Introduction

This watershed management plan addresses local water quality conditions identified in three 14-digit Hydrologic Unit Code (HUC) subwatersheds located within the Upper White River Watershed in Delaware County. This plan was created by the members of the White River Watershed Project (WRWP), a project overseen by the Delaware County Soil and Water Conservation District.

The White River Watershed Project is a community-driven, voluntary effort to clean-up and reduce non-point source water pollution for a better quality of life in Delaware County. This management plan shall serve as a guide for local citizens from all sectors of the community to accomplish that stated goal. This plan identifies local water quality issues and concerns, provides step-by-step methods for addressing each one, and steers the reader towards sources that can help them implement the listed suggestions.

The WRWP had maintained an assertive public outreach program from its onset: with the goal to inform and involve as much of the public as possible in the planning process. Through the high level of community involvement that was achieved, wide spread support for the implementation phase of this project has been gained. Orchestrating such involvement was not without its challenges, as anyone who has tried to bring people together from widely differing backgrounds can attest to. However, it was these very challenges that provided the foundation for this strong, well thought out, and highly supported watershed management plan.

All of the work conducted by the White River Watershed Project Committees, the Soil and Water Conservation District Board and the general public has been brought together to create this plan. This is a document that has truly been developed by and for the people of Delaware County, Indiana.

Executive Summary

This White River Watershed Project (WRWP) Watershed Management Plan covers three 14-digit HUC subwatersheds within the Upper White River Watershed within Delaware County, Indiana. The WRWP is a community-driven, voluntary project to clean-up and prevent non-point source water pollution through the development and implementation of this management plan. The EPA, Section 319 Clean Water Act 3-year (2001–2004) grant which funded this project was held by the Delaware County Soil and Water Conservation District, who provided a Watershed Coordinator to manage the project.

The three specific subwatersheds studied as a part of this project are the Killbuck/Mud Creek, Buck Creek and Prairie Creek Subwatersheds. Each subwatershed is roughly between 10,000 and 17,000 acres in size and has a mixture of agricultural (primarily), suburban and urban land use. Both historic and new baseline information were gathered on all three subwatersheds to obtain the clearest understanding of current water quality and land use conditions. Analysis of the historic and newly gathered baseline information on water quality, habitat, land cover and land use revealed non-point source water pollution problems and positive conditions throughout each subwatershed. Correlations between land cover type and width along the stream corridors and specific water pollution conditions were discovered through regression analysis.

Killbuck/Mud Creek Subwatershed was found to have problems with total suspended solids, ammonia, nitrogen, orthophosphates, *E. coli*, dissolved oxygen, stream biology and habitat. Most of the wooded vegetation along both Killbuck and Mud Creeks has been removed and the channels have been dredged to the point that they are not stable over the long term. The main positive finding in this subwatershed is that the majority of the failed/failing septic systems that plague this subwatershed will be connected to a sewer system by the end of 2004. This should greatly reduce not only the *E. coli* levels, but some of the nutrient and total suspended solids, which should in turn improve the stream biology. However, without some actions taken to stabilize and restore vegetation along the banks of the stream channels, only limited improvements can be expected.

Buck Creek Subwatershed has issues with total suspended solids, ammonia, orthophosphates, nitrates and *E. coli*. One notable positive finding with the Buck Creek Subwatershed is that its stream temperature regime classifies it as a coolwater stream throughout its reaches, and a coldwater stream at its headwaters. This is possible through a combination of the stream being spring fed near its headwaters and the fact that a good portion of its banks are still covered by woody vegetation. The potential for Buck Creek to become an official coldwater stream is possible with some protective and remedial action.

Prairie Creek Subwatershed is a rather unique subwatershed as it possesses a man-made drinking water reservoir as its major waterbody. This reservoir was created by damming the major creek in the subwatershed (which is also fed by three other smaller tributaries). From the results of the baseline study, it was determined that ammonia, orthophosphates, nitrates, *E. coli*, and in some instances dissolved oxygen and stream biology and habitat were problematic in this subwatershed. The major positive finding for this subwatershed was the extensive wooded and grassed buffer acreage that surrounds the reservoir and one of the tributaries that feed into it (Huffman Creek).

The status of this buffer is in jeopardy due to the fact that this acreage is under the ownership of a private water company and the lease held by the local park department (which protects the acreage) is due to expire in 2013. This is compounded by the fact that there is no master plan for the reservoir or the surrounding subwatershed.

Parameter	Total Reduction (lbs/year)/ *E. coli* (cfu/year)
K/M ammonia	3851.07
K/M *E. coli*	6.32307E+15
K/M nitrate	5846.29
K/M orthophosphate	776.55
K/M TSS	1013520.84
BC ammonia	10646.23
BC *E. coli*	6.375E+16
BC nitrate	17554.47
BC orthophosphate	-3455.50
BC TSS	-2806091.24
PC ammonia	4620.71
PC *E. coli*	3.63745E+15
PC nitrate	-33810.11
PC orthophosphate	-2242.85
PC TSS	-1844244.09
Total ammonia	19118.02
Total *E. coli*	7.37105E+16
Total nitrate	-10409.35
Total orthophosphate	-4921.80
Total TSS	-3636814.49

Target load reductions were calculated by sub-subwatershed, subwatershed and for the total three subwatersheds.

This table represents the targeted total load reduction by subwatershed and for the total of all three subwatersheds. Numbers in red indicate that current estimated loads are less than the target load reduction for that specific parameter.

The suggested implementation actions (for the next 3-5 years) are as follows:

Killbuck/Mud Creek Subwatershed

- Increase Filter Strips/Riparian Buffers Along Primary and Secondary Waterways
- Increase Conservation Tillage/Residue Management
- Install a Tile Control Structure Demonstration Site
- Reengineer Both Stream Channels
- Install a Constructed Wetland Storm Water Treatment Demonstration Site
- Repair/Remove Failed/Failing Septic Systems and Treatment Facilities

Buck Creek Subwatershed

- Restore and Protect Riparian Corridor along Buck Creek and Determine Ability to Support Salmonid Species
- Promote Manure/Nutrient Management
- Increase Conservation Tillage/Residue Management
- Remove rock dam upstream of BC-6 sampling point (CR 400 South)
- Install a Tile Control Structure Demonstration Site
- Remove/Repair Failed/Failing Septic Systems

Prairie Creek Subwatershed

- Develop a Master Plan for the Prairie Creek Watershed
- Promote Manure/Nutrient Management
- Increase Conservation Tillage/Residue Management
- Install a Constructed Wetland Demonstration Site
- Install a Tile Control Structure Demonstration Site
- Remove/Repair Failed/Failing Septic Systems

Actions Applicable to All Three

- Public Education
  - Identify and Promote Drainage Management Options
  - Promote Septic System Maintenance
  - Promote Erosion Control
  - Promote Lawn/Turf Management
  - Conduct Education on Organic/Chemical Free Agriculture/Gardening
  - Conduct Public Watershed Education and Outreach
- Provide an Agricultural Technical Assistant
- Conduct a Modified Monitoring Program
  - E. coli source identification
  - Lake study on Prairie Creek Reservoir
  - Modified bacteriological, biological and chemical monitoring of the three subwatersheds
- Update GIS Data Layers

Through these actions, there is an estimated load reduction for several pollution parameters over the collective area of all three studied subwatersheds (as calculated using the EPA Region 5 load reduction worksheet). They are as follows:

Total Suspended Solids: 15869 lbs/year
Sediment: 3706.6 tons/year
Nitrogen: 15933.1 lbs/year
Phosphorus: 5316.3 lbs/year

These actions, once implemented, shall be monitored for success using various methods; including water and land use/cover monitoring, pollutant load reduction calculations, participant reviews and numbers, and monitoring acreage increases in target practices.

The responsibility for measuring the success of the implementation of this management plan shall be with the Delaware County Soil and Water Conservation District. Funds for the implementation phase shall come from a second EPA Section 319 grant, again to be held by the District, in the amount of $400,000.00. The District shall build upon the strong community support garnered during the planning phase of the White River Watershed Project to ensure a successful implementation phase.

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CHAPTER 1

WHITE RIVER WATERSHED PROJECT: OVERVIEW AND STRUCTURE

1.1 Formation of the White River Watershed Project

1.1.1 Project 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), upon the acquisition of an EPA, Section 319 Grant in 2001. This three-year grant was awarded for the purpose of creating this watershed management plan that addresses local non-point source water pollution issues in three priority subwatersheds. Those subwatersheds, chosen by the community, are: Killbuck/Mud Creek, Buck Creek, and Prairie Creek Subwatersheds.

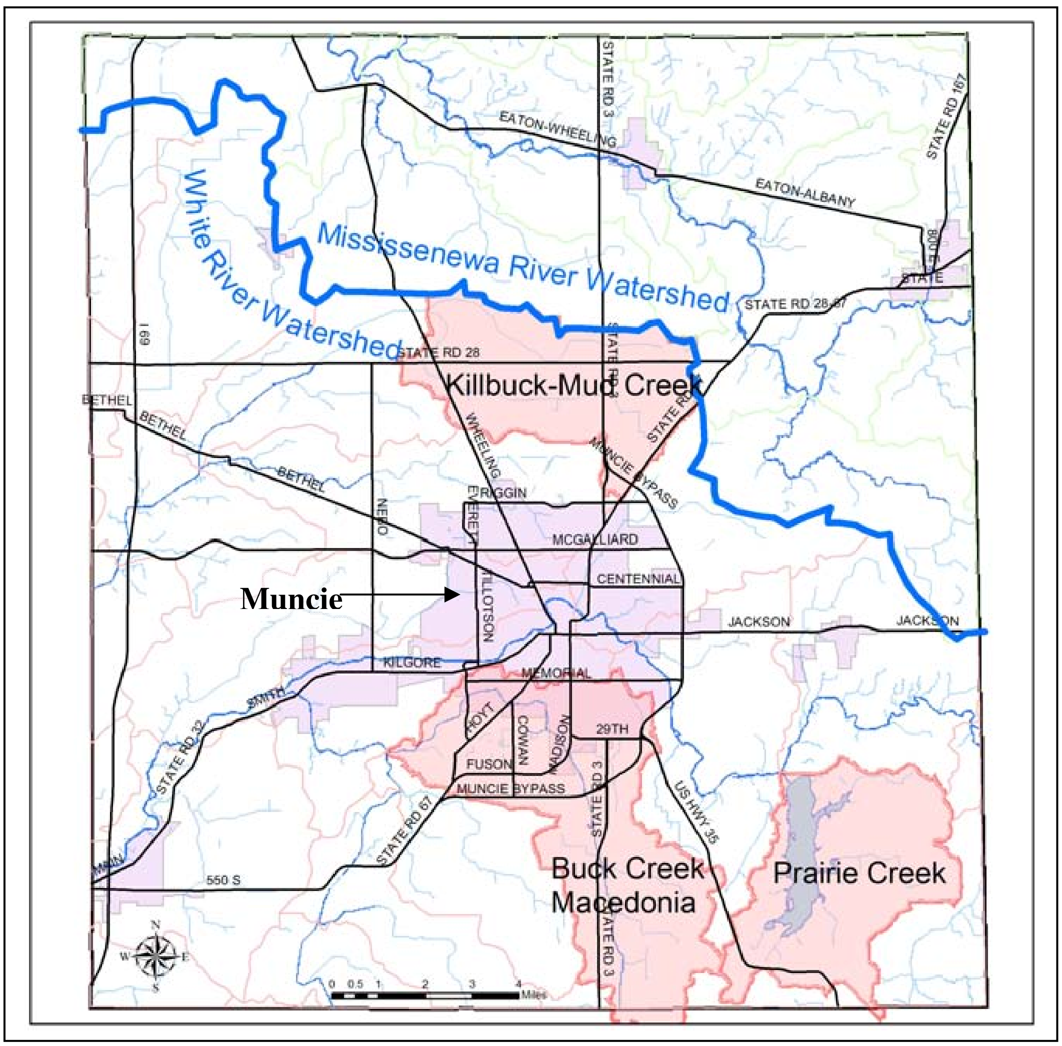


Figure 1.1: Three Selected Subwatersheds Studied for the White River Watershed Project

1.1.2 Mission and Vision Statements

The White River Watershed Project has developed Mission and Vision Statements to help guide the watershed management planning process towards cleaning up and preventing non-point water pollution.

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.*

1.2 Organization of the WRWP

The DCSWCD Board of Supervisors understood early on the importance of having broad community involvement in all aspects the WRWP. Without such 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.

1.2.1 WRWP Structure

On July 1, 2001, the DCSWCD began its search for a full time, in-house Watershed Coordinator. That Coordinator was hired and began working for the WRWP on September 19, 2001.

In keeping with the philosophy that broad community involvement is the key to project success, the Coordinator immediately organized a Steering Committee. The Steering Committee became the primary decision-making body, giving formal recommendations for Board actions with regards to major project direction, fiscal and contractual decisions.

The Coordinator formed seven additional committees to bring in as much local input into the WRWP as possible. There are three Technical and three Watershed Committees, as well as one Advisory Committee. Stakeholders from each subwatershed and the county as a whole were actively recruited and encouraged to participate in these committees.

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

Responsibilities: legal grant holder, provide full-time Watershed Coordinator, final approval on financial transactions, contracts, grant requests, and final plan

DCSWCD Board Community Representation: agricultural community and local business (associate supervisors: Ball State University, Indiana Farm Bureau, agricultural community)

Steering Committee
Responsibilities: overall project direction; major financial and contractual transaction recommendations to DCSWCD Board of Supervisors; co-development of management plan
Steering Committee Community Representation: agricultural community, rural residential community, urban community, Ball State University (Facilities, Planning and Management; Natural Resources and Environmental Management), Delaware County Farm Bureau, Red Tail Conservancy (local land trust), county surveyor (county government), county drainage board (county government), Delaware Greenways, Inc. (local trail development organization), citizens from each of the three subwatersheds (Killbuck/Mud, Buck, Prairie), Bureau of Water Quality (city government), county health department (county government), Muncie-Delaware Metropolitan Planning Commission (county government), Indiana-American Water Company, Town of Yorktown (local government)

Watershed Committees (Killbuck/Mud Creek, Buck Creek, and Prairie Creek)
Responsibilities: Ensure that local issues and concerns are addressed throughout the project; solicit interest and support for the project in their communities; assistance with local land use identification; co-organization of local events and outreach activities; co-development of management plan; provide a representative to serve on the steering committee

Watershed Committee Community Representation: watershed citizens; urban, rural residential and agricultural community, business owners, local government, BioMuncie (local environmental education organization), educators and school administrators (primary, secondary and university)

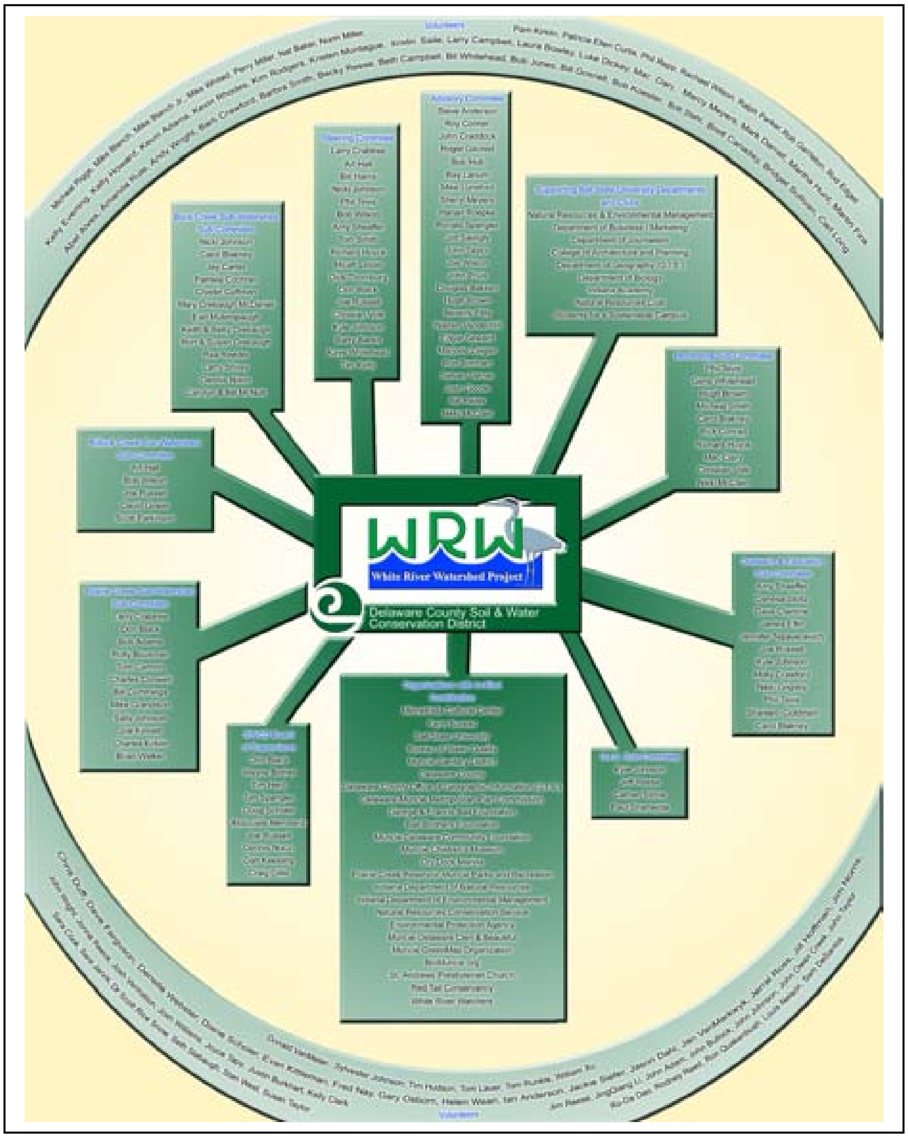
Monitoring Committee
Responsibilities: monitoring program development; creation of the QAPP (quality assurance project plan for WRWP monitoring program); co-development of GIS based land use analysis; study and interpretation of monitoring program results

Monitoring Committee Community Representation: Ball State University (NREM), Bureau of Water Quality, Muncie Sanitary District, Natural Resources Conservation Service, Delaware Greenways, BioMuncie, agricultural community, Indiana-American Water Company

GIS (Geographic Information System) Committee
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; outline development for GIS interactive web site (created and maintained by Ball State University)

GIS Committee Community Representation: Delaware County GIS Department, Muncie-Delaware Metropolitan Planning Commission, Ball State University (Geography), Bureau of Water Quality (city government)

Outreach/Education Committee
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



Outreach/Education Committee Community Representation: BSU (NREM, Marketing, History), BioMuncie, Youth Environmental Council, Minnetrista, Purdue Cooperative Extension, agricultural community, Delaware County Farm Bureau

Advisory Committee
Responsibilities: provide insight and vision for the long-term success of the WRWP

Advisory Committee Community Representation: local business, Ball State University, local government, environmental organizations, agricultural community, local community foundations, local school system, local community groups

Figure 1.2: WRWP Organizational Chart

Role of the Watershed Coordinator
The central role of the Watershed Coordinator was to bring together the vast community representation, which served as the backbone of the White River Watershed Project, as represented above. The Coordinator provided the primary project management, working as translator of ideas and information into a common language for all to work with.

Responsibilities: daily and overall project management, committee and general volunteer coordination, public outreach and education, financial management (including invoicing and bookkeeping), writing of grants, reports, public relations documents and the plan.

1.3 Selecting What Subwatersheds to Study

The DCSWCD was tasked with studying three 14-digit Hydrologic Unit Code (HUC) subwatersheds in the Upper White River Watershed within Delaware County. Those three subwatersheds were not specified. The DCSWCD combined information gathered on the current conditions of the subwatersheds with community input and had the citizen Steering Committee make the final decision.

Through a series of public meetings and the interpretation of known water quality and land use information, the Steering Committee chose the following three subwatersheds (Listed beneath them are the reasons for their selection.):

Killbuck/Mud Creek Subwatershed

- Has both agricultural and suburban land use, which gives a good representation of Delaware County
- Greater ability to affect water quality by being a headwaters subwatershed
- Public perception of poor water quality
- Known to have problems with failing septic systems

Buck Creek Subwatershed

- Has agricultural, urban and sub-urban land use; good representation of Delaware County
- Greater ability to affect water quality by being a headwaters subwatershed
- Listed with the IDEM as a waterway with impaired water quality (303d list)
- Buck Creek is a unique waterway in the county, due to potential as a cold water trout stream

Prairie Creek Subwatershed

- Overwhelming public perception of good water quality
- Drinking water source
- Development pressure
- Greater ability to affect water quality by being a headwaters subwatershed
- Public recreation site
- Potential example of an area with land use practices that work to protect water quality in the county

1.4 Initial Community Concerns

The initial community-identified water quality concerns (generated [prior to the grant starting] in 2000 and 2001) that served as the impetus for WRWP are as follows:

- Public Health
  - Drinking Water
  - Fish Consumption Advisories
- Loss of Natural Habitat
  - Wildlife Diversity
  - Aesthetics
- Impacts to Recreation
  - Fishing; Boating; Swimming

Once the three subwatersheds were chosen, citizen committees from each subwatershed were formed (as described previously). The first task set upon them was to list their concerns and perceptions regarding water quality in their specific subwatershed. This was accomplished over several subwatershed committee meetings in the autumn of 2002. Below are the lists of community concerns for each subwatershed:

Killbuck/Mud Creek Subwatershed

Septic Systems - The watershed has a history of failing/failed septic systems, most of which will be tied into a new sewer system project, however the community was unsure if everyone would be connected and was concerned about the detrimental effects of those remaining unconnected.

Drainage – Broken drainage tiles negatively affect both agriculture and water quality. Such tiles allow sediment, chemicals, and manure to drain into water ways. The community wanted to know where all underground drainage tiles were located and where they outlet into surface waterways.

Conservation Agricultural– Conservation practices on agricultural lands positively affect local water quality. The community wanted to identify all agricultural conservation practices in the watershed and map them.

Chemical Usage on Genetically Engineered Agriculture Crops (GEC) **–** The community felt chemical use has been reduced on acreage where genetically modified crops are planted. It has been stated that residual herbicides were reduced on GEC soybeans and pesticides were increased on GEC corn by members of the Killbuck/Mud Creek Committee.

Illegal Dumping – There is a problem with illegal dumping in the subwatershed, with a particular concern over hazardous household waste making its way into surface water. The community wanted to conduct targeted outreach to local citizens explaining how to properly dispose of such materials.

Outreach/Education – The community felt educating the public on the project and local water quality issues are important.

E. coli – The community was concerned about *E. coli* levels and their impact to local water quality. Identifying sources of contamination were important to this group. Geese were suggested as a possible source, as were failing septic systems.

Buck Creek Subwatershed

Illegal Dumping – Both the dumping of refuse (especially tires) and pets were considered a problem in the subwatershed. The community wanted to educate the public on where they can dispose of refuse and unwanted pets properly.

Urban Sprawl – The conversion of farmland to housing was a concern. The committee wanted to see more planning and zoning done to ensure proper development.

Chemical Contamination –The effects of urban, suburban and agricultural chemical usage was of concern. Lawn applications, salt from water softeners and road application, agricultural over-spraying, and the spraying of county ditch and creek banks were specifically mentioned.

Drainage – Broken drainage tiles negatively affect both agriculture and water quality. Broken drainage tiles allow sediment, chemicals, and manure to drain into water ways. There was a desire to bring the needs of water quality, habitat, and flow together when deciding on how to develop and maintain local drainage ways.

Septic Systems – Failing/failed systems were of concern. There was a desire to include solutions in the plan for fixing/replacing these systems.

Conservation Agricultural - Conservation practices on agricultural lands positively affect local water quality. The community wanted to identify all agricultural conservation practices in the subwatershed and map them.

Outreach/Education - The community felt educating the public on the project and local water quality issues was important. Included was a desire to inform the public about the fish consumption advisory, hunter education (regarding the disposal of entrails, etc, in local waterways), and septic system maintenance.

Prairie Creek Subwatershed

Urban Sprawl – The committee was concerned over potential development on the banks of the reservoir, as well as throughout the subwatershed. Impacts of increased recreational usage in and around the reservoir were also of concern.

Conservation Agricultural - Conservation practices on agricultural lands positively affect local water quality. The community wanted to identify all agricultural conservation practices in the subwatershed and map them. Observations of increased no-till in some areas and increase in chisel plowing in others were noted.

Recreation on the Reservoir – This committee was concerned about the affects recreational activities may have on water quality in the reservoir. Specific issues mentioned were how sewage disposal is handled at the campground, bank erosion, parking lot runoff, chemical and sewage discharge from pontoon and other boats, ATV impacts, and fishing.

Geese – The committee thinks that geese could be contributing to *E. coli* levels.

Drainage - Broken drainage tiles negatively affect agriculture and water quality, both. Broken drainage tiles allow sediment, chemicals, and manure to drain into water ways. There are concerns over the affects of pond installation and the subsequent breakage of tiles.

Woodland Loss – Community was concerned of the impacts of woodland loss around the reservoir.

With this information gathered, the technical committees and the coordinator set out to obtain an understanding of the current conditions in each of the three subwatersheds, both the positives and the problems. Results of this work were used to verify or refute the above listed concerns, and to give everyone an understanding of actual subwatershed conditions, as reported later in this document.

1.5 Plan Development

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 anywhere from single committee sessions to large multi-committee and general public participation meetings. (Please see Appendix A for the WRWP 2001-2004 event calendar.) Each of the committees previously listed played a key role in the development of this plan, as their listed responsibilities explain.

While all committees and members of the general public had a hand in the development of this management plan, and the Watershed Coordinator was responsible for the writing of the document itself, the majority of the work was completed through a combined effort between the DCSWCD Board, Steering Committee and the three Watershed Committees. The Steering and Watershed Committees worked together to identify local water quality issues and recommend voluntary actions, 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 (See Chapters 4 and 5).

CHAPTER 2

DESCRIBING THE SUBWATERSHEDS

2.1 Project Location

The White River Watershed Project encompasses three 14-digit subwatersheds that are part of the larger White River Basin in Indiana (Figure 2.1). 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). (USGS, http://www-dinind.er.usgs.gov/nawqa/wr00002.htm)

Nested within the White River Basin is the Upper White River Watershed, an 8-digit HUC watershed (05120201). (Hydrologic Unit Code is the official numbering system for watersheds nation-wide.) It also begins in Randolph County then extends southwesterly to Monroe and Brown Counties, encompassing (wholly or in part) a total of sixteen counties. The main waterbody flowing through this watershed is the west fork of the White River, which flows for 356 miles and drains 5,600 square miles. Land use in the watershed is predominately agriculture (primarily corn and soybean production), which represents approximately 76 percent of the total land cover. (IDEM (OWQ), 2001)

Indianapolis is the state capitol and largest city in the watershed, with Muncie and Anderson following as the next largest cities. The West fork of the White River, from Farmland to its confluence with the Wabash River, is on the Outstanding Rivers List for Indiana, as having outstanding ecological, recreational, or scenic importance. (IDEM (OWQ), 2001)

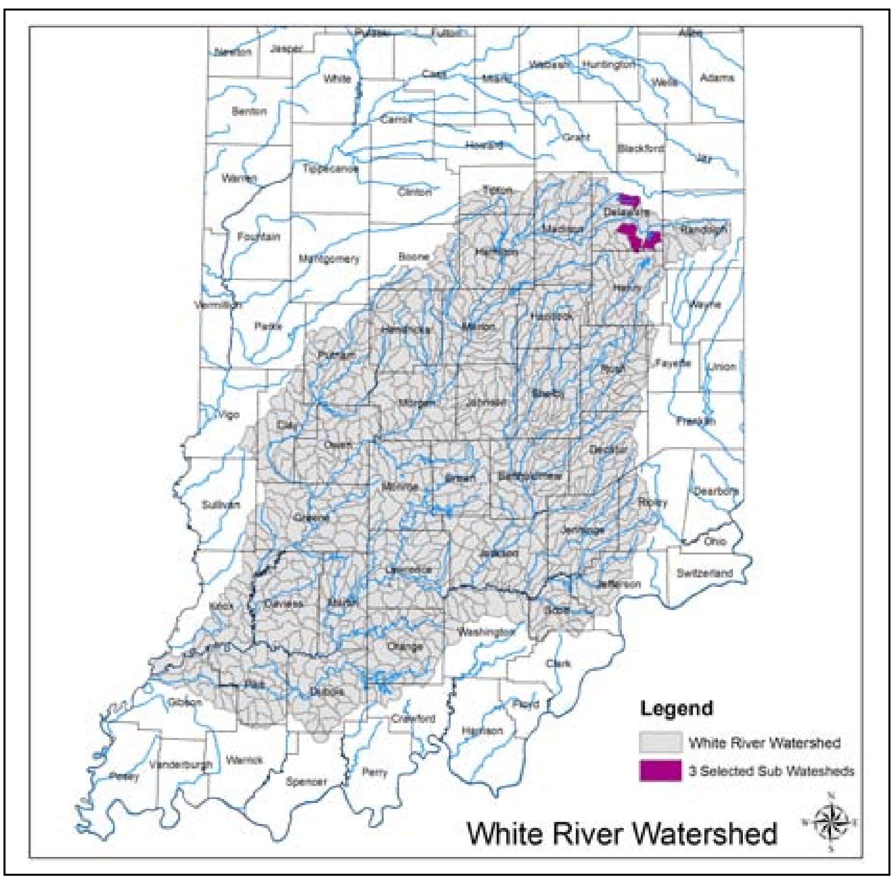


Figure 2.1: Map of the White River Basin with Selected Subwatersheds

The Upper White River Watershed encompasses the lower two-thirds of Delaware County, for a total 174,829.90 acres (273.1812 square miles). In Figure 2.2, the pink shaded areas are the three 14-digit HUC subwatersheds included in this management plan: they are the Killbuck/Mud Creek (05120201040010) (15.7 square miles), Buck Creek (05120201020020) (25.1 square miles), and Prairie Creek (05120201010110) (17 square miles) Subwatersheds.

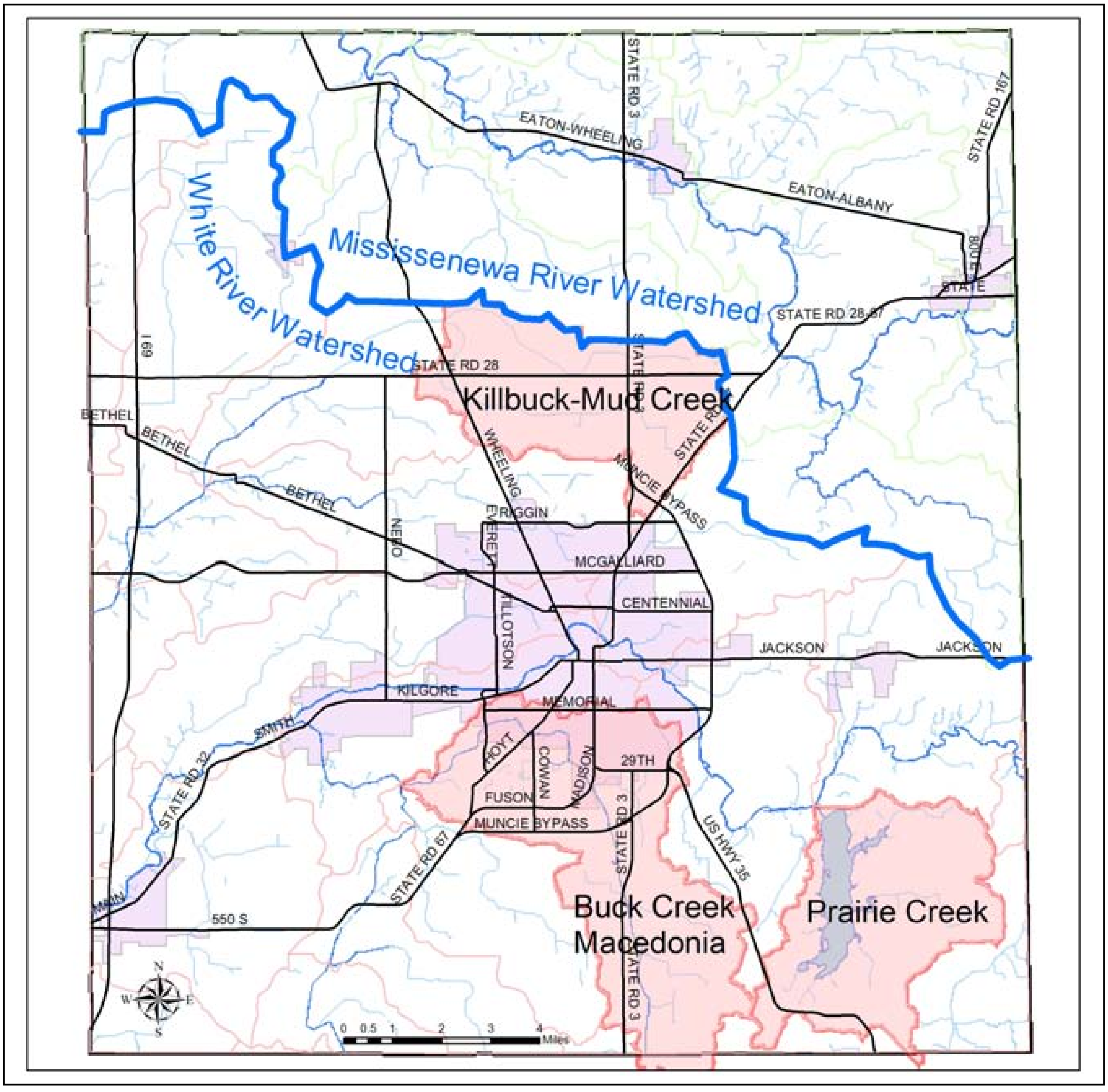


Figure 2.2: Location of the Three Studied 14-Digit Subwatersheds within Delaware County

2.2 Description of the Three Studied Subwatersheds

All three subwatersheds involved in this study share some common characteristics:

Climate: Delaware County has average temperatures ranging from 34°F in January to 72°F in July, with an annual average temperature of 52°F. Average monthly rainfall is 4.7 inches and annual snowfall is 16.5 inches. (Key to the City [Muncie, IN – Weather and Climate], http://www.usacitiesonline.com)

Geology: All three subwatersheds are located within the boundaries of the Wisconsin glacial deposits (a period that lasted from fifty to twelve thousand years ago). Killbuck/Mud, Buck and roughly three-quarters of Prairie Creek subwatershed are located within the Trenton Petroleum Field. That field has historically possessed gas, oil and gas storage. (Indiana Geological Survey, ArcIMS Viewer http://igs.indiana.edu/arcims/statewide/index.html)

Soils: Geographic Information Systems (GIS) technology was utilized to summarize the soils present in the three subwatersheds. Each soil map unit has an assigned soil component (series) name, hydrologic soil group, drainage class, soil texture, K factor (soil erodibility), and T factor (soil loss tolerance). The soil map units were summarized for their individual acreage, hectares and ratio of their individual area by the total area in each subwatershed. The hydrologic soil groups are assigned by the groups A, B, C, or D. Hydrologic soil groups are defined as groups of soils that, when saturated, have the same runoff potential under similar storm and ground cover conditions. The influences of ground cover and slope are treated independently and are not taken into account in hydrologic soil groups. (Detailed soil and drainage descriptions are located in subwatershed sections of this chapter. See Appendix B for methodology.) (Wright, 2004)

Table 2.1: Hydrologic Soils Description Key

Hydrologic Soil Groups	Infiltration Rate/Runoff Potential when thoroughly wet	Drainage	Soil Texture	Rate of Water Transmission
A	High/Low	Very deep, well drained to excessively drained	Sands or gravelly sands	High
B	Moderate/Moderate	Moderately deep or deep, moderately well drained, well drained	Moderately fine to moderately coarse	Moderate
C	Slow	Has layer that impedes downward movement of water	Moderately fine or fine	Slow
D	Very slow/High	Has permanent high water table, claypan or clay layer at or near surface, or shallow over nearly impervious layer	Clayey soil that have high shrink-swell potential	Very slow

Revised Universal Soil Loss Equation (RUSLE) is a tool to predict long-term average annua1 sol loss in ton/acre/year from specific field conditions using specific management systems. RUSLE cannot be used to estimate or predict soil loss from individual storms nor from a particular year of weather and related factors. The factors used in the RUSLE are based on long-term averages.

RUSLE uses the formula:
A = R * K * LS * C * P.
Where:
A = Predicted Average Annual Soil Loss (Tons/Acre/Year)
R = Rainfall Runoff Erosivity Factor
K = Soil Erodibility Factor
LS = Length-Slope Factor
C = Cover-Management Factor and
P = Support Practice Factor

T is the soil loss tolerance factor, expressed in tons per acre. Soil loss tolerance is the maximum amount of soil loss in tons per acre per year, that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely. Erosion losses are estimated by the Universal Soil Loss Equation and the Revised Universal Soil Loss Equation. The T factor is assigned to soils without respect to land use or cover. Soil loss tolerance values of 1 through 5 are used. These values represent the tolerable tons of soil loss per acre per year where food, feed and fiber plants are to be grown. T values are not applicable to construction sites or other non-farm uses of the erosion equation.The five classes range from 1 ton per acre per year for very shallow soil to 5 tons per acre per year for very deep soil that can more easily sustain productivity.

K is the soil-erodibility factor. It is a measure of erodibility for a standard condition. This standard condition is the unit plot, which is an erosion plot 72.6 ft (22.1 meters) long on a 9 percent slope, maintained in continuous fallow, tilled up and down hill periodically to control weeds and break crusts that form on the surface of the soil. The plots are plowed, disked and cultivated the same for a row crop of corn or soybeans except that no crop is grown on the plot.

Soil erodibility factor K represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition. Soils high in clay have low K values, about 0.05 to 0.15, because they resistant to detachment. Coarse textured soils, such as sandy soils, have low K values, about 0.05 to 0.2, because of low runoff even though these soils are easily detached. Medium textured soils, such as the silt loam soils, have a moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having a high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4.
(Natural Resources Conservation Service, eFOTG)

Endangered and Threatened Species: Federally Listed: The Indiana Bat (*Myotis sodalist*), Northern Riffleshell Rangiana (*Epioblasma torulosa*), Clubshell (*Pleurobema clava*), and Running Buffalo Clover (*Trifolium stoloniferum*) are endangered and the Bald Eagle (*Haliaeetus leucocephalus*) is threatened. State Listed: For Delaware County, Indiana, there are nine species of vascular plants, nine species of mussels, five species of reptiles, six species of birds, three species of mammals and one high quality natural community listed on the state endangered and threatened species list. See Appendix B for a complete listing. (IDNR, 1999 http://www.state.in.us/dnr/naturepr/species/index.html)

Historic Land Use: 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 http://www.epa.gov/wed/pages/ecoregions/ohin_eco.htm) 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.". (http://www.countyhistory.com/delaware/start.html)

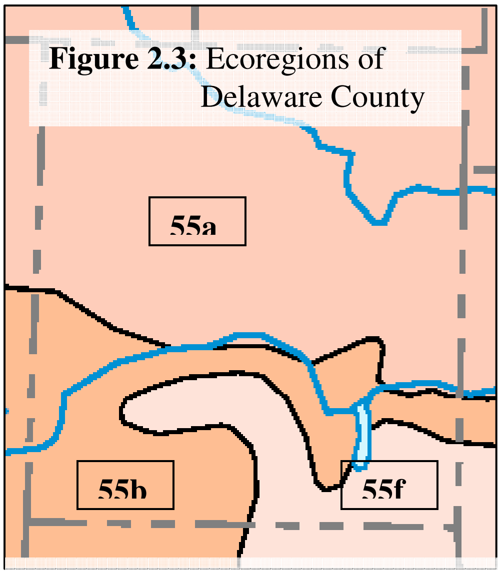
Delaware County was organized in 1826, being named after the largest division of the Delaware Native American tribe that made its home here. That tribe was the Delaware Indians, an Eastern tribe that settled in east central Indiana during the 1770's. The Delaware Indians established several towns along the White River, among these Muncietown, 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. (http://www.rootsweb.com/~indelawa/county.htm)

"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. 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. The college is now known as Ball State University." (City of Muncie, http://65.174.85.151/default.asp)

Natural History:

Delaware County is in "Ecoregion 55, Eastern Corn Belt Plains, which is characterized primarily by rolling till plain with local end moraines. Glacial deposits of the Wisconsonian age are extensive (as previously discussed under **Geology** in this section). (Ecoregions of Indiana, USEPA http://www.epa.gov/wed/pages/ecoregions/ohin_eco.htm) Originally, natural tree cover was extensive (beech forests in the well drained soils and elm-ash forests in the wetter soils). Today extensive corn, soybean and livestock production occur and has affected stream turbidity."

Figure 2.3: Ecoregions of Delaware County



Legend: = Delaware County

There are three sub-categories of the Eastern Corn Belt Plains Ecoregion in Delaware County:

"55a, Clayey High Lime Till Plains, which 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 is dominant and has replaced the original beech forests and scattered elm-ash swamp forests. No exceptional fish communities exist in the turbid, low gradient streams of Ecoregion 55a.

55b, Loamy, High Lime Till Plains**,** which 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 forests, and elm-ash swamp forests grew on the nearly level terrain; today, corn, soybean, and livestock production is widespread.

55f, Whitewater Interlobate Area**,** which has distinctive cool water, coarse-bottomed streams that are perennial and fed by abundant ground water. 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." (Ecoregions of Indiana, USEPA http://www.epa.gov/wed/pages/ecoregions/ohin_eco.htm)

2.2.1 Killbuck/Mud Creek Watershed (05120201040010)

The first of the three subwatersheds studied for this management plan is named the Killbuck/Mud Creek Subwatershed (HUC 14-Digit Number: 05120201040010). It drains 10,039 acres (15.7 square miles) and has two main waterways within in its boundaries (Mud Creek to the North and Killbuck Creek to the South). Mud Creek combines with Killbuck Creek at the northwestern corner of the watershed to form Killbuck Creek from that point on downstream. Almost 100 percent of the watershed is located in Hamilton Township.

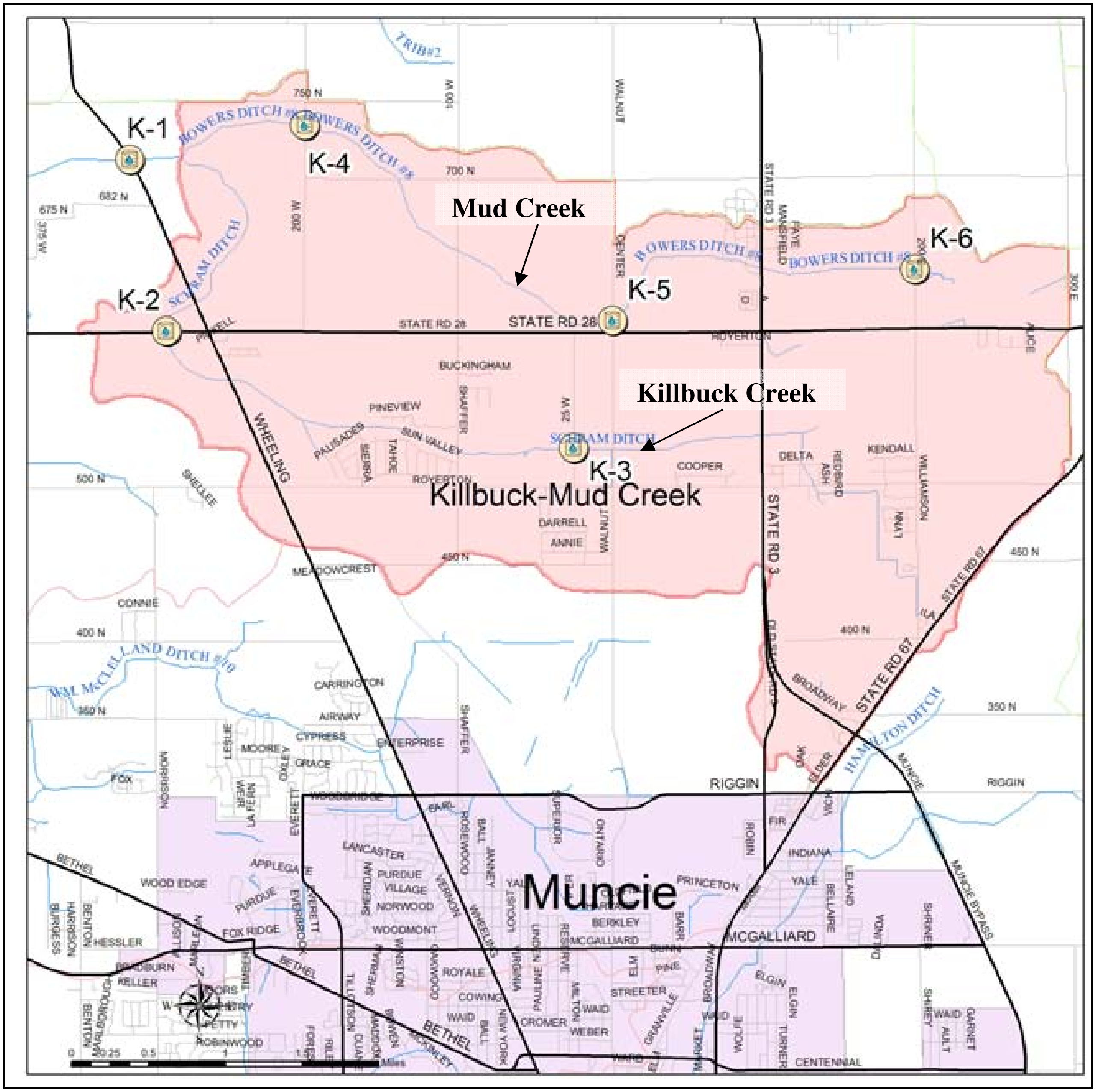


Figure 2.4: Killbuck/Mud Creek Subwatershed

2.2.1.1 Geology

Killbuck/Mud Creek Subwatershed is located in the Bluffton Till Plain section of the Central Till Plain. Its shrink-swell characteristics are moderate throughout, with surficial geology, (unconsolidated thickness), a minimum of 0 and a maximum of 50 meters. The bedrock geology is Silurian (system), Pleasant Mills Formation rock. The subwatershed has a low to non-existent sand and gravel resource potential and no active industrial mineral mining sites. There are two sand/gravel pits and twenty-four petroleum test wells. (Indiana Geological Survey, ArcIMS Viewer http://igs.indiana.edu/arcims/statewide/index.html)

2.2.1.2 Soils and Topography

The Blount and Pewamo soils are most prevalent in the Killbuck Creek Subwatershed (Figure 2.5). The Blount soils comprise approximately 35% of the total area and the Pewamo soils account for nearly 30%. The other soil component names present are less abundant and compose less than 10% of the total area. The Blount soils are somewhat poorly drained, formed under the native vegetation of hardwoods, and have management concerns of wetness for crop production. However, this soil does respond well to tile drainage. The Pewamo soils are poorly drained soils and also have management concerns of wetness for crop production and respond well to tile drainage. These soils formed under the native vegetation of water tolerant grasses and hardwoods. Millgrove and Pella soils appear to be dominant adjacent to the Mud and Killbuck Creeks. Millgrove and Pella are very poorly drained soils and are considered hydric. Wetness is a management concern for crop production, however these soils respond well to tile drainage. The native vegetation for Millgrove and Pella soils are water tolerant grasses and hardwoods. The general topography for the Killbuck/Mud Creek Subwatershed is flat, with little relief throughout.

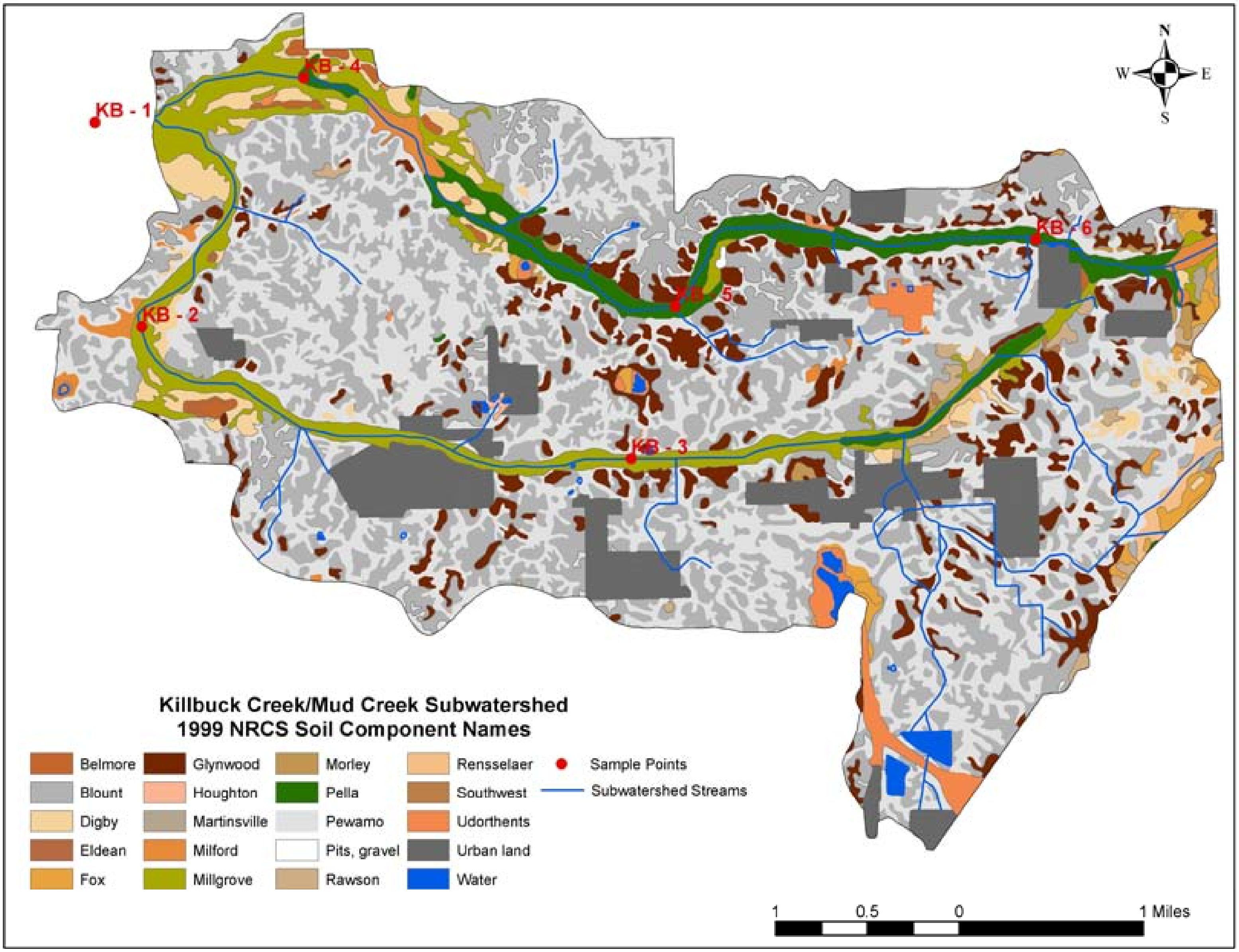


Figure 2.5: Killbuck/Mud Creek Subwatershed Soil Types

The silt loam and the silty clay loam textures are the most prevalent in the Killbuck Creek Subwatershed. They make up approximately 50% and 20% of the total area, respectively. The hydrologic soil group C dominates this subwatershed with nearly 80% of the total area. Hydrologic group C soils have slow infiltration rates when thoroughly wet and consist of soils have a moderately fine or fine texture. The somewhat poorly drained and poorly drained classes compose of 40% and 35% of the total area. The K factor of 0.43 (most erodible) and 28% encompasses nearly 50% and 35% of the total area indicating that the nearly half of the soils have the highest rating to susceptibility from sheet and rill erosion and one-third has an intermediate rating. The assigned T factors of 4 and 5 tons/acre/year (high tolerance) dominate the subwatershed and can withstand soil erosion by water and wind of 4 to 5 tons per acre per year without affecting crop productivity. (Wright, 2004 [interpretations from SSURGO, 1999])

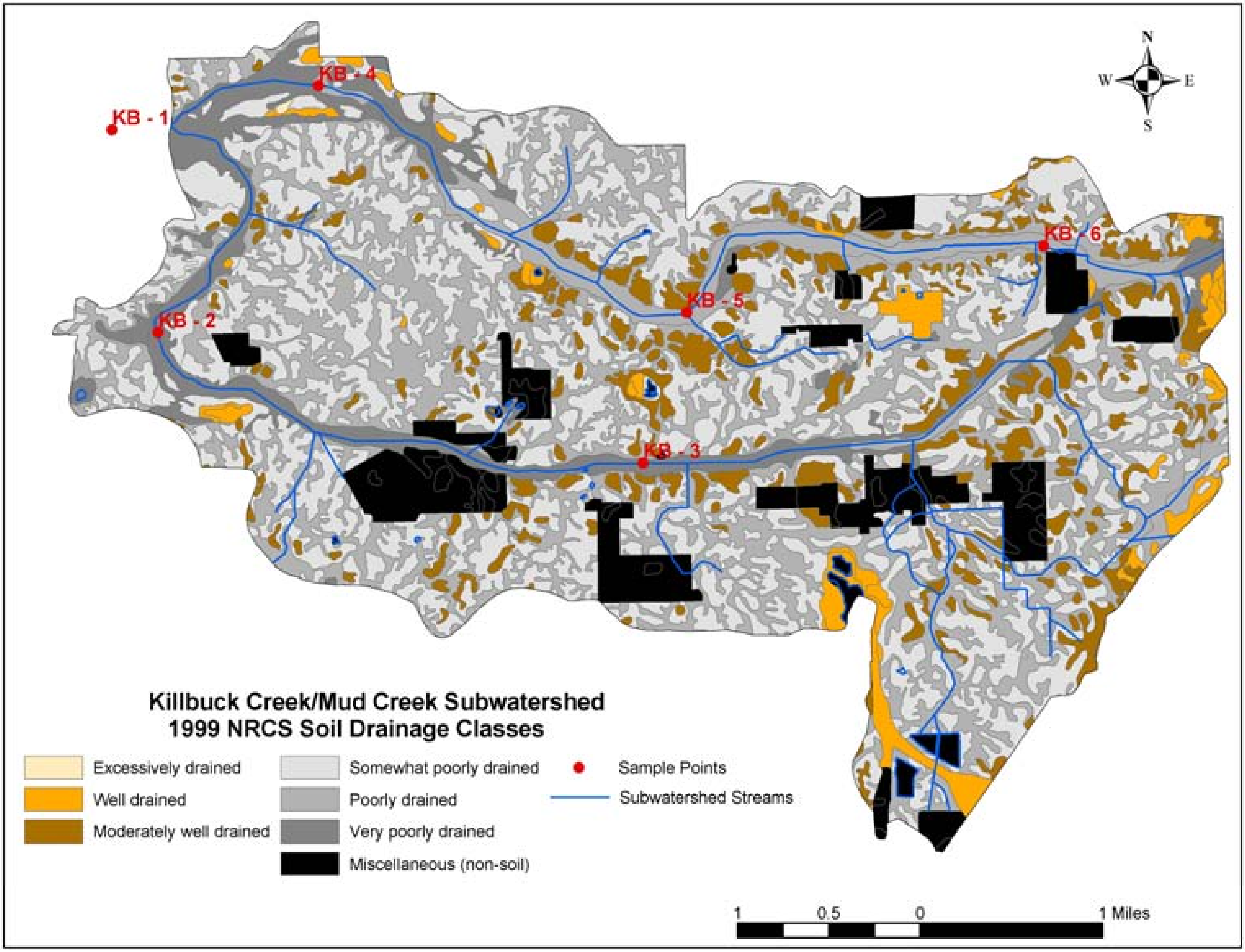


Figure 2.6: Killbuck/Mud Creek Subwatershed Soil Drainage Classes

2.2.1.3 Hydrology

Both Killbuck and Mud Creeks are naturally occurring waterways. However, their original channels have been highly modified by human alterations undertaken in an attempt to increase drainage of the surrounding agricultural fields. These modifications have altered the channel cross section to a degree that it has become unstable and has initiated a cycle of erosion and dredging that will continue until the channels can be engineered to mimic the natural flow of water dictated by the topography, soil types and gradient of the area.

In addition to channel alterations, there has been extensive underground tiling and above ground ditching within the subwatershed which reduces the amount of water that infiltrates into groundwater aquifer storage and increases the flow found in both channels.

Through visual observation, many of the above ground drainage ditches also have structural problems that contribute to the siltation problems found throughout this subwatershed.

Drinking water in this subwatershed is a combination of private wells and municipal water (supplied by the City of Muncie). All municipal drinking water comes from the White River. The aquifer for this subwatershed is the Silurian-Devonian Aquifer.

There is a total of 102.47 acres of wetlands in the Killbuck/Mud Creek Subwatershed (USFWS National Wetland Inventory [NWI], http://wetlands.fws.gov/), representing 1.02 percent of the total subwatershed acreage. (See Appendix H for NWI Map Key.)

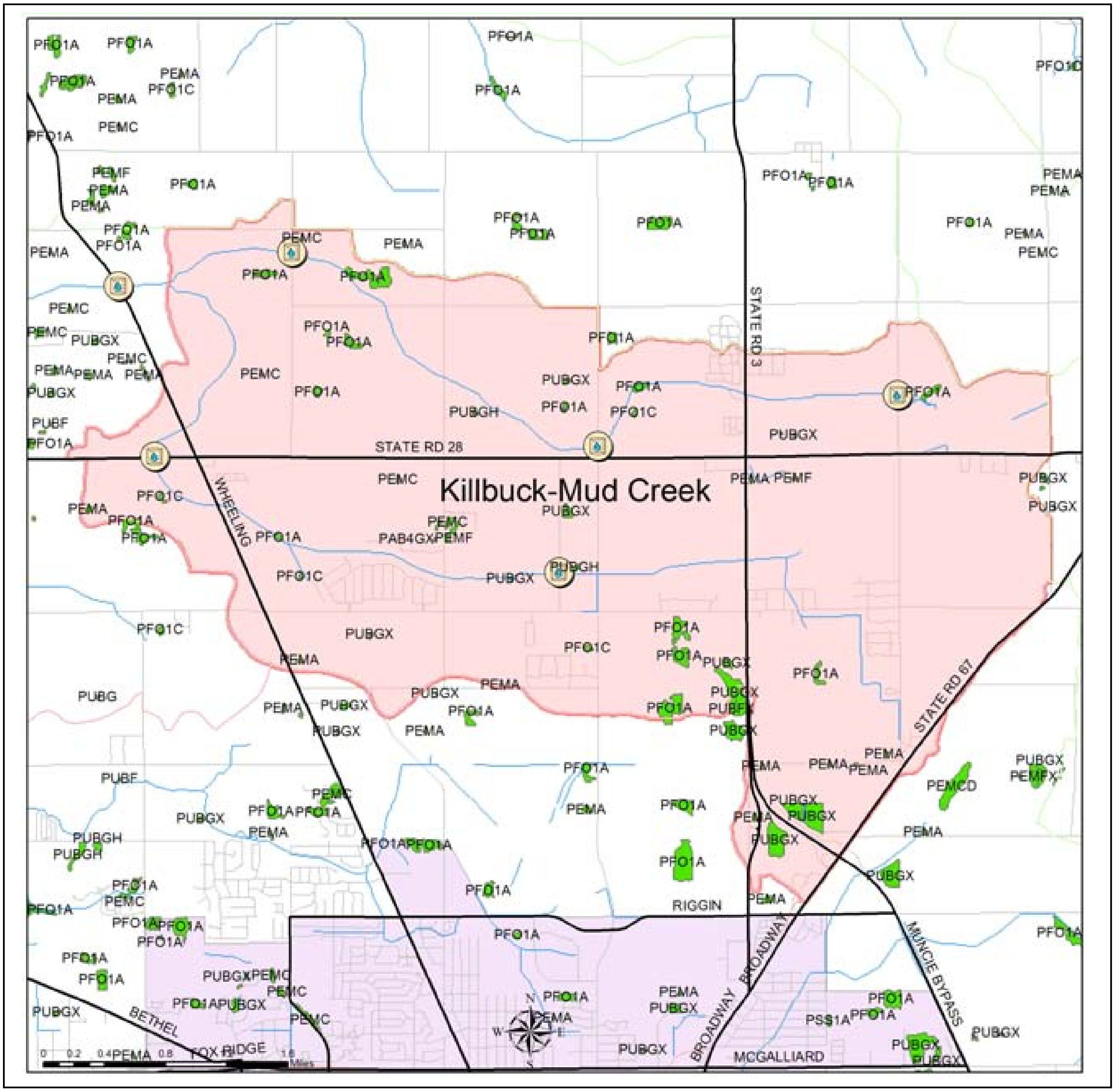


Figure 2.7: Killbuck/Mud Creek Subwatershed Wetland Locations

2.2.1.4 Natural History
The Killbuck/Mud Creek Subwatershed lies in the Clayey High Lime Till Plain Ecoregion. (See Natural History stated previously for further description.)

2.2.1.5 Land Use
Historic
Please see Historic Land Use section of this chapter.

Present
Current land use in this subwatershed is as follows:

- Agricultural 73.35%
- Transportation & Utilities 3.55%
- Residential 14.13%
- Industrial .42%
- Greenspace 6.98%
- Government & Institutional .39%
- Commercial .54%
- Agricultural Support .64%

Data from the land use study is discussed further in Chapter 4, Section 4.2.2.1 of this document.

Future


There are several residential areas within the Killbuck/Mud Creek Subwatershed that are plagued with failed/failing septic systems, as identified by the Delaware County Health Department. Currently, these areas are being tied into a municipal sewer system, a program that should include most (if not all) of these properties.

Unique Resources
There are no unique resources in the Killbuck/Mud Creek Subwatershed.

2.2.1.6 Land Ownership (public, private – trusts, government, reservoir boundaries, military)
Land within the Killbuck/Mud Creek Subwatershed is primarily privately owned, with the exception of Delta High and Middle Schools, Royerton Elementary School and the Hamilton Township Fire Department.

2.2.1.7 Cultural Resources
There are no state registered historic places in the Killbuck/Mud Creek Subwatershed.

2.2.2 Buck Creek Subwatershed (05120201020020)

The second subwatershed is Buck Creek Subwatershed (HUC 14-Digit Number: 05120201020020). This subwatershed drains 16,090 acres (25.1 square miles), beginning in Henry County and flowing north through the southern portion of the City of Muncie. Most of the subwatershed is located in two townships, to the north is Center and to the south is Monroe. However, there is a small portion to the west that is in Mt. Pleasant Township and an equally small portion to the east that is in Perry Township.

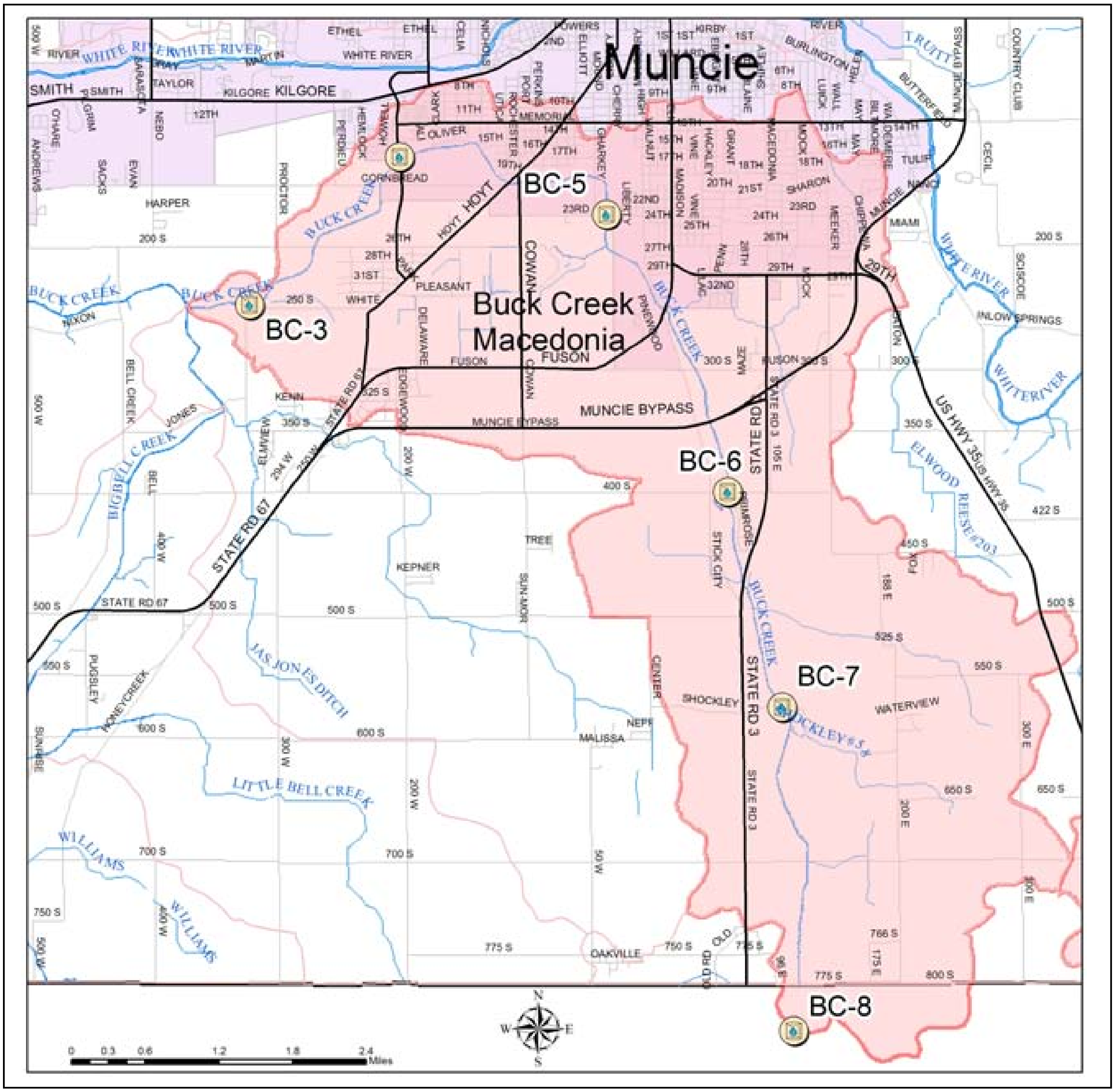


Figure 2.8: Buck Creek Subwatershed

2.2.2.1 Geology

Buck Creek Subwatershed is located in the New Castle Tills and Drainageways section of the Central Till Plain. Its shrink-swell characteristics are moderate throughout the subwatershed. The surficial geology, unconsolidated thickness, is highly variable as you move downstream through the subwatershed (from a minimum of 50 to a maximum of 300 meters). Bedrock is mainly Silurian (system) with either 1) Louisville Limestone through Brassfield Limestone, or Salamonie Dolomite Cataract Formation, and Brassfield Limestone or 2) Pleasant Mills Formation rock units. There is also a small band of Ordovician (system) with undifferentiated Ordovician rock that runs east and west near the head of the subwatershed. The subwatershed has a low to non-existent sand and gravel resource potential and no active industrial mineral mining sites. There is one active gravel pit near the upstream most point in the subwatershed, directly adjacent to Buck Creek. There is an abandoned sand and gravel pit located further north, one gas well and five petroleum wells also located within the subwatershed. (Indiana Geological Survey, ArcIMS Viewer http://129.79.145.5/arcims/statewide/viewer.htm)

2.2.2.2 Soils and Topography

The Crosby, Urban land, and Treaty soil component names have the greatest proportion of area in this respective order (Figure 2.9). The Crosby and Urban land each comprise 23%of the total area of this subwatershed. The Treaty soils approximately comprise 12% of the total area. The other soil component names present are less abundant and compose less than 10% of the total area. The Crosby soils consist of somewhat poorly drained soils that formed under the native vegetation of hardwoods. The Crosby and Treaty soils respond well to tile drainage. The Urban land soils are areas that have been disturbed by man and are therefore highly variable in their properties. Most areas are covered by structures or roads. The Treaty soils are poorly drained and are considered a hydric soil. Wetness is a management concern for crop production for Crosby and Treaty soils. Drouthiness is another management concern for Crosby soils. The Sloan and Bellcreek series are the most prevalent adjacent to the main stem of Buck Creek. Sloan and Bellcreek soils are very poorly drained, considered hydric and their native vegetation is water tolerant grasses and hardwoods. Wetness and the flooding hazard are management concerns for crop production, however Sloan and Bellcreek soils respond well to tile drainage. Because of the flooding hazard, these two soils have severe limitations for most non-agricultural uses. The Miamian is the most prevalent in the southeast portion of the Buck Creek subwatershed. Miamian is a moderately well drained soil its native vegetation is hardwoods. Drouthiness and water erosion are management concern for crop production for Miamian soils. The general topography in the Buck Creek Subwatershed is gently rolling in the southern portion of the watershed and decreases in relief as one moved northwards.

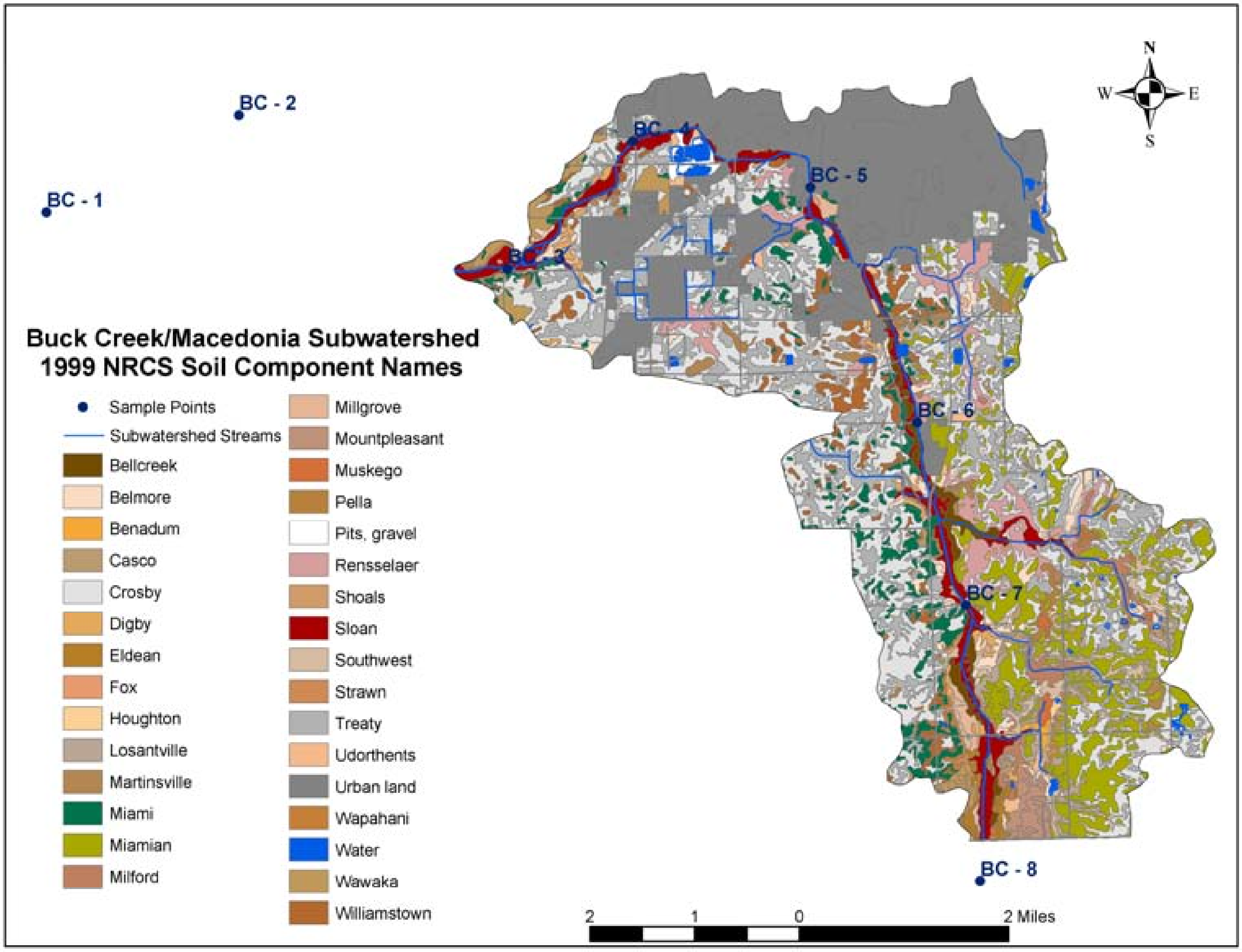


Figure 2.9: Buck Creek Subwatershed Soil Types

The silt loam and loam soil textures are the most abundant in the Buck Creek Subwatershed accounting for approximately 50% and 25% respectively of the total area. The hydrologic soil group C and B are the most common indicating a dominance of soils with slow and moderate infiltration rates when thoroughly wet. The somewhat poorly drained, poorly drained, and moderately well drained soil drainage classes are found in this order. The K factor of 0.43 (most erodible) is assigned to nearly 40% of the total area, indicating that the majority of the soils have the highest rating to susceptibility of sheet and rill erosion by water. The T factor of 4 (highly tolerant) tons/acre/year is assigned to approximately 55% of the total area and 5 (highly tolerant) is assigned to 40% of the total area in the subwatershed. This indicates the majority of the soils present can withstand soil erosion by water and wind of 4 to 5 tons per acre per year without affecting crop productivity. (Wright, 2004 [interpretations from SSURGO, 1999])

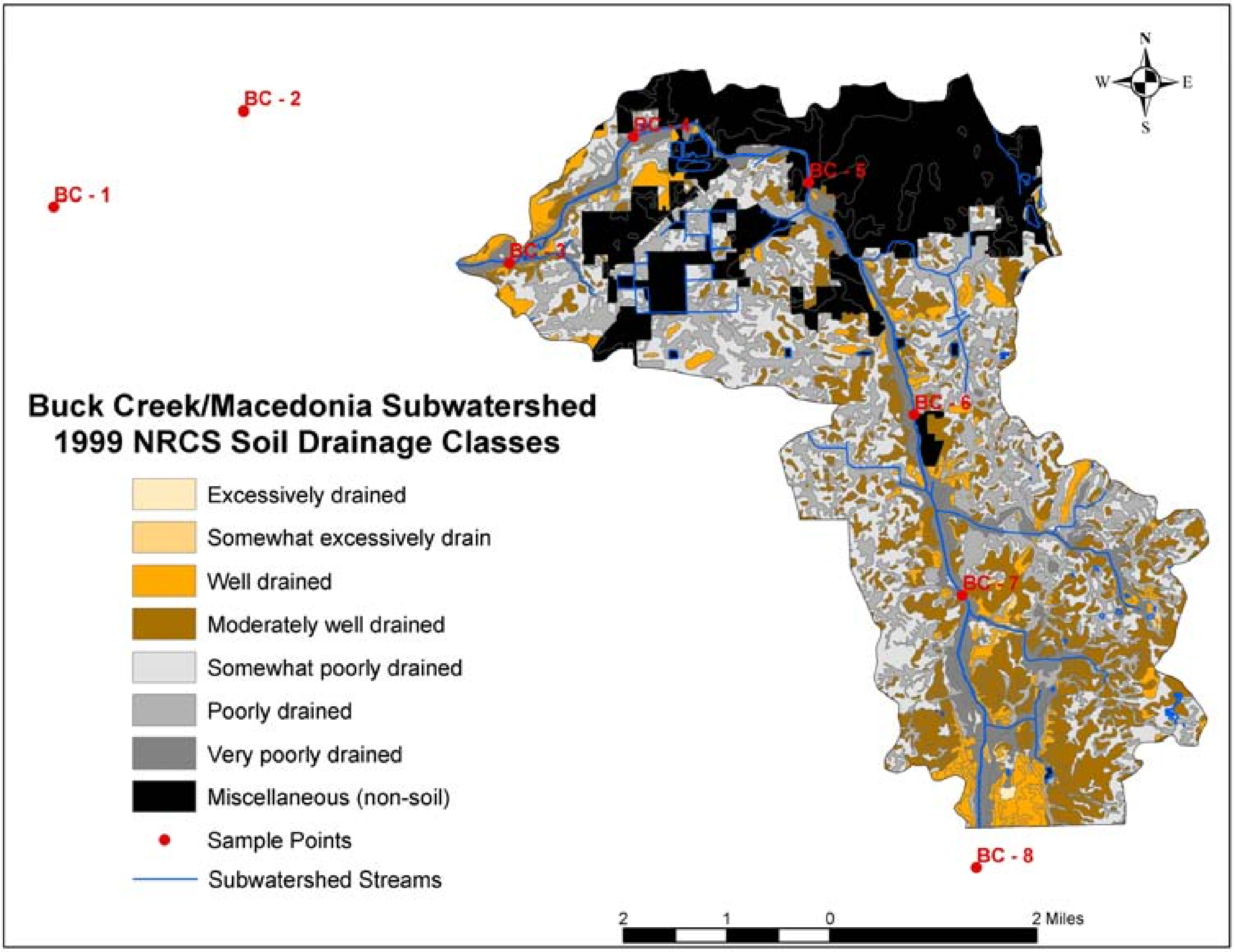


Figure 2.10: Buck Creek Subwatershed Soil Drainage Classes

2.2.2.3 Hydrology

Buck Creek is a rather unique waterway for Delaware County as it is on the border of being considered a cold water stream. Its unusually low water temperature gradient is characteristic of streams that are fed primarily by groundwater springs. The Ecoregion in which Buck Creek subwatershed resides characteristically possesses streams that are fed abundantly by ground water springs. (See Natural History on page 14 for further explanation.) Results of testing conducted by the Muncie Sanitary further support this. (See Chapter 3, Section 2 for further discussion.)

Drinking water in the Buck Creek Subwatershed is obtained through private wells in some areas and through the municipal water supply in others (provided by the City of Muncie). All municipal drinking water comes from the White River. Buck Creek Subwatershed has one principal aquifer, the Silurain-Devonian Aquifer in the north. Groundwater in the southern portion of the subwatershed comes through unconsolidated glacial till.

There is a total of 151.47 acres of wetlands in the Buck Creek Subwatershed (USFWS National Wetland Inventory [NWI], http://wetlands.fws.gov/) representing 0.94 percent of the total subwatershed acreage. (See Appendix H for NWI Map Key.)

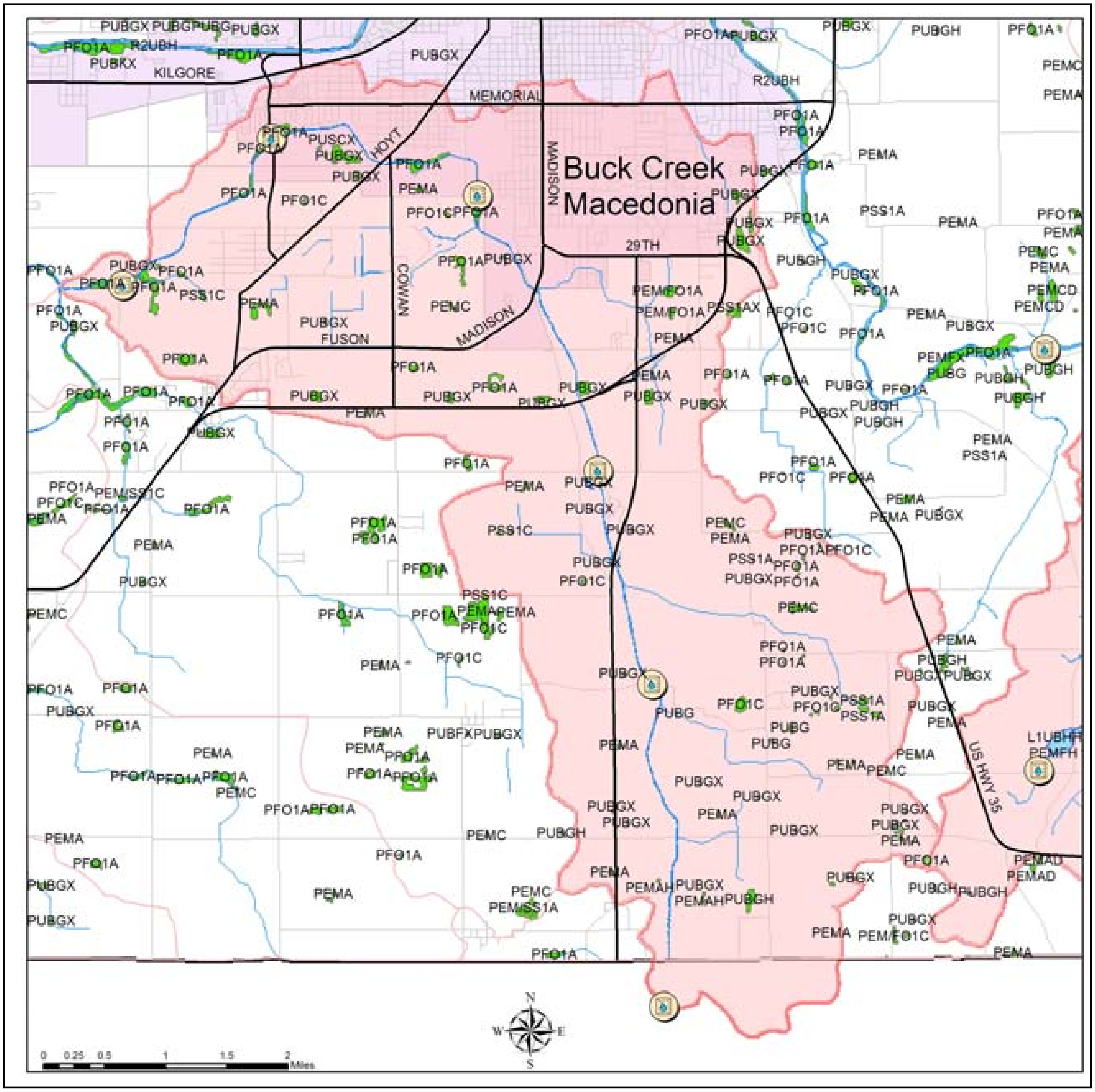


Figure 2.11: Buck Creek Subwatershed Wetland Locations

2.2.2.4 Natural History

Most, if not all, of the Buck Creek subwatershed lies within the Whitewater Interlobate Area Ecoregion. As stated on page 14 under Delaware County's natural history description, this Ecoregion has distinctive cool water, coarse bottomed streams that are perennial and fed by abundant ground water.

2.2.2.5 Land Use and Land Cover

Historic

Please see Historic Land Use earlier in this chapter.

Present

Current land use in this subwatershed is as follows:

- Agricultural 53%
- Transportation & Utilities 7.34%
- Residential 16.03%
- Industrial 2.59%
- Greenspace 12.55%
- Government & Institutional .35%
- Commercial 4.3%
- Agricultural Support .70%
- Salvage Yard .29%
- Vacant/No Use .05%

Data from the land use study discussed further in Chapter 4, Section 4.2.2.2 of this document.

Future

There are development pressures facing this subwatershed, with particular emphasis to the acreage to the south and west of the Muncie city border. With regards to the southside of Muncie, there is an active redevelopment program to bring urban infill to this economically depressed area.

Unique Resources

Buck Creek being a possible cold water stream makes it a unique natural, recreational, and potentially economic resource for Delaware County. It has been suggested by the community that Buck Creek be evaluated for trout stocking. If stocking were to occur, and a perennial population became established, the results could provide Delaware County with a new source of revenue through increased tourism and recreation opportunities. With scientific data in on the status of the stream, discussion on how to proceed shall be included in the next phase of this project.

2.2.2.6 Land Ownership

Land within the Buck Creek subwatershed is primarily privately owned, except for local public schools (Wilson Middle School, South Side High School, etc.) and a U.S. Post Office.

2.2.2.7 Cultural Resources

There is one state registered historic place within the boundaries of the Buck Creek Subatershed: Wilson Junior High School. This structure was added to the registry in 2001 and is located at 2000 South Franklin Street in Muncie. This structure is next to the Maring-Hunt Public Library and is registered under the category Architecture/Engineering, Event. (National Register of Historic Places, http://www.nationalregisterofhistoricplaces.com/IN/state.html)

2.2.3 Prairie Creek Subwatershed (05120201010110)

Prairie Creek Subwatershed (HUC 14-Digit Number: 05120201010110) is the third subwatershed included in this management plan. It drains 10,863 acres (17 square miles) and has within it Prairie Creek Reservoir, the drinking water reservoir for the County's municipal water supply. At the north end of the subwatershed, Prairie Creek Reservoir flows into the White River, which is the primary municipal drinking water source. The majority of the watershed is located in Perry Township, with a small amount of the North end in Liberty.

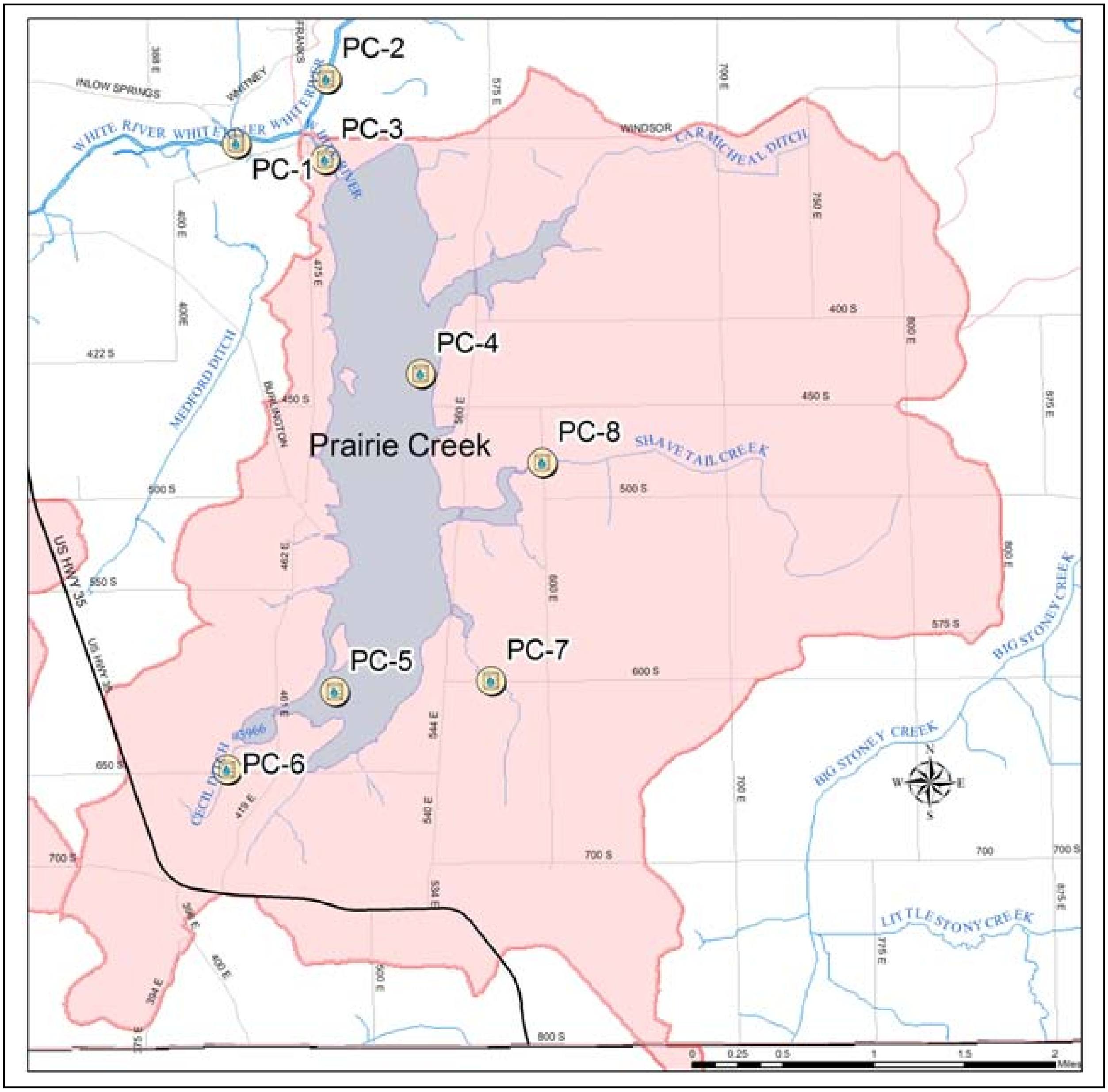


Figure 2.12: Prairie Creek Subwatershed

2.2.3.1 Geology

Prairie Creek Subwatershed is located in the New Castle Till Plains and Drainageways section of the Central Till Plain. The shrink-swell characteristics are moderate throughout the subwatershed. The surficial geology, unconsolidated thickness, varies with a minimum of 50 to a maximum of 250 meters. Bedrock is mainly Silurian (system) with Louisville Limestone through Brassfield Limestone, or Salamonie Dolomite, Cataract Formation, and Brassfield Limestone, with a small amount of Silurian (system) with Pleasant Mills Formation rock. There is also a small amount of Ordovician (system) with undifferentiated Ordovician rock that runs east and west near the southern most edge of the subwatershed. The subwatershed has a low sand and gravel resource potential (with a small section of high potential around the reservoir outlet) and no active industrial mineral mining sites. There are three sand and gravel pits (abandoned), all located close to the southern tip of the reservoir. There are four gas wells and six petroleum test wells located throughout the subwatershed. (Indiana Geological Survey, ArcIMS Viewer http://129.79.145.5/arcims/statewide/viewer.htm)

2.2.3.2 Soils and Topography

The dominant soils in the Prairie Creek Subwatershed include Crosby and Miamian (Figure 2.13). The Miamian soils approximately comprise 27% of the total area and are moderately well drained. They have formed under hardwoods and water erosion is a management concern for crop production. The Crosby soils approximately comprise of 23% of the total area and are somewhat poorly drained soils. They have formed under the native vegetation of hardwoods and respond well to tile drainage. Drouthiness and water erosion are management concerns for crop production for Crosby soils. The Treaty soil approximately comprises 12% of the total area and is a poorly drained soil. Its native vegetation is water tolerant grasses and hardwoods. This soil is hydric and wetness is a management concern for crop production. However, this soil responds well to tile drainage. The other soil components present are less abundant and compose less than 10% of the total area. The general topography of the Prairie Creek Subwatershed is gently rolling.

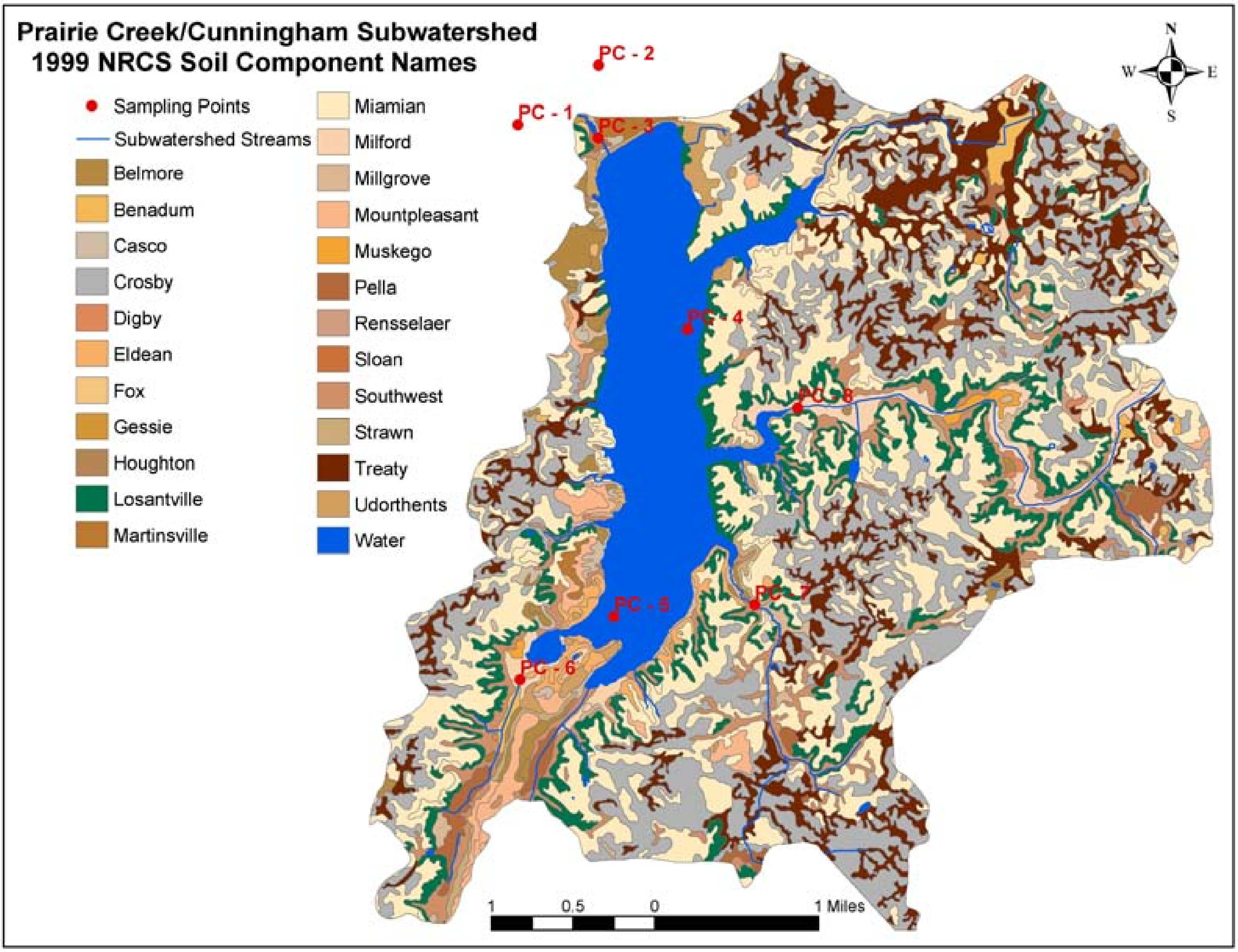


Figure 2.13: Prairie Creek Subwatershed Soil Types

The silt loam, loam, and silty clay loam textures are dominant in the Prairie Creek Subwatershed. They account for approximately 35%, 32%, and 20%, respectively, of the total area. The hydrologic soil group C composes approximately 70% of the total area, which indicates the majority of the soils have a slow infiltration rate when thoroughly wet and consist of moderately fine or fine texture. The moderately well drained soils encompass the most area in this subwatershed. A K factor of 0.37 (moderately erodible) is assigned to nearly 40% of the total area which indicates the second highest rating to susceptibility from sheet and rill erosion by water. The assigned T factor of 4 tons/acre/year (highly tolerant) makes up nearly 60% of the total area and indicates the majority of the soils present can withstand soil erosion by water and wind of 4 tons per acre per year without affecting crop productivity. (Wright, 2004 [interpretations from SSURGO, 1999])

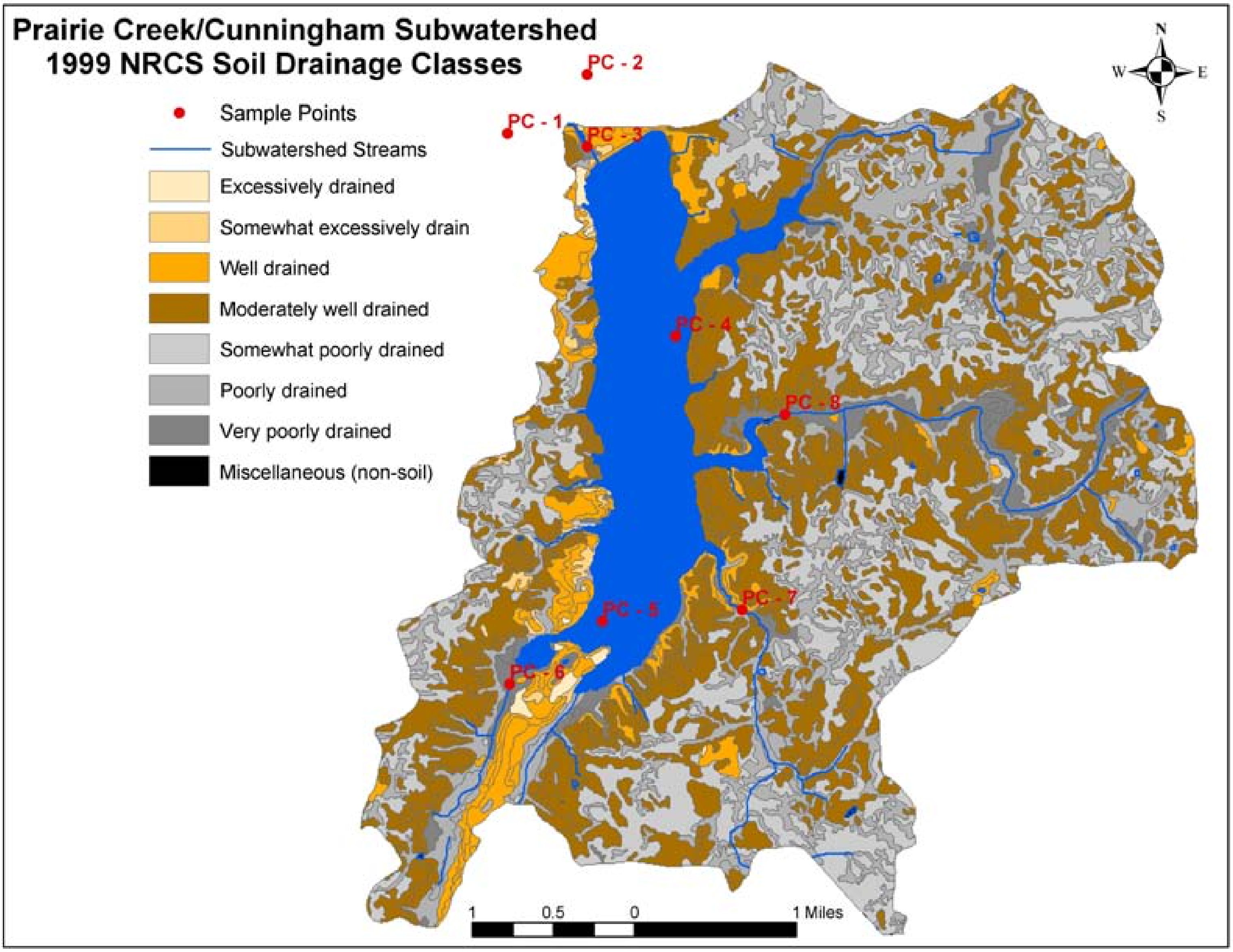


Figure 2.14: Prairie Creek Subwatershed Soil Drainage Classes

2.2.3.3 Hydrology

The main waterbody in the Prairie Creek subwatershed originally was Prairie Creek, with several tributaries flowing into it (i.e. Huffman and Cunningham). In 1960, the United States Army Corps of Engineers dammed off Prairie Creek just above its confluence with the White River to create Prairie Creek Reservoir. The reservoir is now the major waterbody in the subwatershed, at 1250 acres, and serves as Delaware County's secondary source of drinking water (White River being the first).

Prairie Creek Subwatershed has one principal aquifer within its boundaries, the Silurian-Devonian Aquifer in the north. Groundwater in the southern portion of the watershed comes through unconsolidated glacial till.

There is a total of 55.07 acres of wetlands in the Prairie Creek Subwatershed (USFWS National Wetland Inventory [NWI], http://wetlands.fws.gov/) representing 0.51 percent of the total subwatershed acreage. (See Appendix H for NWI Map Key.)

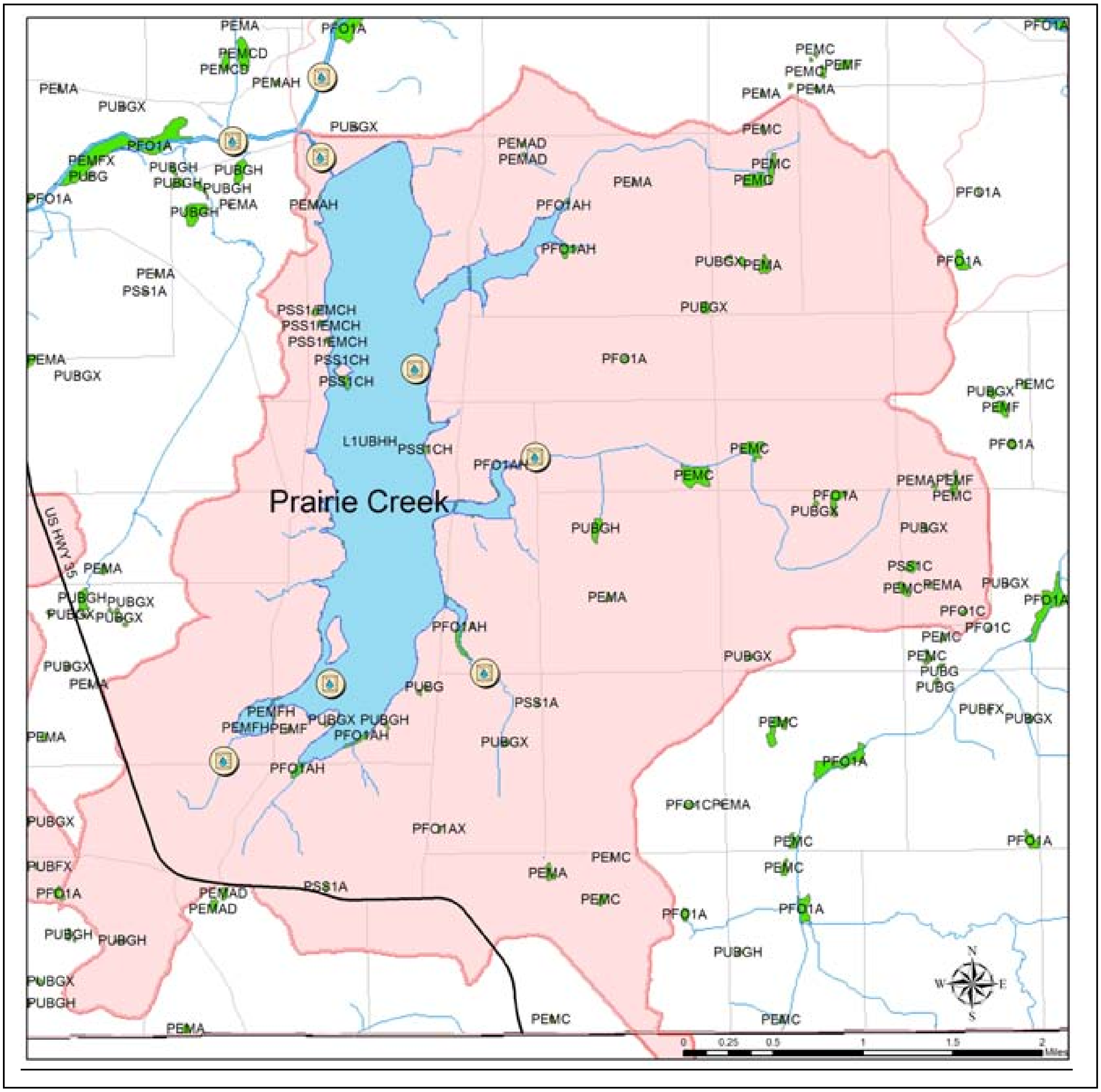


Figure 2.15: Prairie Creek Subwatershed Wetland Locations

2.2.3.4 Natural History

Prairie Creek Subwatershed is split between two Ecoregions: Loamy, High Lime Till Plains to the north and Whitewater Interlobate Area to the south. The soils in the Loamy, High Lime Till Plains Ecoregion typically have better natural drainage than those of Ecoregion 55a (where Killbuck/Mud Creek Subwatershed resides). Beech forests, oak-sugar maple forests, and elm-ash swamp forests grew on the nearly level terrain; today, corn, soybean, and livestock production is widespread.

2.2.3.5 Land Use and Land Cover

Historic

Please see Historic Land Use section located earlier in this chapter.

Present

Current land use in this subwatershed is as follows:

Agricultural 72.15%
Transportation & Utilities 2.3%
Residential 6.34%
Greenspace 18.22%
Agricultural Support .77%
Other .99%

Data from the land use study discussed further in Chapter 4, Section 4.2.2.3 of this document.

Future

The fate of Prairie Creek reservoir is uncertain. The reservoir and the land surrounding its banks are owned by a private water company (Indiana-American Water Company) which leases the property to the Muncie Parks Department. That lease is due to expire in 2013 and the future of the buffer areas around the reservoir may be in jeopardy. Currently, the Muncie-Delaware County Plan Commission has outlined the need to develop a comprehensive plan for the area, but has not yet done so. Citizens both inside and outside of the subwatershed are concerned about the potentially negative effects such lack of planning may have both on the water quality and recreational usage of the reservoir.

In addition to the land immediately surrounding the reservoir, there are increasing development pressures being exuded within the entire subwatershed. Agricultural land is being converted to housing at an increasing rate and with the lack of a comprehensive plan for the subwatershed; the potential negative impacts to local water quality are increased.

Unique Resources

One of the unique resources in Prairie Creek Subwatershed is the Prairie Creek reservoir. It is the County's secondary source for drinking water, a popular recreation site and an important wildlife habitat area. On the east side of the reservoir is a public park operated by the Muncie Parks Department, where they maintain the park campgrounds, a public beach, and picnic areas. The reservoir itself holds walleye, large and small mouth bass, crappie, northern pike, channel catfish, perch, and many other recreational fishing species. Aside from fishing, other recreational opportunities offered to the outdoor enthusiast include motor and pontoon boating, sailing, model boating, off-road riding, camping, swimming and horseback riding. (FishingSpots.net, http://fishingspots.net/IN_Fishing_Camping/Prarie_Creek_Reservoir/~Prarie_Creek.htm)

At the time of this publication, the reservoir has very little development on its banks, which makes it rather unique in Indiana. With that lack of bank development comes a certain degree of water quality protection. Usage on the banks primarily is parks, campgrounds, and natural areas, with only one small community situated on the central west side (New Burlington). In essence, Prairie Creek reservoir has a grass or tree buffer almost entirely around it. This helps to keep both point-source and non-point source pollution from entering this important source of drinking water.

Another unique resource in this subwatershed sitting at the southwest side of the reservoir is the Red-tail Nature Preserve. It is a 105 acre preserve owned by the Red-tail Conservancy, a local land trust organization, with plans to develop a trailhead (to connect with the Cardinal Greenway) and an interpretation center.

Figure 2.16: Cardinal Greenway

The other unique resource that runs through the southwest corner of Prairie Creek watershed is the Cardinal Greenway, a walking/biking trail developed along a former old railroad.

2.3.3.6 Land Ownership

The majority of property in the Prairie Creek subwatershed is privately owned. Prairie Creek reservoir is currently privately owned by the Indiana-American Water Company. They own the reservoir and the land surrounding its banks. A 105 acre section of forested and grass buffer on the southwest corner of Prairie Creek reservoir is owned (or easements held) by Red-tail Conservancy. Red-tail is a local, not-for-profit land trust organization.

2.2.3.7 Cultural Resources

There are no state registered historic places in the Prairie Creek Subwatershed.

CHAPTER 3

UNDERSTANDING HISTORIC SUBWATERSHED CONDITIONS

A key part of the White River Watershed Project was gathering baseline information for all three of the subwatersheds. The purpose was to have the best understanding of current water quality and land use conditions in order to understand what needed protection and what needed correction with regards to non-point source pollution in each subwatershed. This was accomplished through gathering the historic data collected by various state and federal agencies (stated below), as well as conducting a detailed water monitoring and land use/land cover analysis program (Chapter 4).

3.1 Federal Data

3.1.1 United States Geological Survey (USGS)

The White River basin is part of the National Water Quality Assessment (NAWQA) Program, a program started in 1991 by the United States Geological Survey (USGS). As part of this program, ongoing monitoring is occurring to determine trends in surface and ground water quality on a long term scale. The USGS has completed several studies of the White River that directly relate to the type of monitoring being done for the White River Watershed Project.

A study done by the USGS, "Occurrence of Pesticides in the White River, Indiana, 1991-95", monitored pesticide concentrations within the basin. The study found that the dominant pesticides used within the basin were herbicides which were specifically applied to corn and soybeans. It was estimated that ninety-six percent of the total agricultural pesticide used in the White River basin were on corn and soybean crops. Of particular importance were Atrazine concentrations which were detected in all of the samples taken and ranged as high as 11µg/L. 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.

The USGS performed another similar study, "Water-quality Assessment of the White River Basin, Indiana—Analysis of Available Information on Nutrients 1980-92". Results of this study showed that nutrient concentrations were higher in the urbanized areas of the West Fork, primarily due to increased amounts of treated municipal sewage, combined sewer overflows and runoff from urban impervious surfaces. Ammonia and total phosphorus were higher on the downstream side of Muncie than on the upstream side.

On the East Fork of the White River total phosphorus concentrations increased with increasing streamflow, explained by non-point source additions washed off land surfaces (as phosphorus runoff is usually associated with sediment runoff), while concentrations on the West Fork decreased with increasing streamflow, consistent with the dilution of non-point sources as streamflow increases. Seasonal trends were also noted for both parameters, with ammonia concentrations found to be higher in the winter and total phosphorus concentrations found to be higher in the summer and fall.

Fenelon & Moore (1998) performed a study that looked at the transport of agrichemicals to both surface and groundwater in central Indiana. Results of their study showed that pesticides were more readily detectable in surface water than in groundwater, but nitrate potentially impacted both. Subsurface tile drains were found to rapidly transport large quantities of these chemicals from agricultural fields to adjacent surface water.

With more than fifty percent of the cropland in Indiana being drained either by ditches or by tile drains, Indiana ranks second in the United States in terms of total area of drained land.

Another study by J.M. Fenelon, "Water Quality in the White River Basin, Indiana 1992-96" monitored both nutrient and pesticide concentrations within the basin. This study found nitrate concentrations to range from 2-6 mg/L, higher than other NAWQA sites but still below the mandated drinking water standard of 10 mg/L. Pesticide concentrations along urban and agricultural areas were reported as being the highest in the nation, and were both proportional to quantity of pesticide used and heavily affected by the presence of tile drains.

3.1.2 USEPA

3.1.2.1 Hazardous Waste and Superfund Sites

The following information is from BioMuncie.org, http://www.biomuncie.org.

There are two permitted solid waste sites in Delaware County. 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.

Even though there are no current hazardous waste disposal facilities in the county, 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. (IDEM, 2002 http://www.in.gov/idem/land/statecleanup/club.html)

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 (there an additional 50 archived locations listed in Appendix C):

Table 3.1: Superfund Sites in Delaware County (EPA CERCLIS Database http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm)(NPL = National Priorities List)

EPA ID	Site Name	City	County	State	NPL Status
IND981194079	BAKER PROPERTY	MUNICE	DELAWARE	IN	NO
IND006419733	FRANK FOUNDRIES CORPORATION	MUNCIE	DELAWARE	IN	NO
IN0001899269	MEMORIAL DRIVE DUMP	MUNCIE	DELAWARE	IN	NO
INN000509013	MUNCIE MERCURY HOUSE	MUNCIE	DELAWARE	IN	NO
IND984895870	MUNCIE RACE TRACK	MUNCIE	DELAWARE	IN	NO
INN000508755	MUNICE RESIDENTIAL MERCURY	MUNCIE	DELAWARE	IN	NO
IND006062582	WESTINGHOUSE/ABB POWER	MUNCIE	DELAWARE	IN	NO

The Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/) 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.

There are about 4000 Leaking Underground Storage Tanks (LUST) sites in the state of these over eighty require attention in Delaware County. (IDEM, http://www.in.gov/idem/land/lust/) A list of Active LUST Sites in Delaware County was extracted from the state database (see Appendix C). Underground storage tanks are typically found at gas or service stations, dry cleaners, airport or truck refueling facilities, in homes or businesses where heating oil was stored. Gasoline, diesel fuel, hydraulic fuel, jet fuel, oil, 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.

3.1.2.2 NPDES Permits

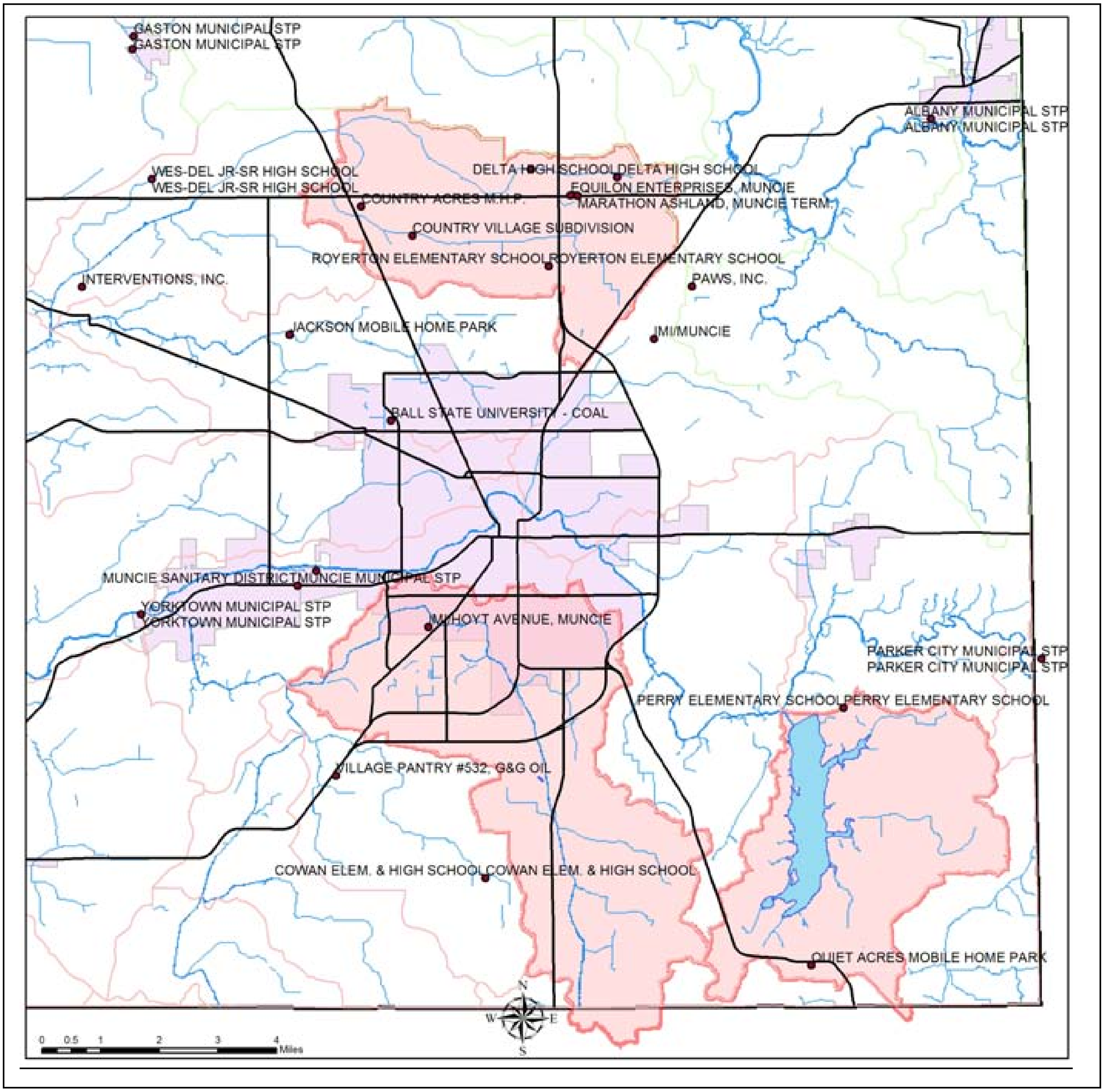


Figure 3.1: NPDES Locations and Permit Holders

3.2 State Data

3.2.1 State Designated Uses of Waterbodies

The following is a list of uses each waterbody in Indiana must meet by law (Indiana Administrative Code, Title 327, Article 2-1-3) as designated by the Indiana Water Pollution Control Board (IWPCB): (For the definition of the Board, see Appendix D.)

Full body contact recreation
Between April 1 and October 31

Aquatic Life
Warm water aquatic communities and (where natural conditions permit) put-and-take trout fishing

Public and Industrial water supply
At point of take (Waters must meet minimum quality standards.)

Agriculture
(Waters used for this purpose must meet minimum quality standards.)

Additional uses identified by the IWPCB which are not applicable to any waterbodies in Delaware County at the time of publication:

Where multiple uses have been designated for a body of water, the most protective of all simultaneously applicable
standards will apply.

Limited Use
All waters in which naturally poor physical characteristics (including lack of sufficient flow), naturally poor chemical quality, or irreversible man-induced conditions, which came into existence prior to January 1, 1983, and having been established by use attainability analysis, public comment period, and hearing may qualify to be classified for limited use and must be evaluated for restoration and upgrading at each triennial review of this rule.

Exceptional Use
All waters which provide unusual aquatic habitat, which are an integral feature of an area of exceptional natural beauty or character, or which support unique assemblages of aquatic organisms may be classified for exceptional use.

Indiana has developed a water quality standard for each of these six uses. By definition, a standard must contain both narrative and numeric criteria. At the time Indiana established its water quality standards, the state chose to establish a narrative standard to cover all the waters of the state and numeric standards for some (but not all) of the parameters. The Indiana Department of Environmental Management sets these standards, which are listed in Title 327, Article 2-1-6 of the Indiana Administrative Code. The numeric criteria for parameters studied during this project can be found in Section 3.3.1 of this document. (For the entire listing of narrative and numeric criterion, please see the above referenced section of the IAC.)

3.2.2 Indiana Department of Environmental Management

As described above, IDEM sets quality standards for surface water bodies as per federal mandate under the Clean Water Act. Status of Indiana surface waterbodies is determined through IDEM's state-wide monitoring program. The waterbodies that are found not to meet those standards are then placed on what is referred to as Indiana's 303(d) list of impaired waters. That list is part of a biennial report submitted to the U.S. Environmental Protection Agency called the Indiana 305(b) Report. Waterbodies are ranked according to the severity of the pollution found and the designated uses of the individual body. (For the latest version of the 305(b) report [named the 2002 Integrated Water Quality Monitoring and Assessment Report], go to http://www.in.gov/idem/water/planbr/wqs/quality.html.)

3.2.2.1 2004 303(d) List

There are currently 22 stream segments listed as not meeting state water quality standards within Delaware County. (See Table 3.1 for a complete listing.) Below is a brief description of the program methodology and the list itself for Delaware County streams taken from the *Notice of Public Comment Period and Public Meetings, Updated List of Impaired Waters under Section 303(d) of the CWA*. For a complete description of IDEM's methodology, please refer to this document found at http://www.in.gov/idem/water/planbr/wqs/notice04.pdf.

"Use Support/Impairment status is determined for each stream waterbody using the assessment guidelines provided in the U.S. EPA documents *Guidelines for Preparation of the State Water Quality Assessments (305[b] Reports) and Electronic Updates: Report Contents.* Washington, DC: U. S. Environmental Protection Agency. (*EPA-841-B-97-002A*.) and *Guidance for 2004 Assessment, Listing, and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, July 21, 2003*, Watershed Branch, U. S. Environmental Protection Agency. Available results from six monitoring result types listed below are integrated to provide an assessment for each stream waterbody for 305(b) reporting and 303(d) listing purposes.

Physical/chemical water results
Fish community assessment
Benthic aquatic macroinvertebrate community assessments
Fish tissue and surficial aquatic sediment contaminant results
Habitat evaluation
E. coli monitoring results

In the 2004 303(d) list, IDEM proposes to add a number of waterbodies to Category 5. For a stream to be listed it must have been sampled and the data collected must support 303(d) listing. The waterbodies proposed to be added to the 2004 303(d) list are primarily in the West Fork White River and Patoka River basins which were sampled in the summer of 2001. The samples were subsequently analyzed and indicate waterbody impairment." http://www.in.gov/idem/water/planbr/wqs/303d.html

Table 3.2: 2004 303(d) List of Impaired Waterbodies for Delaware County, IN

303(d) #	MAJOR BASIN	14 DIGIT HYDROLOGIC UNIT CODE	COUNTY	SEGMENT ID NUMBER	WATERBODY NAME	PARAMETERS OF CONCERN
102	**W. FORK WHITE**	**5120201020020**	**DELAWARE**	**INW0122_T1011**	**BUCK CREEK**	**IBC, E. COLI**
102	W. FORK WHITE	5120201020060	DELAWARE	INW0126_T1012	BUCK CREEK	IBC, E. COLI
102	W. FORK WHITE	5120201020030	DELAWARE	INW0123_00	BELL CREEK-BETHEL BROOK	E. COLI
102	W. FORK WHITE	5120201020040	DELAWARE	INW0124_00	BELL CREEK- WILLIAMS DITCH	E. COLI
102	W. FORK WHITE	5120201020050	DELAWARE	INW0125_00	BELL CREEK- NO NAME CREEK	E. COLI
136	W. FORK WHITE	5120201050010	DELAWARE	INW0151_00	PIPE CREEK-YEAGER FINLEY MENARD DITCH	IBC, E. COLI
158	W. FORK WHITE	5120201020060	DELAWARE	INW0126_T1010	WHITE RIVER	E. COLI
158	W. FORK WHITE	5120201030010	DELAWARE	INW0131_T1013	WHITE RIVER	E. COLI
158	W. FORK WHITE	5120201030020	DELAWARE	INW0132_T1014	WHITE RIVER	E. COLI
162	W. FORK WHITE	5120201010090	DELAWARE	INW0119_T1006	WHITE RIVER	E. COLI
162	W. FORK WHITE	5120201010100	DELAWARE	INW011A_T1007	WHITE RIVER	E. COLI
162	W. FORK WHITE	5120201010120	DELAWARE	INW011C_T1008	WHITE RIVER	E. COLI
162	W. FORK WHITE	5120201010130	DELAWARE	INW011D_T1009	WHITE RIVER	IBC, E. COLI
162	W. FORK WHITE	5120201010090	DELAWARE	INW0119_00	STONEY CREEK AND OTHER TRIBUTARIES	E. COLI
162	W. FORK WHITE	5120201010100	DELAWARE	INW011A_00	MUD CREEK AND OTHER TRIBUTARIES	E. COLI
162	W.FORK WHITE	5120201010130	DELAWARE	INW011D_00	MUNCIE CREEK- OTHER TRIBUTARIES	E. COLI
520	**W. FORK WHITE**	**5120201040010**	**DELAWARE**	**INW0141_00**	**KILLBUCK CREEK**	**IBC, E. COLI**
520	W. FORK WHITE	5120201040020	DELAWARE	INW0142_00	KILLBUCK CREEK- THRUSTON DITCH	IBC, E. COLI
520	W. FORK WHITE	5120201040030	DELAWARE	INW0143_00	JAKES CREEK- EAGLE BRANCH	E. COLI
520	W. FORK WHITE	5120201040040	DELAWARE	INW0144_00	KILLBUCK CREEK- PLEASANT RUN CREEK	IBC, E. COLI
520	W. FORK WHITE	5120201040050	DELAWARE	INW0145_00	KILLBUCK CREEK	E. COLI
521	W. FORK WHITE	5120201030010	DELAWARE	INW0131_00	YORK PRAIRIE CREEK AND OTHER TRIBUTARIES	E. COLI

Note: **Bold** text indicates watersheds that are included in this management plan.
(IBI = Impaired Biotic Communities)

3.2.2.2 Fish Consumption Advisories (FCA)
There are official recommendations regarding human consumption of fish caught in various waterbodies across the United States. Below are the waterbodies listed and the reasons for the listing. (For a the complete Delaware County advisory, see Appendix D.) (Indiana Department of Health, 2004, http://www.state.in.us/isdh/dataandstats/fish/fish_adv_index.htm)

Upper White River Watershed in Delaware County
The White River is under a fish consumption advisory for mercury and Polychlorinated Biphenyls (PCBs).

Killbuck/Mud Creek Subwatershed
There currently is no FCA listed for this watershed.

Buck Creek Subwatershed
Buck Creek is under a fish consumption advisory for mercury and Polychlorinated Biphenyls (PCBs) (IDEM 2003).

Prairie Creek Subwatershed
There currently is no FCA listed for this subwatershed.

3.2.2.3 Total Maximum Daily Load
Public and Project Involvement
Section 303(d) of the federal Clean Water Act requires states to identify waterbodies that do not or are not expected to meet minimum water quality standards for each state (which are listed previously in Table 3.1). From this list, states are required to develop Total Maximum Daily Loads (TMDLs) for each parameter a waterbody is listed for.

It is important to note that while the development of numerical Total Maximum Daily Loads for each cited impairment is mandated, the implementation of TMDL plans is currently voluntary. This is where watershed management plans, like this one, can help eliminate the potential for making implementation mandated. One of the goals for this plan is to remove 303(d) listed streams from that list, thereby resulting in voluntary compliance of the TMDL goals.

During the development of this watershed management plan, a TMDL was under development for *E. coli* on the White River. This included the portion of the Upper White River Watershed that flows through Delaware County. The White River Watershed Project, and some of our partners, worked with TetraTech, Inc. (the contractor hired to develop the TMDL) to assist them with gathering land use and water quality information for Delaware County.

One of those partners, the Muncie Sanitary District provided them with their water quality data. They supplied TetraTech, Inc. with long term monitoring data, locations of Combined Sewer Overflows, data related to the Stream Reach Characterization, data related to the U.S. EPA Storm Water Management Model (SWMM), and maps, plus copies of newspaper articles relating to the TMDL developmental process. In addition to this, the WRWP Watershed Coordinator attended the public meetings and forwarded on meeting information to project participants and encouraged them to attend.

Upper White River Watershed TMDL Schedule
The White River (within Delaware County) is listed to submit TMDLs for the following impairments: Mercury, PCBs, *E.* coli, and Impaired Biotic Communities. The dates for TMDL submittal are December 31 of the following years, in respective order, 2013, 2013, 2005 and 2008.

A TMDL for *E.* coli has been developed for the West Fork of the White River beginning in Muncie and ending in Indianapolis. The report lists that a 91% reduction in *E. coli* is needed in the White River segment from East Memorial Drive in Muncie to Anderson City Park to be in compliance with state regulations.
(IDEM, 2003 http://www.in.gov/idem/water/planbr/wqs/tmdl/assess/wfwhiterscrprt.pdf)

2003 IDEM TMDL Report
Below are the preliminary sources identified in the TMDL report (IDEM, 2003 http://www.in.gov/idem/water/planbr/wqs/tmdl/assess/wfwhiterscrprt.pdf):

"First, CSOs are contributing the largest *E. coli* loads compared to the other source categories evaluated. The current estimate of *E. coli* from CSOs throughout the watershed is based on the assumption that the average per outfall load from Alexandria, Anderson, Elwood, Noblesville, and Tipton is similar to that from Muncie. Even if the average per outfall load is half that of Muncie (which is unlikely), CSOs remain the largest of source categories evaluated. Septic systems and cattle are contributing the next greatest amount of *E. coli* compared to the other source categories evaluated.

The estimated load is based on a number of assumptions, of course, but the results do not change dramatically even if some of the assumptions are changed significantly. For example, if only 20 percent of the septic systems are failing (instead of the assumed 40 percent) the load from septic systems is still more than that from the wastewater treatment plants or the bypasses. Cattle in streams are the next greatest source of *E. coli* loading among those evaluated. They remain the second greatest source (of the categories evaluated) even if only 10 percent of the cattle instead of 50 percent have direct access to streams.

It is important to note that the information regarding *E. coli* in the 2003 TMDL Report addresses only the waste generation and potential transport of *E. coli* in the watershed. It does not address the impact of the sources on resulting water quality. Loads from some of the sources, such as CSOs and storm water runoff, will be driven by wet weather events. During such events the flow in the streams will provide some dilution of the bacteria load. Loads from other sources, such as cattle, septic systems, and wastewater treatment plants, will continue during low flow conditions when there is less dilution capacity in the stream. These factors and others that affect instream conditions will be explored further during the modeling process."

Killbuck/Mud Creek Subwatershed
Killbuck Creek is listed to submit TMDLs for the following three impairments: Mercury, PCBs, and Pathogen Indicators (*E. coli*). The dates for TMDL submittal are December 31 of the following years, in respective order, 2013, 2013 and 2005.

Buck Creek Subwatershed
Buck Creek is listed to submit TMDLs for the following three impairments: Mercury, PCBs, and Impaired Biotic Communities. The dates for TMDL submittal are December 31 of the following years, in respective order, 2013, 2013 and 2008.

Prairie Creek Subwatershed
There are no waterbodies in the Prairie Creek Watershed that are scheduled to develop TMDLs, due to the fact that there are no waterbodies listed on IDEM's 303(d) list.

For more on IDEM's TMDL Program, go to:
http://www.in.gov/idem/water/planbr/wqs/tmdl/tmdldocs.html.

3.2.2.4 Upper White River Watershed Restoration Action Strategy (UWRWRAS)
Based on this document, created in January 2001, the following are the causes and contributing activities of water pollution in the White River Watershed Basin.

Table 3.3: UWRWRAS Listed Causes of Water Pollution and Contributing Activities

Cause	Activity associated with cause
Nutrients	Fertilizer on agricultural crops and residential/ commercial lawns, animal wastes, leaky sewers and septic tanks, direct septic discharge, atmospheric deposition, wastewater treatment plants
Toxic Chemicals	Pesticide applications, disinfectants, automobile fluids, accidental spills, illegal dumping, urban stormwater runoff, direct septic discharge, industrial effluent
Oxygen-Consuming Substances	Wastewater effluent, leaking sewers and septic tanks, direct septic discharge, animal waste
E. coli	Failing septic systems, direct septic discharge, animal waste (including runoff from livestock operations and impacts from wildlife), improperly disinfected wastewater treatment plant effluent

3.2.3 Indiana Department of Natural Resources
The West Fork of the White River is on the list of outstanding rivers with the Indiana Natural Resources Commission (http://www.in.gov/nrc/policy/outstand.html), from Farmland to the confluence with the Wabash River. This stretch passes through Daviess, Delaware, Gibson, Knox, Greene, Hamilton, Madison, Morgan, Owen and Randolph Counties. It has been listed for the following three reasons:

1. 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.

2. State Heritage Program Sites. Rivers identified by state natural heritage programs or similar state programs as having outstanding ecological importance.

3. Canoe Trails. State-designated canoe/boating routes.

CHAPTER 4

ACQUIREING SUBWATERSHED BASELINE INFORMATION

4.1 Baseline Study Methodology

To achieve the most complete understanding of current non-point source water pollution conditions possible, water quality, biology and stream habitat, land use and land cover were all studied for each of the three subwatersheds. Below, you will find the methodologies used and results of these studies. (See Appendix E for complete monitoring program methodology.)

4.1.1 Monitoring Program

For the complete methodology utilized for the White River Water Project Monitoring Program, contact the Delaware County SWCD office or IDEM, Watershed Management Section for a copy of the complete Quality Assurance Project Plan.

4.1.1.1 Parameters Studied

The White River Watershed Project incorporated a water monitoring program as part of its baseline study. The Monitoring Committee developed the program and a team from Ball State University and the Muncie Bureau of Water Quality implemented it. This program involved three major components: water quality (which measures chemical, physical, and bacteriological parameters), biology (which measures fish and macroinvertebrate [stream insect] populations), and stream habitat.

Below are the parameters that were measured:

Chemical:
- Ambient Temperature
- Stream Temperature
- Water pH
- Total Suspended Solids (TSS)
- Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD)
- Ammonia (NH_3)
- Nitrate + Nitrite as N
- Orthophosphate as P
- Atrazine
- Diazinon

Biological:
- Stream Habitat (QHEI)
- Fish (IBI)
- Macroinvertebrates (stream insects) (ICI)

Physical:
- Precipitation
- Water Level
- Discharge Measurements

Bacteriological:
- *Escherichia coli* (*E. coli*)

Monitoring of the chemical, bacteriological, and physical parameters was conducted during seven sampling events over a two year period. Four biology and stream habitat field sampling events were completed during that time, as well. The schedule of all sampling events is as follows:

Chemical, Bacteriological and Physical Parameters
- July 23, 2002
- October 17, 2002
- May 5, 2003 (High Flow Event)
- May 15, 2003
- July 15, 2003
- September 03, 2003 (High Flow Event)
- October 14, 2003

Biological Parameters
- June 4 – August 16, 2002
- July 17 – September 30, 2002
- June 16-23, 2003
- July 23-31, 2003

The chemical, physical, and bacteriological parameters provide a snapshot of direct water conditions, while the biological parameters tell us something about the overall, long-term health of the waterbody being sampled. Since these organisms spend their time in the water, their presence or absence can tell us not only how "clean" the water is, but what is present that may be beneficial or harmful. In addition, percipitation and stream flow were measured to calculate discharge for each subwatershed in order to understand pollutant loadings. Analysis of the chemical, bacteriological and physical conditions, combined with biological and habitat results, can help us get a clearer picture of overall stream conditions.

4.1.1.2 Sampling Locations

Killbuck-Mud Creek
KB-1: CR 700 N
KB-2: SR 28 (Killbuck)
KB-3: CR25 (Killbuck)
KB-4: CR 200 W (Mud)
KB-5: Center/Walnut (Mud)
KB-6: CR 2002 E (Mud)

Buck Creek
BC-1: CR 750 W (White River)
BC-2: CR 575 W (White River)
BC-3: CR 325 W
BC-4: Tillotson Avenue
BC-5: East 23rd Street
BC-6: CR 400 S
BC-7: CR 578 S
BC-8: CR 950 N (Henry County)

Prairie Creek
PC-1: Inlow Springs Road (White River) (coordinates:0644441 4445663 UTM)
PC-2: West of sod farm (White River) (coordinates: 0645210 4446129 UTM)
PC-3: Immediately below the PC Reservoir spillway
PC-4: Near the east shore of the PC Reservoir near the public boat launch
PC-5: Near the south shore of the Prairie Creek Reservoir
PC-6: CR 650 S (Prairie Creek)
PC-7: CR 600 S (Huffman Creek)
PC-8: CR 600 E (Cunningham Ditch)

4.1.1.3 Surface Water Quality Guidelines for Sampled Parameters

The Indiana Administrative Code (IAC) (Title 327, Article 2-1-6) sets forth standards for both the physical and chemical parameters being monitored by this project. The IAC mandates state standards for pH, Dissolved Oxygen (DO), Stream Temperature, Nitrate + Nitrite as N, Ammonia as N and *Escherichia coli* (*E. coli*). In addition to the standards established by the IAC, the EPA also regulates surface water quality through the employment of similar standards and guidelines. The EPA has established standards for Atrazine, Nitrate + Nitrite as N, Nitrate as N, and Ammonia. However, neither the IAC nor the EPA has established standards for Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD) or Orthophosphate.

In order to allow for comparison of results from the parameters with no EPA or IAC standards or guidelines, scientific literature was reviewed to find recommended guidelines, or thresholds by which they could potentially be compared. See Table 4.1 below for a compilation of all standards and guidelines for each of the parameters being monitored, along with a brief citation noting the source of the information: (Maximum Ammonia concentration levels and stream temperature limits can be found in Appendix E.)

Table 4.1: Surface Water Standards/Guidelines

Parameter	Standard/Guideline	Source
Stream Temperature	(See Appendix E)	327 IAC 2-1-6
Total Suspended Solids	≥ 80 mg/L can impact aquatic life	Waters, 1995
pH	No pH values below 6.0 nor above 9.0 except daily fluctuations which exceed pH 9.0	327 IAC 2-1-6
Dissolved Oxygen	For cold water fish habitat: • not less than 6.0 mg/L at any one time • not less than 7.0 mg/L where spawning occurs For other aquatic life: • average of 5.0 mg/L per calendar day not less than 4.0 mg/L at any time	327 IAC 2-1-6 327 IAC 2-1-6
Ammonia	Dependent upon stream temperature and pH (See Appendix E) Target level for streams: 0.41 mg/L	327 IAC 2-1-6 Illinois EPA, 2000
Nitrate	Drinking water standard: 10 mg/L = -MCL Nitrite: Drinking Water MCL = 1 mg/l Modified warm water habitat: 1.6 mg/L	327 IAC 2-1-6 Ohio EPA, 1999
Total Phosphorus Soluble Reactive Phosphorus	Threshold for eutrophication: 0.02 to 0.1 mg/L To maintain eutrophic or highly productive conditions in lake systems: 0.005 mg/L	Pierzynski, 2000 Correll, 1998
E. coli	For full body contact, recreational use: • Shall not exceed 235 cfu/100mL for any one sample in a thirty day period • Shall not exceed 125 cfu/100mL as a geometric mean based on not less than 5 samples equally spaced over a thirty day period	327 IAC 2-1-6 327 IAC 2-1-6
Atrazine	Drinking water standard or Maximum Contaminant Level (MCL): 3 µg/L USEPA aquatic-life guideline: 1.8 µg/L	USEPA, 1999 USGS, 1999
Diazinon	No drinking water standard Drinking Water Equivalent Level 0.003 mg/L Aquatic life criteria 0.0001 mg/L	USEPA, 2000 USEPA, 2004
Biochemical Oxygen Demand, Total	2.2 mg/l (Average) 1.1 mg/l – 3.3 mg/l (Range)	Hoosier River Watch, 2003

The following conditions are for temperature based on 327 IAC 2-1-6:

1.) There shall be no abnormal temperature changes that may adversely affect aquatic life unless caused by natural conditions.

2.) The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained.

3.) The maximum temperature rise at any time or place above natural temperatures shall not exceed five degrees Fahrenheit (5 °F) (two and eight-tenths degrees Celsius (2.8 °C)) in streams and three degrees Fahrenheit (3 °F) (one and seven-tenths degrees Celsius (1.7 °C)) in lakes and reservoirs.

4.) Water temperatures shall not exceed the maximum limits in Appendix E during more than one percent (1%) of the hours in the twelve (12) month period ending with any month; at no time shall the water temperature at such locations exceed the maximum limits in Appendix E, by more than three degrees Fahrenheit (3 °F) one and seven-tenths degrees Celsius (1.7 °C).

4.1.2 Land Use and Land Cover Program

Monitoring water quality provides only a partial picture of potential non-point source pollution issues facing a subwatershed. To understand conditions more completely, the land use and land cover in a subwatershed need to be identified.

Geographic Information Systems (GIS) was utilized for the classification of the land use of the subwatersheds and land cover for the riparian buffers (five and thirty meter strips of land bordering a waterway) utilizing the ArcINFO version of GIS. Sub-subwatershed (drainage area for each monitoring location) limits were also determined using GIS software.

The land use and riparian corridors were interpreted from 1998 aerial photographs of Delaware County. The riparian corridors were created by applying a five and thirty meter (16 and 100 foot) buffer on each side of the waterbody. The continuous sub-subwatershed for the Killbuck/Mud Creek subwatershed was delineated using an ArcHydro extension tool and a Digital Elevation Model (DEM) with raster cell size of 30 meters. The Buck Creek and Prairie Creek continuous sub-subwatersheds were delineated using heads-up digitizing of the DEM with 20 X 20 foot cell sizes. The land use was clipped to each of the discrete sub-subwatersheds. The land uses for each of the discrete sub-subwatersheds were converted from shapefiles into personal geodatabase feature classes. The attribute tables for the land use, riparian buffers, and the discrete sub-subwatersheds were summarized by their area.

The categories for the land use include agricultural and agricultural support, commercial, governmental and institutional, greenspace, industrial, residential, transportation and utilities. The agricultural category includes agricultural row crops and any land utilized in production for agricultural purposes. Agricultural support was grouped with the agricultural category and includes land that is not being used in production but is located around farms and is utilized for the support of agricultural practices. This agricultural category does not include pasture or residential land.

Commercial land use generally pertains to business-oriented pursuits and salvage yards were grouped with the commercial category. Governmental and institutional refers to any county, state or federal owned lands; schools and church properties are also included in this category. The greenspace category includes woodlots, large areas that are not used for agriculture, grasslands, riparian areas, prairie or pasture and golf courses. The industrial category includes both heavy and light industry production facilities. Residential includes apartment buildings, sub-divisions, trailer parks, and other residential neighborhoods. The transportation and utilities category includes any road corridors, electrical or gas substations and railroads. The vacant or no use category includes land that does not fall into in any of the above categories.

The categories for the five and thirty meter riparian buffers include impervious, agricultural, grass, low shrubs and grasses, pasture, turf and woodland. Impervious surface includes buildings, asphalt, and concrete coverings. Agricultural includes agricultural row crops and any land utilized in production for agricultural purposes. The grass category includes low grasses and prairies. The low shrubs and grasses category generally includes all undergrowth but does not include woods. Pasture includes any type of land that appears to be supporting livestock. The turf category includes manicured turf, yards and golf courses. The woodland category only includes areas with trees.

Impervious Surface

The amount of impervious surface in a given subwatershed has a significant impact on the presence and ability to mitigate non-point source water pollution. According to Center for Watershed Protection, an exceedance of 15% impervious surface results in irreversible stream degradation as a result of subsequent changes in hydrology. As part of the land use/land cover identification program, impervious surface was also calculated.

Infra-Red Photography

One of the main concerns that citizens from all three subwatersheds had was that current drainage tiles were contributing to non-point source pollution. Be it through broken tiles that allow sediment, nutrients and chemicals to drain unfiltered into local ditches and streams, their influence on flow, or their possible use to move septic effluent, the WRWP decided to conduct analysis to attempt to better understand current drainage tile status.

This analysis process called for using infra-red aerial photography in order to "view" the underground drainage tiles. This method works by picking up on the temperature difference created when a tile drains water from the surrounding ground. The drier ground heats up more quickly than the tiles, which are full of water. Hence, drainage tiles show up as a different color than the surrounding ground and this makes it possible to locate them.

The photographs were taken in the Spring of 2003, but due to problems with the contractor, the photos were not made available until the Spring of 2004. Due to this delay, review of these photos was just beginning as this plan was being completed. Therefore, their use in analyzing water quality and flow for this plan was limited, however, they will be fully reviewed and utilized during the implementation phase of this project.

4.2 Baseline Study Results

4.2.1 Monitoring Program Results (by Subwatershed)

Below are brief verbal and graphic representations of the results of the monitoring program. Each graph depicts the level of each parameter during a given sampling date. (Note that on the chemical, physical and bacteriological graphs the May 2003 and the July and October 2002 sampling sessions have been averaged.) (Note: all statements regarding state standards in this section refer to Indiana Administrative Code, Title 327, Article 2-1-6.)

4.2.1.1 Killbuck/Mud Creek Subwatershed

Note: When reading the graphs, remember that KB-1 is the confluence of Mud (KB-4, 5, 6) and Killbuck Creeks (KB-2 and 3), which are two separate streams.

Temperature: Within state standards for temperature.

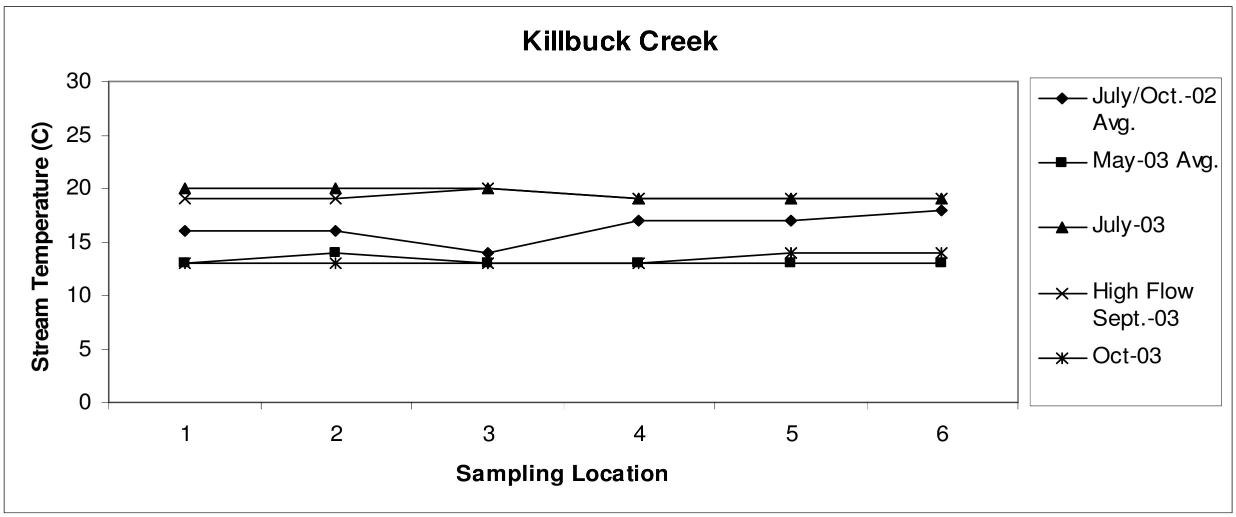


Figure 4.1: Killbuck/Mud Creek Subwatershed Stream Temperature Results

pH: Within state standards for pH.

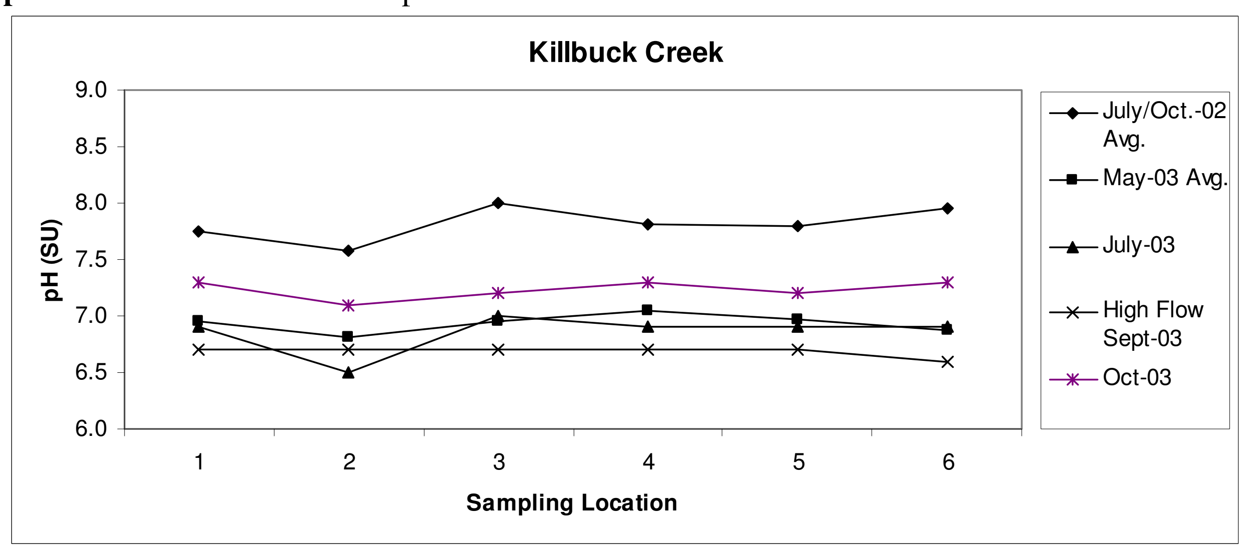


Figure 4.2: Killbuck/Mud Creek Subwatershed pH Results

DO: Within state standards for DO.

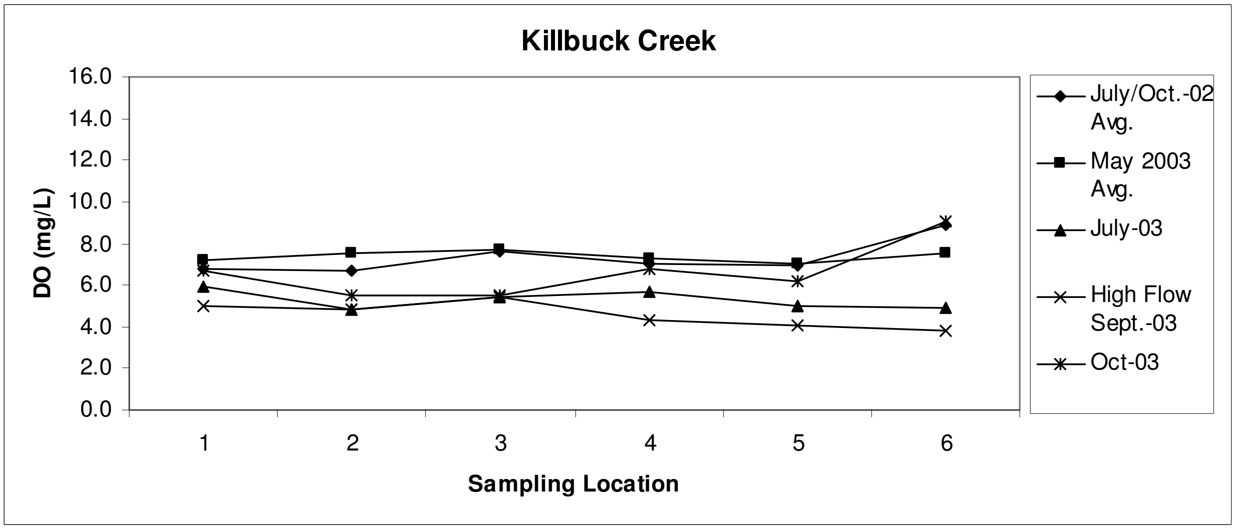


Figure 4.3: Killbuck/Mud Creek Subwatershed Dissolved Oxygen Results

BOD: Most higher than scientific guidelines.

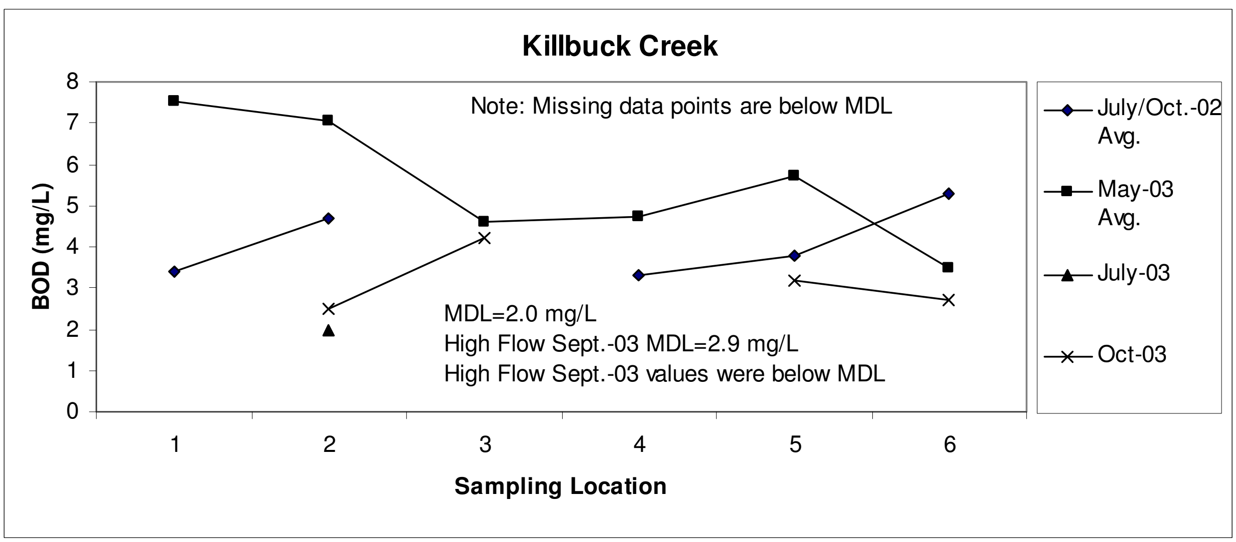


Figure 4.4: Killbuck/Mud Creek Subwatershed Biological Oxygen Demand Results

TSS: Some high (all at or above the aquatic life impact level of 80 mg/L) (Waters, 1995), especially KB-1, 2 & 5 In both Killbuck and Mud Creeks, there was a general tendency for TSS to increase going downstream.

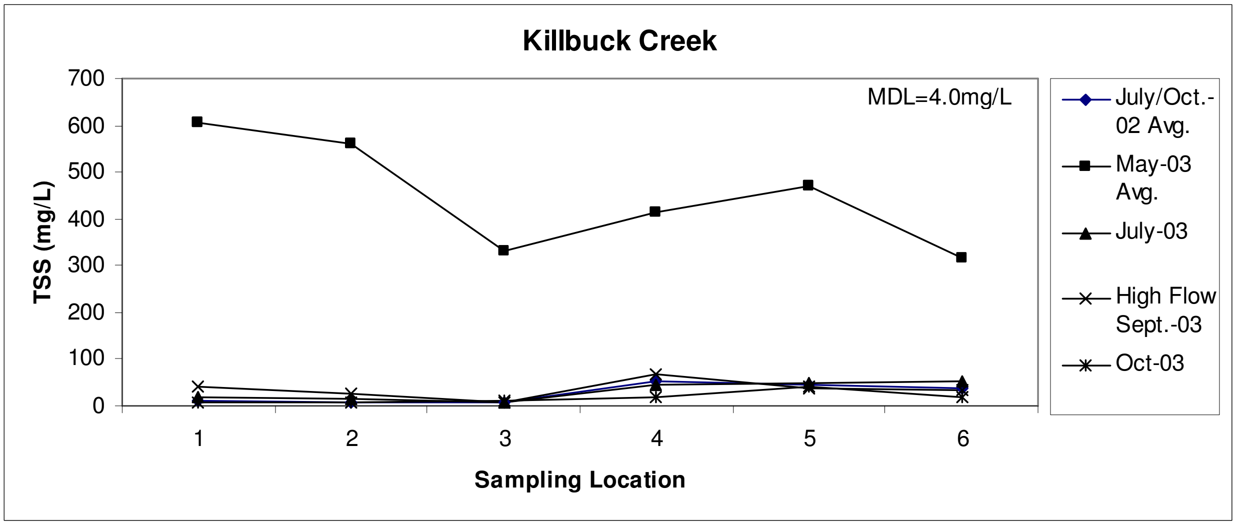


Figure 4.5: Killbuck/Mud Creek Subwatershed Total Suspended Solid Results

Ammonia: All high (above state standard for Ammonia), especially KB-2, 4 & 5 – KB-2 has a high spike

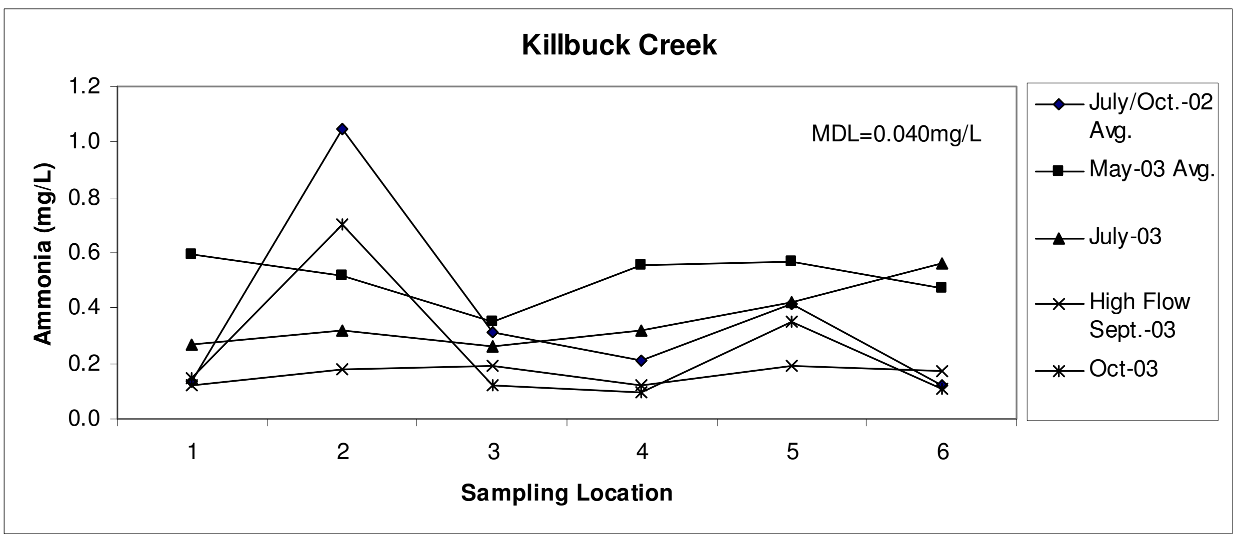


Figure 4.6: Killbuck/Mud Creek Subwatershed Ammonia Results

Nitrate: All high (above the modified warm water habitat guideline of 1.6 mg/L) (Ohio EPA, 1999), especially KB-6, 4 & 5

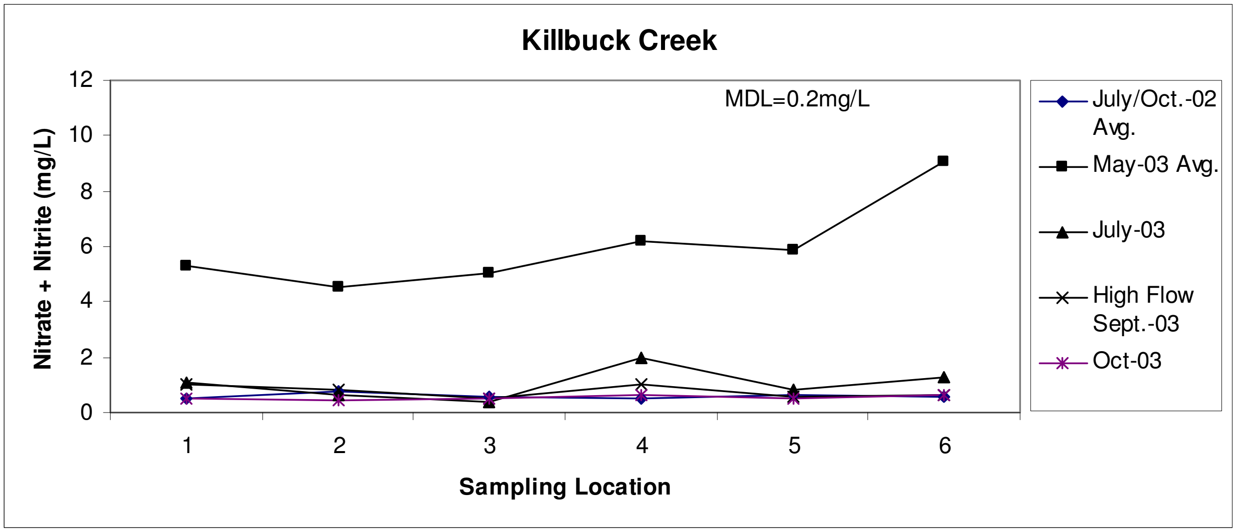


Figure 4.7: Killbuck/Mud Creek Subwatershed Nitrate Results

Orthophosphate (as P): All high (above the threshold for eutrophication of 0.1 mg/L) (Pierzynski, 2000), especially KB-3, 2 and 1 = Killbuck Creek

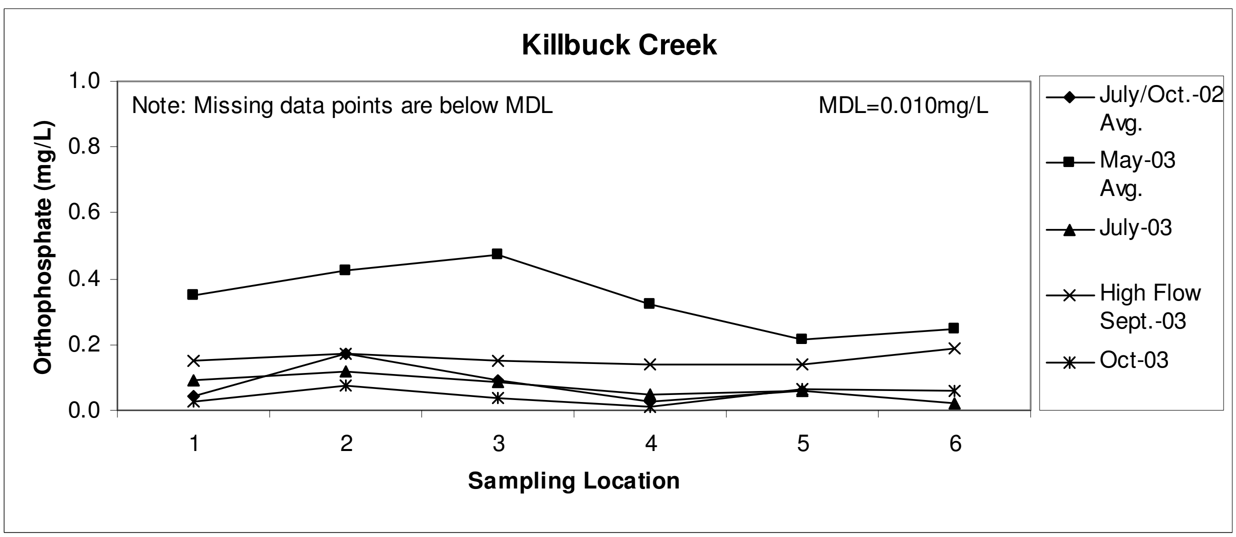


Figure 4.8: Killbuck/Mud Creek Subwatershed Orthophosphate Results

***E. coli*:** All high (above the state standard for *E. coli*), especially KB-6, 2 and 1

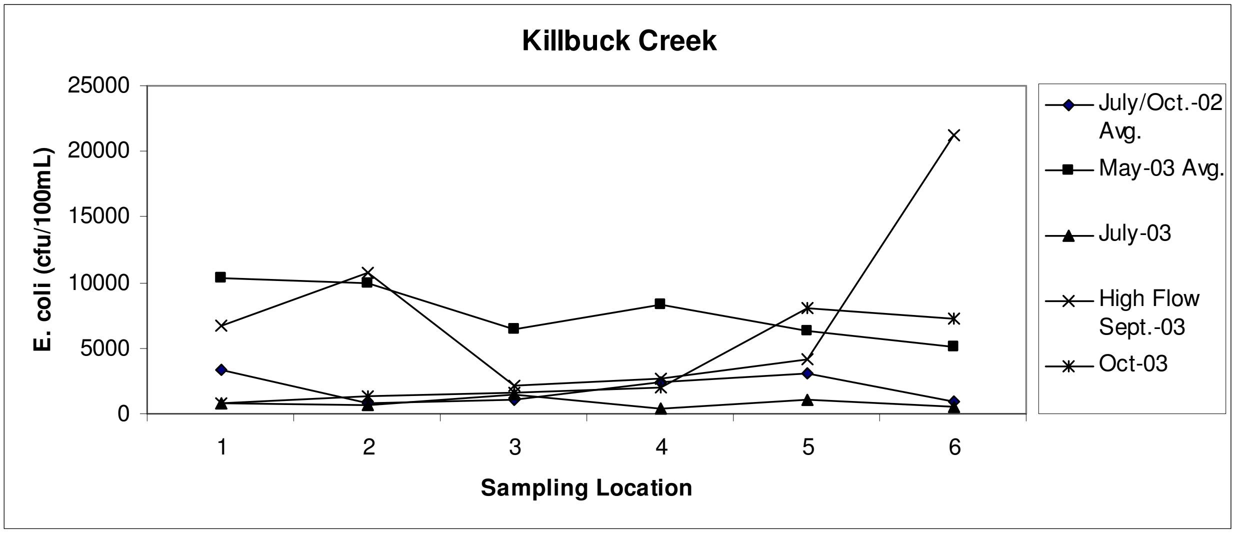


Figure 4.9: Killbuck/Mud Creek Subwatershed *E. coli* Results

Stream Habitat (QHEI): All found to be of poor habitat quality for given stream type.
Macroinvertebrates (ICI): All considered indicative of poor water quality.
Fish (IBI): All considered indicative of poor water quality.

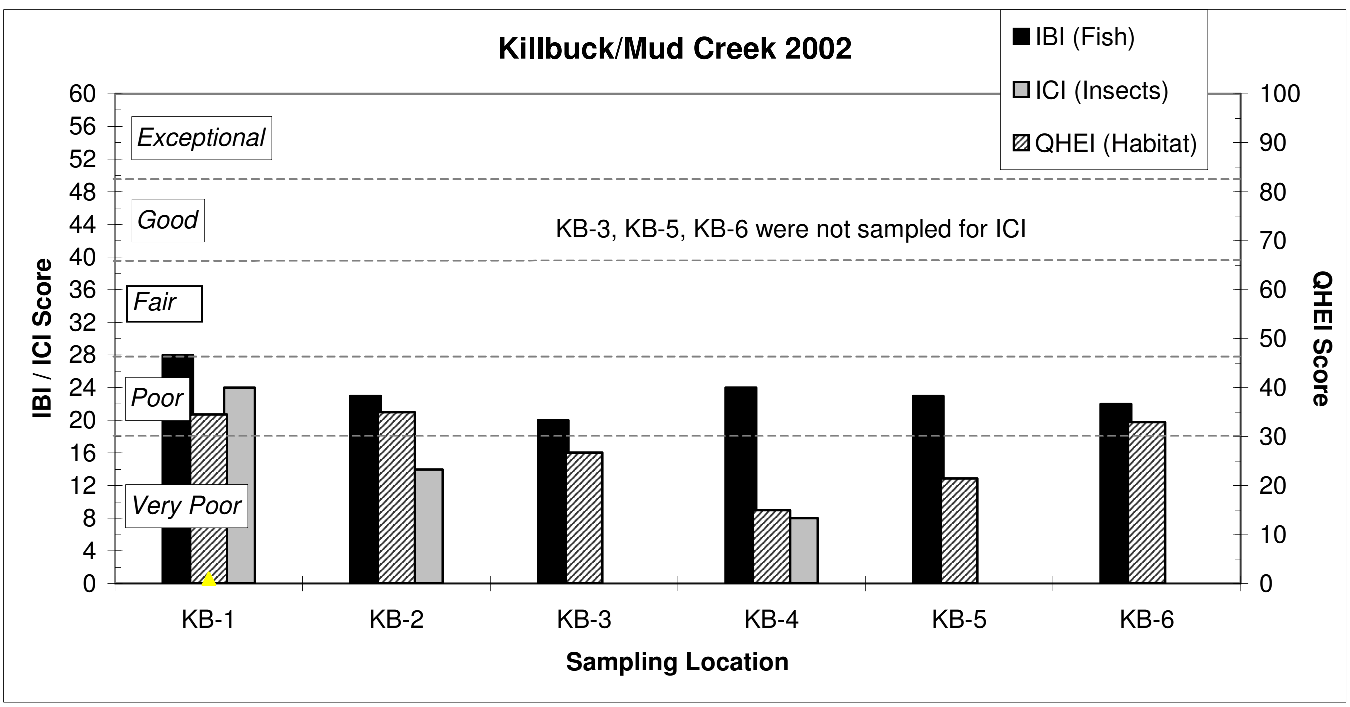


Figure 4.10: Killbuck/Mud Creek Subwatershed 2002 Biological and Stream Habitat Results (Note: QHEI Scores are on the right axis.)

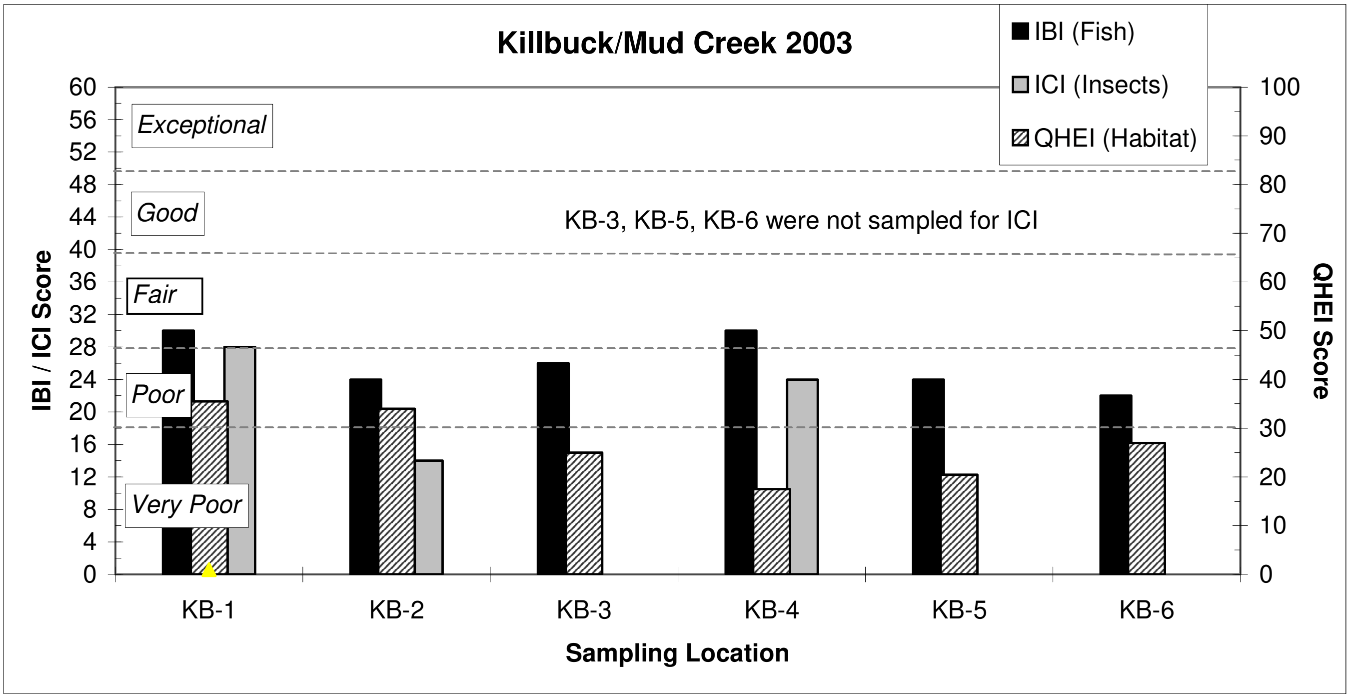


Figure 4.11: Killbuck/Mud Creek Subwatershed 2003 Biological and Stream Habitat Results (Note: QHEI Scores are on the right axis.)

<u>4.2.1.2 Buck Creek Subwatershed</u>

Note: BC-1 and 2 are on the White River and not directly downstream of BC-3 through 8.

Temperature: Cool water stream (potential for cold water if can lower temps slightly)
[Meets coldwater temperature requirements from 23rd St. (BC-5) to headwaters.]
Note: See Appendix E for further discussion of Buck Creek stream temperature.

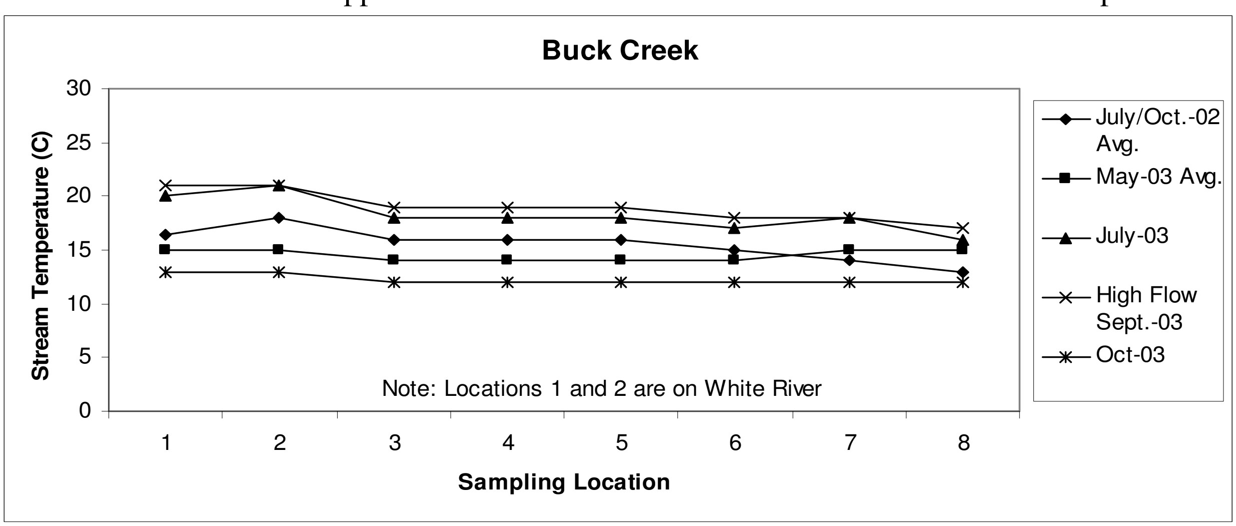


Figure 4.12: Buck Creek Subwatershed Stream Temperature Results

pH: Within state standards for pH.

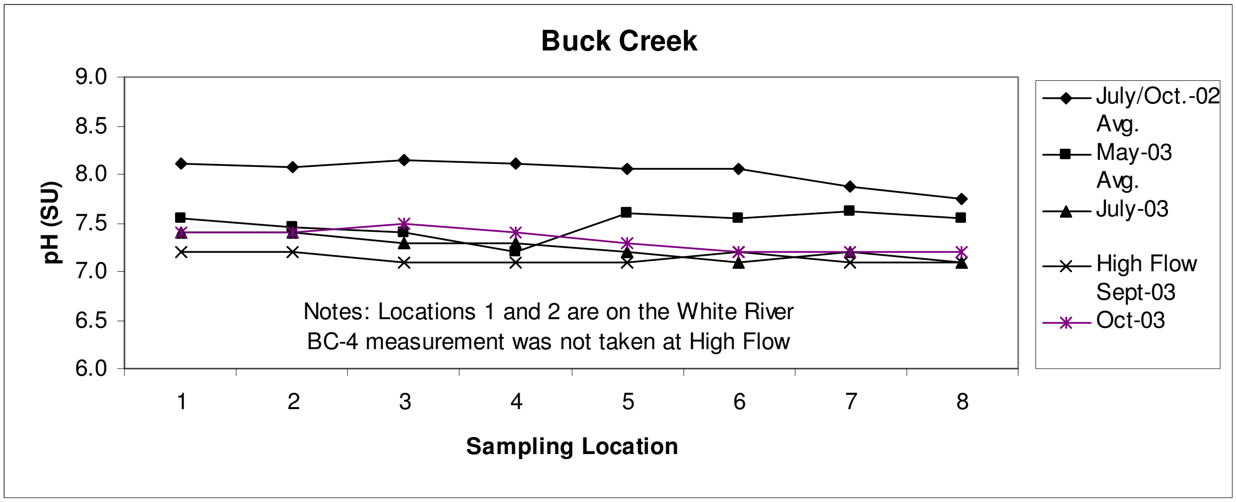


Figure 4.13: Buck Creek Subwatershed pH Results

Dissolved Oxygen: Overall, within acceptable ranges (within state standards for DO, except for BC-4 (having the only site reading below a 6)

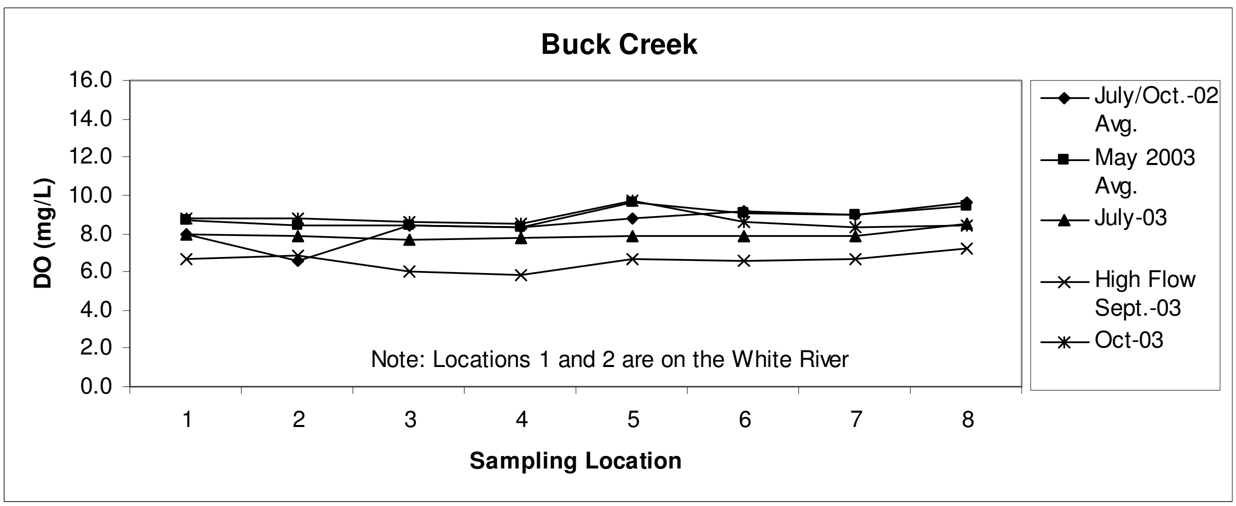


Figure 4.14: Buck Creek Subwatershed Dissolved Oxygen Results

Biological Oxygen Demand: All higher than scientific guidelines.

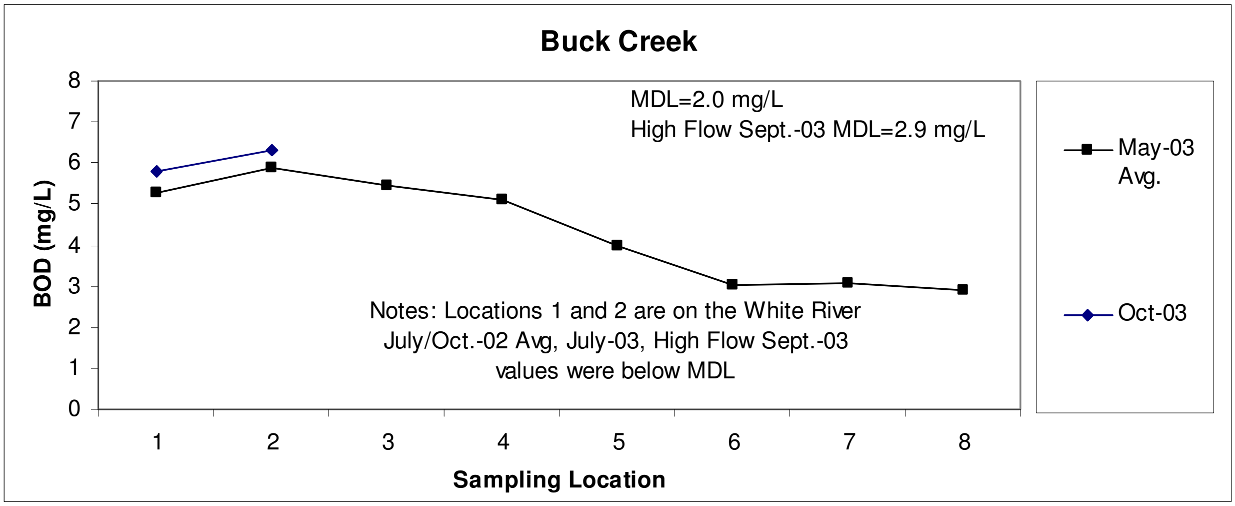


Figure 4.15: Buck Creek Subwatershed Biological Oxygen Demand Results

Total Suspended Solids: BC-7 through 3 – all BC sites have TSS issues (levels above the 80 mg/L) (Waters, 1995) during high flow event (as recorded in May 2003). High readings during the 2nd May cycle in 2003 (past the high flow cycle in early May 2003). This is associated with flow events; however, there was a high flow cycle monitored in September 2003 that had low TSS readings, therefore also seasonal. In addition, BC-4 is the highest and BC-5 is almost as high (both before CSO influence), and BC-3 levels lower (post CSO influence).

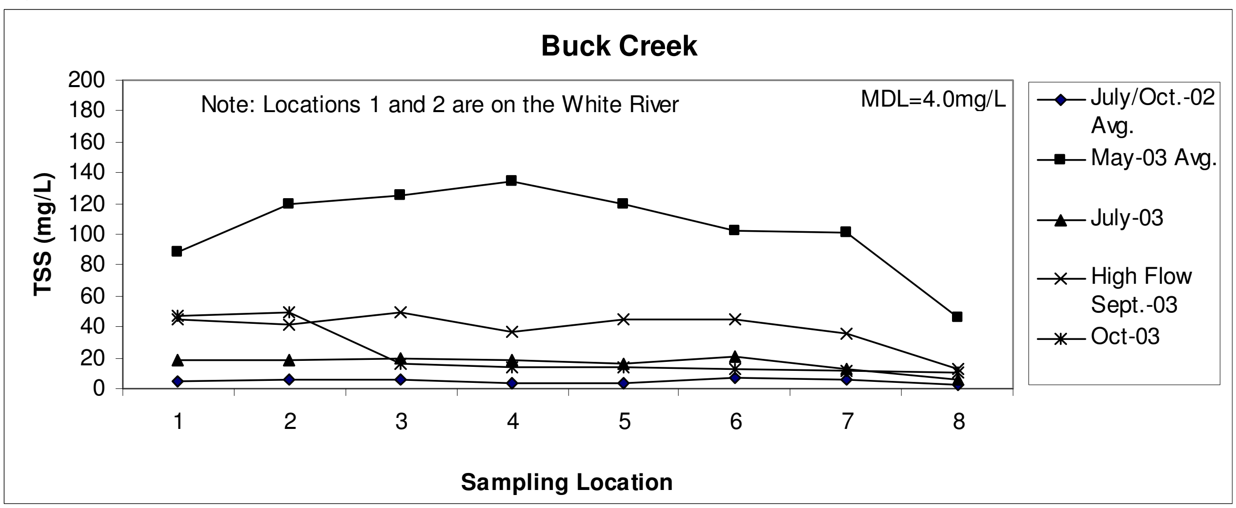


Figure 4.16: Buck Creek Subwatershed Total Suspended Solids Results

Ammonia: BC-4, 7 and 3 – BC-7 spikes in several cases

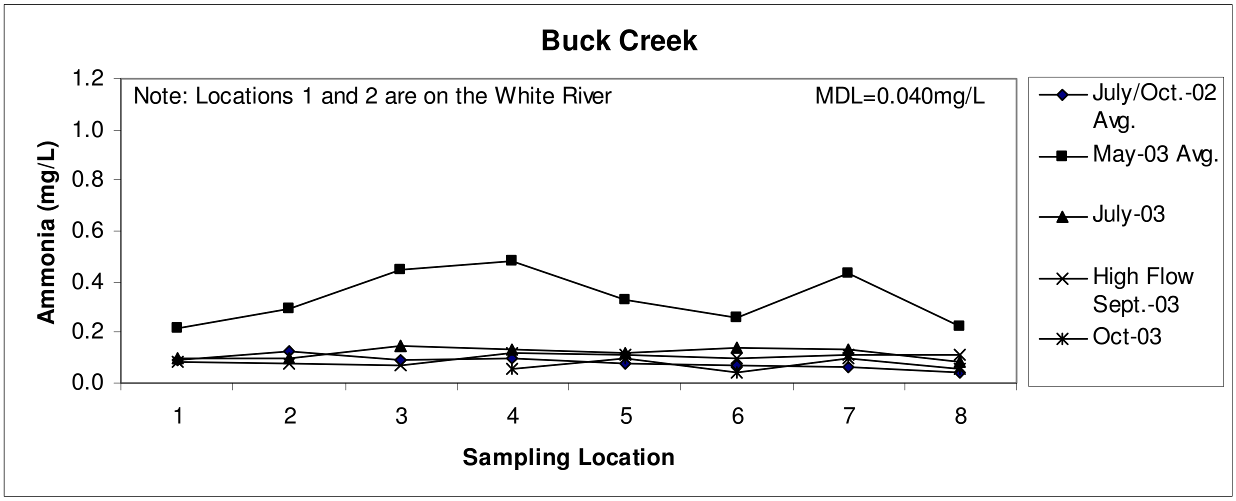


Figure 4.17: Buck Creek Subwatershed Ammonia Results

Nitrate: All of Buck Creek has high nitrate levels (exceeding the guideline for modified warm water habitat of 1.6 mg/L) (Ohio EPA, 1999) – highest readings in May 2003 (BC7 spike) Overall, all sampling sessions had high levels except for the second July 2002 session. Increases evenly as goes downstream, with a spike at BC-7. Not seasonal.

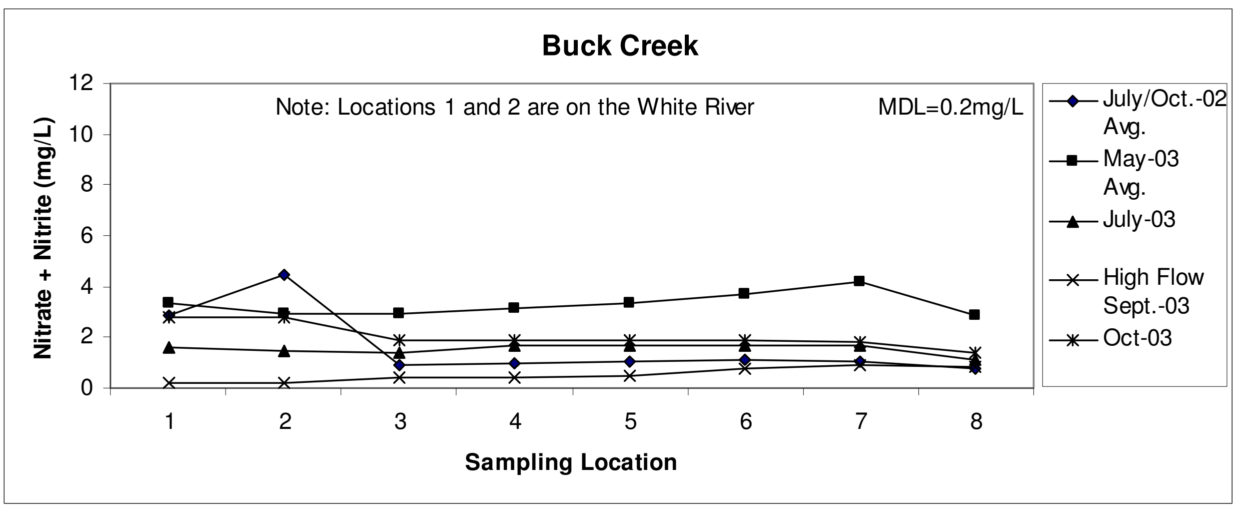


Figure 4.18: Buck Creek Subwatershed Nitrate Results

Orthophosphate: All of Buck Creek has high levels (exceeding the guideline for the threshold for eutrophication of 0.1 mg/L) (Pierzynski, 2000) – increases evenly as goes downstream, with the highest values at BC-3 & 4 (only slightly higher)

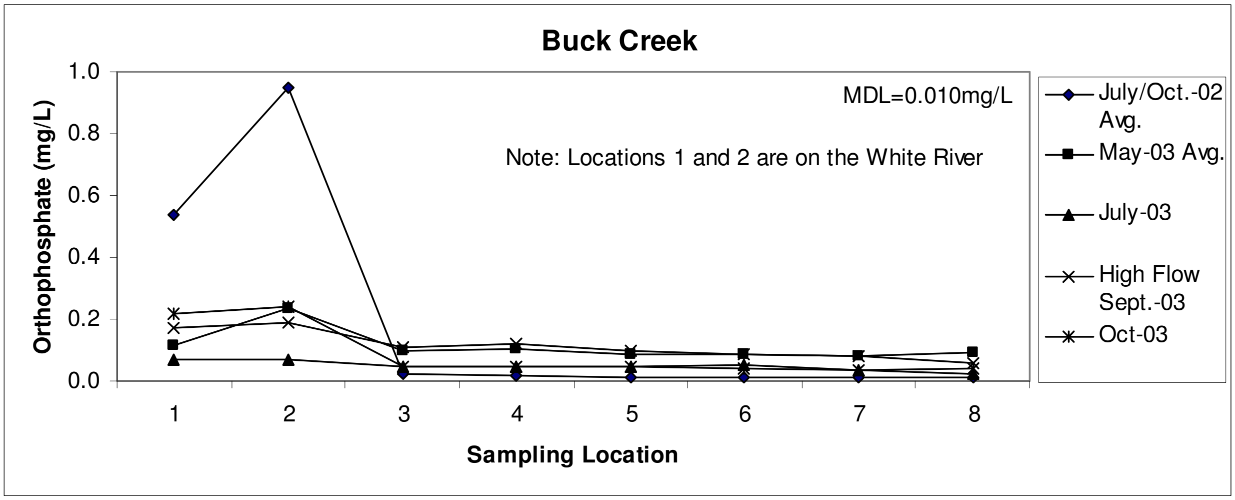


Figure 4.19: Buck Creek Subwatershed Orthophosphate Results

E. coli**:** All of Buck Creek has high levels (exceeding state standards for *E. coli*) – highest readings on BC-3, 4, 5 & 8 with spiked readings on the entire waterway in May 2003, with the lowest reading at 1,200. There is a correlation between increased flow and increased *E. coli* readings. There is some seasonality with the May spikes. (Groundwater is closer to the surface, therefore there is an increase in runoff and discharges, coupled with less robust vegetation equals easy *E. coli* transportation.)

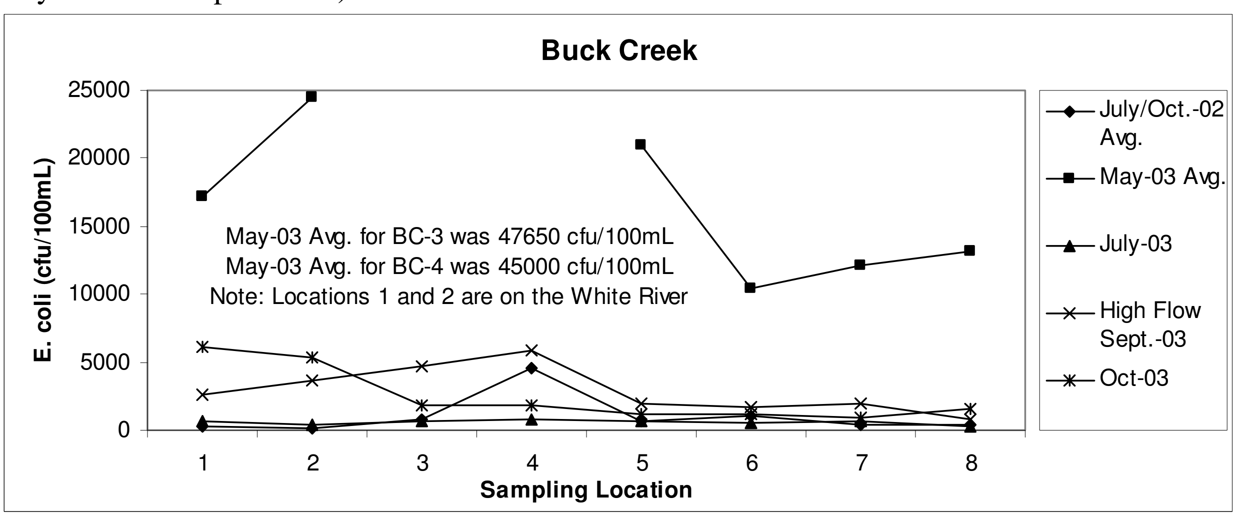


Figure 4.20: Buck Creek Subwatershed *E. coli* Results

Stream Habitat (QHEI): Overall, readings indicative of good stream habitat for stream type. BC-6 was found to have poor habitat conditions, however, due to the presence of an illegal rock dam.
Macroinvertebrates (ICI): From BC-8 until BC-4, reading indicative of good water quality. Readings drop at BC-3 & 4, however.
Fish (IBI): Overall, readings indicative of good water quality. However, BC6 is indicative of poor water quality due to the presence of an illegal rock dam

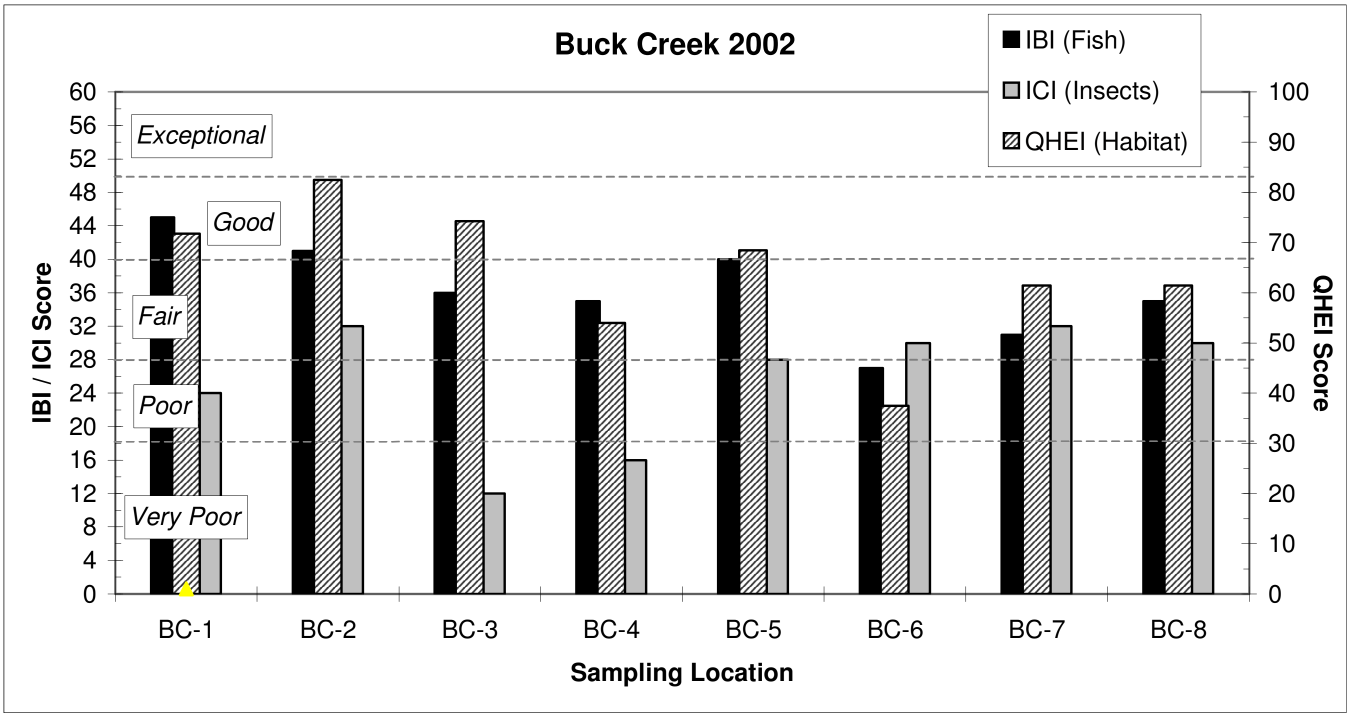


Figure 4.21: Buck Creek Subwatershed 2002 Biological and Stream Habitat Results
(Note: QHEI Scores are on the right axis and BC-1 and 2 are on the White River.)

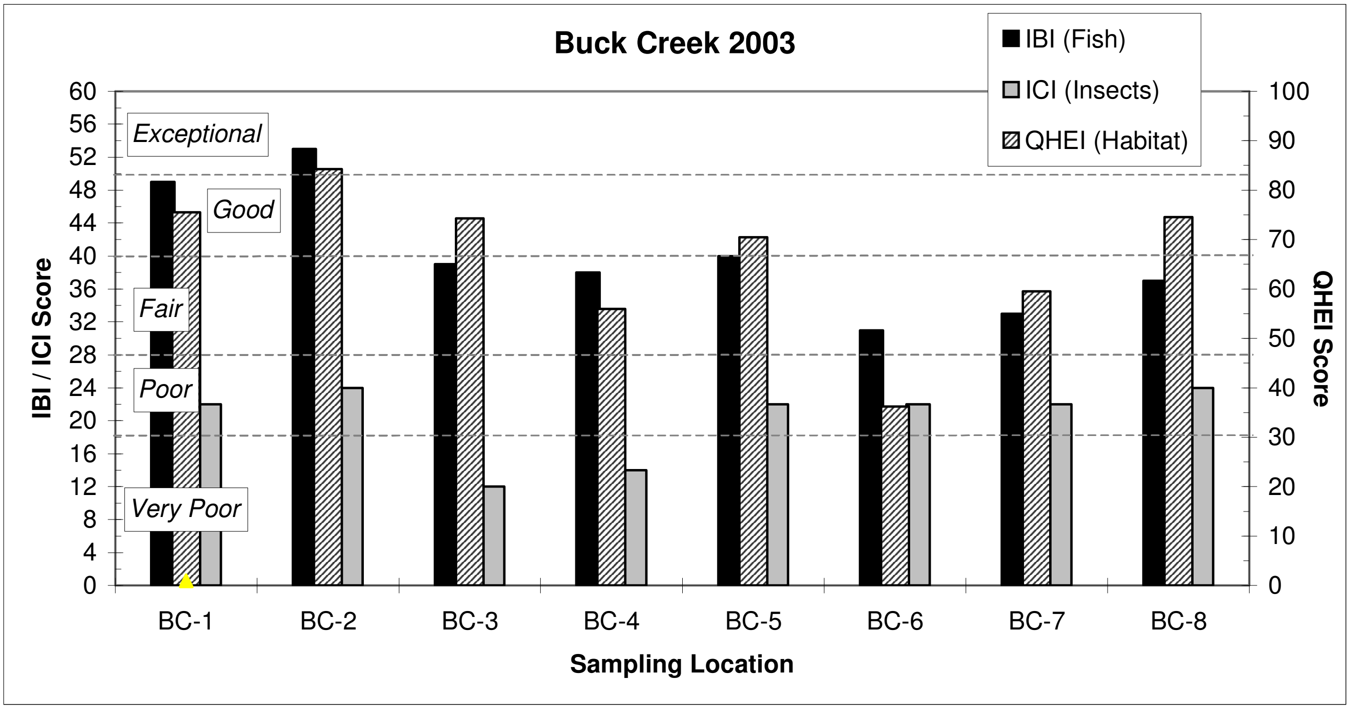


Figure 4.22: Buck Creek Subwatershed 2003 Biological and Stream Habitat Results
(Note: QHEI Scores are on the right axis and BC-1 and 2 are on the White River.)

4.2.1.3 Prairie Creek Subwatershed

Note: PC-1 and 2 are on the White River and are not directly downstream from PC-3 through 8, also PC-3 through 5 in the reservoir (3 is the outfall) and PC-6, 7 and 8 are individual streams that feed into the reservoir at three separate locations.

Temperature: Within state standards for temperature.

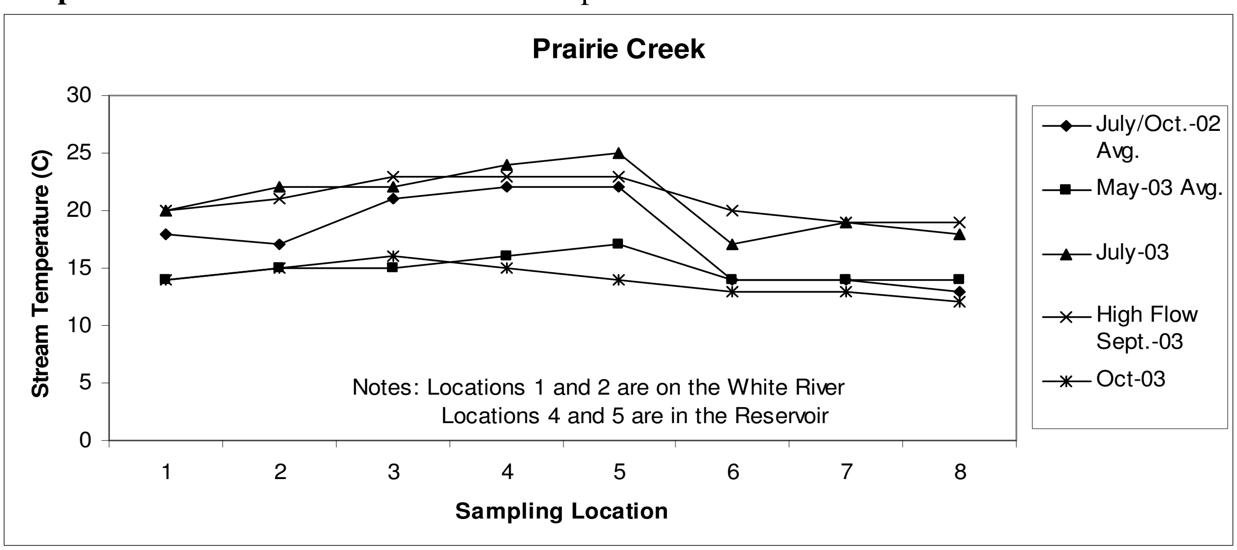


Figure 4.23: Prairie Creek Subwatershed Stream Temperature Results

pH: Within state standards for pH.

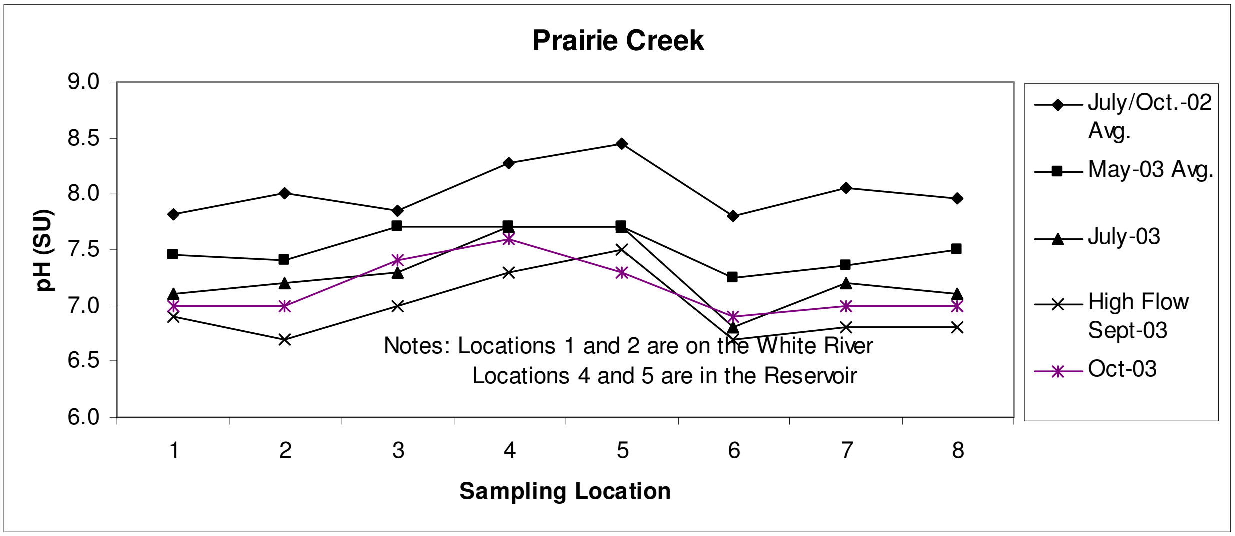


Figure 4.24: Prairie Creek Subwatershed pH Results

DO: Low in PC-4, 5 & 6 in September 2003 sampling session. (Below state standards for DO.)

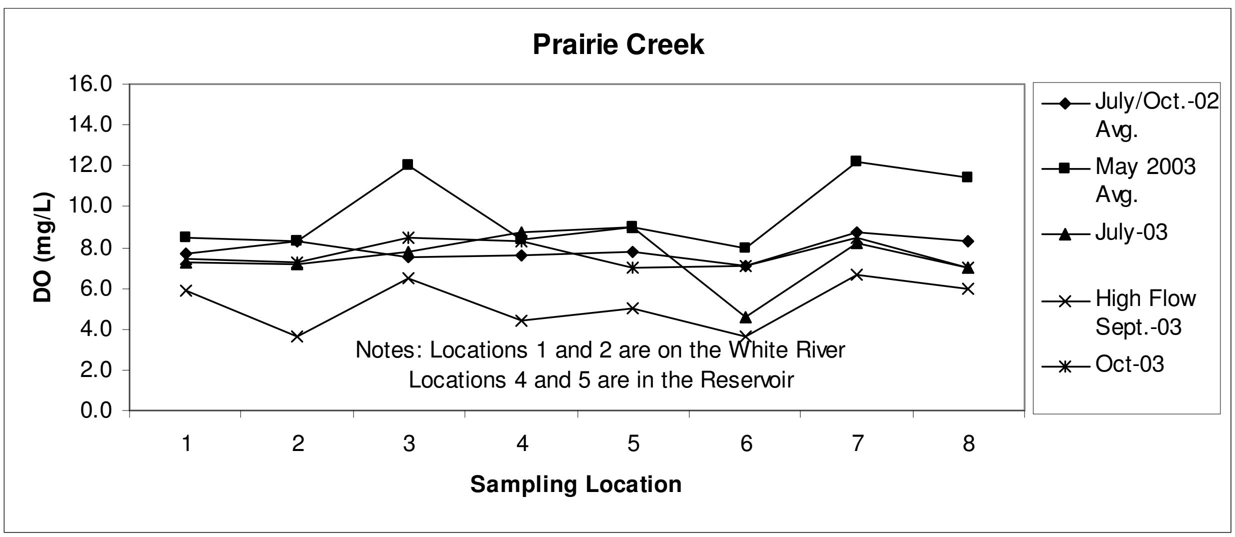


Figure 4.25: Prairie Creek Subwatershed Dissolved Oxygen Results

BOD: Mixed readings: some within and some higher than scientific guidelines.

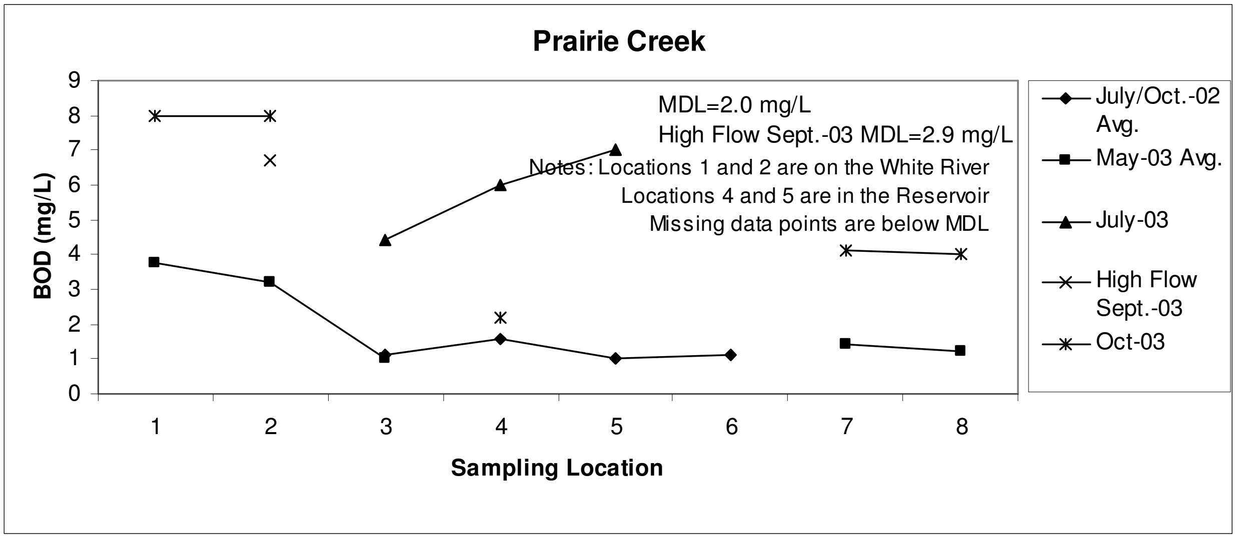


Figure 4.26: Prairie Creek Subwatershed Biological Oxygen Demand Results

TSS: Most reading within the reservoir are within the threshold for eutrophication at 0.1 mg/L, however, readings on the tributaries are higher.

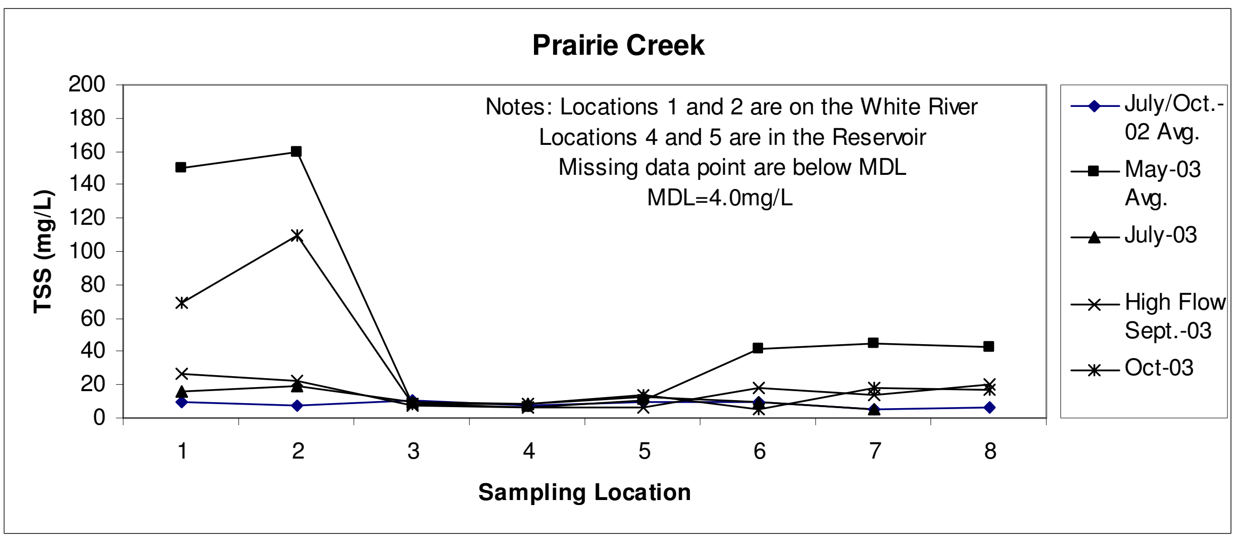


Figure 4.27: Prairie Creek Subwatershed Total Suspended Solids Results

Ammonia: All high (above the state standard for Ammonia), especially in October 2002 and May 2003

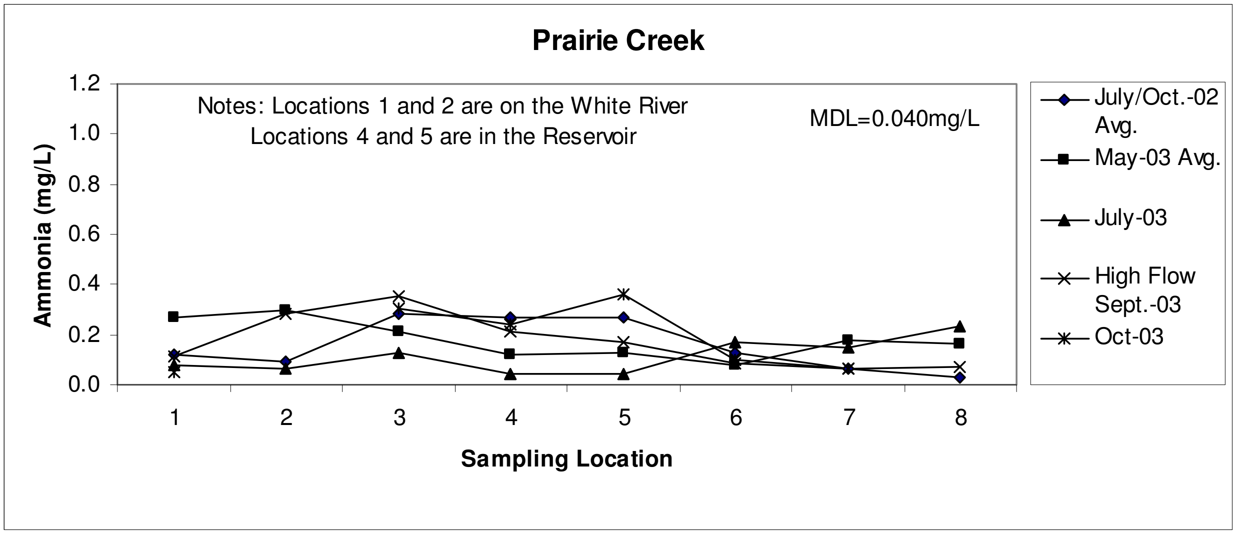


Figure 4.28: Prairie Creek Subwatershed Ammonia Results

Nitrate: High levels at PC-7, 8 & 6, especially during the second May 2003 sampling session. (Levels higher than the guideline for modified warm water habitat of 1.6 mg/L) (Ohio EPA, 1999)

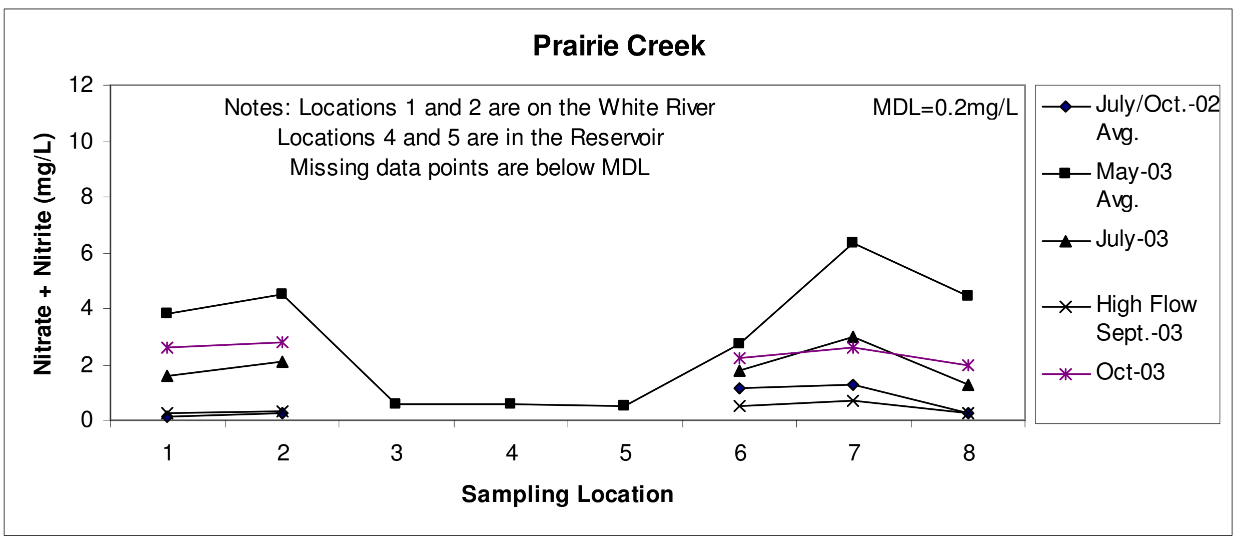


Figure 4.29: Prairie Creek Subwatershed Nitrate Results

Orthophosphate: High levels at PC-7, 8 & 6 – highest September 2003 (Levels higher than the guideline for the threshold for eutrophication at 0.1 mg/L) (Pierzynski, 2000)

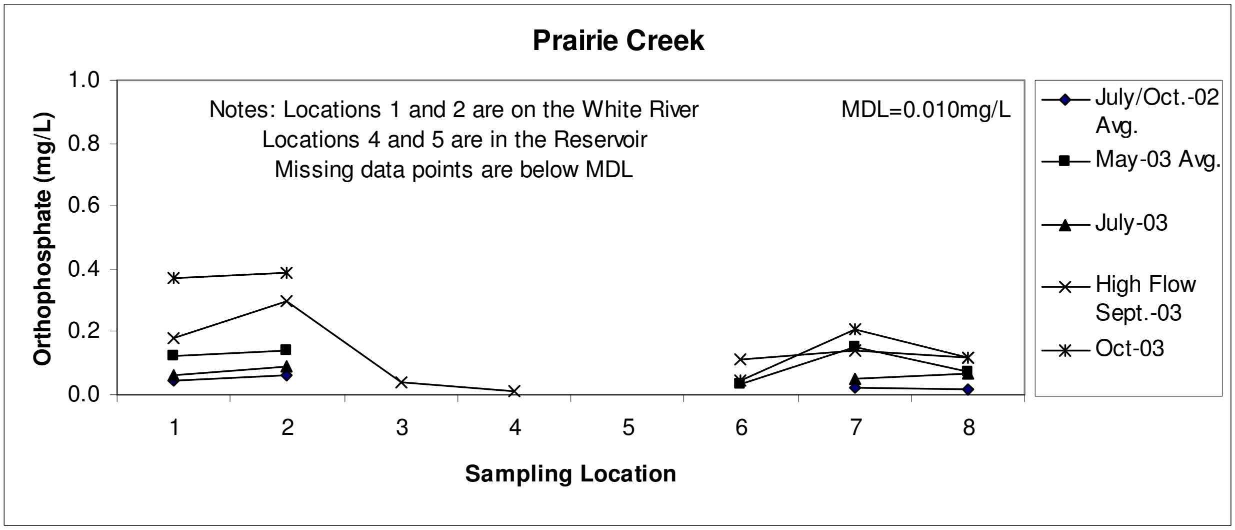


Figure 4.30: Prairie Creek Subwatershed Orthophosphates Results

***E. coli*:** High levels at PC-7, 6 & 8 – overall, Prairie Creek has lower readings than the other two watersheds, but readings are still considered high including in the reservoir itself. October 2003 was higher than the rest (3000-7000 cfu/ml) and the highest reading was at PC-7 = 11,000 cfu/ml. (Levels higher than the state standard for *E. coli*.)

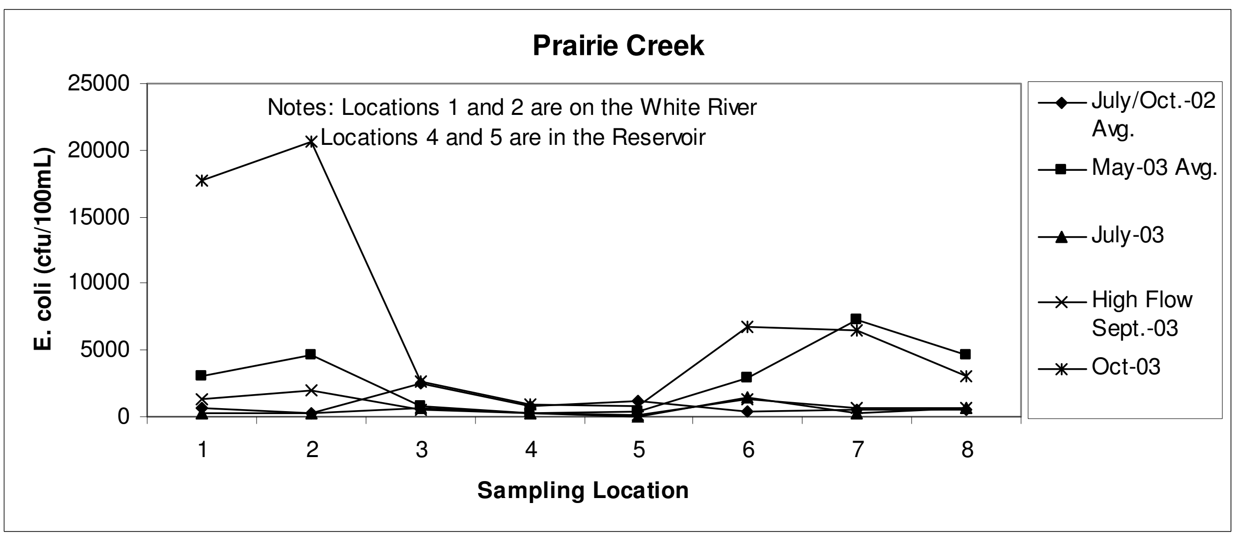


Figure 4.31: Prairie Creek Subwatershed *E.* coli Results

Biology: PC-7 results are indicative of good water quality (for all three)

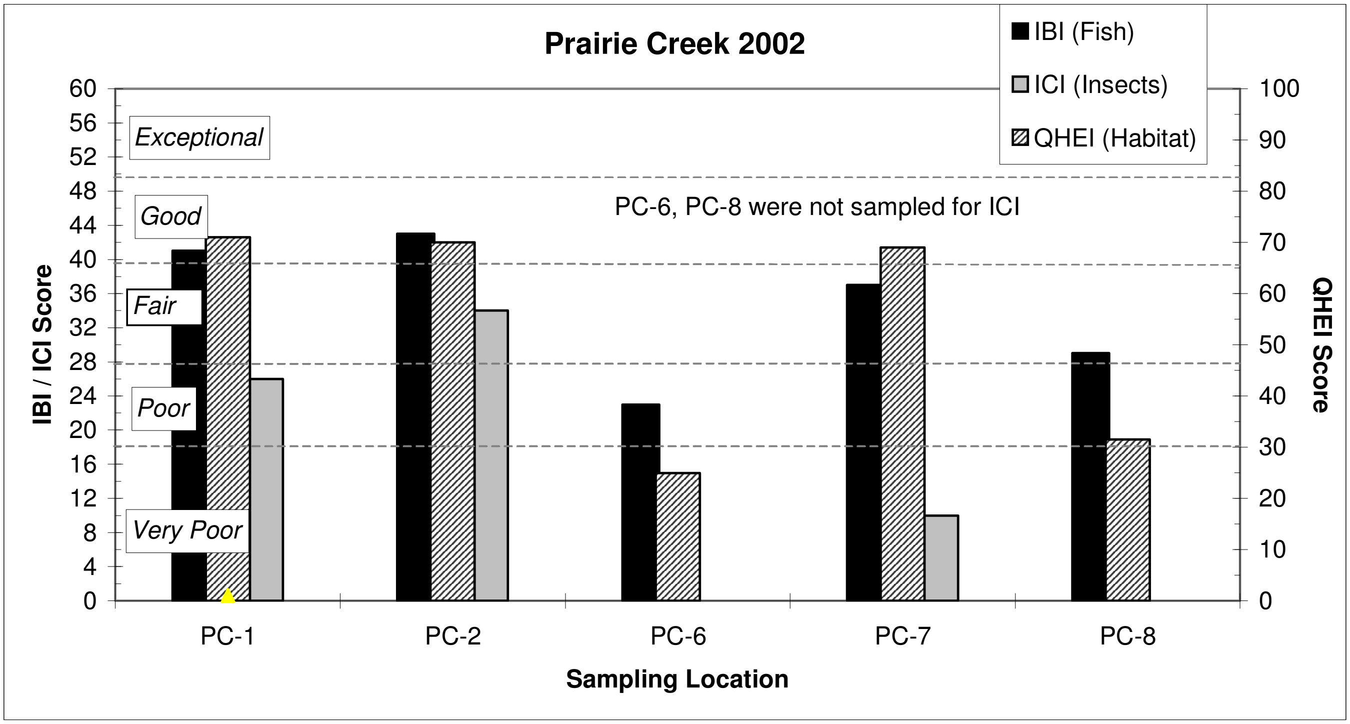


Figure 4.32: Prairie Creek Subwatershed 2002 Biological and Stream Habitat Results (Note: QHEI Scores are on the right axis and PC-1 and 2 are on the White River.)

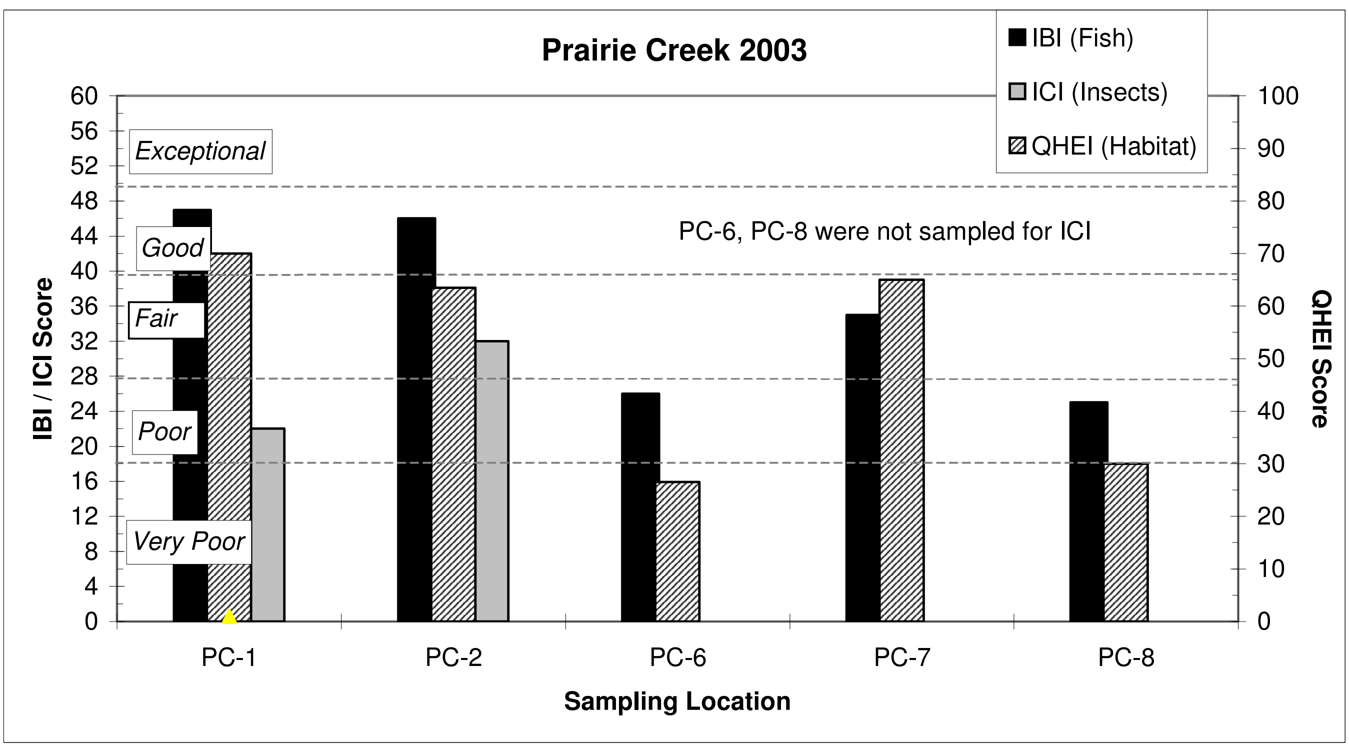


Figure 4.33: Prairie Creek Subwatershed 2003 Biological and Stream Habitat Results (Note: QHEI Scores are on the right axis and PC-1 and 2 are on the White River.)

4.2.1.4 Atrazine and Diazinon Results

Atrazine was detected at all locations sampled for both years. No samples in November 2002 and October 2003 were over drinking water standards (3 µg/L) (USEPA, 1999) or aquatic-life guideline (1.8 µg/L) (USGS, 1999), four out of five were above both those standards in May 2003.

Table 4.2: Atrazine Concentrations for 2002 Sampling Event

Watershed	ID	Nov-02
		µg/L
PC	1	0.24
PC	3	0.1
PC	6	0.01

Table 4.3: Atrazine Concentrations for 2003 Sampling Events

Watershed	ID	May-03 (IAWC)	May-03 (NREM)	Oct.-03 (ECCS)
		µg/L	µg/L	µg/L
BC	1	20	24	0.19
BC	3	7.3	12	0.40
KB	1	15	24	0.10
PC	2	18	24	0.12
PC	3	0.9	1.3	0.98

Diazinon concentrations taken in October of 2003 (reported by Environmental Chemical Consulting Service Inc.[Madison, WI]) were reported to be below the method detection limit of 0.0084 ug/L. Samples analyzed in the NREM Department had a high concentration of 70 ng/L which is less than the aquatic life standard of 100 ng/L (0.1 ug/L) and the drinking water guideline.

Table 4.4: 2003 Diazinon Concentrations

Watershed	ID	Oct. 03 (ECCS)	Nov. 03 (NREM)
		µg/L	ng/L
BC	1	<0.0078	52.0
BC	2	NS	48.9
BC	3	<0.0078	67.2
BC	4	NS	63.2
BC	5	NS	45.2
BC	6	NS	34.7
BC	7	NS	70.3
BC	8	NS	49.8
KB	1	<0.0081	BDL
KB	2	NS	BDL
KB	3	NS	23.1
KB	4	NS	BDL
KB	6	NS	BDL
PC	1	NS	BDL
PC	2	<0.0078	30.9
PC	3	<0.0079	BDL
PC	4	NS	36.6
PC	5	NS	56.3
PC	6	NS	54.4
PC	7	NS	BDL
PC	8	NS	BDL

4.2.1.4 Discharge Calculations

Discharges were measured as part of the monitoring program in order to estimate the individual load each pollutant contributes in a given subwatershed. These loads are reported later in this document.

Table 4.5: Discharge Calculations for All Three Subwatersheds

Location	Year	Date	Discharge (ft^3/sec)
BC-3	2002	10-Jul	59.6
BC-3	2002	22-Jul	37.8
BC-3	2002	8-Aug	26.3
BC-3	2002	2-Nov	22.5
BC-3	2002	9-Nov	24.4
BC-3	2003	16-Jul	92.17
BC-3	2003	17-Aug	52.66
BC-3	2003	4-Sep	173.73
BC-3	2003	13-Sep	54.27

Location	Average	Median	USGS Median
BC-3	78.3805	**59.755**	n/a
BC-6	30.7	20.7	**34.78333**
KB-1	41.83758	**14.75**	n/a
PC-3	27.47667	**13.225**	n/a

BOLD = Medians used to estimate current pollutant loads

BC-3	2003	28-Sep	157.3
BC-3	2003	16-Oct	75.4
BC-3	2003	19-Apr	43.68
BC-3	2003	13-May	148.7
BC-3	2003	15-May	206.3
BC-3	2003	25-May	60.82
BC-3	2003	30-May	41.37
BC-3	2004	28-Feb	55.78
BC-3	2004	6-Mar	101.54
BC-3	2004	13-Mar	59.91
BC-3	2004	19-Mar	73.38
BC-6	2002	7-Sep	17.1
BC-6	2002	21-Sep	19.8
BC-6	2002	5-Oct	22.5
BC-6	2002	12-Oct	20.3
BC-6	2002	19-Oct	21.1
BC-6	2002	9-Nov	18.9
BC-6	2003	16-Jul	53.76
BC-6	2003	13-May	72.14
KB-1	2002	22-Jul	5
KB-1	2002	21-Sep	8.2
KB-1	2002	5-Oct	3.3
KB-1	2002	19-Oct	5.9
KB-1	2003	15-Jul	22.1
KB-1	2003	15-Jul	33.58
KB-1	2003	17-Aug	6.99
KB-1	2003	4-Sep	53.46
KB-1	2003	13-Sep	7.57
KB-1	2003	27-Sep	140.47
KB-1	2003	28-Sep	44.38
KB-1	2003	14-Oct	6.8
KB-1	2003	19-Oct	10.3
KB-1	2003	26-Oct	11.2
KB-1	2003	19-Apr	9.41
KB-1	2003	19-Apr	10.99
KB-1	2003	27-Apr	7.57
KB-1	2003	27-Apr	8.76
KB-1	2003	3-May	21.4
KB-1	2003	3-May	27.38
KB-1	2003	11-May	452.1

KB-1	2003	15-May	98.38
KB-1	2003	21-May	16.84
KB-1	2003	21-May	22.68
KB-1	2003	27-May	10.54
KB-1	2003	27-May	15.78
KB-1	2003	12-Jun	10.25
KB-1	2004	28-Feb	14.75
KB-1	2004	5-Mar	121.9
KB-1	2004	6-Mar	58.46
KB-1	2004	13-Mar	13.43
KB-1	2004	19-Mar	17.71
KB-1	2004	27-Mar	83.06
PC-3	2002	23-Sep	15.2
PC-3	2002	19-Oct	5.1
PC-3	2003	17-Jul	47.98
PC-3	2003	18-Aug	7.93
PC-3	2003	19-Apr	11.25
PC-3	2003	14-May	77.4
PC-7	2003	15-Oct	3.99
PC-8	2003	15-Oct	4.64

4.2.2 Land Use and Land Cover Results (by Subwatershed)
Land use and cover analysis was conducted by EnviroDesigs, Inc., Muncie-Delaware Metropolitan Plan Commission, and the Delaware County GIS Department. By comparing land use (over the entire subwatershed) and cover (along 30 and 5 meters on either side of each major waterbody within each subwatershed), we can achieve a much more complete understanding of our local non-point source water pollution sources.

4.2.2.1 Killbuck/Mud Creek Subwatershed

Land Use

Of the 10,039 acres (15.7 square miles) in the Killbuck/Mud Creek Subwatershed, land use consists of the following:

	Acres	Percentage
Agricultural	7364	73.35
Ag. Support	64	0.64
Commercial	54	0.54
Government & Institutional	39	0.39
Woodlands & Greenspace	701	6.98
Industrial	42	0.42
Residential	1419	14.13
Salvage Yard	0	0
Transportation & Utility	356	3.55
Vacant/No Use	0	0

The percent impervious surface in Killbuck/Mud Creek Subwatershed is 2.98.

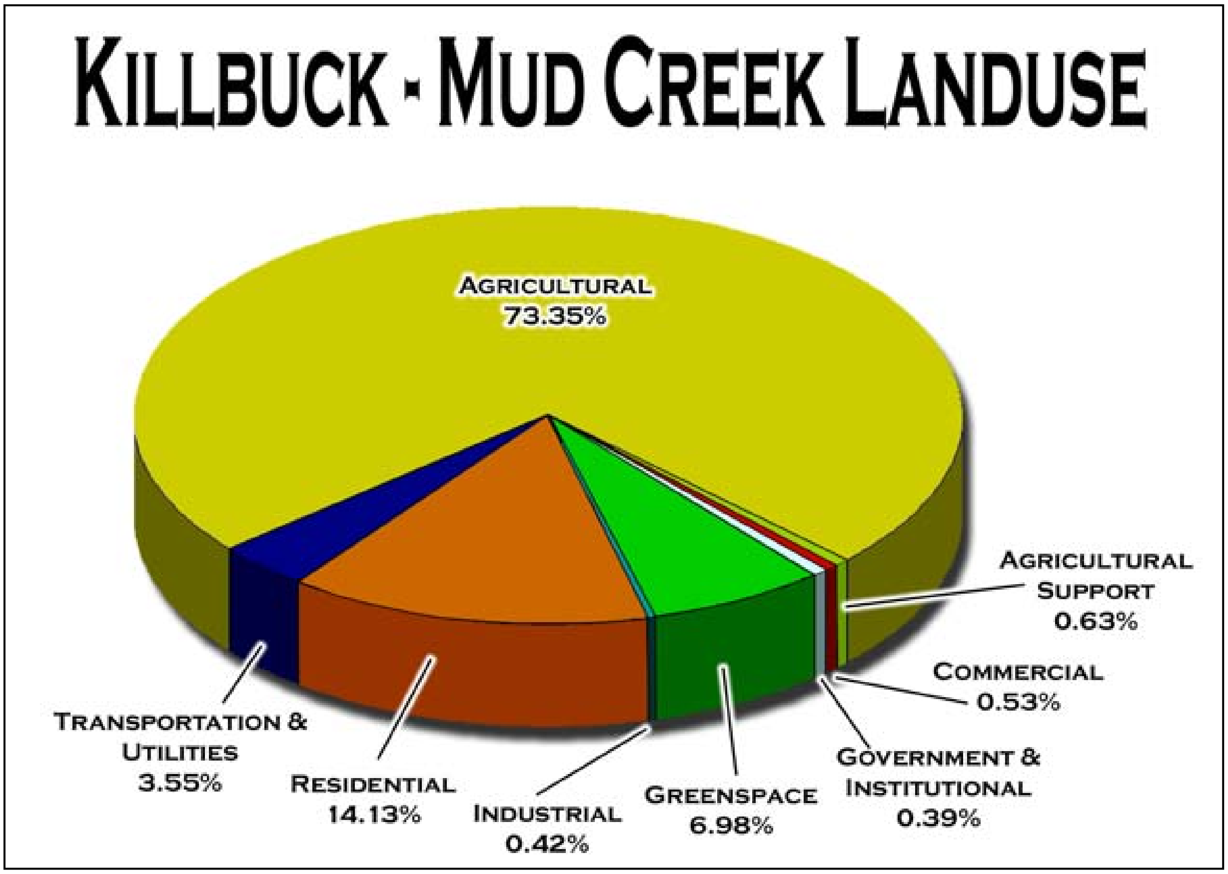


Figure 4.34: Killbuck/Mud Creek Subwatershed Land Use

Table 4.6: Killbuck/Mud Creek Land Use Percentages by Sub-Subwatershed

Land Use	KB-1	KB-2	KB-3	KB-4	KB-5	KB-6
Agricultural	73.35	67.43	68.82	79.05	75.13	74.11
Agricultural Support	0.63	0.75	1.07	0.52	0.47	0.64
Commercial	0.53	0.46	0.75	0.63	1.01	
Govt institutional	0.39	0.24	0.44	0.67	1.10	1.70
Greenspace	6.98	6.50	7.36	6.80	7.87	9.97
Industrial	0.42			1.08	1.76	
Residential	14.13	20.29	16.71	8.31	9.27	10.61
Salvage Yard	0.03	0.05	0.08	0.01	0.01	0.02
Transportation & utilities	3.55	4.28	4.78	2.92	3.38	2.95
Vacant No Use						

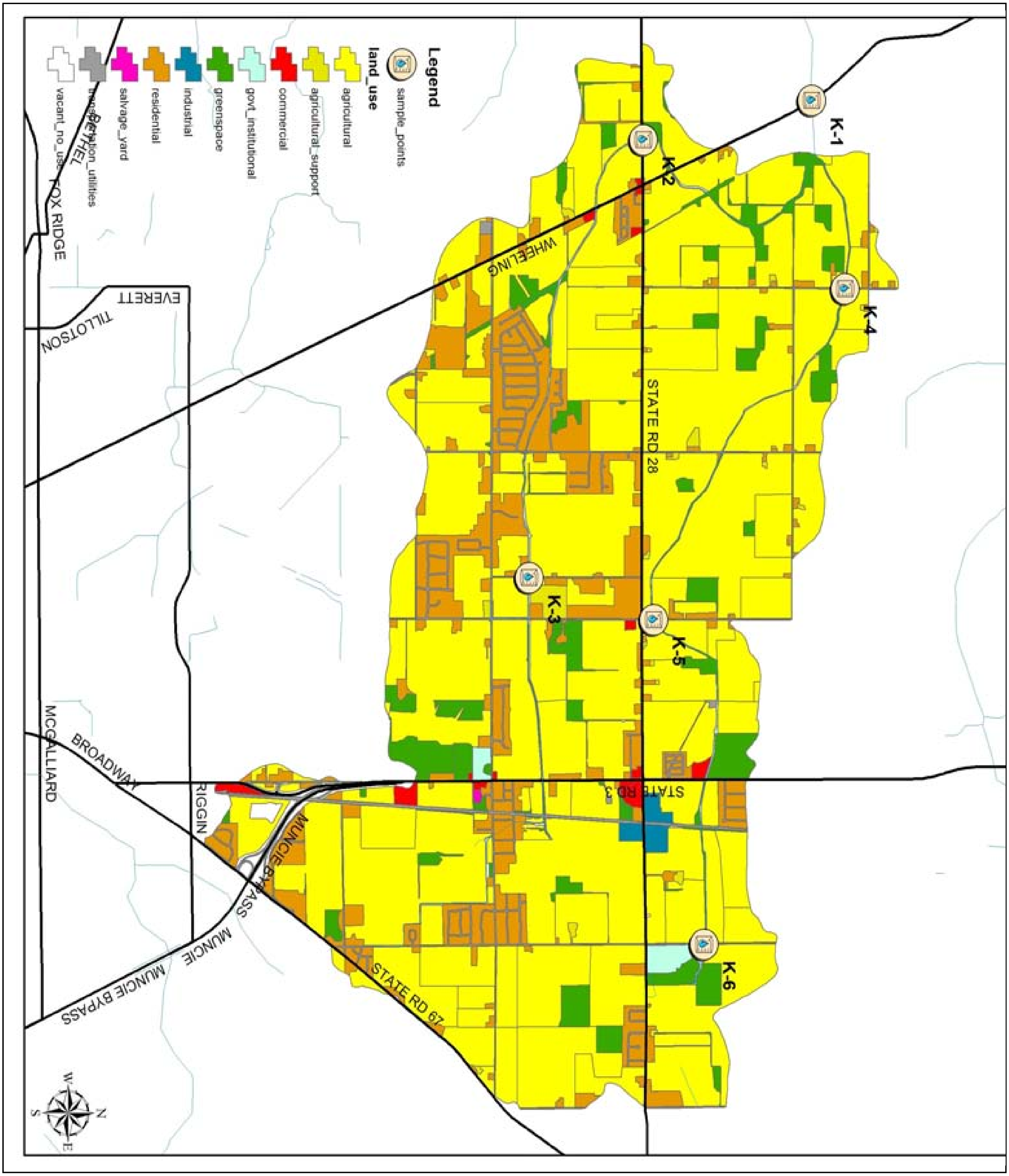


Figure 4.35: Killbuck/Mud Creek Subwatershed Land Use Map

Land Cover

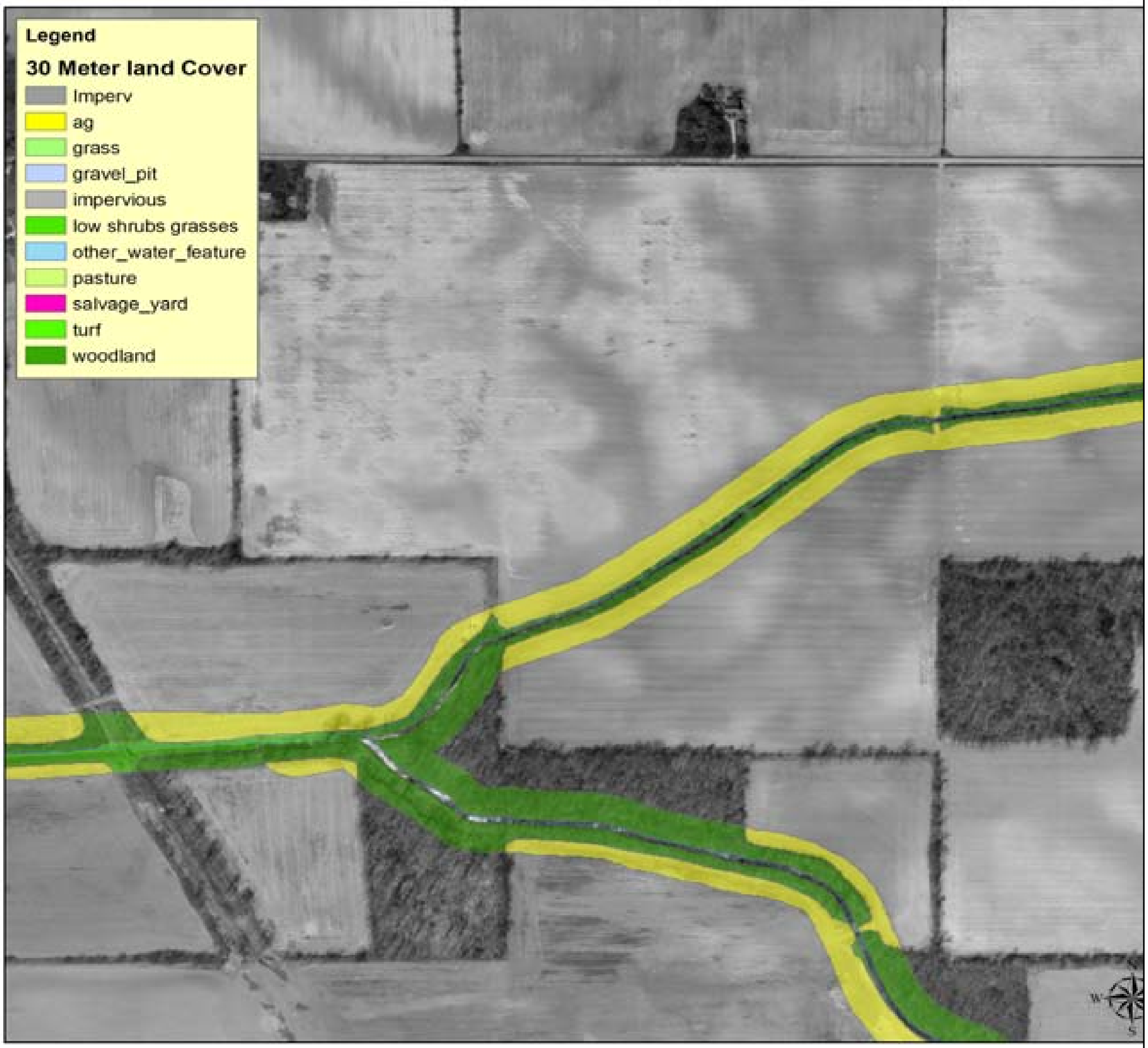


Figure 4.36: Example of Killbuck/Mud Creek Subwatershed Thirty-Meter Riparian Buffer Land Cover

Table 4.7: Thirty-Meter Riparian Buffer Land Use for Killbuck/Mud Creek Subwatershed

Subwatershed	**Location (in relation to sampling site)**	**Agriculture** m^2/m^2	**Woodland** m^2/m^2	**Impervious** m^2/m^2
KB	Above 3	0.52	0.08	0.07
KB	3 to 2	0.49	0.11	0.07
KB	Above 1	0.56	0.13	0.04
KB	Above 6	0.17	0.21	0.01
KB	6 to 5	0.56	0.12	0.03
KB	5 to 4	0.67	0.07	0.02
KB	Overall	0.56	0.18	0.12

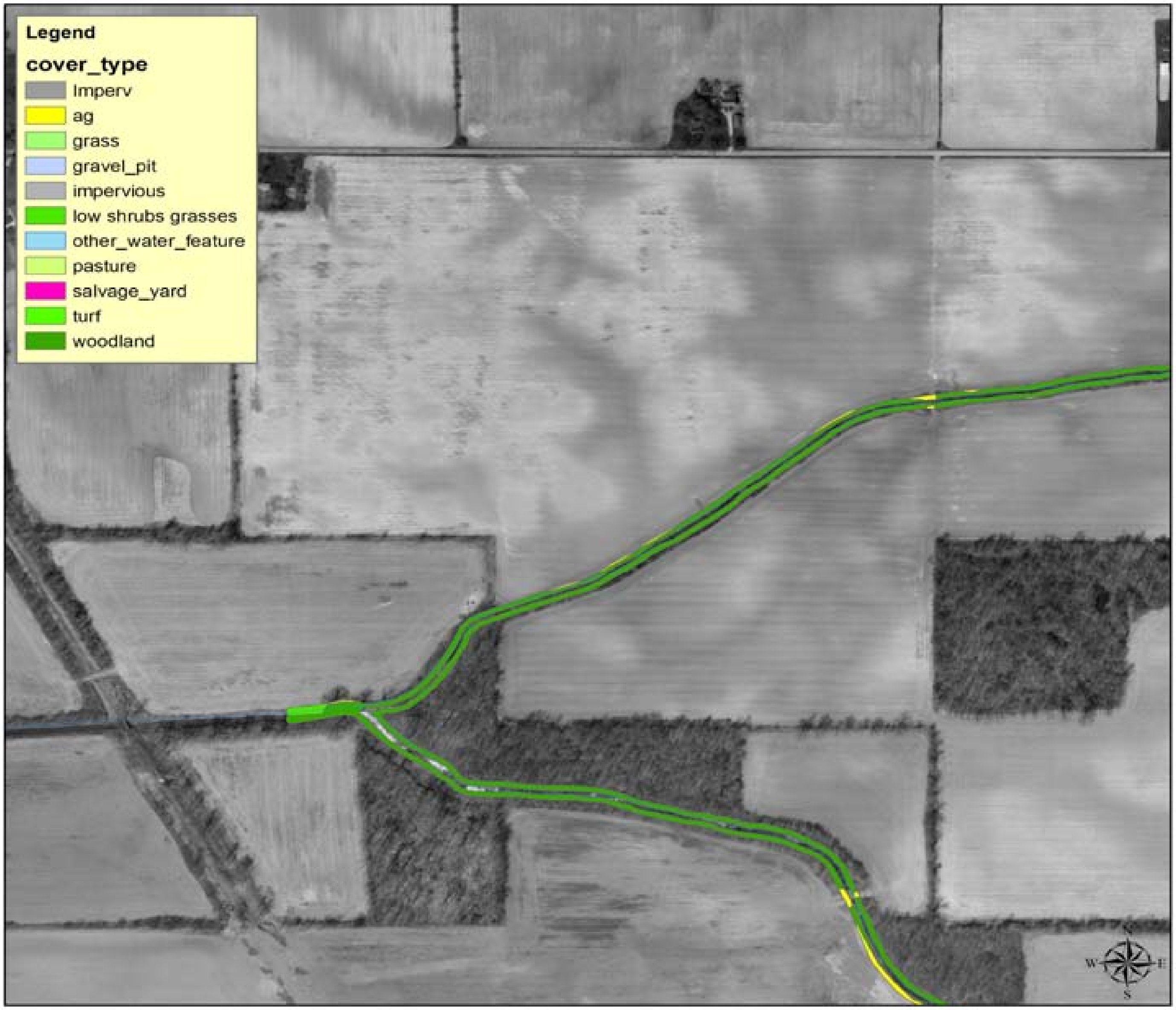


Figure 4.37: Example of Killbuck/Mud Creek Subwatershed Five-Meter Riparian Buffer Land Cover

Table 4.8: Five-Meter Riparian Buffer Land Cover for Killbuck/Mud Creek Subwatershed

Subwatershed	Location	Agriculture	Woodland	Impervious
		m^2/m^2	m^2/m^2	m^2/m^2
KB	Above 3	0.09	0.23	0.07
KB	3 to 2	0.07	0.27	0.05
KB	Above 1	0.07	0.30	0.03
KB	Above 6	0.08	0.26	0.04
KB	6 to 5	0.07	0.27	0.02
KB	5 to 4	0.07	0.18	0.01

In the Killbuck/Mud Creek Subwatershed, there are approximately 11 miles of primary stream channel and 10 miles of secondary waterways for a total of 21 miles. Land cover was calculated for the primary channels only.

Table 4.9: 30 and 5 Meter Riparian Corridor Land Cover

30 Meter Riparian Corridor Land Cover (387 acre area):

	Acreage	Percentage
Impervious	16.02	4.13
Agricultural	217.28	56.14
Grass Buffer	0	0
Low Shrubs and Grass	38.61	9.97
Other Water	0	0
Pasture	1.41	0.36
Turf	46.13	11.91
Woodland	69	17.83

5 Meter Riparian Corridor Land Cover (66.425 acre area):

	Acreage	Percentage
Impervious	2.442	3.68
Agricultural	6.155	9.26
Grass Buffer	0	0
Low Shrubs and Grass	24.931	37.53
Other Water	0	0
Pasture	0.006	.009
Turf	5.293	7.87
Woodland	27.598	41.54

Infra-Red Photography

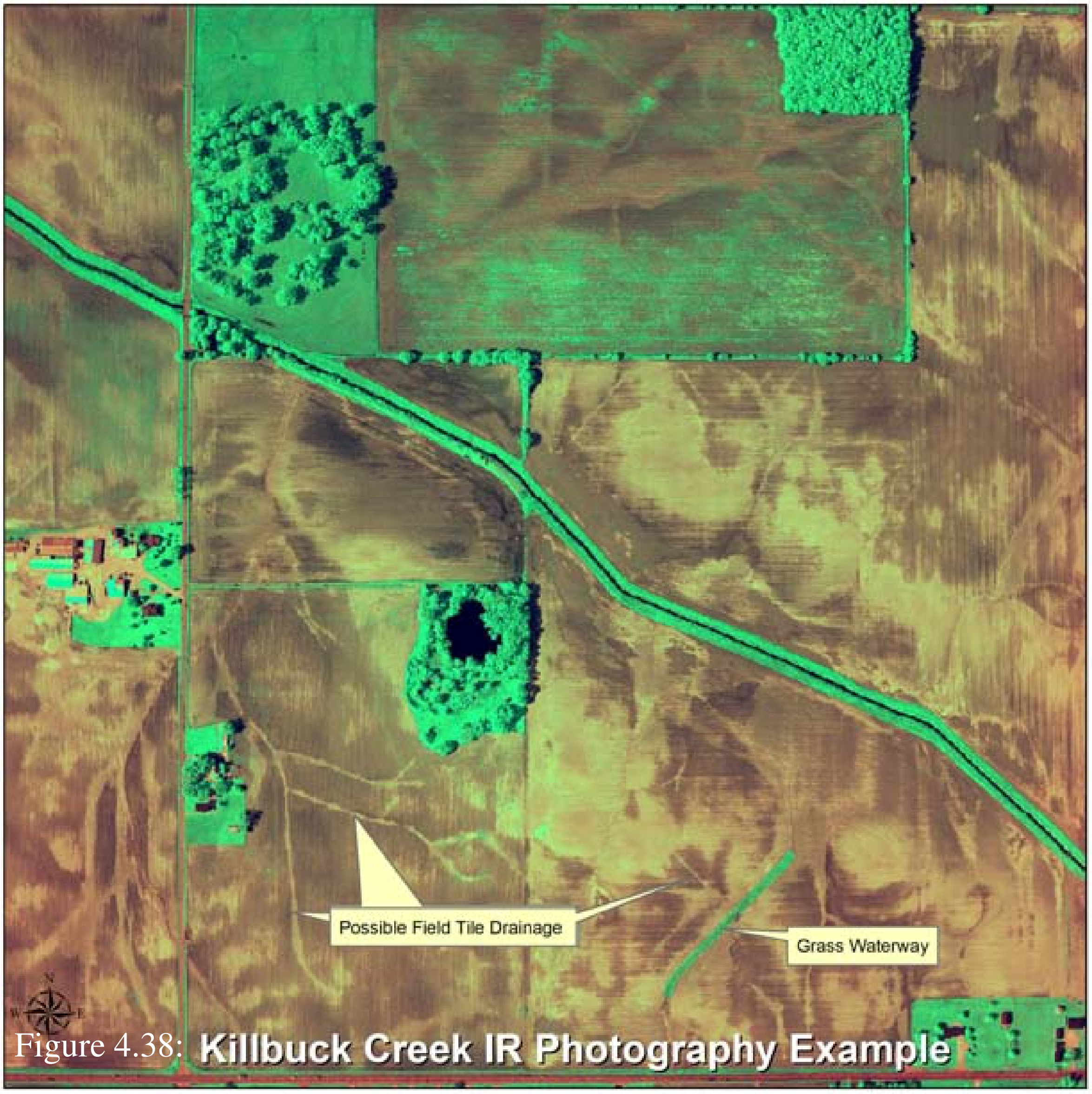


Figure 4.38: Killbuck Creek IR Photography Example

4.2.2.2 Buck Creek Subwatershed

Land Use

Of the16,090 acres (25.1 square miles) in the Buck Creek Watershed, land use consists of the following:

	Acres	Percentage
Agricultural	8528	53.0
Ag. Support	113	0.7
Commercial	692	4.3
Government & Institutional	56	0.35
Woodlands & Green space	2019	12.55
Industrial	417	2.59
Residential	2579	16.03
Salvage Yard	47	0.29
Transportation & Utility	1181	7.34
Vacant/No Use	8	0.05

The percent impervious surface in Buck Creek Subwatershed is 7.05.

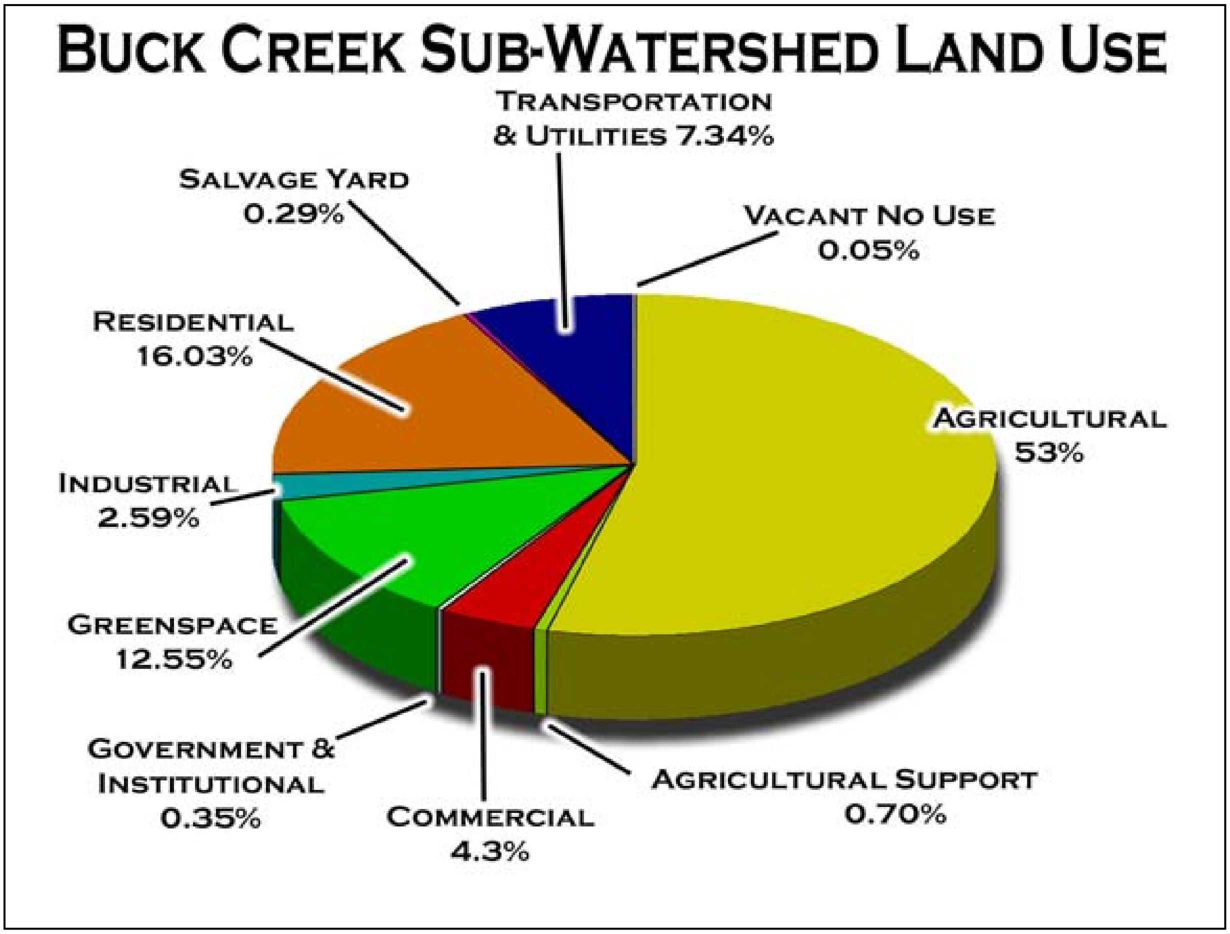


Figure 4.39: Buck Creek Subwatershed Land Use

Table 4.10: Buck Creek Land Use Percentages by Sub-Subwatershed

Land Use	BC-3	BC-4	BC-5	BC-6	BC-7
Agricultural	53.79	53.23	59.80	73.66	70.55
Agricultural Support	0.70	0.74	0.91	1.42	2.16
Commercial	4.30	4.49	3.95		
Govt institutional	0.35	0.37	0.26		
Greenspace	12.55	12.65	12.57	13.52	17.11
Industrial	2.59	2.79	0.70		
Residential	18.03	17.83	15.52	8.99	7.97
Salvage Yard	0.29	0.30	0.18		
Transportation & utilities	7.34	7.55	6.08	2.40	2.22
Vacant No Use	0.05	0.05	0.04		

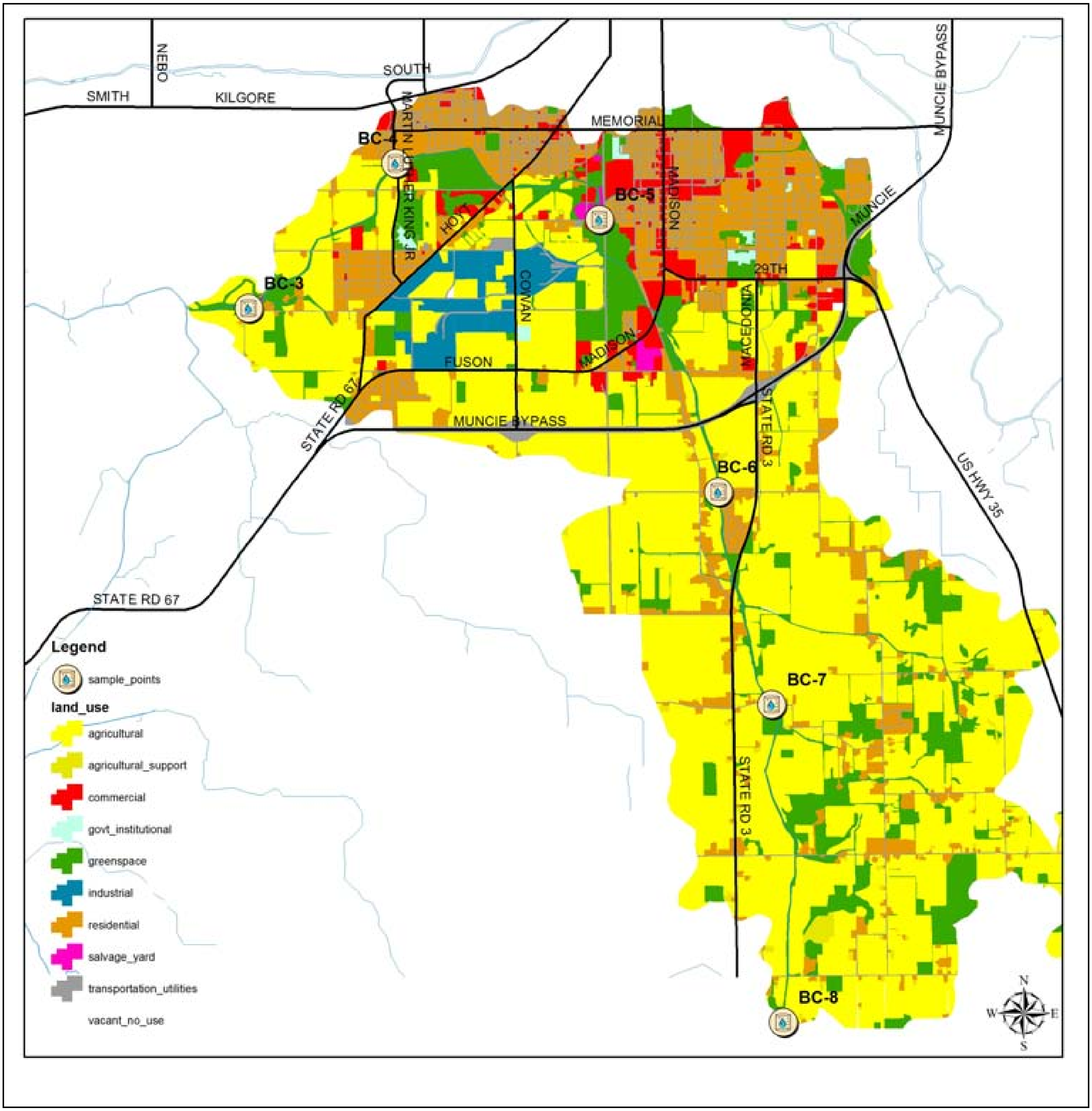


Figure 4.40: Buck Creek Subwatershed Land Use Map

Figure 4.41: Example of Buck Creek Subwatershed Thirty-Meter Riparian Buffer Land Cover

Table 4.11: Thirty-Meter Riparian Buffer Land Cover for Buck Creek Subwatershed

Subwatershed	Location	Agriculture	Woodland	Impervious
		m^2/m^2	m^2/m^2	m^2/m^2
BC	Above 7	0.54	0.41	0.01
BC	7 to 6	0.23	0.41	0.06
BC	6 to 5	0.20	0.36	0.07
BC	5 to 4	0.04	0.64	0.05
BC	4 to 3	0.26	0.50	0.02
BC	Overall	0.26	0.43	0.05

Figure 4.42: Example of Buck Creek Subwatershed Five-Meter Riparian Buffer Land Cover

Table 4.12: Five-Meter Riparian Buffer Land Cover for Buck Creek Subwatershed

Subwatershed	Location in relation to sample sites	Agriculture	Woodland	Impervious
		m^2/m^2	m^2/m^2	m^2/m^2
BC	Above 7	0.02	0.88	0.01
BC	7 to 6	<0.01	0.78	0.03
BC	6 to 5	<0.01	0.68	0.04
BC	5 to 4	0.00	0.96	0.02
BC	4 to 3	0.00	0.80	0.02

In the Buck Creek Subwatershed, there are 15 miles of primary stream channel and 7 miles of secondary waterways for a total of 22 miles. Land cover was calculated for the primary channels, with some areas included on the larger tributaries.

Table 4.13: 30 and 5 Meter Riparian Corridor Land Cover

30 Meter Riparian Corridor Land Cover (348.56 acre area):

	Acreage	Percentage
Impervious	14.66	4.20
Agricultural	87.52	25.11
Grass Buffer	5.20	1.49
Low Shrubs and Grass	36.18	10.38
Other Water	0.40	0.11
Pasture	0.87	0.24
Salvage Yard	3.38	0.97
Turf	36.25	10.40
Woodland	164.1	47.08

5 Meter Riparian Corridor Land Cover (61.21 acre area):

	Acreage	Percentage
Impervious	1.48	2.42
Agricultural	0.34	0.56
Grass Buffer	0.34	0.56
Gravel Pit	0.012	0.02
Low Shrubs and Grass	9.52	15.55
Other Water	0.004	0.007
Pasture	0	0
Salvage Yard	0.010	0.02
Turf	1.79	2.92
Woodland	47.71	77.94

Infra-Red Photography

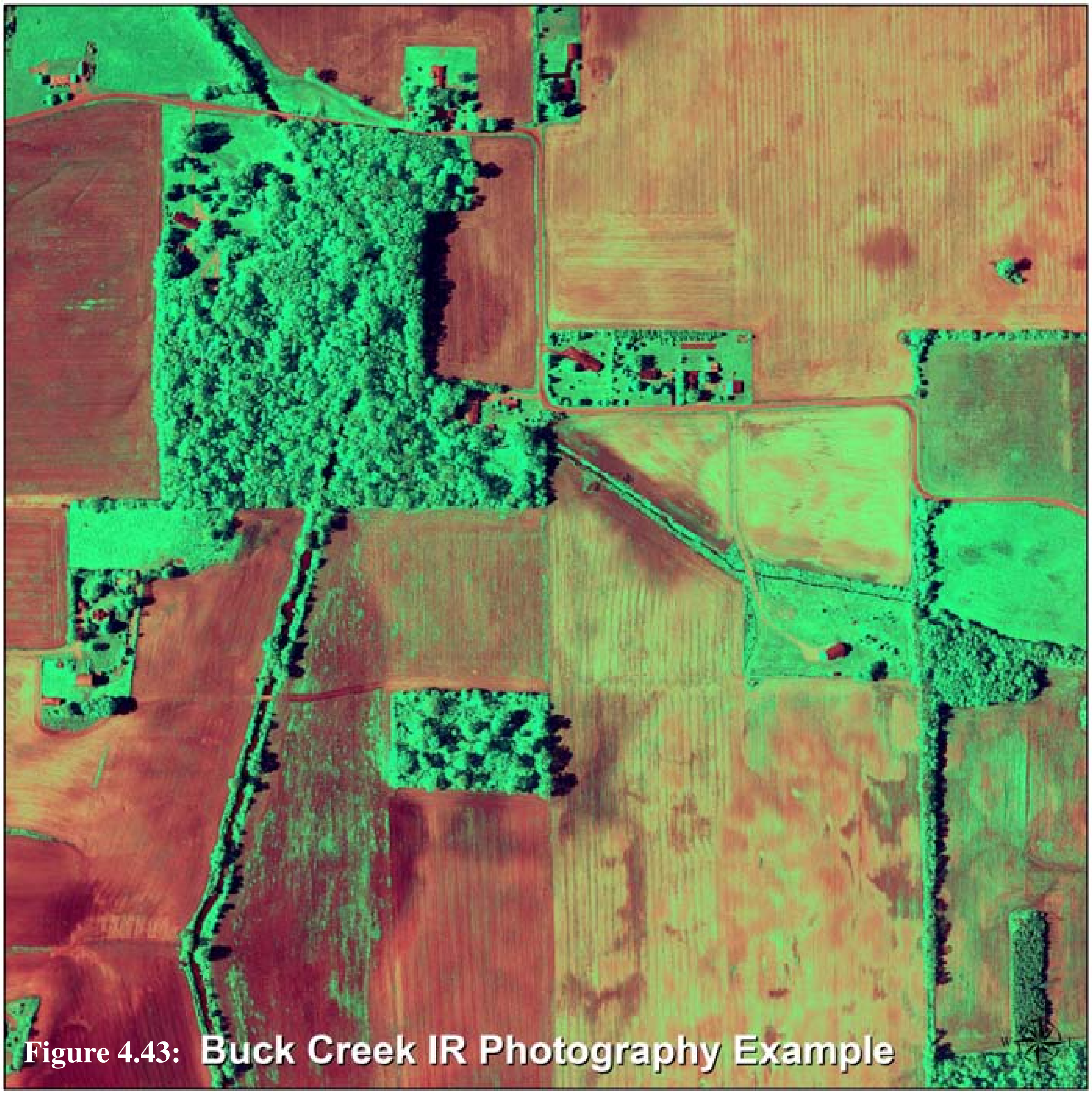


Figure 4.43: Buck Creek IR Photography Example

4.2.2.3 Prairie Creek Subwatershed

Land Use

Of the10,863 acres (17 square miles) in the Prairie Creek Subwatershed, land use consists of the following:

	Acres	Percentage
Agricultural	7838	72.15
Ag. Support	84	0.77
Commercial	0	0
Government & Institutional	0	0
Woodlands & Greenspace	1979	18.22
Industrial	0	0
Residential	689	6.34
Salvage Yard	0	0
Transportation & Utility	250	2.30
Vacant/No Use	0	0
Other	108	0.99

The percent of impervious surface in Prairie Creek Subwatershed is 1.15.

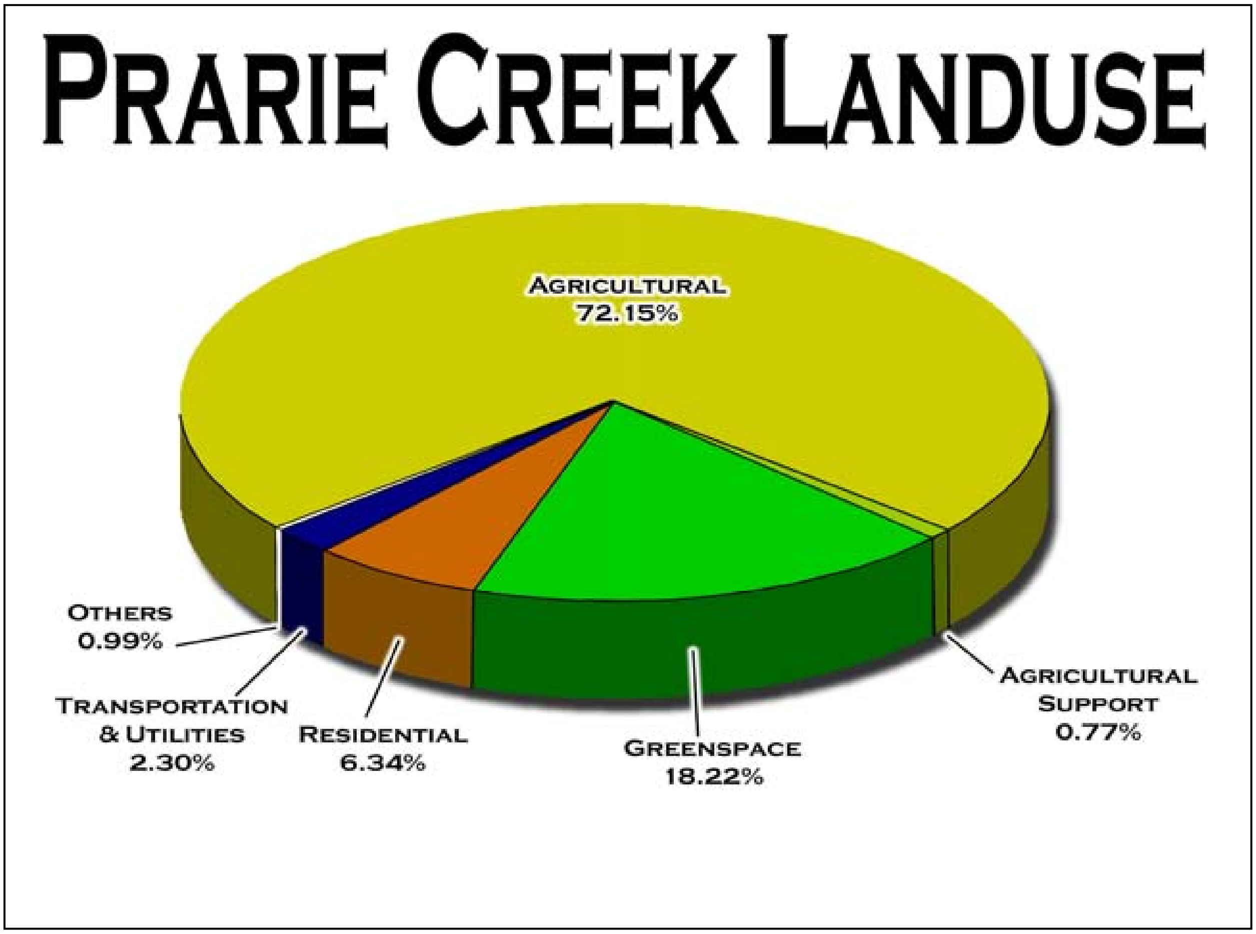


Figure 4.44: Prairie Creek Subwatershed Land Use

Table 4.14: Prairie Creek Subwatershed Land Use Percentages by Sub-Subwatershed

Land Use	PC-6	PC-7	PC-8	PC Reservoir
Agricultural	64.05	84.60	89.78	72.15
Agricultural Support	1.70	0.93	0.78	0.77
Commercial		0.02		0.09
Govt institutional		0.17		0.08
Greenspace	22.40	7.79	5.36	18.22
Industrial				
Residential	9.00	4.30	2.14	6.34
Salvage Yard		0.07		0.01
Transportation & utilities	2.86	1.89	1.95	2.30
Vacant No Use		0.23		0.04

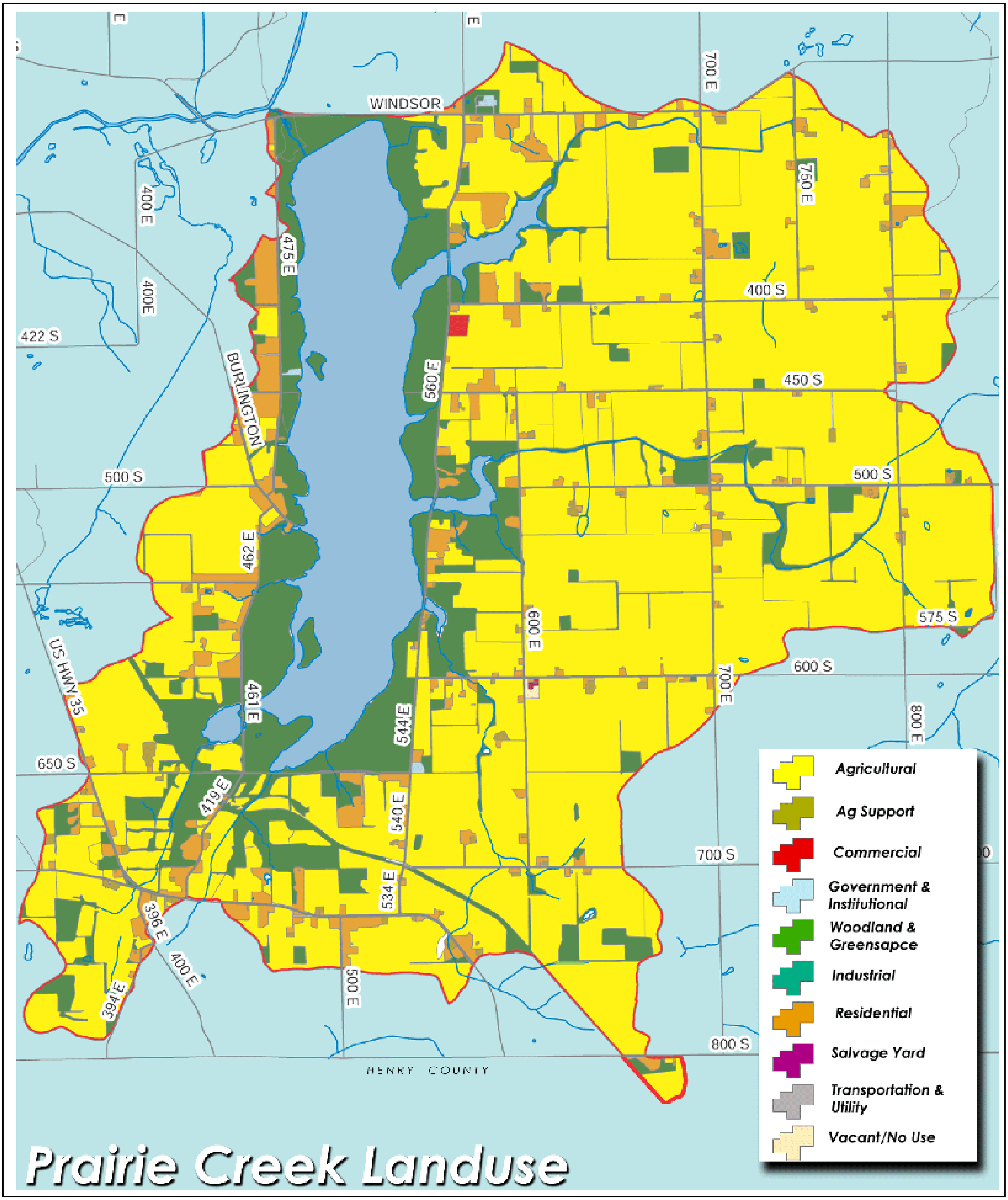


Figure 4.45: Prairie Creek Subwatershed Land Use Map

Land Cover

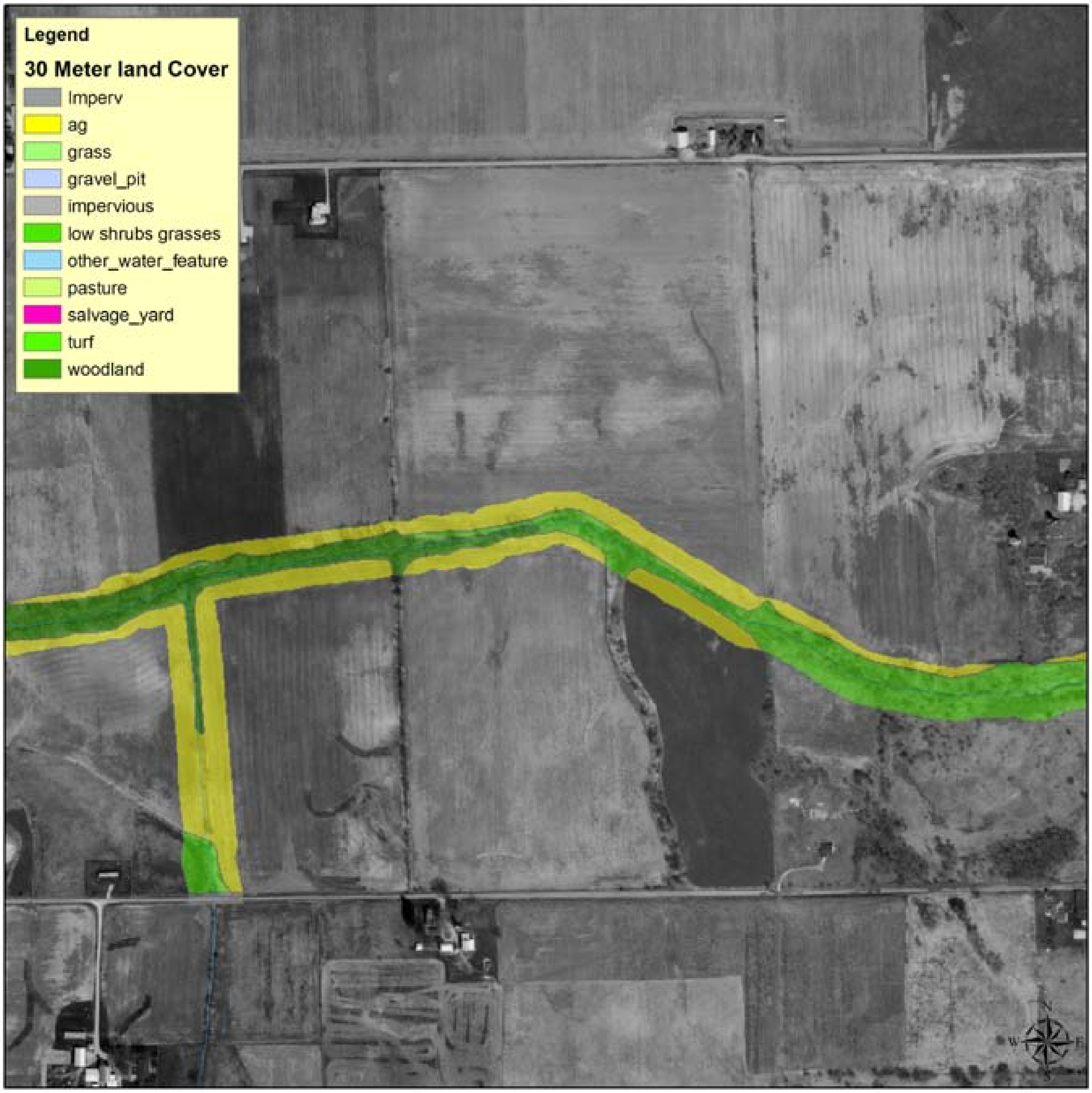


Figure 4.46: Example of Prairie Creek Subwatershed Thirty-Meter Riparian Buffer Land Cover

Table 4.15: Thirty-Meter Riparian Buffer Land Cover for Prairie Creek Subwatershed

Watershed	Sample Site Location	Agriculture	Woodland	Impervious
		m^2/m^2	m^2/m^2	m^2/m^2
PC	6	0.17	0.67	0.03
PC	7	0.45	0.33	0.02
PC	8	0.36	0.07	0.01
PC	Overall	0.20	0.71	0.01

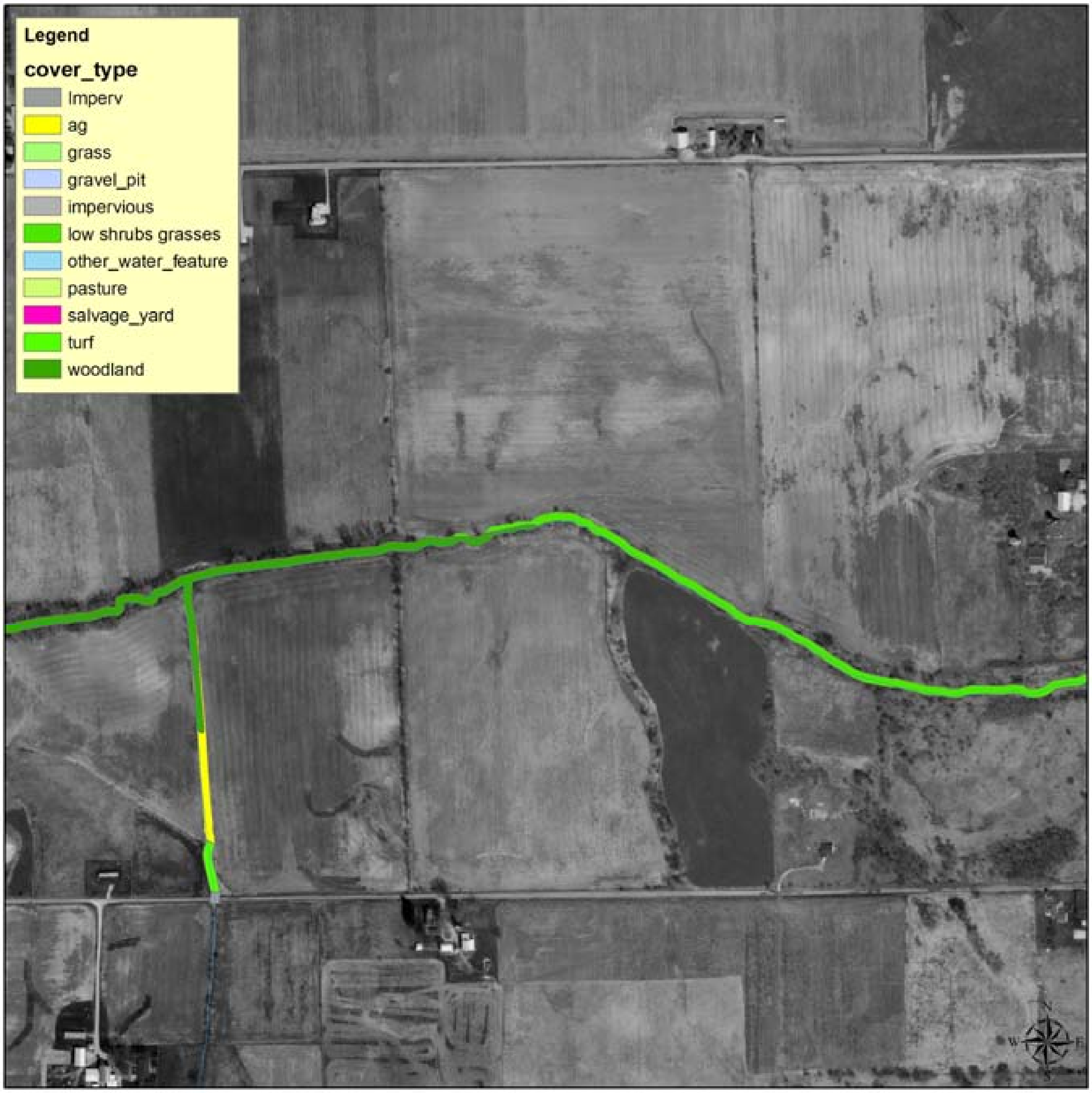


Figure 4.47: Example of Prairie Creek Subwatershed Five-Meter Riparian Buffer Land Cover

Table 4.16: Five-Meter Riparian Buffer Land Cover for Prairie Creek Subwatershed

Subwatershed	Sample Site Location	Agriculture	Woodland	Impervious
		m^2/m^2	m^2/m^2	m^2/m^2
PC	6	0.15	0.64	0.03
PC	7	0.06	0.65	0.01
PC	8	<0.01	0.15	0.01

In the Prairie Creek Subwatershed, there are 7 miles of primary stream channel and 3 miles of secondary waterways for a total of 20 miles. Land cover was calculated for the primary channels only.

Table 4.17: 30 and 5 Meter Riparian Corridor Land Cover

30 Meter Riparian Corridor Land Cover (112.64 acre area):

	Acreage	Percentage
Impervious	2.31	2.05
Agricultural	40.99	36.39
Grass Buffer	0	0
Low Shrubs and Grass	40.37	35.84
Other Water	0.23	.20
Pasture	2.24	1.99
Turf	1.71	1.52
Woodland	24.79	22.01

5 Meter Riparian Corridor Land Cover (19.02 acre area):

	Acreage	Percentage
Impervious	0.31	1.63
Agricultural	0.87	4.57
Grass Buffer	0	0
Low Shrubs and Grass	10.41	54.73
Other Water	0	0
Pasture	0.37	1.95
Turf	0.29	1.52
Woodland	6.77	35.59

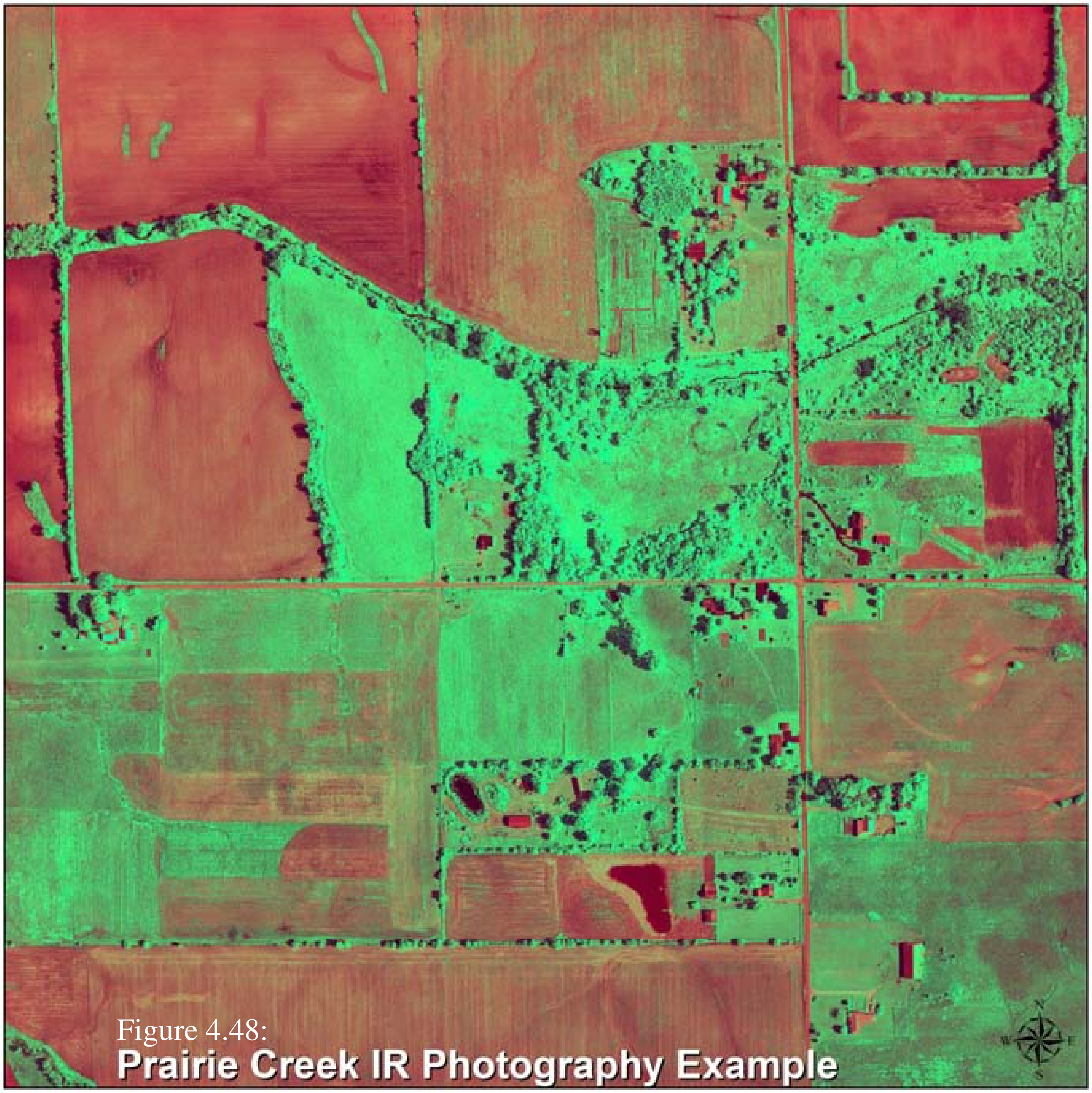


Figure 4.48:
Prairie Creek IR Photography Example

CHAPTER 5

ANALYSIS OF BASELINE STUDY RESULTS AND HISTORIC INFORMATION

Results of the monitoring and land use/land cover studies were reviewed and analyzed using several methods to gain the broadest understanding of conditions in each of the three subwatersheds. The reader will first encounter a discussion of the monitoring program results, giving context to the data and initial suggestions for improvements. Next is a section describing the various methods of analysis used. Following this are the results of the analyses, combining the land use and land cover results with those of the monitoring program. These analyses give further guidance as to what actions should be taken to prevent and reduce non-point pollution, and where to concentrate those efforts. An overview of the historic conditions is then added to complete the analysis.

5.1 Discussion of Monitoring Program Results

5.1.1 Chemical, Physical and Bacteriological Analysis (by Parameter)

5.1.1.1 Stream Temperature

In seven samplings over 2002 and 2003, the maximum allowable stream temperature has not been exceeded at any site. Generally, Buck Creek had lower stream temperature in July and September than other subwatersheds. This lower temperature is likely because of a greater amount of groundwater contribution (springs) to stream flow and tree canopy cover.

The potential coldwater status of Buck Creek opens the possibility of introducing trout species. A sustainable trout population would not only provide a fishery resource that is otherwise unavailable in Delaware County, but most importantly, it would create an opportunity to provide greater protection for Buck Creek under the Indiana Administrative Code which requires streams capable of supporting the natural reproduction of trout to be maintained as such. There are no salmonid species native to the White River Watershed, therefore, and the possibility of Buck Creek successfully supporting introduced trout species would require further research. Current data suggests that the dissolved oxygen and temperature requirements of rainbow trout and brown trout would be marginally consistent with the conditions found within Buck Creek (Wehrly et al. 1999). However, given the historical difficulties with establishing persistent salmonid populations, a thorough investigation would need to be conducted by a fisheries biologist with experience specifically related to the physical habitat requirements of salmonids before stocking could be recommended.

Regardless of whether or not trout are eventually stocked, an effort should be made to maintain or decrease stream temperatures in Buck Creek. The natural structure and function of the fish communities within this cold/cool water stream are unique within Delaware County and they are likely dependent on protection of the narrow riparian corridor that remains throughout most of the length of the stream. Additional protection could be provided by increasing the width of the riparian corridor along Buck Creek and its tributaries and by limiting construction of additional impervious ground cover.

5.1.1.2 Water pH

All samples from both years have been between pH 6 and 9, which are the limits specified in IAC 327 2-1-6. Values tended to be lower in the May 2003, July 2003, September 2003, and October 2003 samplings than for July 2002 and October 2002 dates. Buck Creek had increasing water pH going downstream in the second half of 2002, but decreasing pH downstream during May 2003, July 2003, and September 2003. Killbuck Creek had lower overall values than the other subwatersheds for May 2003, July 2003, and September 2003.

5.1.1.3 Dissolved Oxygen

Levels of dissolved oxygen (DO) were lower than the 5.0 mg/L daily average IAC requirements for eleven instances (7%) in the Killbuck Creek and Prairie Creek subwatersheds. The instances include KB-1 in July 2002 and September 2003, KB-2 in July 2003 and September 2003. KB-4 in September 2003, KB-5 in July 2003 and September 2003, KB-6 in July 2003, and PC-6 in July 2003. PC-4 and PC-5 also had low levels of DO in September 2003. Note: there are no legal standards for water quality in privately owned reservoirs at this time in the state of Indiana.

Levels of DO were below the 4.0 mg/L at any time IAC requirement in three instances (2%). The instances are KB-6, PC-2 (WR-4), and PC-6 in September 2003.

BC-1 (WR-1), BC-2 (WR-2), BC-3, BC-5, BC-6, BC-7, BC-8, PC-3, PC-7, and PC-8 reported DO values that were consistent with the IAC regulation for cold water fish habitat of not less than 6.0 mg/L at any one time. Over all, sampling times twenty three instances (15%) were less than the standard of cold water fish habitat. Generally, the DO values were lower in July and September 2003.

Areas of concern include BC-4, the Mud Creek tributary to Killbuck, and PC-6. Best management practices in agricultural areas include erosion control, filter strips, and manure management. Favorable practices for urban areas include erosion control on developing areas, constructed wetlands for storm water treatment, and septic system repair and maintenance. Septic system elimination, by replacement with sanitary sewer, is also a practice that would increase DO levels. Reduction of flow from combined sewer overflow is another strategy for increasing DO (along with decreasing total suspended solids, *E. coli*, and other contaminants), but that will not be addressed in this report because it is beyond the scope of the project, which is primarily concerned with non-point pollution. Because shading lowers stream temperature, protection of riparian tree cover is appropriate for both urban and agricultural areas.

5.1.1.4 Biological Oxygen Demand

More than half of the water samples tested had Biological Oxygen Demand (BOD) values lower than the Method Detection Limit of 2.0 mg/L and only a few samples had BOD values that would be of concern (higher than 3.3 mg/L, Hoosier River Watch) In Buck Creek BOD levels tended to increase going downstream, but are mostly low. Killbuck had a more random pattern of BOD values, with high readings in the high flow events in May 2003. The Prairie Creek Subwatershed had generally low values, but registered high readings for the White River sites during flooding in October 2003 and moderately high readings in the reservoir in July 2003.

BOD is a measure of the oxygen used by microorganisms to decompose this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline. Nitrates and phosphates in a body of water can contribute to high BOD levels. Nitrates and phosphates are plant nutrients and can cause plant life and algae to grow quickly. When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria. This results in a high BOD level. The temperature of the water can also contribute to high BOD levels. When BOD levels are high, dissolved oxygen levels decrease because the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive.

5.1.1.5 Total Suspended Solids

Thirty-one of the one hundred and fifty-four samples (20%) had total suspended solids (TSS) exceeding the guideline of 80 mg/L (Waters, 1995). All but two of the samples exceeding the guideline were from the May 2003 period. Killbuck Creek, which has more silt and sediment in the channel, had the eleven highest values (ranging from 160 to 800 mg/L). Most of the TSS in May would be soil particles transported by water erosion. TSS results in July samples were elevated as a result of algal growth. Soil particles can carry nutrients such as ammonium and phosphorus as well as pesticides.

Sites of concern are Buck Creek sampling points 3 through 7 and Killbuck 1, 2, and 5 (others also exceeded guideline). In both of these streams, there was a general tendency for TSS to increase going downstream. No Prairie Creek sites exceeded the guideline. Agricultural Best Management Practices (BMPs) would include erosion control (terraces, grass waterways, etc.), conservation tillage, and filter strips. Urban BMPs would include erosion control on construction sites and constructed wetlands for stormwater retention. Streambank restoration of degraded sites would be appropriate in both rural and urban areas.

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 organic and metals tend to bind to particles.

5.1.1.6 Ammonia Nitrogen

The maximum permissible ammonia nitrogen level allowed under Indiana Administrative Code varies with pH and water temperature. For example, a sample with a pH of 7.5 and temperature of 15 ℃ should not exceed a concentration level of 0.1054 mg/L of unionized NH_3-N. One hundred fourteen of the one hundred fifty-four samples (74%) had values exceeding the standard with the highest levels observed in Killbuck Creek. As temperature decreases the allowable concentration of NH_3 also decreases (down to 0.0746 mg/L at 10 ℃). Several additional samples (from each subwatershed) had values above the standard at the lower temperatures. Only one sample was below the detection limit of 0.040 mg/L for Ammonia-N.

A note of caution with regard to this finding is that the method used also detects NH_4 because the samples are elevated to a high pH prior to analysis. The measurement of NH_3 in situ would be very difficult, so the laboratory method is used. However, many of the samples tested would have lower NH_3 concentrations than what the results reported indicate.

Areas of concern (ranked within subwatershed) include BC-4, 7 and 3; KB-2, 4, and 5; and PC-3,5, 4, 8, and 7. Note that PC-3 is below and PC-4 and 5 are in the reservoir and would be influenced by other drainage areas as well as the three tributaries that we are monitoring (Prairie Creek, Cunningham, and Huffman). Agricultural best management practices for reducing N loading are erosion control, conservation tillage, filter strips, and incorporation of manure. Favorable practices for urban areas include erosion control on developing areas, constructed wetlands for storm water treatment, and septic system repair, maintenance or elimination. About three-fourths of the ammonia produced in the United States is used in fertilizer either as the compound itself or as ammonium salts such as sulfate and nitrate. 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. Fish and other aquatic organisms also contribute to ammonia levels in streams. NH_3 is toxic to aquatic organisms at relatively low concentrations.

5.1.1.7 Nitrate + Nitrite Nitrogen

Only one sample (KB-6, May 2003) had a nitrate + nitrite level exceeding the IAC drinking water standard of 10 mg NO_3-N/ L. However, sixty four samples (42%) contained NO_3 above the 1.6 mg/L guideline for modified warm water habitat (Ohio EPA, 1999). All three subwatersheds evidenced nitrates above the 1.6 mg/L guideline, but Killbuck Creek tended to have the highest levels in the May sampling. Despite potential dilution, nitrate levels were generally higher during high flows in May than during low flows observed in the second half of 2002. However, values reported from the high flow event in September 2003 were all below the 1.6 mg/L guideline. The September 2003 lower results were due to the fact that sampling occurred three days after the beginning of the high flow event, and therefore the pollutants which ran off of the landscape and into the waterways were already flushed downstream. Whereas, the May 2003 high flow sampling event took place during the first flush of the high flow event, and therefore sampling captured the complete picture of what pollutants ran off of the surrounding subwatershed. The White River watershed sites (WR-1, WR-2, WR-3, and WR-4) and four of the six sites in the Buck Creek subwatershed exceeded the guideline in July 2003. In October of 2003, the White River sites, PC-6, PC-7, PC-8 and five out of the six Buck Creek sites exceeded the guideline, but none of the Killbuck sites were above the modified warm water habitat guideline.

Areas of concern are all of the Buck Creek sites, especially BC-7; KB-6, 4, and 5; and PC-7, 8, and 6. Best management practices in agricultural areas include nutrient and manure management, constructed wetlands, and retrofitting of tile drains to manage flow. Favorable practices for urban areas include nutrient management of turf grass areas, constructed wetlands for storm water treatment, and septic system repair, maintenance or elimination.

Nitrogen is one of the most abundant elements and composes about 80 percent of the air. 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 acts as nutrients in streams, rivers and reservoirs. The major routes of entry for nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes, runoff from fertilized agricultural fields and lawns and discharges from car exhausts. Bacteria in water quickly convert nitrites [NO_2] to nitrates [NO_3] and the process can deplete the oxygen supply. The major impact of nitrites/nitrates on fresh water bodies is eutrophication. Nitrates stimulate the growth of algae and other plankton which provide food for higher organisms, such as invertebrates and fish; however an excess of nitrogen can cause overproduction of plankton and as they die and decompose they use up the oxygen which causes other oxygen-dependent organisms to die.

Note: In most natural systems, nitrite is rapidly converted to nitrate. Nitrite tends to be more toxic to organisms than nitrate.

5.1.1.8 Orthophosphate -Phosphorus

Orthophosphate as P was found to be greater than or equal to the guideline for water quality of 0.1 mg/L (Pierzynski *et al*., 2000) in fifty five samples (36%) with two of the four highest values associated with the White River (WR-2 in July 2002 and October 2002, due to treatment plant discharge). During the high flow sampling events, May and September 2003, all sites exceeded the guideline because P tends to be attached to soil particles.

Killbuck Creek subwatershed had the most frequent occurrence of exceedance of this guideline. There were particularly high P levels in May 2003, with KB-3 and KB-2 having highest readings. However, no Killbuck sites exceeded the guideline in October of 2003. Buck Creek had many readings above the guideline in the high flow periods of May and Sept. 2003 with BC-3, 4, and 5 showing high levels. The Huffman Creek (PC-7) tributary in the Prairie Creek subwatershed had the highest P values followed by PC-8 and 6.

Areas of concern are all Buck Creek sites; Killbuck Creek (KB-3, 2, and 1); and PC-7, 8, and 6. Best management practices in agricultural areas include conservation tillage, erosion control, filter strips, nutrient and manure management. Favorable practices for urban areas include erosion control on construction sites, nutrient management of turfgrass areas, and septic system repair, maintenance or elimination.

There is not a specific state standard for phosphorus, but levels as low as 0.005 mg/L have been found to cause eutrophication (Correll, 1998). Similar to nitrate + nitrite, phosphates negatively impact water quality by causing accelerated rates of eutrophication. Phosphates naturally found in water are derived from decomposing organic material and leaching of phosphorus-rich bedrock. Sources of elevated readings could come from fertilizer runoff, human and animal waste from failing septic systems, sewage treatment plants, livestock confinement areas, mass quantities of decomposing organic matter, industrial effluent, and detergent wastewater.

5.1.1.9 *E. coli*

The *E. coli* standard (235 colony forming units per 100mL for a single sample: 327 IAC 2-1-6) was frequently exceeded. One hundred and thirty-eight of the one hundred and fifty-four samples (90%) contained *E. coli* above the standard with the top four sites being in urban areas (BC-2, BC-3, BC-4, and BC-5) that were sampled during the high flow period (May 5, 2003).

However, the top four sites, in decreasing order, during the high flow period of September 2003 were KB-6, KB-2, KB-1, and BC-4. Nine out of the fifteen samples that were less than the standard were located in Prairie Creek subwatershed, but six of the reservoir samples were also above the limit. Buck Creek tended to have the highest *E. coli* numbers, followed by Killbuck Creek in 2002 and May 2003 sampling events. In July and September of 2003, Killbuck Creek tended to have the highest E. coli numbers followed by Buck Creek. However, the White River watershed sites PC-2 (WR-4) and PC-1 (WR-3) had the highest E. coli numbers in October of 2003. Also, the Killbuck subwatershed reported the highest numbers followed by the Prairie Creek subwatershed and Buck Creek subwatershed in October of 2003.

Areas of concern are BC-3, 4, 5, and 8; KB-6, 2, and 1; and PC-7, 6, and 8. Best management practices in agricultural areas include filter strips, manure management, and fencing for exclusion of livestock from streams. Appropriate practices for urban areas include septic system repair /maintenance or elimination, proper handling of pet wastes, and constructed wetlands for pretreatment of combined sewer overflow.

5.1.1.10 Atrazine

Atrazine concentrations of four out of five samples taken in May of 2003 exceeded the drinking water and aquatic life standards for the pesticide. Only PC-3 had an Atrazine concentration below the standard and that may reflect biological decomposition or sedimentation of the chemical in the reservoir, which is immediately upstream of that sampling point. The Atrazine concentrations taken in November of 2002 and October 2003 were below the standard. Readers should be aware that concentrations in source water are normally higher than those in the drinking water supply distributed by Indiana American Water Company. This is because the company uses activated charcoal to filter out pesticides and other harmful chemicals before pumping water into the distribution system. BMPs include Integrated Pest Management, low application rates, incorporation of herbicides, filter strips, alternative products, mechanical cultivation, and organic production.

5.1.1.11 Diazinon

Diazinon concentrations taken were reported by Environmental Chemical Consulting Service Inc.(Madison, WI) in October of 2003 and reported to be below the method detection limit of 0.0084 ug/L. Samples analyzed in the NREM Department had a high concentration of 70 ng/L, which is less than the aquatic life standard and the drinking water guideline of 100 ng/L (0.1 ug/L).

5.1.2 Biological and Stream Habitat Analysis (by Subwatershed)

5.1.2.1 Killbuck Creek Subwatershed

Poor habitat quality results in low biological index scores for Killbuck and Mud Creek. QHEI scores were less than 40 for each site indicating very little habitat diversity. Under these conditions, healthy biological integrity is unattainable. Contributing sources to habitat impairment include stream channelization and degraded riparian zones. The extensive silt/muck substrates and the absence of lithophilic species suggest that sedimentation is a primary cause of impairment. Dense algal mats were found at each site indicating high nutrient loads from fertilizers, high sunlight intensity from canopy removal, and low flow velocities due to naturally low gradients, inappropriate channel modifications, or a combination of the two.

5.1.2.2 Buck Creek Subwatershed

The Buck Creek Subwatershed is defined by good habitat quality and underachieving biological communities. The headwaters of Buck Creek possess good habitat quality and biological integrity. The groundwater discharge from springs near the headwaters of Buck Creek has a strong influence on the fish community, depressing IBI scores at BC-8 and BC-7. This is a limitation of the IBI and not an indication of poor fish communities. Both the habitat and biological communities in these areas seem to be of fair quality.

Buck Creek at C.R. 400 S. (BC-6) shows an unusual dip in both habitat quality and biological integrity. The stream has been impounded near the bridge crossing, essentially creating a dammed area within the sample reach. The impact on the habitat and biota is evident in the scores, but the extent of impact is probably limited to a relatively small area in the stream. Removal of the dam would likely be sufficient to restore much of the habitat and biological quality at this United States Geological Survey (USGS) gaging station site. Buck Creek at 23rd St. (BC-5) scored consistently high for all indices. BC-5 is located at the upstream border of the influence of the city of Muncie. Buck Creek at Tillotson Ave. (BC-4) and C.R. 325 W. (BC-3) have the largest disparity between habitat quality and biological index scores.

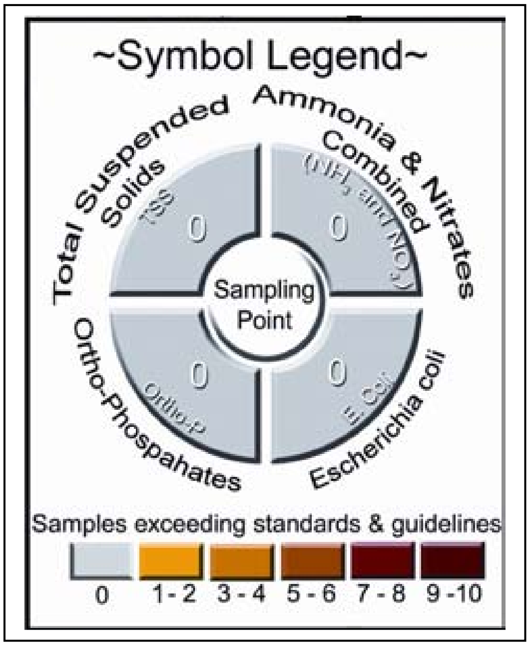
While habitat quality is good at these sites, the macroinvertebrate communities have declined substantially. Fish communities do show a slight improvement, but this is due to increasing water temperatures as the influence of the springs become less significant. IBI scores are still lower than expected given the good habitat quality. These results suggest that BC-4 and BC-5 may be under the influence of chemical stressors. Possible influences include the combined sewer overflows (CSOs) located upstream from these sites or watershed runoff influences such as the highly urbanized nature of this subwatershed.

5.1.2.3 Prairie Creek Subwatershed

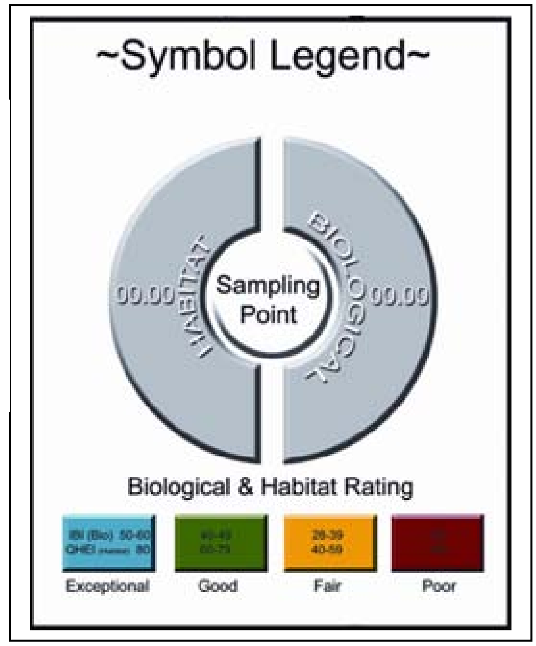
Prairie Creek (PC-6) had unusually low in-stream habitat quality and biological integrity scores given the fair condition of the floodplain. Due to the fact that there is almost no detectable flow, Prairie Creek appears to function more as an arm of the reservoir than as a lotic (flowing) water body. The biological communities found within PC-6 are typical of lake habitats which would support this assumption and make our biological criteria inappropriate for making water quality determinations. As there are no biological criteria for lentic (lake-type environment), only a generalized assumption about biological integrity can be made.

Huffman Creek (PC-7) had relatively high habitat scores considering its size. Typically streams of this size have been highly modified (like those in the Killbuck/Mud Creek Subwatershed) and have correspondingly low biological integrity scores. PC-7, however, has good habitat quality and fair biological index scores. The habitat scores of Cunningham Ditch (PC-8) were poor due to channelization, riparian removal, and livestock access. Like PC-6, the habitat and fish communities of PC-8 were also more typical of a lentic (lake-type environment) during the August 2002 sample. However, due to the lowering of the reservoir, the flow velocity of Cunningham Ditch visibly increased by the September sample. Habitat scores and biological index scores increased as the stream assumed the characteristics more typical of lotic (flowing) waters.

5.1.3 Monitoring Program Visual Summary (by Subwatershed)
The following four maps were used to summarize the plethora of data that was delivered by the monitoring program. These maps were instrumental in assisting the Technical Committee in explaining and gathering input from other members of the public.



Figures 5.1: Symbol Legend for Monitoring Program Results Summary Maps



The above numeric values were derived by quantifying the number of times (from all sampling sessions) a result for a given parameter (chemical or biological) exceeded state standards or scientific guidelines used in the original analysis.

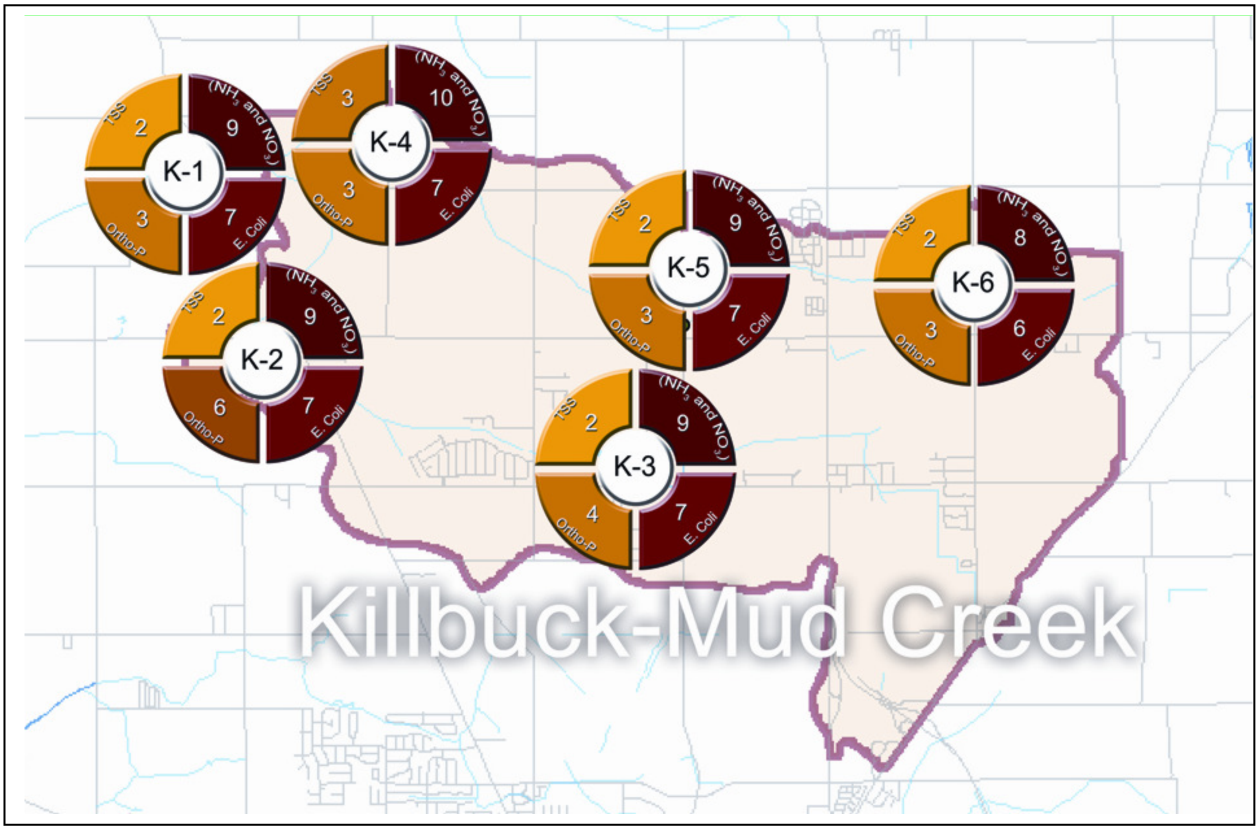


Figure 5.2: Killbuck/Mud Creek Subwatershed Chemical and *E. coli* Results Summary

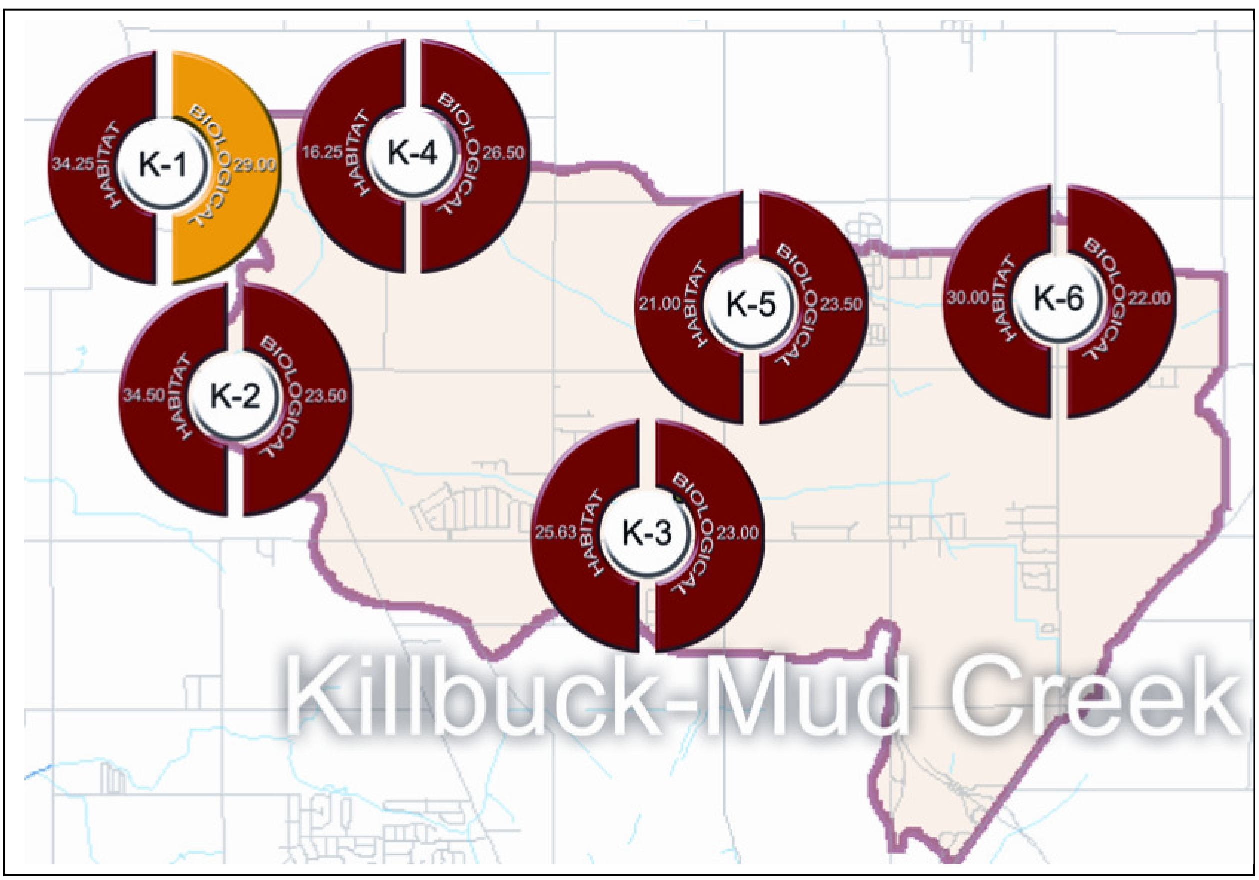


Figure 5.3: Killbuck/Mud Creek Subwatershed Biological and Stream Habitat Results Summary

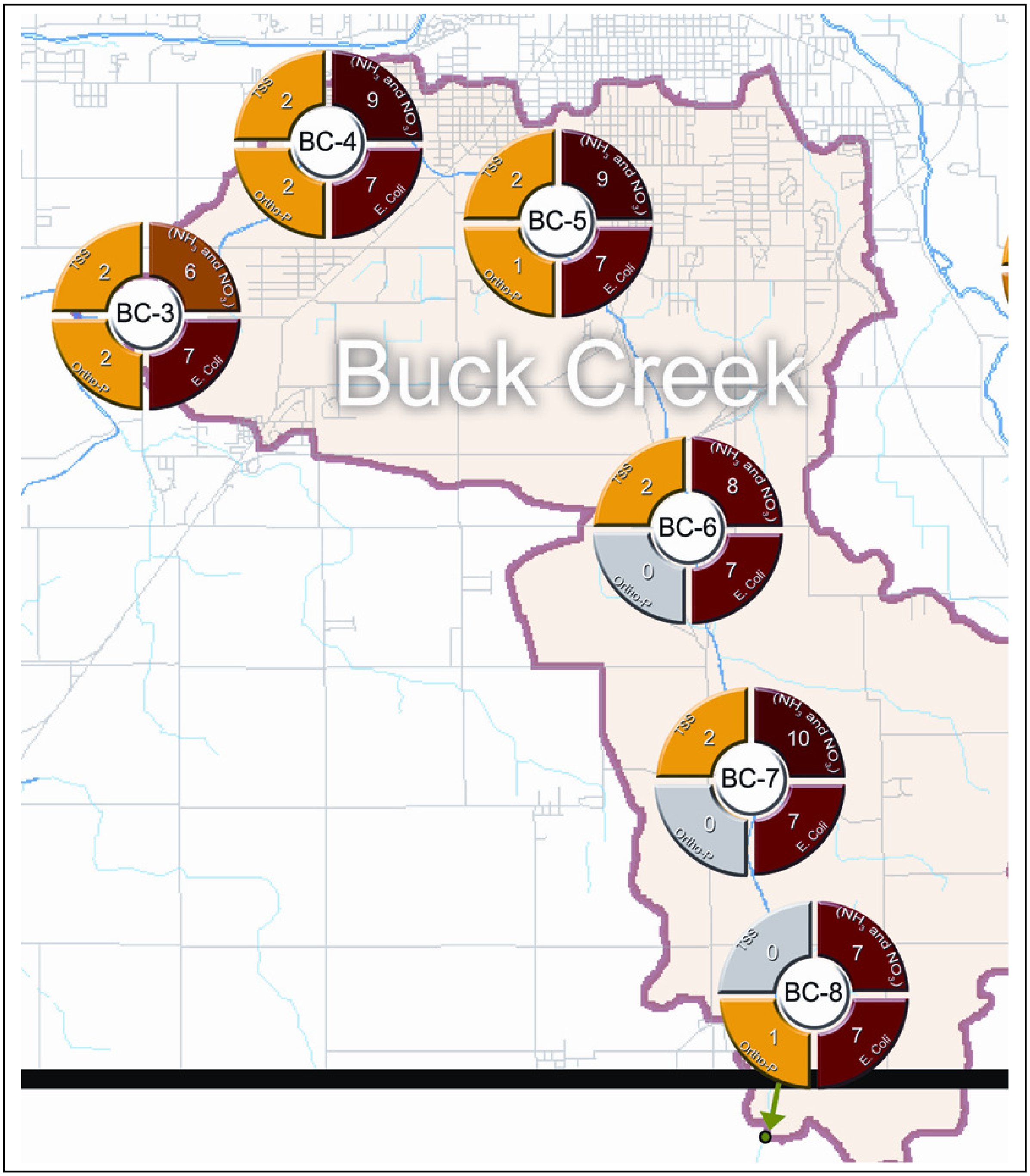


Figure 5.4: Buck Creek Subwatershed Chemical and *E. coli* Results Summary

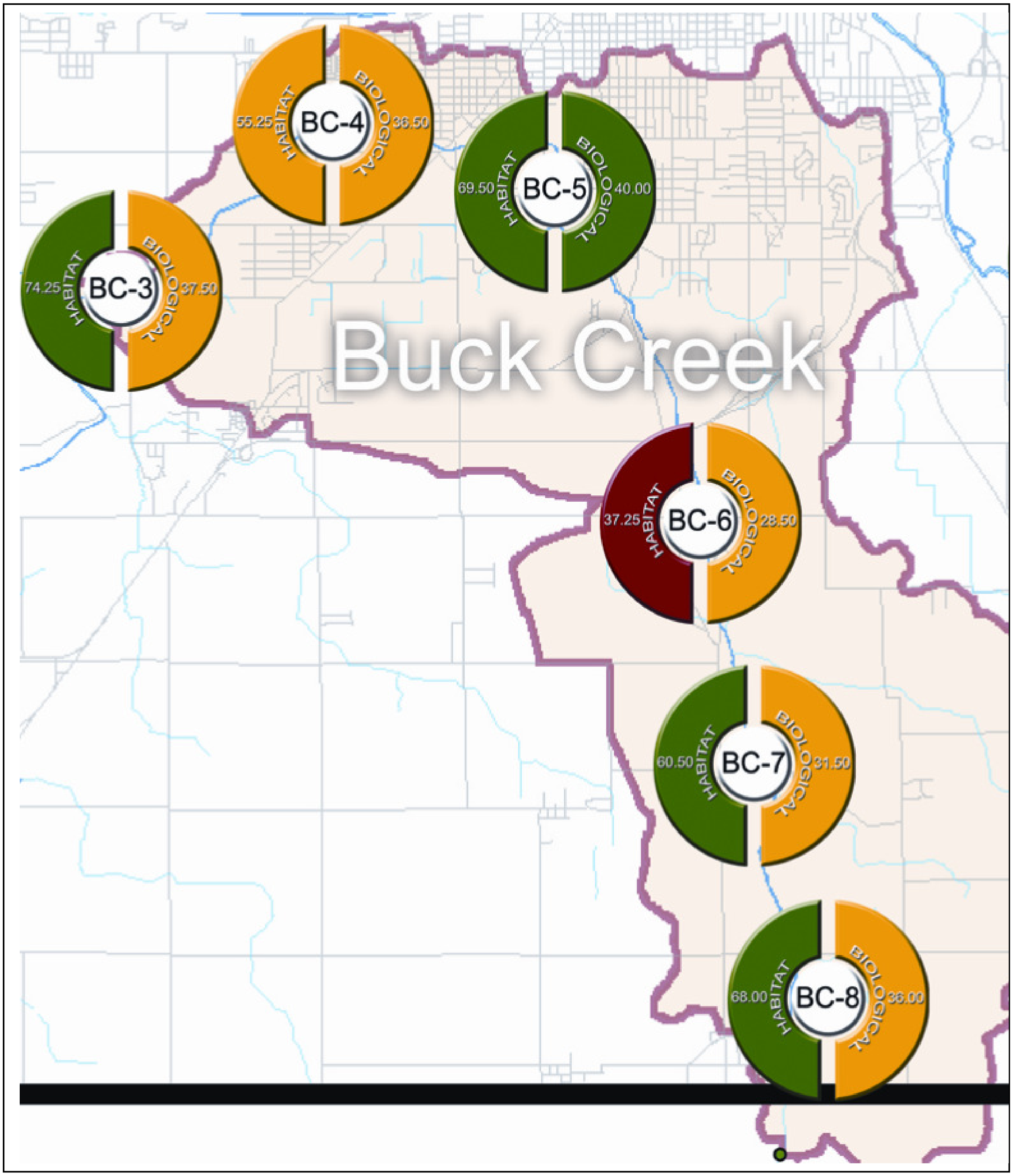


Figure 5.5: Buck Creek Subwatershed Biological and Stream Habitat Results Summary

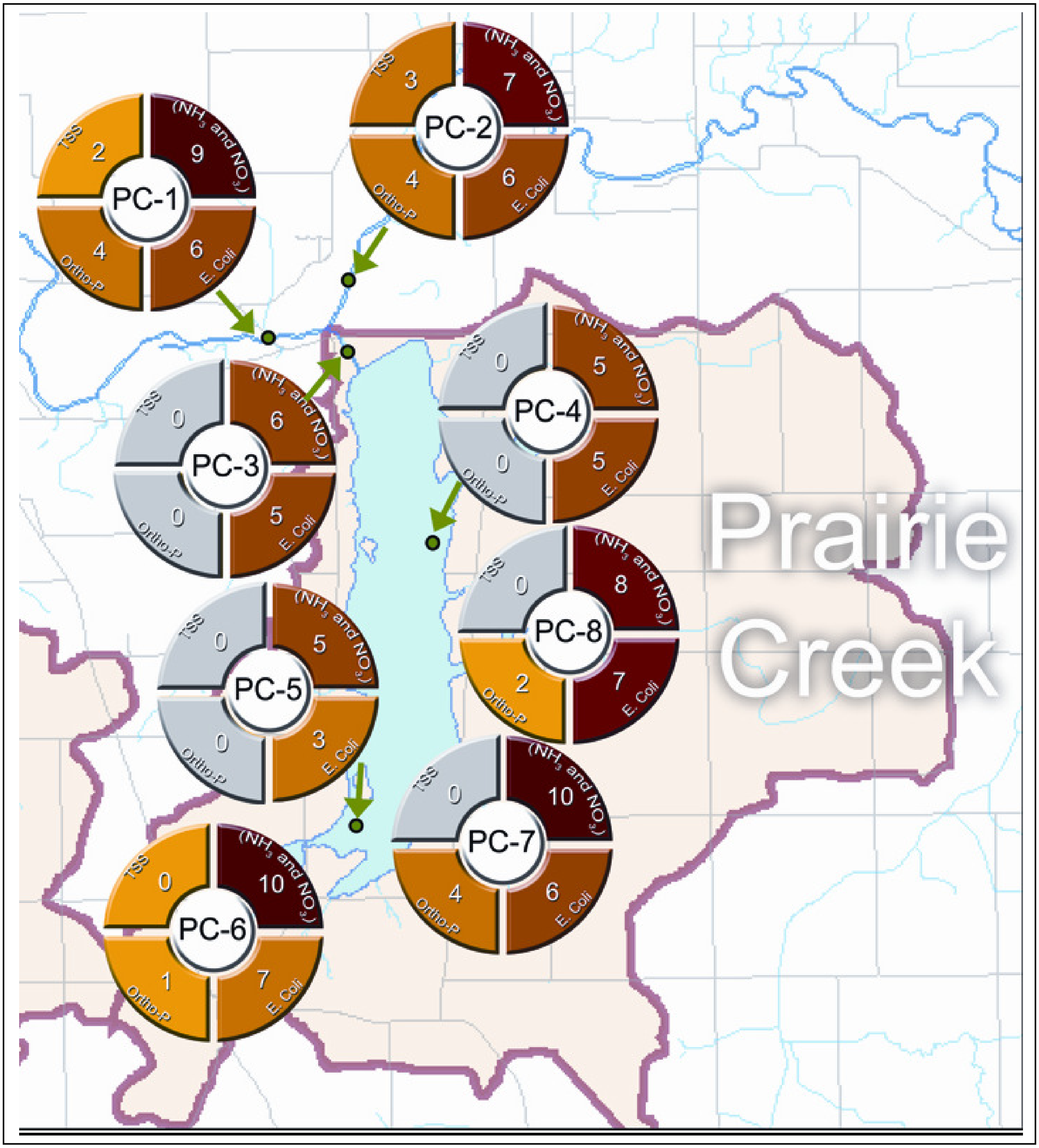


Figure 5.6: Prairie Creek Subwatershed Chemical and *E. coli* Results Summary

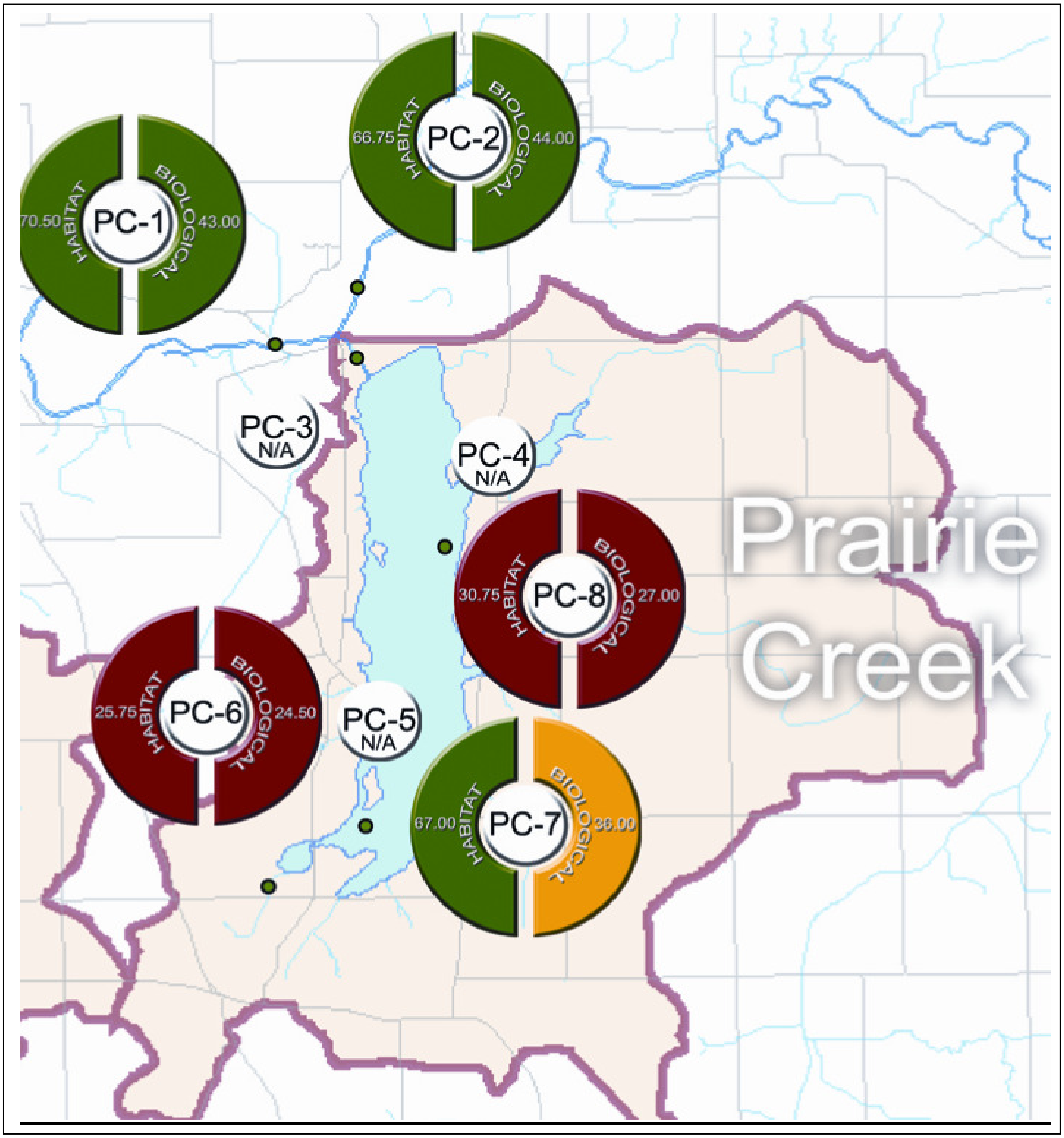


Figure 5.7: Prairie Creek Subwatershed Biological and Stream Habitat Results Summary

5.1.4 Sub-Subwatershed Rankings (by Subwatershed)

Table 5.1: Killbuck Creek Subwatershed Average Rank for Chemical and Biological Parameters Over All Sampling Dates

Subwatershed	Site	TSS Rank	NH_3 Rank	NO_3 Rank	Ortho-P Rank	*E. coli* Rank	QHEI Rank	IBI Rank	Overall Ranking
KB	2	2	1	6	1	3	5	3	3
KB	5	3	2	3	5	4	2	3	3.14
KB	6	5	4	1	6	1	4	1	3.14
KB	4	4	3	2	4	5	1	4	3.29
KB	1	1	5	4	3	2	6	5	3.71
KB	3	6	6	5	2	6	3	2	4.29

Note: Low rankings indicate most impaired sites

Table 5.2: Buck Creek Subwatershed Average Rank for Chemical and Biological Parameters Over All Sampling Dates

Subwatershed	Site	TSS Rank	NH_3 Rank	NO_3 Rank	Ortho-P Rank	*E. coli* Rank	QHEI Rank	IBI Rank	Overall Ranking
BC	4	2	1	4	1	1	2	4	2.14
BC	6	4	5	2	4	6	1	1	3.29
BC	7	5	2	1	5	5	3	2	3.29
BC	3	1	3	5	2	2	6	5	3.43
BC	5	3	4	3	3	3	5	6	3.86
BC	8	6	6	6	6	4	4	3	5.00

Note: Low rankings indicate most impaired sites

Table 5.3: Prairie Creek Subwatershed Average Rank for Chemical and Biological Parameters Over All Sampling Dates

Subwatershed	Site	TSS Rank	NH_3 Rank	NO_3 Rank	Ortho-P Rank	*E. coli* Rank	Overall Ranking
PC	7	3	5	2	1	1	2.40
PC	6	3	4	4	3	2	3.20
PC	8	3	6	3	2	3	3.40
PC	3	5	1	5	4	4	3.80
PC	5	4	2	6	6	5	4.60
PC	4	6	3	5	5	6	5.00

Note: Low rankings indicate most impaired sites

5.2 Statistical and Computer Analysis Methodology

5.2.1 Subwatershed Ranking System Analysis

To analyze problem locations within the subwatersheds, a ranking system was employed for assessing areas that could benefit from implementation of Best Management Practices. The chemical parameters used were TSS, NH_3, NO_3, P, and *E. coli*. Biological parameters including Qualitative Habitat Evaluation Index (QHEI) and the Index of Biological Integrity (IBI) were also incorporated into the ranking system; Invertebrate Community Index (ICI) was intentionally excluded on account of missing data. This list contains the variables that were most commonly above legal limits or guidelines. For each chemical parameter, measured concentrations for each sampling event at each location were ranked with the highest level assigned a rank of one. Ranks for a given location were then averaged (across date) for each parameter. The five rankings for each site were then averaged (across parameters) and the locations re-ranked based on the overall average (of date and parameter).

5.2.2 GIS and Regression Analysis

Regression analysis was used to determine significant relationships between parameters. Regression analysis evaluates the strength and nature of linear association between independent and dependent variables. Scatterplots were used to graphically display the association between the variables used in the regression analysis. The regression equation obtained from this analysis can be used to predict values for one variable based on values for an associated variable if a significant relationship exists. The first column in the following regression statistics tables indicate the independent variable and the second column indicates the dependent variables used in the analysis. The Probability>F (p-value) column indicates the statistical association that exists between the two variables. An association is considered to be significant if $p<0.05$, highly significant if $p<0.01$ and very highly significant if $p<0.001$. The R^2 column shows the "goodness of fit", or how close the individual points are to the trend line. The slope of the trendline is given by the "Slope" column. The sign (positive or negative) indicates whether there is a proportional or inversely proportional association between the variables. The final column, "Intercept", reveals where the trendline crosses the y-axis.

The biological index scores (IBI and QHEI) were averaged across date and regressed against the spatial land use and hydrologic soil groups parameters obtained from the GIS attribute table summarizations. The spatial land use of 5 meter, 30 meter, and sub-subwatershed areas were summarized by the ratio of area/total area at each sampling location. The soil hydrologic soils for each sub-subwatershed were also summarized by area/total area for each hydrological soil group. The hydrologic soil groups A and B areas were grouped together into a low runoff soils category. The hydrologic soil groups C and D areas were also grouped together into a high runoff soils category. The regression analysis between hydrologic soil groups and the biological parameters were not separated by subwatershed and were grouped together. The averaged biological index scores were also regressed against the chemical parameters data values. The chemical parameters were not averaged across date in this analysis and were not separated out by subwatershed. In addition, the chemical parameters concentration data values were also not averaged for the regression analysis between chemical parameter values. Only the estimates of stream discharge (Q) at BC-6 and the chemical parameters were used in regression analysis because of the accuracy the predicted values of Q on days that the sampling occurred and no Q data was collected.

5.3 Statistical and Computer Analysis Results

5.3.1 Subwatershed Ranking System Analysis

The differences in rankings are primarily based on land use patterns in the subwatersheds. Killbuck/Mud Creek has the highest percentage of agricultural land (73.4%), but that is nearly equivalent to Prairie Creek at 72.2%. Buck Creek has the lowest agricultural use at 53%. Thus, agricultural land use is not necessarily a good predictor of water quality.

A more consistent explanation for the ranking of subwatersheds comes from an evaluation of greenspace. The percentage of greenspace is as follows: 7.0% for Killbuck Creek 12.6% for Buck Creek, and 18.2% for Prairie Creek. A similar pattern holds for the 30 meter (almost 100 feet) buffer that border the streams in each subwatershed. Those values are 17.7% for Killbuck Creek 43.3% for Buck Creek, and 71% for Prairie Creek. Thus the ranking of subwatersheds based on high nutrient, sediment, and bacterial concentrations appears to be associated with the extent of woodlands, especially those near the stream. Forested riparian areas help reduce the transport of sediment and nutrients into the stream by creating a natural filter to overland flows and reducing stream bank erosion.

Land use for the main stem portions of the White River watershed has not been analyzed at this point. That analysis is complicated by the fact that a substantial portion of the watershed is located in Randolph County and we do not have the same information on land use for that area. Readers should also be aware that information on PC-3, 4 and 5 is not directly comparable to other sites because those locations are in Prairie Creek Reservoir.

5.3.2 GIS and Regression Analysis

(For detailed graphs and tables of regression analysis, see Appendix F.)
The Qualitative Habitat Evaluation Index (QHEI) and Index of Biological Integrity (IBI) scores were significantly correlated with the five-meter and thirty-meter woodland riparian buffer area. These correlations indicate that increasing wooded areas along the stream banks increases the QHEI and IBI scores. The five-meter riparian woodland buffer was more significant than the thirty meter riparian woodland buffer suggesting that wooded area adjacent to the stream are more critical to the fish communities than woodland further away from the streams. The QHEI and IBI were inversely correlated with the five-meter agricultural buffer, meaning that score decreased (became less favorable) with increasing agricultural land use in the narrow area next to the stream. The associations in the results section above demonstrate the importance of land use adjacent to the stream. The associations were found to be more significant in the five meter buffers. The thirty meter buffers and sub-subwatersheds associations were also found to be significant. However, these associations were less significant than the five-meter buffer. Having greenspace (woodlands and non-agricultural areas) close to the stream helps reduce soil erosion and nutrient loading. This doesn’t mean that there is no relationship between watershed quality and land use, it just indicates that the strongest relationship is between biological indicators and the woodlands that border streams.

The relationship between the NRCS hydrologic soil groups and the biological parameters indicated significant negative linear associations. The high runoff soils (hydrologic soil groups C and D) were found to have a negative influence on the IBI and QHEI index scores. In other words, as the amount of area of these soils increased the IBI and QHEI scores tended to decrease. This would suggest that as high soil runoff potential increases the probability of more sediment, nutrients, and contaminants would enter into the streams and thus have negative impacts on fish communities.

Several significant relationships were found between the chemical parameters and the biological parameters. It was found that as TSS, NH_3, and orthophosphate results increased the IBI and QHEI scores tended to decrease. This would suggest that these chemical parameters have a negative linear relationship with these biological parameters. Also, as the DO results increased the IBI and QHEI scores tended to increase, which would indicate a positive linear association. These results suggest that the amount of sediment and sediment that has contaminants bound to its matrix negatively affect fish communities at our sampling points. Also, as the concentration of DO increases it positively affects our fish communities. The results also indicated several significant relationships between chemical parameters. For example, as TSS data values increased so did NH_3, NO_3, Orthophosphate, and *E. coli* concentrations. Some of these relationships can offer suggestions why they occur but others are more complex and beyond the sampling design of this project. However, as sediment transport and/or erosion process are increased by anthropogenic activities we have found that more contaminants can be deposited in our streams. Ammonia as N (NH_3) and orthophosphate can become attached to sediments and readily deposited into local and eventually regional and national water bodies. Nitrate + Nitrite (NO_3) tends to leach through the soil profile and contaminate underground water supplies or aquifers.

5.4 Recap of Historic Conditions

Summarizing the historic conditions described in Chapter 3, the following are known to be issues related to non-point source pollution in the Upper White River Watershed:

- Herbicides, notably Atrazine
  Source: corn and soybean agriculture; high presence of drainage tiles
  Seasonal: late May, early June

- Pesticides
  Source: agricultural uses and urban lawn care
  tied to high presence of drainage tiles
  Note: pesticide pollution rates highest in the nation;
  mainly a surface water problem

- Nutrients
  - General Sources: urban (impervious surface runoff, municipal sewage treatment, CSOs); agricultural uses; high presence of drainage tiles
    - Ammonia
      - Seasonal: higher in summer and fall
      - Note: levels decrease with increased stream flow; levels higher downstream from Muncie
    - Phosphorus
      - Seasonal: higher in winter
      - Note: levels higher downstream from Muncie
    - Nitrates
      - Source: agricultural use; high presence of drainage tiles
      - Note: problem for both surface and ground water;
        levels higher than other areas around the country;
        levels below drinking water standards

- *E. coli*
  - Sources: urban (CSOs, municipal wastewater treatment plants); residential (septic systems); agricultural (livestock, specifically cattle in streams)
  - Seasonal: CSOs = rainfall events;
    septic systems, livestock and wastewater = continual
  - Note: impairment for all 14-digit subwatersheds (except for Prairie Creek) in the Upper White River Watershed, within Delaware County

- Impaired Biotic Communities
  - Note: impairment in Buck Creek and Killbuck/Mud Creek Subwatersheds

- PCBs and Mercury
  - Note: impairment for West Fork of White River

CHAPTER 6

IDENTIFYING WATER QUALITY PROBLEMS AND SETTING GOALS

6.1 Confirm/Refute Initial Community Concerns

6.1.1 Original Community Concerns

The original impetus of the White River Watershed Project was the community's concerns about local water quality issues relating to public health (drinking water and fish consumption advisories), natural habitat loss (wildlife diversity and aesthetics), and impacts to recreation (fishing, boating, swimming).

Looking at both the historic subwatershed conditions as well as the results of the baseline study, the following can be said about these original concerns:

- Public Health:

  There is a fish consumption advisory for the White River and Buck Creek in Delaware County. The contaminants causing the listing are mercury and PCBs. PCBs are a historic contaminant found in the sediment of these waterways, while mercury comes from air deposition from such places as coal burning power plants (of which Delaware County has one, located at Ball State University).

  The majority of the citizens of Delaware County acquire their drinking water from the municipal water system. This water, which comes from the White River (and Prairie Creek Reservoir when needed), is treated by the Indiana-American Water Company. Therefore, local drinking water sources do not have contaminant levels over legal standards. However, several non-point source pollution contaminants (Atrazine, ammonia, nitrate, orthophosphate, *E. coli*) have been identified in the Prairie Creek Reservoir and its tributaries. Being a drinking water reservoir, it would be prudent for the community to work to eliminate such pollutants and protect the integrity of this public drinking water source.

  E. coli levels found throughout all three subwatersheds are indicative of the presence of not only that particular bacteria, but of other pollutants coming from warm blooded animal fecal matter (humans included) that can be a risk to human health.

- Loss of Natural Habitat:

  Since 1973, actions taken by the Muncie Sanitary District and the Bureau of Water Quality have vastly improved fish and macroinvertebrate populations due to their work to clean up and prevent point source water pollution. Personal interviews have recounted that other wildlife species have returned to the river in that time, as well. However, Buck Creek and Killbuck/Mud Creek are listed as having impaired biotic communities with IDEM. The results of the WRWP baseline study shows that fish and macroinvertebrate populations are lacking to a varying degree in all three of the subwatersheds. Killbuck/Mud Creek Subwatershed results were indicative of low water quality. Buck Creek Subwatershed results were indicative of higher water quality, the best overall of the three subwatersheds. The listing of Buck Creek Subwatershed in the 303(d) list for impaired biotic communities may be a reflection of IDEM's use of warm water sampling parameters, when Buck Creek may be a cool or cold water stream (as discussed earlier in this report).

Further improvements are sure to be made when actions are taken by the community to clean up and prevent non-point source water pollution.

Aesthetics is a subjective term that will differ from person to person. However, there are both positive and negative things that can be said with regards to the way our waterways appear in all three of the subwatersheds. Prairie Creek Subwatershed has most of its reservoir surrounded by trees or grass which is appealing on many different fronts, most importantly as a zone of protection against non-point source pollution runoff. Buck Creek Subwatershed also has a relatively high amount of trees and grass buffers along its stream corridor that works as a protection zone, as well as protecting the fragile temperature range that may allow Buck Creek to one day become a cold water stream. Killbuck/Mud Creek Subwatershed has the greatest amount of acres in grass filter strips of all three subwatersheds. Further work can be done in all three subwatersheds to decrease non-point source water pollution levels, which affect the level of aesthetics of any waterbody.

- Impacts to Recreation

  There is no doubt that if a community feels its waterways are not "clean", their level of recreational participation in and around those areas will be diminished. The White River has, indeed, seen an unbelievable improvement over the last 30 years. Some in the community are not aware of this fact. Even with this improvement, historic and current data have found non-point source pollution problems in Delaware County, including all three of the studied subwatersheds, *E. coli* contamination being the most prevalent. *E. coli* also happens to be one contaminant that can potentially have the most direct and immediate negative affect to human health, and therefore, fear of it can keep people out of the water. Efforts to reduce this contaminant, and several others that have been found to be problematic, are suggested later in this document.

  Another area of impact to recreation is the previously stated fish consumption advisory. There is much to be done with understanding how communities can remove persistent PCB levels in stream sediment. Air deposition from mercury can be reduced by encouraging sources that emit this contaminant to take actions to prevent such deposition.

6.1.2 Subwatershed Community Concerns

As described in Chapter 1, upon selection of the three subwatersheds, citizens from each were brought together to identify their local water quality concerns. Below are the concerns listed by subwatershed:

6.1.2.1 Killbuck/Mud Creek Subwatershed

Septic Systems – Water sampling results and interviews with individuals and the Delaware County Health Department indicate septic system contamination in this subwatershed. Most of the homes in the subwatershed will be connected to the local sewer project by the end of 2004, however, some residences will not be included. Actions to encourage those residents to fix their systems are included in the subsequent goal statements listed in Chapter 7.

Drainage – The request to identify all underground drainage tiles was done with limited success. Further analysis of the infra-red photography turned over to the DCSWCD in 2004 shall be conducted during the next phase of the WRWP. There was evidence of water pollution being transferred through drainage tiles from agricultural sources in this subwatershed.

Agricultural Conservation – Land use/land cover analysis and personal interviews have identified filter strips along both Killbuck and Mud Creeks. Total suspended solid levels were high in this subwatershed, which has an agricultural land use base of over 70% and over 50% of the 30 meter riparian corridor in agricultural crops.

Chemical Usage on Genetically Engineered Agriculture Crops **–** There was no work done to identify which agricultural fields were in genetically engineered crops. There was evidence of Atrazine water contamination in the subwatershed, regardless of crop origin.

Illegal Dumping – In response to the committee's request to educate local citizen on hazardous material disposal, the WRWP worked with the Hamilton Township Fire Department to develop and distribute informational postcards during their April, 2003 boot drive. (See Appendix F to view the postcard template.) Analysis of illicit dumping was not part of the baseline study program.

Outreach/Education – There has been ongoing public outreach and education throughout the planning phase of the White River Watershed Project. This emphasis on outreach and education, on specific topics, will continue into the implementation phase. (Please see Chapter 7 for further details.)

E. coli – Water sampling results indicate a high degree of *E. coli* contamination in this subwatershed. Through the water monitoring and land use analysis, sources are most likely to be coming from septic system contamination. The majority of septic systems in this subwatershed shall be connected to municipal sewers by the end of 2004.

6.1.2.2 Buck Creek Subwatershed

Septic Systems – Water sampling results and personal interviews indicate septic system contamination in this subwatershed. Through the water monitoring and land use analysis, sources are coming from agriculture, septic systems and combined sewer overflows.

Drainage – The request to identify all underground drainage tiles was done with limited success. Further analysis of the infra-red photography turned over to the DCSWCD in 2004 shall be conducted during the next phase of the WRWP. There was evidence of water pollution being transferred through drainage tiles from agricultural sources in this subwatershed.

Agricultural Conservation - Land use analysis and personal interviews have identified riparian buffers and filter strips on over 50% of the 30 meter Buck Creek corridor, and a high amount of reduced tillage practices being used. However, total suspended solid levels were high throughout the subwatershed, especially during the May 2003 high flow events (evidence of surface runoff contamination).

Chemical Contamination – Atrazine and Diazanon were both found in this subwatershed during water sampling, as were above standard/guideline levels of ammonia, nitrates and orthophosphates.

Illegal Dumping – Through land use analysis, salvage yards were identified. No specific education was done with regards to proper disposal in this subwatershed and illicit dumping was not included in the baseline study.

Outreach/Education - There has been ongoing public outreach and education throughout the planning phase of the White River Watershed Project. This emphasis on outreach and education will continue into the implementation phase. (Please see Chapter 7 for more details.)

Urban Sprawl – Through land use analysis, current land use in the subwatershed was identified. Non-point source pollution levels in stream reaches influenced by CSOs were associated with impervious surface runoff from development.

6.1.2.3 Prairie Creek Subwatershed

Drainage - The request to identify all underground drainage tiles was done with limited success. Further analysis of the infra-red photography turned over to the DCSWCD in 2004 shall be conducted during the next phase of the WRWP. There was evidence of water pollution being transferred through drainage tiles from agricultural sources in this subwatershed.

Agricultural Conservation - Land use analysis and personal interviews have identified extensive riparian buffers and filter strips around the Prairie Creek Reservoir, as well as along some of the tributaries. In addition, a good portion of this subwatershed was found to have reduced tillage practices being utilized. However, ammonia was high through the entire subwatershed and nitrates and orthophosphates were high in all three tributaries.

Urban Sprawl – Through land use analysis, current land use in the subwatershed was identified. As part of the implementation phase, there will be efforts to partner with the Muncie-Delaware County Plan Commission to conduct a Master Plan for this subwatershed. The non-point source pollutants found in this subwatershed can be attributed both to agriculture and residential land uses.

Geese – Water sampling results indicate a high degree of *E. coli* contamination in this subwatershed, although it is less severe as in the other two subwatersheds. Levels are even over state standards in the reservoir itself. Through the water monitoring and land use analysis, sources are coming from agriculture and septic systems. *E. coli* source identification analysis will be done as part of the implementation phase of this project. (See Chapter 7)

Recreation on the Reservoir – Focus on recreational usage in and around the reservoir was not part of the baseline study for the WRWP. However, it is anticipated to be included in the Master Plan work that the WRWP plans to partner with the Muncie-Delaware County Plan Commission.

Woodland Loss – As part of the implementation phase, there will be efforts to partner with the Muncie-Delaware Plan Commission to conduct a Master Plan for this subwatershed. A specific recommendation in this plan is to protect and enhance the wooded areas located around the reservoir and the tributaries to protect the quality of the public drinking water reservoir.

6.2 Confirmed Water Quality Impairments (Statement of Problems)

Impairments are listed in the order of priority within each subwatershed.

6.2.1 Killbuck/Mud Creek Subwatershed

Total Suspended Solids: Agricultural runoff, construction and stream bank erosion are all contributing to high levels of total suspended solids in the Killbuck/Mud Creek subwatershed.

Feasibility – It is feasible for the project to provide technical assistance and/or cost-share for agricultural best management practices (no-till, filter strips, riparian restoration, and cover crops), and to encourage proper seeding/erosion control on construction sites. It is feasible for the project to provide technical assistance and cost share for the revegetation of stream banks using trees and/or warm season grasses, and to work with the County Surveyor and local landowners to support such plantings. Accomplishing a complete reengineering of both Killbuck and Mud Creeks is not a feasible option at this time. However, establishing a partnership with Ball State University (or other appropriate group) to conduct a feasibility study may be possible.

Location – Throughout the entire subwatershed.

Urgency – High = TSS levels are very high in this subwatershed; actions taken to reduce TSS should also reduce ammonia and orthophosphates and improve DO levels. Therefore, the multiple benefits associated with actions to address TSS also make such actions potentially the most cost effective.

Ammonia and Orthophosphates: Agricultural runoff, failed/failing septic systems and failing subdivision treatment plants are all contributing to high levels of ammonia, orthophosphates and *E. coli* in the Killbuck/Mud Creek subwatershed.

Feasibility – The issue of septic system and treatment plant failures is currently being addressed by the installation of municipal sewers in the majority of the subwatershed. We expect to see a marked reduction in ammonia, orthophosphates, and *E. coli* upon completion of the sewer project. In addition, it is feasible for the project to provide technical assistance and cost share for agricultural best management practices (no-till, filter strips, riparian restoration, and cover crops).

Location – Ammonia and *E. coli* = agricultural areas throughout the subwatershed; septic systems/treatment plants not included in the sewer project. Orthophosphates = throughout the entire subwatershed, with particular emphasis on the Mud Creek drainage area.

Urgency – High = the same practices to reduce TSS should also reduce ammonia and orthophosphates; the vast majority of septic systems will be connected to the municipal sewer system by the end of 2004.

Nitrates: Leakage through drainage tile systems and failing/failed septic systems have combined to create high nitrate levels in the Killbuck/Mud Creek subwatershed.

Feasibility - The issue of septic system and treatment plant failures is currently being addressed by the installation of municipal sewers in the majority of the subwatershed. We expect to see a marked reduction in nitrates (as well as ammonia, orthophosphates, and *E. coli*) upon completion of the sewer project. In addition, it is feasible for the project to provide technical assistance and cost share for agricultural best management practices (tile flow treatment, filter strips, manure/nutrient management, and cover crops).

Location - Throughout the subwatershed, with particular emphasis on the Killbuck Creek drainage area

Urgency – Medium = the majority of septic systems will be connected to the municipal sewer system by the end of 2004; some of the actions taken to reduce the other nutrients will help reduce nitrates

DO, Stream Habitat, Macroinvertebrates and Fish: All = a lack of stream cover and poor in-stream habitat, improper stream channel design, sedimentation and algal growth have combined to severely lower levels of dissolved oxygen and the scores for biology and habitat are indicative of low water quality in the Killbuck/Mud Creek subwatershed. DO = especially at the three most downstream sampling points.

Feasibility – It is feasible for the project to provide technical assistance and cost share for the revegetation of stream banks using trees and/or warm season grasses, and to work with the County Surveyor and local landowners to support such plantings. Accomplishing a complete re-shaping of both Killbuck and Mud Creeks is not a feasible option at this time. However, establishing a partnership with Ball State University (or other appropriate group) to conduct a feasibility study may be possible.

Location – Primary waterways in the subwatershed.

Urgency – Medium = some of the proposed actions to reduce TSS (specifically stream channel reengineering and riparian corridor restoration) will work to improve DO levels, and stream habitat, macroinvertebrate, and fish scores

***E. coli*:** Failed/failing septic systems and subdivision treatment plants are combining to create high levels of *E. coli* in the Killbuck/Mud Creek subwatershed.

Feasibility – The issue of septic system and treatment plant failures is currently being addressed by the installation of municipal sewers in the vast majority of the subwatershed. We expect to see a marked reduction in *E. coli* (as well as ammonia and orthophosphates) upon completion of the sewer project.

Location – Throughout the entire subwatershed

Urgency – Low = the vast majority of septic systems will be connected to the municipal sewer system by the end of 2004.

6.2.2 Buck Creek Subwatershed

Temperature: Consistently low water temperatures suggest Buck Creek as a cold water stream (potentially able to support salmonid populations), however, if the current level of woody vegetation along the stream corridor is not preserved and enhanced, temperatures are likely to rise.

Feasibility – It is feasible for the project to work with the local plan commission, landowners, and the County drainage board and surveyor to protect and enhance the stream corridor. It is also feasible for the project to provide technical assistance and cost share for agricultural best management practices (riparian corridor restoration and filter strips). The project would also be able to coordinate a study of Buck Creek's ability to support salmonid populations.

Location – Primary stream corridor

Urgency – High = Protection and restoration of the riparian corridor on Buck Creek will work to reduce TSS, ammonia and orthophosphates as well as improve conditions for recreational fishing opportunities and the maintenance of a unique stream ecosystem in this part of the state.

Total Suspended Solids, Ammonia and Orthophosphates: TSS = Spring agricultural runoff, Ammonia and Orthophosphates= combined sewer overflows, agricultural runoff and failed septic systems are creating high total suspended solid levels in the Buck Creek subwatershed.

Feasibility – All = it is feasible for the project to provide technical assistance and cost share for agricultural best management practices (no-till, riparian corridor restoration and protection, filter strips, and grassed waterways, manure/nutrient management, cover crops). Ammonia and Orthophosphates = removal and/or mitigation of all combined sewer overflows is taking place through efforts made by the Muncie Sanitary District.

Location – TSS = agricultural areas in the drainage area upstream from BC-5. Ammonia = agricultural area in the drainage area between BC-8 and BC-7, secondary stream corridor located midway between BC-8 and BC-7 on the East side of Buck Creek, combined sewer overflows. Orthophosphates =levels steadily climb going downstream, therefore actions throughout the subwatershed would be appropriate

Urgency – High = TSS levels are high in this subwatershed; actions taken to reduce TSS should also reduce ammonia and orthophosphate levels. In addition, some actions suggested would also protect and improve the unique temperature conditions found in Buck Creek (specifically protection and restoration of the riparian corridor). Therefore, the multiple benefits associated with actions to address TSS also make such actions potentially the most cost effective.

***E. coli*:** Failed/failing septic systems, combined sewer overflows and agricultural runoff have combined to create high levels of *E. coli* in the Buck Creek Subwatershed, with a particular spike occurring during high flow events in May.

Feasibility – The project is not able to provide funds to repair/replace failed/failing septic systems, but it can provide education and outreach regarding system maintenance. Removal and/or mitigation of all combined sewer overflows are taking place through efforts made by the Muncie Sanitary District. It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (manure management, filter strips, and riparian restoration and protection).

Location – Throughout the entire subwatershed.

Urgency – High = actions being taken by the Muncie Sanitary District to remove and/or mitigate all CSOs will help reduce *E. coli* loads; public education and outreach on maintenance and repair of septic systems will also help reduce *E. coli* loads; installing manure runoff reducing agricultural BMP installation should also help

Nitrate: Leakage through drainage tiles and failed/failing septic systems are combining to create high levels of nitrates throughout the entire Buck Creek subwatershed.

Feasibility – It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (tile flow treatment, manure/nutrient management, filter strips). The project is not able to provide funds to repair/replace failed/failing septic systems, but it can provide education and outreach regarding proper system maintenance. Removal and/or mitigation of all combined sewer overflows is taking place through efforts made by the Muncie Sanitary District.

Location – Throughout the subwatershed.

Urgency – Medium = some of the actions taken to reduce the other nutrients will help reduce nitrates; public education and outreach on maintenance and repair of septic systems will also help

Stream Habitat and Macroinvertebrates: Stream habitat is good throughout the Buck Creek subwatershed, except for BC-6, due to the presence of wooded stream corridors.

Feasibility – It is feasible for the project to work with the local plan commission, county surveyor, landowners, and the county drainage board to protect and enhance the stream corridor. It is also feasible for the project to provide technical assistance and cost share for agricultural best management practices (no-till and riparian corridor restoration). It is also feasible for the project to work with the proper authorities to remove the unauthorized rock dam located in the vicinity of BC-6.

Location – Protection and enhancement of entire stream corridor; removal of illegal dam just upstream from BC-6

Urgency – Medium = it would be relatively easy to remove the illegally placed dam and restore these parameters to their natural states

Fish (IBI): Fish scores are better throughout the Buck Creek subwatershed than the other two subwatersheds.
Feasibility – Removal and/or mitigation of all combined sewer overflows is taking place through efforts made by the Muncie Sanitary District.

Location – Combined sewer overflows.

Urgency – Low = Removal and/or mitigation of all combined sewer overflows is taking place through efforts made by the Muncie Sanitary District.

Dissolved Oxygen: Dissolved oxygen seems to be problematic only at the BC-4 sampling site, due to combined sewer overflow discharge.

Feasibility – Removal and/or mitigation of all combined sewer overflows is taking place through efforts made by the Muncie Sanitary District.

Location – Combined sewer overflows.

Urgency – Low = Removal and/or mitigation of all combined sewer overflows is taking place through efforts made by the Muncie Sanitary District.

6.2.3 Prairie Creek Subwatershed

Ammonia: Agricultural runoff and failed/failing septic systems have combined to create high levels of ammonia in the entire Prairie Creek Subwatershed, especially during high flow events.

Note that ammonia attaches to soil particles, hence actions that reduce TSS would also reduce ammonia. However, TSS levels are not problematic in the Prairie Creek Subwatershed. This indicates that the source(s) of ammonia in this subwatershed are reaching the waterways in a more direct manner.

Feasibility – The project is not able to provide funds to repair/replace failed/failing septic systems, but it can provide education and outreach regarding system maintenance. It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (manure/nutrient management, filter strips, cover crops).

Location – Throughout the entire subwatershed.

Urgency – High = Ammonia was found (along with *E. coli*) to be the most problematic parameter in this subwatershed. Certain actions suggested to reduce ammonia would also reduce *E. coli*, orthophosphates and nitrates, and increase DO levels. Therefore, actions taken to reduce ammonia would be more cost effective by improving levels of multiple parameters.

Stream/Reservoir Habitat, Fish, and Macroinvertebrates: Stream habitat, fish and macroinvertebrate scores are good in the tributary of PC-7. The rest of the sampling locations more closely resemble a lake environment than a stream, therefore population measurements were not tallied using the current sampling methodology.

The good ratings for PC-7 are due to the stream corridor being wooded and/or in filter strips. Habitat around the reservoir itself is also good due to the current wooded and grassed buffer surrounding the entire reservoir.

Feasibility – The project is able to work with the plan commission, land owners, and other entities to protect and enhance the reservoir buffer area.

Location – Reservoir and stream corridors.

Urgency – High = protection of the well established woods and grassed areas around the reservoir and along some of the tributaries is working to help keep contaminant levels lower in Prairie Creek Subwatershed than in the other two subwatersheds.

DO: Failing/failed septic systems and agricultural runoff is combining to create low levels of dissolved oxygen in the reservoir and PC-6 of Prairie Creek Subwatershed.

Feasibility – The project is not able to provide funds to repair/replace failed/failing septic systems, but it can provide education and outreach regarding system maintenance. It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (manure/nutrient management, filter strips).

Location – Throughout the subwatershed for septic system failure; agricultural areas in the drainage area for PC-6

Urgency – Medium = actions taken to reduce ammonia in these areas should also work to improve DO levels.

Nitrate: Flow in drainage tiles and agricultural runoff are leading to high nitrate levels in the three tributaries (PC-6, 7 and 8) that feed into the reservoir in the Prairie Creek Subwatershed.

Feasibility – It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (tile flow treatment, manure/nutrient management, filter strips.

Location – Agricultural areas within the drainage areas of PC-6, 7 and 8.

Urgency – Medium = actions to improve ammonia should work to reduce Nitrates; installation of tile flow treatment would also be beneficial

Orthophosphate: Agricultural runoff is leading to high orthophosphate levels in the three tributaries (PC-6, 7 and 8) that feed into the reservoir in the Prairie Creek Subwatershed.

Feasibility – It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (no-till, manure/nutrient management, filter strips.

Location – Agricultural areas within the drainage areas of PC-6, 7 and 8.

Urgency –Medium = actions to reduce ammonia should also reduce orthophosphate levels

***E. coli*:** Failed/failing septic systems and agricultural runoff are contributing to high levels of *E. coli* in the Prairie Creek Subwatershed (the three tributaries [PC-6, 7, and 8] in particular). Note that *E. coli* levels are lower in this subwatershed than the other two involved in this plan, however, levels are still considered high (even within the reservoir itself).

Feasibility – The project is not able to provide funds to repair/replace failed/failing septic systems, but it can provide education and outreach regarding system maintenance. It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (manure management).

Location – Throughout the subwatershed.

Urgency – Medium = actions to reduce ammonia should also reduce *E. coli*

6.2.4 General Subwatershed Parameters

Atrazine: Atrazine, an herbicide used in the agricultural production of corn, was found at the downstream most point in all three subwatersheds. Levels were high during the May 2003 sampling session, due to the fact that May is the general time when this herbicide is applied. Finding this chemical in the waterways in indicative of three things: 1. Surface runoff from fields, 2. Tile drainage from fields, and/or 3. Drift or overspray into waterways bordering fields. Historical conditions in the White River Basin also note agricultural herbicides, in particular Atrazine, as being problematic for water quality.

Feasibility - It is feasible for the project to provide technical assistance and cost share for agricultural best management practices (tile flow treatment, riparian restoration, filter strips) and public education on alternative agricultural/gardening methods (organic/chemical-free).

Urgency – High = The occurrence of Atrazine is indicative of agricultural runoff, which can also contribute to increased TSS, ammonia, nitrate, orthophosphate, and (if livestock is involved) *E. coli*, and can reduce fish and macroinvertebrate populations. Therefore, actions taken to reduce agricultural runoff will reduce many other contaminants; hence, such actions are more cost effective than those that target only one parameter.

Diazinon: Levels were reported to be below the method detection limit for the October 2003 sampling session, and November 2003 samples had a high concentration, but less than both the aquatic life standard and the drinking water guideline.

Feasibility – With such low levels, there is no need for action.

Urgency – Low

6.3 Estimated Current Pollutant Loads and Targeted Load Reductions

6.3.1 Methodology and Calculations

Pollutant loads for the sampling points listed below were calculated by; a) calculating the median flow using the flow data collected for each subwatershed, b) determining the percentage of flow contributed by the acreage of each sub-subwatershed identified for each sampling point, and c) calculating the average (median for *E. coli*) for each water quality parameter studied, all for which there was a reasonable amount of data to do such calculations with a sound degree of confidence.

Target load reductions for each parameter were calculated by a) determining target concentrations (based on standards and guidelines previously mentioned in this document), b) calculating target loads for each parameter based on those standard/guideline based target concentrations and multiplying by average streamflow and, c) determining target load reductions by subtracting the target loads from the estimated loads for each parameter within a given sub-subwatershed.

Table 6.1: Estimated Current Pollutant Loads and Targeted Load Reduction
(continued on the next two pages)

Parameter	Total Reduction (lbs/year)/ *E. coli* (cfu/year)
K/M ammonia	3851.07
K/M *E. coli*	6.32307E+15
K/M nitrate	5846.29
K/M orthophosphate	776.55
K/M TSS	1013520.84
BC ammonia	10646.23
BC *E. coli*	6.375E+16
BC nitrate	17554.47
BC orthophosphate	-3455.50
BC TSS	-2806091.24
PC ammonia	4620.71
PC *E. coli*	3.63745E+15
PC nitrate	-33810.11
PC orthophosphate	-2242.85
PC TSS	-1844244.09
Total ammonia	19118.02
Total *E. coli*	7.37105E+16
Total nitrate	-10409.35
Total orthophosphate	-4921.80
Total TSS	-3636814.49

Note: BC-8 was not calculated for due to the lack of acreage for the BC-8 sub-subwatershed area (lack of data available for Henry County). Flow was not calculated for any of the tributaries studied in the Prairie Creek Subwatershed due to the lack of flow data for those tributaries. Flow was only calculated for the reservoir outflow (PC-3). Target concentrations for ammonia were determined by averaging the temperature results for each sampling point, taking the neutral pH of 7.0 and using the state standards chart (327 IAC 2-1-6 in Appendix E) identified the standard target for ammonia.

Values in red type indicate parameters where estimated current load levels are lower than targeted levels based on current state standards and scientific guidelines

Sampling Point	Median Flow (ft3 /sec)	Parameter	Average /Median	Load (lbs/day)/ *E. coli* (cfu/day)	Load (lbs/year)/ *E. coli* (cfu/year)	Target Concen-tration	Target Load (lbs/year)/ *E. coli* (cfu/year)	Target Load Reduction (lbs/year)/ *E. coli* (cfu/year)
KB - 1	14.75	ammonia (mg/l)	0.286	22.72	8292.62	0.0539	1565.19	6727.44
	14.75	*E. coli* (cfu/100ml)	1130.000	4.07782E+13	1.48841E+16	235	3.09536E+15	1.17887E+16
	14.75	nitrate (mg/l)	2.020	160.71	58658.16	1.60	46461.91	12196.25
	14.75	orthophosphate (mg/l)	0.151	12.01	4384.84	0.10	2903.87	1480.97
	14.75	TSS (mg/l)	185.143	14729.61	5376306.52	80.00	2323095.41	3053211.11
KB - 2	7.63	ammonia (mg/l)	0.620	25.51	9311.72	0.0539	809.52	8502.20
	7.63	*E. coli* (cfu/100ml)	1370.000	2.55701E+13	9.33307E+15	235	1.60093E+15	7.73214E+15
	7.63	nitrate (mg/l)	1.793	73.77	26926.76	1.60	24030.25	2896.50
	7.63	orthophosphate (mg/l)	0.222	9.15	3338.49	0.10	1501.89	1836.60
	7.63	TSS (mg/l)	169.514	6975.12	2545919.46	80.00	1201512.64	1344406.82
KB - 3	4.27	ammonia (mg/l)	0.271	6.25	2282.64	0.0539	453.28	1829.36
	4.27	*E. coli* (cfu/100ml)	1660.000	1.73486E+13	6.33222E+15	235	8.96429E+14	5.43579E+15
	4.27	nitrate (mg/l)	1.810	41.70	15221.62	1.60	13455.57	1766.04
	4.27	orthophosphate (mg/l)	0.201	4.62	1687.95	0.10	840.97	846.98
	4.27	TSS (mg/l)	99.843	2300.42	839651.83	80.00	672778.69	166873.14
KB - 4	5.75	ammonia (mg/l)	0.295	9.16	3343.90	0.0539	610.38	2733.52
	5.75	*E. coli* (cfu/100ml)	1170.000	1.64653E+13	6.00983E+15	235	1.20710E+15	4.80273E+15
	5.75	nitrate (mg/l)	2.424	75.21	27453.31	1.60	18118.86	9334.45
	5.75	orthophosphate (mg/l)	0.130	4.04	1475.39	0.10	1132.43	342.96
	5.75	TSS (mg/l)	151.657	4705.23	1717409.27	80.00	905943.10	811466.17
KB - 5	3.52	ammonia (mg/l)	0.419	7.95	2900.59	0.0539	373.51	2527.08
	3.52	*E. coli* (cfu/100ml)	2620.000	2.25627E+13	8.23540E+15	235	7.38671E+14	7.49673E+15
	3.52	nitrate (mg/l)	2.157	40.95	14948.46	1.6	11087.60	3860.86
	3.52	orthophosphate (mg/l)	0.116	2.21	806.82	0.1	692.97	113.85
	3.52	TSS (mg/l)	164.714	3127.20	1141428.61	80	554379.90	587048.71
KB - 6	1.69	ammonia (mg/l)	0.291	2.65	965.82	0.0539	178.98	786.84
	1.69	*E. coli* (cfu/100ml)	688.000	2.83910E+12	1.03627E+15	235	3.53958E+14	6.82311E+14
	1.69	nitrate (mg/l)	3.113	28.32	10336.60	1.6	5312.99	5023.62
	1.69	orthophosphate (mg/l)	0.111	1.01	370.01	0.1	332.06	37.95
	1.69	TSS (mg/l)	115.571	1051.42	383768.32	80	265649.27	118119.05

Sampling Point	Median Flow (ft3 /sec)	Parameter	Average /Median	Load (lbs/day)/ *E. coli* (cfu/day)	Load (lbs/year)/ *E. coli* (cfu/year)	Target Concen- tration	Target Load (lbs/year)/ *E. coli* (cfu/year)	Target Load Reduction (lbs/year)/ *E. coli* (cfu/year)
BC - 3	59.76	ammonia (mg/l)	0.191	61.51	22452.66	0.0539	6340.86	16111.80
	59.76	*E. coli* (cfu/100ml)	1635.000	2.39029E+14	8.72455E+16	235	1.25399E+16	7.47056E+16
	59.76	nitrate (mg/l)	1.630	525.36	191755.09	1.6	188225.85	3529.23
	59.76	orthophosphate (mg/l)	0.064	20.72	7562.65	0.1	11764.12	-4201.47
	59.76	TSS (mg/l)	49.857	16069.18	5865252.02	80	9411292.63	-3546040.62
BC - 4	55.54	ammonia (mg/l)	0.208	62.40	22776.11	0.0539	5893.98	16882.13
	55.54	*E. coli* (cfu/100ml)	3825.000	5.19786E+14	1.89722E+17	235	1.16561E+16	1.78066E+17
	55.54	nitrate (mg/l)	1.754	525.57	191831.74	1.6	174960.55	16871.20
	55.54	orthophosphate (mg/l)	0.066	19.82	7232.74	0.1	10935.03	-3702.29
	55.54	TSS (mg/l)	49.714	14893.90	5436274.12	80	8748027.32	-3311753.20
BC - 5	49.32	ammonia (mg/l)	0.163	43.36	15826.43	0.0539	5233.40	10593.03
	49.32	*E. coli* (cfu/100ml)	911.000	1.09923E+14	4.01217E+16	235	1.03497E+16	2.97720E+16
	49.32	nitrate (mg/l)	1.837	488.70	178376.78	1.6	155351.48	23025.31
	49.32	orthophosphate (mg/l)	0.055	14.55	5312.47	0.1	9709.47	-4397.00
	49.32	TSS (mg/l)	46.743	12434.20	4538482.40	80	7767573.79	-3229091.39
BC - 6	40.20	ammonia (mg/l)	0.133	28.90	10548.60	0.0539	4265.79	6282.80
	40.20	*E. coli* (cfu/100ml)	1060.000	1.04253E+14	3.80525E+16	235	8.43616E+15	2.96163E+16
	40.20	nitrate (mg/l)	1.996	432.73	157946.30	1.6	126628.39	31317.91
	40.20	orthophosphate (mg/l)	0.054	11.65	4251.10	0.1	7914.27	-3663.18
	40.20	TSS (mg/l)	42.800	9280.30	3387309.36	80	6331419.36	-2944110.00
BC - 7	12.69	ammonia (mg/l)	0.188	12.90	4708.18	0.0539	1346.77	3361.40
	12.69	*E. coli* (cfu/100ml)	816.500	2.53533E+13	9.25396E+15	235	2.66342E+15	6.59054E+15
	12.69	nitrate (mg/l)	2.121	145.23	53007.13	1.6	39978.44	13028.69
	12.69	orthophosphate (mg/l)	0.047	3.25	1185.08	0.1	2498.65	-1313.58
	12.69	TSS (mg/l)	40.000	2738.25	999460.98	80	1998921.95	-999460.98
PC - 3	13.23	ammonia (mg/l)	0.254	18.09	6602.08	0.0761	1981.37	4620.71
	13.23	*E. coli* (cfu/100ml)	543.000	1.75693E+13	6.41278E+15	235	2.77533E+15	3.63745E+15
	13.23	nitrate (mg/l)	0.301	21.50	7848.11	1.6	41658.22	-33810.11
	13.23	orthophosphate (mg/l)	0.014	0.99	360.79	0.1	2603.64	-2242.85
	13.23	TSS (mg/l)	9.167	653.88	238666.88	80	2082910.97	-1844244.09

6.3.2 Summary of Load Calculation Table (Table 6.1)

As with any calculation based on assumptions, there are limitations to the results found in the table above. The calculation limitations are present due to the finite amount of flow and sampling data available for each subwatershed.

Results of this table can be interpreted in a multitude of ways. First, the table characterizes the loading under ambient conditions (averaging both high and seasonal flow events and their associated sampling data) thereby mediating the affects of extremes in flow conditions. For example, target loads may not be met under high flow conditions when the chances of non-point source pollution running off into surface water bodies are increased. Second, target reductions were calculated for both sub-subwatershed and subwatershed levels, as well as for the total of all three subwatersheds. Looking at load reductions in multiple ways provides the ability to identify critical areas for both protection and improvement of water quality on several scales. It would be misleading to only list the target reductions for the total areas of the three subwatersheds, as they are three separate headwater subwatersheds and do not influence one another. One is provided a clearer picture of conditions when looking at the subwatershed and sub-subwatershed levels.

By looking at the results of the loading calculations, it is apparent that Killbuck/Mud Creek Subwatershed has a greater level of non-point source water pollution in a larger number of parameters than the other two subwatersheds. Buck Creek and Prairie Creek Subwatersheds are experiencing reduced levels of pollutants, with specific parameters being more problematic than others. These figures match what has been observed both in the field and by comparing water quality results with land use and land cover analysis.

Determining cost estimates for each parameter for each sub-subwatershed was attempted, in order to give the reader an idea of what it may cost to bring a given area to the target load reduction. This was done with very limited success due to several factors: there is an innumerable combination of remedial actions that can be taken in a community to reduce various non-point source pollutants. There is no true way to predict the mixture and concentration of future actions to be taken; calculating load reductions for ammonia and *E. coli* was not done for this plan due to a lack of methodology (like the EPA Region5 worksheets used for TSS, P and N load reduction calculations). There have been costs calculated for the 3-5 year implementation actions (listed in Chapter 7 of this document). This provides the reader an idea of costs associated with specific management practices, outreach and education activities, monitoring and management requirements needed to reduce specific non-point source pollution parameters designated as priorities by the local community.

Some of the goals listed in the next section work to reduce the levels of pollutants in each of the subwatersheds, while some work to protect currently high water quality levels. Both types of actions are vital to managing for low levels of non-point source water pollution.

6.4 Goal Statements (for the next 3 to 5 years)

Load reductions were calculated using the EPA Region 5 load reduction model worksheets. Load reductions were not able to be calculated for ammonia and *E. coli*, as there were no methods available to do so (such as the EPA Region 5 worksheets). The goals and their designated priorities were determined through a series of public meetings (with the technical, steering, watershed committees). It was the desire of these community members to create goals for the next three to five years, with the anticipation to revisit the plan and these goal statements periodically to revise, add to or remove them as needed. The specific acreages listed under the goal statements were also decided upon by the previously described group of community citizens, based on the known land use acreages and their perception of an attainable acreage goal within the boundaries of voluntary community participation.

6.4.1 High Priority

Reduce levels of total suspended solids, ammonia, orthophosphates, Atrazine and nitrates coming from agricultural areas through the installation 250 acres (20 miles at 50' wide) of wooded and/or grass buffer strips in the next five years (primary and secondary waterways, widths and cover type to vary accordingly) and 6 acres of grassed waterways (2 miles at an average of 25' wide). This would give an estimated load reduction for the following parameters: sediment = 307 tons/year, phosphorus = 470 lbs/year, and nitrogen = 934 lbs/year. TSS, ammonia, orthophosphate and nitrate levels would continue to be monitored to determine the extent of load reduction.

Reduce levels of total suspended solids, ammonia, orthophosphates, Atrazine and nitrates coming from agricultural areas by increasing the acreage of reduced tillage by 7400 acres in the next five years (roughly 1/3 of the total agricultural acreage for the three subwatersheds). This would give an estimated load reduction for the following parameters: sediment = 3324 tons/year, phosphorus = 4782 lbs/year, and nitrogen = 9554 lbs/year. TSS, ammonia, orthophosphate and nitrate levels would continue to be monitored to determine the extent of load reduction.

Reduce levels of total suspended solids, ammonia, orthophosphates, *E. coli* and nitrates coming from urban/suburban areas through the installation of 100 acres (approximately 4 miles at and average of 100' wide) of wooded and/or grass buffer strips in the next five years (primary and secondary waterways, widths and cover type to vary accordingly). This would give an estimated load reduction for the following parameters: TSS = 11242 lbs/year. TSS, ammonia, orthophosphate and nitrate levels would continue to be monitored to determine the extent of load reduction.

Develop targeted methods of *E. coli* reduction by identifying sources of *E. coli* contamination through the implementation of an *E. coli* source water quality monitoring program during the next three years. Results of this program would indicate local sources and their degree of contribution.

Maintain the low temperature regime in Buck Creek through the protection and enhancement of the primary riparian corridor by partnering on planning efforts with the Muncie-Delaware County Plan Commission and local landowners over the next three years.

Maintain and improve the water quality in Prairie Creek reservoir by protecting and enhancing its vegetated buffer area through partnering on planning efforts with the Muncie-Delaware County Plan Commission and local landowners over the next three years.

Reduce *E. coli* contamination, TSS, ammonia, orthophosphates, nitrates through targeted public education and outreach programs over the next three years. Public participation and feedback will be measured to estimate the effectiveness of such programs.

6.4.2 Medium Priority

Reduce total suspended solids and *E. coli* through the installation of ten acres of constructed wetlands (one for septic effluent treatment and one for stormwater filtration) during the next three years. This would give an estimated load reduction for TSS of 4627 lbs/year.

Reduce nitrate levels coming from agricultural areas by installing 3 tile flow treatment demonstration sites (one per watershed) over the next five years. Nitrates will be measured to determine if the practice works.

Improve stream habitat and biology in Buck Creek, remove the illegal rock dam at BC-6 during the next three years. Habitat and biology would continue to be monitored to determine the affects of the removal.

6.4.3 Low Priority

Reduce total suspended solid, nitrate and orthophosphate levels in Buck Creek by stabilizing 400 feet of the bank upstream of BC-7 within the next five years. TSS levels would continue to be measured to determine load reductions. This would give an estimated load reduction for the following parameters: sediment = 75.6 tons/year, phosphorus = 64.3 lbs/year, and nitrogen = 128.5 lbs/year. TSS, ammonia, orthophosphate and nitrate levels would continue to be monitored to determine the extent of load reduction.

Improve stream habitat and biology, along with reducing total suspended solids by conducting a feasibility study to reengineer Killbuck and Mud Creeks during the next three years. Reengineering a stream channel would take years of planning and, therefore, it is suggested to start by determining if such actions are even feasible prior to developing a plan for such action.

Total load reductions for the above actions total (ammonia and *E. coli* were not calculated):

Total Suspended Solids: 15869 lbs/year
Sediment: 3706.6 tons/year
Nitrogen: 15933.1 lbs/year
Phosphorus: 5316.3 lbs/year

These reductions would alter the total reduction for each parameter in the following manner:
(a "–" indicates target load is already met)

Total TSS:
Reduction needed to meet target = -3636814.49
Implementation Load Reduction = 15869
New Target Reduction = -3652683.49

Total Nitrogen:
Reduction needed to meet target = -10409.35
Implementation Load Reduction = 15933.1
New Target Reduction = -26342.45

Total Phosphorus:
Reduction needed to meet target = -4921.80
Implementation Load Reduction = 5316.3
New Target Reduction = -10238.10

CHAPTER 7

MEASURES TO APPLY

7.1 Measures to Apply (by Subwatershed)

The measures listed below are a combination of targeted public education and outreach, best management practices, land use planning, and revised monitoring, all with the goal to reduce specific non-point source pollution in each subwatershed. They are the result of the recommendations of the technical committees, based on the aforementioned information in Chapters 2-5, along with input and approval from citizens from all three subwatersheds and around Delaware County. Comments and input were gathered in a wide variety of ways, both in writing (mail, email, and hand delivered) and verbally (phone, public meetings, and personal interviews). The draft of this plan was made available to the public for review and comment. It was made available via the internet (project website – pdf downloadable files by chapter) and in print (by mail or for pick up in the DCSWCD office). Several meetings were held in Muncie and in each of the three subwatersheds to ensure the public had multiple opportunities to comment on the document.

Note: All best management practices installed shall follow all NRCS technical guidelines (where appropriate), or other scientifically accepted specifications where NRCS guidelines are not available.

Through the public education and outreach efforts listed below, there will be active public education to enhance the community's understanding of our efforts and encourage their participation in specific WRWP programs. Techniques such as personal interviews, media spots (newspaper and radio), direct mailings, establishing partnerships with local agencies and organizations, and public events shall be utilized.

Actions listed below are in order of priority within each subwatershed and under the overall actions sections. It is the desire of the WRWP to implement actions in the listed critical areas, however, being a voluntary, community-driven project, this will depend entirely upon willing partners.

7.1.1 Killbuck/Mud Creek Subwatershed

Increase Filter Strips/Riparian Buffers Along Primary and Secondary Waterways

Why: High ammonia, orthophosphates, and total suspended solid levels, along with fish and macroinvertebrate scores indicative of poor water quality found during monitoring, and low dissolved oxygen levels observed during monitoring sampling events. Atrazine was also detected.

Where: Along stream/ditch channels that are being farmed or mowed up to/near the edge

Critical Areas: Along Mud Creek (Northern most stream) and the area between KB-2 and KB-3 on Killbuck Creek (Southern most stream)

Partners: Land owners/operators (agricultural and residential); Delaware County Surveyor Office; Delaware County Drainage Board, USDA, IDNR

How: Provide technical and financial assistance for installation of above practices through providing cost-share dollars for application installation and hiring a agricultural technician (to promote listed practices, identify willing landowners, assist in application design, and to implement cost share program).

Increase Conservation Tillage/Residue Management

Why: High total suspended solids on both creeks (especially KB-1, 2 and 5); high phosphate levels on Mud Creek, fish; high ammonia and nitrate levels on Killbuck Creek and macroinvertebrate scores indicative of poor water quality throughout; low dissolved oxygen throughout; and Atrazine was also detected in this subwatershed.

Where: Throughout the subwatershed – there is relatively little in the entire subwatershed

Critical Areas: Areas on highly erodable or leachable soils

Partners: Agricultural land owners/operators

How: Provide technical assistance for installation of above practices through hiring a agricultural technician (to promote listed practices, identify willing landowners, and assist in application design).

Install a Water Table Control Structure Demonstration Site

Why: High nitrate levels present – source agricultural tile drainage

Where: Drainage Area of KB-6 – KB-4
(highest nitrate levels – primarily agricultural land use in this area)

Critical Areas: Drainage Area of KB-6 – highest nitrate levels in KB subwatershed

Partners: Agricultural land owners/operators

How: Provide technical and financial assistance for installation of above practices through providing cost-share dollars for application installation and hiring a agricultural technician (to promote listed practices, identify willing landowners, assist in application design, and to implement cost share program).

Reengineer Both Stream Channels

Why: Current channel dimensions have resulted in instability and will continue to cause increased TSS levels and negatively impact fish and macroinvertebrate scores

Where: Both Killbuck and Mud Creeks

Critical Areas: Both Killbuck and Mud Creeks

Partners: Delaware County Surveyor Office; Land Owners along Killbuck and Mud Creek; Delaware County Drainage Board; IDNR; Ball State University

How: Partner with Ball State University to conduct a feasibility study.

Install a Constructed Wetland Storm Water Treatment Demonstration Site

Why: Country Village sewers will also have a storm water line discharging directly into Mud Creek (a wetland would be able to clean the runoff before it polluted the water); Due to the cost of the lines to connect those unsewered land owners, tying in would be cost prohibitive.

Where: Mud Creek drainage area (specifics under "Partners")

Critical Areas: Country Village

Partners: Country Village; IDNR; Delaware County Drainage Board; Ball State University

How: Provide technical and financial assistance by providing cost-share for demonstration site and bringing together technical professionals to assist in the design of said site.

Repair/Remove Failed/Failing Septic Systems and Treatment Facilities

Why: High ammonia, *E. coli*, nitrogen, and total suspended solid levels and fish and macroinvertebrate scores indicative of low water quality, and low dissolved oxygen levels

Where: Throughout the entire subwatershed

Critical Areas: Dense residential populations along Mud Creek (Southern most stream)

Partners: Residents with these systems; Some being completed by the Regional Wastewater District. Ones not included in the sewer project, Delaware County Health Department especially 1) between KB-2 and KB-3, 2) Country Village treatment plant

How: Public education and outreach (conduct a septic system maintenance workshop, publish and distribute education/outreach materials on maintenance – both in conjunction with the Regional Wastewater District and the Delaware County Health Department); the majority of septic systems will be tied into municipal sewers by the end of 2004

7.1.2 Buck Creek Subwatershed

Restore and Protect Riparian Corridor along Buck Creek and Determine Ability to Support Salmonid Species

Why: Temperatures are at levels bordering a cold water stream, riparian cover is needed to keep those temperatures low; such vegetation buffers help to protect water quality by reducing the amount of unfiltered water runoff entering the waterway; fish and macroinvertebrate scores were positive throughout the subwatershed as a result of the current riparian corridor and temperature; TSS, orthophosphates, ammonia, nitrate, and *E. coli* levels were high; Atrazine was also detected

Where: Restore = East bank of Buck Creek just North of BC-5 (where they were removed in 2003) Protect = the entire length of Buck Creek (within an agreed boundary, i.e. the 100 year floodplain)

Critical Areas: Same as above

Partners: Land Owners along Buck Creek; Muncie-Delaware Metropolitan Plan Commission; Delaware County Surveyor Office; Delaware County Drainage Board

How: Public education and outreach (conduct a drainage conference, publish and distribute education/outreach material on drainage management options); develop conservation buffers with Plan Commission along Buck Creek; promote tree planting to restore areas denuded of woody vegetation (provide technical assistant and cost-share); bring local stakeholders into the decision making process

Promote Manure/Nutrient Management

Why: Ammonia, total suspended solids, nitrate show elevated levels at BC-7 compared to other sampling points in this subwatershed, orthophosphate and *E. coli* elevated throughout the subwatershed

Where: Lands where manure is applied/livestock is raised

Critical Areas: Drainage area for BC-7

Partners: Agriculture land owners/operators

How: Provide technical and financial assistance for installation of above practices through providing cost-share dollars for application installation and hiring a agricultural technician (to promote listed practices, identify willing landowners, assist in application design, and to implement cost share program).

Increase Conservation Tillage/Residue Management

Why: High total suspended solids throughout (with most of the increase occurring by BC-5 during increase); ammonia, nitrate and orthophosphates were all high; Atrazine was also detected

Where: Throughout the watershed

Critical Areas: Drainage area for BC-5 (this includes the drainage areas of BC-8, 7 and 6)

Partners: Agricultural land owners/operators

How: Provide technical assistance for installation of above practices through hiring a agricultural technician (to promote listed practices, identify willing landowners, and assist in application design).

Remove rock dam upstream of BC-6

Why: This illegal dam is negatively affecting the macroinvertebrate populations by the alteration of the natural stream habitat.

Where: Site of the dam, upstream of BC-6

Critical Areas: Site of the dam, upstream of BC-6

Partners: Delaware County Surveyor Office, Delaware County Drainage Board, County Highway Department Muncie Sanitary District; United States Geologic Survey (due to proximity of gage station)

How: Physically remove the illegal dam with assistance from above partners.

Install a Tile Control Structure Demonstration Site

Why: High nitrate levels present – suspected source is agricultural tile drainage

Where: Agricultural drainage areas

Critical Areas: Drainage area for BC-7 and BC-6 – highest nitrate levels

Partners: Agricultural land owners/operators

How: Provide technical and financial assistance for installation of above practices through providing cost-share dollars for application installation and hiring a agricultural technician (to promote listed practices, identify willing landowners, assist in application design, and to implement cost share program).

Remove/Repair Failed/Failing Septic Systems

Why: *E. coli* is high throughout the watershed, as are nitrate, orthophosphates, and total suspended solids

Where: Throughout the subwatershed (possibly beyond, in Oakville)

Critical Area: Septic discharge from Oakville (just downstream from BC-8)
Note: Oakville possibly has received a grant or low interest loan to address some of the problems; Beverly Hills Edition (interested parties)

Partners: Septic System Owners, Delaware County Health Department; Regional Wastewater District

How: Public education and outreach (conduct a septic system maintenance workshop, publish and distribute education/outreach materials on maintenance – both in conjunction with the Regional Wastewater District and the Delaware County Health Department).

7.1.3 Prairie Creek Subwatershed

Develop a Master Plan for the Prairie Creek Watershed

Why: Prairie Creek Reservoir is the secondary drinking water source for the City of Muncie Master planning will achieve a balance between development and resource protection needed for a subwatershed that provides drinking water.

Where: The entire watershed

Critical Areas: Wooded and grassed area surrounding the reservoir

Partners: Muncie-Delaware County Metropolitan Plan Commission; Indiana-American Water Company; Land owners

How: Work with local stakeholders, Indiana-American Water Company, and the Muncie-Delaware County Metropolitan Plan Commission to develop a Master Plan for the Prairie Creek Reservoir and the subwatershed; provide financial assistance to create the Master Plan

Promote Manure/Nutrient Management

Why: Highest *E. coli* readings are at PC-7, which occur during wet weather events reducing the septic system failure that would result in consistently high bacteria readings, . *E. coli*, nitrate, orthophosphate and ammonia are elevated in all three of the tributaries (PC-6,7 and 8) draining into Prairie Creek Reservoir, with a spike of *E. coli* at PC-7. Ammonia can be correlated to runoff, however, total suspended solid levels are within acceptable ranges, therefore a more direct contamination is suspected occurring.

Where: Lands where manure is applied/livestock is raised

Critical Areas: Drainage area for PC-7 – highest *E. coli* readings; little residential development; PC-8 – highest ammonia readings

Partners: Agricultural land owners/operators

How: Provide technical and financial assistance for installation of above practices through providing cost-share dollars for application installation and hiring a agricultural technician (to promote listed practices, identify willing landowners, assist in application design, and to implement cost share program).

Increase Conservation Tillage/Residue Management

Why: Atrazine was detected; nitrate and orthophosphate all were high in the tributaries feeding into the reservoir (PC-6, 7, and 8); ammonia was high in both the tributaries and in the reservoir itself. Further, ammonia can be tied to soil runoff, however, total suspended solid levels are within acceptable ranges, therefore a more direct contamination is occurring.

Where: Throughout the watershed.

Critical Areas: Drainage area for BC-5 (this includes the drainage areas of BC-8, 7 and 6)

Partners: Agricultural Land Owners

How: Provide technical assistance for installation of above practices through hiring a agricultural technician (to promote listed practices, identify willing landowners, and assist in application design).

Install a Constructed Wetland Demonstration Site
Why: New Burlington is known to have failed septic systems, therefore is contributing to the high *E. coli* levels in the reservoir, and is too isolated to be put on municipal sewers

Where: New Burlington; Drainage area for PC-7

Critical Areas: New Burlington

Partners: Land owners, Delaware County Regional Wastewater District; Delaware County Board of Health; Indiana American Water Company, City of Muncie Parks Department

How: Provide technical and financial assistance by providing cost-share for demonstration site and bringing together technical professionals to assist in the design of said site.

Install a Tile Control Structure Demonstration Site
Why: High nitrate levels present – source agricultural tile drainage; there are high nitrate, phosphorus and *E. coli* levels at PC-7, which already has high amount of riparian cover along the stream and grassed covered tile drainage upstream of the open channel.

Where: Agricultural drainage areas

Critical Areas: Drainage area for PC-7

Partners: Agricultural land owners/operators

How: Provide technical and financial assistance for installation of above practices through providing cost-share dollars for application installation and hiring a agricultural technician (to promote listed practices, identify willing landowners, assist in application design, and to implement cost share program).

Remove/Repair Failed/Failing Septic Systems
Why: *E. coli* is high throughout the watershed

Where: Throughout the watershed

Critical Area: New Burlington; Drainage area of PC-7

Partners: Septic System Owners, Delaware County Health Department

How: Public education and outreach (conduct a septic system maintenance workshop, publish and distribute education/outreach materials on maintenance – both in conjunction with the Regional Wastewater District and the Delaware County Health Department).

7.1.4 Overall Actions

Public Education:

Identify and Promote Drainage Management Options

Goal: Investigate and adopt management options that combine both drainage and water quality needs, consistent with the Indiana Drainage Handbook (published by Christopher B. Burke Engineering, Ltd.)

Reason: Found a direct correlation between water quality and riparian corridor land cover; such a balance is key to the reduction of non-point source pollution. Without properly designed, maintained, and protected waterways the community will not be able to achieve their stated pollutant load reductions.

Target Audience: Delaware County Surveyors Office; Drainage Board

Actions: Conference; publication production and distribution; partner with Delaware County Surveyor's Office on public education

Promote Septic System Maintenance

Goal: Encourage self-maintenance, repair and replacement of septic systems and disconnect illegal connections to reduce water contamination

Reason: *E. coli* contamination found throughout all three watersheds; many areas known to have failed/failing septic systems in all three watersheds

Target Audience: Residents with septic systems

Actions: Workshop; publication production and distribution; partner with Health Department and Regional Wastewater District on public education

Promote Erosion Control

Goal: Work with contractors, MS4 entities, and agricultural landowners/operators to encourage self-management of sediment contamination

Reason: Total suspended solids were found to be problematic in Killbuck/Mud Creek and Buck Creek subwatersheds. Nutrients that are associated with sedimentary runoff were also found to be problematic in these watersheds in urban and agricultural areas.

Actions: Partner with MS4 entities and Purdue Extension to conduct a workshop, create and distribute publications, and other public education efforts

Promote Lawn/Turf Management
Goal: Encourage self-management of lawns/turf to reduce water contamination

Reason: Pesticides and herbicides have been identified as problematic, with pesticide levels the highest in the nation in the White River Basin

Target Audience: General Public; Golf Courses; Turf Growers

Actions: Workshop; publication production and distribution; partner with Purdue Extension

Conduct Education on Organic/Chemical Free Agriculture/Gardening
Goal: Encourage self-management for reduction of pesticide/herbicide water contamination

Reason: Pesticides and herbicides have been identified as problematic, with pesticide levels the highest in the nation in the White River Basin; Atrazine was found at every sampling location; ammonia, nitrate, phosphorus

Target Audience: Agricultural landowners and Operators; General Public

Actions: Partner with local organic/chemical free producers and Purdue Extension on public education

Conduct Public Watershed Education and Outreach
Goal: Provide the community (youth and adults) with a deeper understanding of what watersheds are and how we interact with them to positively or negatively affect water quality

Reason: Non-point pollution has been identified in all three subwatersheds from a variety of sources. Increased knowledge of the consequences of our actions allows us all to become better stewards and positively affect water quality.

Target Audience: General Public (youth and adults)

Actions: Public presentations; continued Project Wet! teacher training workshops (using WRWP information); website update and maintenance; newspaper articles; subwatershed tours; newsletter

Provide an Agricultural Technical Assistant
Goal: To reduce agriculturally related non-point source pollution

Reason: Total suspended solids, Atrazine, ammonia, nitrogen, orthophosphates and *E. coli* were found to be problematic in the subwatersheds in agriculturally dominant sub-subwatershed drainage areas

Actions: Put landowners/operators in touch with current NRCS programs; coordinate/identify “new” cost-share opportunities using 319 funds; secure some cost-share projects as demonstration sites for public education

Target Practices: Promote manure/nutrient management; increase conservation tillage/residue management; increase filter strips/riparian buffers

<u>*Conduct a Modified Monitoring Program*</u>

E. coli source identification

Goal: Identify the source(s) of *E. coli* contamination in all three subwatersheds

Reason: Source(s) of such contamination are not definitive; community has requested such identification to further focus remediation and prevention efforts

Actions: Develop and contract out *E. coli* source monitoring program

Lake study on Prairie Creek Reservoir

Goal: Gain a better understanding of water quality and biological conditions in the reservoir and its tributaries (the ones that act more like lake [lentic] systems)

Reason: Monitoring conducted in the Prairie Creek Subwatershed was limited due to the methodology utilized for the study; the community has requested such a study

Actions: Develop and contract out a Prairie Creek Reservoir lake-methodology study

Modified bacteriological, biological and chemical monitoring of the three subwatersheds

Goal: Continue to monitor water quality, biological and stream habitat conditions

Reason: Identify if the implementation plan has an impact on non-point source pollution

Actions: Develop and contract out a modified monitoring program

Update GIS Data Layers

Goal: Provide the most accurate picture of land use and land cover for the three subwatersheds

Reason: To measure the success of plan implementation

Actions: Digitize new color aerial photography and practices installed through the WRWP implementation program

7.2 Action Register

Below is the action register for the first implementation phase of the White River Watershed Project. Please note that there are some actions that will require longer than three years to complete. These shall be worked on during the initial three year implementation period and the goals continued pending future funding.

Table 7.1:
Action Register   Prioritization: Orange: High, Green: Medium, Blue: Low

Goal	Objective	Task (linked to objectives)	Start	End	Responsible (in addition to WC)	Resources	Progress Indicators	Products	Estimated Load Reductions
Reduce TSS, ammonia, nitrates, atrazine, *E. coli* and orthophosphates from agricultural areas	1. Install 250 acres (20 miles at 50' wide) of wooded or grassed filter strips	1-5. Hire agricultural technician	2004	2009	DCSWCD agricultural technical assistant	NRCS; FSA; IDNR	Water quality monitoring; track acreage	At least 20 miles of additional wooded or grassed buffers on primary and secondary wateways	Sediment: 307 tons/year P: 470 lbs/year N: 934 lbs/year (Figures for acreage combined with acreage for 6 acres grassed waterways.)
	2. Increase reduced tillage practices by 7400 acres (roughly 1/3 of total agricultural area)	1-5. Identify interested landowners	2004	2009	DCSWCD agricultural technical assistant	NRCS; FSA; IDNR	Water quality monitoring; track new acreage	At least 7400 acres of reduced tillage practices	Sediment:3324 tons/year P: 4782 lbs/year N: 9554 lbs/year
	3. Promote manure/nutrient management	1-5. Develop cost-share program for WRWP funds	2004	2007	DCSWCD agricultural technical assistant	NRCS; FSA; IDNR; Purdue Extension	Track number of management plans created	Increase participation in manure/nutrient management	
	4. Install 3 tile flow treatment demonstration sites	1-5. Create and distribute education and outreach materials	2004	2007	DCSWCD agricultural technical assistant	NRCS; FSA; IDNR; Purdue Extension; Ball State University	Track the number of demonstration sites created	Install one active tile flow demonstration site in each subwatershed	

Goal	Objective	Task (linked to objectives)	Start	End	Responsible (in addition to WC)	Resources	Progress Indicators	Products	Estimated Load Reductions
	5. Install 6 acres (2 miles at 25' wide average) of grassed waterways		2004	2007	DCSWCD agricultural technical assistant	NRCS; FSA; IDNR	Measure pollutant levels and calculate load reductions; track acreage	Install at least 6 acres of grassed waterways	Sediment: 307 tons/year P: 470 lbs/year N: 934 lbs/year (Figures for acreage combined with acreage for 250 acres filter strips.)
	6. Provide education on organic/chemical free practices	6. Partner with local organic/chem free producers to develop education and outreach materials	2004	2007	Outreach/ Education Committee	Local producers; Purdue Extension	Track attendance and information output	Produce and distribute educational materials to the general public	
	7. Identify and promote drainage management options	7. Identify range of practices suitable for drainage and water quality protection	2004	2007	Outreach/ Education Committee	Surveyor; Drainage Board; Purdue Extension; NRCS; BSU	Track attendance and feedback from participants	Increase use of drainage management practices that protect drainage and water quality	
		7. Partner with local Surveyor and Drainage Board to implement practices							
		7. Conduct conference on drainage management options							
Reduce TSS, ammonia, nitrates, *E. coli* and orthoph-osphates from urban/suburban areas	1. Install 100 acres (4 miles at 100' wide average) of wooded or grassed filter strips	1&2. Identify interested landowners	2004	2007	Monitoring Committee	NRCS; IDNR; Purdue Extension; Ball State University	Water quality monitoring; track acreage	At least 100 acres of wooded or grassed filter strips	TSS: 11242 lbs/year

Goal	Objective	Task (linked to objectives)	Start	End	Responsible (in addition to WC)	Resources	Progress Indicators	Products	Estimated Load Reductions
	2. Install 10 acres of constructed wetlands (septic effluent and stormwater treatment)	1&2. Develop cost-share program for WRWP funds	2004	2007	Monitoring Committee	IDEM; County and State Health Departments; local Regional Wastewater District	Water quality monitoring; track acreage	At least 10 acres of constructed wetlands treating both septic effluent and storm water runoff (together or separately)	TSS: 4627 lbs/year
	3. Conduct septic system maintenance workshop	3. Identify presenter and develop education/outreach materials	2004	2007	Outreach/ Education Committee	IDEM; County and State Health Departments	Track attendance and feedback from participants	Conduct workshop, develop educational materials	
	4. Provide education on organic/chemical free practices	4. Partner with local organic/chem free producers to develop education and outreach materials	2004	2007	Outreach/ Education Committee	Local producers; Purdue Extension	Track attendance and information output	Produce and distribute educational materials to the general public	
	5. Conduct a lawn/turf management workshop	5. Have BSU students develop basic landscape plans for several lawn and garden styles 5. Partner with local greenhouses/plant growers to provide materials for installation	2004	2007	Outreach/ Education Committee	NRCS; Purdue Extension; Master Gardeners; BSU	Track attendance and feedback from participants	Conduct workshop, develop educational materials, intall practices	

Goal	Objective	Task (linked to objectives)	Start	End	Responsible (in addition to WC)	Resources	Progress Indicators	Products	Estimated Load Reductions
	6. Identify and promote drainage management options	6. Identify range of practices suitable for drainage and water quality protection	2004	2007	Outreach/ Education Committee	Surveyor; Drainage Board; Purdue Extension; NRCS	Track attendance and feedback from participants	Increase use of drainage management practices that protect drainage and water quality, consistent with the Indiana Drainage Handbook	
	7. Conduct an erosion control workshop	7. Partner with local MS4 entities to develop participant list and presenter list	2004	2007	Outreach/ Education Committee	Purdue Extension; County MS4 entities; Muncie Sanitary District	Track attendance and feedback from participants	Conduct workshop, develop educational materials	
Develop targeted methods for reducing *E. coli* levels	1. Identify sources of *E. coli* contamination	1. Research available technology/monitoring methods and select appropriate method	2004	2007	Monitoring Committee	Ball State University; U.S.Geological Survey; IDEM; Center for Watershed Protection	Evaluate monitoring program ability to accurately identify *E. coli* sources	Identify sources of local *E. coli* contamination and their relative contribution	
		2. Conduct monitoring program							
	2. Conduct septic system maintenance workshop	2. Identify presenter and develop education/outreach materials	2004	2007	Outreach/ Education Committee	IDEM; County and State Health Departments	Track attendance and feedback from participants	Conduct workshop, develop educational materials	

Goal	Objective	Task (linked to objectives)	Start	End	Responsible (in addition to WC)	Resources	Progress Indicators	Products	Estimated Load Reductions
Maintain the low temperature regime in Buck Creek	1. Protect and restore wooded riparian corridor along the primary channel	1. Partner with Muncie-Delaware County Plan Commission to develop conservation zones; Drainage Board; Surveyor	2004	2007	Monitoring Committee; DCSWCD agricultural technical	Plan Commission; County GIS Department; IDNR; Surveyor; Drainage Board	Monitor progress of zoning; track stream temperature	Conservation zones along Buck Creek	
	2. Install wooded plantings along Buck Creek	2. Identify interested landowners	2004	2009	Monitoring Committee; DCSWCD agricultural technician	NRCS; IDNR; Purdue Extension; Ball State University	Track stream temperature and planted acreage	Enhanced wooded riparian corridor along Buck Creek	
		2. Develop cost-share program for WRWP funds (tie into program stated above to increase buffer strips in ag and urban areas)							
Maintain and improve overall water quality in Prairie Creek reservoir	1. Protect and enhance the wooded and grassed buffer strip around the reservoir	1. Develop a master plan for the Prairie Creek Subwatershed	2004	2007	Muncie-Delaware County Plan Commission; Indiana-American Water Co.	Plan Commission; Delaware County GIS Department; Water Company	Creation of a completed Master Plan	Master plan for the Prairie Creek Subwatershed	
Continue to educate public on local non-point source issues and the WRWP project	1. Conduct watershed tours – highlight implementation practices	1&2. Partner with local organizations to conduct tours and give presentations, etc.	2004	2007	Outreach/ Education Committee	Local Organi-zations	Track public participation in tours and other outreach activities	Public tours, presentations, and publications	

Goal	Objective	Task (linked to objectives)	Start	End	Responsible (in addition to WC)	Resources	Progress Indicators	Products	Estimated Load Reductions
	2. Maintain public outreach campaign: newsletters, articles, presentations								
Improve TSS, stream habitat and biology in Buck Creek	1. Remove illegal rock dam at BC-6	1. Identify regulatory/permit requirements needed	2004	2007	Monitoring Committee	Surveyor;County Highway Dept. USGS (gauging station at same location); IDEM; IDNR	Determine what is needed to remove dam (regulatory)	Remove illegally placed dam	
		1. Partner with local organizations and citizens to conduct a dam removal field day							
	2. Stabilize 400 feet of stream bank upstream of BC-7	2. Determine best methods for bank stabilization	2004	2009	Monitoring Committee	IDEM; IDNR; BSU; Purdue Extension	Measure TSS, stream habitat and biology; identify any improvements	Stabilize bank at site upstream from BC-7	Sediment: 75.7 tons/year P: 64.3 lbs/year N: 128.5 lbs/year
		2. Identify regulatory/permit requirements needed							
Improve TSS, stream habitat and biology in Killbuck and Mud Creeks	1. Reengineer both stream channels	1. Conduct a feasibility study to assess possibility of conducting reengineering	2004	2009	Monitoring Committee	NRCS; IDEM; Purdue; BSU	Evaluate feasibility study results	At least a feasibility study that provides recommendations for or against further action	

7.3 Estimated Implementation Costs

The following is an estimated cost breakdown for the first three-year implementation phase of the WRWP:

<u>Personnel = $185,000</u>

Watershed Coordinator - $140,000
Agricultural Technician - $45,000

<u>Best Management Practices = $100,000</u>

Cost share for agricultural, suburban and urban on-ground practices - $75,000
(buffer strips [avg. $150/acre], manure/nutrient mgmt, grassed buffers, reduced tillage)
Constructed wetlands = $15,000
Tile flow systems = $10,000

<u>Outreach and Education (includes in-house expenses) = $50,000</u>

Conferences and Workshops (lawn/turf mgmt., septic, drainage, erosion) - $15,000
Community outreach and education programs – $30,000
Watershed Tours (2) - $5,000

<u>Land Use Planning = $15,000</u>

Master plan (Prairie Creek) and zoning development (Buck Creek) - $15,000

<u>Monitoring = $50,000</u>

E. coli sourcing program - $25,000
Baseline water quality, biology and stream habitat - $20,000
Update GIS layers - $5,000

Note: Estimations based on average costs per activity, known salary requirements, and review of expenses from the initial planning phase of the WRWP.

7.4 Funding Sources

Funding for the implementation phase of the White River Watershed Project shall come from the following sources (for further information on these and other funding sources, see Chapter 9):

Clean Water Act Non-Point Source, Section 319 Grant = $400,000
($300,000 is cash with a mandatory match of $100,000 in cash or in-kind services)

Ball Brothers Foundation = $10,000

George and Frances Ball Foundation = $10,000

Community Foundation of Muncie and Delaware County = $10,000

In-Kind Commitment from the Local Community = $70,000

7.5 Implementation Action Responsibilities and Regulatory/Legal Needs

All actions shall be carried out under the direction of the DCSWCD and their representatives. Maintenance of BMPs installed by landowners shall be the responsibility of those parties that own the land on which the practice(s) are installed upon. 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. All necessary permits, easements, landowner agreements, land acquisition, or other legal actions that are necessary to implement above listed actions shall be determined prior to any such actions being taken. All participation in the WRWP program is strictly voluntary, thereby being a result of the willingness of the individual/organization.

CHAPTER 8

MEASURING SUCCESS

The success of the previously listed implementation actions shall be monitored using a variety of methods, dictated by the specific action being measured. Below are listed the types of measurements suggested for use

8.1 Best Management Practices

Tracking of participation by landowner, acreage, and type of practice shall be used to measure the success of the implementation of this set of actions. Monitoring shall be conducted of parameters such as TSS, nitrates, orthophosphates, *E. coli,* ammonia, stream biology and habitat in order to identify any changes resultant from practices implemented (with pollutant load reductions being part of those calculations). 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.

8.2 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.

8.3 Land Use Planning

The creation and adoption of a Prairie Creek Subwatershed Master Plan and the development and adoption of riparian corridor zoning standards in the Buck Creek Subwatershed shall be the measures of success for this portion of the plan.

8.4 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 1) the implementation of an *E. coli* source identification program and 2) 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, ammonia, nitrate, orthophosphate, DO, *E. coli,* biology and stream habitat. *3*) Digitization of new aerial photography and implemented practices into GIS data layers. Details of these programs shall be determined prior to their implementation, with the appropriate QAPP revisions submitted and approved. Load reductions for all parameters shall be calculated as the program progresses. Data collected through this program shall be used to examine improvements in water quality.

CHAPTER 9

PRACTICAL MATTERS

9.1 Contact Information

For a copy of this management plan, or any other White River Watershed Project information, please contact:

Watershed Coordinator
Delaware County Soil and Water Conservation District
White River Watershed Project
3641 North Briarwood Lane
Muncie, IN 47304-5227
Phone: 765-747-5531, ext. 3
Fax: 765-747-5511
Website: www.co.delaware.in.us/watershed/

9.2 Plan Distribution

This plan shall be distributed in a manner that makes it available to as many interested citizens as possible. The final plan shall be made available digitally on the project web site (pdf format, downloadable by Chapter). It shall be available in print at all Delaware County Library branches and the Delaware County Soil and Water Conservation District Office. Copies may be requested and picked up at the Delaware County Soil and Water Conservation District Office (a nominal fee may be applied for personal copies in order to cover cost of printing). Additional copies shall be made available for public consumption as locations are suggested.

9.3 Evaluation and Adaptation of the WRWP Management Plan

The Delaware County Soil and Water Conservation District, as grant holder, shall be responsible for updating the WRWP Management Plan. This shall be accomplished with guidance from the public under the supervision of the designated Watershed Coordinator. This plan shall be updated no later than the completion of the first three-year implementation phase of this project. During said update, it will be determined what, if any, further or revised actions should be taken to move forward with the reduction and elimination of local sources of non-point source water pollution in the three studied subwatersheds. Such decisions shall be made in conjunction with stakeholders from each subwatershed, as well as other members of the public, as has been the case with the planning phase of this project.

9.4 Future TMDL Involvement

It is anticipated that several new and continuing TMDL studies are to take place during the first three-year implementation phase of this project. As before, the WRWP will make every reasonable effort to be an active participant in that process, both to provide IDEM with local information and to utilize their findings to better guide our implementation process. The designated Watershed Coordinator shall be the official contact person for the project.

9.5 Funding Sources

The primary potential funding sources for the implementation phase of the White River Watershed Management Plan are as follows:

Clean Water Act Non-Point Source, Section 319 Grant
Administered: U.S. Environmental Protection Agency
Indiana Department of Environmental Management

Maximum Award: $400,000.00, with a 25% match from the grantee required

Application Date: Annually - October 1

Contact Information: IDEM, Department of Water Quality
Watershed Management Section
100 North Senate Avenue
P.O. Box 6015
Indianapolis, IN 46206-6015
317-233-0480

Ball Brothers Foundation
Administered: Ball Brother Foundation, Muncie, Indiana

Maximum Award: Unknown, standard request is $10,000.00

Application Date: Quarterly

Contact Information: Ball Brothers Foundation
P.O. Box 1408
222 South Mulberry Street
Muncie, IN 47308
765-741-5500

George and Frances Ball Foundation
Administered: George and Frances Ball Foundation, Muncie, Indiana

Maximum Award: Unknown, standard request is $10,000.00

Application Date: Quarterly

Contact Information: George and Frances Ball Foundation
222 South Mulberry Street
P.O. Box 1408
Muncie, IN 47308
765-741-5500

Community Foundation of Muncie and Delaware County
Administered: Muncie-Delaware Community Foundation, Muncie, Indiana

Maximum Award: Unknown, standard request is $10,000.00

Contact Information: Community Foundation of Muncie and Delaware County
201 East Jackson Street (First Floor)
P.O. Box 807
Muncie, IN 47308

Delaware County EDIT Funds
Administered: Delaware County Commissioners

Maximum Award: Unknown, standard request is $10,000.00

Contact Information: Delaware County Commissioners
100 West Main Street, Room 309
Muncie, IN 47305

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APPENDIX A

2001-2004 WRWP Event Calendar

2001

July 2001

01 Official Start Date of the WRWP

August 2001

September 2001

19 Hired Watershed Coordinator

October 2001

November 2001

01 WRWP Public Meeting – formed Steering Committee Meeting
13 Steering Committee Meeting

December 2001

11 Steering Committee Meeting

2002

January 2002

15 Steering Committee Meeting

February 2002

06 WRWP Public Stakeholder Meeting
19 Steering Committee Meeting

March 2002

13-14 WRWP Educational Booth – Delaware County Farm Festival
12 WRWP Public Stakeholder Meeting
19 Steering Committee Meeting
21 WRWP Public Stakeholder Meeting

April 2002

1 Steering Committee meeting
3 Outreach/Education Committee meeting
3 Delaware County SWCD Board meeting
5 Sub-Watershed Selection Announcement to Government Officials
9 GIS Committee meeting
11 County Commissioners project update meeting
12 Monitoring Committee meeting
15 Proposal Review Group meeting
16 Steering Committee meeting
19 Ball State Earth Day
22 Outreach/Education Committee meeting
24 Ball Brothers Foundation project update meeting

25 Jaycees – project presentation
30 Steering Committee meeting

May 2002
1 Delaware County SWCD Board meeting
2 Ball State University professor - project presentation
7 Negotiations Group meeting
9 Monitoring Committee meeting
14 Ball State University – class presentation
15 Project Announcement and Invitation to Delaware County Schools
20 Ball State University – professor workshop presentation
20 Ball State University – class presentation

June 2002
3 Ball State University – meeting with Provost
4 Steering Committee
5 Delaware County SWCD Board meeting
6 Ball State University – class presentation
12 Community Enhancement Project Committee – project presentation
18 Steering Committee meeting
18 Monitoring Committee meeting
18 Ball State University professor – project presentation
18 RiverFest organizational meeting
19 Public Radio – public presentation
21-22 WRWP Public Field Day – RiverFest at Minnetrista

July 2002
2 GIS Committee meeting
3 BSU NREM 405/505 class involvement planning meeting
3 Delaware County SWCD Board meeting
12 BSU PR class presentation
16 Soil and Water Conservation Society presentation
16 Steering Committee meeting
17 Interactive Website planning meeting
24 Indiana Water Quality Atlas workshop
25 Outreach/Education Committee meeting
29 Project meeting with Jim Dunaway
30 Muncie Noon Rotary project presentation
30 Organizational meeting for Sub-Watershed Committees

August 2002
1 Exchange Club project presentation
1 Watershed Exhibit organizational meeting with Muncie Children's Museum
5 Public Meeting – Prairie Creek Watershed
6 Public Meeting – Kilbuck/Mud Creek Watershed
7 Delaware County SWCD Board Meeting

8	BSU NREM 405/505 class involvement planning meeting
8	Project presentation to Boys and Girls Club (Director)
14	Outreach/Education Committee meeting
15	Project Website development meeting
16	BSU Honors project organizational meeting (student project)
17	Methodist Men's Club project presentation
19	Interpretive Sign Development meeting for Greenways project
20	Steering Committee Meeting
22	BSU NREM 405/505 project presentation
22	Public Meeting – Buck Creek Watershed
24	White River Cleanup – Yorktown
27	Buck Creek Committee meeting
28	Outreach/Education Committee meeting

September 2002
3	Outreach/Education Committee meeting
4	Monitoring Committee meeting
4	Delaware County SWCD Board Meeting
5	Watershed Exhibit development meeting – Indianapolis Children's Museum and Indy Zoo
7	Royerton Pork Roast – project information booth for Kilbuck/Mud Creek Watershed
7	Level 1 Hoosier RiverWatch Training
10	BSU Honors project development meeting
10	Kilbuck/Mud Creek Committee meeting
11	BSU Interactive Web Site development meeting
12	Watershed Exhibit development meeting – Children's Museum
13	Cowan Fish Fry – project information booth for Buck Creek Watershed
16	Watershed Exhibit development meeting
17	BSU Marketing class project presentation
18	Monitoring Committee meeting
20	BSU Interactive Web Site development meeting
23	Indiana Water Quality Atlas follow-up meeting
24	Buck Creek Committee meeting
25	Prairie Creek watershed video tour – biological sampling sites
27	BSU UniverCity – 3 class presentations and a project information booth

October 2002
1	IDEM TMDL Meeting – White River (*E. coli*)
3	Delaware County SWCD Board meeting
4	Timeline Development Meeting
6	Environmental Group Picnic
7	Buck Creek Watershed Sample Site Tour and Video
9	Muncie-Delaware Clean and Beautiful Awards Ceremony
10	Project Video Meeting (Dr. VanMeter)
10	Outreach/Education Committee Meeting
15	Steering Committee Meeting
16	Regional Planning Class Presentation

17 American Fisheries Society Presentation
23 Killbuck/Mud Creek Watershed Sample Site Tour and Video
23 Prairie Creek Watershed Committee Meeting
24 Buck Creek Watershed Committee Meeting
24 GIS Committee Meeting
28 Center On The Environment (COTE) Presentation – Amy Sheaffer
29 Project Progression Meeting
29 Killbuck/Mud Creek Watershed Committee Meeting
31 Board of Supervisors Executive Session: First Monitoring Report

November 2002
1 Technical (Monitoring) Committee Meeting Committee
6 Delaware County SWCD Board Meeting
7 MS4 Meeting
7 Legislative Tour Presentation
13 Muncie On The Move Presentation: Amy Sheaffer
13 Prairie Creek Watershed Committee Meeting
14 Upper White River Watershed Alliance Annual Meeting
15 Advisory Committee Organizational Meeting
18 Project Planning Meeting
20 GIS Day Project Presentation
20 Steering Committee Meeting
21 Watershed Exhibit Organizational Meeting: Muncie Children's Museum
26 Interactive GIS Website Planning Meeting
27 Watershed Exhibit Organizational Meeting: Muncie Children's Museum

December 2002
3 NREM Class Presentations of WRWP Projects
10 MS4 Meeting
12 Advisory Committee Meeting
13 Outreach/Education Committee Meeting
13 Community Center Presentation Meeting
16 COTE Presentation: Amy Sheaffer
17 Land Use Identification Meeting with Buck Creek Citizen

2003
January 2003
1/06-8 IASWCD Annual Conference
1/09 IRDIP Organizational Meeting
1/14 Prairie Creek Committee Meeting
1/22 IRDIP Organizational Meeting
1/23 Delaware County SWCD Annual Meeting
1/27 Outreach/Education Committee Meeting

February 2003
2/05 Delaware County SWCD Board Meeting
2/07 BSU Class Presentation – Prof. Martha Hunt, School of Architecture

2/13 Upper White River Watershed Alliance Meeting
2/20 WRWP Video Development Meeting – Dr. Donald VanMeter
2/20 Steering Committee Meeting
2/24 Outreach/Education Committee Meeting
2/26 Monitoring Committee Meeting
2/26 IDEM Quarterly Site Visit
2/28 Indiana GIS Award Luncheon

<u>March 2003</u>
3/03 GIS/Monitoring Combined Committee Meeting
3/05 Delaware County SWCD Board Meeting
3/07 WRWP Video Development Meeting – Dr. Donald VanMeter
3/10 Outreach/Education Committee Meeting
3/12 Outreach/Education and Sub-Watershed Combined Committee Meeting
3/14 Sunrise Rotary Presentation
3/19-20 Farm Festival
3/26 Steering Committee Meeting
3/28 Monitoring Committee Meeting
3/28 WRWP Video Production Meeting
3/31 Ground Truthing Watershed Tour with Monitoring and GIS Committees

<u>April 2003</u>
4/02 Delaware County SWCD Board Meeting
4/4-5 Indiana Lakes Management Conference
4/07 Outreach/Education Meeting
4/10 Meeting with IDEM on Non-Point Pollution Indicators
4/11 Monitoring Committee Meeting
4/14 Meeting with the Hamilton Township Fire Company – project advertising
4/17 Earth Day Presentation at Minnetrista, with Nataki Osborne
4/22 Ball State University Earth Day Celebration
4/23 Steering Committee - Advisory and Watershed Committees Invited
4/24 Meeting with Ball State University Regarding Website Contract

<u>May 2003</u>
5/07 GIS Committee Meeting with Rick Conrad (Monitoring Program Biologist)
5/08 Monitoring and GIS Combined Committee Meeting
5/08 Brainstorm Session for Watershed Tour
5/14 Delaware County SWCD Board Meeting
5/20 TMDL Public Meeting
5/21 White River Watershed Poker Run Organizational Meeting
5/28 Quarterly Site Visit with Jody Arthur
5/28 Watershed Presentation at BSU Green for Green Workshop
5/28 Steering Committee Meeting
5/29 Connecting Ohio's Watersheds Conference Presentation Organizational Meeting
5/30 Meeting with John Motloch, BSU Land Design Institute – partnership opportunities

<u>June 2003</u>

6/3-4 Connecting Ohio's Watersheds WMAO Conference – WRWP Presented on 6/4
6/05 Buck Creek Committee Meeting
6/09 Prairie Creek Committee Meeting
6/11 Delaware County SWCD Board Meeting
6/16 Outreach/Education Committee Meeting
6/17 Indiana Water Quality Atlas Meeting
6/18 Presentation for BSU, Center for Economics Education
6/19 WRWP Video Interview Session
6/21 Normal City Fly Fishing Derby – WRWP was a Sponsor
6/25 Steering Committee Meeting – Advisory and Watershed Committees Invited
6/28 White River Watershed Poker Run – Watershed Tour
6/30 Quarterly Newsletter Completed

July 2003
02 Delaware County SWCD Board Meeting
09 Monitoring Committee Meeting
11 Financial Review with Shareen Goldman, SWCD
16 Quarterly Site Visit – Jody Arthur, IDEM
21 GIS Committee Meeting
22 Project Development Meeting – John Motloch, BSU
23 Public Meeting (August 13) Preparatory Meeting – Phil Tevis and Mitty Barnard
23 Project Video Taping Session – Dr. Donald VanMeter, BSU
28 Public Meeting (August 13) Preperatory Meeting – Phil Tevis
29 Watershed Exhibit Grant Development Meeting with Muncie Children's Museum
29 Video Taping Session – Dr. VanMeter & Phil Tevis

August 2003
06 Delaware County SWCD Board Meeting
08 Monitoring Committee Meeting
12 WRWP Presentation – Gethsemane United Methodist Church
13 WRWP Public Meeting
19 Upper White River Watershed Alliance GIS Project Meeting – Polis Center, Indianapolis
25 Project Meeting – Jody Arthur, IDEM
25 Video Taping Session – Dr. VanMeter and Art Hall
27 WRWP Steering Committee Meeting

September 2003
02 Project Meeting – Douglas Bakken, Ball Brothers Foundation
03 Delaware County SWCD Board Meeting
04 Monitoring Committee Meeting
08 Southside Muncie Redevelopment Meeting, Environmental Breakout Group
09 Project Development – Marta Moody, County Plan Commission & John Motloch, BSU
12 Project Development – Barry Banks, Redtail Conservancy
15 Project Development – Barry Banks, Redtail Conservancy
17 WRWP Steering Committee Meeting
19 Delaware County SWCD Executive Meeting
19 Delaware County SWCD Newsletter Distributed – with WRWP Article

October 2003

01 Submitted Final 319 Application and Support Letters to IDEM
01 Delaware County SWCD Board Meetings
02 Project Update Meeting with Douglas Bakken, Ball Brothers Foundation
08 Watershed Geology Meeting, Dr. Rice-Snow and graduate student
08 Submitted Local Match Grant Requests (George and Frances Ball, Ball Brothers, Muncie-Delaware County Community Foundation)
09 Cardinal Environmental Network
15 This Land Is Our Land presentation development with Delaware Greenways
17 Ball State University Landscape Architecture student projects review, Prof. Anne Hoover
21 This Land Is Our Land presentation at Carnegie Library with Delaware Greenways
21 Indiana Water Quality Atlas Meeting
21 Golden Broom Awards
22 Steering Committee Meeting
23 Cardinal Environmental Network
27 Video Shoot of Don Black with Dr. Donald VanMeter, BSU
28 BSU class presentation and watershed tour, Dr. Rice-Snow
29 GIS Committee Meeting

November 2003

03 Project Update and Grant Application Review, Jud Fisher with Ball Brothers
05 Outreach/Education Committee Meeting
07 Video Shoot of Hugh Brown with Dr. VanMeter
11 Video Shoot of Rich Huyck, Rick Conrad, etc. with Dr. VanMeter
12 WRWP Presentation for Pheasants Forever in Carmel
17 WRWP Presentations (3) at Wapahani High School
18 Outreach/Education Committee
19 Delaware County SWCD Board Meeting
19 Steering Committee Meeting
25 Project Update with Nathan Rice, IDEM Project Manager
25 Minnetrista Affiliate Meeting

December 2003

01 Video Editing with Dr. VanMeter
03 Delaware County SWCD Board Meeting
03 Video Editing with Dr. VanMeter
04 Upper White River Watershed Alliance Meeting
04 Brownfields Taskforce Meeting
04 TMDL Public Meeting
05 John Craddock wetland ribbon cutting ceremony
08 Project Study meeting with Dr. Linda Prokopy, Purdue University
08 Video Editing with Dr. VanMeter
11 Video Editing with Dr. VanMeter
12 Quarterly Monitoring Report Meeting with Dr. Brown and graduate students
12 BSU White River Greenways Plan Review
16 Swanfelt Ditch Watershed Steering Committee Meeting, Madison County
29 Project Update meeting with BSU

2004

January 2004

05-07 IASWCD Annual Meeting
06 Delaware County SWCD Board Meeting
08 Brownfields Taskforce Meeting
09 Project Brainstorming Session – Phil Tevis
14 Monitoring Committee Meeting
15 Plan Deliverables Meeting – Phil Tevis
15 Project Update – Doug Bakken
15 Project Update – John Craddock
16 WRWP Presentation – Sunrise Rotary
19 Outreach/Education Meeting
22 Project Update Meeting – John Craddock
28 Steering Committee Meeting
29 Delaware County SWCD Annual Meeting

February 2004

02 Outreach/Education Meeting
04 Delaware County SWCD Board Meeting
04 Video Development Meeting – Dr. VanMeter
06 Project Wet! Training Session – Outreach/Education Committee
09 GIS Committee Meeting
13 IRDIP Program Meeting
17 Project Update – Phil Tevis
18 Monitoring Committee Meeting
20 WRWP Presentation – Spray Applicators Workshop
24 Project Update – Doug Bakken
25 Steering Committee Meeting

March 2004

02 Project Update and Tree Planting Project Planning Meeting – Phil Tevis, Jim Reece
03 Delaware County SWCD Board Meeting and Executive Session
08 Quarterly Site Visit – Nathan Rice
09 Steering Committee Meeting
09-10 Delaware County Farm Festival
11 Outreach Project Meeting – Green3
26 Landowner Meeting – Killbuck/Mud Creek Monitoring Information
26 Volume Five of the WRWP Newsletter Submitted
29 Project Update – Phil Tevis, Don Black
30 Purdue University Study Interview
30 WRWP Presentation – Purdue Career Panel
31 Project Update and Brainstorming Session – Phil Tevis
31 Greenmap Meeting

April 2004

4/07 Monitoring Committee Meeting
4/07 SWCD Board Meeting
4/07 WRWP Steering Committee Meeting
4/08 Brownfileds Taskforce Meeting
4/08 WRWP Presentation - Kiwanis
4/21 *Restore the River* Tree Planting Preparation
4/21 Video review – Dr. VanMeter
4/22 BSU Earth Day Celebration
4/23 *Restore the River* Tree Planting Prep – Delaware Greenways
4/23 WRWP Informational Booth Meeting – Sierra Club
4/24 *Restore the River* Tree Planting Project
4/27 Buck Creek Committee Meeting
4/28 Prairie Creek Committee Meeting
4/28 WRWP Steering Committee Meeting
4/29 Center for Economic Education Meeting
4/29 Eleventh Quarterly Report Distributed to IDEM
4/29 IDEM Project Update Meeting – Nathan Rice
4/29 Killbuck/Mud Creek Committee Meeting
4/29 EnviroScape Presentations - Muncie Children's Museum

May 2004

5/12 Green Map Meeting
5/20 SWCD Executive and Board Meetings
5/20 WRWP Presentation – Sierra Club
5/26 Green for Green, BSU, Panel Discussion
5/27 WRWP and Mississinewa Presentation – Minnetrista

June 2004

6/02 Delaware County SWCD Board Meeting
6/05 Delaware Greenways Depot Grand Opening (6/05 only)
-06 and Garden Spectrum at Minnetrista - WRWP Field Days
6/23 Environment, Economics, and Education Teacher Training – WRWP Presentation
6/26 WRWP and Mississinewa Minne-Trip – WRWP Watershed Tour

APPENDIX B

Geographic Information Systems Subwatershed Soils Analysis

Geographic Information Systems (GIS) was utilized to summarize the soils present in the three subwatersheds. An ArcInfo version of ArcGIS 8.3 software was used in conjunction with the Natural Resources Conservation Service (NRCS) 1999 Soil Survey Geographic Database (SSURGO) digital soil survey of Delaware County, Indiana. The digital soil survey was projected to the Universal Transverse Mercator (UTM) North American Datum (NAD) 1983 zone 16N coordinate system. The NRCS SSURGO soil features and water features tables were joined to the Delaware county soil's polygon layer based on a common table attribute. The table attribute, MUSYM, which indicates the soil map units, was utilized for the basis of the table joins. The individual subwatershed boundaries were each clipped to the soil polygons that are within their respective boundaries. Each subwatershed, which contained only the soil polygons present within their boundaries, were turned into feature classes and saved into a personal geodatabase. The subwatersheds soils were summarized for their soil map units, soil component (series) names, hydrologic soil groups, drainage classes, soil textures, K factors, and T factors. The summarized tables were exported out of ArcGIS 8.3 and imported into Microsoft Excel files for further data summarization.

Each soil map unit has an assigned soil component (series) name, hydrologic soil group, drainage class, soil texture, K factor, and T factor. The soil map units were summarized for their individual acreage, hectares and ratio of their individual area by the total area in each subwatershed.

The soil map units represent an area dominated by one major kind of 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). The soil component names represent the series, taxonomic unit, or miscellaneous area of the soil map unit.

The hydrologic soil groups are assigned by the groups A, B, C, or D. Hydrologic soil groups are defined as 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.

Hydrologic Soil Group Descriptions

Hydrologic Soil Groups	Infiltration Rate/Runoff Potential when thoroughly wet	Drainage	Soil Texture	Rate of Water Transmission
A	High/Low	Very deep, well drained to excessively drained	Sands or gravelly sands	High
B	Moderate/Moderate	Moderately deep or deep, moderately well drained, well drained	Moderately fine to moderately coarse	Moderate
C	Slow	Has layer that impedes downward movement of water	Moderately fine or fine	Slow
D	Very slow/High	Has permanent high water table, claypan or clay layer at or near surface, or shallow over nearly impervious layer	Clayey soil that have high shrink-swell potential	Very slow

The soil drainage classes identify the natural drainage condition of the soil and refer 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). The well drained soils have a seasonal water table greater than 40 inches. Moderately well drained soils have a seasonal water table between 20 inches to 40 inches. Somewhat poorly drained soils have a seasonal water table from 10 inches to 20 inches. Poorly drained soils have a seasonal water table of less than 10 inches and very poorly drained soil's seasonal water table is near the surface.

The soil textures are relative proportions of various soil separates. The soil separates include sand, silt, and clay. Sand sized particle range from 2.00 to 0.05 millimeters (mm), silt ranges from 0.05 to 0.002 mm, and clay sized particles are less than 0.002 mm in diameter. The soil textures include loam, silt loam, silty clay loam, clay loam, clay, muck, mucky silty clay, stratified sand to very gravelly coarse sand, etc.

Soil K factors indicates the susceptibility of a soil to sheet and rill erosion by water. It is 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). The soil T factors are 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).

Indiana Endangered and Threatened Species List

November 16, 1999

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM DELAWARE COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
VASCULAR PLANT					
CAREX ALOPECOIDEA	FOXTAIL SEDGE	SE	**	S1	G5
GLYCERIA BOREALIS	SMALL FLOATING MANNA-GRASS	SE	**	S1	G5
MATTEUCCIA STRUTHIOPTERIS	OSTRICH FERN	SR	**	S2	G5
SILENE REGIA	ROYAL CATCHFLY	ST	**	S2	G3
TRICHOSTEMA DICHOTOMUM	FORKED BLUECURL	SR	**	S2	G5
TRIFOLIUM STOLONIFERUM	RUNNING BUFFALO CLOVER	SE	LE	S1	G3
VALERIANELLA CHENOPODIIFOLIA	GOOSE-FOOT CORN-SALAD	SE	**	S1	G5
VERONICA ANAGALLIS-AQUATICA	BROOK-PIMPERNELL	ST	**	S2	G5
WISTERIA MACROSTACHYA	KENTUCKY WISTERIA	SR	**	S2	G5
MOLLUSCA: BIVALVIA (MUSSELS)					
ALASMIDONTA VIRIDIS	SLIPPERSHELL MUSSEL	**	**	S2	G4G5
EPIOBLASMA TORULOSA	RANGIANA NORTHERN RIFFLESHELL	SE	LE	S1	G2T2
LAMPSILIS FASCIOLA	WAVY-RAYED LAMPMUSSEL	SSC	**	S2	G4
PLEUROBEMA CLAVA	CLUBSHELL	SE	LE	S1	G2
PLEUROBEMA CORDATUM	OHIO PIGTOE	SSC	**	S2	G3
PTYCHOBRANCHUS FASCIOLARIS	KIDNEYSHELL	SSC	**	S2	G4G5
TOXOLASMA LIVIDUS	PURPLE LILLIPUT	SSC	**	S2	G2
TOXOLASMA PARVUM	LILLIPUT	**	**	S2	G5
VILLOSA FABALIS	RAYED BEAN	SSC	**	S1	G1G2
REPTILES					
CLEMMYS GUTTATA	SPOTTED TURTLE	SE	**	S2	G5
CLONOPHIS KIRTLANDII	KIRTLAND'S SNAKE	SE	**	S2	G2
EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	SE	**	S2	G4
SISTRURUS CATENATUS	CATENATUS EASTERN MASSASAUGA	SE	**	S2	G3G4T3T4
THAMNOPHIS BUTLERI	BUTLER'S GARTER SNAKE	SE	**	S1	G4
BIRDS					
ARDEA HERODIAS	GREAT BLUE HERON	**	**	S4B,SZN	G5
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	SE	**	S2B	G4
LANIUS LUDOVICIANUS	LOGGERHEAD SHRIKE	SE	**	S3B,SZN	G5
NYCTANASSA VIOLACEA	YELLOW-CROWNED NIGHT-HERON	SE	**	S2B	G5
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	SE	**	S1B,SAN	G5
RALLUS ELEGANS	KING RAIL	SE	**	S1B,SZN	G4G5
MAMMALS					
LYNX RUFUS	BOBCAT	SE	**	S1	G5
MYOTIS SODALIS	INDIANA BAT OR SOCIAL MYOTIS	SE	LE	S1	G2
TAXIDEA TAXUS	AMERICAN BADGER	SE	**	S2	G5

November 16, 1999

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM DELAWARE COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
HIGH QUALITY NATURAL COMMUNITY					
FOREST - FLATWOODS CENTRAL TILL PLAIN	CENTRAL TILL PLAIN FLATWOODS	SG	**	S2	G3

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but
rarity warrants concern
FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered,
PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

(Indiana Dept. of Natural Resources, Division of Nature Preserves. 1999. List of Endangered, Threatened and Rare Species – Delaware County. http://www.state.in.us/dnr/naturepr/species/index.html.)

APPENDIX C

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) Archival for Delaware County

EPA ID	Site Name	City	NPL Status
IND984898577	ALBANY METAL TREATING (AMT)	ALBANY	N
IND982071177	ALTCO INCORPORATION	MUNCIE	N
IND000810713	BALL CORPORATION	MUNCIE	N
IND981957202	BALL RD DUMP	MUNCIE	N
IND981199037	BENNINGTON DUMP	MUNCIE	N
IND982071185	BRADY STREET DUMP #2	MUNCIE	N
IND006055032	BRODERICK COMPANY, INC.	MUNCIE	N
IND035878685	BURLINGTON MOBILE HOME PK	MUNCIE	N
IND981957053	DUMP	MUNCIE	N
IND984984385	EATON ROAD LANDFILL	MUNCIE	N
IND094470028	ENGINUITY, INCORPORATED	ALBANY	N
IND980607949	ESSEX GROUP INC	MUNCIE	N
IND984869735	FEENEY'S FARM	MUNCIE	N
IND980678098	FOSTER'S LANDFILL	MUNCIE	N
IND000806877	GMC DELCO REMY DIV	MUNCIE	N
IND081523714	HICKORY HAVEN MOBILE HOME PARK	MUNCIE	N
IND981957061	HODSON ST DUMP	MUNCIE	N
IND006066286	HYDRAMATIC DIV. OF GM	MUNCIE	N
IND984903492	INDIANA MICHIGAN POWER PLANT	MUNCIE	N

EPA ID	Site Name	City	NPL Status
IND980605851	METROPOLITAN SANIATRY LANDFILL	ALBANY	N
IND980607923	METROPOLITAN SANITARY LANDFILL	MUNCIE	N
IND984895136	MILLER BATTERY SITE	DALEVILLE	N
IND981957095	MISSISSINEWA RIVER LANDFILL	MUNCIE	N
IND984869784	MT PLEASANT ROAD SITE	MUNCIE	N
IND981787401	MUNCIE AVIATION	MUNCIE	N
IND981957103	MUNCIE FOUNDRY SAND DUMP	MUNCIE	N
IN0001118710	MUNCIE RECLAMATION	MUNCIE	N
IND092017698	MUNCIE RECLAMATION & SUPPLY CO	MUNCIE	N
IND980677900	NO NAME LDFL	MUNCIE	N
IND980678247	NO NAME LDFL	MUNCIE	N
IND102227246	ONTARIO FORGE CORP	MUNCIE	N
IND981957137	PHILLIPS LAKE #1	MUNCIE	N
IND981957145	PHILLIPS LAKE #2	MUNCIE	N
IND981957152	SCHAFER PROPERTY	MUNCIE	N
IND079589628	SHELLER-GLOBE CORPORATION	MUNCIE	N
IND984867499	SHROYER DUMP	MUNCIE	N
IND981199060	SHUTTLEWORTH DUMP	MUNCIE	N
IND981957186	SIEFERT DUMP	MUNCIE	N

IND041855776	INDIANA STEEL & WIRE COMPANY	MUNCIE	N	IND006066955	STOUT STORAGE BATTERY CORP.	MUNCIE	N
IND980677892	INDIANA STEEL & WIRE LABDFILL SITE III	MUNCIE	N	IND981199086	TEAL'S FILL	MUNCIE	N
IND981957087	JACKSON STREET DUMP SITE	MUNCIE	N	IND984873141	THORNBURGH SLUDGE DUMP	ALBANY	N
IND016541351	JORDAN PAPER PRODUCTS INC	MUNCIE	N	IND981199094	VOLLMAR FILL AREA	MUNCIE	N
IND079568515	KEESLING LEROY FARMS	MUNCIE	N	IND981199102	WASHINGTON SCHOOL AREA DUMP	MUNCIE	N
IND981199052	LENNINGTON AREA DUMP	MUNCIE	N	IND982071201	WILLARD MEMORIAL DRIVE DUMP	MUNCIE	N

(U.S. Environmental Protection Agency, Superfund Program, http://www.epa.gov/enviro/html/cerclis/cerclis_query.html)

LUST Leaking Underground Storage Tanks in Delaware County

P = priority: high, medium and low

= High Priority

Incident#	Facility	Name	Street Address	City	Zipcode	Name	P	Description
199811570	7083	Abb Power T&D Company Inc	3500 S Cowan Rd	Muncie	47302	ABB Power T&D Company Inc	M	Soil; Groundwater
199010587	20796	Albany Boat Sales	480 W Walnut	Albany		Albany Boat Sales	L	Soil
199105549	17814	Albany Liquor Inc	1012 W State St	Albany	47320	Albany Liquors	L	Soil
199204509	20285	Albany Machine Shop	248 N Broadway	Albany	47320	Albany Machine Shop	M	Soil; Groundwater
199101559	1283	Asher Corporation	4500 S Madison	Muncie	47302	Former Muncie Truck Center	L	Soil
199510534	16605	Ball State University	3401 N Tillotson Ave	Muncie	47306	Ball State University Garage	L	Soil
199110543	2478	Borg Warner Automotive, Dtpc	5401 Kilgore Avenue	Muncie	47304	Borg-Warner Automotive	L	Soil
198912535	2768	Broderick Co	500 Lincoln St	Muncie	47302	Brodemick Corp	L	Soil
199607519 199108534	13454	Bypass Marathon	3908 E Jackson	Muncie	47303	Marathon Unit #3121	H M	Soil; Groundwater; MTBE; Free Product, Vapors
199407530	19030	Caar Inc	1500 W Mcgalliard Rd	Muncie	47304	Stoops Buick Toyota/Vacant Lot	L	Soil
199804517	22698	Cardinal Greenway	Washington & Lincoln	Muncie	47305	Cardinal Greenway	L	Soil
199805525 199202086	29302933	Clark Oil & Refining #1601	308 S Tillotson	Muncie	47304	Clark Store #1601	M	Soil; Groundwater
199905517	4921	David Kistler	2801 W Jackson	Muncie	47304	David Kistler	H	Soil; Groundwater; MTBE; Free Product, Vapors
199011506	20456	Delaware Trucking Co	418 W. Powers	Muncie		Delaware Trucking Co	L	Soil
199101513	6771	Emro Marketing United #6042	1301 E Jackson St	Muncie	47303	United Oil # 6042	M	Soil; Groundwater; MTBE
199806501	13417	Feeny Mfg Co	2517 S Macedonia St	Muncie	47302	Feeny Mfg Co	L	Soil
200103512	24332	Ferrellgas	1115 W Walnut St	Albany	47320	Ferrellgas	L	Soil

199402136	18899	Former Bell Brothers Foundation	311 W St Joseph St	Muncie	47305	Minnestrista Cultural Center-Muncie	M	Soil; Groundwater; MTBE and Surface Water
199104532	3659	Fred Stewart Trucking	3822 N Broadway	Muncie	47303	Stewart Trucking	M	Soil; Groundwater
199004552	13430	G & C Marathon	1020 W Memorial Dr	Muncie	47302	Marathon Unit #3122	M	Soil; Groundwater
199001563	2253	G & G Oil Mcquik's Oilube	3500 Broadway Ave	Muncie	47302	G & G Oil (mc Quiks Oilube #3)	M	Soil; Groundwater
199110203	20255	G & G Oil Co	616 S Hutchinson St	Muncie	47303	G & G Oil Co	L	Soil
199808514	2261	G & G Oil Co Bulk Plant	220 E Centennial Ave	Muncie	47303	G & G Oil Co Of Ind	M	Soil; Groundwater; MTBE
199211155 200002515	10524	Gasamerica Services Inc #14	5831 W Kilgore Ave	Muncie	47302	Gas America Station #14	H	Soil; Groundwater; MTBE and Surface Water
199101535 200004507	17298 10534	Gasamerica Services Inc #30	3300 E Jackson St	Muncie	47305	Monoil Indiana Inc	M	Soil; Groundwater; MTBE
199406503	10540	Gasamerica Services Inc #41	15801 W Commerce Rd	Daleville	47334	Station 41	H	Soil; Groundwater; MTBE; Free Product, Utility Lines
200201508	10520	Gasamerica Services Inc #5	9300 W Smith St	Yorktown	47396	Gasamerica Services Inc #5		Soil; Groundwater
199607044	2134	Goodyear Auto Service #6767	3501 N Granville	Muncie	47303	Goodyear Auto Service #6767	L	Soil
199410530	13475	Gross Service	Sr 67 & Walnut	Daleville	47334	Wise Property	H	Soil; Groundwater; Utility Lines
199304264	19316	Heat Plant	2000 W University	Muncie	47306	Ball State University	M	Soil; Groundwater
200104503	2259	Hoosier Pete #11	2535 S Hoyt Ave	Muncie	47302	Port & Hoyt Hoosier Pete	M	Soil; Groundwater; MTBE; Free Product
200106208	3307	Hoosier Pete #21	300 E Mcgalliard	Muncie	47302	Hoosier Pete #21	M	Soil; Groundwater
199905519	2255	Hoosier Pete (southside 76)	1401 E 29th St	Muncie	47302	Hoosier Pete (southside 76)	H	Soil; Groundwater; Free Product
200002508	2256	Hoosier Pete 76	Rr 3 Box 46	Royerton	47303	Hoosier Pete 76	M	Soil; Groundwater; MTBE; Free Product
199902539	2251	I 69 Auto Truck Plaza	14000 Sr 28 W	Gaston	47342	I-69 Auto/Truck Plaza	M	Soil; Groundwater
199801501	12338	Indiana State Police Dist #25	Sr 67 N Of Sr 1	Redkey	47373	Indiana State Police Dist #71	M	Soil; Groundwater; MTBEI
199508545	3393	Jefferson Smurfit Corporation	301 South Butterfield Road	Muncie	47303	Jefferson Smufit Corp	M	Groundwater
199706509	2272	Jiffy Lube	3423 S Madison St	Muncie	47302	Mcquiks Oilube	M	Soil; Groundwater
199311561	12622	Jim's Standard	1700 W Jackson St	Muncie	47303	Jimm's Standard	L	Soil
199604523	7929	Jordan Paper Products	1500 E Washington St	Muncie	47303	Jordon Paper Products	M	Soil; Groundwater; Utility Lines

199312514	10858	Key Chevrolet Inc	4101 W Clara Ln	Muncie	47302	Johnny Morris Chevrolet-Geo	M	Soil; Groundwater
199404505	6052	Louis T Ollesheimer & Sons Inc	520 E Highland Avenue	Muncie	47303	Mcguff Supply Inc.	L	Soil
199308168 199511513 199009503	6772	Marathon #6044	701 W Memorial Dr	Muncie	47302	United Station # 6044	ML	Soil; Groundwater
199612505	13157	Marathon Oil Co	811 W Jackson St	Muncie	47305	Marathon Unit #3119	M	Soil; Groundwater; Free Product
199311543	12926	Marathon Unit #3120	523 S Tillotson Ave	Muncie	47304	Marathon Unit #3120	M	Soil; Groundwater
200103511	5660	Marathon Unit 1192	Memorial And Macedonia	Muncie		Marathon Unit 1192	L	Soil
199807510 200101510	2241 2267	Marsh Village Pantry 500	715 University	Muncie	47303	Village Pantry #500	M	Soil; Groundwater; MTBE
200006500	2269	Marsh Village Pantry 566	1901 S Burlington Dr	Muncie	47302	Village Pantry #566	H	Soil; Groundwater; MTBE; Free Product
199807512	2270	Marsh Village Pantry 575	427 E Willard St	Muncie	47302	Village Pantry #575	M	Soil; Groundwater; MTBE
198910142	12147	Mcclure Oil Corp Muncie	3700 N Broadway	Muncie	47302	Mcclure Oil	M	Soil; Groundwater; Surface Water
200103515 199706508	2252	McGalliard Center Hoosier Pete	1915 W McGalliard Rd	Muncie	47304	McGalliard Center Hoosier Pete	M	Soil; Groundwater; MTBE; Free Product
199501546	15590	MDTT Corp	1701 N Broadway	Muncie	47303	Broadway Marathon	M	Soil
199811565	13241	Mr Superent	1018 W Centennial	Muncie	47303	Mr Superent	L	Soil
200010508	10646	Mt Pleasant Citco	11529 S Us 35	Losantville	47308	Mt Pleasant Citco	L	Soil
199011576	12672	Muncie Aviation Co	5201 N Walnut St	Muncie	47303	Muncie Airport	M	Soil; Groundwater
199303089 199303289	6003	Muncie Public Transprt Corp	1300 E Seymour St	Muncie	47302	Muncie Transit System	M	Soil; Groundwater
199009500	11437	Muncie Service Center	5000 Wheeling Pike	Muncie	47305	Muncie Service Center	M	Soil
199808533	3708	Muncie Unit	5400 M Old Sr 3	Muncie	47302	Muncie Unit	M	Soil; Groundwater
199512501	2093	New Venture Gear, Inc.	1200 West Eighth Street	Muncie	47307	General Motors	L	Soil
198912046	2093	New Venture Gear, Inc.	1200 West Eighth Street	Muncie	47307	Hydra Matic	M	Soil; Groundwater
199809500	5898	Old City Garage	1200 Hoyt Ave	Muncie	47305	Old City Garage	M	Soil; Groundwater
199408517	19060	Peachtree Inn	2000 N Broadway	Muncie	47305	Peachtree Inn	L	Soil
199808521	2260	Point Marathon	3308 North Wheeling Ave.	Muncie	47302	Wheeling 76	M	Soil; Groundwater
199010532	7782	Pyromet Industries Inc	801 W Riggin Rd	Muncie	47304	Pryromet Industries	M	Soil; Groundwater
198912512	18265	Sears Roebuck & Co	3501 N Granville Ave	Muncie	47304	Sears Roebuck & Co	L	Soil
199107532	20241	See Fid 19686	1705 N Walnut St	Muncie		City Of Muncie	L	Soil

199906506 199907527	144 143	Shell Dealer Muncie W Mcgalliard	105 W Mcgalliard	Muncie	47303	Shell Service Station	M	Soil; Groundwater; MTBE
199509531	6669	Speedway #6045	2300 W Kilgore	Muncie	47304	United Unit 6045	M	Soil; Groundwater
198909011	12283	Speedway #6046	2720 S Madison	Muncie	47302	United Unit 6046	M	Soil; Groundwater; MTBE
199508505	612	Speedway Unit #5005	3210 N Wheeling Ave	Muncie	47303	Speedway Unit #5005	L	Soil
200005503 199601513	617	Speedway/Sm #5013	9621 N Sr 3	Muncie	47303	Speedway Unit 5013	M	Soil; Groundwater; MTBE; Free Product
198910501	5352	Speedway/Sm #5547	1900 S Madison	Muncie	47302	Speedway Unit # 5680	L	Soil
199709533	253	Swifty Service Station #171	2410 S Madison St	Muncie	47302	Swifty Service Station #171	L	Soil
200107511	5588	Tobacco Road	3401 E Memorial Dr	Muncie	47302	Tobacco Road	M	Soil; Groundwater; MTBE
199904501	22904	Tri-Etch Inc Dda Sonitrol	433 E Charles St	Muncie	47303	Tri-Etch Inc Dda Sonitrol	L	Soil
199410555	6886	U-Haul 76467	2211 N Broadway	Muncie	47303	U-Haul #76467	L	Soil
199809519	6985	Village Pantry #374	2501 S Macedonia	Muncie	47302	Village Pantry #374	M	Soil; Groundwater
199406504	2230	Village Pantry #632	6500 Sr 67 S	Muncie	47302	Village Pantry #532	H	Soil; Groundwater; MTBE; Drinking Water
199210095	14062	Williams TravelCenters #3366	15876 W Commerce Rd	Daleville	47334	Daleville 76 Truck Stop	L	Soil

APPENDIX D

Indiana Water Pollution Control Board

Definition of the Water Pollution Control Board:
"The Water Pollution Control Board (WPCB) was established as an independent board under Indiana Code 13-18-1. State statutes provide authority for the WPCB to adopt rules regarding various water pollution matters. Indiana Code 13-18-3-2 provides the board the authority to adopt rules necessary for the implementation of the Federal Water Pollution Control Act and the Federal Safe Drinking Water Act. Indiana Code 13-18-3-1 provides the board the authority to adopt rules for the control and prevention of pollution in waters of Indiana and prevent any aquatic life or any beneficial animal or vegetable life from being destroyed or injured.
The board has eleven (11) members. The first two (2) are a technical secretary, and a legal counsel. The technical secretary and legal counsel are not voting members of the board, and may not be state employees. There are three (3) ex officio representatives on the board, who represent other state agencies and interests in water regulations. The remaining eight (8) members are representatives of various constituencies, and are appointed by the governor. The procedure the board and the department must follow in adopting rules is also set out in statute, in Indiana Code 13-14-9." (IDEM, http://www.in.gov/idem/water/planbr/rules/wpcbmembers.html)

Angling Indiana - 2004 FISH CONSUMPTION ADVISORY

Group 1 = Unrestricted consumption (at-risk population - limit consumption to 1 meal/week)*
Group 2 = Limit consumption to 1 meal/week (at-risk population - limit to 1 meal/month)*
Group 3 = Limit consumption to 1 meal/month **(at--risk population -- DO NOT EAT)***
Group 4 = Limit consumption to 1 meal/2 months **(at--risk population -- DO NOT EAT)***
Group 5 = DO NOT EAT
*At--risk populations include children under 15, pregnant or nursing women, and those women planning to have children within 6 years

County Name **River, Stream, Lake, or Reservoir Name**	**Fish Species**	**Fish Length (inches)**	**Contaminant** PCBs Hg (Mercury)	**Group (1-5)**
Delaware County				
All Indiana Rivers and Streams (unless otherwise specified)	**Carp**	15-20	PCB, Hg	3
		20-25	PCB, Hg	4
		25+	PCB, Hg	**5**
Buck Creek	Longear Sunfish	5-6	PCB	3
		6+	PCB	4
	Smallmouth Bass	14+	Hg	3
	White Sucker	14+	PCB	3
Mississinewa River	Green Sunfish	6+	PCB	3
	Rock Bass	7+	PCB, Hg	3
West Fork of WhiteRiver	Black Bullhead	9+	PCB	3
	Carpsucker	14-16	PCB	3
		16+	PCB	4
	Channel Catfish	14-16	PCB	3
		16+	PCB	4
	Largemouth Bass	10-15	PCB, Hg	3
		15+	PCB, Hg	4
	Quillback	13-18	PCB	3
		18+	PCB	4
	Smallmouth Bass	13+	PCB, Hg	3
	Spotted Sucker	11-13	PCB	3
		13+	PCB	4
	White Sucker	10-15	PCB	2
		15+	PCB	3

(Indiana Dept. of Health. 2004. 2003 Indiana Fish Consumption Advisory. http://www.state.in.us/isdh/dataandstats/fish/fish_adv_index.htm.)

APPENDIX E

Monitoring Program Methodology

Methods of sampling and analysis conform to the Quality Assurance Project Plan submitted to the IDEM (ARN # A 305-1-00-206) in June of 2002.

Physical Parameter Methods

Precipitation Measurements

Data logging precipitation gauges have been installed in all three subwatersheds to measure the timing and depth of precipitation. The precipitation gauge consists of two major components, a tipping bucket precipitation collector and a HOBO event data logger. The water enters the gauge, is funneled in a downward motion and is deposited onto the tipping bucket. The bucket tips with each 0.01 inch of rain and the water flows out of the bottom of the precipitation gauge. The data logger will record the date and time of each tip. The data loggers information was downloaded and exported using BoxCar 4.0 software.

Water Level Measurements

Two Global Water WL-15 water level loggers were installed in the Killbuck Creek and Buck Creek Subwatersheds. This instrument has a submersible sensor that is connected to a data logger housed in PVC pipe. Slits were made in the vertical portions of the PVC pipe placed in the stream to allow water to enter the pipe. The data was downloaded (using the Global Water software) to a personal computer. The data was extracted into a Microsoft Excel spreadsheet to display the difference in the water levels at a given time and day. The water level loggers are located near the Killbuck Creek subwatershed by CR 650 North and 450 West near the Cardinal Greenway and at Buck Creek subwatershed at sampling site BC-3.

Discharge Measurements

The rate of flow, or discharge, of a stream is the quantity of water flowing past a cross section of the stream in a unit of time. Discharge in the subwatersheds was accomplished by measuring the water depth and stream velocity for several stream subsections. The first step is to measure the width of a cross section in the subwatershed from bank to bank and separate the width into approximately twenty (20) subsections. An ideal cross section has uniform flow, a confined channel, a stable streambed and easy access. Subsections with shallow depths and visibly low velocity will be wider than areas with greater depths and visibly higher velocity. Sampling depth of each subsection is determined by multiplying the measured depth by 0.6. For depths greater than two and a half feet, velocity was obtained at 0.2 and 0.8 depth ratios in each subsection. These depths are used to approximate the average velocity in the stream subsection. The current/velocity meter used by Ball State University (BSU) is a Teledyne Gurley. In order to obtain current velocity, the Teledyne Gurley instrument is positioned in the appropriate level in each subsection and a cone-shaped bucket wheel on the instrument turns as the water flows past. One revolution of the bucket wheel sends an electrical impulse that is translated into an audible click. The numbers of revolutions, or clicks, are counted for sixty (60) seconds. A table is used to determine feet per second based on the rpm on a sixty (60) second time interval.

The following equation was used to calculate discharge.

$$Q = AV$$

Q = discharge (ft^3 per second)

V = velocity (feet per second)

A = area (ft^2)-subsection width times depth of subsection

Finally, the total discharge for the cross section can be calculated by summing discharges in the several subsections. English units of cubic feet per second are then converted to scientific units of cubic meters per second by multiplying by 0.028. Early discharge measurements were made at 0.6 of the depth from the bottom of the streambed. A correction factor was applied by calculating the discharge at KB-1A and BC-3 by measuring the velocity at 0.6 of the depth from the bottom of the streambed and 0.6 of the depth from the water surface. A ratio was calculated (BC = 1.19, KB = 1.22, PC = 1.22) and applied to discharge measurements in July and August of 2003. The Indiana American Water Company had opened the Prairie Creek Reservoir at PC-3 on 8/27/03 at a flow rate of 3 Million Gallons per Day (MGD) and was shut down on 10/09/03.

Chemical and Bacteriological Parameter Methods

Ambient Temperature: The outside air temperature is measured with a standard thermometer and reported in degrees Celsius.

Stream Temperature: The stream temperature is measured at each sampling location using EPA method 170.1 and reported in degrees Celsius.

Stream Temperature

Month	Ohio River Main Stem ℉ (℃)	Other Indiana Streams ℉ (℃)
January	50 (10)	50 (10)
February	50 (10)	50 (10)
March	60 (15.6)	60 (15.6)
April	70 (21.1)	70 (21.1)
May	80 (26.7)	80 (26.7)
June	87 (30.6)	90(32.2)
July	89 (31.7)	90(32.2)
August	89 (31.7)	90(32.2)
September	87 (30.7)	90(32.2)
October	78 (25.6)	78 (25.5)
November	70 (21.1)	70 (21.1)
December	57 (14.0)	57 (14.0)

Total Suspended Solids (TSS): The weight of particles that are suspended in water. The Bureau of Water Quality (BWQ) analyzed TSS using EPA method 160.2.

pH: The negative log of the hydrogen ion concentration (-log [H+]) is a measure of the acidity or alkalinity of a solution. Water pH is 7 for neutral solutions, increases with increasing alkalinity and decreases with increasing acidity. The scale range is 0-14. The BWQ analyzed pH using EPA method 150.1.

Dissolved Oxygen (DO): The amount of oxygen present in the water column. 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 as least 3-5 parts per million (ppm) of DO. The BWQ analyzed DO using method 4500-0 G from Standard Methods 18th Edition.

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. The BWQ analyzed BOD using method 5210 B, from Standard Methods 18th Edition.

Ammonia (NH_3): Ammonia (NH_3) is a colorless gas with a pungent odor. It is easily liquefied and solidified and is very soluble in water. According to the IAC, maximum unionized ammonia concentrations within the temperature and pH ranges measured for the study streams should range between approximately 0.015 and 0.21 mg/L (327 IAC 2-1-6). Toxic levels are both pH and temperature dependent. High pH increases the conversion of NH_4 to NH_3. Ammonia was analyzed by the BWQ using EPA method 350.3.

Maximum Ammonia Concentrations (Unionized Ammonia as N mg/l)

	Temperature (°Celsius)						
pH	0	5	10	15	20	25	30
6.5	0.0075	0.0106	0.0150	0.0211	0.0299	0.0299	0.0299
6.6	0.0092	0.0130	0.0183	0.0259	0.0365	0.0365	0.0365
6.7	0.0112	0.0158	0.0223	0.0315	0.0444	0.0444	0.0444
6.8	0.0135	0.0190	0.0269	0.0380	0.0536	0.0536	0.0536
6.9	0.0161	0.0228	0.0322	0.0454	0.0642	0.0642	0.0642
7.0	0.0191	0.0270	0.0381	0.0539	0.0761	0.0761	0.0761
7.1	0.0244	0.0316	0.0447	0.0631	0.0892	0.0892	0.0892
7.2	0.0260	0.0367	0.0518	0.0732	0.1034	0.1034	0.1034
7.3	0.0297	0.0420	0.0593	0.0837	0.1183	0.1183	0.1183
7.4	0.0336	0.0474	0.0669	0.0946	0.1336	0.1336	0.1336
7.5	0.0374	0.0528	0.0746	0.1054	0.1489	0.1489	0.1489
7.6	0.0411	0.0581	0.0821	0.1160	0.1638	0.1638	0.1638
7.7	0.0447	0.0631	0.0892	0.1260	0.1780	0.1780	0.1780
7.8	0.0480	0.0678	0.0958	0.1353	0.1911	0.1911	0.1911
7.9	0.0510	0.0720	0.1017	0.1437	0.2030	0.2030	0.2030
8.0	0.0536	0.0758	0.1070	0.1512	0.2135	0.2135	0.2135
8.1	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.2	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.3	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.4	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.5	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137

8.6	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.7	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.8	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
8.9	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137
9.0	0.0537	0.0758	0.1071	0.1513	0.2137	0.2137	0.2137

Nitrate + Nitrite as N: 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. Nitrate and nitrite as N was analyzed by the BWQ using EPA method 353.2.

Orthophosphate as P: Orthophosphate as P is an inorganic form of phosphorus found in natural waters and readily available to plants. This is the tested form of phosphate because it is the form of phosphate used in fertilizer and applied to agricultural fields and residential lawns. Orthophosphate as P was analyzed by the BWQ using the American Society for Testing and Materials (ASTM) method D515-88(A).

***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. *E. coli* levels were analyzed by the BWQ using the Coliscan Method by membrane filtration.

Biological and Stream Habitat Parameter Methodology

Biological communities reflect an ecosystem's overall chemical, physical and biological integrity because they are sensitive to changes in a wide array of environmental factors (EPA, 1989; Karr, 1981). The Qualitative Habitat Evaluation Index (QHEI) is composed of several metrics that describe the physical attributes of the habitat that may be important in explaining species presence or absence and composition of fish communities in a stream (Rankin, 1989). A fish community is a group of fishes belonging to a number of different species that live in the same area and interact with each other (Baker & Frey, 1997). The 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 (Rankin, 1989). Physical habitat in streams strongly influences fish community composition (Richards *et al.*, 1996). Generally, the preferred fish sampling season is middle to late summer, when stream and river flows are moderate to low and less variable than during other seasons (EPA, 1989). The Index of Biological Integrity (IBI) is composed of several metrics that are combined to produce a total 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 (Smith, 1999).

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 Invertebrate Community Index (ICI) is very similar to the Index of Biological Integrity (IBI) except it measures the health of the macroinvertebrate community. The ICI is comprised of ten metrics based on community structure that are scored 0, 2, 4, or 6 depending on how closely the results approximate least disturbed reference conditions. A score of 6 approaches the highest quality community conditions. Summation of the individual metric scores yields an ICI value between 0 and 60.

Fish sampling methods are based on the electrofishing guidelines provided by the U.S. Environmental Protection Agency and Ohio Environmental Protection Agency (OEPA). These methods were used for the determination of the Index of Biological Integrity (IBI) within the Eastern Corn Belt Plains ecoregion (OEPA, 1989; Simon & Dufour, 1997). The sampling sites indicated (QAPP, 2002) were sampled twice between June and September of 2002 and 2003. Whenever possible, the sampling sites were sampled with a tote-barge electrofishing sampler (TBS). In extremely small tributaries where a TBS is inoperable a lightweight, battery-powered backpack electrofishing (BPS) was used (QAPP, 2002). The TBS has an output of 4 to 6 amperes and the BPS unit has 0.5 to 1.5 amperes of output. Sample sites were classified as headwater (<20 square miles), wading (>20 square miles and shallow enough to wade) and boat sites (too deep to wade) (QAPP, 2002). Headwater and wading sites sampling lengths were at least 150 meters or 15 times the average width of the stream (QAPP, 2002). In the field, all fish were sorted by species and measured in one of two ways. Game fish, such as bass, bluegill, and catfish were individually measured for length and weight. Non-game species, such as minnow, suckers, and darters were mass weighed and measured for a single minimum and maximum length. Since the MIwb is not valid in headwater streams, weight measurements will not be taken at these sites to reduce unnecessary stress on the fish (QAPP, 2002). Fish under 20 mm were not included due to difficulties in reliable identification. If the identification of any fish was in question, it was preserved in 10% formalin and taken to the lab for identification (QAPP, 2002). Any endangered, threatened, or rare species were photographed and released. According to Scientific Collector's Permit regulations, the collection of any endangered or threatened species were reported to the State Endangered Species Coordinator within five business days (QAPP, 2002).

Macroinvertebrate sampling procedures are based on the guidelines provided by the OEPA for determination of the Invertebrate Community Index (ICI) scores (OEPA, 1989; EPA 1990). At each designated sampling site, 3 multi-plate samplers were placed in areas of similar flow velocity (above the 0.3 ft/sec required for ICI calculations) according to the methods of Hester and Dendy (1962) and serve as quantitative samples. The samplers were suspended and secured at similar depths and left in the stream for a period of six weeks between June and September of 2002 (QAPP, 2002). The samplers were removed and placed in bags of 100% isopropyl alcohol in the field. At the time of retrieval, a representative qualitative sample was taken using D-frame kicknets from all major habitat types present. In the lab, all organisms collected from the artificial substrates were washed through a standard #30 sieve (QAPP, 2002). The organisms were placed on a gridded pan and a random numbers table was used to select an associated grid on the pan from which to begin sorting the organisms.

The grids were sorted until at least 100 organisms were sorted. The organisms collected from the quantitative 3 multi-plate samplers were used to calculate the ICI scores and the qualitative kicknet samples were used only to provide an accurate account of the species present (QAPP, 2002).

Buck Creek Temperature Analysis

Temperature affects both biotic and abiotic variables of streams (Myrick and Cech 1998). In addition to decreasing dissolved oxygen levels, higher summer stream temperatures may affect aquatic organisms by disrupting metabolism, increasing susceptibility to toxins, increasing vulnerability to disease, and reducing food supplies. Streams may be classified in terms of their maximum average daily temperature as one of three types; coldwater (< 22 ^{o}C), coolwater (22 to 24 ^{o}C), and warmwater (> 24 ^{o}C) (Simon and Lyons 1995). Coldwater streams are typically dominated by salmonids (trout) or cottids (sculpins), coolwater streams are typically too warm to support either salmonids or cottids, and warmwater streams are most likely to support centrarchids such as, bass and bluegill (Simon and Lyons 1995).

Increased summer stream temperatures may occur as a result of many of the same human activities that are already known to negatively influence other parameters of water quality (Bartholow 2000). The absence of canopy cover reduces shading. The loss of riparian vegetation or the presence of impervious ground cover can inhibit infiltration of rainwater and increase runoff. Reduced infiltration decreases the recharge of ground water subsequently reducing the discharge of springs responsible for supplying cold water to streams during the summer. Many other microclimate characteristics that influence stream temperature may also be negatively affected as a result of riparian loss such as air temperature, humidity, wind speed, ground temperature, ground reflectivity, stream width, and stream roughness.

In 2002 and 2003, the Bureau of Water Quality collected stream temperature data from Buck Creek to examine the potential influence of ground water (springs) on the stream's fish communities. StowAway TidbiT ® data loggers recorded the water temperature every 10 minutes during the summer months to determine the maximum average daily temperature from sites along Buck Creek. In 2002, stream temperatures near the mouth of Buck Creek (Morrow's Meadow) and near Tillotson Avenue had maximum average daily temperatures of ~23 ^{o}C, while sites near the headwaters had temperatures of < 22 ^{o}C. In 2003, all sites along Buck Creek from the mouth to the headwaters had maximum average daily temperatures < 22 ^{o}C. These results suggest either a marginal coldwater or a coolwater thermal regime. The large populations of mottled sculpin collected throughout the Buck Creek further support the possibility of a coldwater stream classification. Since the Index of Biotic Integrity is calibrated for use in warmwater streams, special considerations have been made concerning the interpretation of the results of the fish community samples from Buck Creek. Further collection of temperature data from Buck Creek is planned for 2004.

The potential coldwater status of Buck Creek opens the possibility of introducing trout species. A sustainable trout population would not only provide a fishery resource that is otherwise unavailable in Delaware County, but most importantly, it would create an opportunity to provide greater protection for Buck Creek under the Indiana Administrative Code which requires streams capable of supporting the natural reproduction of trout to be maintained as such. There are no salmonid species native to the White River Watershed, therefore, and the possibility of Buck Creek successfully supporting introduced trout species would require further research.

Current data suggests that the dissolved oxygen and temperature requirements of rainbow trout and brown trout would be marginally consistent with the conditions found within Buck Creek (Wehrly et al. 1999). However, given the historical difficulties with establishing persistent salmonid populations, a thorough investigation would need to be conducted by a fisheries biologist with experience specifically related to the physical habitat requirements of salmonids before stocking could be recommended.

Regardless of whether or not trout are eventually stocked, an effort should be made to maintain or decrease stream temperatures in Buck Creek. The natural structure and function of the fish communities within this cold/coolwater stream are unique within Delaware County, and they are likely dependent on protection of the narrow riparian corridor that remains throughout most of the length of the stream. Additional protection could be provided by increasing the width of the riparian corridor along Buck Creek and its tributaries, and by limiting construction of additional impervious ground cover.

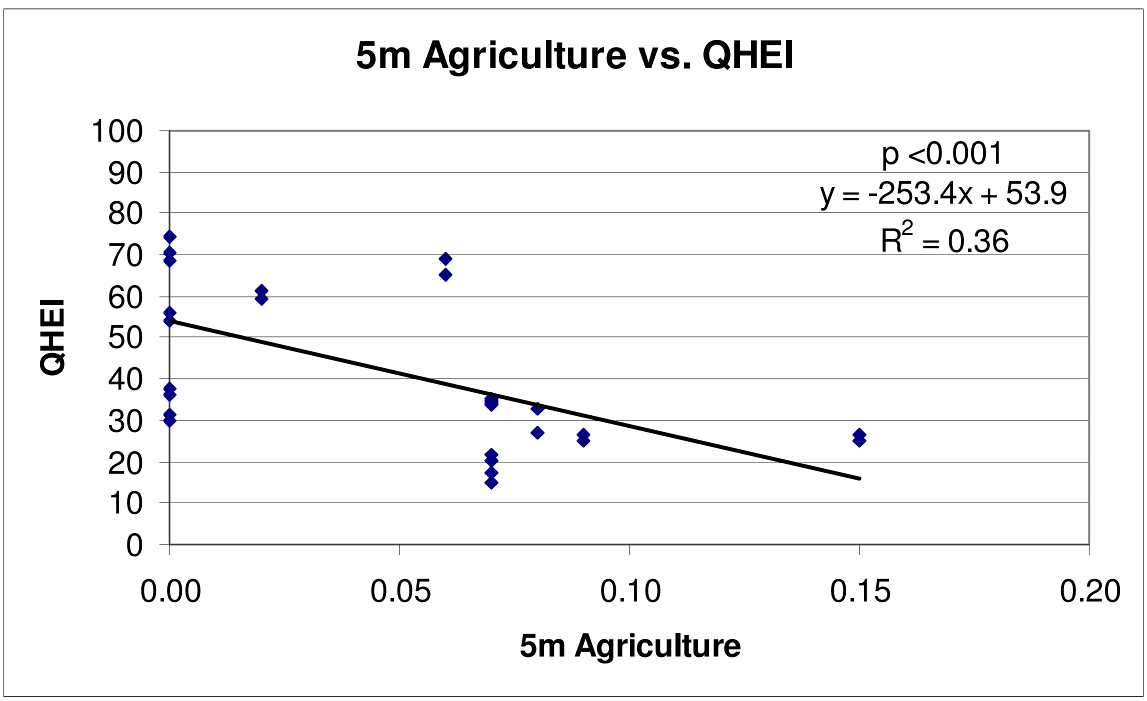
APPENDIX F

<u>Regression Analysis Tables and Graphs</u>

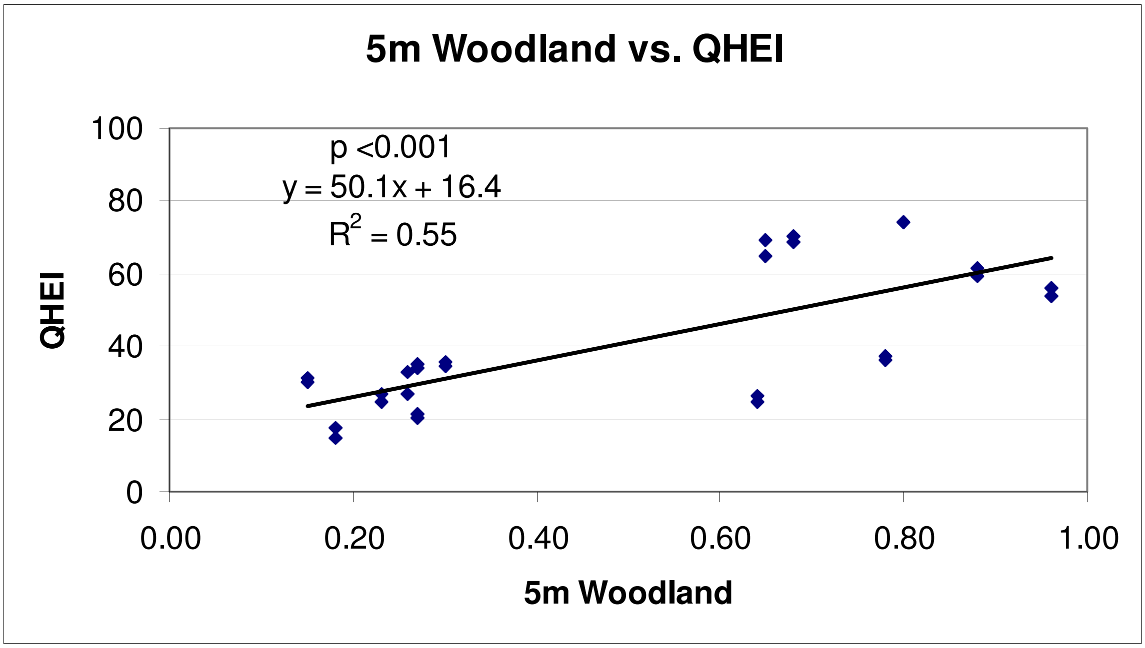
Regression Statistics for Significant Relationships between Spatial Land Use and 2002-2003 Averaged Biological Index Scores.

Independent	**Dependent**	**Probability>F (p-value)**	R^2	**Slope**	**Intercept**
5m Agriculture	QHEI	<0.001	0.36	-253.4	53.9
5m Woodland	QHEI	<0.001	0.55	50.1	16.4
30m Woodland	QHEI	0.004	0.28	48.6	27.3
Sub-sub Agriculture	QHEI	0.01	0.21	-50.2	76.4
5m Agriculture	IBI	<0.001	0.41	-87.9	33.6
5m Woodland	IBI	<0.001	0.49	15.2	21.7
30m Woodland	IBI	0.006	0.25	15.0	24.9
Sub-sub Agriculture	IBI	0.01	0.22	-16.7	40.9

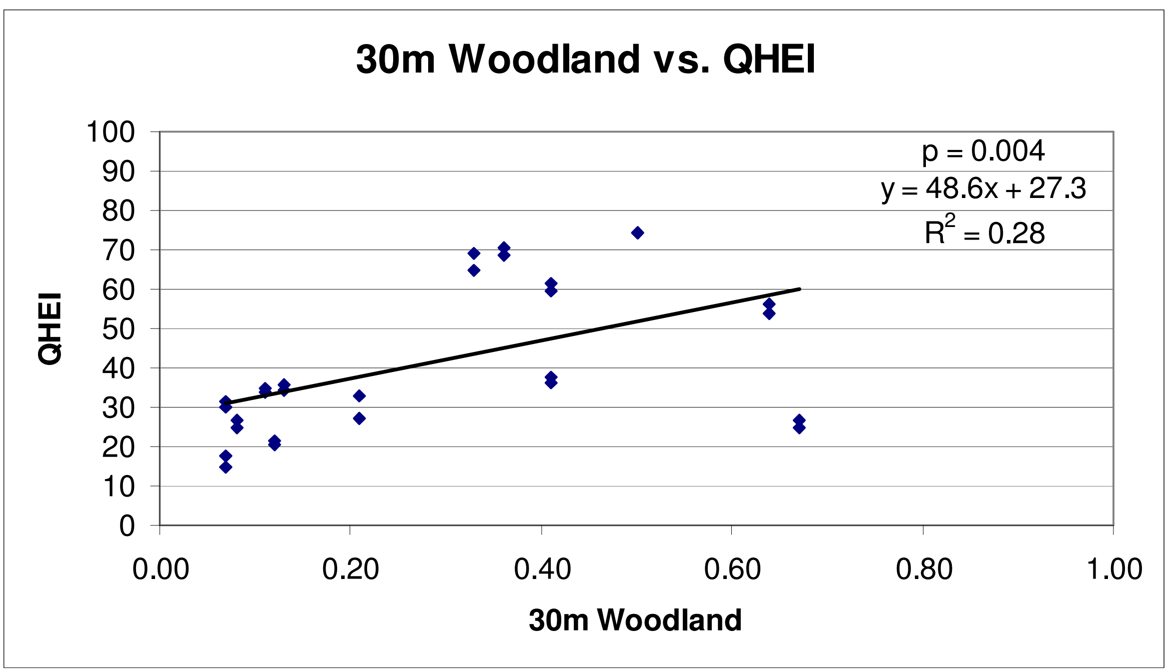
The scatterplot graphs below represent the significant relationships determined by the regression analyses. In addition to the scatter plot, a trendline has been added showing the equation and R^2 value for the line.



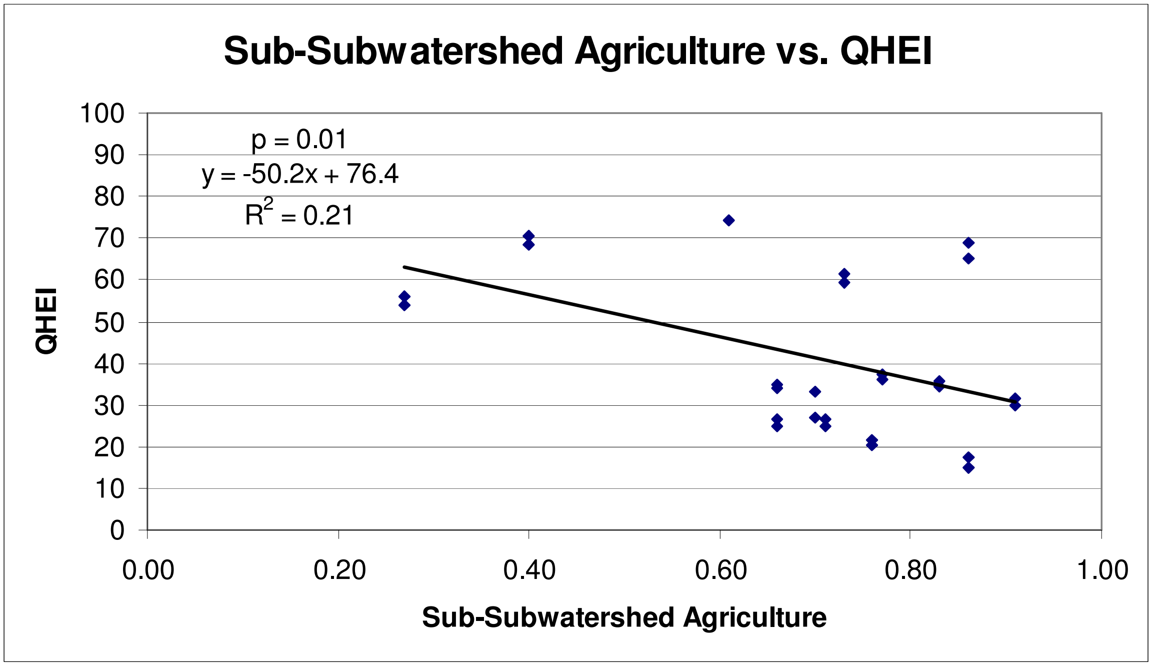
Relationship between Five Meter Agriculture vs. Qualitative Habitat Evaluation Index (QHEI)



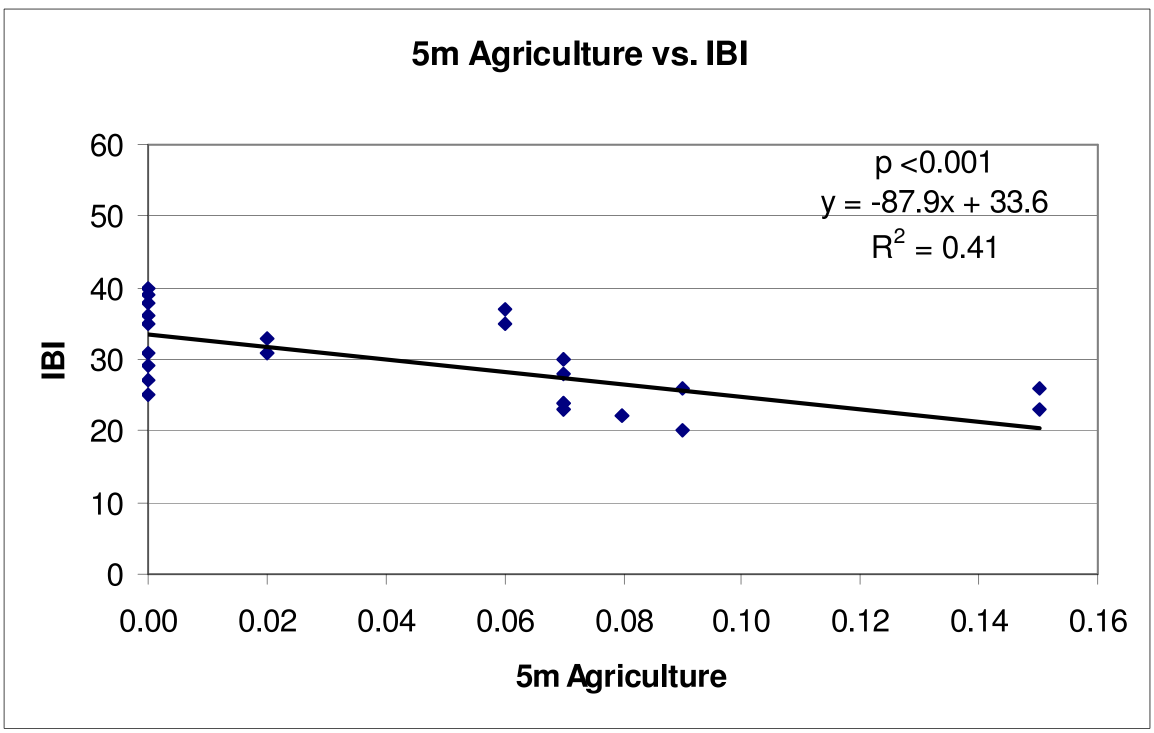
Relationship between Five Meter Woodland vs. Qualitative Habitat Evaluation Index (QHEI)



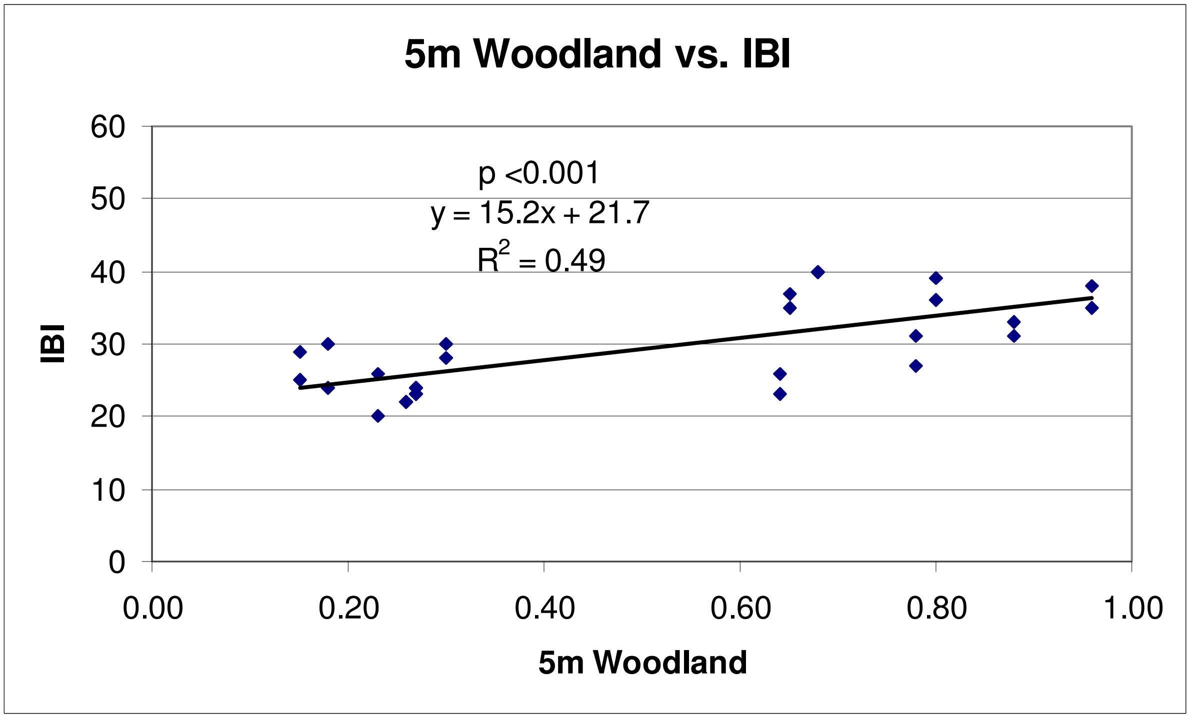
Relationship between Thirty Meter Woodland vs. Qualitative Habitat Evaluation Index (QHEI)



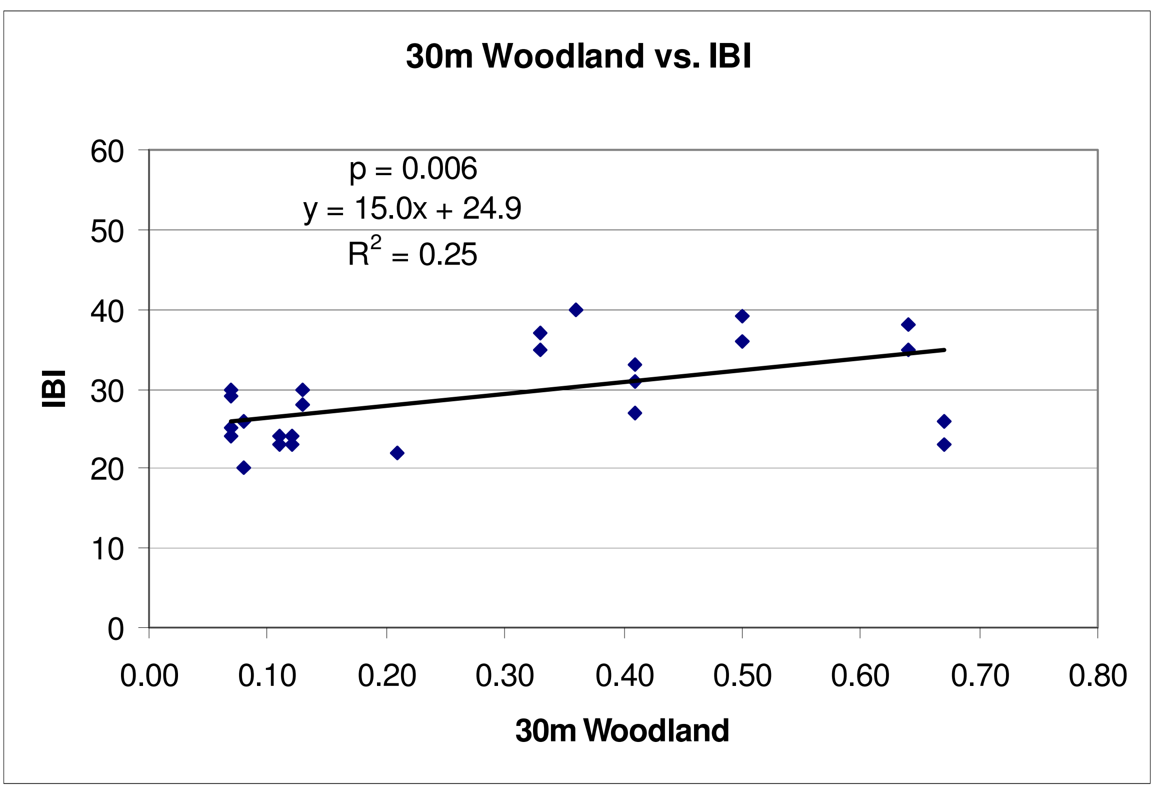
Relationship between Sub-Subwatershed Agriculture vs. Qualitative Habitat Evaluation Index (QHEI)



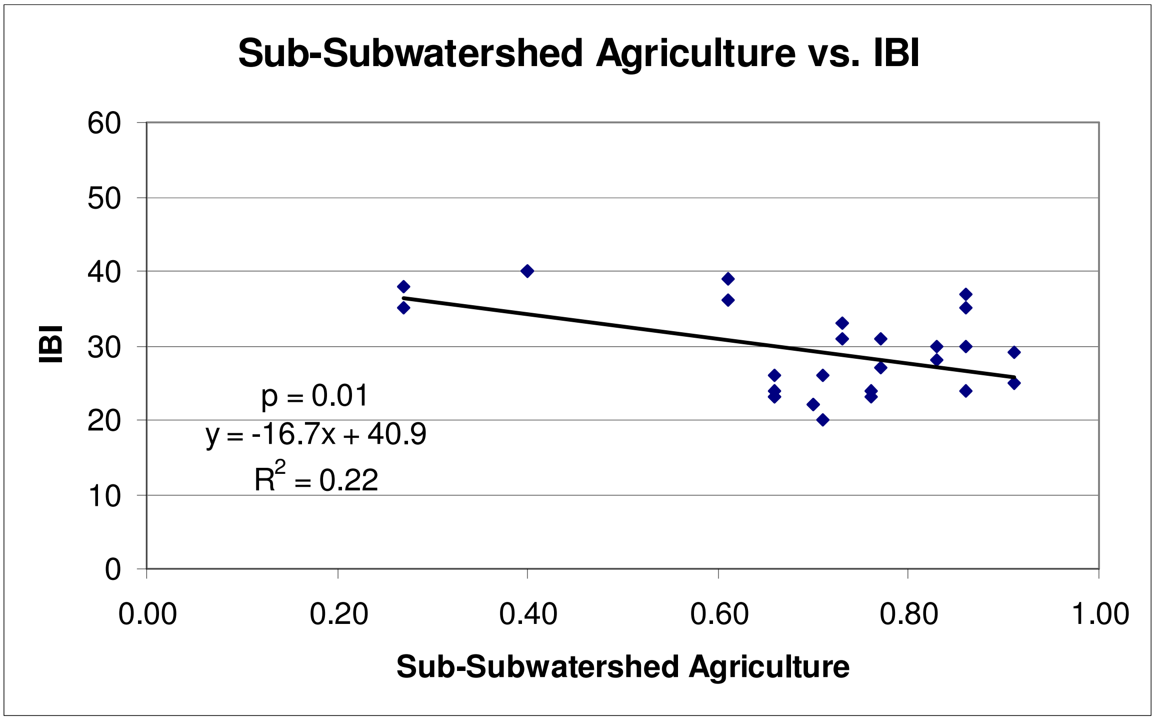
Relationship between Five Meter Agriculture vs. Index of Biological Integrity (IBI)



Relationship between Five Meter Woodland vs. Index of Biological Integrity (IBI)



Relationship between Thirty Meter Woodland vs. Index of Biological Integrity (IBI)

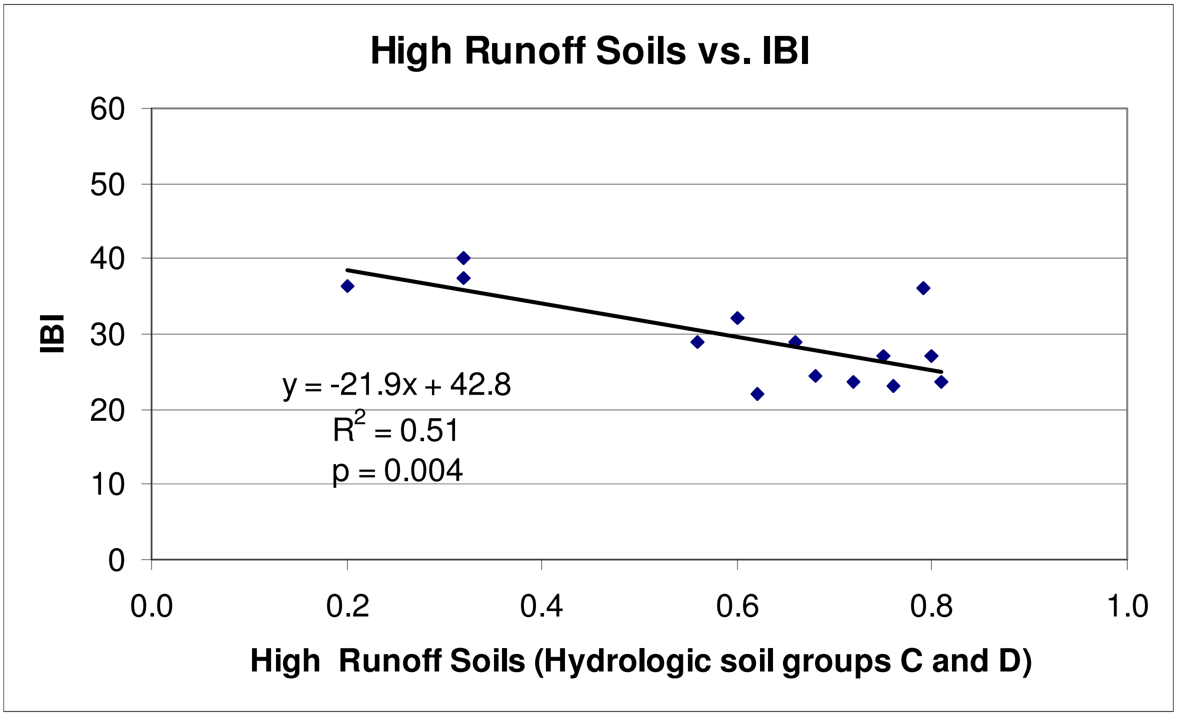


Relationship between Sub-Subwatershed Agriculture vs. Index of Biological Integrity (IBI)

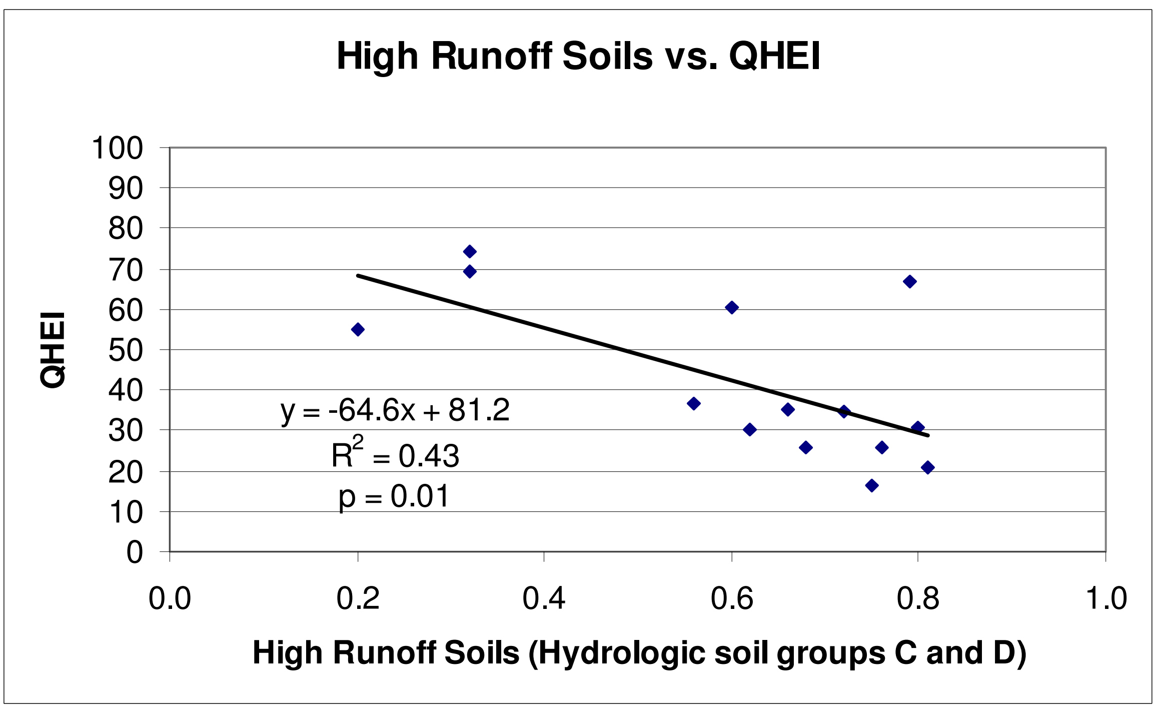
Regression Statistics for Significant Relationships of Soil Runoff Potential and 2002-2003 Averaged Biological Index Scores

Independent	Dependent	Probability>F (p-value)	R^2	Slope	Intercept
High Runoff Soils (C and D)	IBI	0.004	0.51	-21.9	42.8
High Runoff Soils (C and D)	QHEI	0.01	0.43	-64.6	81.2

Note: NRCS SSURGO (1999) soil hydrologic groups A & B (low-runoff soils) and C & D (high-runoff soils)



Relationship between High Runoff Soils vs. Index of Biological Integrity (IBI)

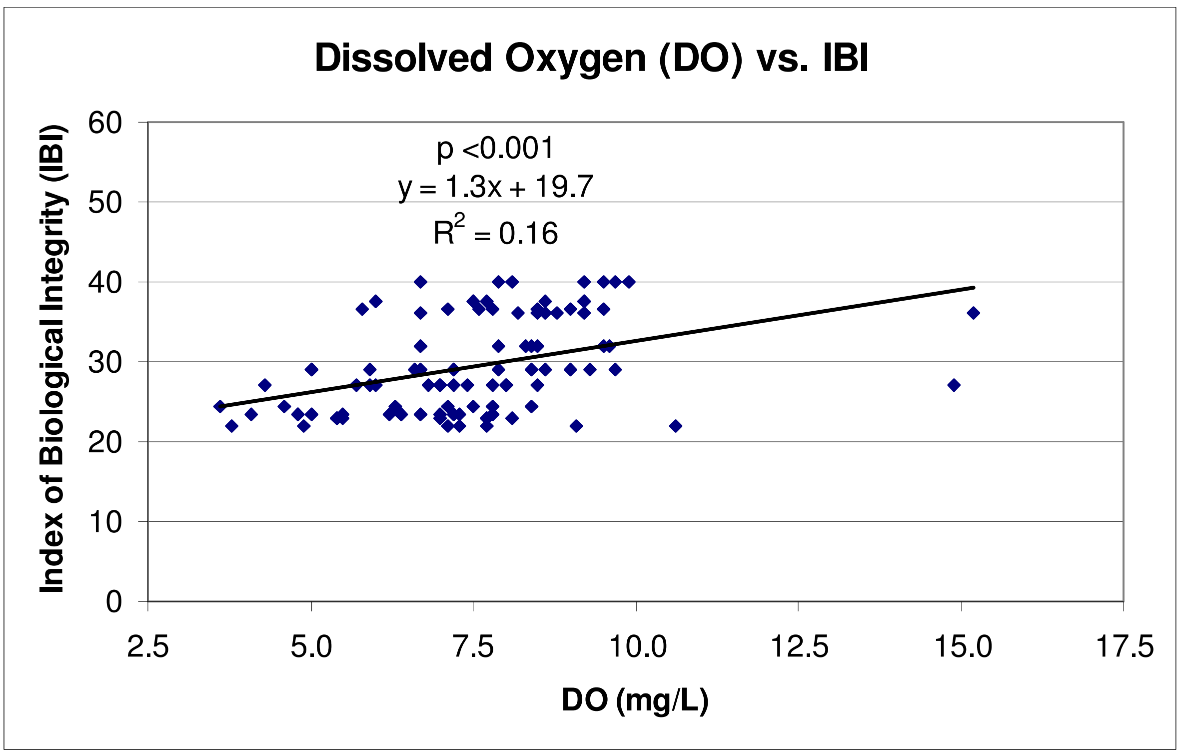


Relationship between High Runoff Soils vs. Qualitative Habitat Evaluation Index (QHEI)

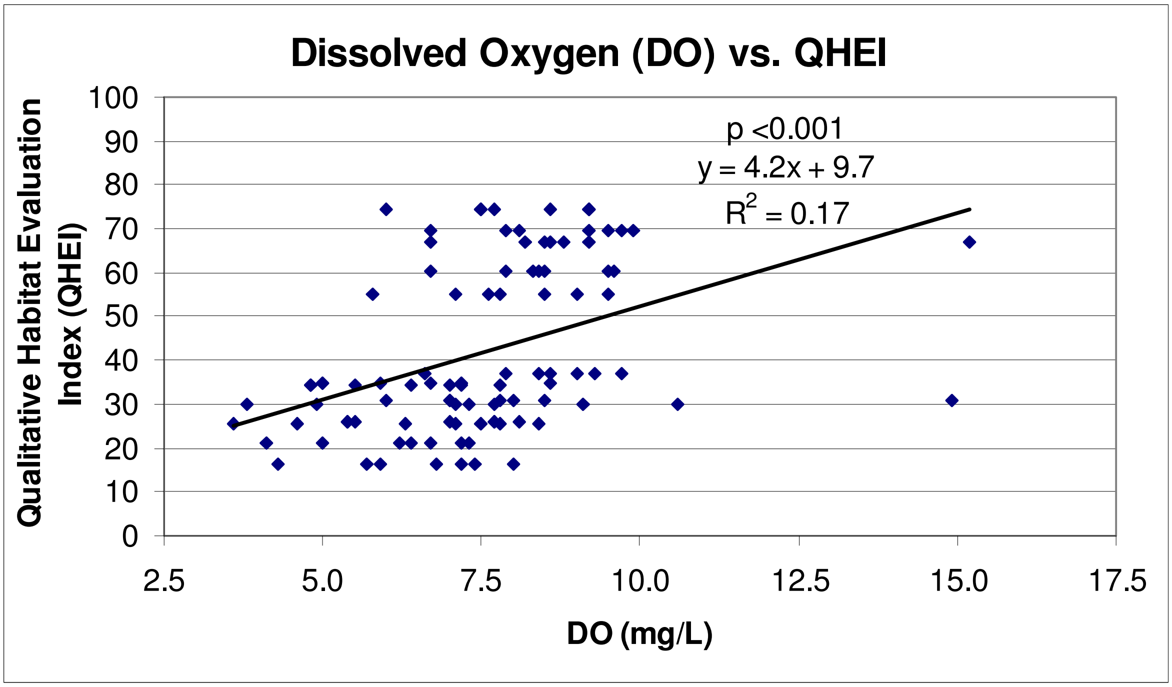
Regression Statistics for Significant Relationships of Chemical Parameters and 2002-2003 Averaged Biological Index Scores

Independent	Dependent	Probability>F (p-value)	R^2	Slope	Intercept
TSS	IBI	0.05	0.03	-0.01	29.9
NH_3	IBI	0.004	0.08	-7.1	31.0
Ortho-P	IBI	0.01	0.06	-12.7	30.6
DO	IBI	<0.001	0.16	1.3	19.7
pH	IBI	<0.001	0.15	5.9	-13.1
TSS	QHEI	0.04	0.04	-0.02	43.6
NH_3	QHEI	0.02	0.04	-17.8	45.9
Ortho-P	QHEI	0.04	0.04	-33.6	45.0
DO	QHEI	<0.001	0.17	4.2	9.7
pH	QHEI	<0.001	0.11	16.9	-79.4

Note: Index of Biologic Integrity (IBI), Qualitative Habitat Evaluation Index (QHEI)



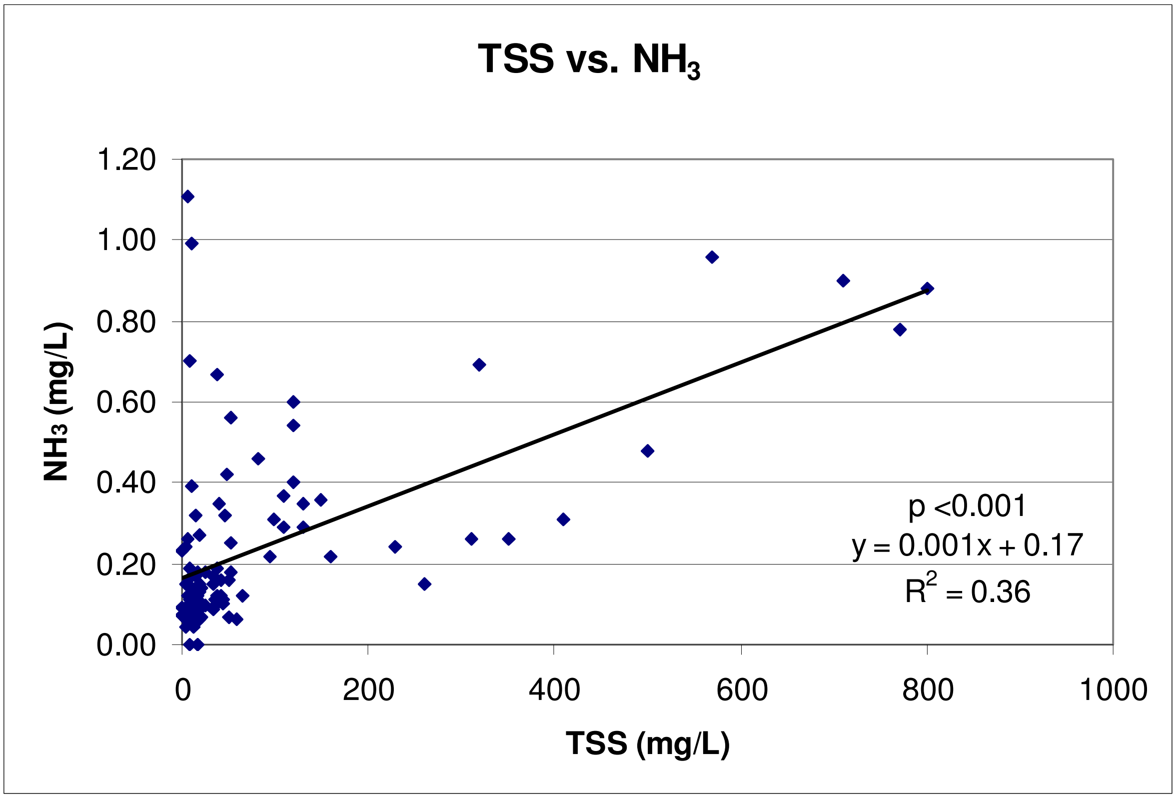
Relationship of Dissolved Oxygen (DO) to Index of Biological Integrity (IBI)



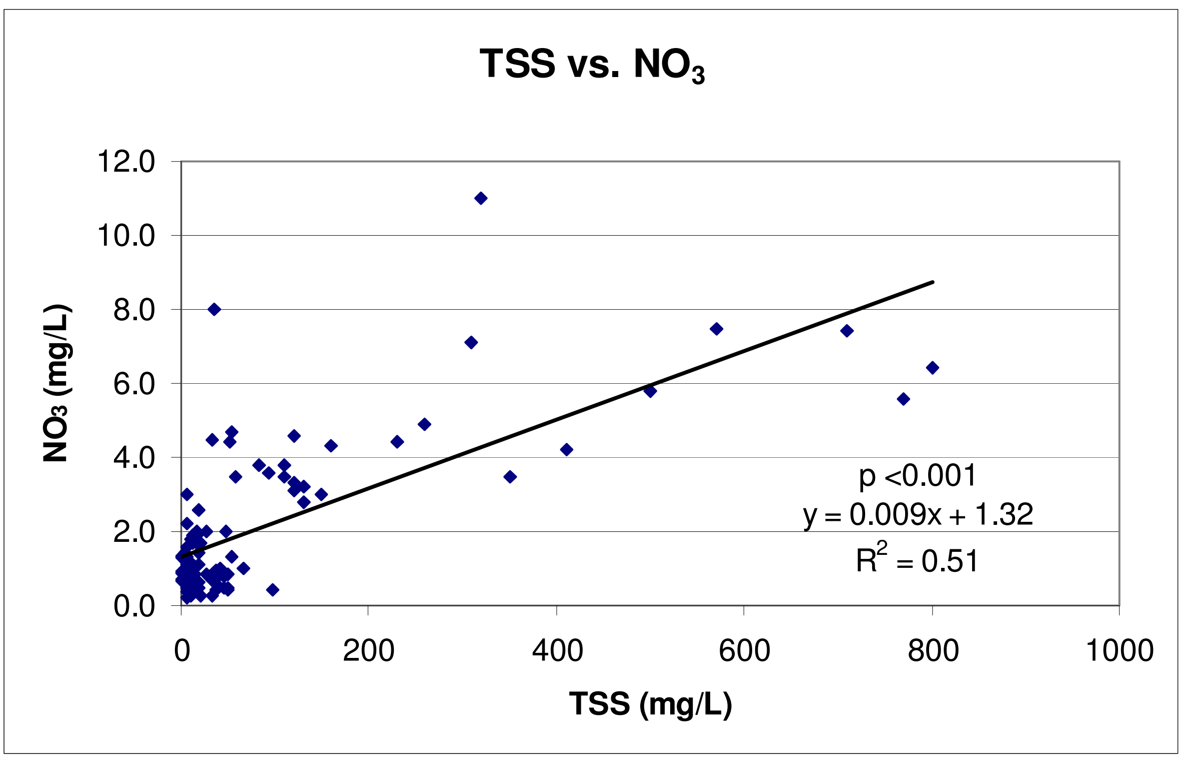
Relationship of Dissolved Oxygen (DO) to Qualitative Habitat Evaluation Index (QHEI)

Regression Statistics for Significant Relationships between Chemical Parameters

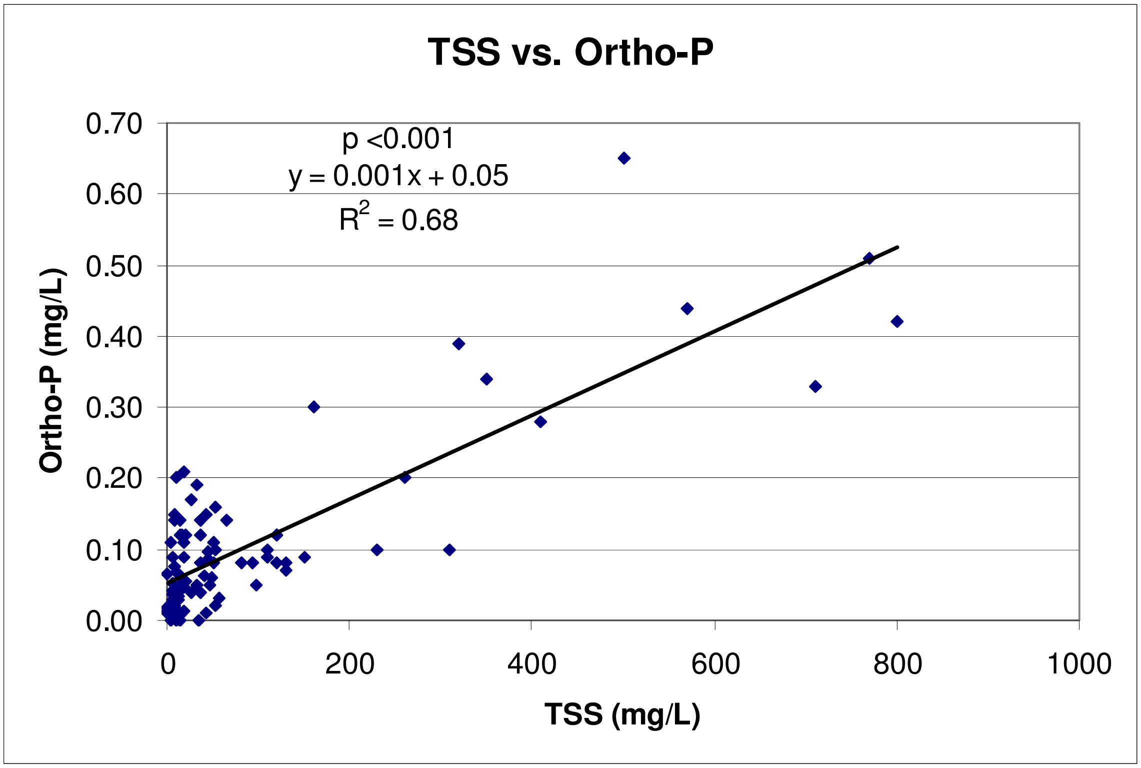
Independent	Dependent	Probability>F (p-value)	R^2	Slope	Intercept
TSS	NH_3	<0.001	0.36	0.001	0.17
TSS	NO_3	<0.001	0.51	0.01	1.32
TSS	Ortho-P	<0.001	0.68	0.001	0.05
TSS	E.*coli*	0.05	0.04	14.90	4436
NH_3	NO_3	<0.001	0.19	3.78	1.18
NH_3	Ortho-P	<0.001	0.32	0.27	0.04
NH_3	E.*coli*	0.003	0.09	14618	2160
NO_3	Ortho-P	<0.001	0.40	0.04	0.03
NO_3	E.*coli*	0.01	0.06	1418	2712
Ortho-P	E.*coli*	0.05	0.04	20147	3631



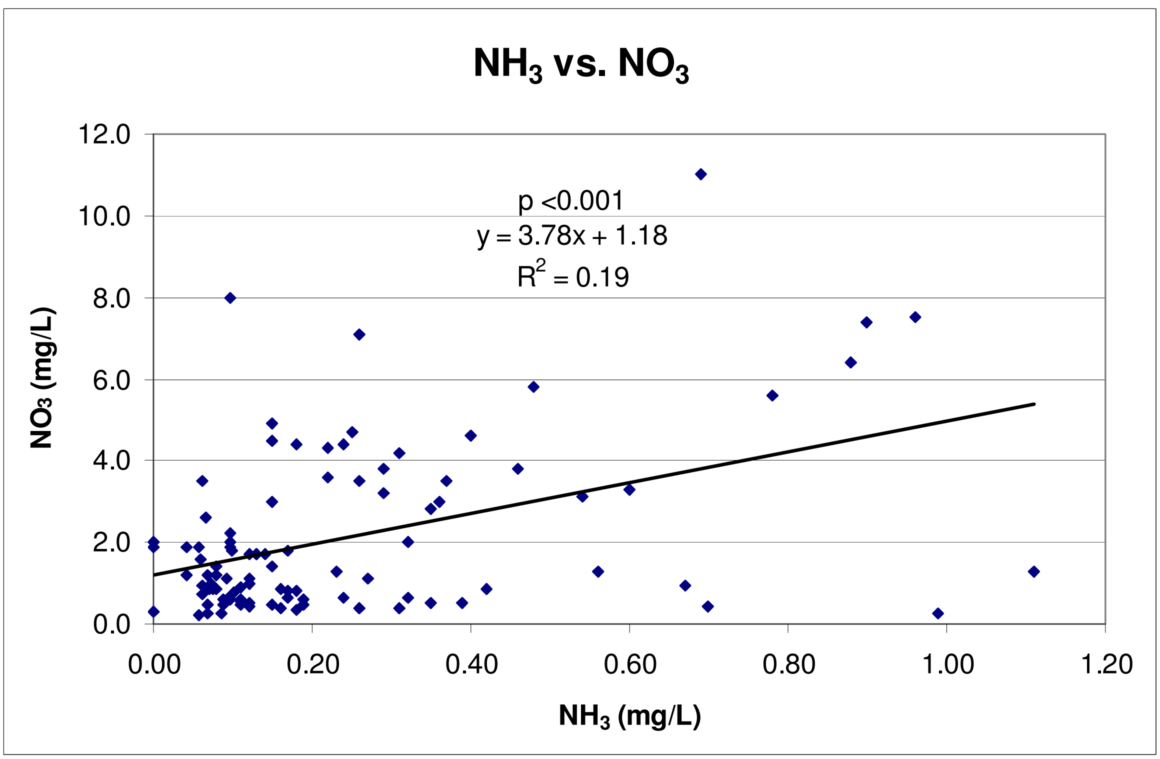
Relationship between Total Suspended Solids (TSS) vs. Ammonia as N (NH_3)



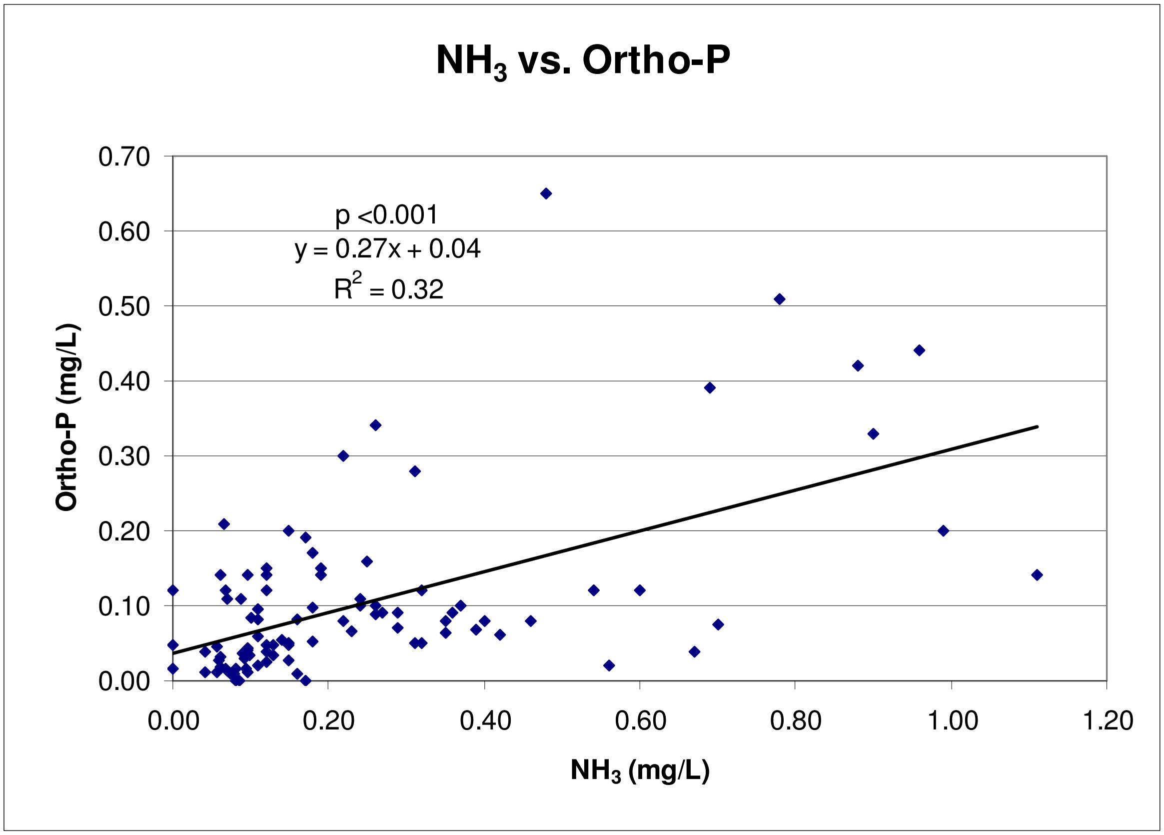
Relationship between Total Suspended Solids (TSS) vs. Nitrate + Nitrite (NO_3)



Relationship between Total Suspended Solids (TSS) vs. Orthophosphate as P (Ortho-P)



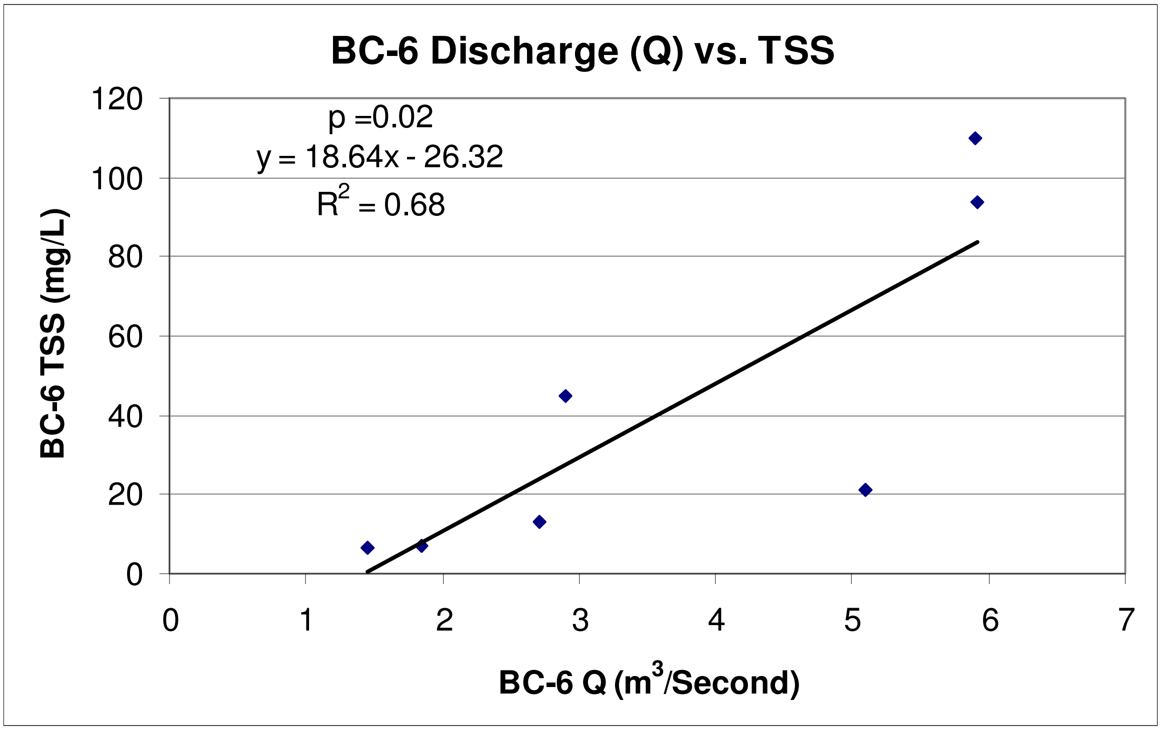
Relationship between Ammonia as N (NH_3) vs. Nitrate + Nitrite (NO_3)



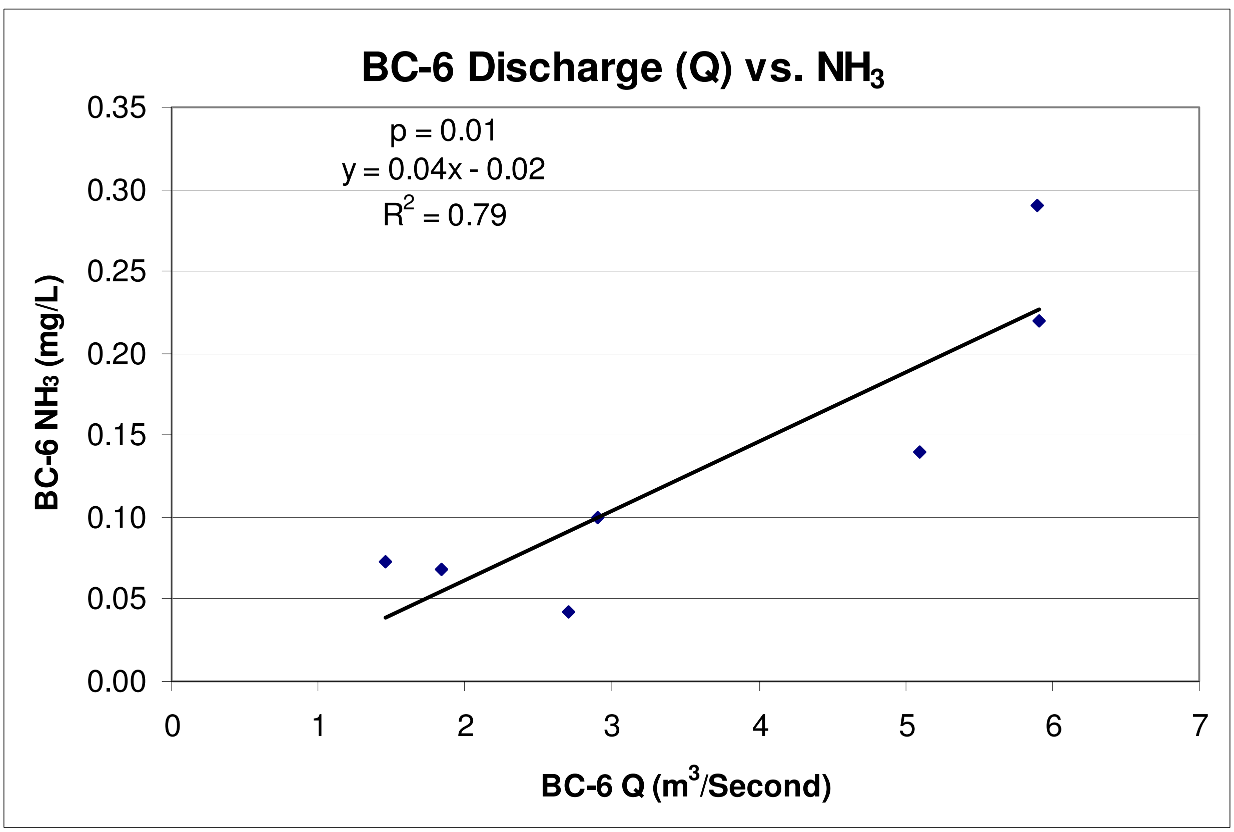
Relationship between Ammonia as N (NH_3) vs. Orthophosphate as P (Ortho-P)

Regression Statistics for Significant Relationships between Sampling Site BC-6 Discharge (Q) and Chemical Parameters

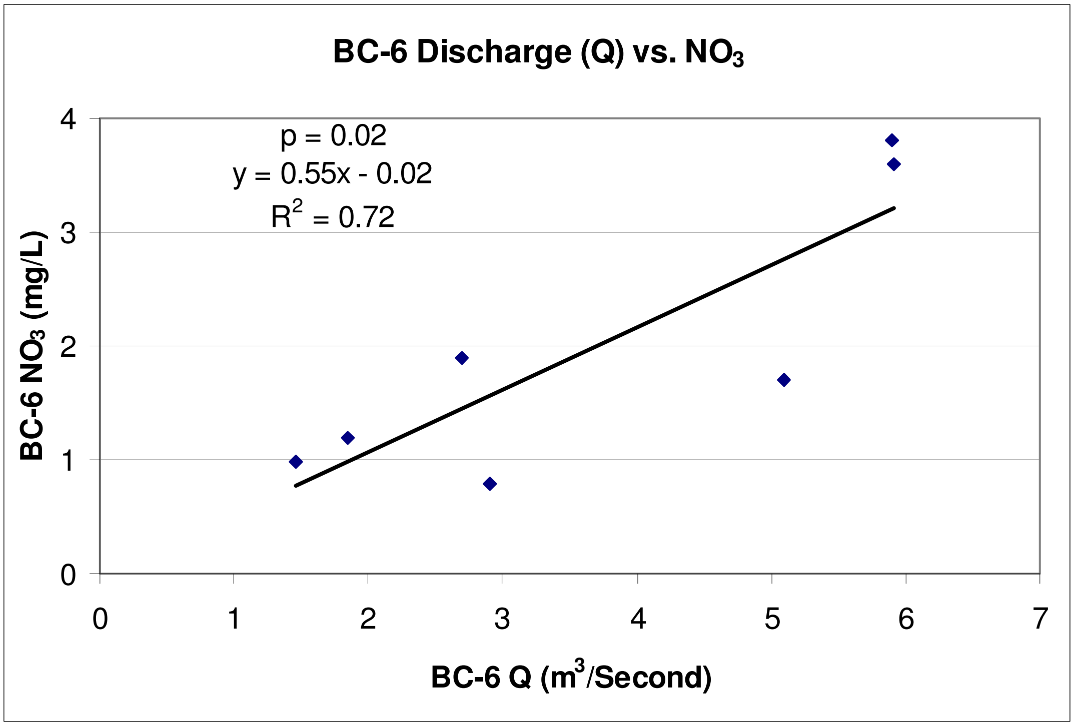
Independent	Dependent	Probability >F	R^2	Slope	Intercept
BC-6 Q	TSS	0.02	0.68	18.64	-26.32
BC-6 Q	NH_3	0.01	0.79	0.04	-0.02
BC-6 Q	NO_3	0.02	0.72	0.55	-0.02
BC-6 Q	Ortho-P	0.04	0.61	0.01	0.004
BC-6 Q	E.coli	0.05	0.56	1843	-3036



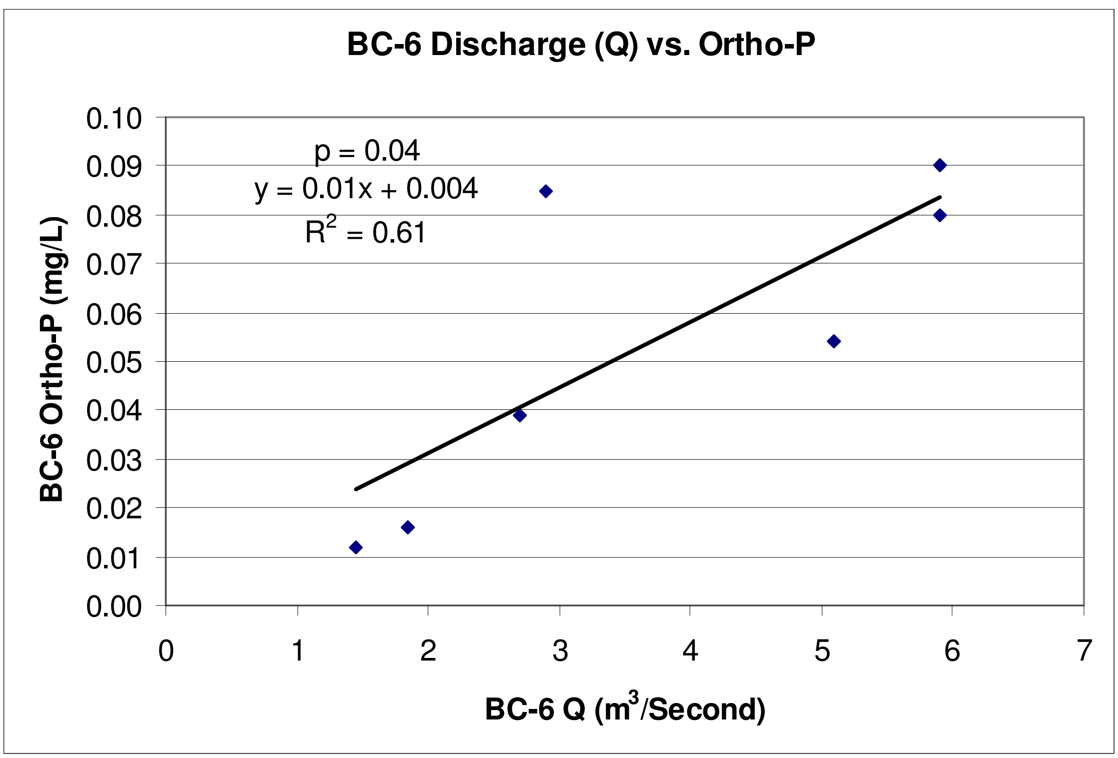
Relationship between BC-6 Discharge (Q) vs. BC-6 TSS



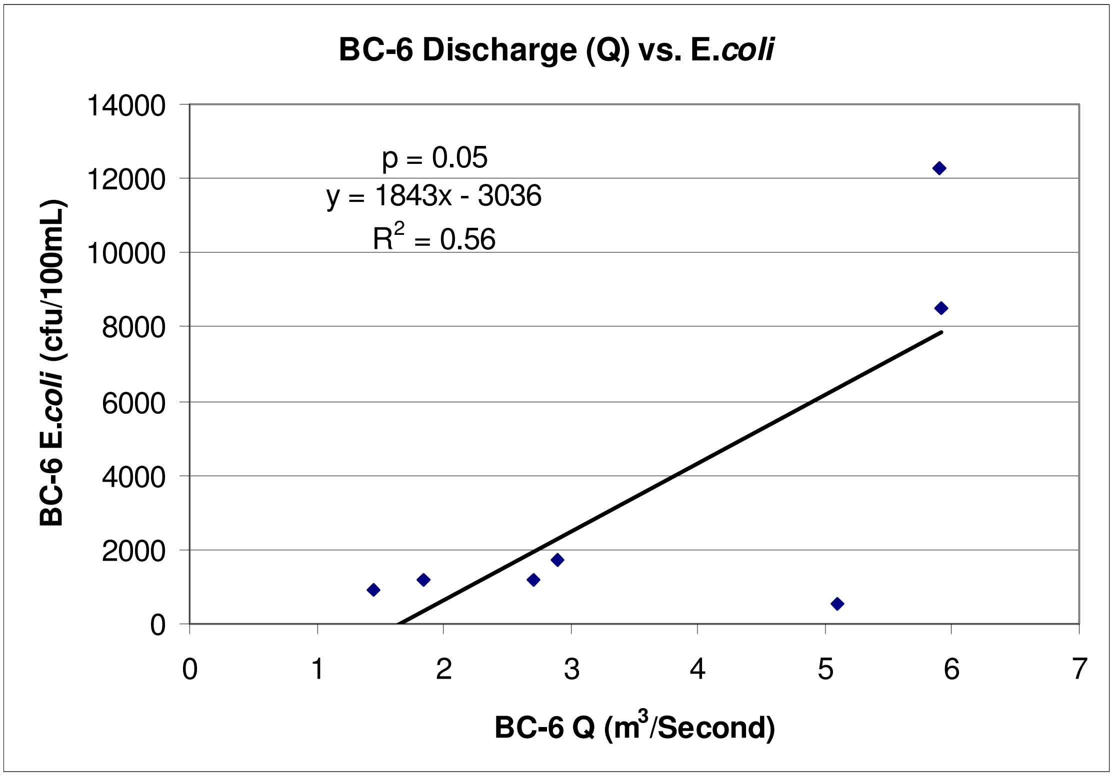
Relationship between BC-6 Discharge (Q) vs. BC-6 NH_3



Relationship between BC-6 Discharge (Q) vs. BC-6 NO_3



Relationship between BC-6 Discharge (Q) vs. BC-6 Orthophosphate as P (Ortho-P)

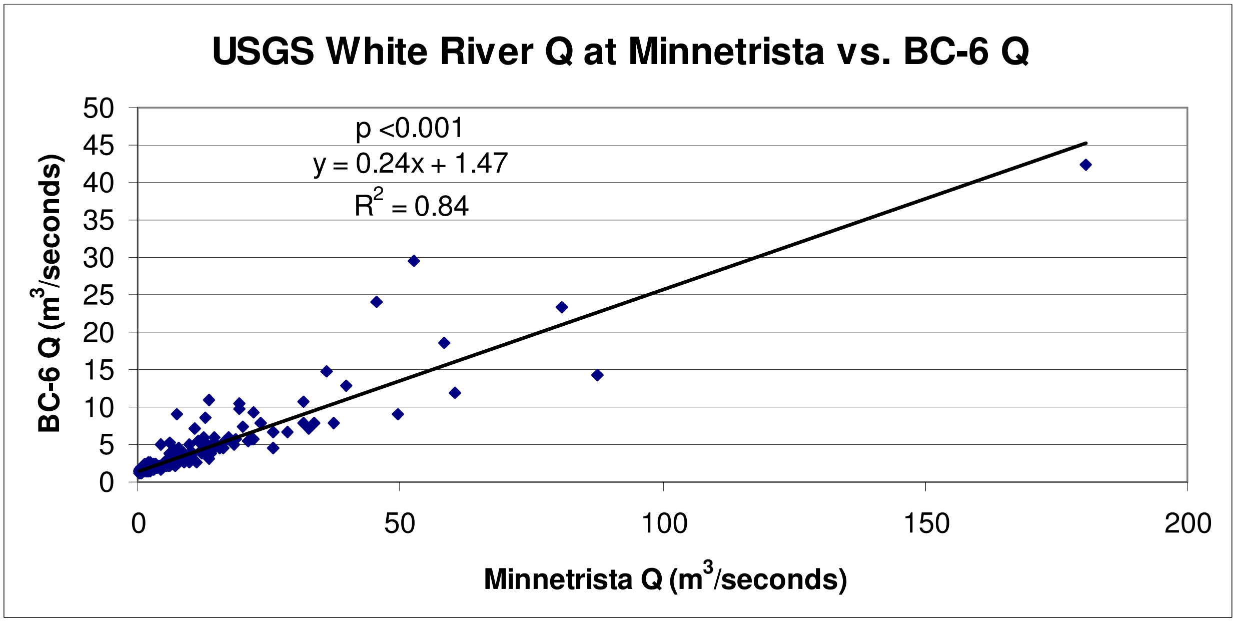


Relationship between BC-6 Discharge (Q) vs. BC-6 E. *coli*

Regression Statistics for Significant Relationships between Discharge (Q) at USGS White River gauging station at Minnetrista and BC-6 Q, BC-3 Q; and between KB-1A (Q) and KB-1 (Q)

Independent	Dependent	Probability >F (p-value)	R^2	Slope	Intercept
White River Q	BC-6 Q	<0.001	0.84	0.24	1.47
White River Q	BC-3 Q	<0.001	0.84	0.07	1.44
White River Q	KB-1A	<0.001	0.74	0.05	0.44
KB-1A	KB-1	<0.001	0.96	0.63	0.05

Note: United States Geological Survey (USGS) gauging station located on White River at Minnetrista was used to obtain stream discharge data which was used in regression analysis



Relationship between White River Discharge (Q) at Minnetrista and BC-6 Discharge (Q)
Note: Regression equation used to estimate discharge (Q) at BC-6 for days that did not have water level data to use in rating curve prediction of Q

APPENDIX G

Household Hazardous Waste Local Education Postcard

BE SAFE WITH HOUSEHOLD HAZARDOUS WASTE

Household Hazardous Waste is a big concern for your local fire department. The members of the Hamilton Township Fire Company need your help in reducing the risks they and your local water quality face.

Properly storing and disposing of these materials helps keep your firefighters safe and prevents such dangerous materials from contaminating your surface and ground water.

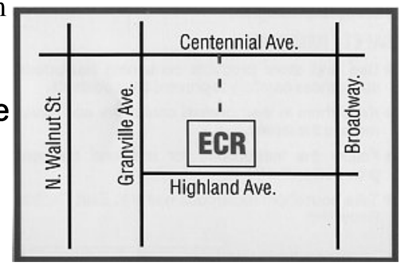
Only **YOU** can keep hazardous waste from endangering you, your fire fighters and your water quality!

For more information: call 282-1900 or visit www.munciesanitary.org/abouthhw.htm

What Can YOU Do?

Bring your Household Hazardous Waste to East Central Recycling....

Monday-Friday 8:00 a.m. to 5:00 p.m.
Saturday 8:00 a.m. to 12:00 p.m.



Working Together for Clean Water!

With the **White River Watershed Project**
Project of: Delaware County Soil and Water Conservation District

The **White River Watershed Project** is a community-driven, voluntary project to clean-up and prevent non-point source water pollution for a

This Project is **lead by citizens** like you who live, work and play in Delaware County. The one thing they have in common is that they **care about our water**.

We are in the process of developing a plan to address water quality concerns for Killbuck and Mud Creeks in your area, and **we want your input**.

For More Information go to www.co.delaware.in.us/watershed/ or call Tia Agnew at 747-5531, ext. 3 or email her at watercons@comcast.net

APPENDIX H

National Wetland Inventory Map Key

```
SYSTEM                  SUBSYSTEM          CLASS                          SUBCLASS
                                          |- RB=Rock Bottom               1=Bedrock
                                          |                               2=Rubble
                                          |
                                          |- UB=Unconsolidated Bottom     1=Cobble-Gravel
                                          |                               2=Sand
                                          |                               3=Mud
                                          |                               4=Organic
                                          |
                                          |- AB=Aquatic Bed               1=Algal
                                          |                               2=Aquatic Moss
                                          |                               3=Rooted Vascular
                                          |                               4=Floating
                                          |                                 Vascular
                                          |                               5=Unknown
                                          |                                 Submergent
                                          |                               6=Unknown Surface
                                          |
                                          |- US=Unconsolidated Shore      1=Cobble-Gravel
                                          |                               2=Sand
                                          |                               3=Mud
                                          |                               4=Organic
                                          |                               5=Vegetated
                                          |
                                          |- ML=Moss-Lichen               1=Moss
                                          |                               2=Lichen
                                          |
P=PALUSTRINE------------------------------|- EM=Emergent                  1=Persistent
                                          |                               2=Nonpersistent
                                          |
                                          |- SS=Scrub-Shrub               1=Broad-Leaved
                                          |                                 Deciduous
                                          |                               2=Needle-Leaved
                                          |                                 Deciduous
                                          |                               3=Broad-Leaved
                                          |                                 Evergreen
                                          |                               4=Needle-Leaved
                                          |                                 Evergreen
                                          |                               5=Dead
                                          |                               6=Indeterminate
                                          |                                 Deciduous
                                          |                               7=Indeterminate
                                          |                                 Evergreen
                                          |
                                          |- FO=Forested                  1=Broad-Leaved
                                          |                                 Deciduous
                                          |                               2=Needle-Leaved
                                          |                                 Deciduous
                                          |                               3=Broad-Leaved
                                          |                                 Evergreen
                                          |                               4=Needle-Leaved
                                          |                                 Evergreen
                                          |                               5=Dead
                                          |                               6=Indeterminate
                                          |                                 Deciduous
                                          |                               7=Indeterminate
                                          |                                 Evergreen
                                          |
```

```
                                |- OW=Open Water/Unknown Bottom (used on older maps)
                                 MODIFIERS

                                |- A=Temporarily Flooded
                                |- B=Saturated
                                |- C=Seasonally Flooded
                                |- D=Seasonally Flooded/Well Drained
                                |- E=Seasonally Flooded/Saturated
                                |- F=Semipermanently Flooded
                 |--Non-Tidal------|- G=Intermittently Exposed
                 |              |- H=Permanently Flooded
                 |              |- J=Intermittently Flooded
                 |              |- K=Artificially Flooded
                 |              |- W=Intermittently Flooded/Temporary (used on
                 |              |                                    older maps)
                 |              |- Y=Saturated/Semipermanent/Seasonal (used on
                 |              |                                    older maps)
                 |              |- Z=Intermittently Exposed/Permanent (used on
                 |              |                                    older maps)
WATER REGIME----|              |- U=Unknown
                 |
                 |
                 |
                 |
                 |              |- K=Artificially Flooded
                 |              |- L=Subtidal
                 |              |- M=Irregularly Exposed
                 |              |- N=Regularly Flooded
                 |--Tidal----------|- P=Irregularly Flooded
                                |-*S=Temporary-Tidal
                                |-*R=Seasonal-Tidal
                                |-*T=Semipermanent-Tidal
                                |-*V=Permanent-Tidal
                                |- U=Unknown
                                |
                                |-*These water regimes are only used in
                                |  tidally influenced, freshwater systems.


                                |- 1=Hyperhaline
                                |- 2=Euhaline
                 |--Coastal        |- 3=Mixohaline (Brackish)
                 |  Halinity-------|- 4-Polyhaline
                 |              |- 5=Mesohaline
                 |              |- 6=Oligohaline
                 |              |- 0=Fresh
                 |
                 |
                 |
WATER CHEMISTRY-|
                 |              |- 7=Hypersaline
                 |--Inland         |- 8=Eusaline
                 |  Salinity-------|- 9=Mixosaline
                 |              |- 0=Fresh
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                |--pH Modifiers   |- a=Acid
                   for all        |- t=Circumneutral
                   Fresh Water----|- i=Alkaline

SOIL------------------------------|- g=Organic
                                  |- n=Mineral



                                  |- b=Beaver
                                  |- d=Partially Drained/Ditched
SPECIAL MODIFIERS-----------------|- f=Farmed
                                  |- h=Diked/Impounded
                                  |- r=Artificial Substrate
                                  |- s=Spoil
                                  |- x=Excavated

U = Uplands
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Definitions

Algae: Any of various primitive, chiefly aquatic, one-or multi-celled, nonflowering plants that lack true stems, roots, and leaves, but usually contain chlorophyll. Algae convert carbon dioxide and inorganic nutrients such as nitrogen and phosphorus into organic matter through photosynthesis and form the basis of the marine food chain. Common algae include dinoflagellates, diatoms, seaweeds, and kelp.

Algal bloom: A condition which occurs when excessive nutrient levels and other physical and chemical conditions facilitate rapid growth of algae. Algal blooms may cause changes in water color. The decay of the algal bloom may reduce dissolved oxygen levels in the water.

Ammonia (NH_3+): A colorless gas with a pungent odor. It is easily liquefied and solidified and is very soluble in water. Large quantities of ammonia are used in the production of nitric acid, urea and nitrogen compounds. Since ammonia is a decomposition product from urea and protein, it is found in domestic wastewater. Aquatic life and fish also contribute to ammonia levels in streams. NH_3 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 (-log10 [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