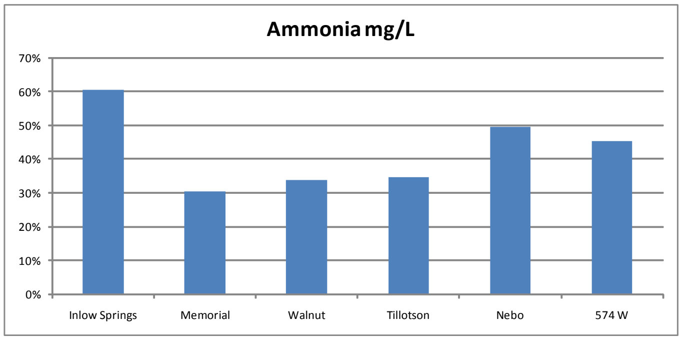
TABLE 2.64: 574 W Nonpoint Source Pollutants

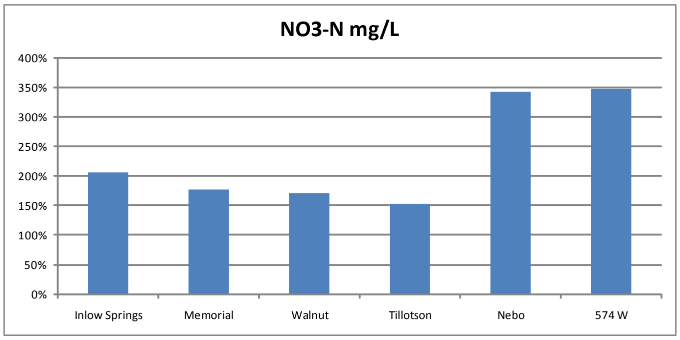
574 W	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.10	1166	56	5%
NO3-N mg/L	1.00	3.47	279	60	22%
PO4-P mg/L	0.08	0.43	282	61	22%
Suspended Solids mg/L	30.00	22.17	1167	196	17%
E. coli per 100mL	235.00	2762.96	785	352	45%

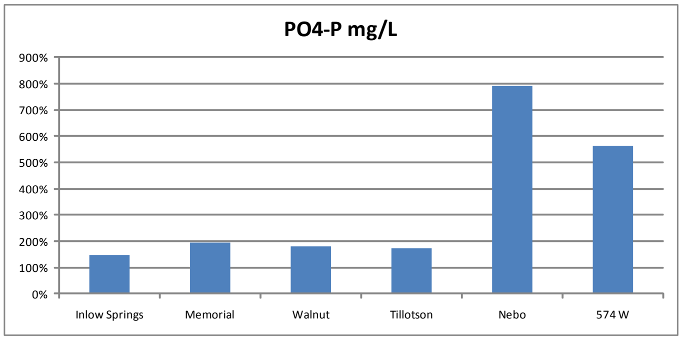
This site had varying degrees of samples (per impairment) over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.62; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels 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.

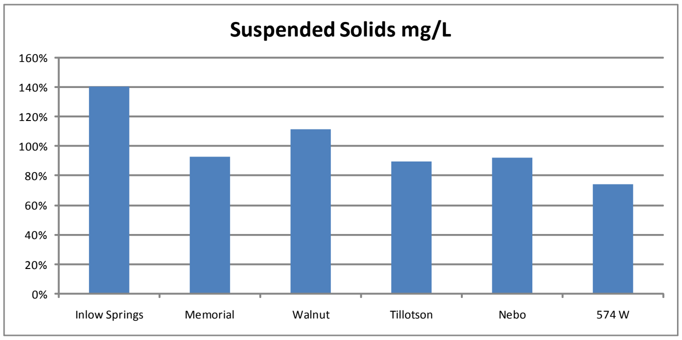


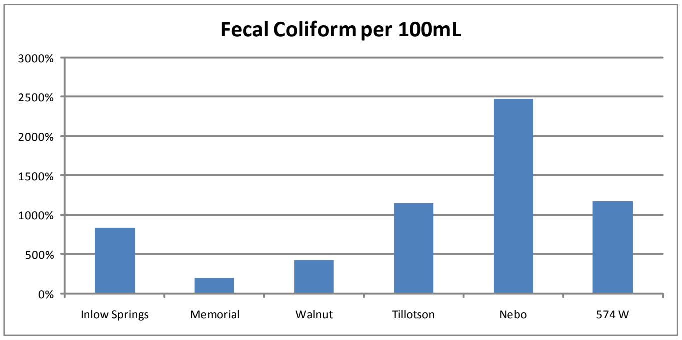
MAP. 2.76 574 W Sampling Location











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

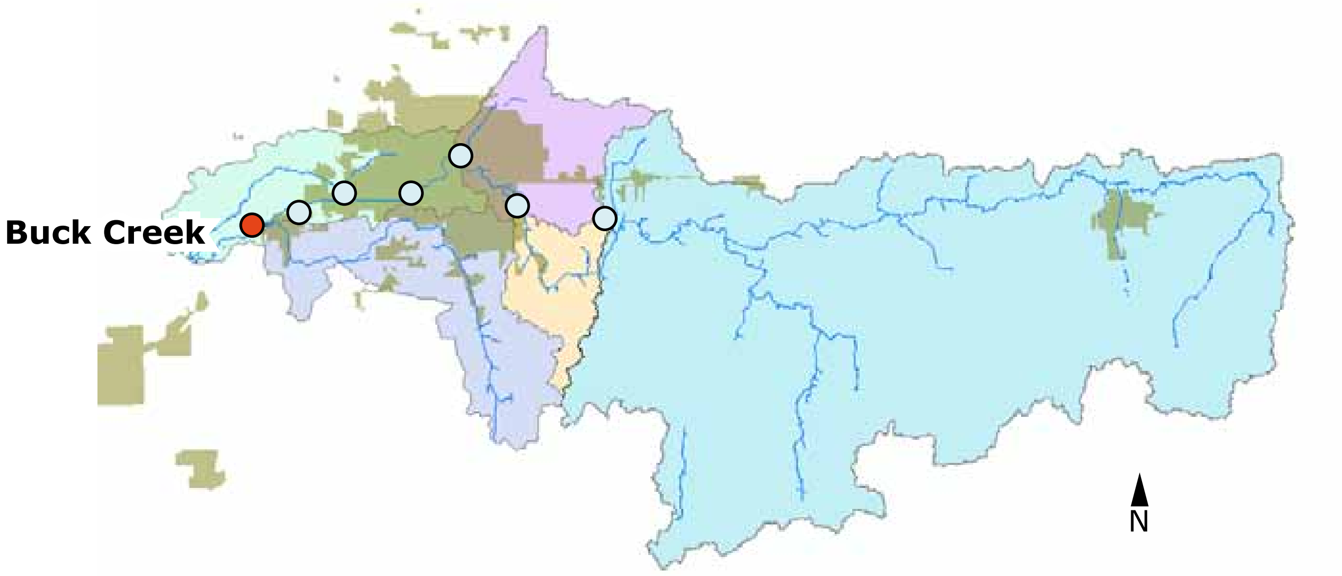
INVENTORY

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.

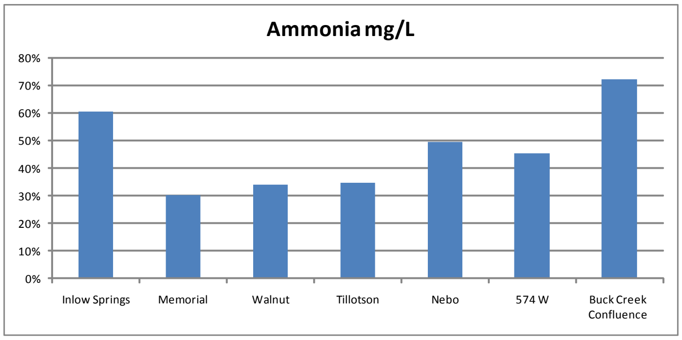
TABLE 2.65: Buck Creek Confluence Nonpoint Source Pollutants

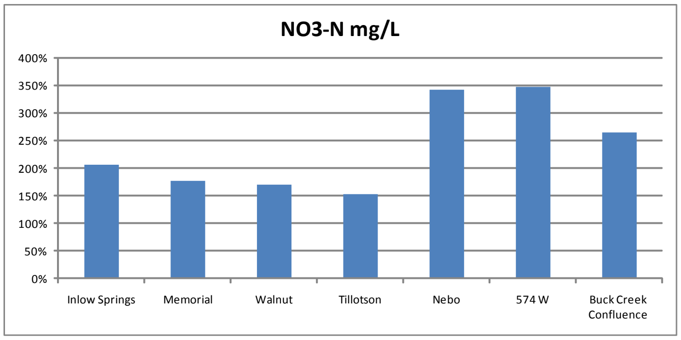
Buck Creek Confluence	max	average	count	Exceedence (E)	% of E
Ammonia mg/L	0.21	0.15	8	2	25%
NO3-N mg/L	1.00	2.65	8	7	88%
PO4-P mg/L	0.08	0.37	8	8	100%
Suspended Solids mg/L	30.00	95.65	8	3	38%
Fecal Coliform per 100mL	235.00	4528.75	8	6	75%

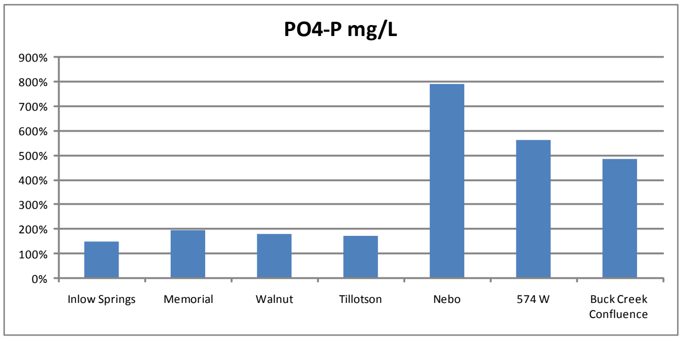
This site had 8 samples taken over the three year sampling period. The percentage by which each parameter exceeds state water quality standards can be seen in Chart(s) 2.63; comparing other Mainstem sampling points (continuing as you travel downstream). The Ammonia as N levels at this site averaged 0.15 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.

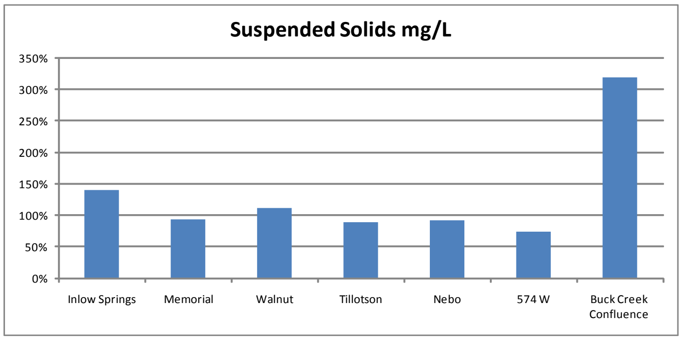


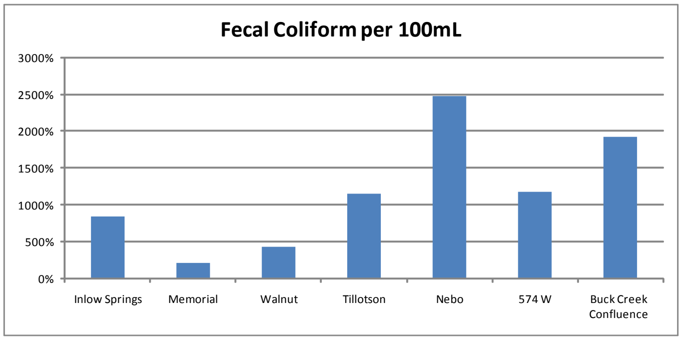
MAP. 2.77 Buck Creek Confluence Sampling Location











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 transsect 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.

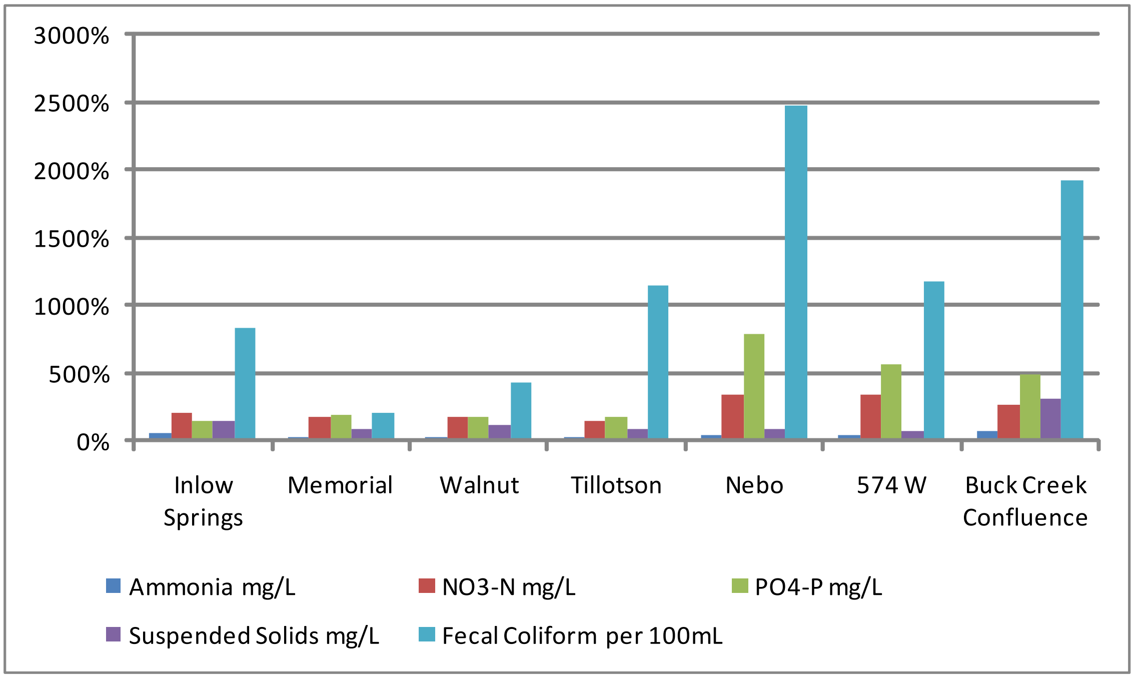
E. coli begins to exceed the state standard by more than 1000% as it moves into the Muncie Urban core. A significant spike occurs at Nebo road downstream of the WPCF. The Muncie BWQ tests the plant daily and it rarely exceeds 10 cfu/100 ml due to chlorination. Water from the plant is almost sterile in 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

INVENTORY

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, 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. (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.

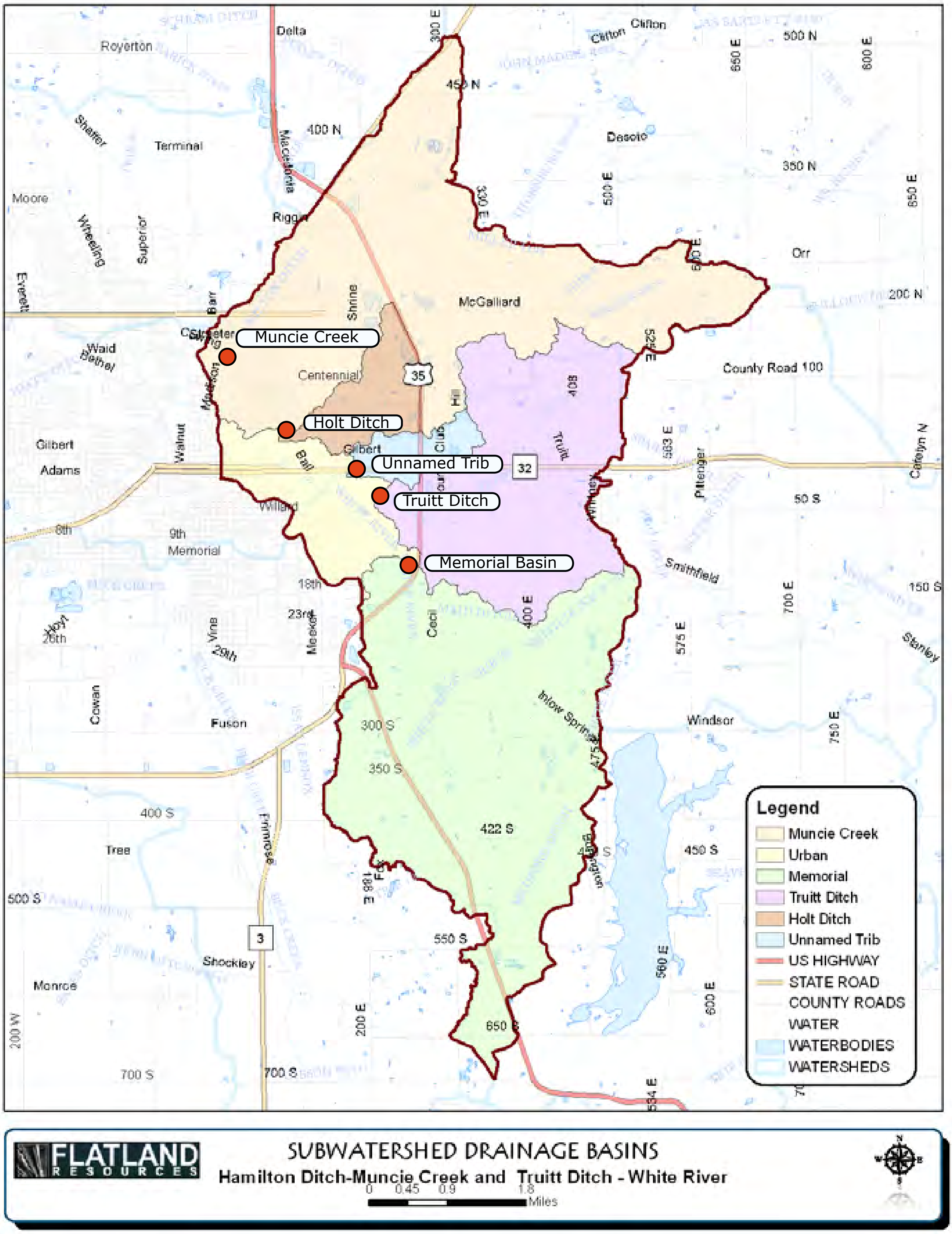
Primary Subwatershed Drainage Basins

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. [1]

TABLE 2.67: Primary Drainage Basins	Acres	Stream Mi.
Total Combined Subwatersheds	19,654	31
Walnut Basin	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
Memorial Basin	7,184	11
Randolph County - Upper White River Headwaters Basin	130,842	204
SOURCE: ArcGIS Indianamap.org		

1 Data Generated by ArcGIS



MAP. 2.78 Location of Drainage Basins

INVENTORY

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.

TABLE 2.70: Unnamed Tributary Basin Nonpoint Source Pollutants					
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.

TABLE 2.71: Truitt Ditch Basin Nonpoint Source Pollutants					
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

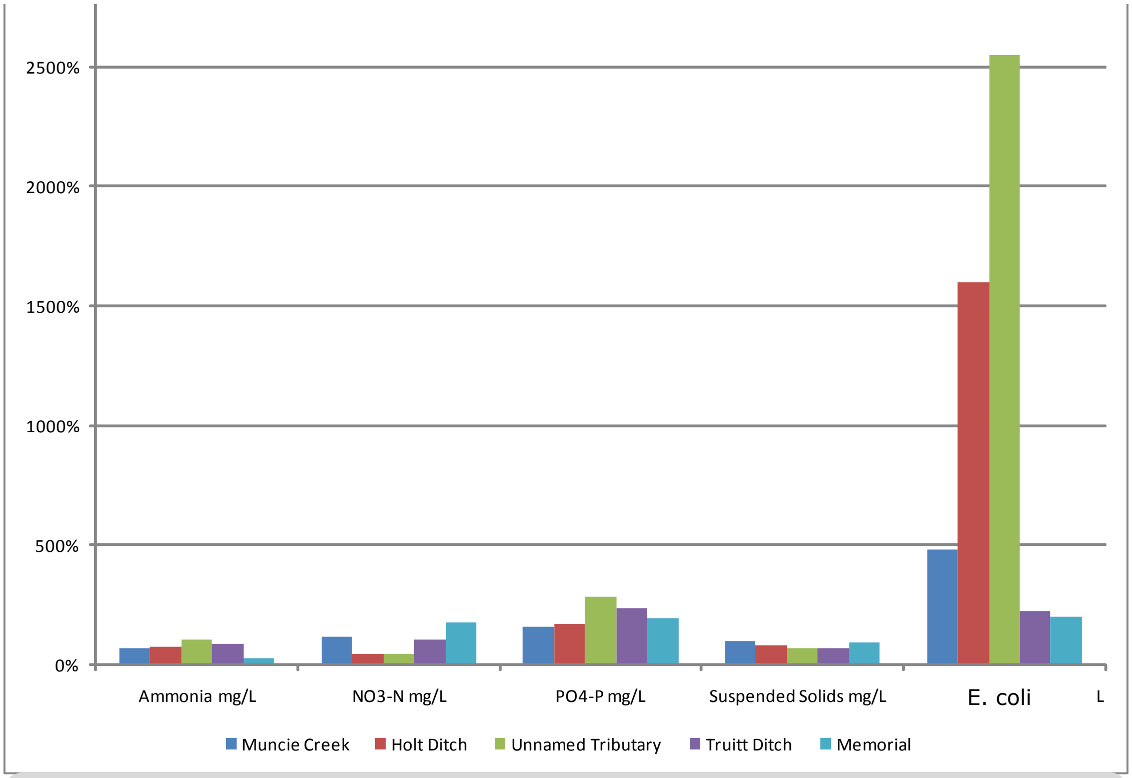
Memorial	max	average	count	exceedence	%
Ammonia mg/L	0.21	0.06	1006	20	2%
NO3-N mg/L	1.00	1.76	184	36	20%
PO4-P mg/L	0.08	0.15	187	41	22%
Suspended Solids mg/L	30.00	27.88	1007	193	19%
Fecal Coliform per 100mL	235.00	476.91	557	209	38%

INVENTORY

Sub-basin Trends

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 McCullouch 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 Sus-pended 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

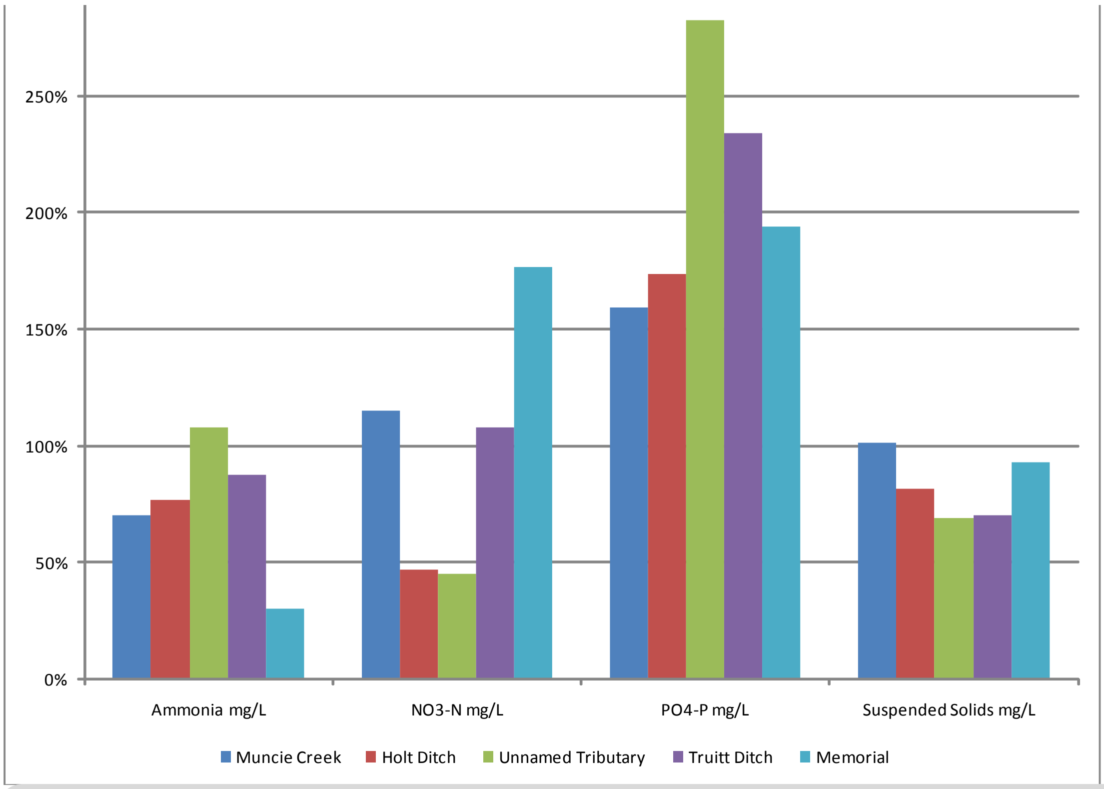


CHA. 2.65 Basin comparison of Nonpoint Source Pollutants

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 Boule-vard	Muncie Creek at McCullouch Bou-levard
Ammonia as N	38.89	93.94	80.65	90.91	75.76
E. coli by Mem-brane 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 Suspend-ed Solids	30.56	18.18	16.13	27.27	15.15
Turbidity	75.00	63.64	45.16	51.52	87.88
Dissolved Oxy-gen	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)

INVENTORY

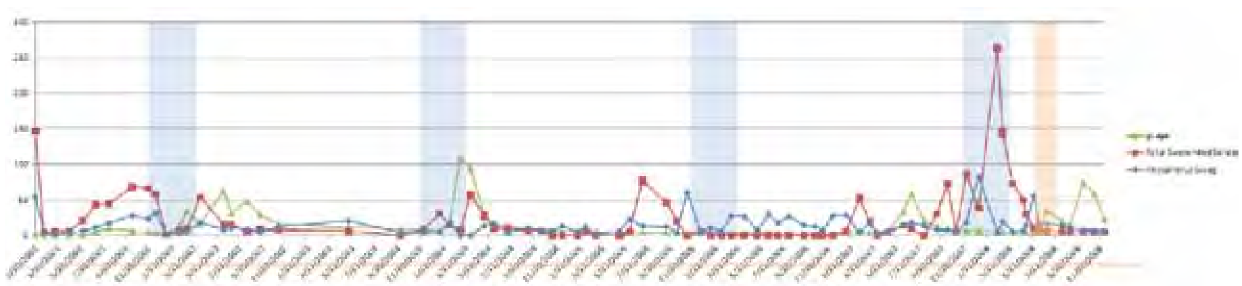
Sub-basin Trends

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

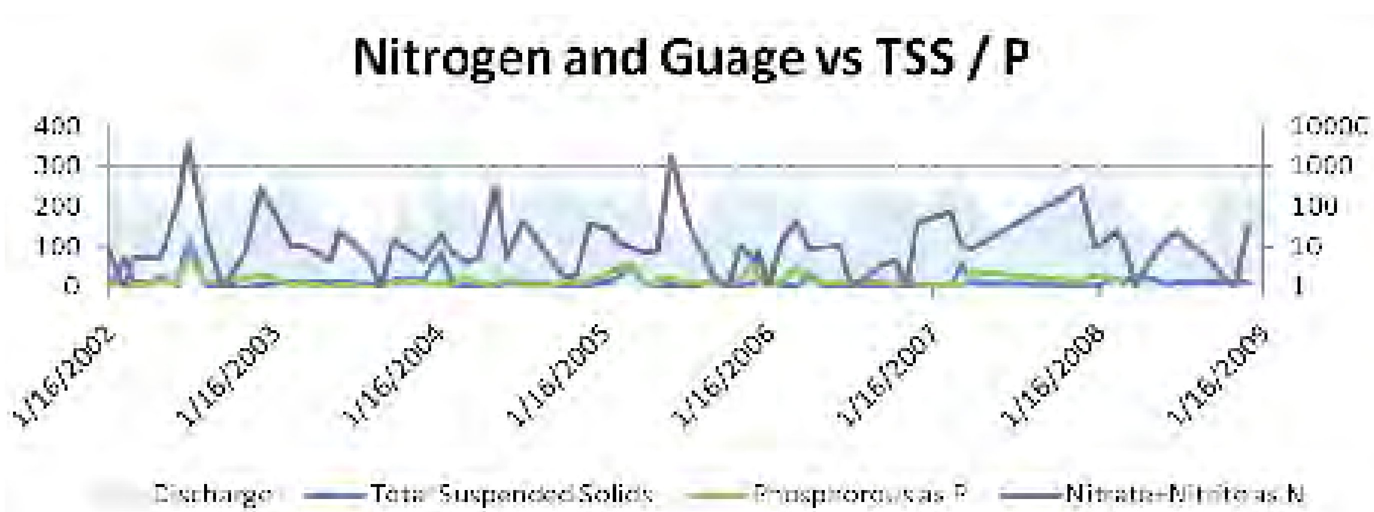
General Basin Level trends

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.

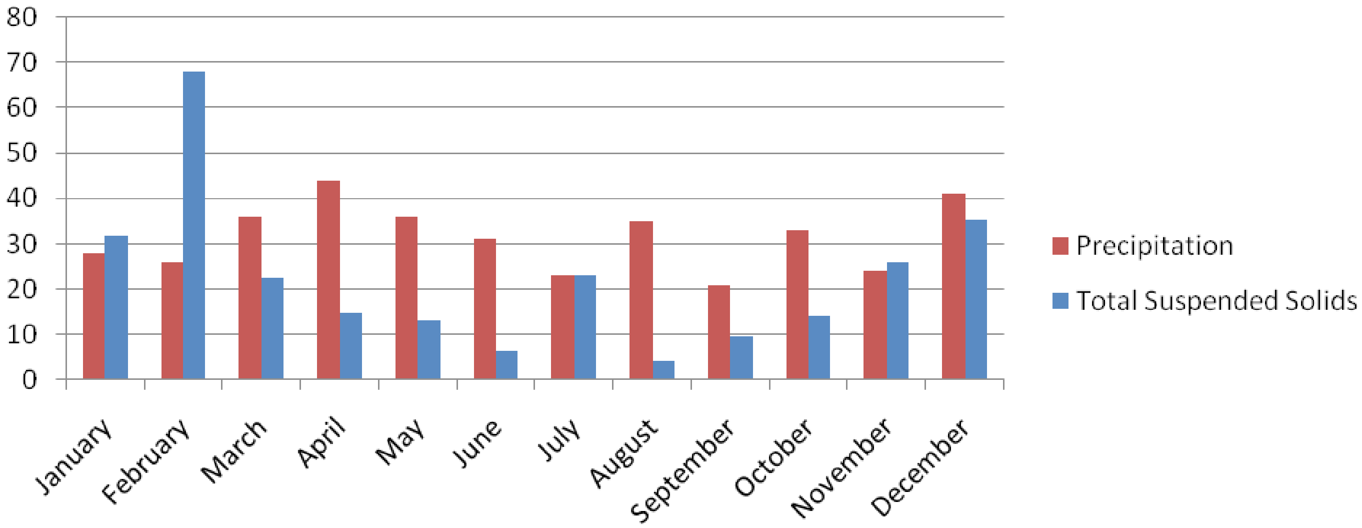
Nitrogen, phosphorus, and sediment were also compared at two sampling locations. Data shows a greater correlation between sediment and phosphorus than nitrogen and all others, confirming national trends that indicate show phosphorus attaching and migrating with sediment. (Chart 2.67) Nitrogen fluctuation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



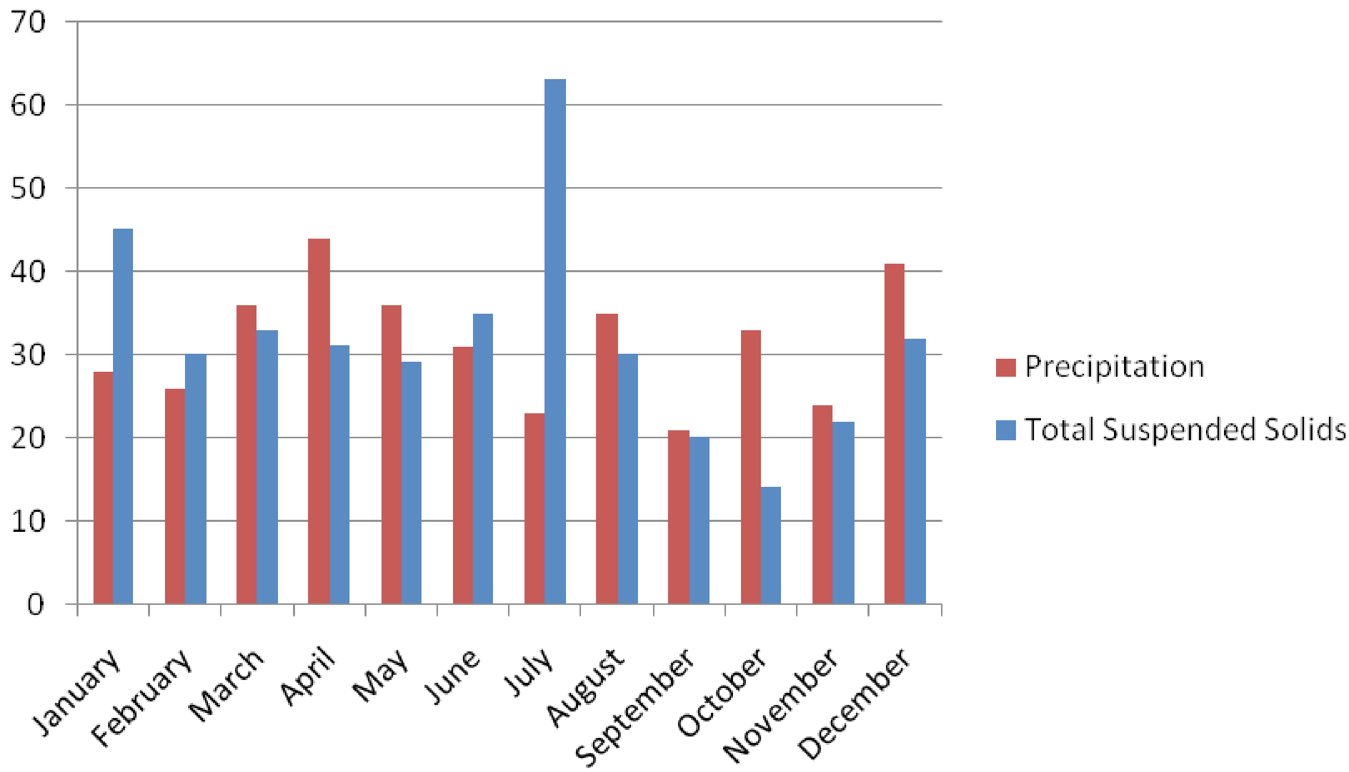
CHA. 2.67 Spikes in TSS and Phosphorus During non growing seasons



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)

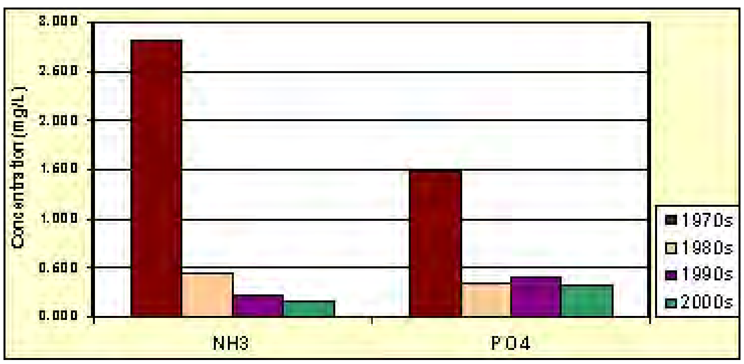
These studies were important in demonstrating the role vegetation can play as a means to stabilizing soil and concurrently reducing the amount of phosphorus and ammonia entering our streams (through soil attachment). When we compare phosphorus and sediment spikes to the growing seasons, we see increases 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

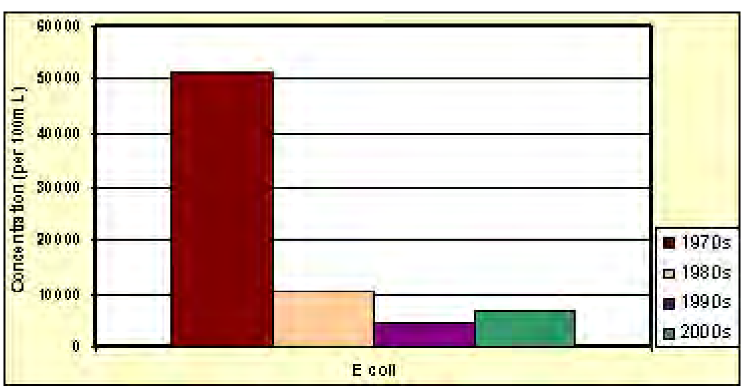
Historic vs. Baseline Water Quality Data Trends

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.



CHA. 2.71 Historic Ammonia Reductions

Ammonia (NH3) has seen a 94% reduction since the 1970s, while phosphate (PO4) has seen a 78% reduction



CHA. 2.72 Historic E. coli Reductions

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

TABLE 2.75: Summary of baseline water quality data				
Parameter	Target Level	Units	Truitt Ditch at Butterfield Road	Muncie Creek at McCullouch 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

INVENTORY

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 McCullouch Boulevard	Baseline Data for Muncie Creek at McCullouch 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.

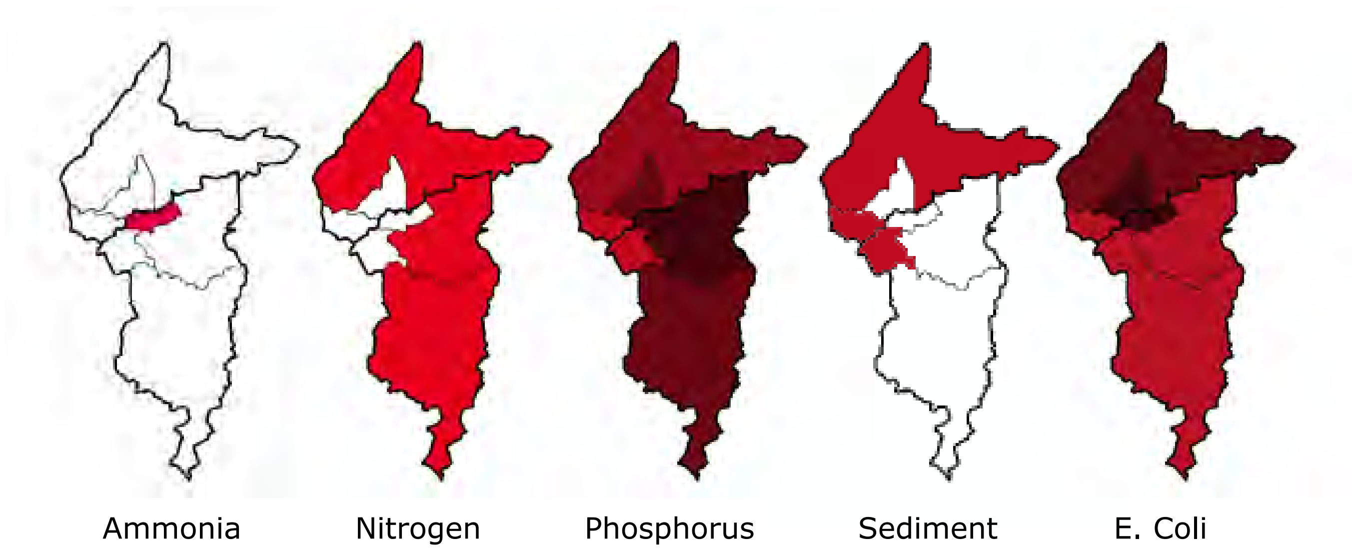
The Unnamed Tributary basin was the only basin that exceeded the state standard for Ammonia during the sampling period.

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



DIA. 2.14 Critical Pollutants in each Basin

INVENTORY

SECTION THREE - BIOLOGICAL INVENTORIES

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

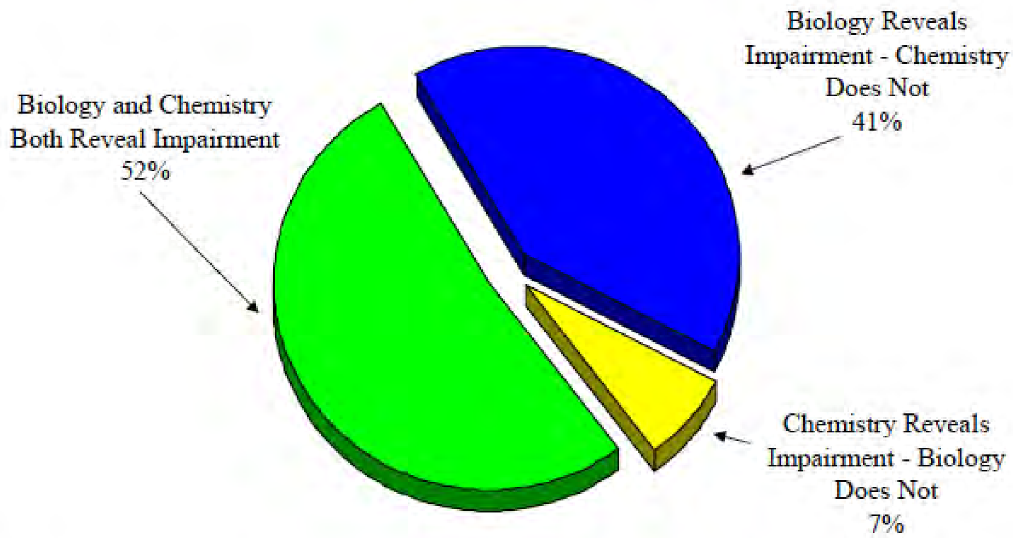
Biological Inventories
WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 1

"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." [1]

"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." [2]

"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." [3]

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 impairement, BWQ

INVENTORY

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." [1]

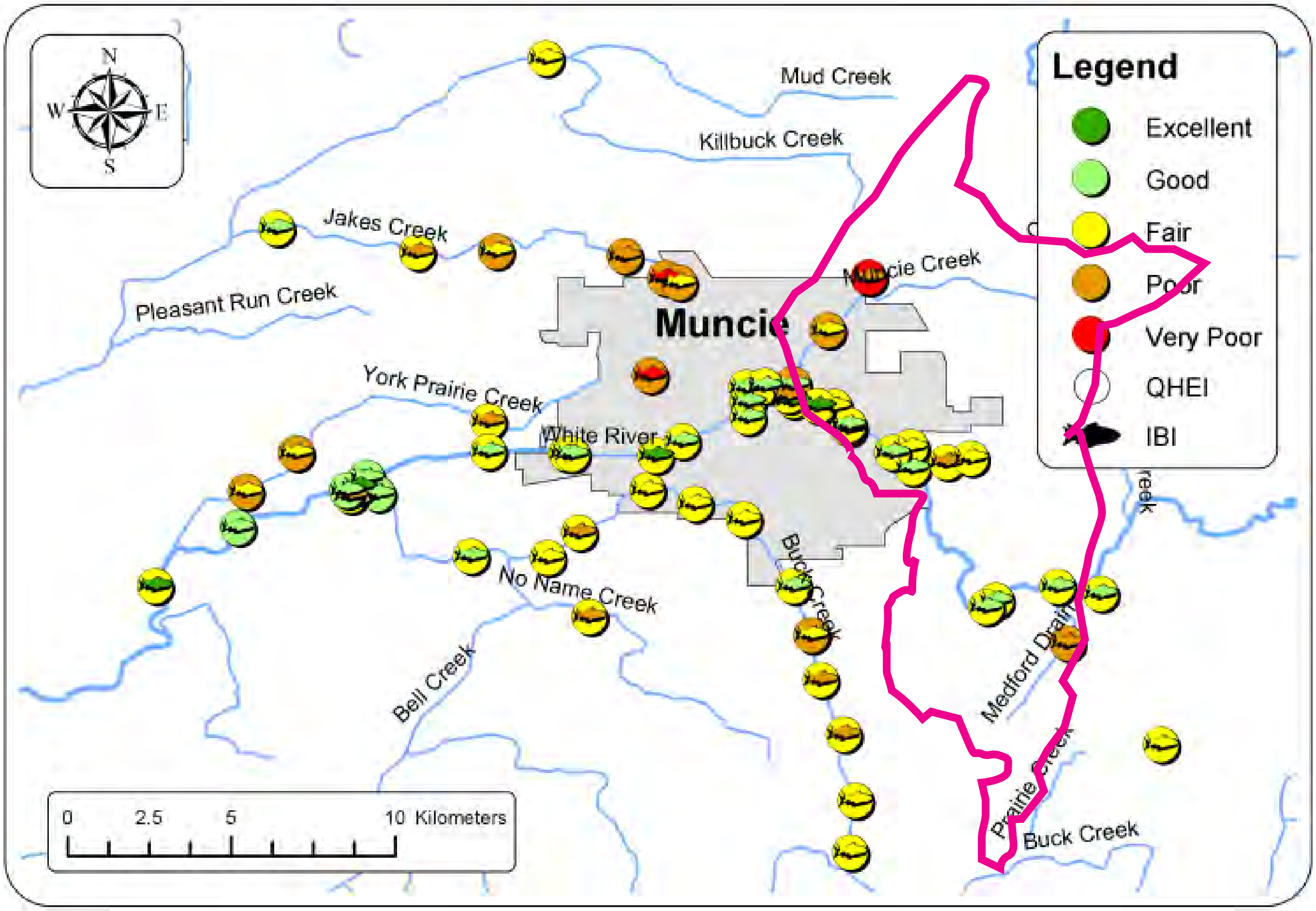
Index of Biotic Integrity and Modified Index of Well-Being
"The Muncie Bureau of Water Quality sampled 62 sites from the West Fork White River and its tributaries in Delaware County in 2010 in order to evaluate the health and integrity of their fish communities. IBI scores for 2010 ranged from a low of 18 very poor at York Prairie Creek near Maddox 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."[2]

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."[3] (Chart 2.74, 2.75)

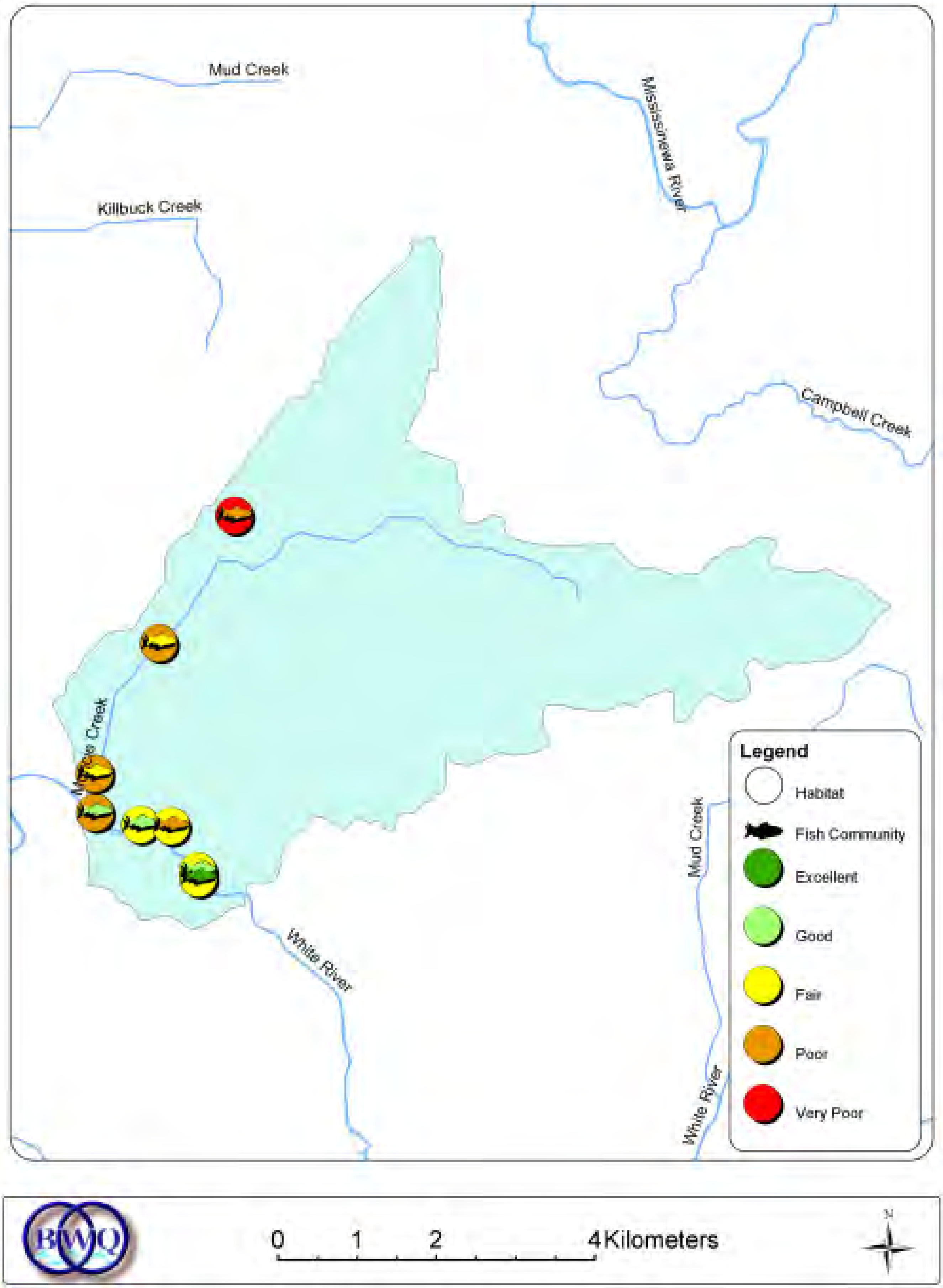
1 BWQ Annual Fish Community Report
2 BWQ Annual Fish Community Report
3 BWQ Annual Fish Community Report



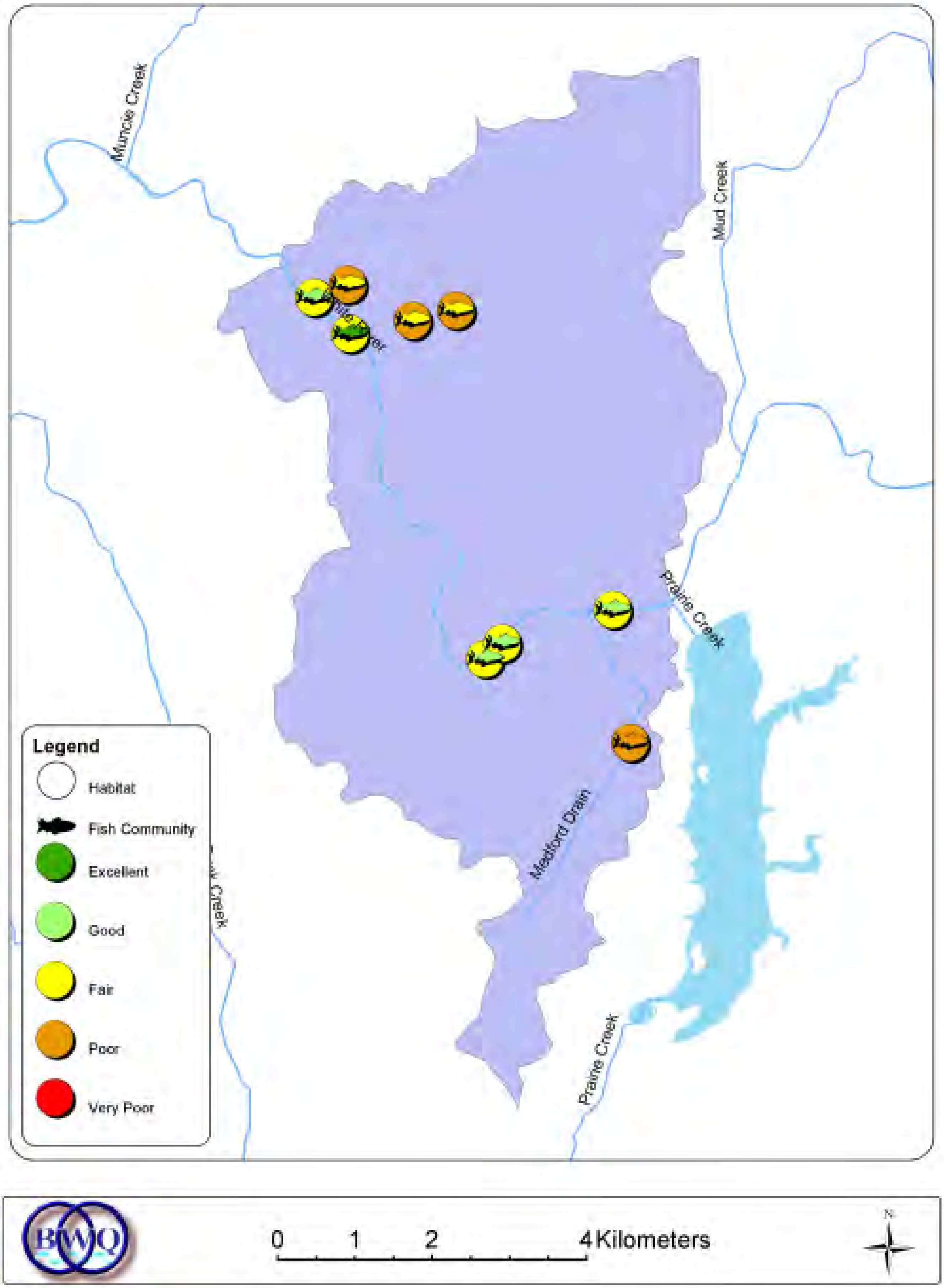
MAP. 2.79 QHEI and IBI Scores in Delaware County, BWQ

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

INVENTORY

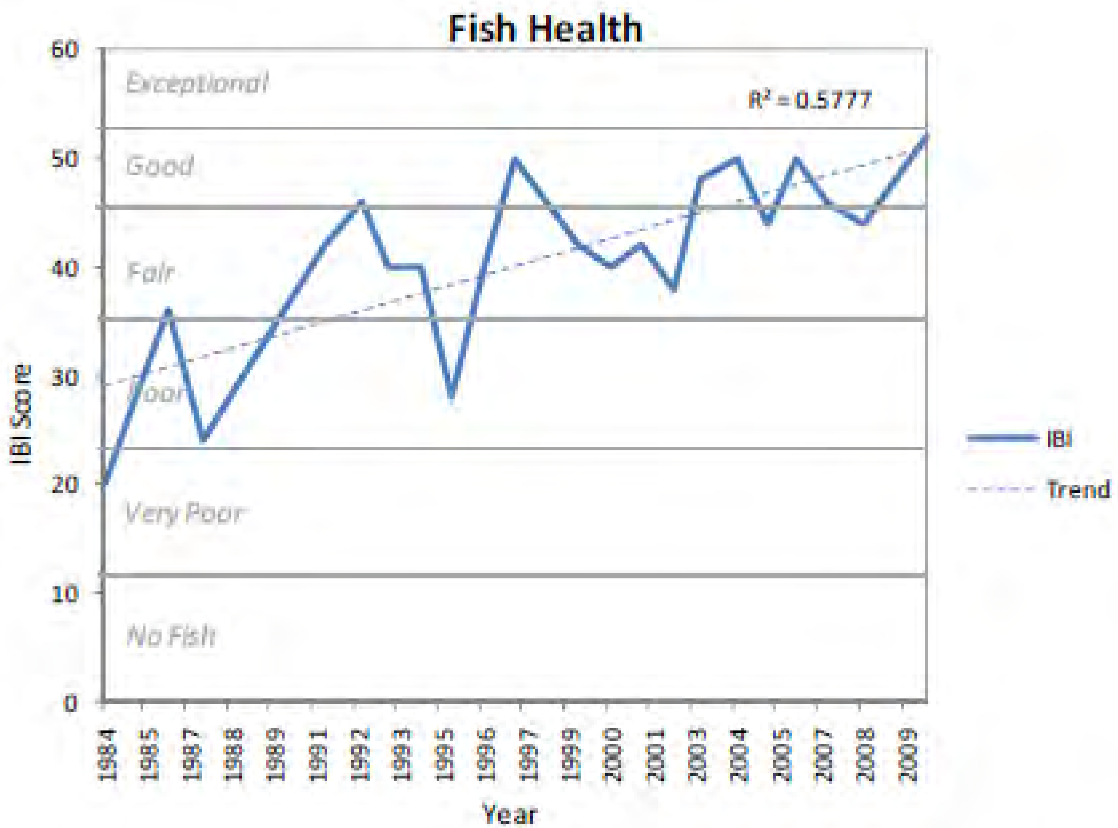


MAP. 2.80 Hamilton Ditch-Muncie Creek QHEI and IBI Scores

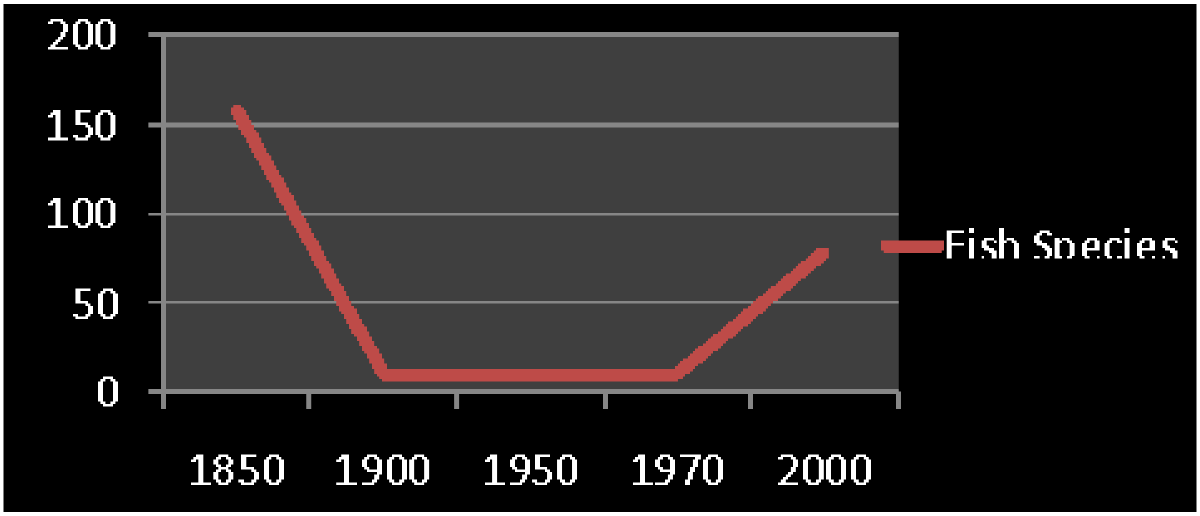


MAP. 2.81 Truitt Ditch - White River QHEI and IBI Scores

INVENTORY



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

INVENTORY

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)." [1]

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." [2] (Chart 2.76, Table 2.82)

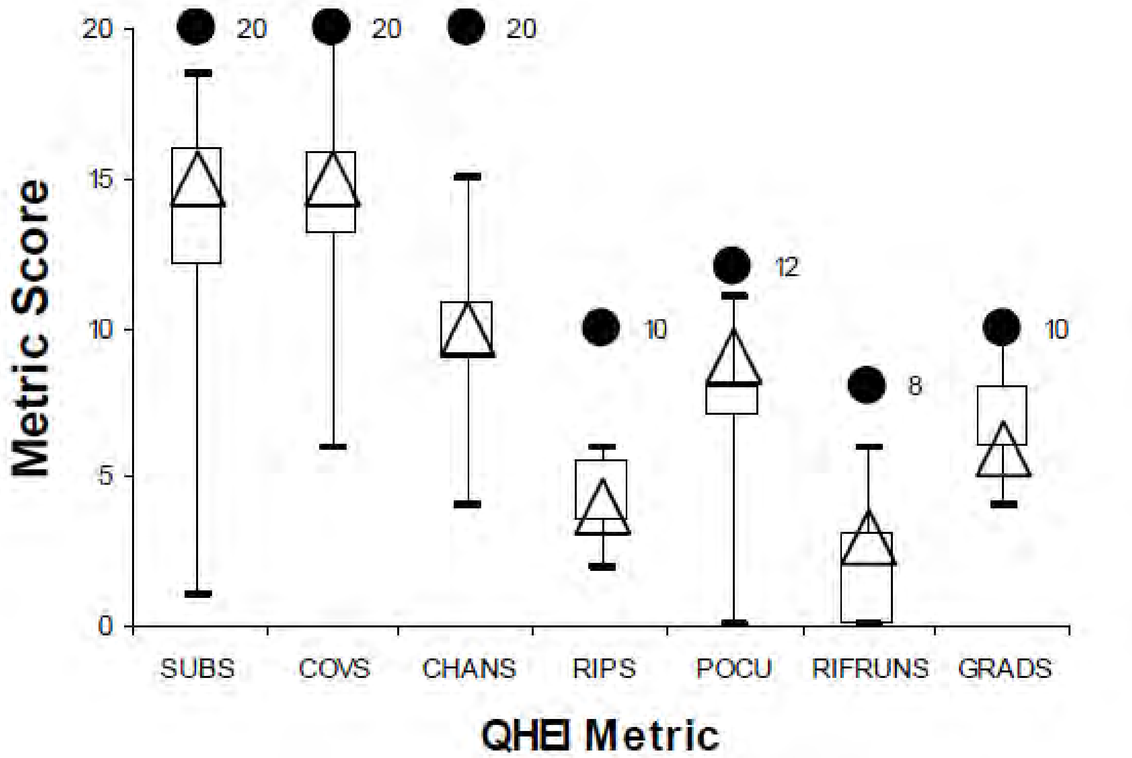
QHEI Comparison to IBI
"Comparison of QHEI scores to biological index scores is a vital step in determining potential sources of impaired biological communities. Habitat quality is often the limiting factor of biological integrity; therefore, the quality of a fish community rarely exceeds the quality 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." [3] (Chart 2.77)

TABLE 2.82: Stand Alone Indices

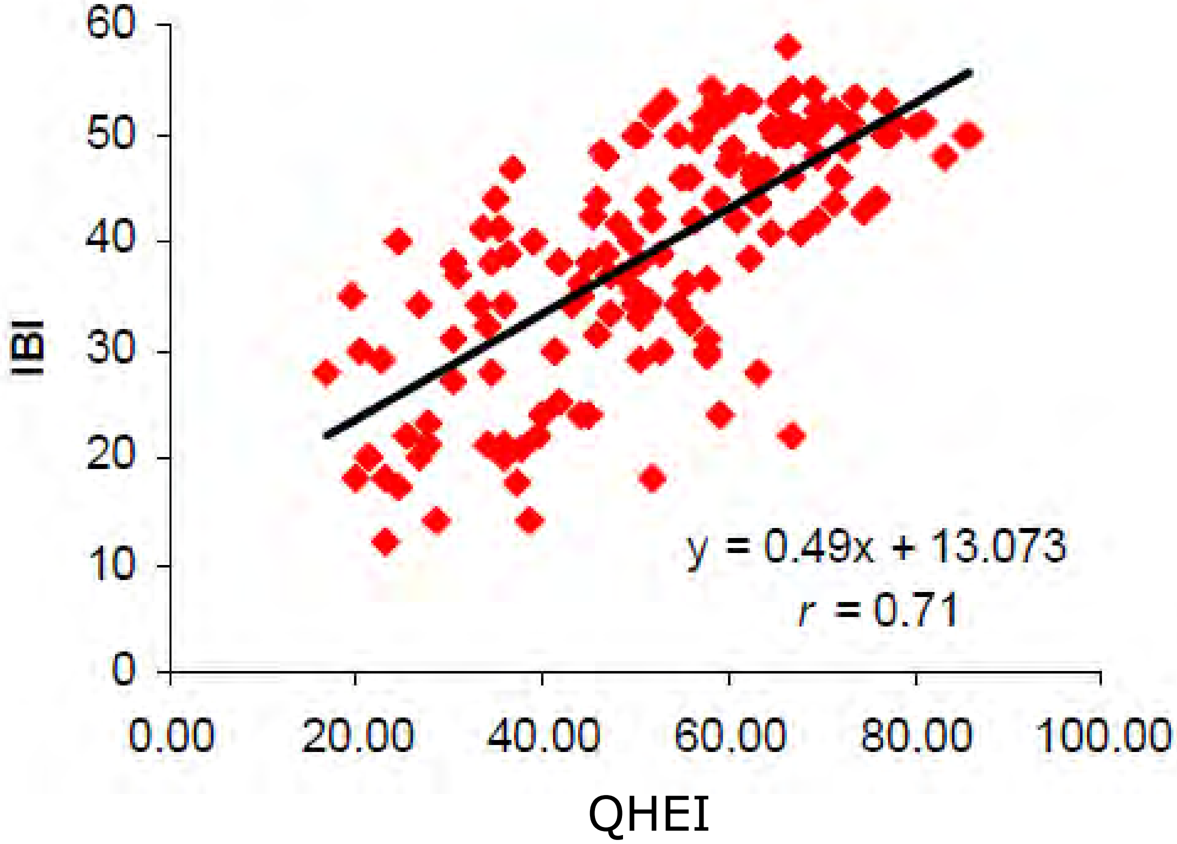
	TD-1	MC-1
Hilsenhoff Index	7.13	4.91
Shannon Index of Diversity	2.70	2.77
Shannon Evenness Index	0.90	0.90
% Dominance of Top Three Taxa	0.44	0.41
% Chironomidae	0.09	0.33
QHEI Scores	46.5	54.3
	Fair	Good
*results (except QHEI) are an average of duplicate QAQC samples; submetrics results for both samples 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:

IBI Score	MIwb Score	QHEI Score	Rating
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:

IBI Score	MIwb Score	QHEI Score	Rating
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

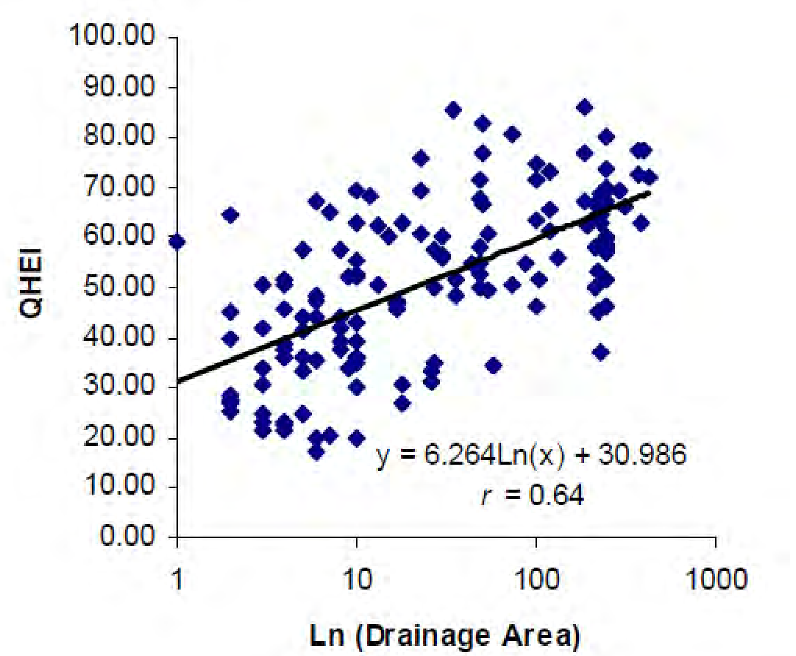
IBI, QHEI, and drainage

"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."[1]

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. [2]

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. [3]

This analysis suggests that the IBI can not be compared with the QHEI using standard linear models.[4]



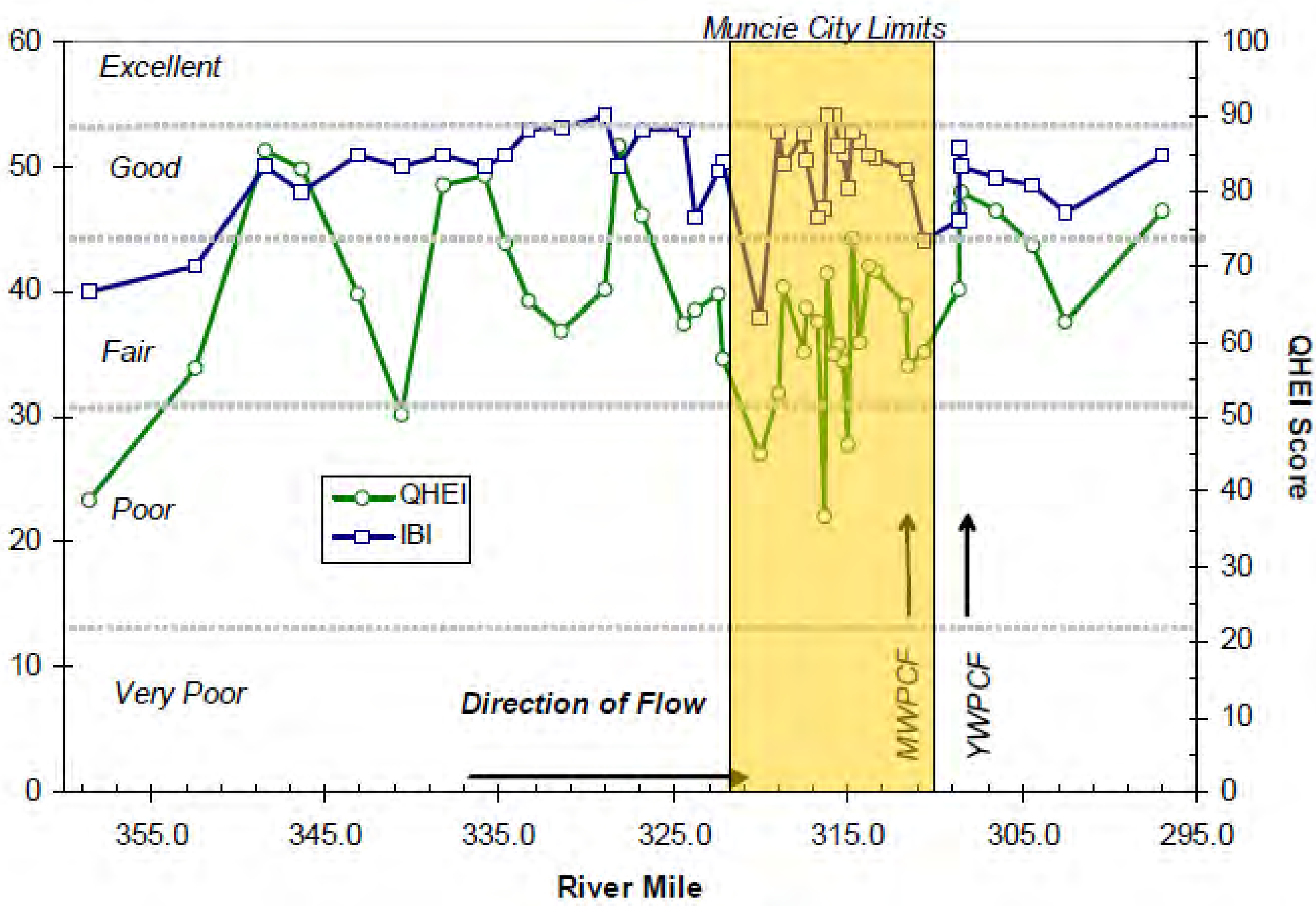
CHA. 2.78 QHEI per Drainage Area, BWQ

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." [1]

"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." [2]



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

1 BWQ Annual Fish Community Report
2 BWQ Annual Fish Community Report

INVENTORY

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.” [1]

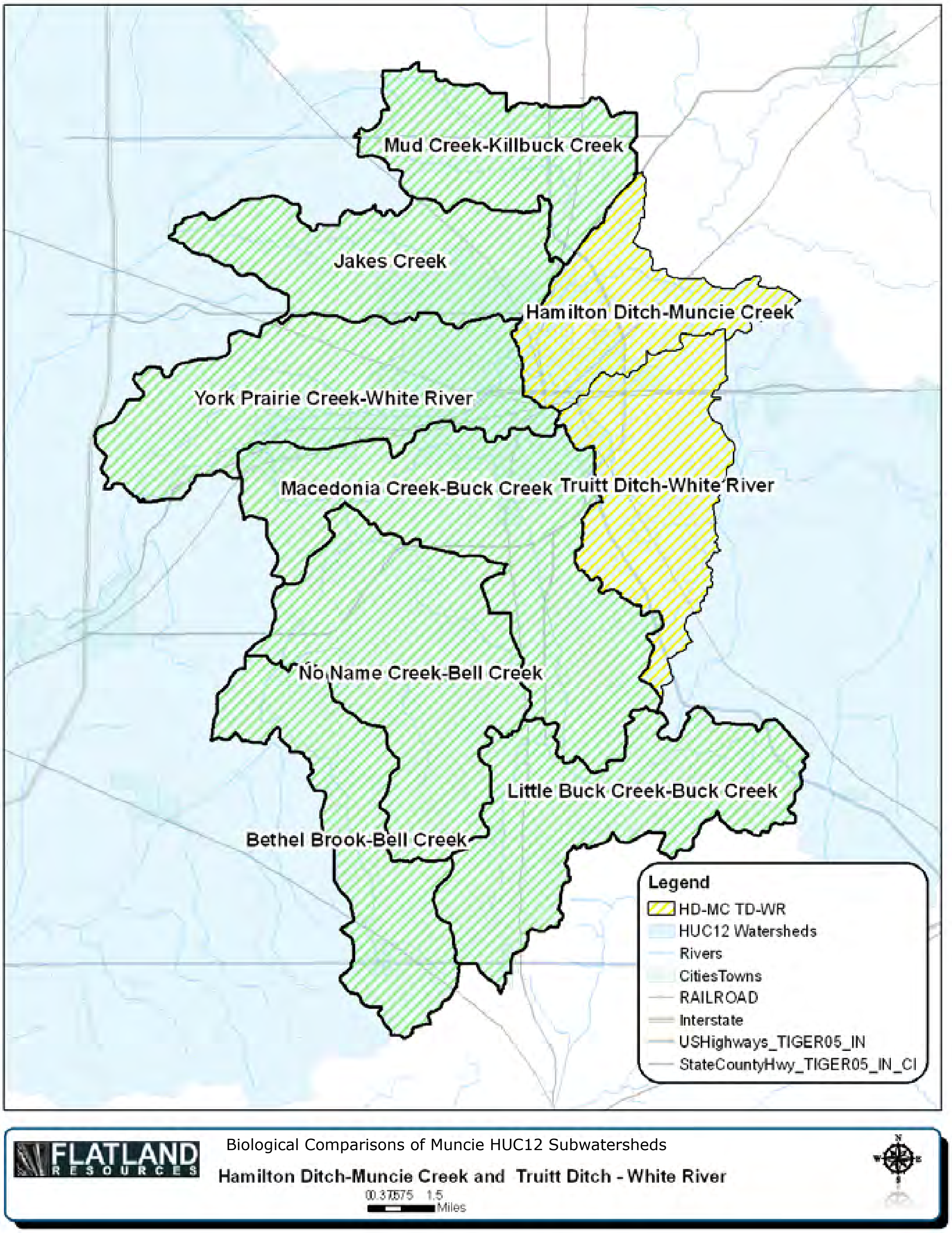
“Pair-wise comparisons indicated the White River – York Prairie Creek (WRYPC) (Map 2.82) watershed was the most unique as it was significantly different than all the other watersheds except the Jake’s Creek – Eagle Branch (JCEB) watershed . The WRYPC watershed primarily includes sites on York Prairie 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.” [2]

“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.” [3]

“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%).” [4]

This data confirms Maintstem White River Studies that concluded York Prairie Creek - White River and Jake’s Creek were more impaired that 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

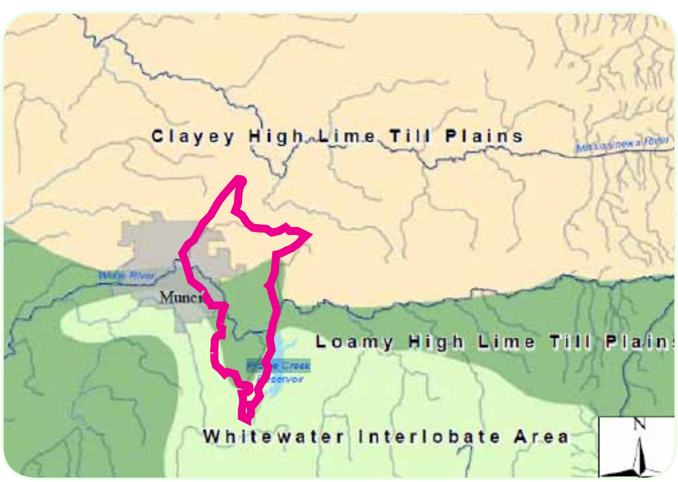
WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 7

The Muncie Bureau of Water Quality compared IBI scores based on locations in specific ecoregions. (2.81) Because the City of Muncie on the cusp of three major ecoregions, one for one comparisions 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.” [1]

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%).” [2]

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.” [3]



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 ± 4.3) followed by the WIA (60.1 ± 1.5) and the LHLTP (62.3 ± 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 LHTP. 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 mi2 would yield an IBI metric rating of 3 while the same number of species at a site with a drainage area of 1000 mi2 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." [4]

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." [5]

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:[1]

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.

1 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

INVENTORY

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. [1]

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. [2]

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). [3]

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. [1]

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.[2] 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.[3]

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

1 Indiana Integrated Water Monitoring and Assessment Report
2 Indiana Integrated Water Monitoring and Assessment Report
3 Indianapolis Star, indystar.com

INVENTORY

Macroinvertibrates

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

"As with fish communities, benefits to using mussels and macroinvertibrate 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: Macroinvertbrate 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

Macroinvertibrates 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 essential 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."

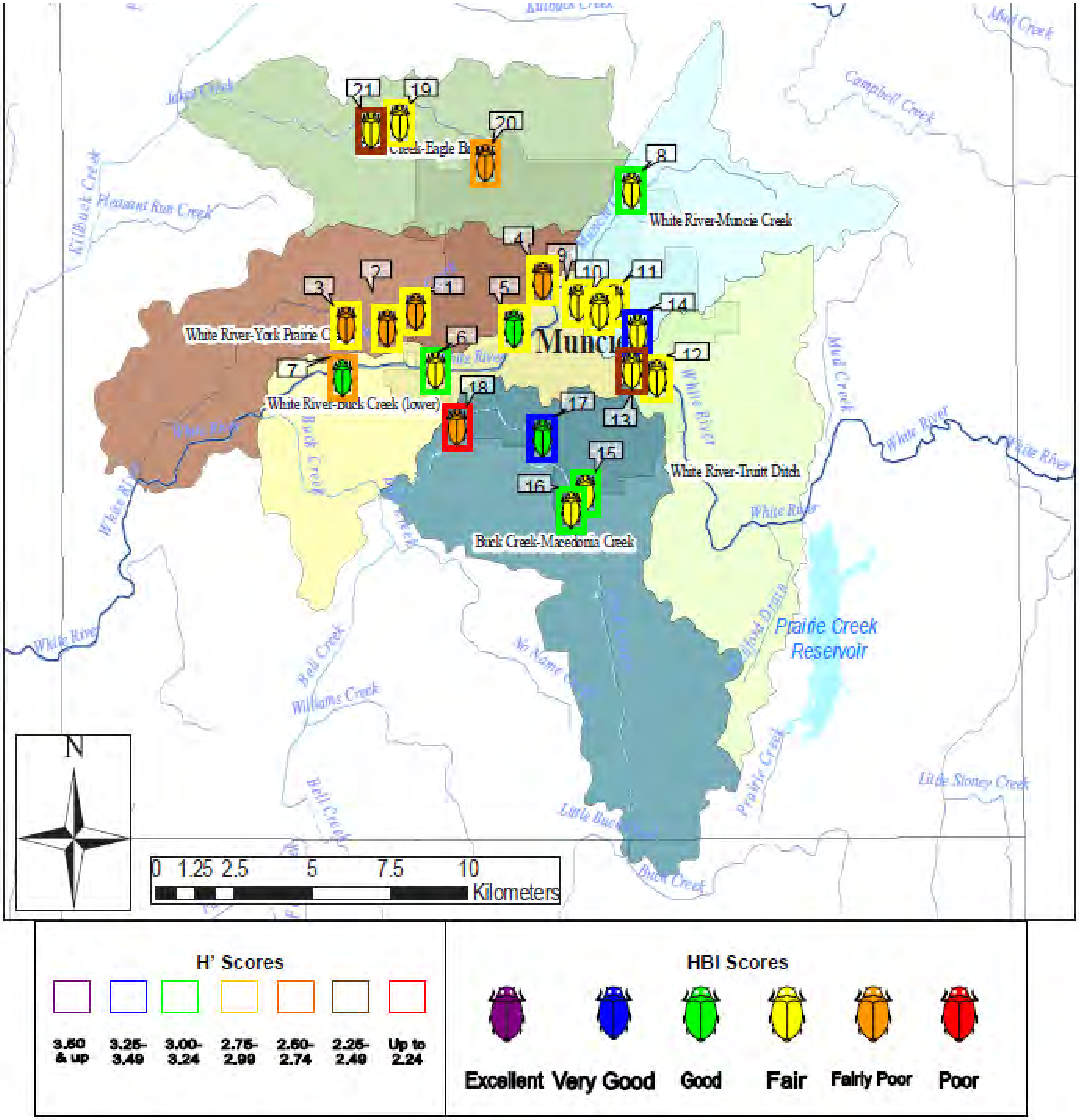
"Dramatic improvements have been seen County-wide since the inception of Muncie Bureau of Water Quality's macroinvertebrate and mussel sampling program. Point source pollutants have been controlled through the utilization of local permits regulated by the Bureau of Water Quality. Improvements have been 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."

Bureau of Water Quality

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



MAP. 2.84 Macroinvertibrate Scores

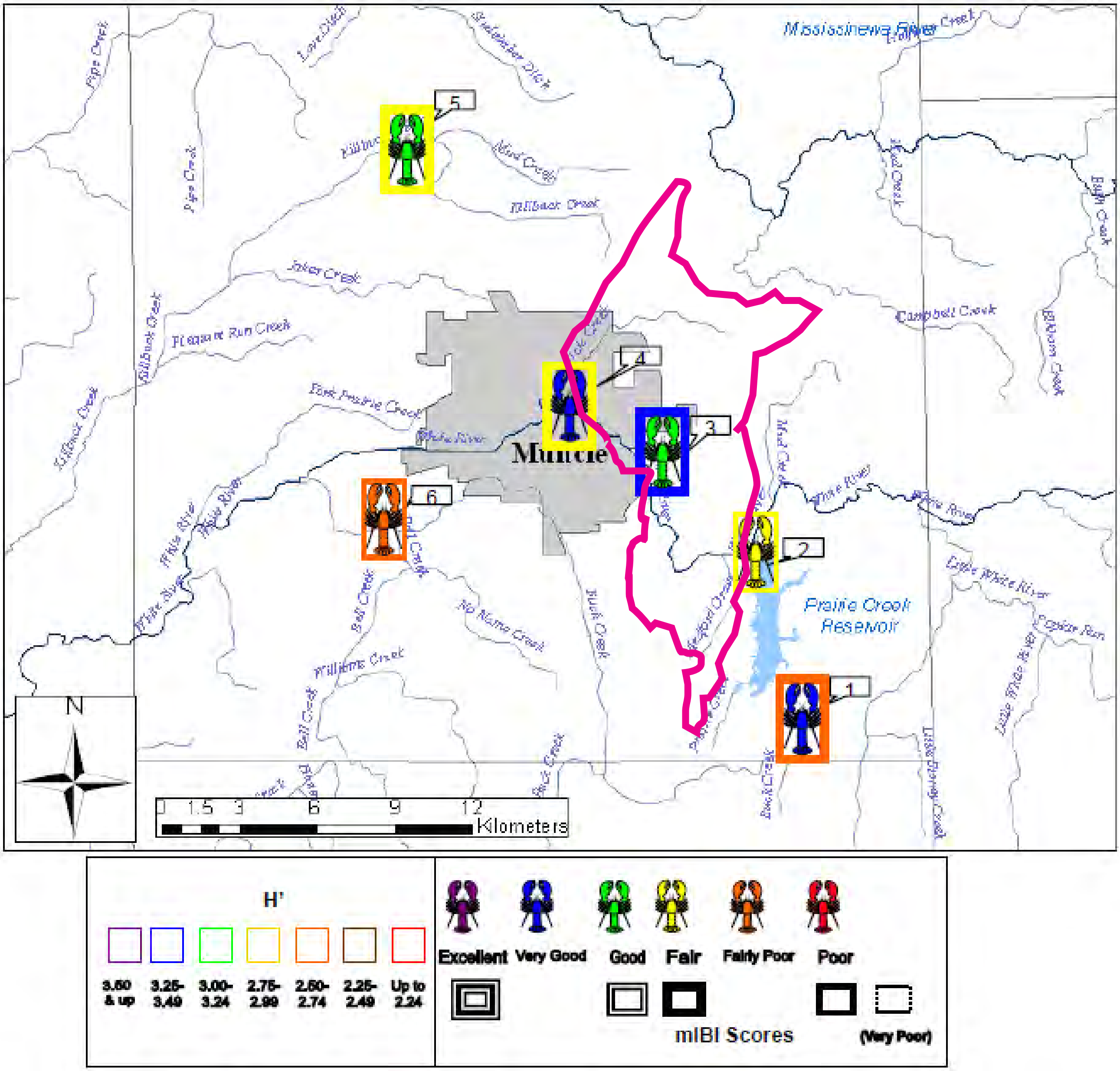
Macroinvertibrates Results
WMP - CHAPTER 2 - PART 2 - SECTION 3 - SUBSECTION 12

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

TABLE 2.89: Aquatic Insect Scoring Chart	
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 (hydromodifcation) 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.

Macroinvertibrates

Macroinveribates 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 macroinvertibrates. 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 (eutrophicantion) 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 macroinvertibrates. 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 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.

INVENTORY

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 aerials 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

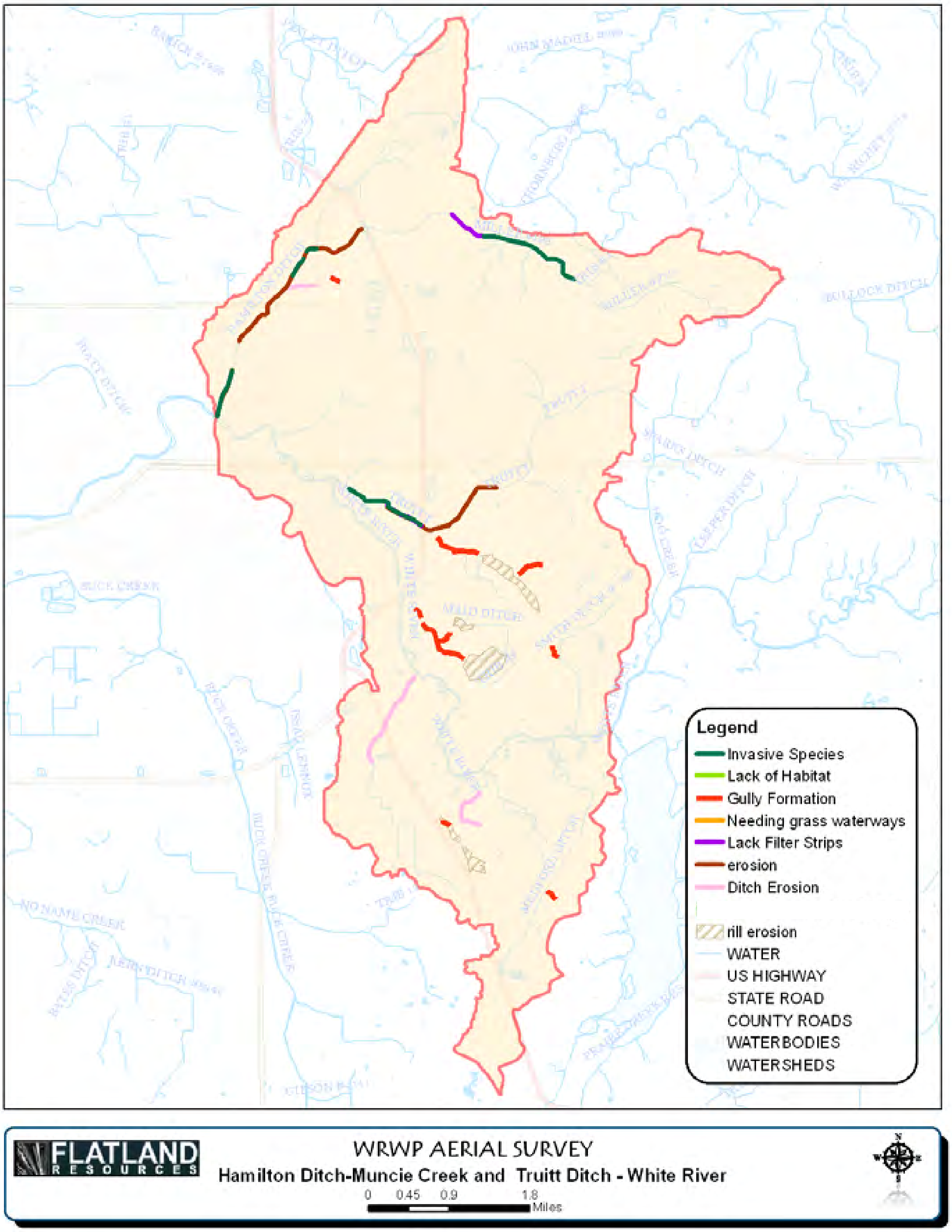
Parameter	Truitt Ditch - White River Subwatershed	Hamilton Ditch - Muncie Creek Subwatershed
Eroded Stream banks	9,400 feet	13,700 feet
Eroded Agricultural Ditches	9,250 feet	1,750 feet
Rill Erosion & Gully Formation	200 acres	50 acres
Areas Needing Grass Waterways	12,000 feet	610 feet
Banks Lacking 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 aerials from the Hamilton Ditch - Muncie Creek Subatershed 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

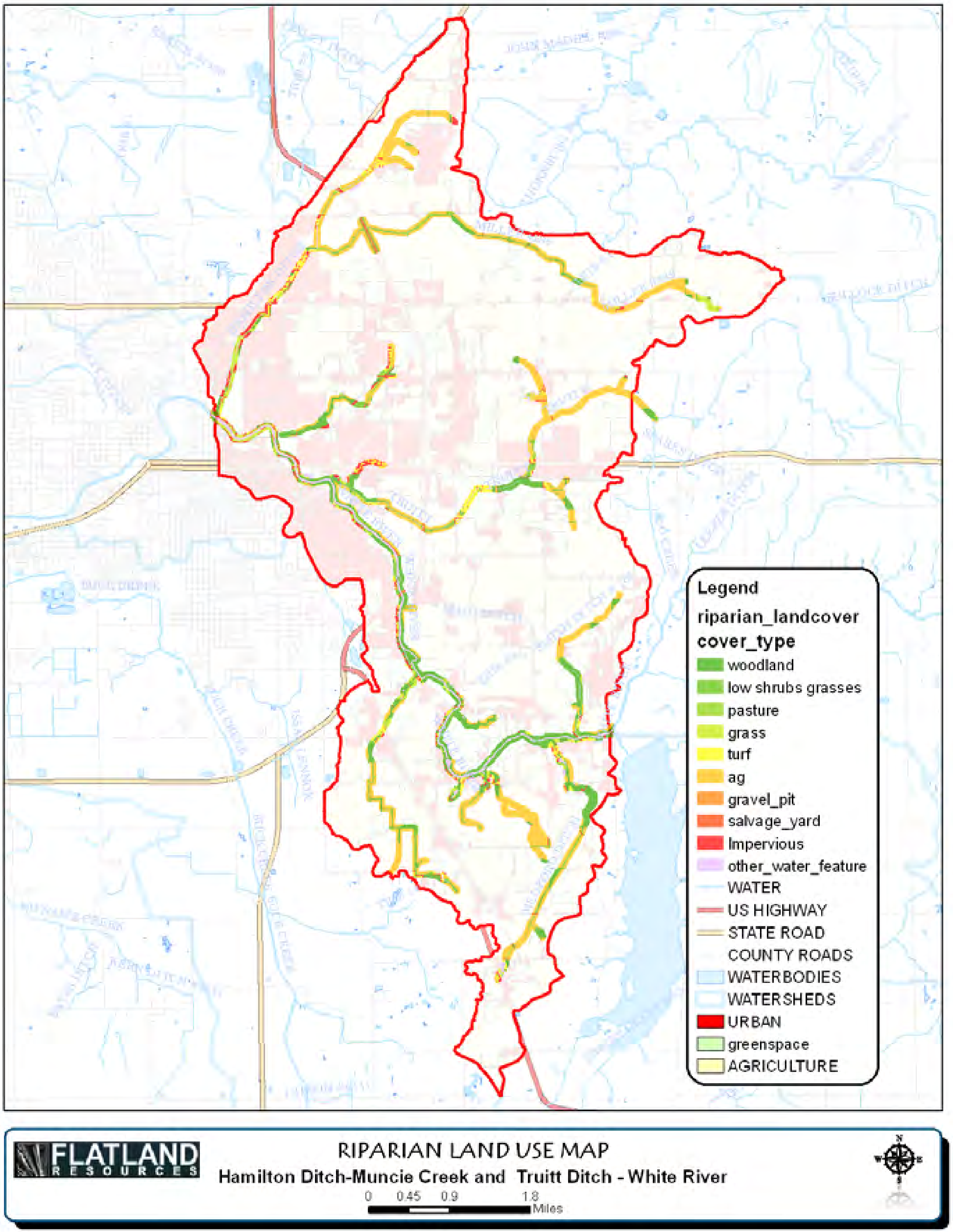
Truitt Ditch-White River Watershed
The examination of the aerials from the Truitt Ditch Watershed (Map 2.87) showed a large number of areas where nonpoint source pollution could be potentially occurring. There were large sections of the main stem of Truitt Ditch and the agriculture ditches that showed 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

INVENTORY

BSU Aerial Survey

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

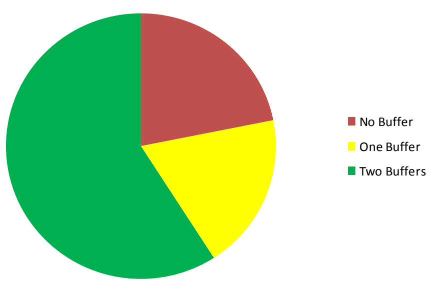
Aerial Survey #2

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.

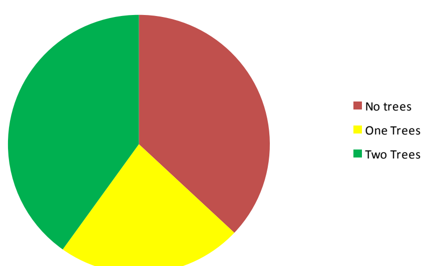
The students used the following stream Attribute Coding: Trees, Trees on both sides=2, Trees on one sides=1, Trees on zero sides=0 Buffers; Buffer on two side=2, Buffer on one side=1, Buffer on zero side=0 (Chart 2.80, 2.81, Map 2.89, 2.90). If tributaries do not have designation, it was due to the fact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

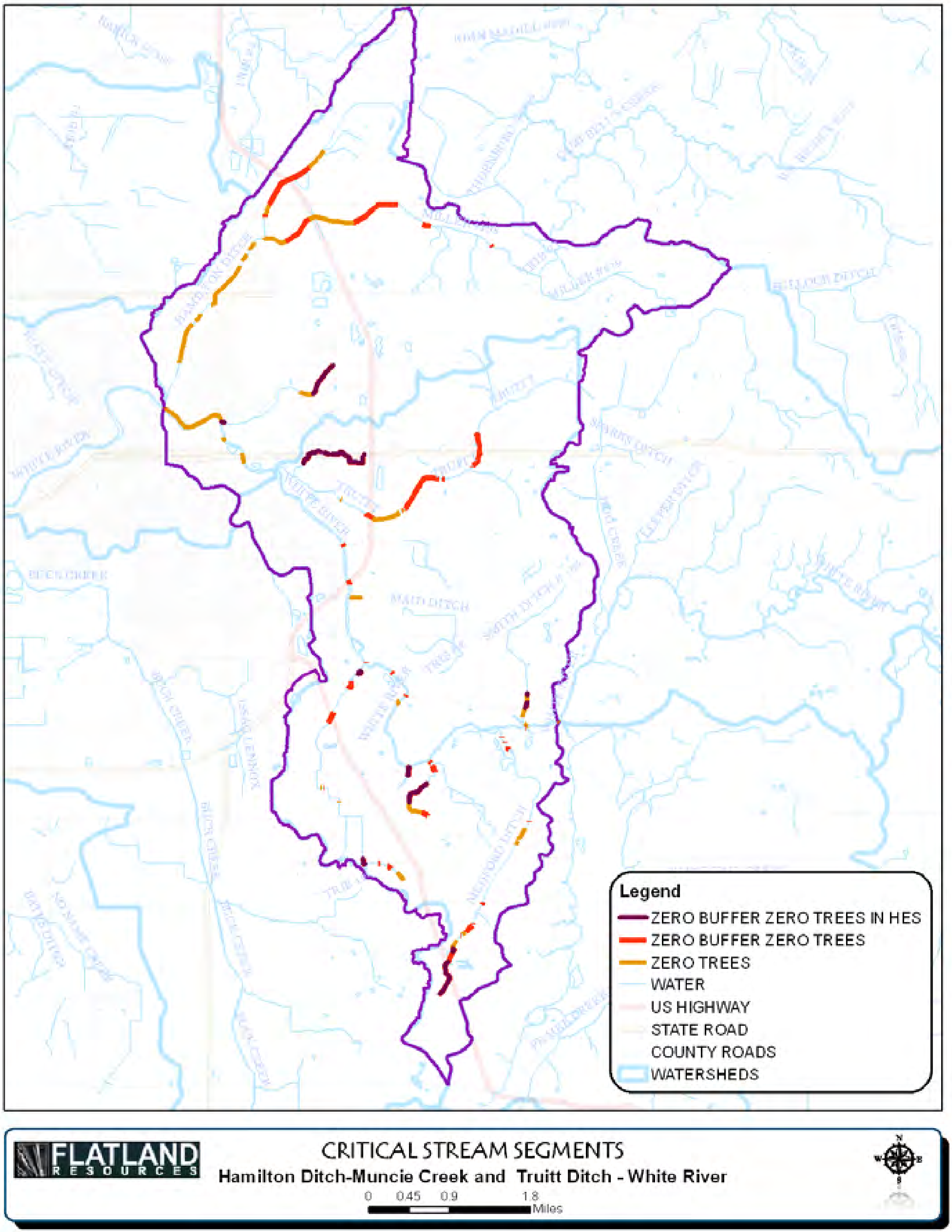


CHA. 2.81 Vegetation in Riparian Zones

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	

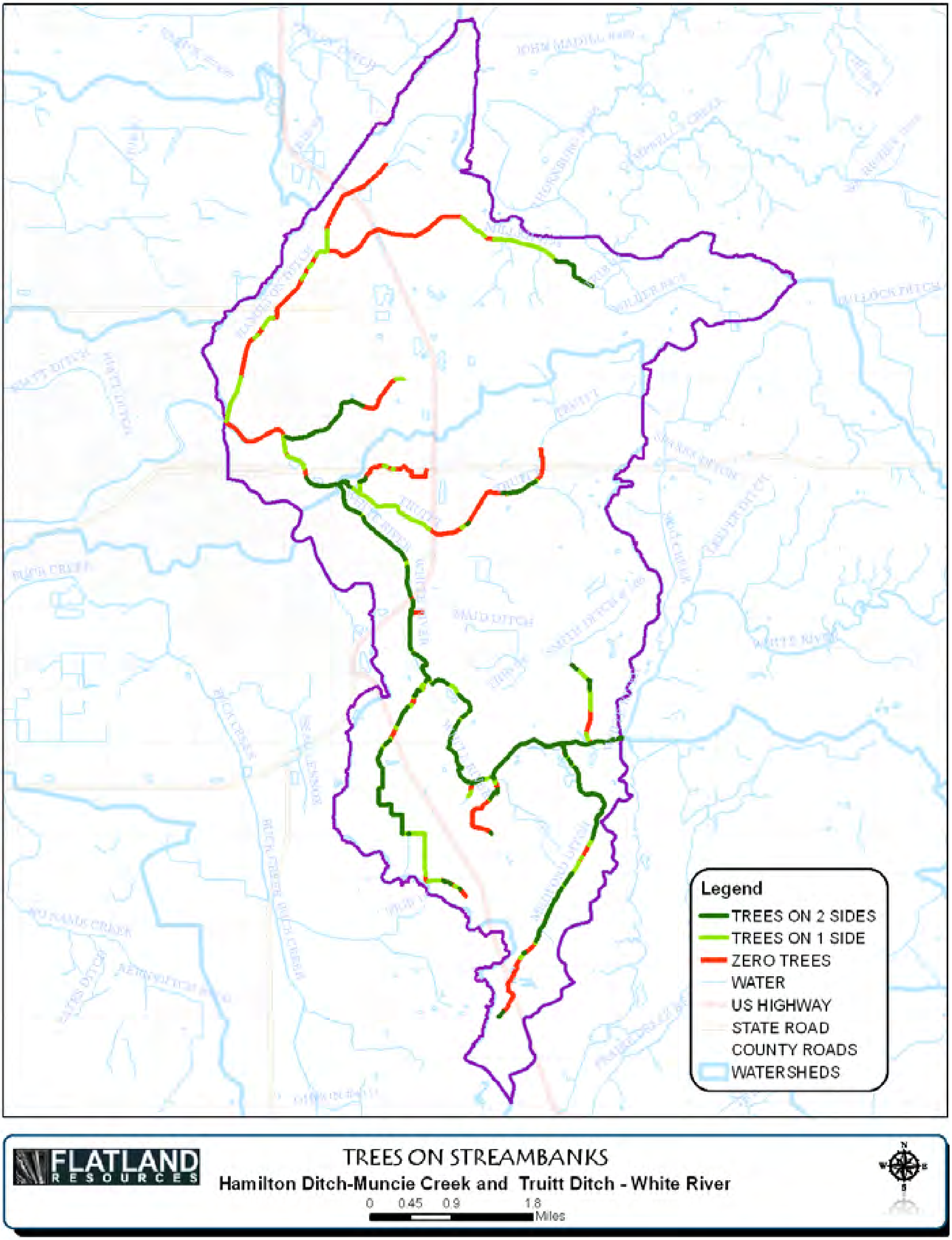
TABLE 2.92: Vegetation in Riparian Zones			
	feet	total miles	%
No trees	60346	11.43	37%
One Trees	37315	7.07	23%
Two Trees	65429	12.39	40%
total		30.89	

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

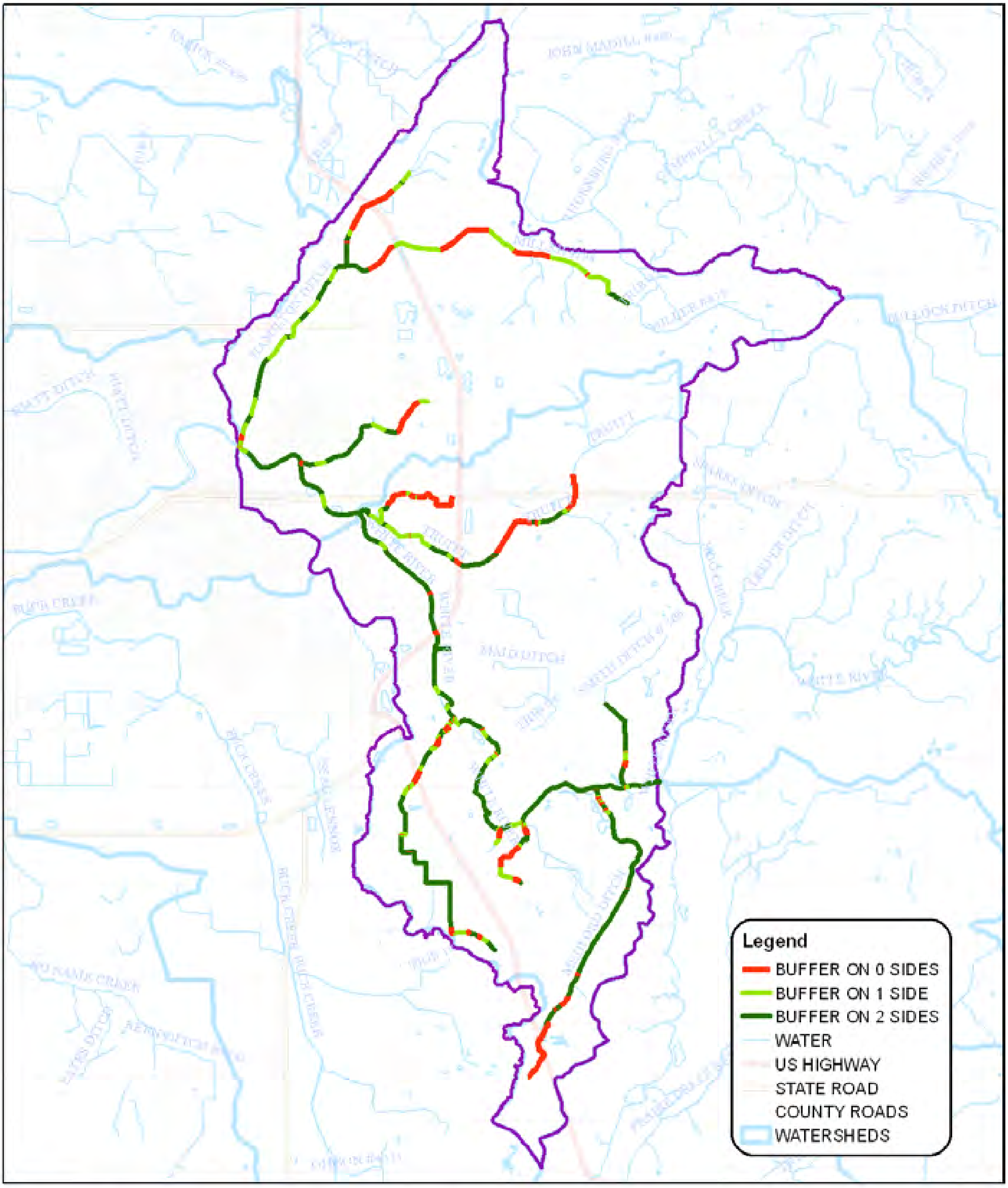


MAP. 2.88 Areas Critical for Stream bank Habitat

INVENTORY



MAP. 2.89 Vegetation in Riparian Zones



FLATLAND RESOURCES

LOCATION OF STREAM BUFFERS

Hamilton Ditch-Muncie Creek and Truitt Ditch - White River

0 0.45 0.9 1.8 Miles

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 ft3/sec to 1.1 ft3/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 empting 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.

INVENTORY

IMG. 2.16 Muncie Creek at Yale Road

Crossing #7 Muncie Creek at Yale Road

Crossing number seven is located in the Morningside 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 Morningside 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.

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 hydromodification 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 though 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 it's 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

INVENTORY

BSU Windshield Survey

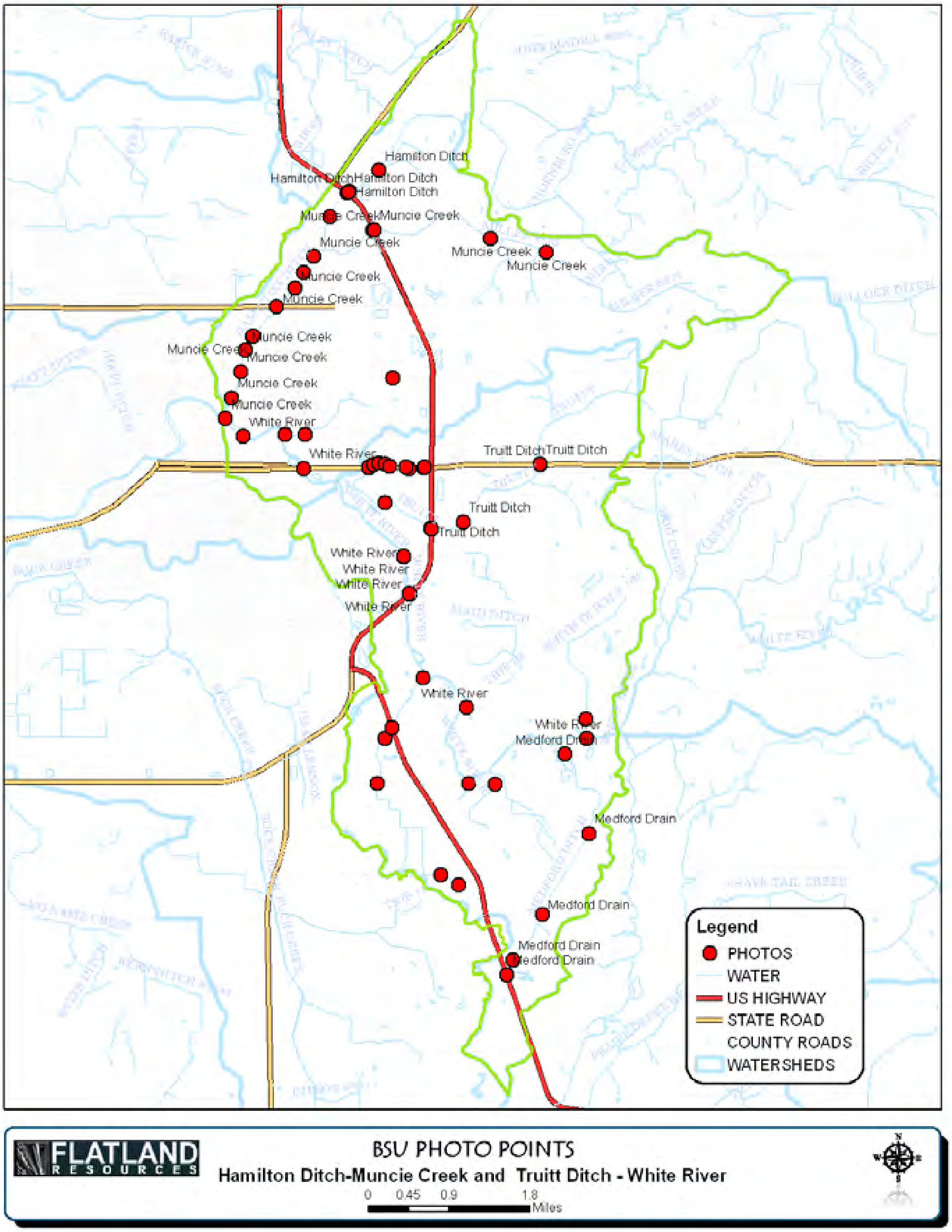
WMP - CHAPTER 2 - PART 2 - SECTION 4 - SUBSECTION 11

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.

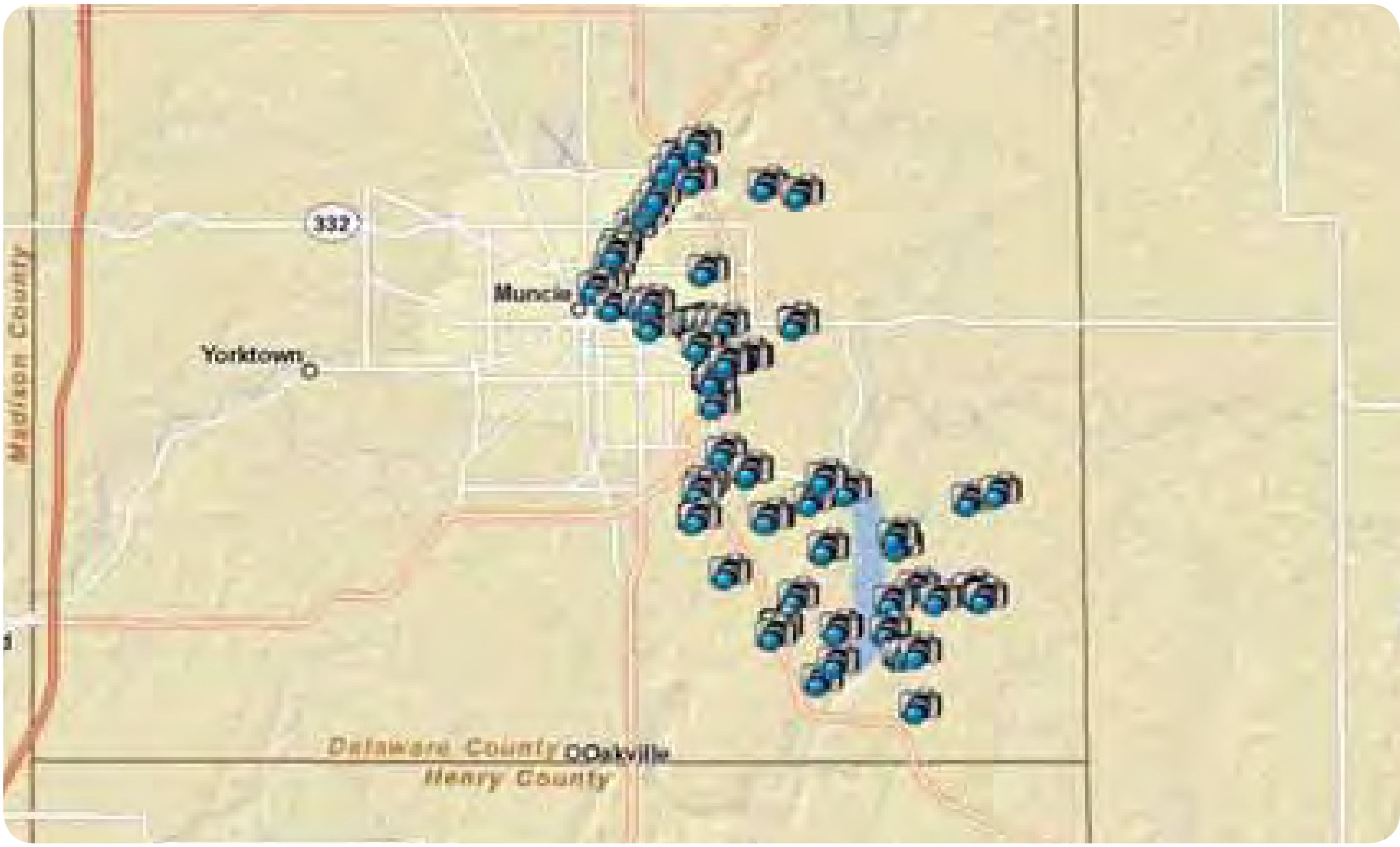
Their work with DCGIS's Trimble Yuma and ArcPad was the most important contribution. Each photo point was documented by stream direction and uploaded to the Delaware County GIS servers.

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.



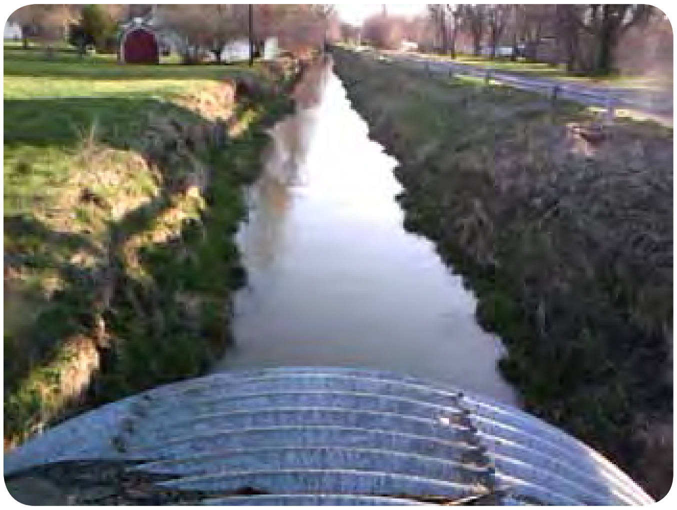
MAP. 2.92 Photo Location Points

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

INVENTORY

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.

Hydromodifcation

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.

INVENTORY

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 Subbasin 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 Sates.

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 Subswatersheds.

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 surifical 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 depending (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 septics 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 septics 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. septics 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 septics 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 hydromodication, 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.

TABLE 2.95: Critical Pollutant Level by Subbasin	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				
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 defendable 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. [1]

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.

1 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

INVENTORY

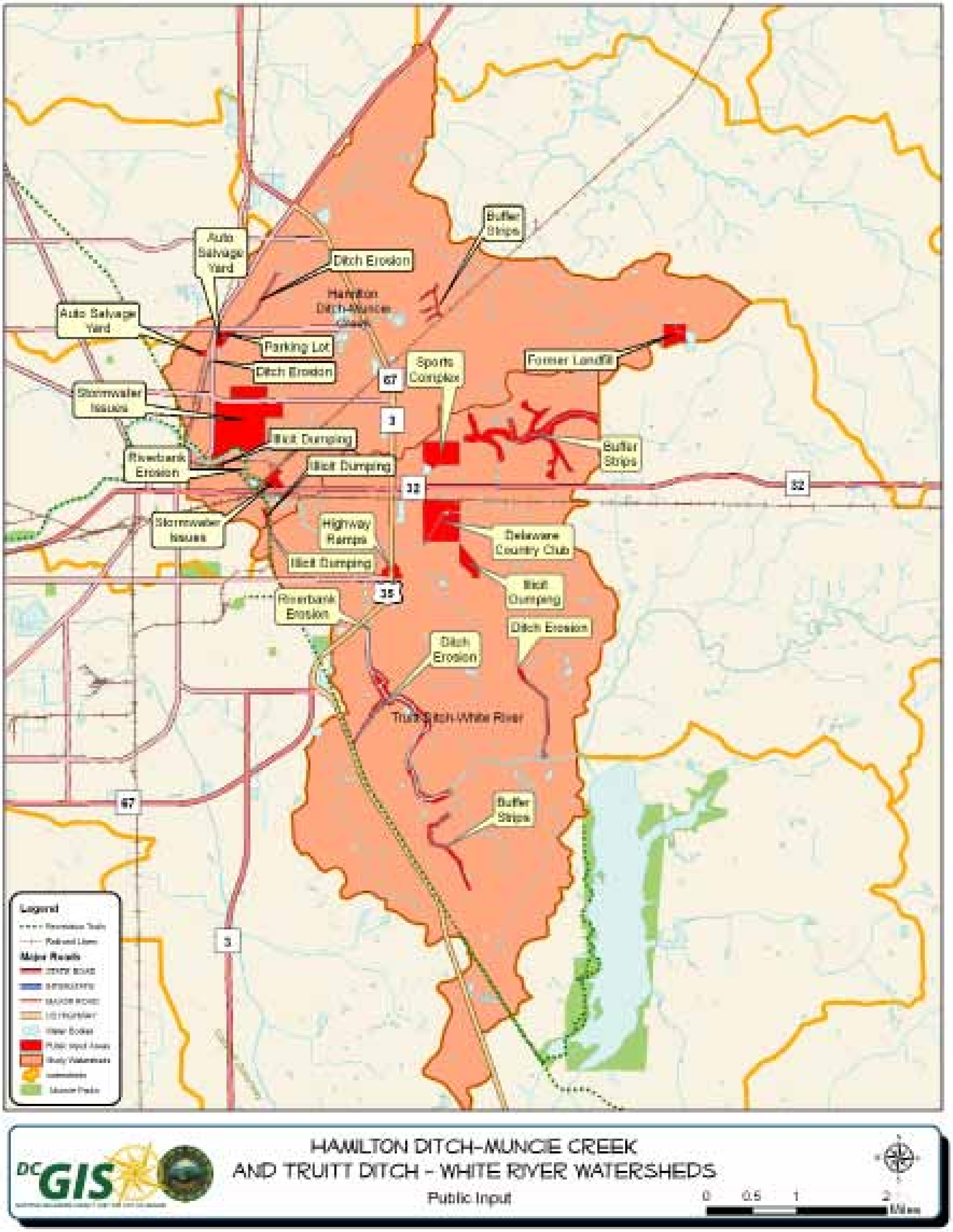
Analysis of Stakeholder Concerns

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 hydromodifcation	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?

INVENTORY

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 contaminates	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 septics, 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?

INVENTORY

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. chemcials 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 there of). 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
Fish and Wildlife - 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
Recreational - 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
Economic - Sediment - Nutrient - Public Education - Limited BMPs	Loss of agricultural capital through erosion.	Area streams are very cloudy and turbid

PROBLEMS | CAUSES

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.[1]

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

(1) The 2000 National Water Quality Inventory[2] 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.

1 Indiana Integrated Water Monitoring and Assessment Report
2 2000 National Water Quality Inventory

IDEM Cause/Stressor Inventory

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TABLE 3.2: IDEM Cause/Stressor Inventory

Cause/Stressor	Miles
Cause unknown	
Impaired Biotic Communities	2,469
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	
Total dissolved solids	341
Nutrient/Eutrophication Indicators	749
Organic Enrichment (Sewage) Indicators	36
pH	81
Oxygen Depletion	702
Temperature	15
Siltation	118
Flow alteration	57
Other habitat alterations	89
Pathogens (E. coli indicator)	8,322
Oil and grease	11
Algal Growth	123

SOURCE:Indiana Integrated Water Monitoring and Assessment Report

PROBLEMS | CAUSES

WRWP Causes / Stressors

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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[1]

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[2]

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.

1 Tom Reeve, White River Watershed Project
2 Tom Reeve, White River Watershed Project

Nutrients[1]

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 methemoglocinemia, "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.

1 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[1] (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.[2]

(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

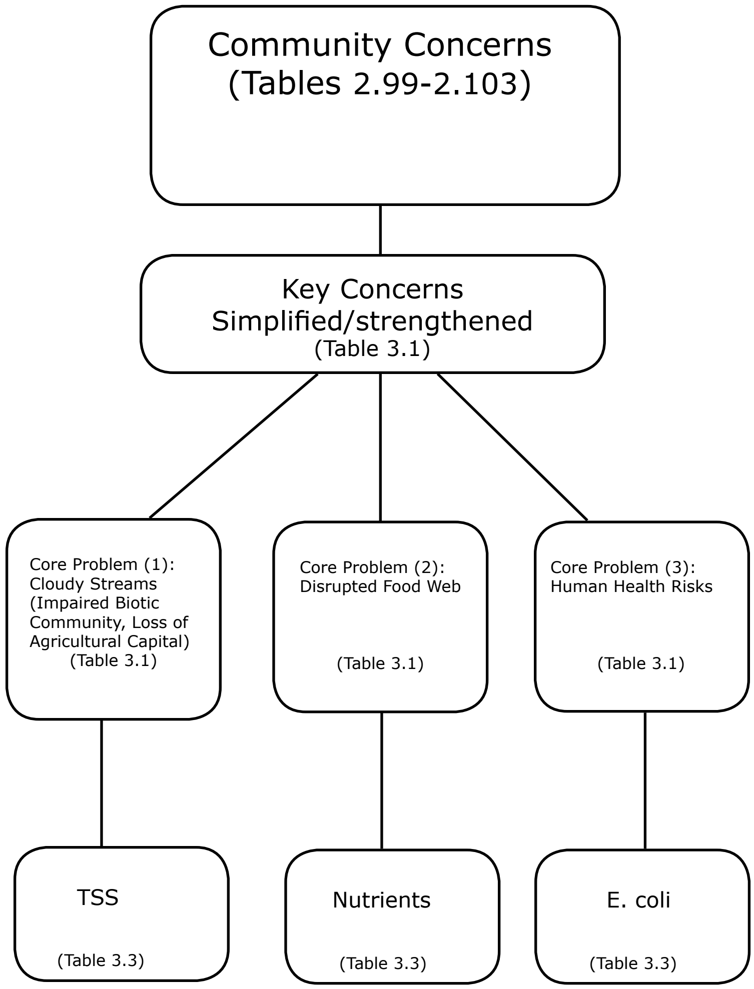
Concerns/Problems/Stressors

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 though 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



CHA. 3.1 Concerns, Problems, Stressors: Process

PROBLEMS | CAUSES

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

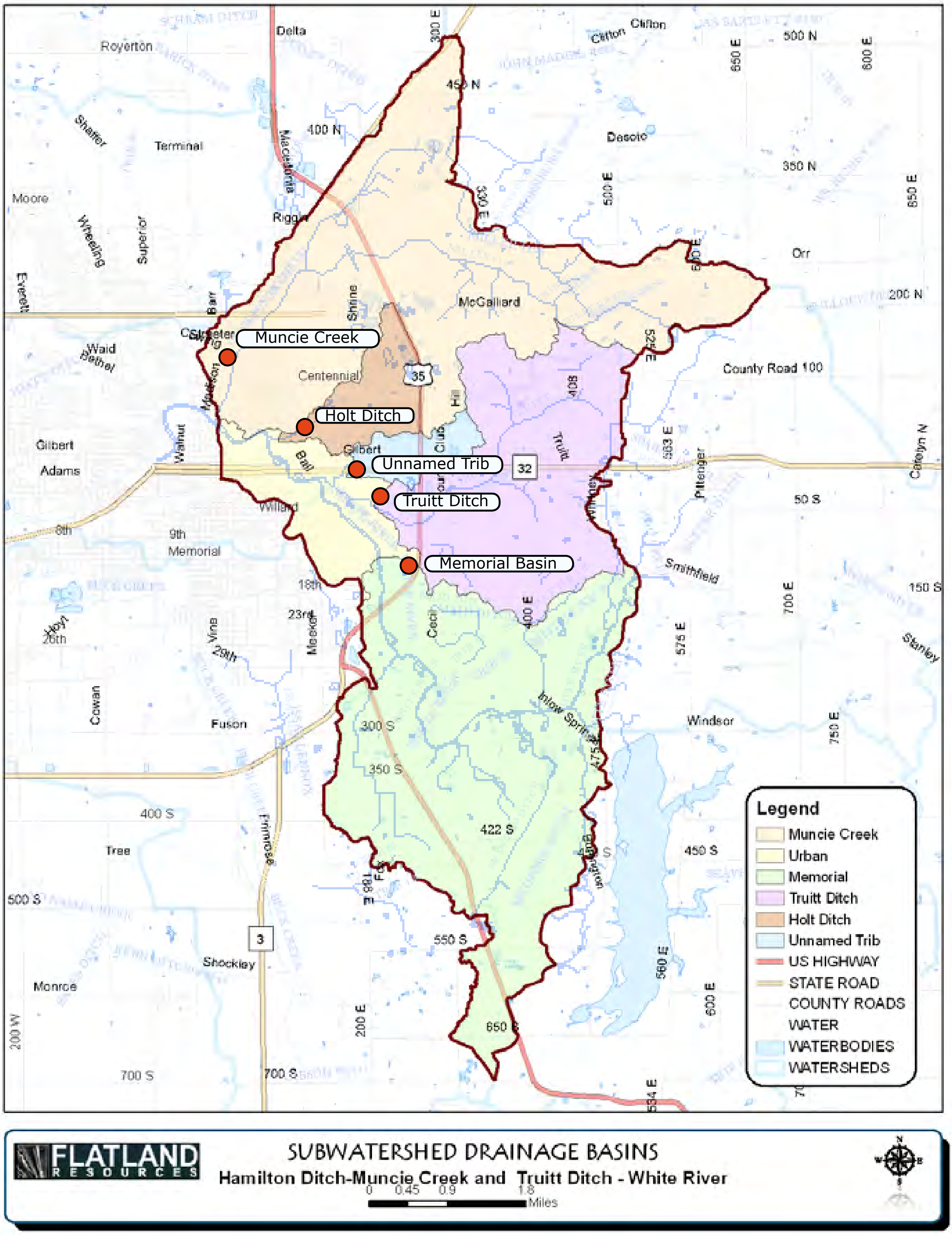
	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek	70%	115%	159%	101%	481%
Holt Ditch	77%	47%	174%	82%	1597%
Unnamed Tributary	108%	45%	282%	69%	2548%
Truitt Ditch	87%	108%	234%	70%	224%
Memorial	30%	176%	194%	93%	203%

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
Walnut Basin	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
Memorial Basin	7184	11
Randolph County - Upper White River Headwaters Basin	130842	204

SOURCE: ArcGIS Indianamap.org

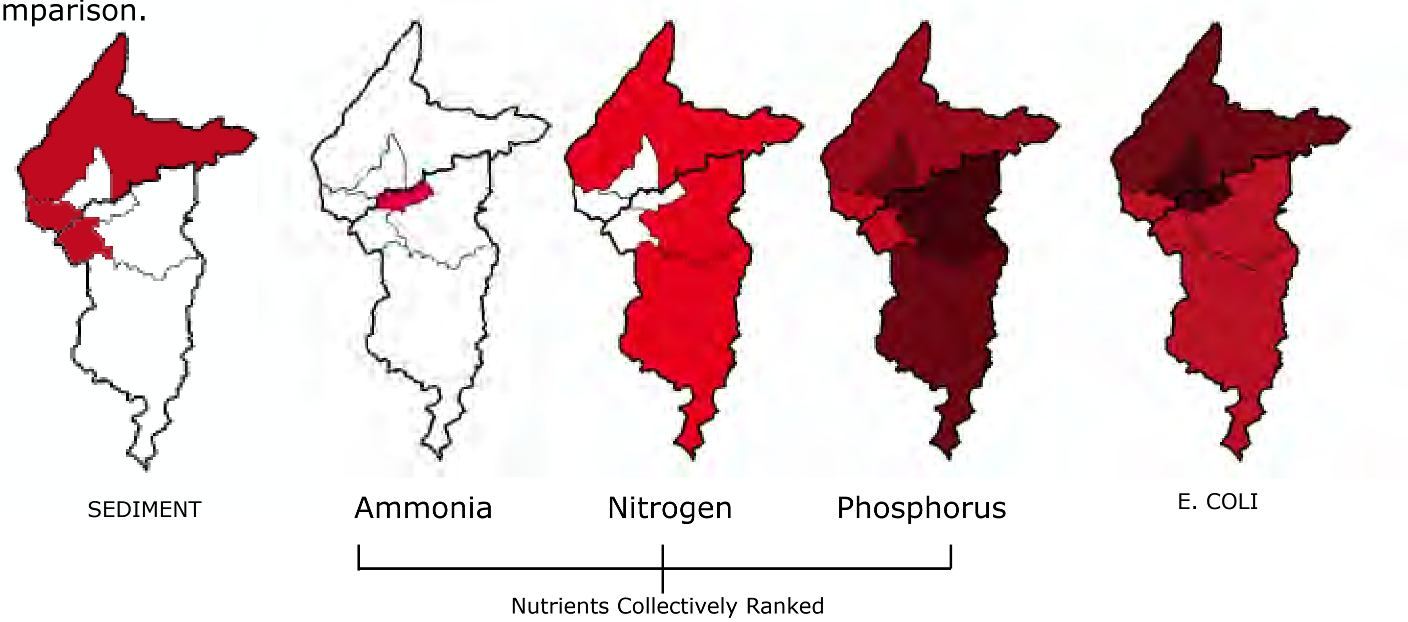


MAP. 4.1 Location of Drainage Basins

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.



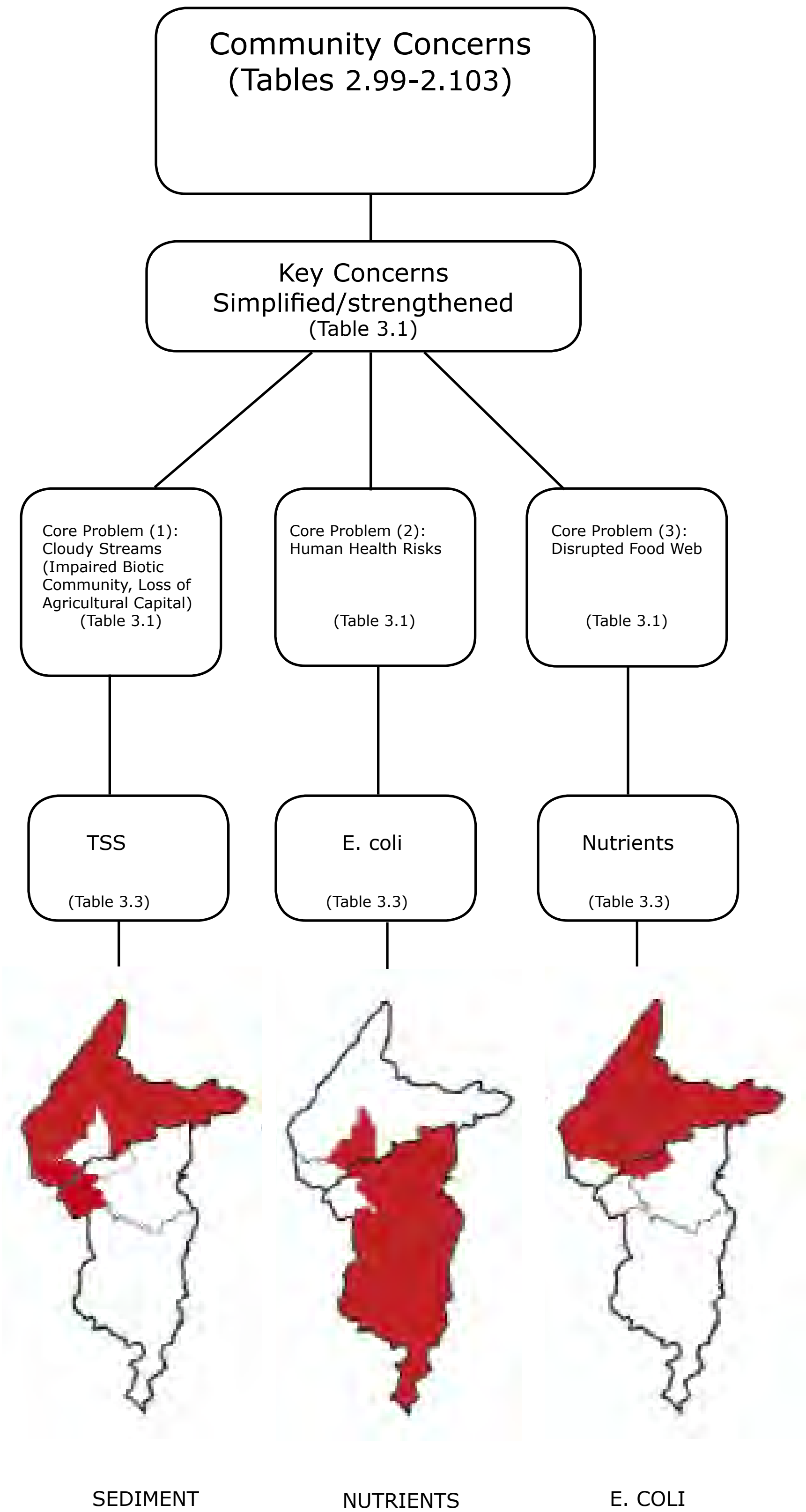
DIA. 4.1 Basin Level Critical Areas

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.

TABLE 4.3: 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%

Table 4.3 highlights in yellow the basins that are 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).



CHA. 4.1 Concerns, Problems, Stressors, Critical Areas

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. [1]

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.[2]

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 IDEMs 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.

1 Indiana Integrated Water Monitoring and Assessment Report
2 Indiana Integrated Water Monitoring and Assessment Report

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

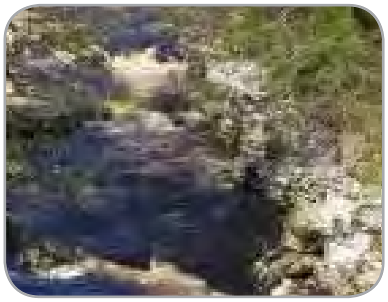
To increase our effectiveness at implementing Water Quality improvements, the WRWP seeks to understand the sources of selected critical water quality pollutants. To affect the greatest impact per project, we need to know, for each impairment, the most significant source of the stressor per basin.

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	Potential Sources include: (1) stream banks due to poor vegetative and structural integrity, channelization and increased sheer stress, dams and backwater pooling, and ditching (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.
Area streams have nutrient levels exceeding the target set by this project	Nutrient levels exceed the target set by this project	(1) stream banks due to dams and backwater pooling (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 Livestock, and animal wastes used as field applications
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.[1] (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.[2]

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 sheer 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.

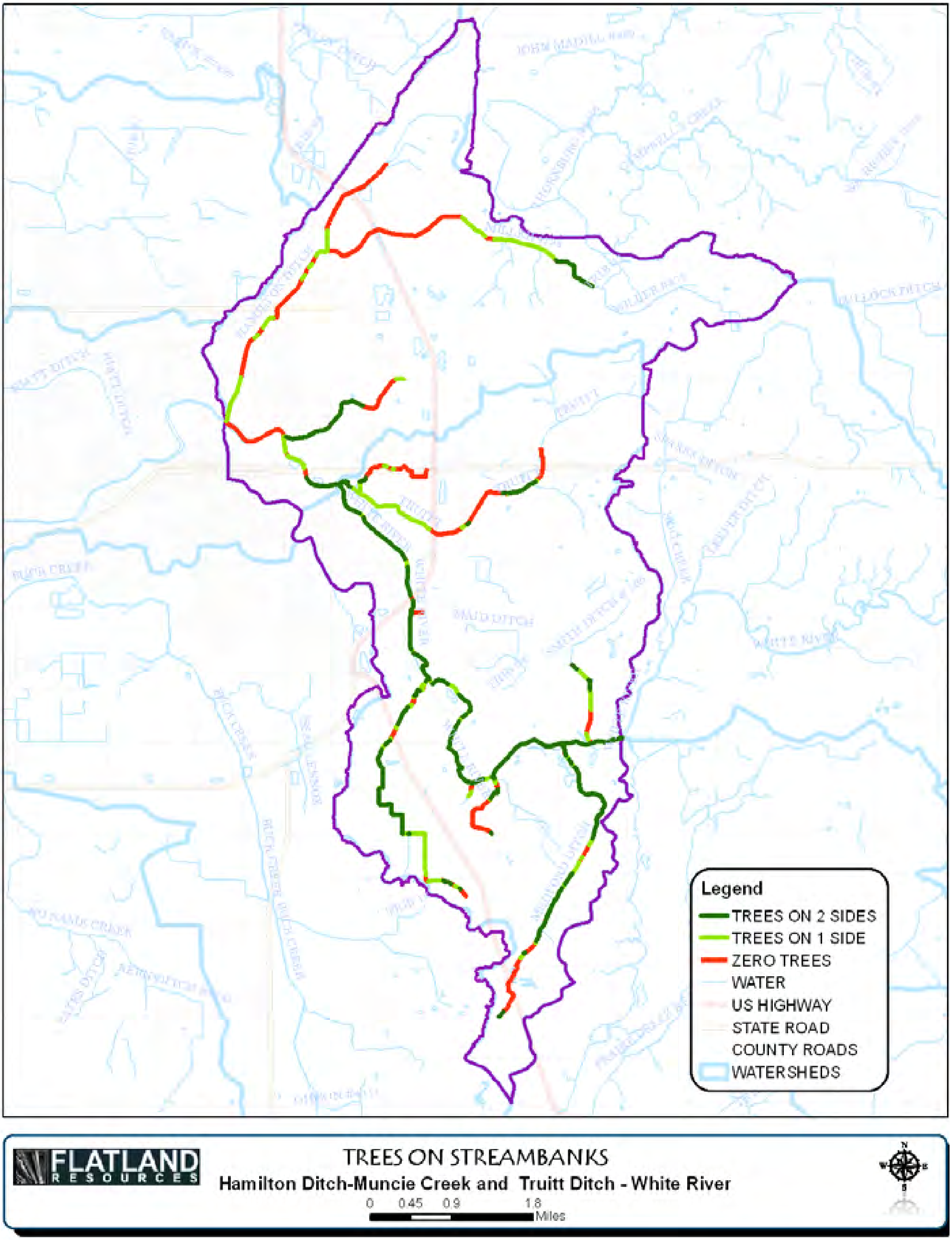
Often overlooked, stream bank erosion is a significant contributor of sediment in our nation's waterways. According to the EPA Region 5 model for Estimating Load Reductions for Agricultural and Urban BMPs, an eroded 500 foot section of bank that is 10 feet high, with silt loam soils, would contribute 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
SUPPORT
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. 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. 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. 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. 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. 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. 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.

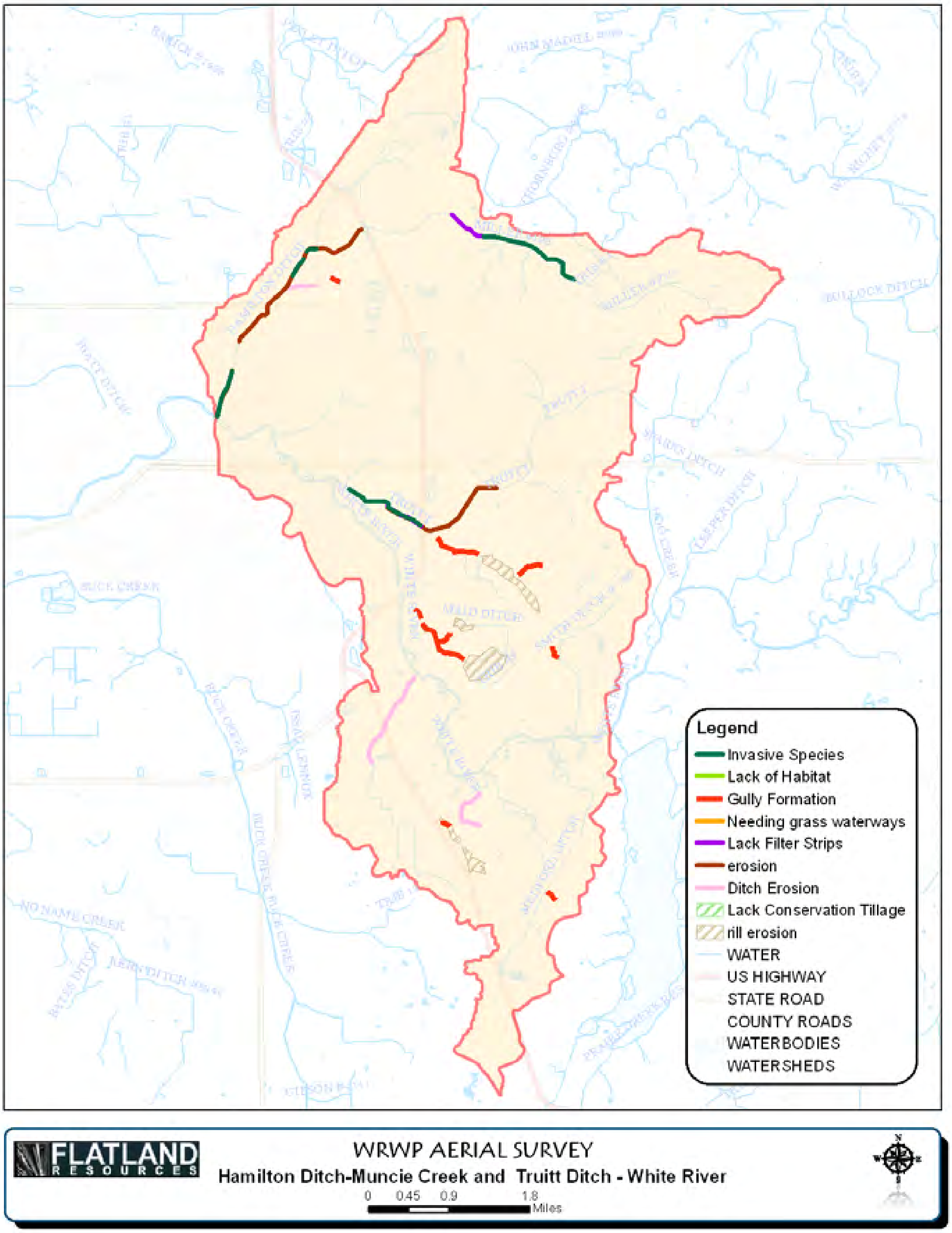


MAP. 4.2 Streambank Tree Assessment

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 hydromodification 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
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. 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. 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. 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.

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[1]

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[2]

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[3]

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
2 Non Point Source Pollution, whiteriverwatershedproject.org
3 Non Point Source Pollution, 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 Bufffer Analysis maps (Map 4.5) help us identify locations where there are zero agricultural/urban buffers or 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 that 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 nutrients 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 adminsterested though 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.

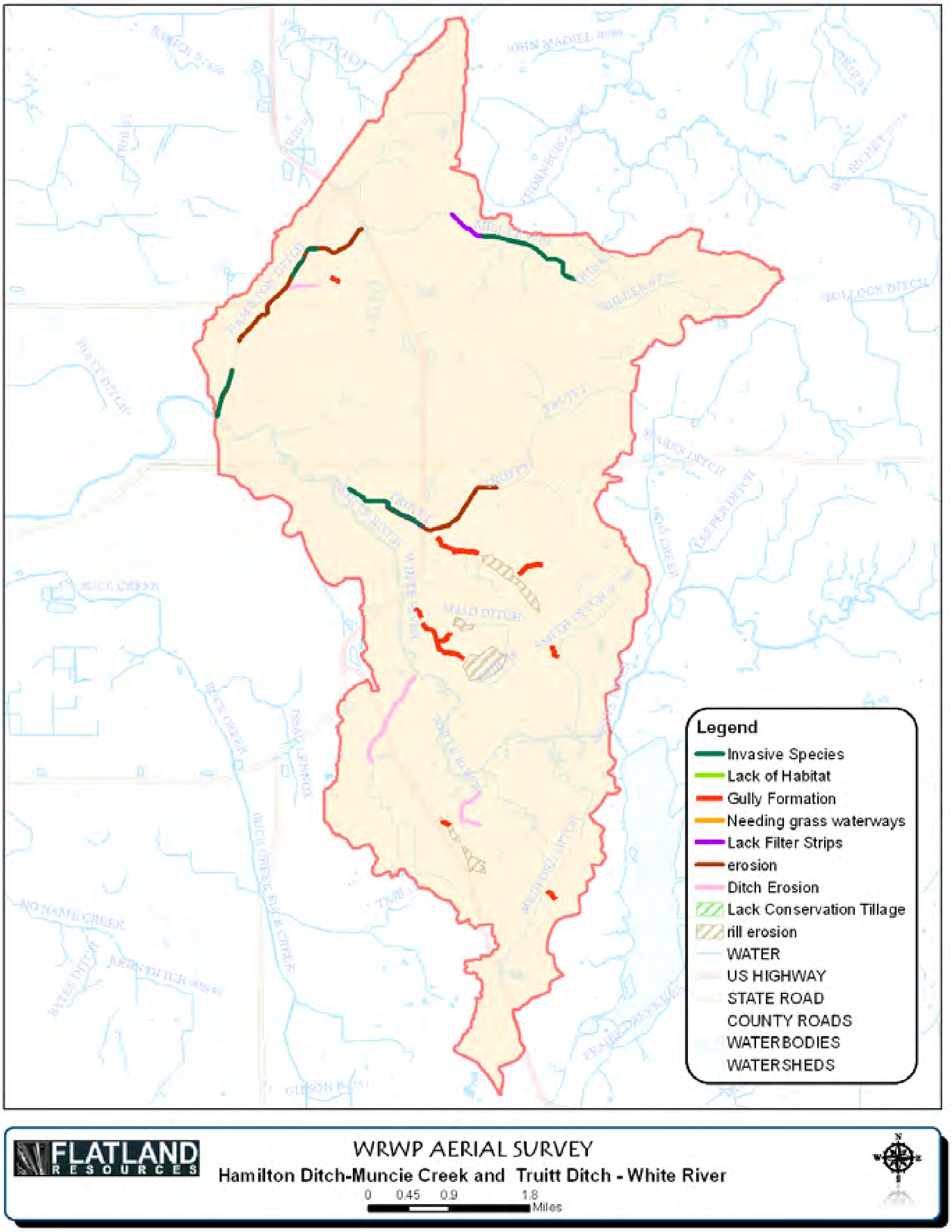
Animal waste improperly used on agricultural lands can be a major contributor to nutrient pollution in watersheds through runoff. One potential contributor to livestock waste pollution is farms, ranches and pastures that house livestock.

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.

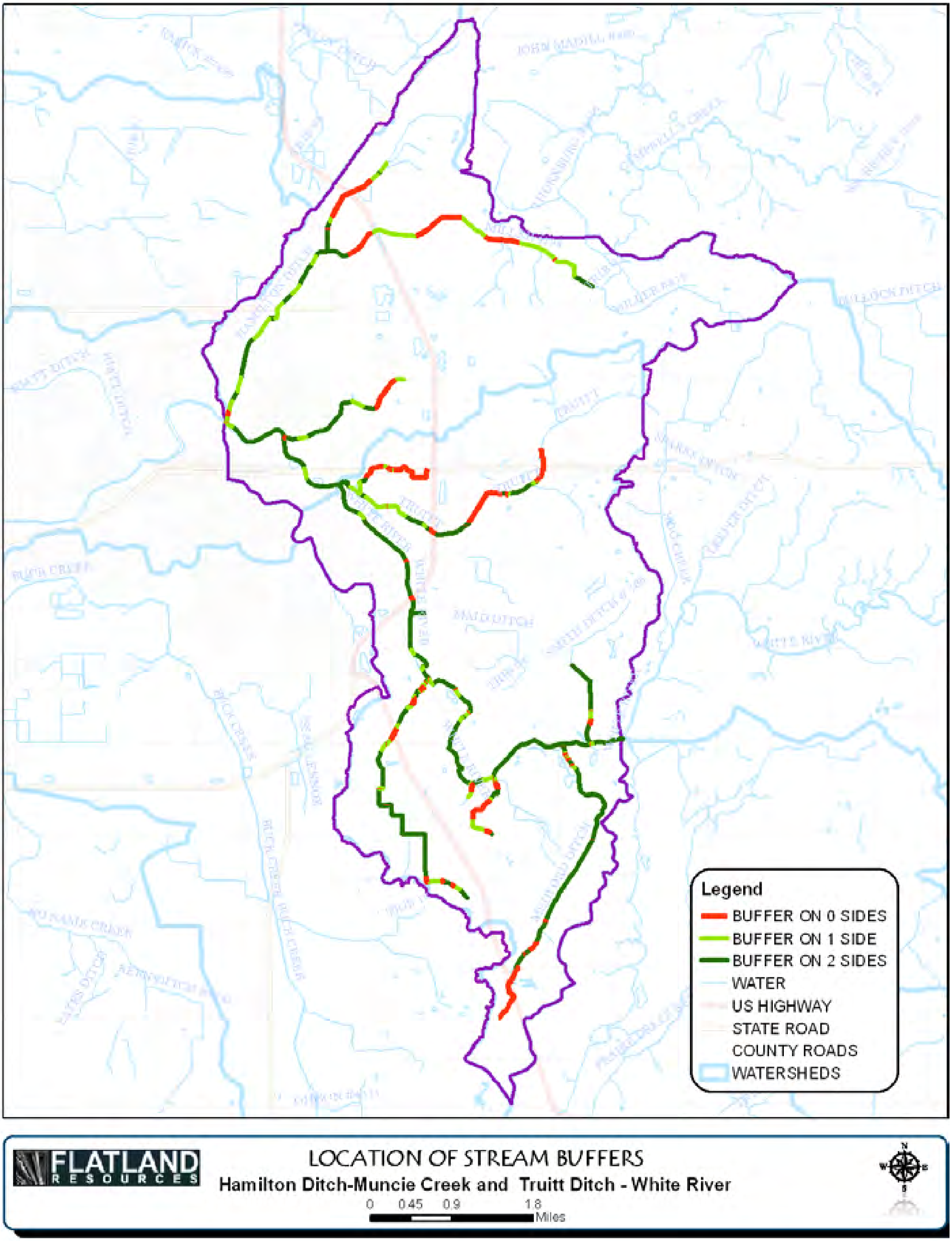
Streambanks
Lack of ground cover is mostly likely caused by numerous human activities that have altered the natural chemical and physical environment of the riparian areas. These activities impair aquatic life communities by degrading habitat, disrupting natural processes like reproduction, and altering 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
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. 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. 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.

TABLE 4.9: Nutrient Sources
Source
Streambanks
SUPPORT
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. 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 plated as grass waterways.



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 Qaulity 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. coil 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).

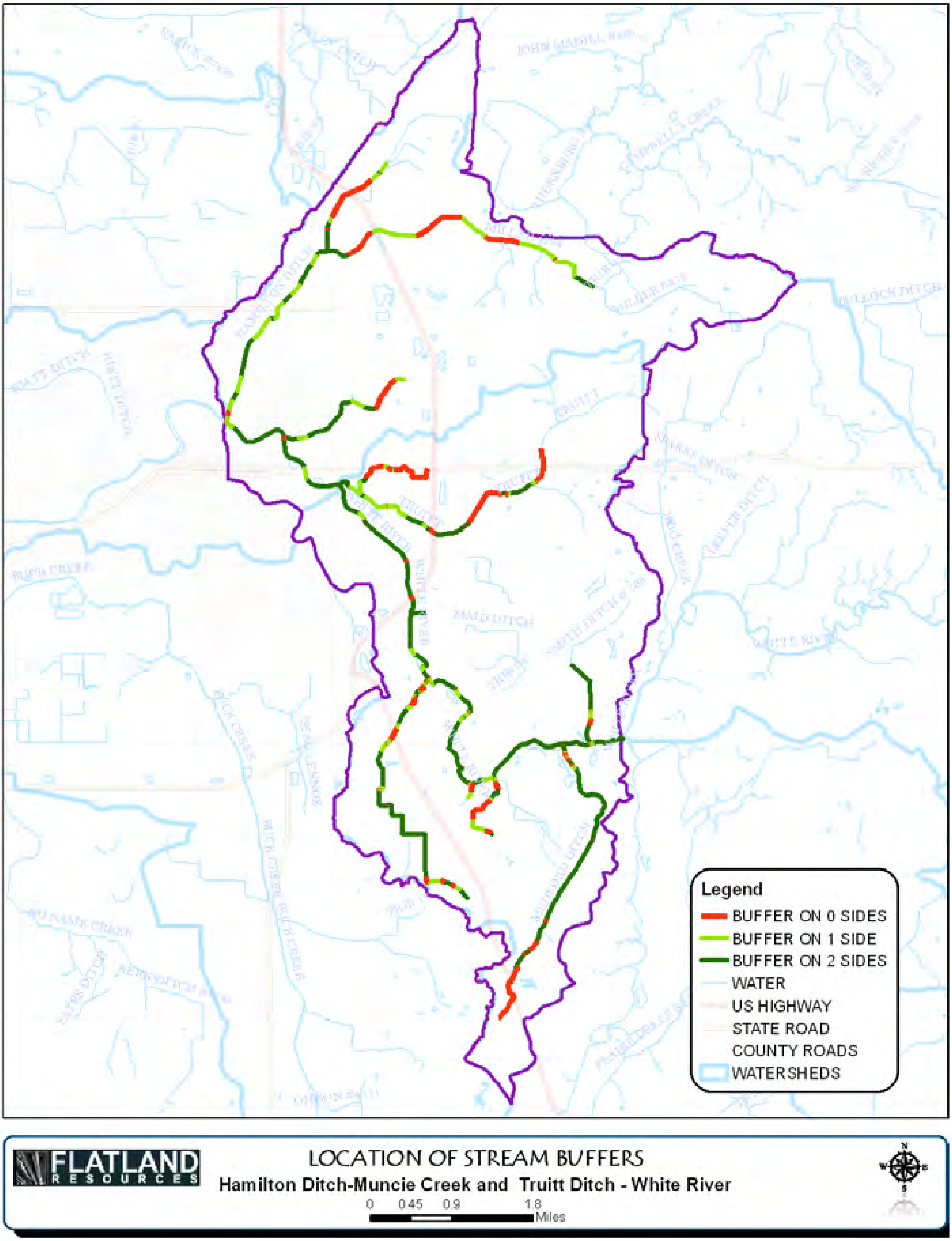
Nonpoint Sources: Waste
E. coli and other fecal coliforms are bacteria that, when present in water bodies, indicates human or animal waste contamination. E. Coli commonly enters water bodies through storm water run-off from failed, failing, or illegally hooked up septic systems, animal feed operations, 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. (Sterring 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 E +07 bacteria cells per acre per year. (Tetra Tech 2004)

TABLE 4.10: E. coli Sources
Source
Sheetflow
SUPPORT
Best Management Practices can reduce the frequency and amount of the E. coli that enters the waterway. 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. 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. 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. 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.



MAP. 4.6 Streambank Buffer Survey

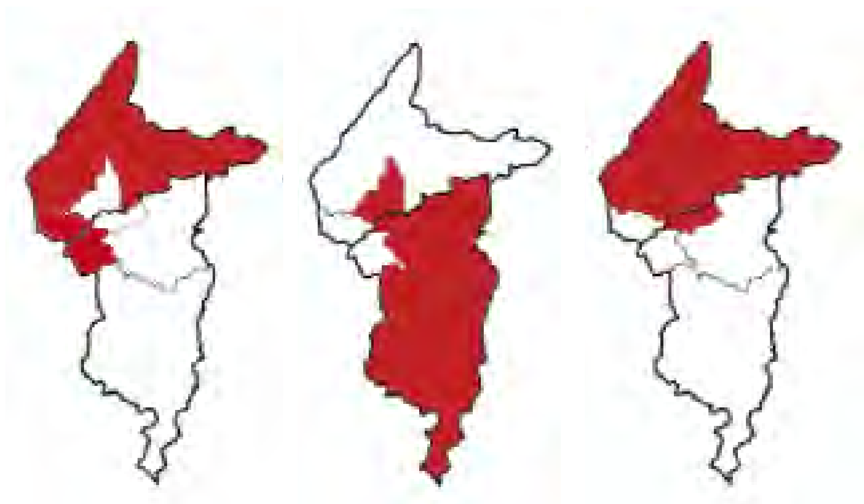
LOADS, GOALS, CRITICAL AREAS

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

Critical Area Determination
WMP - CHAPTER 5 - PART 1 - SECTION 1 - SUBSECTION 1

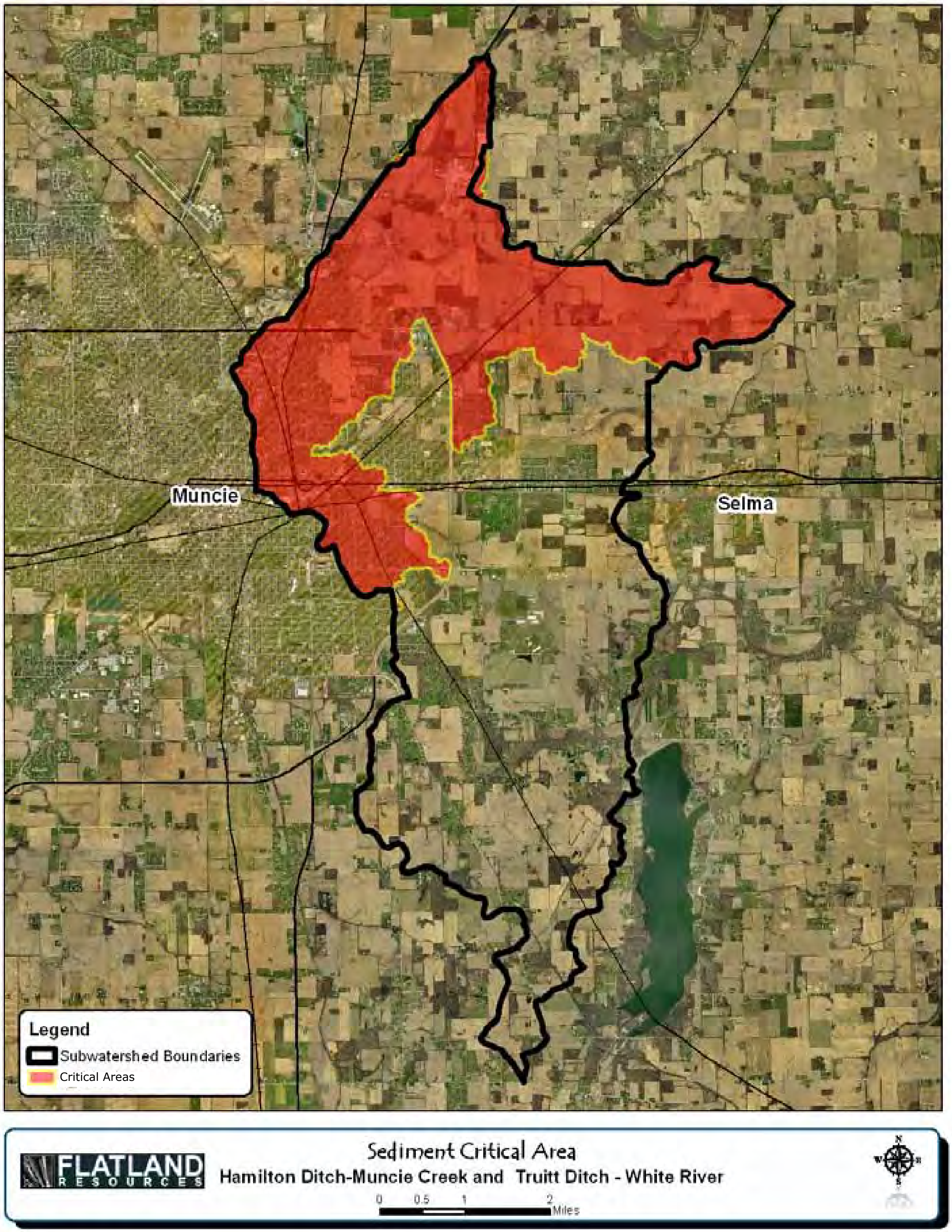
We have completed the following steps in the Management Planning Process:
(a) Collected, through the Inventory and Analysis process, WQ data and land use information,
(b) Used the catalogue of information as a means confirming or disproving community concerns,
(c) We have taken those community concerns 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 excedance of state and federal WQ standards and guidance,
(f) and we have taken individual NPS stressors and sought to 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.

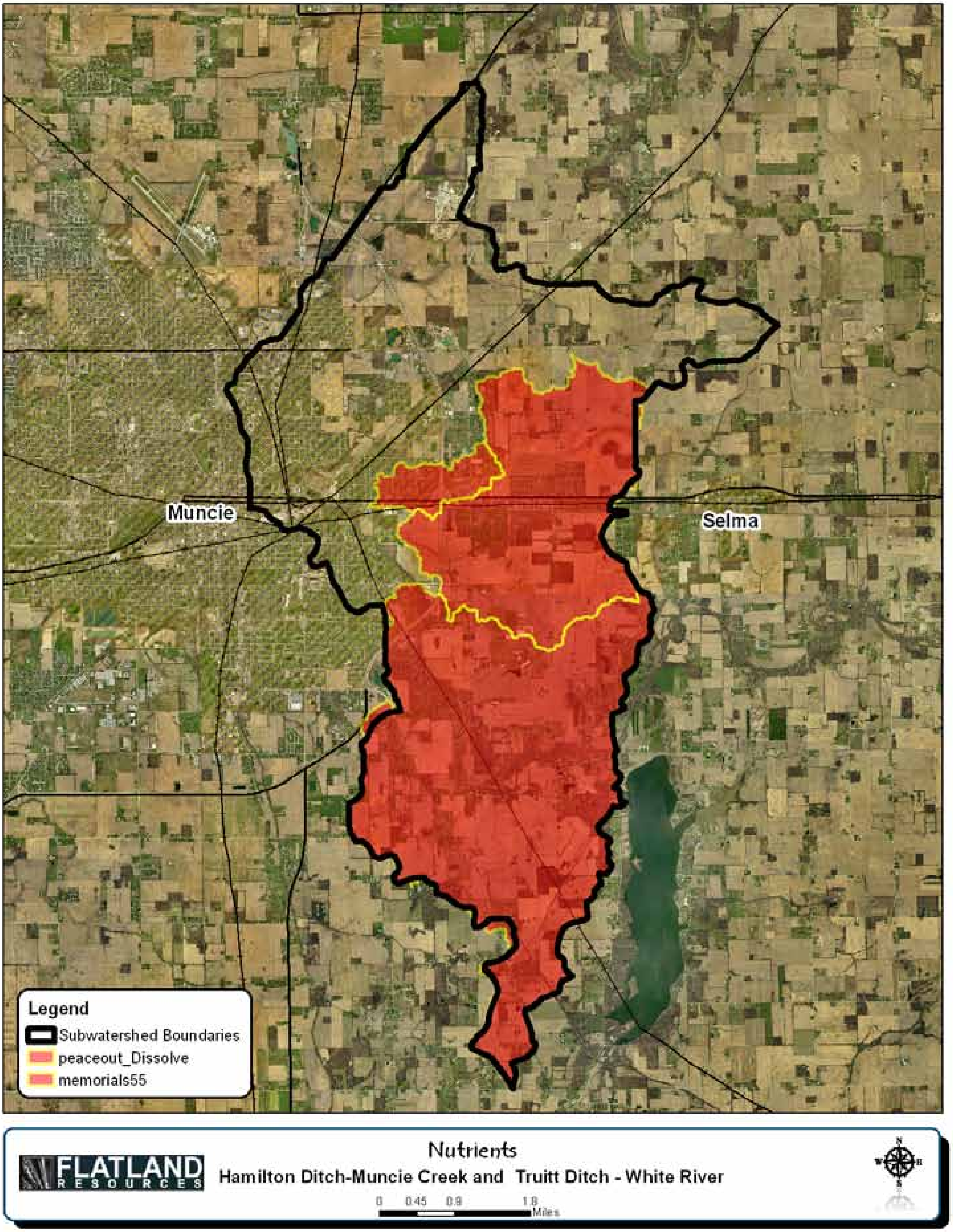


SEDIMENT NUTRIENTS E. COLI

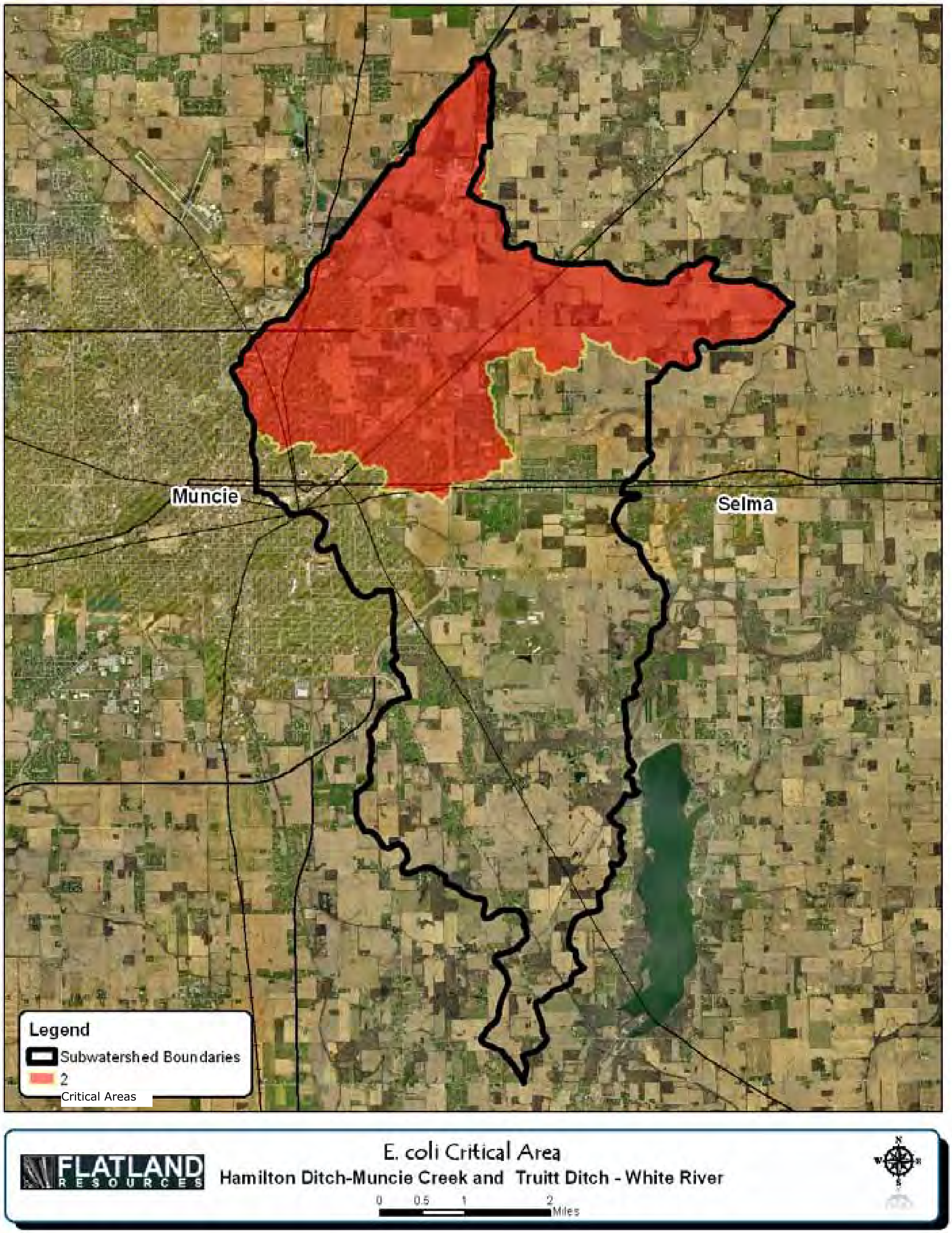
TABLE 5.1: Percentage above state water quality standard					
	Ammonia	NO3-N	PO4-P	TSS	E.Coli
Muncie Creek	70%	115%	159%	101%	481%
Holt Ditch	77%	47%	174%	82%	1597%
Unnamed Tributary	108%	45%	282%	69%	2548%
Truitt Ditch	87%	108%	234%	70%	224%
Memorial	30%	176%	194%	93%	203%



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 emphasized that these prioritization of projects is not mandated but is created to serve as guidance for the WRWP cost-share steering committee.

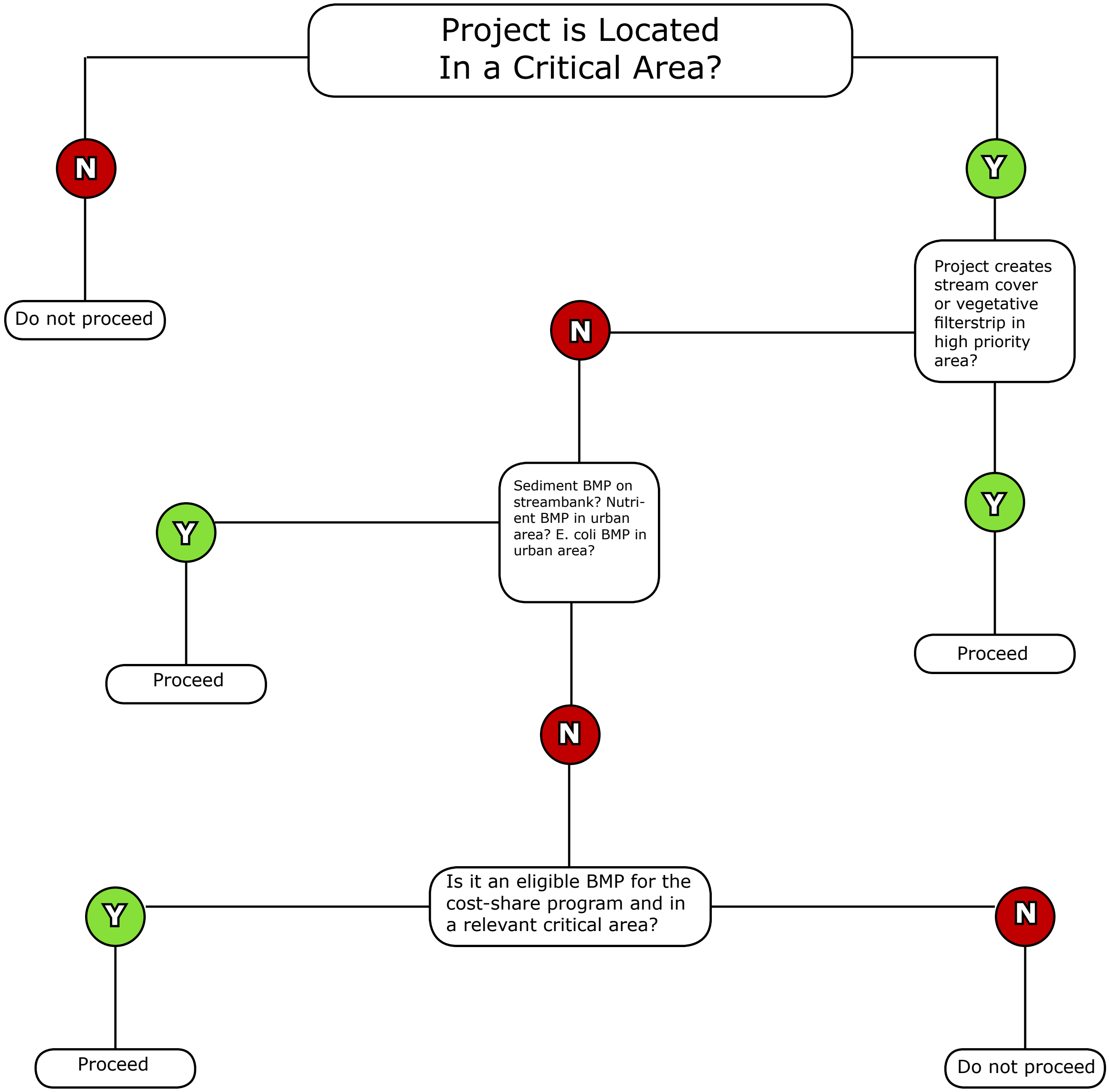
Tier one projects
Based on our source identification studies, we concluded that within the Critical Areas boundaries, specific sites may be functioning as gateways for water quality stressors to enter the waterways. These “gateways” are weak points in water filtration, sediment stabilization and nutrient 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	HIGEST 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 in in critical areas). New BMPs will be added to the list if valid need arises.



Projects authorized to proceed will be selected based upon the degree in which they reduce NPS loading.

CHA. 5.1 Cost-share Application Process

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.

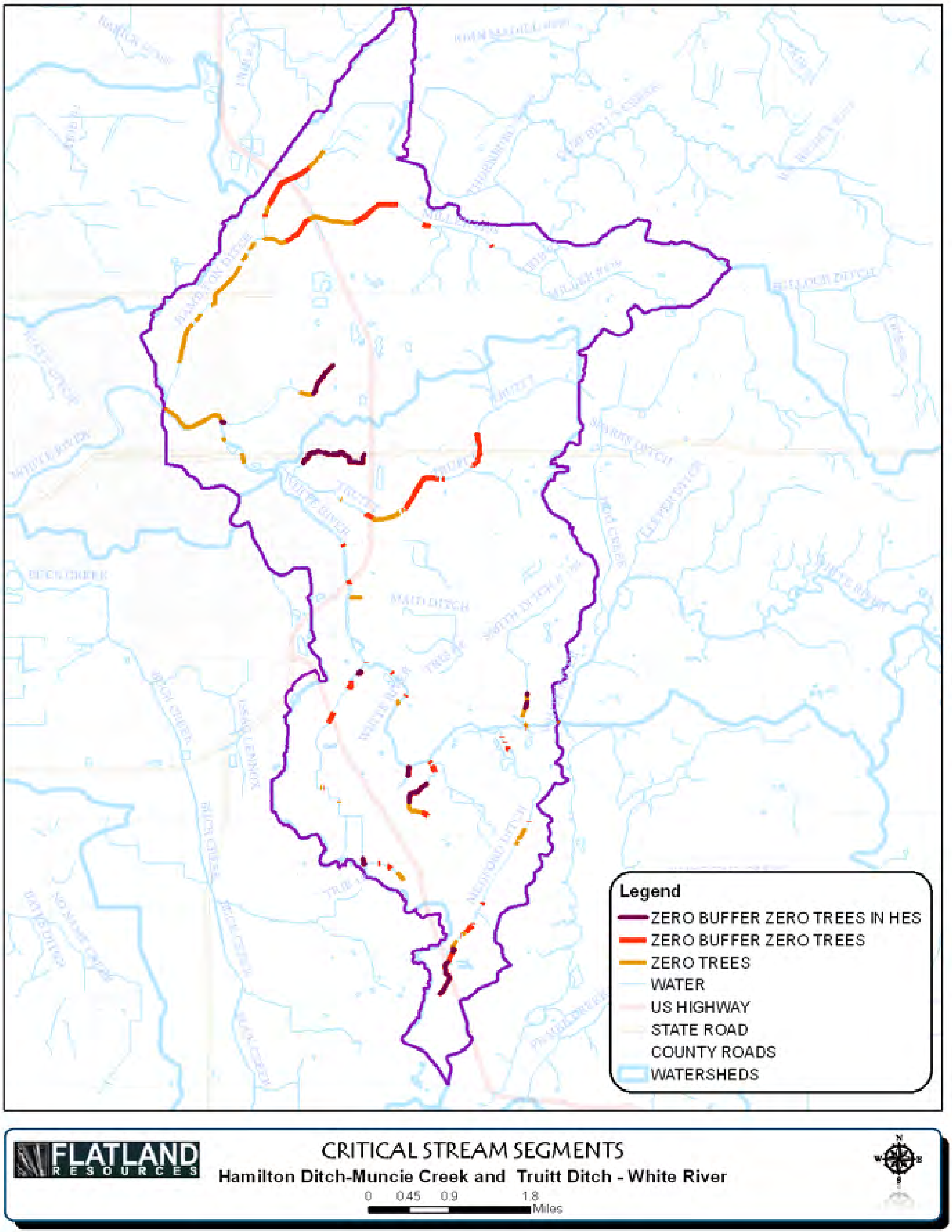
Each individual project must advance overall sub watershed reduction goals. Each cost-share project will be used as a means of tracking effectiveness to reach WRWP reduction goals. Finally, aside from reduction estimations, installed projects will be analyzed by the Bureau of Water quality as a means 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.

TABLE 5.5: Load Calculations Hamilton Ditch - Muncie Creek				
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

TABLE 5.6: Load Calculations Truitt Ditch - White River				
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.[1]

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.[2]

1 Tom Reeve, White River Watershed Project
2 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	**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.
E. coli levels exceed the water quality standard	**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.
Nutrient levels exceed the target set by this project	**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

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 with 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.[1]

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.

1 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 1.92E+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.

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 a 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 a 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 peek 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 3inches of depth to 2feet.

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" were 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 slops 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 EPAs 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.[1]

1 Tom Reeve, White River Watershed Project

BMPs | STRATEGIES

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 t he 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

ACTION REGISTER

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 amound 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 about 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, DCSWCD, EPA, Consultants
less than $5,000	IDEM, MSD, IDNR, DCSWCD, BSU, NRCS, FSA, property owners,	USFWS, IDEM, IDNR, NRCS, DCSWCD, EPA, Consultants

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

ACTION REGISTER

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.

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 HRFP 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 Agriculture 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

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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

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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 (NH3+): 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. NH3 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 increases 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_2^-] to nitrates [NO_3^-] 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_2, or as nitrate NO_3, nitrite NO_2 or ammonia NH_3. 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

APPENDIX