VFC Index - Watershed (Plan)

Program:	Watershed
IDEM Document Type:	Plan
Document Date:	4/30/2007
Security Group:	Public
Project Name:	Trail Creek WMP Update
Plan Type:	Watershed Management Plan
HUC Code:	04040001 Little Calumet-Galien
Sponsor:	Sanitary District of Michigan City
Contract #:	4-155
County:	Laporte
Cross Reference ID:	16182312
Comments:	

Additional WMP Information

Checklist:	2003 Checklist
Grant type:	319
Fiscal Year:	2004
IDEM Approval Date:	4/30/2007
EPA Approval Date:	
Project Manager:	Nathan Rice

Trail Creek during dry weather

A TALE OF TWO CREEKS

Trail Creek Watershed Management Plan

A Guide for Cleaner Water

Trail Creek after heavy rainfall

Prepared by: American Structurepoint, Inc.
Address: 7260 Shadeland Station
Indianapolis, Indiana 46256
Phone: 317.547.5580

Funding Source: IDEM Section 319 Grant, Unity Foundation, Sanitary District of Michigan City

April 2007

“Through collaborative efforts, we can not only reduce the financial impacts resulting from a polluted Trail Creek, but more importantly, we can provide the stewardship and leadership required now in order for future generations to be able to enjoy the natural beauty of Trail Creek for decades to come.”

Maggi Spartz, President of the Unity Foundation

Table of Contents

List of Figures

List of Tables

Acknowledgements

THIS UPDATED Trail Creek Watershed Management Plan would not have been possible without the participation and input of many concerned citizens from northwestern LaPorte County. In January of 2006, the Sanitary District of Michigan City invited dozens of local organizations and the public at large to engage with water quality professionals in a focused effort aimed at reducing pollution in Trail Creek. We thank the many concerned citizens who attended our public meetings, participated as Steering Committee members, asked many questions, and challenged us to find common sense solutions for reducing pollution. The collective voice of local citizens concerned about water pollution forms the basis for this report. Thus, first and foremost, we thank the citizens who gave freely of their time to develop this plan for achieving cleaner water in Trail Creek.

SECONDLY, we must acknowledge the exemplary efforts and technical abilities of our State regulatory agencies that helped guide us through this year-long process. Specifically, we thank the Indiana Department of Environmental Management representatives Sky Schelle, Steve West, and Linda Schmidt; and Indiana Department of Natural Resource representative Joe Exl. The collective watershed acumen of our regulatory agency consultants has been critical to the success of this watershed management plan update and we commend them for being outstanding stewards of our state's water resources.

LASTLY, the vision to re-engage LaPorte County's citizenry for the purpose of updating the 1993 Trail Creek Watershed Management Plan began with a commitment from the Unity Foundation of LaPorte County to help our local environment. In the Summer of 2003, the Unity Foundation approached the city of Michigan City to discuss opportunities for collaboration that would lead to long-lasting improvements in our environment. Rather than pursue a site-specific individual project, both entities quickly agreed that combining local resources to leverage additional outside grant funding for a wide-spread initiative would provide the greatest return for northwest LaPorte County. We applaud the foresight and vision of the Unity Foundation Board of Directors for embarking on this effort that will result in cleaner water in LaPorte County for generations to come.

Introduction

UNDER the Clean Water Act, each state was mandated by the US Environmental Protection Agency to determine designated uses and water quality standards for each waterbody within their state. For the State of Indiana, all waterbodies have been designated as fishable and swimable. Each state was also mandated to develop a Total Maximum Daily Load (TMDL) calculation of the maximum amount of a pollutant that a waterbody can receive and still meet state water quality standards. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated.

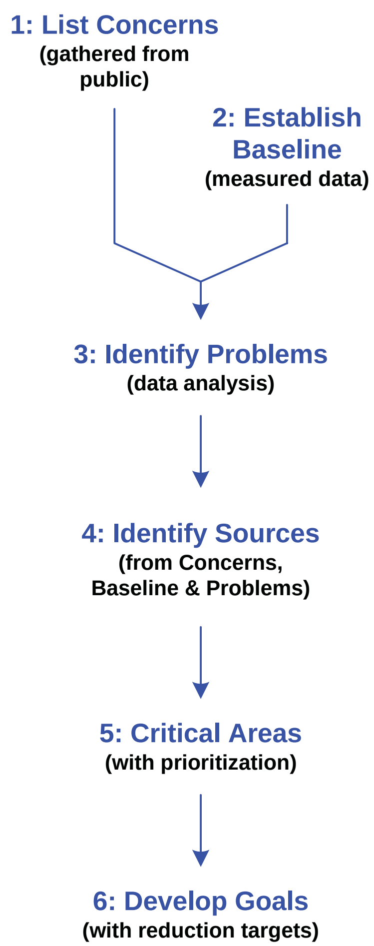
IN DECEMBER of 2003, the Indiana Department of Environmental Management (IDEM) issued a detailed technical report regarding excessive *E. coli* levels in Trail Creek entitled "Trail Creek Escherichia Coli TMDL (Total Maximum Daily Load) Report." This report indicates that for point sources of *E. coli* pollution, such as wastewater treatment plants, the "NPDES permitting and monitoring requirements will provide the necessary reasonable assurance that these sources are not contributing to violations of state *E. coli* standards." For non-point sources of *E. coli* pollution, the report concludes that: "non-point sources will need to be monitored locally for implementation of BMPs (best management practices) or in providing access to watershed grants to assist in reducing non-point sources to meet the load allocations (LA) developed under this TMDL." The preparation of this watershed management plan update is the next logical step in achieving cleaner water in northwestern LaPorte County as envisioned by IDEM in 2003.

WITHIN the Trail Creek Watershed, there are naturally occurring non-point sources of pollution along with man-made point and non-point sources of pollution. As the 2003 Trail Creek TMDL report indicates, the total elimination of all pollutant sources within the watershed is not realistic and not economically feasible. However, through the efforts of multiple entities and utilizing a variety of different approaches, it is possible to reduce the pollutant loading to a level which will not adversely affect either human health or water quality. As local citizens, we must rely on the technical expertise of water quality professionals to set maximum levels of pollution (load allocations) that will not cause long-term harm to human and aquatic health. But as local citizens, we must also educate ourselves with respect to practices that, if implemented, will result in verifiable reduction in levels of pollution in our local watershed.

AT THIS point in time, Trail Creek is a tale of two creeks, heavily influenced by stormwater and watershed land use. The first creek is a rich, vibrant, high quality, cold water habitat full of salmon, steelhead and trout. This creek's water is clear and flows gently over cobble riffles. The streambanks are stable and vegetation covers the entire width of the creek. This creek is a source of pride and enjoyment for the community with multiple parks and recreational areas along the creek.

THE SECOND creek, the one influenced by stormwater pollutants during rain events, is murky and muddy carrying untold pollutants and trash. Sediment carried by the creek fills the riffles and high water flows cause streambank erosion. Pollutant loads associated with stormwater runoff, including bacterial contamination, are excessive and warnings are issued to avoid touching the creek's water and to avoid entering Lake Michigan as a result.

WITH all of the complexities and time demands of modern day life, why concern ourselves with 'watershed management'? We must engage ourselves in watershed management to educate all citizens that every drop of water is a precious resource. As a drop of rain falls to the ground, one of two things can happen: the drop of water can become a carrier of pollution rushing into Trail Creek and its tributaries; or, if we can educate enough people, each raindrop can help replenish our watershed and Lake Michigan with clean water that can help sustain future generations. We believe that the Trail Creek Watershed Management Plan provides comprehensive guidance for voluntary efforts that will result in the latter: a cleaner source of water.



Report Format

The Trail Creek Watershed is made of three distinct branches: the East Branch, West Branch and the Main Branch. Each branch has a unique 14-Digit Hydraulic Unit Code, or HUC. Across Indiana, there are 2,407 individual 14-digit watersheds. Thus, to ensure consistency regarding watershed management planning, IDEM has issued technical guidance documents to aide communities with watershed management planning. A critical document that all watershed management plans must comply with is the "Watershed Management Plan Checklist." The checklist provides a general framework for the preparation of watershed management plans and includes specific and sequenced plan components.

All watershed management plans must begin with the engagement of local citizens to determine the concerns of the general public living in the watershed. Through Public Involvement and Stakeholder Meetings and working with local steering committee members, the first step in the sequenced plan is to **List Concerns** gathered from the public.

The second step is working with water quality professionals to assess actual measured data obtained throughout the watershed to **Establish Baseline** water quality conditions. Typically, data acquisition involves physical, chemical, and biological attributes of the watershed.

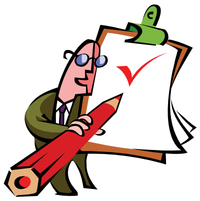
The third step in IDEM's framework sequence is the analysis of the baseline data with the list of concerns to **Identify Problems** in the watershed. The marriage of the concerns raised by the general public with the measured data provides a scientific basis for problem identification. Once problem identification has been accomplished via Step 1 through Step 3, the work of the community can then focus on the "where" and "what" components of the watershed management plan.

The fourth step in the sequence is to **Identify Sources** throughout the watershed that cause the identified problems. However, with limited resources to address pollution, watershed management plans are required to define **Critical Areas** that can be prioritized for implementation. Finally, the community must **Develop Goals** with specific reduction targets. This last step allows the community to assess the success of the plan's implementation from year to year and revise the plan in order to achieve the desired results.

Accordingly, the Trail Creek Watershed Management Plan Update report format was based on IDEM's recommended "Watershed Management Plan Checklist" sequence of: concerns, baseline, problems, sources, critical areas, and goals.

Various Appendices are attached including additional reference material or data. A list of acronyms is included in Appendix C for reference. Full size versions of the mapping included in the text are included in the Appendix L.

And finally with respect to format, the arrangement of the text columns, footnotes, photographs, and illustrations follows the example set forth in Beautiful Evidence, written by Edward Tufte.



WATERSHED MANAGEMENT PLAN CHECKLIST

(Updated 2003 Checklist)

Please see the *Watershed Management Plan Guidance* document for additional information and guidance on meeting these checklist elements.

INTRODUCE WATERSHED

Page #

O __6_ Define the mission, vision, or purpose statement that the group came up with for the watershed
Included in Overview of Trail Creek Watershed Management

O 12-34 Include map(s) of the watershed
Included in Baseline Watershed Information

O 12-34 Give a detailed description of the watershed
Included in Baseline Watershed Information

IDENTIFY PROBLEMS AND CAUSES

O 10-11 List the stakeholders' concerns that were gathered from the public meetings
Included in Watershed Concerns

O 12-34 List and briefly summarize information/data gathered to establish baseline conditions
Included in Baseline Watershed Information

O 35-38 Identify problems in the watershed based on the information gathered
Included in Water Quality Problems

O 35-45 Identify known or probable causes of water quality impairments and threats. Tie concerns, benchmarks, problems, and causes together so there is a clear thought process.
Included in report format, Water Quality Problems, and Sources of Water Quality Problems.

IDENTIFY SOURCES

O 39-45 Identify specific sources for each pollutant or condition that will need to be controlled to achieve the load reductions estimated and the goals in the plan. Include enough information to explain the magnitude of the source.
Included in Sources of Water Quality Problems.

IDENTIFY CRITICAL AREAS

O 29-30 Estimate existing loads for pollutants to assist with prioritization
Included in 2006 Watershed Management Plan Baseline Assessment

O 46-48 Identify critical areas where measures will be needed to implement the plan. Summarize the thought process used for targeting and prioritization.
Included in Critical Areas.

SET GOALS & SELECT INDICATORS

O 35-38 Develop water quality improvement or protection goals
Included in Water Quality Problems and in Implementation

O 49-51 For each goal, determine what indicators can be measured to determine whether pollutant load reductions are being achieved and progress is being made towards attaining water quality standards, and if not, criteria for determining whether the plan or an existing NPS TMDL needs to be revised.
Included in Goals and Decisions

O _vi_ There is a clearly understandable train of thought from problems, causes and sources to critical areas, goals, and indicators.
Included in Report Format

CHOOSE MEASURES/BMPS TO APPLY

O 53-70 Determine BMPs or measures that will need to be implemented to achieve the load reductions required to reach the goals.
Included in Implementation

O 53 Describe how the stakeholders were involved in selecting, designing, and implementing the NPS management measures. Discuss what information/education techniques will be used to enhance public understanding and encourage continued participation in implementing the chosen NPS management measures.
Included in Implementation

O 53-55 Estimate load reductions for the management measures identified.
Included in Goals and Decisions

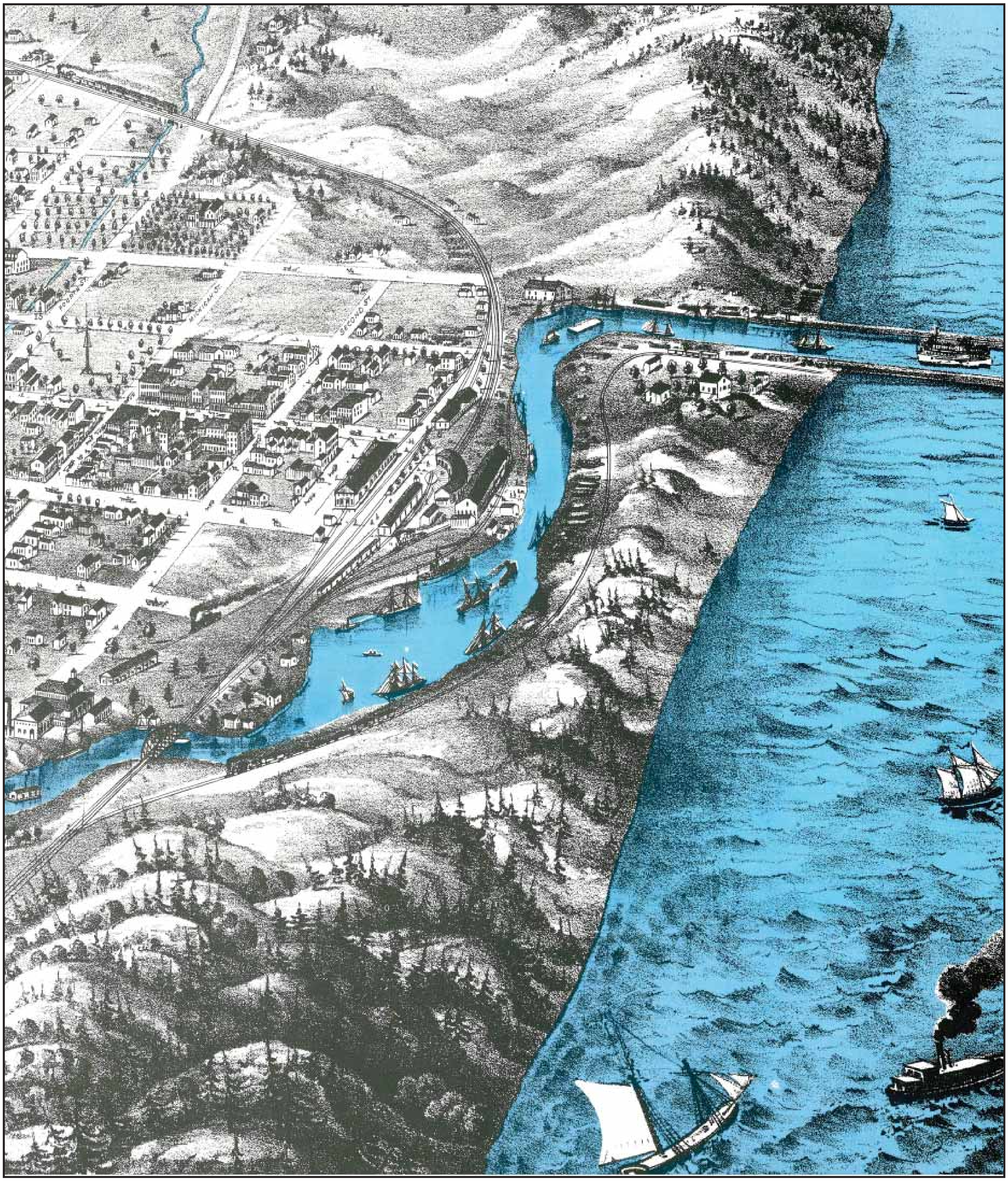
O 53-70 Describe the planned order of implementation, the time requirements for implementing the plan, and who is responsible for carrying out tasks.
Included in Implementation

O 53-70 Estimate financial and technical assistance needed to implement the plan.
Included in Implementation

O 53-70 Describe interim measurable milestones for determining whether NPS management measures or other control actions are being implemented.
Included in Implementation

MONITOR EFFECTIVENESS (INDICATORS)

O 49-51 Develop a monitoring plan to track the indicators and evaluate the effectiveness of the implementation efforts over time.
Included in Goals and Decisions


MICHIGAN ST
SECOND ST

Overview of Trail Creek Watershed Management

THE USE of Trail Creek for economic purposes began in earnest as early as 1836, with the construction of port facilities and the dredging of a navigable channel, allowing commercial shipping access from Lake Michigan.[1] An 1869 artist's rendering of Trail Creek's navigable waters depicts 21 sailboats, three steam-powered tugboats, multiple railroad lines, a major railroad depot with roundhouse, and two swing bridges within the last mile of Trail Creek.

[1]"Early History of Michigan City, Indiana," Michigan City Public Library Pamphlet File, *Michigan City-History*

While the alteration of Trail Creek near Lake Michigan transpired rather quickly, water quality degradation in Trail Creek upstream of the harbor area occurred more gradually, as a result of changing land use practices over several decades. The Trail Creek Watershed Management Plan of 1993 described this process as follows:

"Watersheds become degraded because there is no tradition of planning or management at the watershed level. Management is difficult because of the segmented property ownership where numerous decision makers, each pursuing different objectives, modify their land without considering the full impact of such modifications. In addition, there is lack of effective control by any single level of government over land use changes in watersheds as they affect water and adjacent land resources."[2]

[2] Trail Creek Watershed Management Plan, September 30, 1993

This quotation from the 1993 Watershed Management Plan underscores two significant challenges that have existed and remain today: land use planning and multiple governmental jurisdictions.

From a land use aspect, we must recognize that many scattered, incremental changes over time can have a cumulative impact that degrades the watershed, while also recognizing that a single, large scale land use change can immediately impact the watershed for decades. One historical example of a single land use change that has forever altered the landscape of Trail Creek occurred at the mouth of Trail Creek and involved what was once known as Hoosier Slide. One account of the history of Hoosier Slide is found in the Michigan City Public Library archives

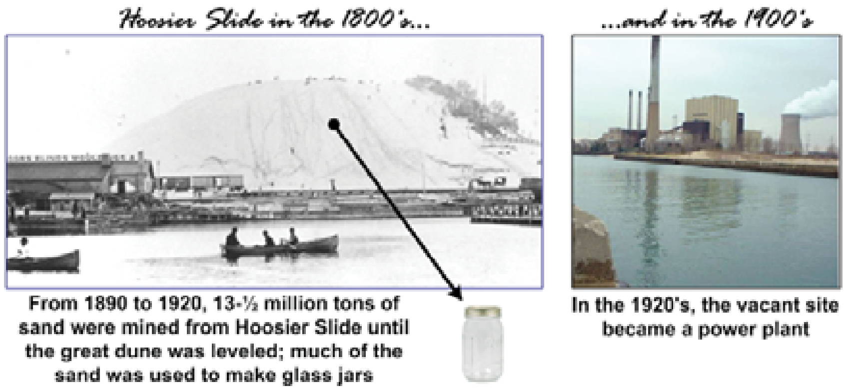
"Once Indiana's most famous landmark, Hoosier Slide was a huge sand dune bordering the west side of Trail Creek where it entered Lake Michigan. At one time it was nearly 200 feet tall, mantled with trees. Cow paths marked its slopes and people picnicked upon its crest. With the development of Michigan City, the timber was cut for building construction and the sand began to blow, sometimes blanketing the main business district of the town on Front Street, which nestled near its base.

Climbing Hoosier Slide was very popular in the late 1800's with the excursionist crowds who arrived in town by boat and train from Chicago and other cities. The summit, where weddings were sometimes held, afforded an excellent view of the vast lumberyards which then covered the Washington Park area.

Bird's Eye View of Michigan City, 1869, A. Ruger, partial print shown opposite page.

When it was discovered that the clean sands of Hoosier Slide were useful for glassmaking, the huge dune began to be mined away. Dock workers loaded the sand into railroad cars with shovel and wheelbarrow to be shipped to glassmakers in the U. S. and Mexico. Much of the sand also went to Chicago in the 1890's as fill for Jackson Park and for the Illinois Central RR right-of-way. Over a period of 30 years, from about 1890 to 1920, 13-1/2 million tons of sand were shipped from Hoosier Slide until the great dune was leveled and, chances are, little, if any, of it was moved via the Monon. NIPSCO acquired the site for use as a generating plant in the late 1920's."[3]

[3] *"Hoosier Slide,"* http://www.mclib.org/port3.htm



Mt. Baldy as seen from Lake Michigan; Mt. Baldy is ~120 ft. high, as compared to the former Hoosier Slide that was ~200 ft. tall

Conversely, the Mount Baldy sand dune, approximately 120 feet high and located only 1-1/2 miles west of the former Hoosier Slide, was preserved as part of the Indiana Dunes National Lakeshore Park which opened in 1966 and now hosts approximately two million visitors each year.[4] This is just one historical example of how one land use decision has forever altered the Trail Creek watershed landscape.

[4] North *End Redevelopment Strategy, Michigan City, Indiana"* prepared by Anderson and Camiros, October 2001, page 38.

The second significant challenge in the Trail Creek watershed noted in 1993 was the number of governmental jurisdictions who have authority throughout the watershed. Since the Trail Creek Watershed drainage area includes more than 59 square miles of northwestern LaPorte County, the many complexities arising from multiple governmental jurisdictions presents significant challenges for improving water quality.

An overlay of Trail Creek's tributaries onto a map of local units of government (Figure 1) yields the involvement of four townships: Michigan, Springfield, Center and Coolspring; two towns: Town of Trail Creek and Town of Pottawattamie Park; one City: Michigan City; and the entire watershed lies within the jurisdiction of LaPorte County.

Concerns with respect to specific water quality problems in Trail Creek began to be identified with the 1988-89 Indiana 305(b) Report[5] issued by the Indiana Department of Environmental Management (IDEM). Problems identified at that time included poor aquatic life support due to low dissolved oxygen levels, impairment of recreational uses due to *E. coli* bacteria levels, and substandard water clarity due to urban/rural runoff and stream bank erosion.

[5] Trail Creek Watershed Management Plan of 1993

After the issuance of the IDEM report, local civic leaders recognized the importance of addressing water quality issues in Trail Creek. In the "Horizon 2000 Michigan City Area Strategic Plan" issued on March 30, 1992, a plan that was prepared for and in conjunction with the citizens of Michigan City, a specific lakefront and Trail Creek water quality goal was identified:

"Our goal is to have the highest quality of water for recreation and aquatic production in the area by eliminating debris, pollutants and sediment build-up in the creeks."[6]

[6] http://www.lc-link.org/horizon2000/

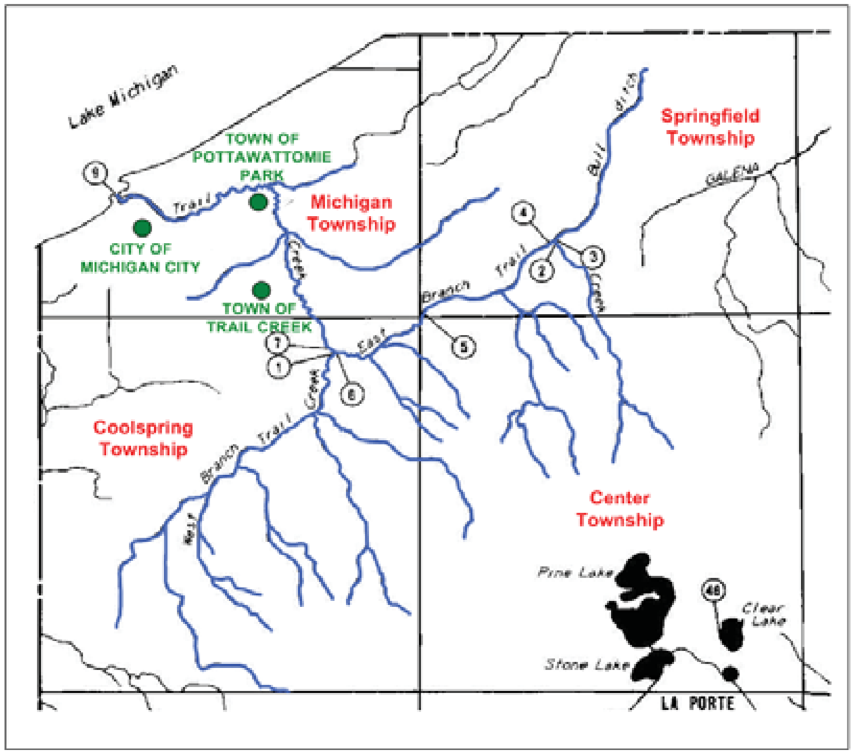


Figure 1: Trail Creek
Map Source: DNR website, http://www.in.gov/dnr/water/surface_water/drainage_area/pdf/laporte.pdf; coloring added

The Horizon 2000 report also identified several action items: work with local, state and federal agencies to characterize sediments in all lake tributaries and identify sources of pollution; monitor sources of pollution after they are identified and encourage enforcement and compliance with regulations; clean up current sediments in all lake tributaries and prevent future sediment build-up; provide better aquatic reproduction; and, develop soil conservation and management regulations.

An immediate product of these early efforts included the preparation and completion of the "Trail Creek Watershed Management Plan of 1993". This report offered a multi-faceted and substantive plan focused on nonpoint sources of pollution, with recommendations to reduce sedimentation and nutrient loading to the stream of Trail Creek. Several demonstration projects including 4 streambank restoration projects and a constructed wetland for residential sewage disposal were implemented with grant monies as a result of the 1993 Trail Creek Watershed Management Plan; however long term monitoring was implemented nor were additional grant monies sought for implementation. The Watershed Management plan stated that a "Lead Agency" needed to be identified to coordinate watershed improvement activities. In hindsight, a fatal shortcoming of the implementation of the 1993 Watershed management plan was that no "Lead Agency" was ever identified.

Nonetheless, despite not having a Lead Agency to implement Trail Creek watershed improvements, successes have occurred: agricultural best management practices such as wildlife watering areas, grass waterways and filter strips have been constructed in Springfield Township; the ecological integrity of the stream has been restored in some locations with the use of lunkers and j-hooks; the levels of the primary pollutant (*E. coli*) in Trail Creek have been reduced through storm sewer separation, sanitary sewer expansions and the disinfection of the J.B. Gifford Wastewater Treatment Plant's combined sewer overflow discharge (Figure 2, Appendix L); and public access along Trail Creek within Michigan City has been expanded significantly with the opening of the Trail Creek Greenway, Winding Creek Cove, Karwick Nature Park and a renovated Hansen Park. For reference to the grassed waterways and stream structures implemented previously see the photographs on page 5. A previous implementation

Michigan City's Combined Sewer Overflow Control: A National Success Story

Progress thru 1983	Progress thru 1990	Progress thru 1996	Progress thru 2003	Progress thru 2006
35% of original combined sewers were separated	A 54" relief sewer was constructed in the city's north end	60% of original combined sewers were separated	91% of original combined sewers were separated	94% of original combined sewers were separated
Sewer system had 18 CSO points into Trail Creek	18 sewer system CSO points **RE-DUCED** to only 6	Investment in sewer separation since 1962 was >$50 mill.	Investment in sewer separation since 1962 was >$80 mill.	Investment in sewer separation since 1962 was >$85 mill.
41 million gallons of CSO discharge yearly to Trail Creek	6.15 mill. gal. Storm Retention Basin built at WWTP	All 6 sewer system CSO points were **ELIMINATED**	From 1990-1997, the Storm Basin CSO rate was 19 events per yr.; from 1998-2003 the Storm Basin CSO rate was 1 per yr.; a **95% REDUCTION**	Headworks upgrade achieves **15 MGD** wet weather flow
CSO's during rain events **VIOLATE** the >7.0 mg/l DO criteria in Trail Creek for salmon	Coll. Sys. CSO flow **REDUCED** by 75%; strength of CSO reduced by 70%	The **ONLY** CSO point in Michigan City is the Storm Basin overflow; the Storm Basin provides the equivalent of primary & secondary treatment; thus, the only CSO Water Quality impairment is E. Coli		Storm Basin Disin-fection Project leads to **ATTAINMENT** of acute Water Qual. Standards for CSO
	WWTP CSO flow **REDUCED** by 95%; strength of CSO reduced by 75%		WWTP wet weather flow rating is 15 MGD, but due to equip. wear the max. wet weath. flow is only 13.9 MGD	Watershed approach leads to >500 homes removed from a floodplain; marina, urban & rural BMPs planned for the creek
			For Oct. 2001 CSO, creek DO was 9.6!	**For Jan. 2005 CSO, creek DO was 10.6!**

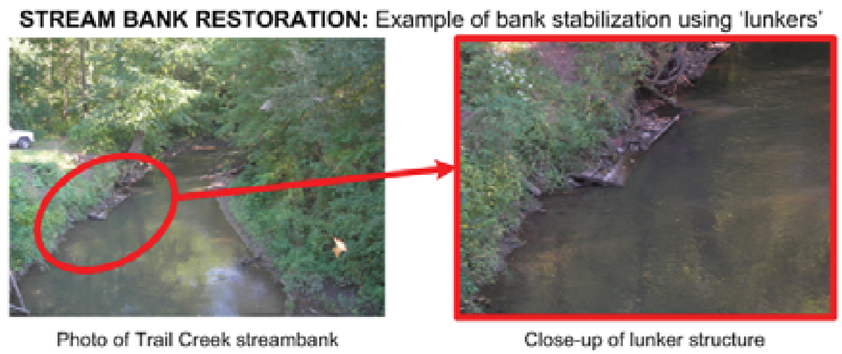
This comprehensive multi-part strategy for improved stormwater controls at the J.B. Gifford WWTP has led to dramatic success in reducing CSO events in Michigan City as one can see from the following table:

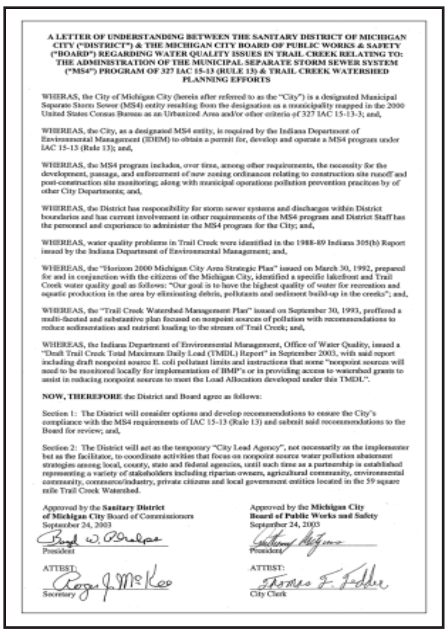
Historical Number of CSO Events per Year

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
47	24	2	32	3	0	19	14	1	0	0	1	1	0	0	1

Figure 2: Michigan City's Combined Sewer Overflow Control - A National Success Story (appendix page 64)

Grassed waterway photos provided by Anton Ekovich, Springfield Township





A LETTER OF UNDERSTANDING BETWEEN THE SANITARY DISTRICT OF MICHIGAN CITY ("DISTRICT") & THE MICHIGAN CITY BOARD OF PUBLIC WORKS & SAFETY ("BOARD") REGARDING WATER QUALITY ISSUES IN TRAIL CREEK RELATING TO: THE ADMINISTRATION OF THE MUNICIPAL SEPARATE STORM SEWER SYSTEM ("MS4") PROGRAM OF 327 IAC 15-13 (RULE 13) & TRAIL CREEK WATERSHED PLANNING EFFORTS

WHERAS, the City of Michigan City (herein after referred to as the "City") is a designated Municipal Separate Storm Sewer (MS4) entity resulting from the designation as a municipality mapped in the 2000 United States Census Bureau as an Urbanized Area and/or other criteria of 327 IAC 15-13-3; and,

WHEREAS, the City, as a designated MS4 entity, is required by the Indiana Department of Environmental Management (IDEM) to obtain a permit for, develop and operate a MS4 program under IAC 15-13 (Rule 13); and,

WHEREAS, the MS4 program includes, over time, among other requirements, the necessity for the development, passage, and enforcement of new zoning ordinances relating to construction site runoff and post-construction site monitoring; along with municipal operations pollution prevention practices by of other City Departments; and,

WHEREAS, the District has responsibility for storm sewer systems and discharges within District boundaries and has current involvement in other requirements of the MS4 program and District Staff has the personnel and experience to administer the MS4 program for the City; and,

WHEREAS, water quality problems in Trail Creek were identified in the 1988-89 Indiana 305(b) Report issued by the Indiana Department of Environmental Management; and,

WHEREAS, the "Horizon 2000 Michigan City Area Strategic Plan" issued on March 30, 1992, prepared for and in conjunction with the citizens of the Michigan City, identified a specific lakefront and Trail Creek water quality goal as follows: "Our goal is to have the highest quality of water for recreation and aquatic production in the area by eliminating debris, pollutants and sediment build-up in the creeks"; and,

WHEREAS, the "Trail Creek Watershed Management Plan" issued on September 30, 1993, proffered a multi-faceted and substantive plan focused on nonpoint sources of pollution with recommendations to reduce sedimentation and nutrient loading to the stream of Trail Creek; and,

WHEREAS, the Indiana Department of Environmental Management, Office of Water Quality, issued a "Draft Trail Creek Total Maximum Daily Load (TMDL) Report" in September 2003, with said report including draft nonpoint source E. coli pollutant limits and instructions that some "nonpoint sources will need to be monitored locally for implementation of BMP's or in providing access to watershed grants to assist in reducing nonpoint sources to meet the Load Allocation developed under this TMDL".

NOW, THEREFORE the District and Board agree as follows:

Section 1: The District will consider options and develop recommendations to ensure the City's compliance with the MS4 requirements of IAC 15-13 (Rule 13) and submit said recommendations to the Board for review; and,

Section 2: The District will act as the temporary "City Lead Agency", not necessarily as the implementer but as the facilitator, to coordinate activities that focus on nonpoint source water pollution abatement strategies among local, county, state and federal agencies, until such time as a partnership is established representing a variety of stakeholders including riparian owners, agricultural community, environmental community, commerce/industry, private citizens and local government entities located in the 59 square mile Trail Creek Watershed.

Approved by the **Sanitary District of Michigan City** Board of Commissioners
September 24, 2003
President
ATTEST:
Secretary

Approved by the **Michigan City Board of Public Works and Safety**
September 24, 2003
President
ATTEST:
City Clerk

Figure 4: Letter of Understanding, larger version included (appendix page 4).

In 2003, grassroots efforts for improving Trail Creek's water quality produced results once again. Since the Mission of the Sanitary District of Michigan City includes providing for "the efficient drainage of storm water through best management practices" and "protecting the designated uses for the Trail Creek Watershed and Lake Michigan through environmental stewardship," the District agreed to outreach efforts by the city of Michigan City and a local nonprofit agency, the Unity Foundation of LaPorte County, to pursue a Section 319 Grant for funding an update to the "Trail Creek Watershed Management Plan of 1993." With a $10,000 contribution from the Unity Foundation and a $5,000 funding commitment from the Sanitary District, Michigan City received a $45,000 grant from IDEM to fund the preparation of this Watershed Management Plan Update to comply with current standards. The creation of a Watershed Management Plan is a voluntary process, enabling a community or watershed organization to apply for additional implementation funding and assistance from several state and federal agencies. Once the updated Watershed Management Plan is completed, local watershed advocates would be eligible for additional grants to begin implementation and start achieving the desired Trail Creek water quality improvements envisioned by local civic leaders back in 1992.

The first step in this Watershed Management Plan Update process was the designation by Michigan City that the Sanitary District would facilitate the City's renewed efforts to mitigate pollution in Trail Creek. Through a Letter of Understanding between the Board of Public Works and Safety of Michigan City and the Sanitary District of Michigan City (Figure 4), the following was agreed to:

"The District will act as the temporary 'Lead Agency', not necessarily as the implementer but as the facilitator, to coordinate activities that focus on nonpoint source water pollution abatement strategies among local, county, state and federal agencies, until such time as a partnership is established representing a variety of stakeholders including riparian owners, the agricultural community, environmental community, commerce/industry, private citizens and local government entities located in the 59 square mile Trail Creek Watershed." [7]

[7] Letter of understanding between the Michigan City Board of Public Works and Safety and the Sanitary District of michigan City, September 24, 2003.

Once the designation of the Sanitary District as the Lead Agency to facilitate Trail Creek watershed improvements was formalized, the next step was to reconnect, reinvigorate, and recommit the original stakeholder participants from 1993 to participate in this critical update of the watershed management plan. Through these outreach efforts, additional new stakeholders have agreed to participate and a total of 25 entities and organizations are now part of substantive watershed management planning in LaPorte County. The original stakeholders from 1993 and the additional stakeholders from 2003 are identified as follows in Figure 3.

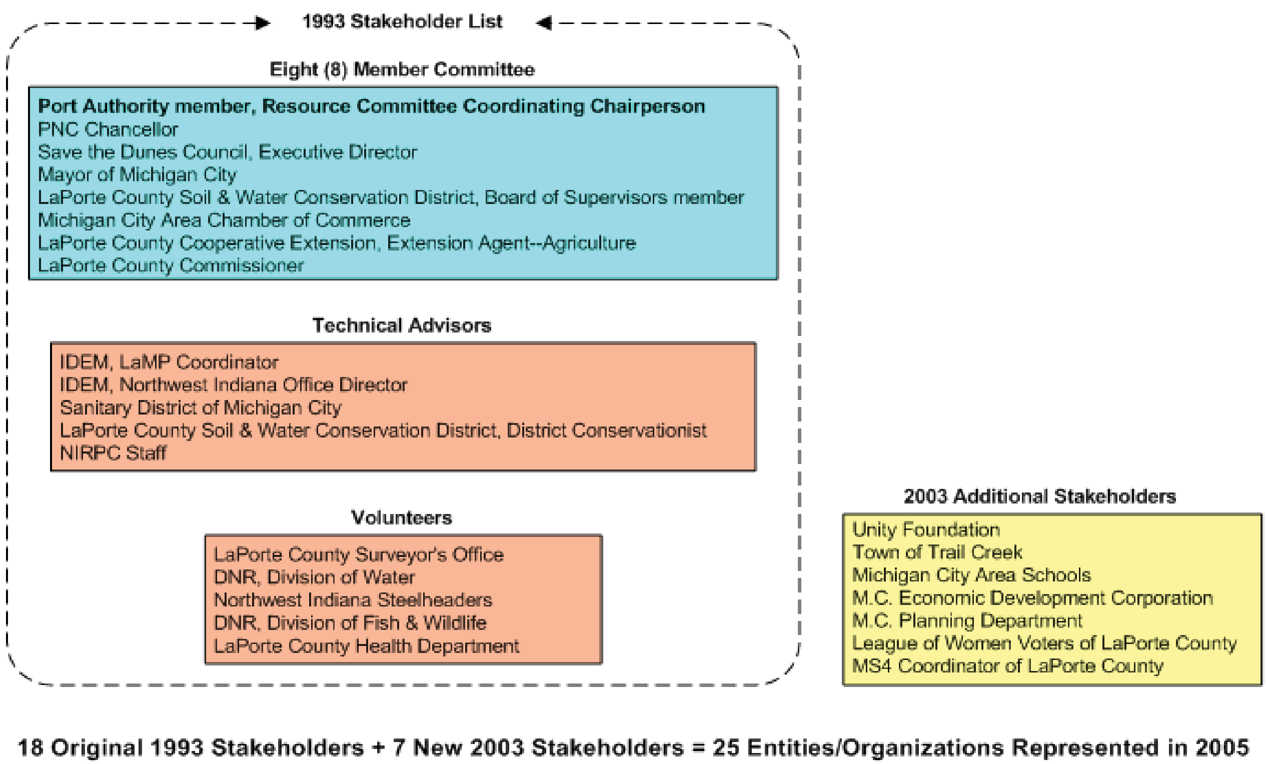


Figure 3: Stakeholders

The efforts of the collective local watershed community in 1993, coupled with the successes noted above, provide evidence that water quality improvements can be achieved in the Trail Creek Watershed. Thus, the volunteers who committed themselves to the development of this Trail Creek Watershed Management Plan update have defined our vision and mission for moving forward as follows:

Vision: *Through collaborative efforts, we can provide the stewardship and leadership required now in order for future generations to enjoy the natural beauty and prosperity of a clean Trail Creek.*

Mission: *Citizens of the Trail Creek Watershed will assess water quality issues and develop meaningful implementation strategies targeted to improve the quality of life within the watershed through water quality enhancement and realization of the long term goals with regard to the environmental, recreational, and aesthetic use of our Lake Michigan lakefront and Trail Creek.*

Watershed Concerns

THE KEY to success in the Trail Creek Watershed management is the participation and inclusion of local citizens and as many public and private institutions as possible. To achieve this desired participation, selected stakeholders were invited to participate in the Trail Creek Watershed Management Plan as Steering Committee members. Thus, representatives of the City Lead Agency, funding partners, local citizens, local conservation agencies, and local and state resource agencies were invited and agreed to serve on the Trail Creek Watershed Management Plan Steering Committee. Organizations and entities represented on the Steering Committee include: the Sanitary District of Michigan City, the Indiana Department of Environmental Management (IDEM), the Unity Foundation, local property owners including farmers, the Save the Dunes Council, the Indiana Department of Natural Resources (IDNR), the LaPorte County Soil and Water Conservation District, the LaPorte Field Office of the Natural Resources Conservation Service, the Purdue University Cooperative Extension Service, and the Northwestern Indiana Regional Planning Commission. Contact information for the Steering Committee members are included as an Appendix A to this report.

The role of the Steering Committee is to provide detailed input and direction from the local community with regard to the Trail Creek Watershed Management Plan including identifying the mission of the plan, problems within the watershed, and potential solutions. The first Steering Committee meeting was held on January 19, 2006 and those meetings have continued on approximately a monthly basis throughout 2006. At the first meeting, the history of watershed management planning in the Trail Creek Watershed was reviewed. For reference see Appendix E. Members were provided with a handbook and relevant materials to be used during the planning process. Data collected to date in support of the Trail Creek Watershed Management Plan were reviewed and other sources of available data within the watershed were discussed.

The first windshield tour of the Trail Creek Watershed and sampling locations with Steering Committee Members was conducted with Kevin Lackman, the LaPorte County MS4 Coordinator, on January 27, 2006 to assess potential problem areas within the watershed.

The second Steering Committee meeting was held on February 2, 2006. At that meeting, the role of individuals with their sub-committee assignments, the mission and vision of the Trail Creek Watershed Management Plan, problem identification measures, and the future public involvement opportunities were addressed. Seven sub-committees were established to focus the efforts of the Trial Creek Watershed Management Plan including problem identification, data management, and implementation. Each Steering Committee member was selected for at least one specific sub-committee. Additional sub-committee members were selected based on interest and specialized knowledge from the public and stakeholders. These sub-committees are as shown in Figure 5:

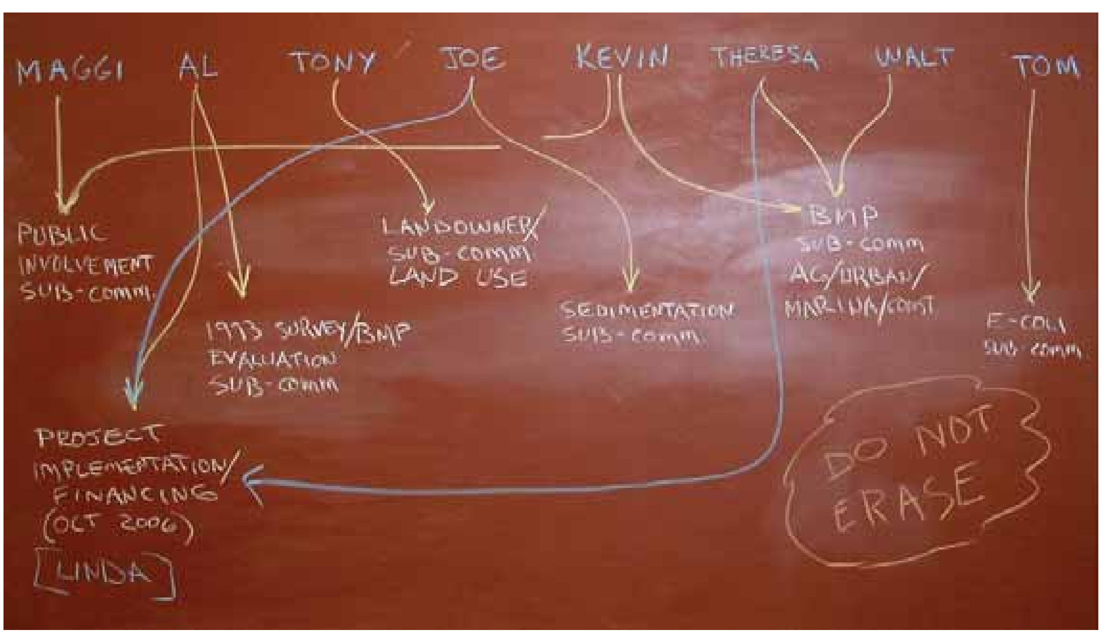


Figure 5: Steering committee and sub-committee

The Steering Committee met on April 3, May 5, and June 29, 2006 to review water quality data collected and problem areas within the watershed in preparation for presentation to the public. The second windshield tour of the watershed with Steering Committee Members was conducted on June 27, 2006.

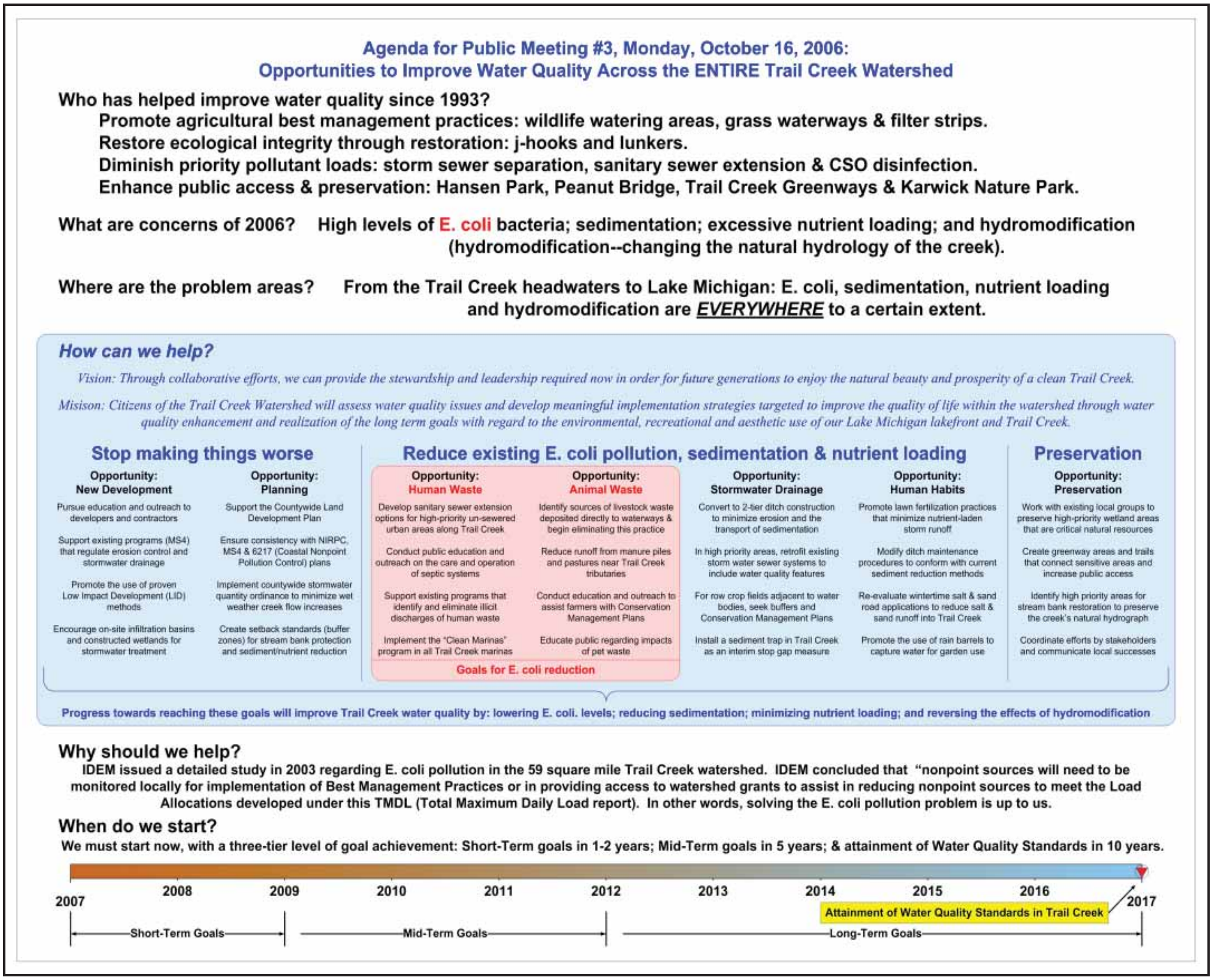
The Steering Committee continued to meet during the summer and fall to discuss the critical areas within the watershed and goals and management strategies. Meetings were held on July 13, August 2, September 26, and October 4, 2006.

In addition to the Steering Committee, public participation into the plan development was solicited at three separate Public Involvement and Stakeholder meetings. A significant amount of work by the Steering Committee was preparation for substantive dialog with the general public at quarterly public meetings. The first Public Involvement and Stakeholder meeting was held on February 8, 2006 at 7:00 pm in the City Hall Council Chambers in Michigan City. The press release advertising the first Public Involvement and Stakeholder meeting, the agenda and the informational materials distributed are included in the Appendix F and G. The public was encouraged to attend this first meeting and provide input on concerns regarding Trail Creek water quality issues. The agenda of the first Public Involvement and Stakeholder meeting included an historical overview of Trail Creek watershed management planning; a summary of water sampling results from the past year; the identification of problem issues affecting the Trail Creek watershed; and an open discussion with all attendees regarding the purpose, mission, and vision of the Watershed Management Plan and problem issues to be addressed. Approximately 45 people were present at this meeting.

The second Public Involvement and Stakeholder meeting occurred on June 29, 2006, 7:00 pm, at Springfield Elementary School in Michigan City. This venue was selected for its location within the watershed, outside of Michigan City, in order to gain wider participation in the public involvement process. The press release for this public meeting, the agenda, and the informational materials distributed are is included in the Appendix H and I. This meeting was used to inform the public of the progress that has taken place in the study associated with the writing of the Trail Creek Watershed Management Plan and to gather specific input on the location of possible nonpoint pollution locations. The beginning portion of the meeting was spent giving the public a general background of the knowledge and information associated with watersheds and pollution, followed by an overview of the current data and its analysis. The remaining portion of the public meeting was used to allow the public to physically become involved by examining aerial photography, marking the printouts with areas of concern, and allowing their voice to help guide the creation of the Trail Creek Watershed Management Plan. This method provide an in-valuable insight into parts of the watershed that otherwise would have not been reasonably able to be examined. Approximately 20 people were present at this meeting.

The third Public Involvement and Stakeholder meeting occurred on October 16, 2006, 7:00 pm, at in the City Hall Council Chambers in Michigan City. The press release for this public meeting, the agenda, and the informational materials distributed are is included in the Appendix J and K. This meeting was used to inform the public of the progress that has taken place in the study and to review the goals of the Trail Creek Watershed Management Plan. Comments regarding critical areas, pollutants of concern, and watershed management goals were discussed. In addition, the project approach for the Watershed Management Plan as seen in Figure 6 was discussed. Approximately 25 people were present at this meeting.

In addition to being open to the public, each of the three public meetings were also filmed and re-broadcast on the local cable access channel.



Agenda for Public Meeting #3, Monday, October 16, 2006:
Opportunities to Improve Water Quality Across the ENTIRE Trail Creek Watershed

Who has helped improve water quality since 1993?
Promote agricultural best management practices: wildlife watering areas, grass waterways & filter strips.
Restore ecological integrity through restoration: j-hooks and lunkers.
Diminish priority pollutant loads: storm sewer separation, sanitary sewer extension & CSO disinfection.
Enhance public access & preservation: Hansen Park, Peanut Bridge, Trail Creek Greenways & Karwick Nature Park.

What are concerns of 2006? **High levels of E. coli bacteria; sedimentation; excessive nutrient loading; and hydromodification (hydromodification--changing the natural hydrology of the creek).**

Where are the problem areas? **From the Trail Creek headwaters to Lake Michigan: E. coli, sedimentation, nutrient loading and hydromodification are *EVERYWHERE* to a certain extent.**

How can we help?

Vision: Through collaborative efforts, we can provide the stewardship and leadership required now in order for future generations to enjoy the natural beauty and prosperity of a clean Trail Creek.

Misison: Citizens of the Trail Creek Watershed will assess water quality issues and develop meaningful implementation strategies targeted to improve the quality of life within the watershed through water quality enhancement and realization of the long term goals with regard to the environmental, recreational and aesthetic use of our Lake Michigan lakefront and Trail Creek.

Stop making things worse		Reduce existing E. coli pollution, sedimentation & nutrient loading				Preservation
Opportunity: New Development	Opportunity: Planning	Opportunity: Human Waste	Opportunity: Animal Waste	Opportunity: Stormwater Drainage	Opportunity: Human Habits	Opportunity: Preservation
Pursue education and outreach to developers and contractors	Support the Countywide Land Development Plan	Develop sanitary sewer extension options for high-priority un-sewered urban areas along Trail Creek	Identify sources of livestock waste deposited directly to waterways & begin eliminating this practice	Convert to 2-tier ditch construction to minimize erosion and the transport of sedimentation	Promote lawn fertilization practices that minimize nutrient-laden storm runoff	Work with existing local groups to preserve high-priority wetland areas that are critical natural resources
Support existing programs (MS4) that regulate erosion control and stormwater drainage	Ensure consistency with NIRPC, MS4 & 6217 (Coastal Nonpoint Pollution Control) plans	Conduct public education and outreach on the care and operation of septic systems	Reduce runoff from manure piles and pastures near Trail Creek tributaries	In high priority areas, retrofit existing storm water sewer systems to include water quality features	Modify ditch maintenance procedures to conform with current sediment reduction methods	Create greenway areas and trails that connect sensitive areas and increase public access
Promote the use of proven Low Impact Development (LID) methods	Implement countywide stormwater quantity ordinance to minimize wet weather creek flow increases	Support existing programs that identify and eliminate illicit discharges of human waste	Conduct education and outreach to assist farmers with Conservation Management Plans	For row crop fields adjacent to water bodies, seek buffers and Conservation Management Plans	Re-evaluate wintertime salt & sand road applications to reduce salt & sand runoff into Trail Creek	Identify high priority areas for stream bank restoration to preserve the creek's natural hydrograph
Encourage on-site infiltration basins and constructed wetlands for stormwater treatment	Create setback standards (buffer zones) for stream bank protection and sediment/nutrient reduction	Implement the "Clean Marinas" program in all Trail Creek marinas	Educate public regarding impacts of pet waste	Install a sediment trap in Trail Creek as an interim stop gap measure	Promote the use of rain barrels to capture water for garden use	Coordinate efforts by stakeholders and communicate local successes
		Goals for E. coli reduction				

Progress towards reaching these goals will improve Trail Creek water quality by: lowering E. coli. levels; reducing sedimentation; minimizing nutrient loading; and reversing the effects of hydromodification

Why should we help?
IDEM issued a detailed study in 2003 regarding E. coli pollution in the 59 square mile Trail Creek watershed. IDEM concluded that "nonpoint sources will need to be monitored locally for implementation of Best Management Practices or in providing access to watershed grants to assist in reducing nonpoint sources to meet the Load Allocations developed under this TMDL (Total Maximum Daily Load report). In other words, solving the E. coli pollution problem is up to us.

When do we start?
We must start now, with a three-tier level of goal achievement: Short-Term goals in 1-2 years; Mid-Term goals in 5 years; & attainment of Water Quality Standards in 10 years.

Figure 6: Agenda for Public Meeting No. 3. Monday, October 16, 2006. Opportunities to Improve Water Quality Across the entire Trail Creek Watershed

A telephone survey of 600 random LaPorte County residents was conducted in 2000 and utilized to prepare the 2001 LaPorte County Resource and Needs Assessment on Environmental Concerns. Key indicators from that survey indicated that "Environment" ranked No. 5 in importance out of ten quality of life categories to those surveyed; Water Quality was considered the highest environmental issue by respondents, with air quality and the environment in general trailing. Focus groups and telephone respondents identified E-coli, water & beach quality, septic systems, soil/water conservation and industrial chemical leakage into drinking water as some of their environmental concerns.

In addition to the LaPorte County Resource and Needs Assessment on Environmental Concerns, through coordination and collaboration of the watershed partners a variety of concerns with regard to Trail Creek and the Trail Creek Watershed have been expressed during the preparation of this plan. Concerns included in this report represent those concerns of the general public, the stakeholders, and the Steering Committee members. Following is a summary of the concerns expressed. The majority of the concerns fall into a few major categories. As project planning progresses these concerns will be narrowed to problem areas.

Areas of Concern Expressed by Steering Committee Members, Stakeholders, and the Public

- Stream and Water Quality
    - Combined sewer overflows
    - Agricultural impacts to water quality
    - *E. coli* within the stream and impacts to human health
    - Stormwater runoff from commercial and industrial sites, especially truck stops
    - Illegal discharges from permitted point sources
    - Livestock (cattle and horses) allowed access to streams
    - Illegal discharge of manure to streams
    - Runoff from roadways including sand and salt
    - Runoff from roadways from tire wear
    - Impacts to streams from construction runoff
    - Water clarity and aesthetics
    - Runoff and discharge from industrial and commercial sites
    - Nutrient loading to streams
    - Algae growth
    - Riparian buffers
    - Lake water levels
    - Water and beach quality
    - Airborne particulate depostion from NIPSCO Generating Station's emissions
- Aquatic Health and Fisheries
    - Fish advisories
    - Aquatic health and fisheries, native fisheries
    - Invasive species
    - Lowered water levels in the streams
    - Cold water stream impacts/temperature
    - Nuisance wildlife
    - Fish kills
    - Soil and water conservation
- Public Health
    - Beach closings
    - Atrazine and other herbicides and pesticides in the water
    - Failing septic systems and installation of systems in areas with unsuitable soils
    - Superfund site and potential contamination in streams
    - Contaminated sediment in Trail Creek
    - Fish advisories
    - Septic systems
    - Pollutants from marinas
- Sedimentation and Streambank Erosion
    - Streambank stability
    - Streambank stability at brownfield sites
    - Channel modification
    - Regrading of ditches and impacts to streams and natural areas from county highway department maintenance operations
    - Sedimentation within the navigable channel and dredging, sedimentation upstream
    - Habitat degradation
    - Salmonoid and trout fisheries, particularly native reproducing fisheries

- Operational and Planning Organization
    - Property rights of owners along streams being informed of activities along stream
    - Low impact development
    - Recreational boating
    - Recreational opportunities and greenways
    - Interferences with projects
    - Regional detention
    - Coordination with county planners
    - Coordination with MS4
    - Funding
    - Implementation of plan and lead agency
    - Coordination of agencies within county and overlap of efforts
    - Education and outreach
    - Preservation and restoration of wetlands and natural areas
    - Coordination with agencies and organizations working towards better water quality in Lake Michigan
    - Data gathering and mapping of point and non-point source discharges and sharing of data
    - Marina's and coordination with Lake Michigan Costal Program (LMCP)

Baseline Watershed Information

TRAIL Creek is located in LaPorte County in northwest Indiana and flows into Lake Michigan at Michigan City's lakefront park and marina, Figure 7. The creek flows 14.5 linear miles through various land uses including urban residential and industrial areas as well as rural agricultural and residential. Trail Creek has both an east and a west branch which drain predominantly low density housing, farmland, and wooded tracts. The land that drains to the main stem of Trail Creek downstream from Johnson Road and US 20 is essentially totally developed and includes Michigan City, Potawatomie Park, and the Town of Trail Creek.

Within LaPorte County, the area included in the Trail Creek Watershed is the most rapidly developing land use due to proximity to Michigan City, interstate transportation, and public services. The steering committee for the LaPorte County Plan Commission Countywide Land Development Plan has indicated that much of the anticipated future growth within the county will be encouraged to take place within the Trail Creek Watershed.

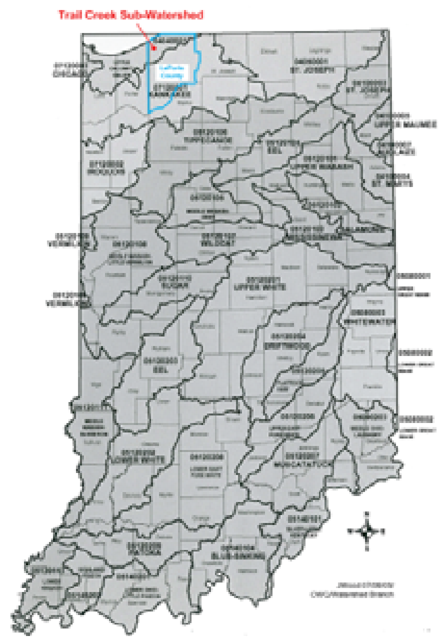


Figure 7: Trail Creek Watershed Location Mapping (see appendix page 71)

Watershed Location

The Trail Creek Watershed is located in northwestern Indiana, in LaPorte County, and drains into Lake Michigan at Michigan City, Indiana. The 37,800 acre watershed lies almost entirely within Michigan, Center, Coolspring, and Springfield Townships.

The drainage area for Trail Creek is approximately 59.1 square miles. The main stem of the creek divides into two main tributaries – East Branch and West Branch, Figure 8.

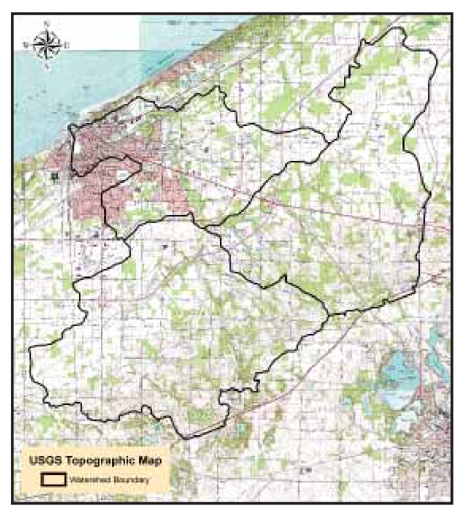


Figure 8: Trail Creek Watershed Topographic Mapping (see appendix page 72)

Description and History

Natural History

LaPorte County, Indiana is located in the Great Lakes section of the Central Lowland physiographic province. The present landscape of LaPorte County is subdivided into three distinct physiographic subsections including the Calumet Lacustrine Plain located along Lake Michigan, the Valparaiso Morainal Plain located in the central portion of the county, and the Kankakee Outwash Lacustrine Plain located in the southern portion of the county, Figure 9. These physiographic subsections resulted from the last major glaciation event during which continental glaciers and associated depositional processes produced the current surface features (Soil Survey of LaPorte County, 1978)

Watershed Land and Stream Use

The Trail Creek Watershed, located along the southeastern shoreline of Lake Michigan in LaPorte County, Indiana is composed of a combination of different land uses. These land uses include moderate to dense residential, major shipping, multiple levels of industrial, commercial, agricultural, and recreational land use. The agricultural and less developed areas of the watershed lie further from the watershed's mouth at Lake Michigan. Of the three sub-watersheds, the Trail Creek-Otter Creek Sub-watershed or the Main Branch has the greatest amount of developed land. Table 1 and Figure 10 display land use acreage throughout the Trail Creek Watershed and for each of the three individual sub-watersheds,

Figure 9: Physiographic Areas (see appendix page 73)

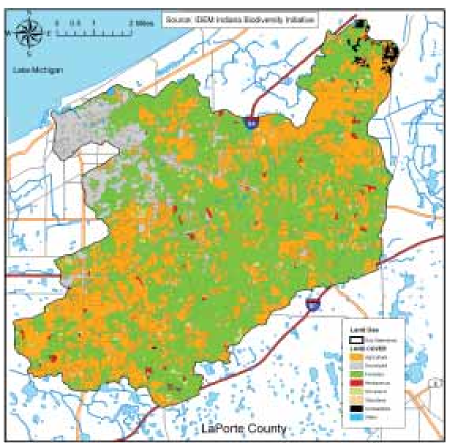


Figure 10: Watershed Land Use (see appendix page 74

the East Branch, the West Branch, and the Trail Creek-Otter Creek Branch, see Figure 10.

Current land use within the Trail Creek Watershed is approximately 39% agricultural, 9% developed, 51% forested or natural areas, and 1% water or unclassified. Land use within the sub-watersheds of Trail Creek Watershed is as follows. The Main Branch of Trail Creek including the majority of Michigan City, the Town of Trail Creek, and Potawatomi Park includes approximately 23% agricultural, 32% developed, 44% forested or natural areas, and 1% water or unclassified. The East Branch of Trail Creek includes approximately 47% agricultural, 3% developed, 49% forested or natural areas, and 1% water or unclassified. The West Branch of Trail Creek includes approximately 39% agricultural, 2% developed, 58% forested or natural areas, and 1% water or unclassified.

Land use within a watershed directly influences the quantity and quality of non-point stormwater run-off which in turn influences the overall water quality and health of a stream or tributary. Agricultural land uses can contribute a variety of pollutant loadings to streams and tributaries including sediment, nutrients including fertilizers, bacteria, and agricultural chemicals of concerns. Storm water discharges from developed or urbanized areas are generally increased due to large areas of impervious surfaces, such as city streets, driveways, parking lots, and sidewalks. Pollutant loadings from these developed areas can include sediment, nutrients including fertilizers, oils, salt, litter, bacteria, and other chemicals of concern. Natural land uses such as forests or wetlands and riparian buffers can decrease pollutant loadings to streams due to non-point source pollution.

Historically, Trail Creek has been utilized as a major industrial shipping port and recreational destination. The stream of Trail Creek was originally named Riviere du Chermin (River of the Trail) by French traders because trails of the Potawatomie Indians converged along the stream. The first survey of the Lake Michigan shore in 1816 indicated Trail Creek was 30 feet wide at its mouth. Hoosier Slide, a giant sand dune, stood at the harbor entrance until it was removed by sand mining. Michigan City was founded in 1832 and with it began the utilization of Trail Creek for shipping and recreation.

In the 1800s 13 grist mills were located on the banks of Trail Creek. Trail Creek also served as a major port for farm goods and passengers. Goods shipped from the port include lumber and farm products. Passenger traffic, particularly day trips from Chicago to Washington Park, was also strong until the Eastland disaster in 1915.

According to the LaPorte County Historical Society, prior to 1830, all of LaPorte County was a part of the Potawatomie Nation. In 1838, the Potawatomie were removed by the United States Government to Osage County, Kansas. LaPorte officially became a county on May 28, 1832, consisting then of 462 square miles and extended only as far south as the southern line of present Clinton Township. Due to difficulty in crossing the Kankakee River, the southern portion of what is today LaPorte County requested to be annexed to LaPorte County. This was completed in January 28, 1842. On January 10, 1850, twenty sections of land were taken from St. Joseph County on the east and added to LaPorte County to give LaPorte County its present boundaries.

Michigan City arose from the ambition of Isaac Elston to create a harbor on Lake Michigan, and a road to transport supplies to homesteaders in Indianapolis and central Indiana. Isaac Elston purchased 160 acres of land including Trail Creek and the harbor in 1830. Early visitors to the region were captivated by its rugged beauty, its abundance of wildflowers and berries, and especially the majestic sand dunes, one towering to 200-foot height. The land, however, was not suitable for farming. The growth of Michigan City was due to the flowing waters of Trail Creek which afforded good locations for lumber and gristmills. Farmers came from miles around to have their wheat ground into flour.

By 1836, the year of its incorporation, Michigan City had 1,500 residents, a

		Trail Creek Land Use Data					
Watershed		**Land Use Type**	**Acres**	**% of watershed**	**Wetland Type***	**Acres**	**watershed**
Trail Creek							
	Agricultural	Developed Agriculture Pasture/Grassland	4974.53	13.21%	Palustrine emergent	453.23	1.20%
		Developed Agriculture Row Crop	9657.30	25.64%	Palustrine forested	2804.27	7.45%
	Developed	Developed Non-Vegetated	533.94	1.42%	Palustrine scrub/shrub	209.90	0.56%
		Developed Urban High Density	1360.45	3.61%	Palustrine submergent	5.78	0.02%
		Developed Urban Low Density	1567.46	4.16%	Ponds	25.94	0.07%
	Forested	Terrestrial Forest Deciduous	14251.35	37.84%	Riverine	9.31	0.02%
		Terrestrial Forest Evergreen	208.63	0.55%			
		Terrestrial Forest Mixed	82.46	0.22%			
		Palustrine Forest Deciduous	3470.64	9.21%			
	Woodland	Terrestrial Woodland Deciduous	402.57	1.07%			
		Palustrine Woodland Deciduous	3.15	0.01%			
	Herbaceous	Palustrine Herbaceous Deciduous	285.72	0.76%			
	Shrubland	Palustrine Shrubland Deciduous	20.37	0.05%			
		Terrestrial Shrubland Deciduous	684.48	1.82%			
	Water	Water	160.68	0.43%			
	Unclassified	Unclassified Cloud/Shadow	234.54	0.62%			
	Total Acres		**37663.73**			**3508.43**	
	Percentage of Trail Creek Watershed		**100.00%**	Percentage of Trail Creek Watershed		**9.32%**	
Main Branch of Trail Creek							
	Agricultural	Developed Agriculture Pasture/Grassland	896.65	10.43%	Palustrine emergent	60.99	0.71%
		Developed Agriculture Row Crop	1067.30	12.41%	Palustrine forested	654.17	7.61%
	Developed	Developed Non-Vegetated	173.34	2.02%	Palustrine scrub/shrub	36.96	0.43%
		Developed Urban High Density	1213.18	14.11%	Palustrine submergent	2.22	0.03%
		Developed Urban Low Density	1353.46	15.74%	Ponds	3.96	0.05%
	Forested	Terrestrial Forest Deciduous	2770.09	32.21%	Riverine	9.31	0.11%
		Terrestrial Forest Mixed	2.86	0.03%			
		Palustrine Forest Deciduous	802.14	9.33%			
	Woodland	Terrestrial Woodland Deciduous	126.48	1.47%			
		Palustrine Woodland Deciduous	3.15	0.04%			
	Herbaceous	Palustrine Herbaceous Deciduous	21.02	0.24%			
	Shrubland	Terrestrial Shrubland Deciduous	97.69	1.14%			
	Water	Water	71.61	0.83%			
	Total Acres		**8598.97**			**767.70**	
	Percentage of Trail Creek Watershed		**22.83%**	Percentage Sub-Watershed containing		**8.93%**	
West Branch Of Trail Creek							
	Agricultural	Developed Agriculture Pasture/Grassland	1521.60	11.09%	Palustrine emergent	210.47	1.53%
		Developed Agriculture Row Crop	3876.38	28.25%	Palustrine forested	1330.28	9.70%
	Developed	Developed Non-Vegetated	152.67	1.11%	Palustrine scrub/shrub	36.39	0.27%
		Developed Urban High Density	20.10	0.15%	Palustrine submergent	1.89	0.01%
		Developed Urban Low Density	63.10	0.46%	Ponds	6.80	0.05%
	Forested	Terrestrial Forest Deciduous	5756.76	41.96%			
		Terrestrial Forest Evergreen	126.88	0.92%			
		Terrestrial Forest Mixed	29.66	0.22%			
		Palustrine Forest Deciduous	1620.26	11.81%			
	Woodland	Terrestrial Woodland Deciduous	93.72	0.68%			
	Herbaceous	Palustrine Herbaceous Deciduous	129.83	0.95%			
	Shrubland	Palustrine Shrubland Deciduous	6.42	0.05%			
		Terrestrial Shrubland Deciduous	254.80	1.86%			
	Water	Water	68.81	0.50%			
	Unclassified	Unclassified Cloud/Shadow	229.07	1.67%			
	Total Acres		**13721.02**			**1585.83**	
	Percentage of Trail Creek Watershed		**36.43%**	Percentage Sub-Watershed containing		**11.56%**	
East Branch Of Trail Creek							
	Agricultural	Developed Agriculture Pasture/Grassland	2556.28	16.65%	Palustrine emergent	181.77	1.18%
		Developed Agriculture Row Crop	4713.62	30.71%	Palustrine forested	819.82	5.34%
	Developed	Developed Non-Vegetated	207.93	1.35%	Palustrine scrub/shrub	136.55	0.89%
		Developed Urban High Density	127.17	0.83%	Palustrine submergent	1.66	0.01%
		Developed Urban Low Density	150.90	0.98%	Ponds	15.19	0.10%
	Forested	Terrestrial Forest Deciduous	5724.49	37.30%			
		Terrestrial Forest Evergreen	81.74	0.53%			
		Terrestrial Forest Mixed	49.94	0.33%			
		Palustrine Forest Deciduous	1048.24	6.83%			
	Woodland	Terrestrial Woodland Deciduous	182.37	1.19%			
	Herbaceous	Palustrine Herbaceous Deciduous	134.86	0.88%			
	Shrubland	Palustrine Shrubland Deciduous	13.95	0.09%			
		Terrestrial Shrubland Deciduous	332.00	2.16%			
	Water	Water	20.26	0.13%			
	Unclassified	Unclassified Cloud/Shadow	5.47	0.04%			
	Total Acres		**15349.21**			**1154.98**	
	Percentage of Trail Creek Watershed		**40.75%**	Percentage Sub-Watershed containing		**7.52%**	

*Subset of land use data pertaining to Wetlands, These figures are included in the adjacent data set

Table 1: Trail Creek Land Use

* GIS Data Obtained from IDEM Indiana Biodiversity Initiative. All data was gathered from 2005 Aerial Photography with on the ground land proofing.

Marina

Trail Creek Navigable Channel upstream of Franklin Street bridge

church, post office, newspaper, and a thriving commercial district with twelve dry goods stores and ten hotels. Although some progress was made on the harbor, the project was afflicted by under-funding, competition from Chicago, political wrangling, shipwrecks, and the drifting sands which kept clogging the dredged waterways.

Today the most prominent use within Trail Creek and the marina is recreational boating and fishing as seen in the photographs on this page. Trail Creek from the outlet at the marina to the E Street Bridge, which encompasses the entire navigable channel, is lined with residential and commercial structures, marinas and docks, and the Blue Chip casino. An increased focus on the recreational aspects of Trail Creek is on-going with the addition and enhancement of greenways and parks along the stream, including a canoe launch constructed in 2006.

Additionally, recreational fishing along Trail Creek, particularly at the IDNR and local designated fishing locations is a predominant use of the stream. Trail Creek has six public fishing sites. These include the access site adjacent to the IDNR building, Robert Peo Public Access located on Liberty Trail, US 35, Trail Creek Forks located at US 20, Johnson Road and Creek Ridge Park. Creek Ridge Park located five miles east of US 421 on County Road 400 in Michigan City is also a LaPorte County park.

Trail Creek is a designated trout and salmonoid stream supporting one of the few remaining cold water fisheries in Indiana. In the early 1970's the IDNR Division of Fish and Wildlife began stocking Trail Creek with Chinook salmon, Coho salmon, Skamania summer-run steelhead, and winter-run steelhead. Trail Creek has supported and continue to support a trout and salmon fishery along with other native game and non-game species.

Soils

Unlike most parts of northern Indiana which are dominated by clay-rich soils of glacial origin, soils within the Trail Creek Watershed are comprised of mostly sand. Soils range from loose sandy soils of beach deposit and eolian origin to black sandy and loamy soils of lacustrine origin. All soils within the basin are highly transmissive because of their high sand content. As a result, drainage within the watershed is good despite low topographic relief (USACOE, 1992). Table 2 and Figure 11 indicate the various soil types located within the watershed.

Soil types and soil associations found within the Trail Creek Watershed are generally poorly suited to sanitary facilities and building site development. Slow permeability or moderately slow permeability, ponding and wetness, flooding, and pollution of groundwater due to poor filtering qualities of sandy soils are limitations within the watershed. These limitations can affect stormwater run-off quantity and quality potentially leading to increased pollutant loading to streams and tributaries in the watershed.

Soils of the Trail Creek Watershed

A thorough survey of the soils in LaPorte County, Indiana was completed in

Watershed				Trail Creek Watershed		East Branch Trail		Trail Creek-Otter		West Branch Trail	
Common Name	Map Symbol	Drainage Value	Hydric	Total Acres	% Of Watershed	Total Acres	% Of Watershed	Total Acres	% Of Watershed	Total Acres	% Of Watershed
ADRIAN	Ad	Very Poorly	Yes	597.78	1.58	252.85	1.81	10.18	0.12	334.75	2.18
BLOUNT	BaA	Somewhat Poorly	No	4556.57	12.02	1157.74	8.30	992.55	11.54	2406.28	15.68
BOURBON	Br	Somewhat Poorly	No	1243.98	3.28	97.62	0.70	82.22	0.96	1064.14	6.93
BREMS	BtA	Moderately Well	No	2922.93	7.71	1730.86	12.41	722.55	8.40	469.53	3.06
CHEEKTOWAGA	Cd	Poorly	Yes	154.90	0.41	60.99	0.44	91.65	1.07	2.26	0.01
CHELSEA	ChB	Excessive	No	2674.58	7.06	1294.88	9.28	N/A	N/A	1379.70	8.99
CHELSEA	ChC	Excessive	No	1842.23	4.86	886.10	6.35	N/A	N/A	956.13	6.23
CHELSEA	ChD	Excessive	No	561.54	1.48	313.96	2.25	N/A	N/A	247.58	1.61
COHOCTAH	Ck	Very Poorly	Yes	130.83	0.35	16.06	0.12	N/A	N/A	114.77	0.75
DUNELAND	Du	Well	No	45.28	0.12	10.65	0.08	45.28	0.53	N/A	N/A
EDWARDS	Ed	Very Poorly	Yes	73.69	0.19	468.16	3.36	N/A	N/A	63.04	0.41
FLUVAQUENTS	Fh	Well	No	1286.99	3.40	204.76	1.47	514.49	5.98	304.34	1.98
GILFORD	Gf	Poorly	Yes	649.91	1.71	29.06	0.21	22.75	0.26	422.39	2.75
HANNA	HaA	Moderately Well	No	258.41	0.68	81.40	0.58	10.77	0.13	218.59	1.42
HISTOSOLS	Hh	Well	Yes	366.88	0.97	303.00	2.17	5.92	0.07	279.55	1.82
HOMER	Hk	Somewhat Poorly	No	807.87	2.13	177.05	1.27	8.58	0.10	496.30	3.23
HOUGHTON	Hm	Very Poorly	Yes	391.09	1.03	82.85	0.59	18.62	0.22	195.41	1.27
HOUGHTON	Ho	Very Poorly	Yes	82.85	0.22	N/A	N/A	N/A	N/A	N/A	N/A
MARTISCO	Md	Very Poorly	Yes	259.37	0.68	183.11	1.31	N/A	N/A	76.27	0.50
MAUMEE	Mm	Poorly	Yes	374.18	0.99	216.21	1.55	96.78	1.13	61.18	0.40
MILFORD	Mp	Very Poorly	Yes	69.72	0.18	69.72	0.50	N/A	N/A	N/A	N/A
MORLEY	MrB2	Moderately Well	No	365.29	0.96	121.58	0.87	43.27	0.50	200.45	1.31
MORLEY	MrC2	Moderately Well	No	109.54	0.29	34.39	0.25	4.87	0.06	70.28	0.46
MORLEY	MrD2	Moderately Well	No	40.90	0.11	29.57	0.21	N/A	N/A	11.33	0.07
MOROCCO	Mx	Somewhat Poorly	No	2413.61	6.37	1639.45	11.75	495.43	5.76	278.72	1.82
NEWTON	Nf	Poorly	Yes	512.98	1.35	244.53	1.75	242.66	2.82	25.79	0.17
OAKVILLE	OaC	Well	No	1660.45	4.38	639.38	4.58	877.25	10.20	143.82	0.94
OAKVILLE	OaE	Well	No	14.97	0.04	7.46	0.05	7.52	0.09	N/A	N/A
PALMS	Pa	Very Poorly	Yes	25.22	0.07	25.22	0.18	N/A	N/A	N/A	N/A
PEWAMO	Pe	Poorly	Yes	680.00	1.79	242.09	1.74	98.02	1.14	339.90	2.21
PINHOOK	Ph	Poorly	Yes	70.47	0.19	4.21	0.03	N/A	N/A	66.25	0.43
QUINN	Qu	Poorly	Yes	105.81	0.28	105.81	0.76	N/A	N/A	N/A	N/A
RIDDLES	RlA	Well	No	16.98	0.04	9.51	0.07	N/A	N/A	7.47	0.05
RIDDLES	RlB2	Well	No	755.24	1.99	273.97	1.96	N/A	N/A	481.28	3.14
RIDDLES	RlC2	Well	No	580.36	1.53	147.66	1.06	N/A	N/A	432.70	2.82
RIDDLES	RlD2	Well	No	382.36	1.01	69.26	0.50	5.19	0.06	307.91	2.01
RIDDLES	RlF	Well	No	95.01	0.25	N/A	N/A	N/A	N/A	95.01	0.62
SAUGATUCK	Sa	Poorly	Yes	462.37	1.22	98.59	0.71	363.78	4.23	N/A	N/A
SEBEWA	Sb	Very Poorly	Yes	408.71	1.08	124.57	0.89	11.65	0.14	272.50	1.78
SELFRIDGE	SeA	Somewhat Poorly	No	1371.14	3.62	634.91	4.55	709.57	8.25	26.66	0.17
SELFRIDGE	SeB	Somewhat Poorly	No	662.93	1.75	297.69	2.13	177.82	2.07	187.42	1.22
SUMAN	So	Very Poorly	Yes	117.11	0.31	22.45	0.16	82.94	0.96	11.73	0.08
TRACY	TcA	Well	No	200.62	0.53	60.26	0.43	6.93	0.08	140.37	0.91
TRACY	TcB	Well	No	1226.26	3.24	216.82	1.55	N/A	N/A	1009.44	6.58
TRACY	TcC2	Well	No	1124.99	2.97	280.84	2.01	N/A	N/A	844.15	5.50
TRACY	TcD2	Well	No	598.87	1.58	105.94	0.76	N/A	N/A	492.94	3.21
TRACY	TcF	Well	No	31.97	0.08	N/A	N/A	N/A	N/A	31.97	0.21
TROXEL	Tr	Well	No	5.73	0.02	N/A	N/A	N/A	N/A	5.73	0.04
TYNER	TyA	Somewhat Excessive	No	918.48	2.42	519.89	3.73	N/A	N/A	391.65	2.55
UDORTHENTS	Ua	Well	No	565.13	1.49	189.04	1.36	223.33	2.60	152.76	1.00
URBAN LAND	UoC	Well	No	1686.75	4.45	N/A	N/A	1683.48	19.58	3.27	0.02
URBAN LAND	Uv	Well	No	819.20	2.16	N/A	N/A	819.20	9.53	N/A	N/A
WATER	W	Well	Yes	192.04	0.51	79.83	0.57	77.86	0.91	34.35	0.22
WALLKILL	Wa	Very Poorly	Yes	63.33	0.17	4.37	0.03	2.46	0.03	56.50	0.37
WARNERS	We	Very Poorly	Yes	65.75	0.17	14.04	0.10	43.68	0.51	8.02	0.05
WASHTENAW	Wh	Poorly	Yes	196.38	0.52	69.73	0.50	N/A	N/A	126.65	0.83
Total				37898.52	100.00	13950.08	100.00	8599.23	100.00	15349.21	100.00

Trail Creek Watershed		East Branch Trail		Trail Creek-Otter		West Branch Trail	
Soil Type	% Of Watershed	Soil Type	% Of Watershed	Soil Type	% Of Watershed	Soil Type	% Of Watershed
BaA	12.02	BtA	12.41	BaA	15.68	BaA	15.68
BtA	7.71	Mx	11.75	ChB	8.99	ChB	8.99
ChB	7.06	ChB	9.28	Br	6.93	Br	6.93
Mx	6.37	BaA	8.30	TcB	6.58	TcB	6.58
ChC	4.86	ChC	6.35	ChC	6.23	ChC	6.23

Table 2: Soils of the Trail Creek Watershed

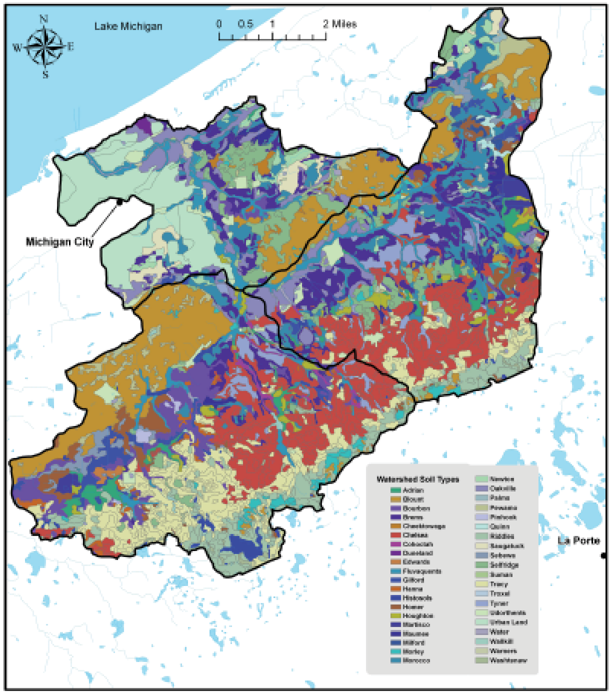


Figure 11: Soil Types within the Trail Creek Watershed (see appendix page 76)

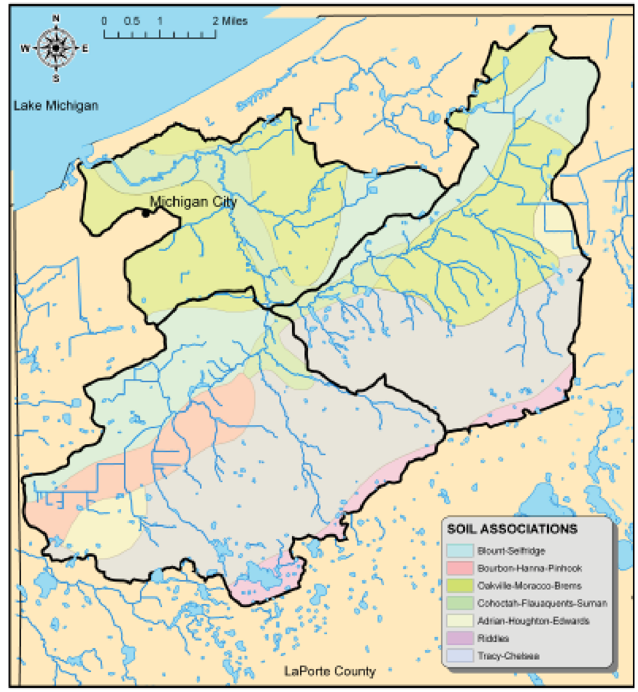


Figure 12: Trail Creek Watershed Soil Associations (see appendix page 75)

the time between 1971 and 1977; these soil names and descriptions were approved in 1976. Due to the vast area of the watershed and the extensive numbers of soils present in the watershed, this report deals mainly with the general soils map of the county and the soils associations it displays. Soils associations are typed after the most common soils type in the area and give a broad overview of the soils within each association.

There are seven soils associations within the Trail Creek Watershed: Bourbon-Hanna-Pinhook, Adrian-Houghton-Edwards, Riddles, Blount-Selfridge, Tracy-Chelsea, Oakville-Morocco-Brems, and Cohoctah-Fluvaquents-Suman. Table 3 indicates the total acreage, percentage of the watershed it covers, and a brief description of each particular soils association. Figure 12 depicts the soil association locations for the Trail Creek Watershed.

Watershed Soil Associations

Trail Creek Watershed Soils Associations			
Soil Association	Total Acreage	% of Watershed	Description
Bourbon-Hanna-Pinhook	2235.71	5.90%	Nearly level and gently sloping, poorly drained to moderately well drained soils that formed in loamy and sandy outwash sediment.
Adrian-Houghton-Edwards	1262.66	3.33%	Nearly level, very poorly drained soils that formed in organic material over sand and marl.
Riddles	1291.23	3.41%	Nearly level to very steep, well drained soils that formed in loamy glacial till.
Blount-Selfridge	6688.03	17.65%	Nearly level and gently sloping poorly drained soils that formed in loamy glacial till and in sandy deposits over loamy material.
Tracy-Chelsea	13126.49	34.64%	Nearly level to very steep, well drained and excessively drained soils that formed in loamy and sandy outwash and eolian material.
Oakville-Moracco-Brems	10387.27	27.41%	Nearly level to moderately steep, well drained to somewhat poorly drained soils that formed in sandy outwash and eolian material.
Cohoctah-Fluvaquents-Suman	2906.52	7.67%	Nearly level, very poorly drained and somewhat poorly drained soils that formed in loamy and sandy alluvium.

Table 3: Watershed Soil Associations

Topography

The topography of LaPorte County is a broad, flat plain sloping from southeast to northwest with a band of knob and kettle topography coincident with the Valparaiso Morainal Plain, Figure 13. The highest point in LaPorte County is 957 feet above sea level and is located on a knoll several miles north of the city of LaPorte. The shore of Lake Michigan is 581 feet above sea level and is the lowest point in the county. The average elevation of the county is 730 feet above sea level, which is 149 feet above the level of Lake Michigan.

The topographic relief of LaPorte County varies within each physiographic subsection. The southern portion of the county, or the Kankakee Outwash Plain, is nearly flat or depressional to gently sloping. The Valparaiso Morainal Plain, in the northern portion of the county, consists of a dissected gently sloping to moderately steep ridge than contains the highest point in the county. The local relief ranges from 100 to 150 feet. The elevations are lowest where streams have cut down through the range to the level of Lake Michigan.

The Valparaiso Morainal Plain forms a drainage divide in LaPorte County. Small streams and agricultural channels on the south side of the Valparaiso Morainal Plain flow into the Kankakee River and are part of the Mississippi River drainage. Small rivers and streams north of the Valparaiso Morainal Plain flow into Lake Michigan and are part of the St. Lawrence Seaway drainage basin. The Trail Creek watershed is located within the Valparaiso Morainal Plain and therefore drains to Lake Michigan. As such, any water quality impairment within Trail Creek can directly affect Lake Michigan and other Great Lakes.

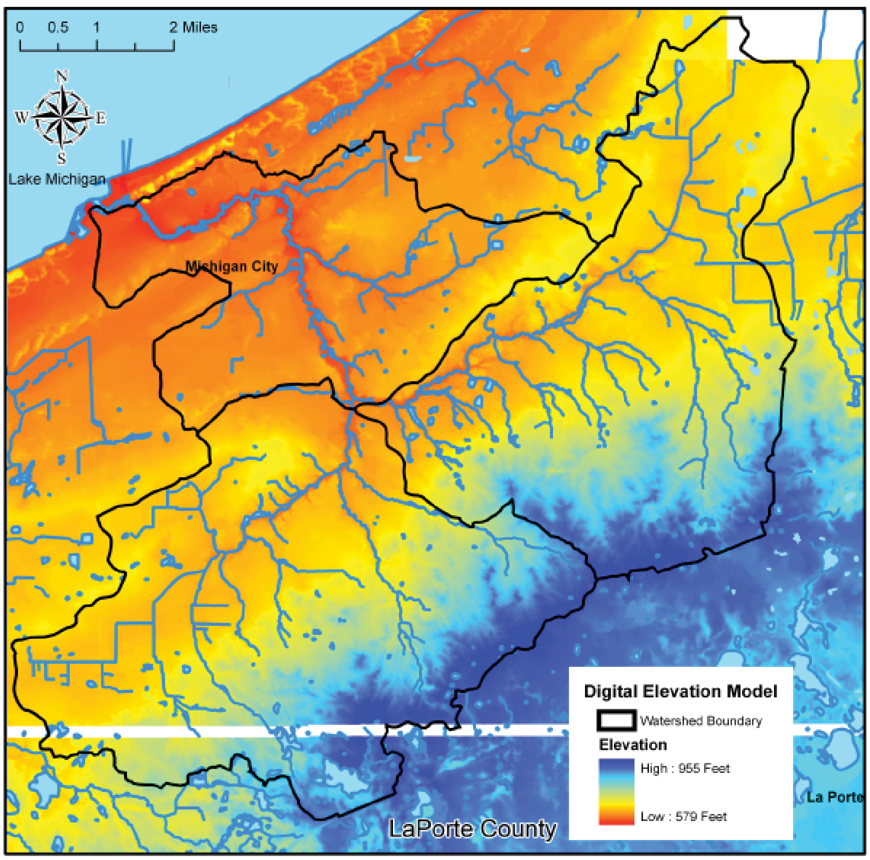


Figure 13: Topography of the Trail Creek Watershed (see appendix page 77)

Hydrology

The Trail Creek Watershed covers approximately 37,824 acres and is made up of three sub watersheds: the East Branch, approximately 13,875 acres; the Main Branch, approximately 8,595 acres; and the West Branch, approximately

15,194 acres. The watershed itself drains approximately 59 square miles within LaPorte County and is made up of multiple smaller tributaries. The West Branch of the watershed has two main tributaries, Waterford Creek and Wolf Run. The East Branch sub watershed has five main tributaries, Bull Ditch, Brown Ditch, South Arm, Bosserman Creek, and Moon Ditch. The Main Branch has one major stream, Trail Creek, which extends for 14.5 linear miles through LaPorte County. Three lakes are contributing factors to this watershed and include Dingler Lake, Ohms Lake, and Browdy Lake.

Within the Trial Creek Watershed, several tributaries are included in the LaPorte County Legal Drain System, Figure 14. As part of the Legal Drain System, the LaPorte County Surveyor and Drainage Board are charged with the maintenance of these streams and maintaining drainage to the adjacent property owners. Maintenance of these legal drains is funded from residents living within the legal drain watershed boundary. Maintenance can include herbicide treatment, dredg-

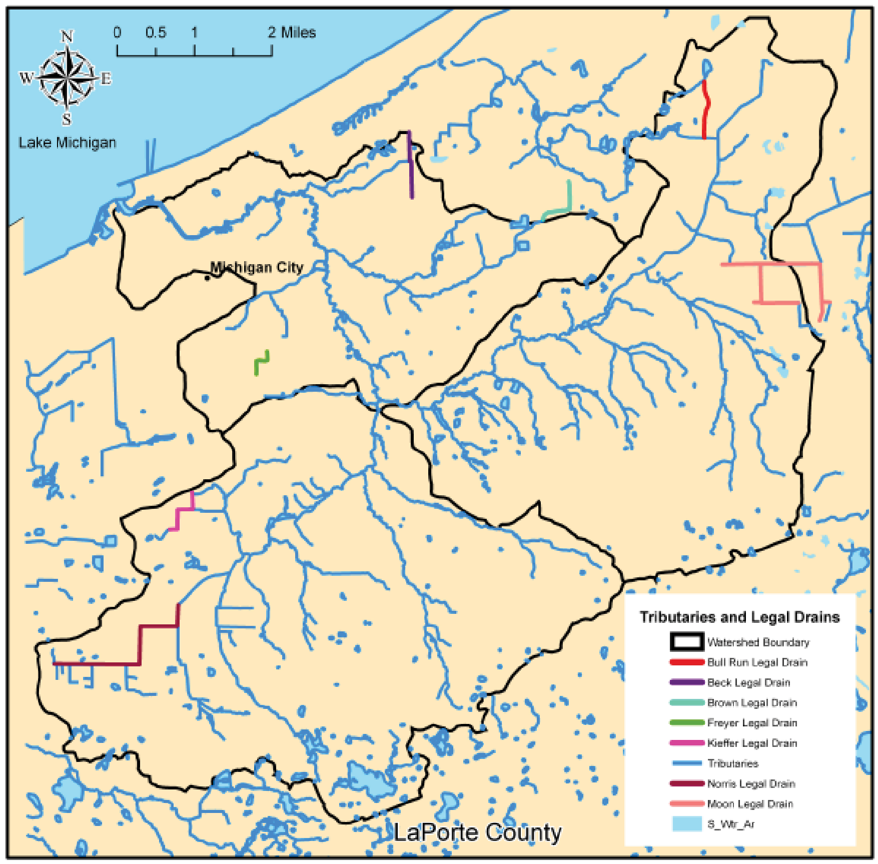


Figure 14: Trail Creek and Tributaries including Legal Drains (see appendix page 78)

ing, and removal of sediment and debris. Within the corporate limits of Michigan City, the Sanitary District of Michigan City has jurisdiction and maintenance responsibility for the legal drain system.

The Trail Creek discharge rate into Lake Michigan at the mouth of the stream ranged between 84 and 294 cubic feet per second in 1998 and had a average of 131 cubic feet per second; between 67 and 318 cubic feet per second in 1999 and an average of 125 cubic feet per second; between 45 and 396 cubic feet per second in 2000 and an average of 114 cubic feet per second; and between 34 and 144 cubic feet per second in 2001 and an average of 93 cubic feet per second.

Long term average flow for the stream at the USGS Gaging Station at Springland Avenue in Michigan City is 72.6 cubic feet per second (cfs), which is equivalent to 18.2 inches of runoff. The minimum daily flow observed in the stream was 20 cfs in August 1977. The maximum instantaneous flow recorded was 2,430 cfs in July 1986 (USGS, Suspended Sediment in Trail Creek at Michigan City, Indiana, 1992).

Due to the natural seiche action of Lake Michigan, Trail Creek is subject to frequent flow reversals at its mouth. Seiches are periodic oscillations of lake levels caused by wind, earthquakes, changes in barometric pressure, or other natural forces. Seiche can last seconds to minutes and reoccur at intervals of tens of minutes to more than eight hours. Seiche action occurs in Lake Michigan when sustained high winds blowing from the north drag water toward the south end of the lake, causing the water level to rise at Indiana's coast, with a corresponding water level drop of the same amount at the north end of the lake. The result is a tilt of Lake Michigan's water surface and water within the lake tributaries to rise. As long as the sustained high wind continues to blow, the tilt in the lake's surface is maintained. Once the winds have ceased the lake levels return to normal. This reversal results in water level fluctuations of between one and two inches. The flow reversals are capable and do extend past two miles upstream.

As part of the development of this plan, a flow study was undertaken in order to calculate pollutant loading within the stream at various sampling locations. This study is included in Appendix O.

Land Ownership

Throughout the entire watershed are various private and public land owners including several areas of land owned by various land conservation organizations. Preservation of sensitive and high quality riparian areas and rare or endangered communities is a critical component of the Trail Creek Watershed Management Plan.

Cultural Resources

Based on a review of the National Register of Historic Places there are 15 properties listed in LaPorte County. Of the places listed on the National Register of Historic Places, several are within the Trail Creek Watershed and are of particular interest to watershed management along Trail Creek. These include

Figure 15: Location of properties on the National Register of Historic Places (see appendix page 79)

http://www.nature.nps.gov/nnl/registry/usa_map/States/Indiana/nnl/pb/index.cfm

http://www.southeasternoutdoors.com/wildlife/mammals/indiana-bat.html

http://www3.nationalgeographic.com/animals/birds/bald-eagle.html

http://www.btinternet.com/~tellhicks/details/e-massasauga-d.htm

http://www.ecsltd.com/mitchells_satyr.htm

the Michigan City East Pierhead Light Tower and Elevated Walk located at the Michigan City Harbor at the mouth of Trail Creek, the Michigan City Lighthouse located at Washington Park along Trail Creek, and Washington Park located along Trail Creek, Figure 15. (LaPorte County Interim Report, March 1989.)

Unique Natural Resources

Pinhook Bog located in the Trail Creek Watershed was designated a National Natural Landmark in 1965 and is part of the Indiana Dunes National Lakeshore. Pinhook Bog is the only true bog in located within Indiana. A bog is a specific type of wetlands that accumulates acidic peat from dead plant material. This bog was formed by glacial meltwater on a clay bed. Pinhook Bog consists of about 580 acres of which approximately 145 acres are a floating peat mat with approximately 45 acres of wetland separating the bog from the adjacent uplands.

Endangered Species

Based on review of data available from the US Fish and Wildlife Service Region 3 Database, the Indiana bat (*Myotis sodalis*), the bald eagle (*Haliaeetus leucocephalus*), the eastern massasauga (*Sistrurus c. catenatus*), and Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) are the only federally threatened, endangered, or candidate species noted in LaPorte County.

Based on the Indiana Department of Natural Resources listing of endangered, threatened, and rare species documented from LaPorte County as of December 11, 2005, there are 128 species of vascular plants, 1 species of mollusk, 2 species of insects, 1 species of fish, 1 species of amphibians, 7 species of reptiles, 28 species of birds, 6 species of mammals, and 20 high quality natural community types listed within LaPorte County. A listing of each of these is located in the Appendix M.

Natural Heritage Database information on the Trail Creek Watershed was provided by the Indiana Department of Natural Resources. This information is an account of threatened, endangered, or rare species that have been observed inside the hydrological boundaries of the Trail Creek Watershed. This information relies on the observation of many individuals and is not the result of comprehensive field surveys conducted at the site.

The Natural Heritage Database indicated 3 bird species, 2 mammal species, 3 reptile species, 48 plant species, and 2 insect species that are either threatened, endangered, or rare which have been observed in the Trail Creek Watershed. Also noted in the database are 9 high quality natural communities. Listing of each of these is located in the Appendix N.

In addition to threatened and endangered species within the Trail Creek Watershed, Trail Creek is noted as one of the few streams within the State of Indiana which can support a cold water fisheries including populations of trout and salmon.

Wetlands

According the 1993 Watershed Management Plan, there were approximately 5,400 acres of wetlands present within the Trail Creek Watershed. Current land use data (Table 1 and Figure 10) indicate there are approximately 3,500 acres of wetland present within the Trail Creek Watershed, with 1,155 acres of wetland within the East Branch of Trail Creek watershed, 1,585 acres of wetland in the West Branch of Trail Creek watershed, and 767 acres of wetland in the Trail Creek and Otter Creek watershed The National Wetlands Inventory prepared by the US Fish and Wildlife Services includes mapping and characterization of wetlands in the United States. According to the National Wetlands Inventory there are approximately 3,850 acres of wetland present in the Trail Creek Watershed with 1,725 acres of wetland within the East Branch of Trail Creek watershed, 1,251 acres of wetland in the West Branch of Trail Creek watershed, and 870 acres of wetland in the Trail Creek and Otter Creek watershed, Figure 17.

Historically, wetland loss within the State of Indiana since pre-settlement times is approximately 85% with the majority of wetland loss due to draining of agricultural lands. Mapping of areas with hydric or wetland soil types indicates the historic location of wetlands within the watershed, see Figure 16. Wetlands are an important portion of the watershed due to the water quantity and quality functions which are present within a wetland. Wetlands reduce flood levels and flood damage and act as a natural water filtration system.

Within LaPorte County large areas of wetlands have been drained or altered so they are no longer providing flood storage, water quality treatment, or habitat. Wetland and natural area restoration or enhancement can be an effective tool in watershed management. Wetland restoration within areas which previously demonstrated wetland characteristics but have been drained or altered are generally the most successful projects in terms of water quality enhancement. Within the Trail Creek Watershed, areas mapped with hydric soils are indicative of potentially drained or altered wetlands. The Figure 16 indicates areas of hydric soils within the watershed which may be suitable for wetland restoration.

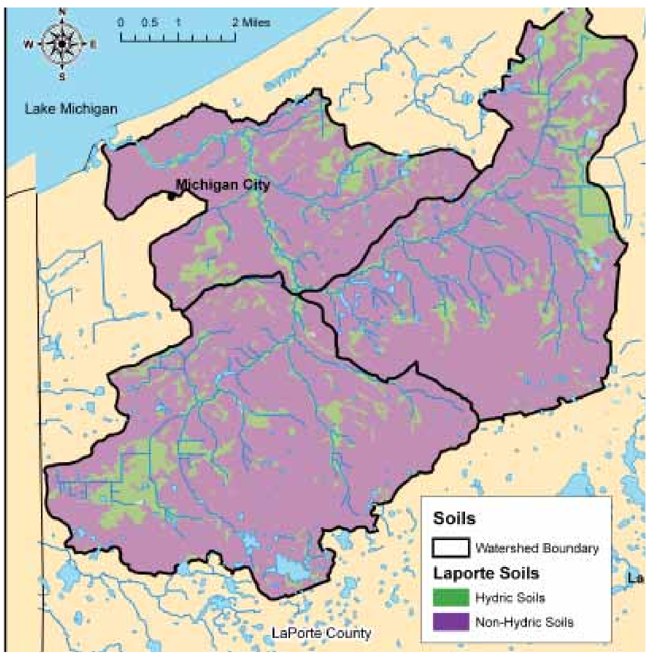


Figure 16: Hydric Soils (see appendix page 80)

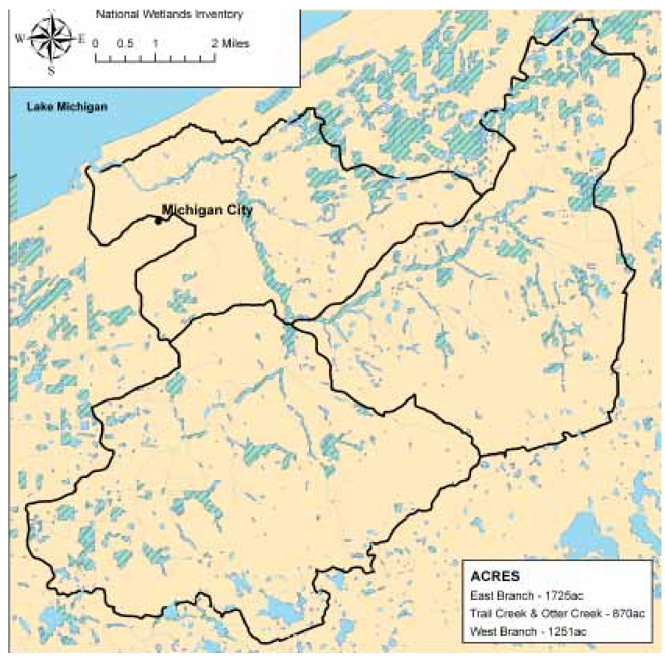


Figure 17: Trail Creek Watershed - National Wetlands Inventory (see appendix page 81)

Previous Water Quality within Trail Creek Watershed

East branch of Trail Creek at
Sample Point E1

AS PART of the preparation of this report and a variety of other reports, multiple water quality studies have been completed within the Trail Creek Watershed. An initial assessment of the data collected as part of this study between January 2005 and April 2006 as well as review of previous studies indicates the majority of water quality problems in the watershed are associated with abnormally high spikes in concentration levels of pollutants including total suspended solids and *E. coli*. Further calculations of loading and statistical analysis of the loads, concentrations, and precipitation events indicate water quality problems are associated with non-point source pollutant loading and recurring spikes in the levels of pollutants in the watershed. These spikes are able to be directly linked to precipitation event and their intensity, indicating runoff is a major contributor to the poor water quality in the Trail Creek Watershed.

The Trail Creek Watershed has been extensively studied by the Sanitary District of Michigan City, the Indiana Department of Environmental Management, the Indiana Department of Natural Resources, and various other agencies. The following is a summary of the various studies which have been conducted and their conclusions.

2006 Watershed Management Plan Baseline Assessment

The Trail Creek Escherichia Coli TMDL Report (Triad, 2003) recommended continued monitoring in the watershed. Based on that report, goals of this study include identifying potential sources of non-point pollutants (both biological and physical), quantifying the extent of that pollution, and evaluating potential programs to effectively reduce pollutant loading. Data was collected to identify potential sources of pollutants, establish baseline conditions of the watershed, and calculate pollutant loading. Future monitoring data will be compared against the baseline to gauge the success of the prevention and remediation methodologies that will be developed.

Sampling Locations

East branch of Trail Creek at
Sample Point E2

Throughout the course of this study, 12 separate water quality sampling locations were sampled from a period of January 2005 through April 2006. For reference to these locations see Figure 18 and the photographs through this section of the report. Sample locations were strategically chosen by the Sanitary District of Michigan City and the Indiana Department of Environmental Management to be representative of common land use types within the watershed as indicated in Figure 10. Water quality monitoring was designed to provide proper spatial coverage of the watershed and collect data during both wet and dry weather conditions in order to assess potential sources of pollutants. Three sample sites are located within the West Branch Sub-Watershed, three within the East Branch Sub-Watershed and six within the Main Branch Watershed. Water samples from each site were analyzed in the field and at the on-site laboratory in the Sanitary District of Michigan City's Wastewater Treatment Plant.

Water quality sampling locations were selected to determine potential sources of non-point source pollutants and the effects of land use on water quality. Sample locations located in the West Branch of Trail Creek include primarily rural agricultural including both livestock and row crops, rapidly developing areas, large lot rural housing, and forested areas. Sample locations within the East Branch of Trail Creek include primarily rural agricultural including livestock and row crops, large lot rural housing, and small lot rural subdivisions. Sample locations located in the Main Branch of Trail Creek include primarily urban and suburban land uses including the un-sewered towns of Trail Creek and Potawatomie Park, Michigan City, and the majority of the commercial and industrial sites within the watershed. One sample location was selected near the USGS Gage station at the mouth of Trail Creek in order to correlate data collected with stream flow. A second sample location was selected at the former USGS Gage Station at Springland Avenue. As part of this study, the USGS Gage Station at Springland Avenue was re-activated in order to correlate future sampling data with stream flow. Sample locations were located throughout the watershed along all major branches within both rural and urban settings in order to evaluate non-point source contributions from each branch and land use within the watershed.

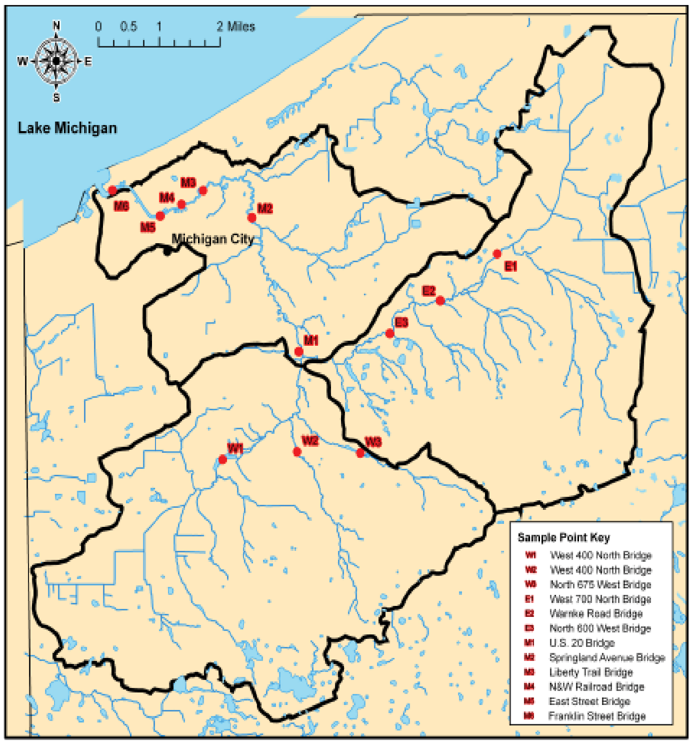


Figure 18 (see appendix page 82)

Physical and Chemical Measurements

Sampling within the Trail Creek Watershed was conducted at twelve locations throughout the watershed. Data collection was performed bi-monthly during winter months (November through March) and weekly during the summer (April through October) at each of sample location. The following parameters were evaluated:

- Conductivity
- pH
- Temperature
- Dissolved oxygen
- Turbidity
- Total suspended solids (TSS)
- Nitrogen ammonia
- Ortho phosphorus
- Total phosphorus
- *E. coli*
- Biological oxygen demand (BOD) (once monthly)
- TKN
- Nitrate/Nitrite

Samples were collected from January 2005 through April 2006. Sampling was used to determine loading of various pollutants to Trail Creek.

The following table indicates the maximum, minimum, and mean values for sampling data collected at each sample site.

Sample Site	Field Analysis		Concentration Data Statistics For Trail Creek Watershed Sampleing Points									
Parameter	Conductivity	pH	Temperature	Dissolved Oxygen	Turbidity	TSS	Nitrogen Ammonia	Ortho Phosphorus	Total Phosphorus	*E.Coli*	BOD_5	TKN	Nitrate + Nitrite
Unit of Measurement	uS	I.U.	°C	(mg/l)	NTU	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(col/100)	(mg/l)	(mg/l)	(mg/l)
Target Concentrations	N/A	N/A	N/A	**7.00**	N/A	**15.00**	**0.25-0.01***	**0.05**	**0.05**	**235**	N/A	**1.00**	**10.00**
E1													
Averages	545.94	8.15	12.01	10.28	12.19	12.27	0.06	0.02	0.04	696.00	0.76	0.52	0.38
MAX	753.00	9.40	22.10	19.70	166.00	134.00	0.21	0.08	0.46	4100.00	4.90	2.10	1.38
MIN	261.00	7.00	1.90	7.60	2.90	1.80	0.03	0.02	0.02	40.00	2.00	0.50	0.19
E2													
Averages	510.85	8.18	12.29	10.31	10.20	11.20	0.06	0.02	0.04	837.21	0.72	0.49	0.38
MAX	703.00	8.60	21.90	19.80	123.00	78.00	0.25	0.06	0.32	5060.00	3.80	1.60	1.24
MIN	269.00	7.80	0.90	8.00	3.30	1.80	0.03	0.02	0.02	20.00	2.00	0.50	0.19
E3													0.37
Averages	529.00	8.13	12.10	10.23	11.75	14.32	0.05	0.02	0.04	663.09	0.73	0.47	
MAX	725.00	8.50	20.90	18.90	192.00	172.00	0.20	0.08	0.48	5050.00	4.20	1.80	1.24
MIN	285.00	7.00	1.20	7.80	3.30	1.80	0.03	0.02	0.02	20.00	2.00	0.50	0.04
M1													
Averages	509.28	8.04	12.87	9.67	22.21	25.35	0.06	0.02	0.05	768.87	0.76	0.49	0.29
MAX	745.00	8.60	23.50	17.40	605.00	552.00	0.24	0.05	0.94	6440.00	5.80	2.40	1.10
MIN	279.00	7.60	1.30	7.50	3.40	1.80	0.04	0.02	0.02	65.00	2.00	0.50	0.14
M2													
Averages	541.32	8.19	12.94	10.09	22.73	26.40	0.06	0.02	0.06	719.72	0.85	0.56	0.33
MAX	758.00	8.50	23.60	20.10	553.00	516.00	0.21	0.07	1.00	5440.00	5.90	3.30	1.60
MIN	274.00	7.90	1.00	7.40	3.70	1.80	0.02	0.02	0.02	40.00	2.00	0.50	0.16
M3													
Averages	551.81	8.18	13.14	9.96	21.22	24.91	0.07	0.02	0.06	900.55	1.01	0.58	0.36
MAX	761.00	8.50	24.00	20.20	436.00	428.00	0.28	0.06	0.88	9100.00	8.20	3.10	1.90
MIN	298.00	7.90	0.20	7.00	3.40	1.80	0.04	0.02	0.02	40.00	2.00	0.50	0.10
M4													
Averages	546.68	7.99	13.44	9.39	19.58	27.89	0.07	0.01	0.07	586.98	0.79	0.50	0.34
MAX	758.00	8.70	23.80	19.90	425.00	556.00	0.25	0.03	0.90	3540.00	6.40	2.70	2.10
MIN	304.00	7.70	1.80	6.50	3.70	1.80	0.05	0.02	0.02	53.00	2.00	0.50	0.10
M5													
Averages	592.68	8.08	13.89	9.57	17.78	18.85	0.08	0.05	0.10	685.47	0.85	0.56	1.53
MAX	795.00	8.40	25.00	19.00	424.00	358.00	0.27	0.21	0.74	6100.00	5.90	2.50	4.40
MIN	331.00	6.80	2.00	6.60	3.40	1.80	0.04	0.03	0.05	15.00	2.00	0.50	0.50
M6													
Averages	557.17	8.10	14.53	9.80	10.46	11.40	0.09	0.04	0.07	293.17	0.76	0.57	1.37
MAX	801.00	8.70	26.50	18.70	158.00	144.00	0.39	0.12	0.32	2050.00	4.20	2.20	4.40
MIN	342.00	6.80	0.50	6.40	2.00	1.80	0.04	0.02	0.05	10.00	2.00	0.50	0.10
W1													
Averages	532.06	8.19	16.29	10.08	27.52	27.27	0.10	0.02	0.06	2637.09	0.79	0.60	0.28
MAX	846.00	8.60	189.30	18.70	403.00	264.00	0.40	0.08	0.74	9000.00	5.60	2.70	1.73
MIN	237.00	7.60	1.50	7.70	4.40	1.80	0.02	0.02	0.03	70.00	2.00	0.50	0.10
W2													
Averages	468.09	8.23	11.46	10.40	28.60	33.89	0.05	0.01	0.05	402.49	0.74	0.43	0.21
MAX	696.00	8.70	18.50	18.20	784.00	732.00	0.20	0.05	0.98	2900.00	3.60	2.90	0.93
MIN	255.00	7.80	2.80	8.10	3.20	1.80	0.03	0.02	0.02	16.00	2.00	0.50	0.10
W3													
Averages	477.32	7.94	11.79	9.04	10.58	21.31	0.04	0.02	0.03	204.96	0.68	0.35	0.08
MAX	674.00	8.30	18.20	14.60	46.30	153.00	0.16	0.05	0.13	1250.00	2.00	1.10	0.43
MIN	278.00	7.00	4.60	7.50	4.20	1.80	0.03	0.02	0.02	2.00	2.00	0.50	0.04

Table 4: * Target Ammonia Concentrations are a function of the relative toxicity of the Ammonia at the time of a given sample event. The Toxicity of Ammonia is a variable which is dependent on the pH and the Temperature of the water during the time of the sampling event.

Aquatic Macro invertebrates collected from Trail Creek

Biological and Habitat Sampling

Of the twelve water quality sampling locations, four sites were selected to conduct biological and habitat assessment. One sample location was selected in both the East and West Branches of Trail Creek, one near the confluence of the branches, and one within the urbanized area. All sites selected were shallow enough to be waded in order to facilitate proper sampling. Biological sampling was completed to supplement the chemical water quality data collected. Chemical water quality data represents a specific point in time at which the sample was collected and may not be representative of the overall health of the stream. Biological sampling and the calculation of an Index of Biotic Integrity utilizes species collected in the stream to determine the overall health of the stream and changes in water quality over time. The Index of Biotic Integrity utilizes parameters such as the EPT Index which is a measurement of the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) found within a stream. These species of macroinvertebrates are also those collected and used to determine water quality by volunteer programs such as Hoosier Riverwatch.

Biological assessment evaluations were completed at sampling stations W1, E3, M1, and M2, see Figure 18. Benthic macro-invertebrate communities were collected and analyzed using the Rapid Bio-assessment Protocol II in accordance with current operating procedures for aquatic macro-invertebrate sampling, water quality assessment, and habitat assessment according to the Indiana Department of Environmental Management Biological Studies Section Standard Operating Procedures and Rapid Bio-assessment Protocols for Use in Streams and Wadable Rivers (USEPA). Biological data collection for establishment of baseline conditions was performed on September 26, 2005. Samples collected at Site W1 during the September sampling event were collected downstream of the water quality sampling location and therefore samples for Site W1 were also collected on June 14, 2006 at the same location as the water quality sampling. For reference to the biological data collected see Appendix P.

Main branch of Trail Creek at Sample Point M2

Macro-invertebrate collection was performed using a kick-net. The net was held downstream of an area where substrate was agitated, which enabled macro-invertebrates to be carried by streamflow and collected in the net. Approximately 15 sampling passes were performed except in the events of a low specimen count in which case sampling continued until a minimum of 100 individuals were collected. Specimens were placed in a 70 percent isopropyl alcohol solution for preservation until they could be identified in a laboratory. Specimens were identified to at least the family level using taxonomic keys referenced in Aquatic Entomology (McCafferty, 1998).

After specimens were identified by family, several biotic indices were used to determine the quality of each sample location based on the presence or absence of various macro-invertebrates species, total number of specimens collected, and taxonomical richness.

Main branch of Trail Creek
at Sample Point M1

Nine metrics were calculated including the following:

- Family Level Hilsenhoff's Biotic Index
- Number of Taxa
- Number of Individuals
- Percent Dominant Taxa
- Ephemeroptera, Plecoptera, and Trichoptera Index
- Ephemeroptera, Plecoptera, and Trichoptera Count
- Ephemeroptera, Plecoptera, and Trichoptera Count to Total Number of Individuals
- Ephemeroptera, Plecoptera, and Trichoptera Count to Chironomid Count
- Chironomid Count

Hilsenhoff's Biotic Index

This index was proposed by Chutter (1972) and modified by Hilsenhoff (1977) for use with index values proposed by Hilsenhoff. The calculation can be used to evaluate organisms at the species level as well as the family level using the following formula:

$$\text{HBI} = \frac{\Sigma(\text{ni ai})}{\text{N}}$$

where "ni" is the number of individuals in the "ith" taxa, "ai" is the index value of that taxa, and "N" is the total number of individuals in the sample. Hilsenhoff's family level Biotic Index uses the values 0-10.

The following are water quality value categories for Hilsenhoff's Biotic Index (1988a):

- 0.00-3.75 (excellent)
- 3.76-4.25 (very good)
- 4.26-5.00 (good)
- 5.01-5.75 (fair)
- 5.76-6.50 (fairly poor)
- 6.51-7.25 (poor)
- 7.26-10.00 (very poor)

Number of Taxa and Number of Individuals

The number of taxa is the total number of families identified in each sample. The number of individuals is the total number of individuals for all families identified in each sample. These numbers increase with increased water quality. The maximum number of taxa anticipated to be in a high quality Indiana stream is dependent on the natural conditions of the stream. A healthy stream could exhibit ten or more taxa equally distributed between sensitive, intermediate, and tolerant species.

West branch of Trail Creek
at Sample Point W2

Percent Dominant Taxa

The percent dominant taxa are an indication of the community balance. A community dominated by relatively few species would indicate some kind of environmental stress to the stream. Healthy streams should show large numbers in diversity and smaller population sizes with a fairly even composition of species. If the community is dominated by 1 or 2 species at 50% or greater there is some type of environmental stress on the community.

Main branch of Trail Creek
at Sample Point M5

Ephemeroptera, Plecoptera, and Trichoptera Count
Ephemeroptera, Plecoptera, and Trichoptera Index
Ephemeroptera, Plecoptera, and Trichoptera Count to Total Number of Individuals

The Ephemeroptera, Plecoptera, and Trichoptera Count is the total number of individuals for Orders Ephemeroptera, Plecoptera, and Trichoptera. The Ephemeroptera, Plecoptera, and Trichoptera Index is the total number of families represented in the Orders Ephemeroptera, Plecoptera, and Trichoptera. These orders are generally considered to be pollution sensitive. This number increases with higher water quality. Typically, five or more species with an even distribution from all three orders (Ephemeroptera, Plecoptera, and Trichoptera) constitute a good indicator of a healthy stream. Likewise, the absence of these orders or the predominance of a single species can indicate a stress on the environment that has unbalanced the system.

Ephemeroptera, Plecoptera, and Trichoptera Count to Chironomid Count/ Chironomid Count

The Chironomid Count is the total number of Chironomids present in the sample. The Ratio of Ephemeroptera, Plecoptera, and Trichoptera to Chironomid is a measure of the community balance. Good biotic condition is reflected in the fairly even distribution among the four major groups, with a substantial representation of Ephemeroptera, Plecoptera, and Trichoptera (EPT). EPT includes the more sensitive groups of macro-invertebrates that will not be present in low quality waters. Chironomidae will exist in any water source. Often, Chironomidae are the most abundant taxa in highly impacted water. A healthy community will have at least an equal, and in more desirable cases, a greater ratio of EPT to Chironomidae. A community that exhibits a greater ratio of Chironomidae to EPT is an indication that the community is impacted in some way.

Table 5 is a summary of biological data collected on September 26, 2005. Samples collected at Site W1 during the September sampling event were collected downstream of the water quality sampling location and therefore samples for Site W1 were also collected on June 14, 2006 at the same location as the water quality sampling. For reference to the biological data collected see Appendix P.

Table 5: Summary of Index of Biotic Integrity Scores for Biological Sampling Sites

	W1	W1	E3	M1	M2
Family Level HBI	0.27	3.00	4.65	3.98	3.68
Number of Taxa	11.00	8.00	11.00	8.00	9.00
Number of Individuals	131.00	56.00	339.00	197.00	123.00
Percent Dominant Taxa	83.97	42.86	23.01	65.48	65.04
EPT Index	5.00	1.00	5.00	4.00	3.00
EPT Count	9.00	1.00	103.00	156.00	103.00
EPT Count to Total Number of Individuals	0.07	0.02	0.30	0.79	0.84
EPT Count to Chironomid Count	4.50	0.04	1.32	39.00	51.50
Chironomid Count	2.00	26.00	78.00	4.00	2.00
Aquatic Life Support Metric	**3.33**	**2.22**	**4.44**	**5.33**	**4.89**

A *Hilsenhoff's Biotic Index* or HBI for the sample locations indicated the streams sampled were rated as good to excellent. Additionally, the aquatic life support (ALUS) metric score was calculated for each site. An ALUS metric score of $\geq$2.2 is considered fully supporting of aquatic life, while a score of <2.2 is considered non-supporting of aquatic life. Sample location W1 was the lowest score calculated at 2.2, indicating that all four sample locations were fully supporting of aquatic life.

Qualitative Habitat Evaluation Index (QHEI)

Main branch of Trail Creek
at Sample Point M3

West branch of Trail Creek
at Sample Point W3

The Qualitative Habitat Evaluation Index (QHEI) is a visual habitat assessment method developed by the Ohio Environmental Protection Agency as a tool for designating aquatic life uses and assessing potential causes of impairment. QHEI data was collected at each of the four sample sites for which biological sampling was also completed in order to provide comparative analysis of habitat quality across the watershed and to establish baseline conditions during the initial monitoring effort. The following parameters were examined and scored according to QHEI methods:

- Substrate
- Instream Cover
- Channel Morphology
- Bank Erosion and Riparian Zone
- Pool/Glide Quality
- Riffle/Run Quality
- Gradient and Drainage Area

Each of the parameters scored are used to determine the availability and quality of instream habitat for macroinvertebrates and fish such as riffle and instream cover, the stability of the streambank, and the stream type. Determination of instream habitat and steam type were utilized to determine if water quality or habitat availability and quality were the factors most influencing species present in Trail Creek. Stream type was also used to determine which species would be anticipated to be found in that type of stream. For example, the upper reaches of Trail Creek have a natural sand bottom and therefore would not be anticipated to support a large population of Ephemeroptera, Plecoptera, and Trichoptera which generally prefer rocky riffles.

Sampling sites evaluated for QHEI cover a wide range of habitat types. Site M2 is a wide, low gradient stream, located in an urban area, and whereas, Site E3 is a smaller stream located in a more rural area. Furthermore, results of the QHEI assessment reveal general habitat quality from excellent to poor. QHEI scores reported will be used as baseline conditions for comparison to habitat changes in subsequent monitoring years. Results of the QHEI field data are summarized in the Table 6 below and in Appendix Q.

Table 6: Qualitative Habitat Evaluation Index

Sample Point	M1	M2	W1	E3	Maximum Score
Substrate	13	10	3	8	20
Instream Cover	14	14	6	15	20
Channel Morphology	16	16	13	17	20
Riparian Zone/ Bank Erosion	8	5	4.5	5.5	10
Pool/Glide Quality	9	9	5	5	12
Riffle/Run Quality	5	5	0	2	8
Gradient	8	4	10	6	10
Total QHEI Score	73	63	41.5	58.5	100
Narrative Rating*	Excellent	Good	Poor	Good	

*Narrative rating classes were designed to communicate general habitat classes to the public. Ratings are general and not always representative of aquatic assemblages at any given site.

Calculated Pollutant Loading

As part of the Watershed Management Plan, the calculation of pollutant loads is required. Pollutant loads were calculated for all parameters sampled. As flow data was not collected at the time of the sampling, estimated flows were calculated for each sample location and utilized to determine the pollutant loading.

Following is the summary of the estimated loading for each sample location for those pollutants of concern in the watershed. This loading was calculated using the calculated base flow.

Table 7: Trail Creek Watershed Sampling Data Analysis Results Using Calculated Base Flow Data

Sample Site E1 Descriptive Statistics	*E. coli* (cfu/year)	Total Suspended Solids	Ammonia	TKN	Nitrate + Nitrite	Ortho Phosphorus	Total Phosphorus
Max Load (tons/yr)	4.97E+14	1716.35	8.20	81.97	53.87	3.12	17.96
Min Load (tons/yr)	4.85E+12	23.06	1.17	19.52	7.42	0.78	0.78
Mean Load (tons/yr)	8.62E+13	157.19	3.79	31.75	23.54	1.20	2.68
Sample Site E2 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	7.85E+14	1334.39	4.28	27.37	21.21	1.03	5.47
Min Load (tons/yr)	3.10E+12	30.79	0.51	8.55	3.25	0.34	0.34
Mean Load (tons/yr)	1.30E+14	191.61	1.59	13.09	10.21	0.49	1.17
Sample Site E3 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	9.17E+14	3443.36	4.00	36.04	24.82	1.60	9.61
Min Load (tons/yr)	3.63E+12	36.04	0.60	10.01	0.80	0.40	0.40
Mean Load (tons/yr)	1.20E+14	286.66	1.67	14.78	11.46	0.61	1.39
Sample Site M1 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	2.79E+15	26331.84	11.45	114.49	52.47	2.39	44.84
Min Load (tons/yr)	2.81E+13	85.86	1.91	23.85	6.68	0.95	0.95
Mean Load (tons/yr)	3.40E+14	1235.50	4.67	38.24	22.72	1.23	4.15
Sample Site M2 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	2.81E+15	29416.65	11.97	188.13	91.21	3.99	57.01
Min Load (tons/yr)	2.07E+13	102.62	1.14	28.50	9.12	1.14	1.14
Mean Load (tons/yr)	3.72E+14	1504.80	5.78	49.81	29.23	1.56	5.28
Sample Site M3 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	4.91E+15	25444.06	16.65	184.29	112.95	3.57	52.31
Min Load (tons/yr)	2.16E+13	107.01	2.38	29.72	5.94	1.19	1.19
Mean Load (tons/yr)	4.86E+14	1480.65	6.90	54.30	33.27	1.53	5.39
Sample Site M4 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	1.92E+15	33206.65	14.93	161.26	125.42	1.79	53.75
Min Load (tons/yr)	2.87E+13	107.50	2.99	29.86	5.97	1.19	1.19
Mean Load (tons/yr)	3.25E+14	1701.88	6.57	48.52	32.62	1.42	7.19
Sample Site M5 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	3.33E+15	25519.10	16.25	150.47	264.82	12.64	44.54
Min Load (tons/yr)	8.19E+12	108.34	2.41	30.09	30.09	1.81	3.01
Mean Load (tons/yr)	3.74E+14	1218.84	7.20	52.80	144.01	5.04	9.43
Sample Site M6 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	1.14E+15	8853.86	23.98	116.82	270.53	7.38	9.22
Min Load (tons/yr)	5.58E+12	110.67	2.46	30.74	6.15	1.23	1.23
Mean Load (tons/yr)	1.50E+14	700.93	8.55	49.43	116.03	3.17	5.59
Sample Site W1 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	1.21E+15	3908.68	5.92	39.98	25.61	1.18	10.96
Min Load (tons/yr)	9.40E+12	26.65	0.30	7.40	1.48	0.30	0.44
Mean Load (tons/yr)	3.54E+14	403.78	2.24	13.92	6.56	0.42	1.46
Sample Site W2 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	1.07E+14	2974.07	0.81	11.78	3.78	0.20	3.98
Min Load (tons/yr)	5.90E+11	7.31	0.12	2.03	0.41	0.08	0.08
Mean Load (tons/yr)	1.48E+13	137.67	0.31	2.77	1.31	0.09	0.30
Sample Site W3 Descriptive Statistics	***E. coli* (cfu/year)**	**Total Suspended Solids**	**Ammonia**	**TKN**	**Nitrate + Nitrite**	**Ortho Phosphorus**	**Total Phosphorus**
Max Load (tons/yr)	2.25E+13	304.04	0.32	2.19	0.85	0.10	0.26
Min Load (tons/yr)	3.61E+10	3.58	0.06	0.99	0.08	0.04	0.04
Mean Load (tons/yr)	3.69E+12	42.36	0.12	1.10	0.24	0.05	0.08

For reference to calculated pollutant loads for other flow calculations, the calculations for the loading for Trail Creek, and the flow study see the Appendix R Load Calculations and Appendix O – Trail Creek Flow Study.

Results and Conclusions of 2006 Watershed Management Plan

Physical and chemical water quality measurements indicate the maximum recorded values for total suspended solids, nutrients (nitrogen and/or phosphorus), and *E. coli* exceed the target concentrations at all of the sample locations. Maximum recorded values are generally associated with higher flow events and increased stormwater run-off. This indicates that potential non-point source pollutant loading associated with significant rain events is an issue throughout the watershed. However, only sample locations located on the Main Branch of Trail Creek and at Sample Location W1 in the West Branch of Trail Creek exceed target concentrations for total suspended solids, nutrients (nitrogen and/or phosphorus), and *E. coli* for the average recorded value. Average recorded water quality records for sample locations within the East Branch of Trail Creek and at Sample Locations W2 and W3 did not exceed the target concentrations for total suspended solids, nutrients (nitrogen and/or phosphorus), and *E. coli*. These sample locations represent the least developed portions of the watershed and those agricultural areas which have through general observation have more farmers with implemented best management practices. This data indicate the Main Branch of Trail Creek and the western portion of the West Branch of Trail Creek may be more heavily influenced by non-point source pollutants of concern during a minor or typical rain event.   Sample Location W1 is also heavily influenced by livestock in the stream which is reflected in the both the maximum and average recorded values for total suspended solids, nutrients, and *E. coli*.

Biological sampling indicate that all streams which were sampled ranged from good to excellent with the lowest rated Sample Location at W1 and the highest rated sample at M1. None of the sample locations indicated impaired aquatic life measurements and sample variation is most likely due to differences in stream type and habitat.

Qualitative Habitat Evaluation Indexes indicate that sample locations along the Main Branch of Trail Creek and the East Branch of Trail Creek are generally good to excellent with sufficient in-stream habitat, structure, stability, and cover to support aquatic life. The sample location at W1 was ranked as “poor” due to significant in-stream disturbance and erosion. Sample location M1 was ranked as “excellent” primarily due to stream restoration projects implemented at this site and preservation of the riparian corridor.

Sampling indicated degraded water quality due to various pollutants, particularly for the maximum recorded values throughout the watershed with the “hot spots” located in both the Main Branch of Trail Creek and western portion of the West Branch of Trail Creek. Stream health as indicated through aquatic sampling and habitat was rated as good and fully supporting of aquatic life for all except Sample Location W1 which was degraded due to in-stream disturbance from livestock in the stream.

Total Maximum Daily Load

Triad Engineering Incorporated, Milwaukee, Wisconsin, prepared a Trail Creek Escherichia coli TMDL Report for the Indiana Department of Environmental Management in December 2003. A TMDL (Total Maximum Daily Load),

West branch of Trail Creek
at Sample Point W1

established under Section 303(d) of the Federal Clean Water Act, is a calculation of the maximum amount of pollutant that a waterbody can receive and still meet water quality standards, and allocates pollutant loadings among point and non-point sources. The focus was a study designated toward the reduction of *E. coli* pollutant inputs into Trail Creek.

The calculation of the TMDL must include a margin of safety which accounts for scientific uncertainty and future growth. Seasonal variations are also included. The TMDL is calculated using the following equation:

TMDL = WLA + LA + MOS + SV

Where:

WLA = Waste Load Allocations (point sources)
LA = Load Allocations (nonpoint sources)
MOS = Margin of Safety
SV = Seasonal Variation

The TMDL target suggested in this report for *E. coli* is the state water quality standard which is a monthly geometric mean standard of 125 cfu/100 ml and a maximum daily standard of 235 cfu/100 ml. Triad Engineering Inc. found that high *E. coli* levels are present in the watershed in both wet and dry conditions, negating the need to use low-flow criteria in the development of their TMDL for the watershed. In order to obtain the TMDL concentration, limits on the four permitted point sources in the watershed have been suggested. The permitted flow anticipated to meet the TMDL for Trail Creek is limited to the following effluent limits from each permitted source. It should be noted that since the TMDL was completed for Trail Creek, the Indian Springs Subdivision wastewater treatment plan has been decommissioned and flow to this plant is now treated at the J.B. Gifford Wastewater Treatment Plant.

J. B Gifford Wastewater Treatment Plant (Michigan City) -- 12 million gallons per day (MGD)
Friendly Acres Mobile Home Park -- 0.015 MGD
Autumn Creek Mobile Home Park -- 0.010 MGD
Indian Springs Subdivision -- 0.018 MGD

The TMDL also indicated a significant loading to Trail Creek from non-point sources. Non-point sources of *E. coli* include agricultural drainage and run-off, livestock, failing septic systems, illicit connections/non-permitted discharges, urban stormwater runoff, and natural sources. Non-point source loading of *E. coli* needs to be reduced to meet the TMDL established for Trail Creek. The recommended waste load and load allocation for Trail Creek according to the TMDL ranges from 1.49×10^{11} to 5.48×10^{11} depending upon the month. The total estimated non-point source load for the year 2000 ranged from 7.34×10^{11} to 4.07×10^{13}. Therefore the reduction required to meet the TMDL can range up to 4.01×10^{13} based on the estimated load and load allocations.

1993 Trail Creek Watershed Management Plan

On September 30, 1993 the Northwestern Indiana Regional Planning Commission, under contract to the Indiana Department of Environmental Management, prepared the first Trail Creek Watershed Management Plan. The intent of that plan was to gain access to Section 319 funds and begin restoring the watershed. Although that plan was never fully implemented, multiple successes with regard to reduction in pollutant loading to the stream have occurred since the 1993 Watershed Management Plan was completed. This current plan serves as an update to the 1993 Watershed Management Plan.

Main branch of Trail Creek
at Sample Point M4

Main branch of Trail Creek
at Sample Point M6

Main branch of Trail Creek
at Sample Point M4

303(d) List of Impaired Waters

The 2004 303(d) List of Impaired Waters for Indiana contains six records of importance to our watershed. The East Branch of Trail Creek, Trail Creek, the West Branch of Trail Creek and tributaries, and Waterford Creek all have *E. coli* listed as a parameter of concern. Trail Creek and its tributary basin are listed as the parameter of impaired biotic communities. Trail Creek is also listed as having a fish advisory for both PCBs and mercury.

Fish Consumption Advisories

Trail Creek appears on the 2006 Indiana Fish Consumption Advisory of Streams and Rivers for three separate species of fish. These include carp, smallmouth bass, and walleye. Carp up to 23 inches are to be eaten for only one meal every two months, while carp 23 inches and larger are not to be eaten at all. Smallmouth bass between 14 and 19 inches are to be eaten in only one meal per month, while smallmouth bass larger than 19 inches are to be eaten only one meal every two months. Walleye between 18 and 27 inches are to be eaten in only one meal per month, while walleye larger than 27 inches are to be eaten only one meal every two months. There is a 14 inch size limit on smallmouth bass and walleye. All advisories are due to PCB contamination. See Figure 19.

In addition, Trail Creek appears on the 2006 Lake Michigan and Tributary

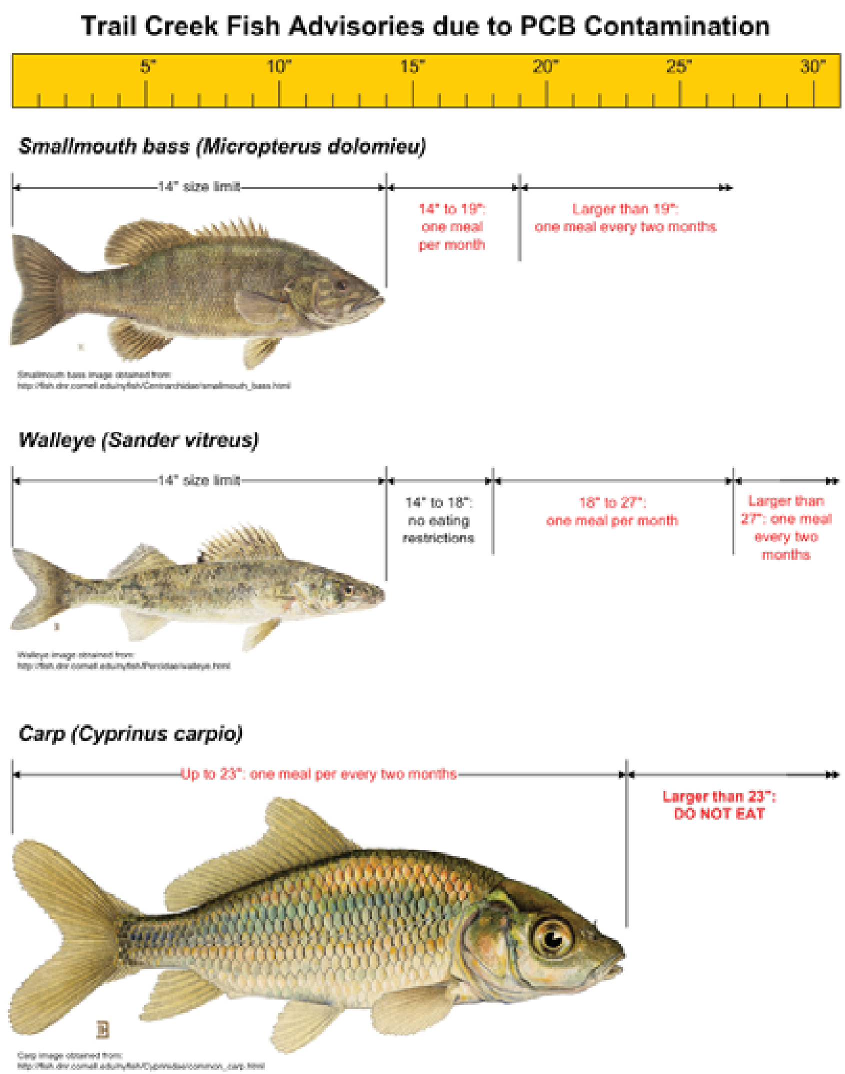


Figure 19: Fish Advisories

Fish Consumption Advisory for 24 separate species of fish. These include black crappie, bloater, bluegill, brook trout, brown trout, carp, channel catfish, Chinook salmon, chubs, Coho salmon, freshwater drum, lake trout, lake whitefish, large mouth bass, longnose sucker, northern pike, pink salmon, quillback, rainbow trout or steelhead, rock bass, silver redhorse, smallmouth bass, walleye, and white sucker. All advisories are due to contamination. For further reference to the 2006 Fish Consumption Advisories see http://www.state.in.us/isdh/dataandstats/fish/2006/index.htm.

East branch of Trail Creek
at Sample Point E3

Other water quality studies and results

In March of 1984, Hydroqual, Inc., Mahwah, New Jersey, under contract from the Indiana State Board of Health, preformed the first Waste Load Allocation Study for Trail Creek. At that time, low levels of dissolved oxygen were the primary concern. Since that time, improvements in water quality though elimination of combined sewer overflows and point source pollutants have been implemented. Dissolved oxygen levels within Trail Creek are within the state water quality standard and are no longer an issue.

Fixed Station Data

Fixed Station Data provided by IDEM was reviewed for the Trail Creek Watershed. This data has been collected annually at three stations within Michigan City along Trail Creek since 1991. These stations include the Liberty Street Bridge, the Franklin Street Bridge, and the US 12 Bridge. The objective of this program is to provide basic information that will reveal water quality trends and provide data for the many existing and prospective users of surface water in Indiana. The program was developed to determine chemical, physical, and bacteriological characteristics of Indiana water under changing conditions. Table 8 is a summary of the data collected as part of the fixed station data collection for those parameters which were also studied as part of this Watershed Management Plan. This data indicated a wide fluctuation in pollutant concentrations over the sampling period.

	pH	TSS (mg/l)	Nitrogen	Total	E coli	TKN (mg/l)	Nitrate + Nitrite (mg/l)
Target Concentrations	N/A	**15.00**	**0.25-0.01***	**0.05**	**235**	**1.00**	**10.00**
E1							
Averages	7.9	19.30	0.17	0.09	1130	0.71	1.59
MAX	8.6	294	2.1	0.43	26100	2.8	4.5
MIN	6.6	4	0.1	0.03	6	0.2	0.1

Table 8: Summary of Fixed Station Data

In addition to the Fixed Station Sampling data obtained from IDEM, several other studies including an *E. coli* study conducted in 2000 were reviewed, however, given these were limited time period studies which occurred over 5 years ago this data was only utilized for general observation and trends, not to indicate the current status of the stream.

Water Quality Problems

WATER quality data collected as part of this study indicate that many of the concerns expressed by the stakeholders and Steering Committee members are measurable problems within Trail Creek and its tributaries. Water quality data indicate high levels of *E. coli*, total suspended solids and turbidity, nutrient loading, and hydromodifications leading to streambank erosion and instability are demonstrated water quality problems within the watershed. Based on the expressed concerns, water quality data gathered to date, and anticipated resources, four water quality problems were identified by the Steering Committee and stakeholders which will be the focus of this Watershed Management Plan. These include the following.

- *E. coli*
- Sedimentation
- Nutrient loading
- Hydromodifications

Information provided by the public, stakeholders and Steering Committee members indicated several major areas of concern with regard to the Trail Creek Watershed. These concerns are discussed in more detail in the previous Watershed Concerns section and break very generally into the following categories: stream and water quality issues, aquatic health and fisheries, public health concerns, sedimentation, streambank erosion, and operation and planning organization. The identified water quality problems are reflected within each of these areas of concern with the exception of Operation and Planning. While Operation and Planning is not a water quality problem in itself, poor operation and planning decisions within the watershed can negatively impact water quality, riparian areas and instream habitat.

For this reason, operation and planning will be addressed during implementation of the Trail Creek Watershed Management Plan.

Many of the concerns expressed will be addressed through implementation of best management practices within the four water quality problem areas. For example, through implementation of best management practices to reduce nutrient loading to Trail Creek, concerns caused by high levels of nutrients such as algae growth (stream and water quality concern), fish kills (aquatic health and fisheries concern), and failing septic systems (public health concern) will be addressed.

The majority of the water quality problems identified were also previously expressed in the 1993 Trail Creek Watershed Management Plan. That plan indicated stream quality, dissolved oxygen, bacteria, sedimentation, and fish advisories were the significant water quality problems within Trail Creek. Of those issues, only dissolved oxygen has been eliminated as a problem within Trail Creek since the 1993 Study was completed and dissolved oxygen is no longer an expressed concern or water quality problem.

***E. coli* bacteria**

The *E. coli* bacteria is usually a frequently a helpful bacteria with a symbiotic relationship with most exothermic or warm blooded animals. This bacterium is found in the gut of warm blooded animals acting to aid in digestion of food. Rare strains of these bacteria can cause illness; however that in itself is not the reason *E. coli* is important and pertinent for a watershed study. Similar to other pollutants of concern like ammonia, *E. coli* comes from the excretion of solid animal

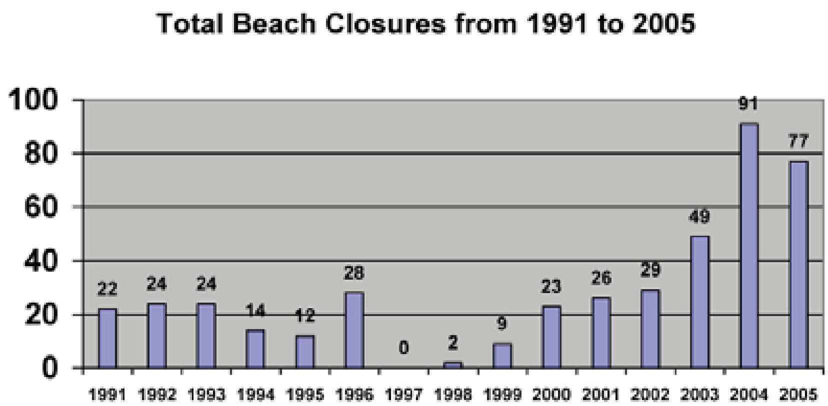


Figure 20: Data Provided by the LaPorte County Health Department with regards to Historical Beach Closings.

waste. Sources of *E. coli* can be, but are not limited to, runoff from animal pastures and livestock pens, poorly constructed or damaged septic tanks, runoff from areas with high concentrations of pet waste, combined sewer and storm water systems, illicit discharges, and natural wildlife. *E. coli* levels are directly correlated to the quantity of biological waste pollution in a given body of water. In this way, *E. coli* can be used as a measurement of general water quality. *E. coli* can also be an indicator of the likelihood of the presence of more infectious and dangerous bacteria in the water.

Stream water quality, aquatic health, fisheries populations, and public health were identified as concerns as part of this report. Water quality data gathered for this report, as part of the TMDL study prepared for Trail Creek, and in preparation of the list of Impaired Waters of the State, indicate that *E. coli* levels within Trail Creek and its tributaries rarely meet the State Water Quality Standard for *E. coli* at any of the sample locations. Trail Creek has been listed as an “impaired waterway” with respect to the levels of *E. coli* by the State of Indiana. Impaired water quality from Trail Creek has closed beaches in Washington Park and has resulted in the expenditure of federal funds to continually dredge the navigable waterways of Trail Creek, Figure 20.

As such, *E. coli* was identified as a problem in Trail Creek. The Steering Committee has established a goal to meet the State Water Quality Standard for *E. coli* of 125 cfu/100 ml as a geometric mean on not less than five samples equally spaced over a 30-day period nor exceeding 235 cfu/100 ml in any one sample within that 30-day period.

Erosion and Sedimentation

Erosion is the process by which larger objects are broken down into smaller particles and then carried to a separate site. Processes that cause erosion can be natural weathering, rainfall, runoff, wind and the actions of living organisms. Sedimentation occurs when the smaller particles can no longer be carried by the eroding medium and are allowed to be deposited. These two processes act together and directly affect each other’s severity. Erosion and sedimentation are problems in watersheds for multiple reasons including streambank stability and channel movement, boating hazards created due to sedimentation, increased risk of flooding, and aquatic health.

The origin of sediment in a stream can be natural or caused by human activity and development. Sediments can come from constructions sites, areas of high topography and erodible soils, exposed soils, channelization of a waterway, increased flow, increased runoff, recreational areas, poor agricultural practices, and natural events. While the transportation and erosion of sediment is a natural

Trail Creek at Sample Point M1 with high total suspended sediments

process, human activity has increased the rate and intensity of erosion to the point that sedimentation and erosion are a priority for most waterways, including the Trail Creek watershed as indicated by highly turbid waters at Sample Point M1.

Stream water quality, aquatic health, fisheries populations, public health, and sedimentation and streambank erosion were identified as concerns as part of this study. Sedimentation within Trail Creek has necessitated frequent and repeated dredging of the navigable channel within Trail Creek located downstream of the E Street Bridge in Michigan City. Sedimentation within Trail Creek has been identified as a water quality problem due to water clarity within the stream; nutrient and pollutant loading associated with sedimentation; and habitat degradation. Many sensitive aquatic species, including many of the salmonoid fisheries, cannot tolerate high sediment loads within a stream.

No state water quality standard has been established for sedimentation or turbidity within a stream nor have direct sedimentation measurements been studied within Trail Creek. Thomas Waters in his publication "Sediment in Streams" indicates that TSS concentrations of 25-80 mg/l are known to reduce fish yield within a stream system. Based on the best available data and a goal towards achieving a more aggressive water quality standard than the minimum concentration known to have an impact (25 mg/l), the Sediment Subcommittee recommended to the Steering Committee a water quality goal of 15 mg/l for TSS. The Steering Committee accepted this goal and established a benchmark of 15 mg/l for turbidity as a measurable water quality goal for sedimentation. Water quality sampling indicates that this benchmark is exceeded during high flow and stormwater runoff events. This is evident by water clarity in the stream and by the data collected.

Nutrient Loading

In small amounts, nutrients are needed and play a vital role in the base of most aquatic ecosystems. These nutrients help the growth of aquatic plants which serve dual roles in an aquatic ecosystem as the base of the food chain and as habitat. However, nutrient loading can lead to eutrophication and algae blooms which can in turn cause fish kills due to oxygen depletion during the decomposition of the organic plant litter (Salt Creek Fish kill). Sources of nutrients in the watershed include run-off from residential areas; erosion and runoff from pasture and cultivated land; discharges from point sources and septic systems; and river/streambank erosion. The two primary nutrients of concern with regard to water quality are phosphorus and nitrogen.

Fish kill in Salt Creek (IDNR)

Stream water quality, aquatic health, fisheries populations, and public health were identified as concerns as part of this study. Nutrient loading within Trail Creek has been identified as a water quality problem through water quality sampling and load calculations. The most common nutrients of concern are phosphorus and nitrogen, which are found naturally occurring in the watershed, in fertilizers, in sanitary sewer overflows, and septage. Nutrient loading is a significant contributor to eutrophication of lakes, nuisance algal blooms, and in-stream plant growth. No state water quality standard has been established for nutrient loading within a stream nor have TMDLs established for Lake Michigan indicated target load reduction or concentration goals for tributary streams. The Steering Committee has established a benchmark of a meeting the established target concentrations within 15 years as a measurable water quality goal for nutrient loading.

With regards to calculation of pollutant loading within Trial Creek, target concentrations were established as follows: 0.25 to 0.1 mg/l for nitrogen ammonia; 1.0 mg/l for TKN; and 10 mg/l for nitrate and nitrite. These targets were established based on the best available data with regards to water quality parameters and toxicity to aquatic organisms.

Ammonia can be an extremely toxic substance to a watershed. The toxicity of ammonia is a function of the temperature and pH. Along with temperature and pH, low levels of oxygen in water can increase the toxicity of ammonia and its likelihood of causing a fish kill. The most common source of ammonia that enters into a watershed is manure. Ammonia itself is a biological waste product of respiration.

There are two main sources of manure that enable the ammonia to enter a watershed. First is via the spreading of manure as fertilizer in agricultural areas. The use of manure as fertilizer is a valuable practice; however, during storage and after use it is vulnerable to the processes of erosion. Recently spread manure is easily carried into a stream system during the runoff of the first rain after application or during storage.

The second main source of manure from pasture and livestock holding areas immediately on, around, or too near the waterway. The close location of livestock to waterways allows the manure to be quickly carried to the stream either in water or physically on the animal itself, either before or after excretion.

Ammonia can also come from other types of animal waste including human. Ammonia from human waste enters a waterway from poorly constructed or maintained septic tanks and during the overflow of combined storm and sewer systems. High levels of ammonia and known locations of livestock in the waterways of the Trail Creek Watershed make this a high priority for this management plan.

Phosphorus is generally the limiting nutrient within a waterbody. By allowing and encouraging unregulated plant growth, phosphorous causes algal blooms that in turn create fish kills, by depleting oxygen levels during decomposition. Phosphorus can enter the waterway via runoff in high concentrations. The sources of the phosphorus pollutants include, but are not limited to, human and animal waste, lawn chemicals and fertilizers and some agricultural practices. With regards to calculation of pollutant loading within Trial Creek, a target concentration of 0.05 mg/l ortho-phosphorus and total phosphorus was established based on the best available data. The Steering Committee has established a benchmark of a meeting the established target concentrations within 15 years as a measurable water quality goal for nutrient loading.

Hydromodification

Cheney Run Confluence with Trail Creek

Monday, November 27, 2006, after eight days of dry weather

Friday, December 1, 2006, after 3 days of rain (0.88+0.78+0.63 = 2.29")

Hydromodification includes channelization and channel modification, stream relocation, headwater stream and wetlands fills, straightening, levee and dam construction, bank erosion and armoring/bank stabilization, clearing and snagging, riparian encroachment, bridge and culvert construction, draining, filling, and urbanization. Hydromodification can result in both short and long term water quality degradation, accelerated erosion and sedimentation, destruction of aquatic habitat, and impairment or elimination of certain aquatic functions. For reference to erosion and flooding issues see photographs of Cheney Run and Trail Creek before and during a storm event.

Stream water quality issues, aquatic health, fisheries populations, public health concerns, sedimentation and streambank erosion, and operation and planning organization were identified as sources of concern as part this study. Hydromodification is the most prevalent source of degradation in streams leading to erosion and sedimentation, nutrient loading, and a wide range of water quality issues. Historically within the Trail Creek Watershed, drainage practices for agricultural lands and dams were the most prevalent source of hydromodification. As development is expanding outside of the urbanized areas of Michigan City and Trail Creek, land that was previously fallow or used for agricultural purposes is being converted to developed land with the associated increased impervious surface and run-off, stream channelization, stream relocation, wetland degradation and destruction, bank erosion, and increased flows. The Steering Committee has established adopted the goal to ensure the protection of waterbodies with the Trail Creek Watershed from further impacts of hydromodification and wetland loss to meet and maintain applicable water quality standards.

Sources of Water Quality Problems

Point Sources of Pollution

A point source pollutant is a substance originating from a specific tangible point which makes its way into an environment in greater concentrations than would be present under natural conditions. Physically these sources are pipes, drainage ditches, leaking vessels, channels, sewers, tunnels, and smoke stacks. The threat this type of pollution creates to any watershed is great and one that in many cases may be permitted and legal. The discharge into the body of water may be within the boundaries of the law and therefore subject to regulation. Point source pollution can be any by-product created from manufacturing, leaking chemicals, runoff, sedimentation, and any substance which its discharge into the environment creates higher concentrations of the substance than were present before the point source existed. Three permitted point sources of pollution are located in the watershed (Figure 21), all of which are fully compliant with regulations imposed on them. Therefore, those point sources are not a current focus of this management plan. Continual monitoring of those sites is necessary to ensure against an accidental failure to comply with the regulations under which they have been permitted. This monitoring is part of the permits and falls of the hands of the permitting body and the operators of the permitted source.

Stormwater and polutent runoff from parking lot

Stormwater pipes discharging to Trail Creek

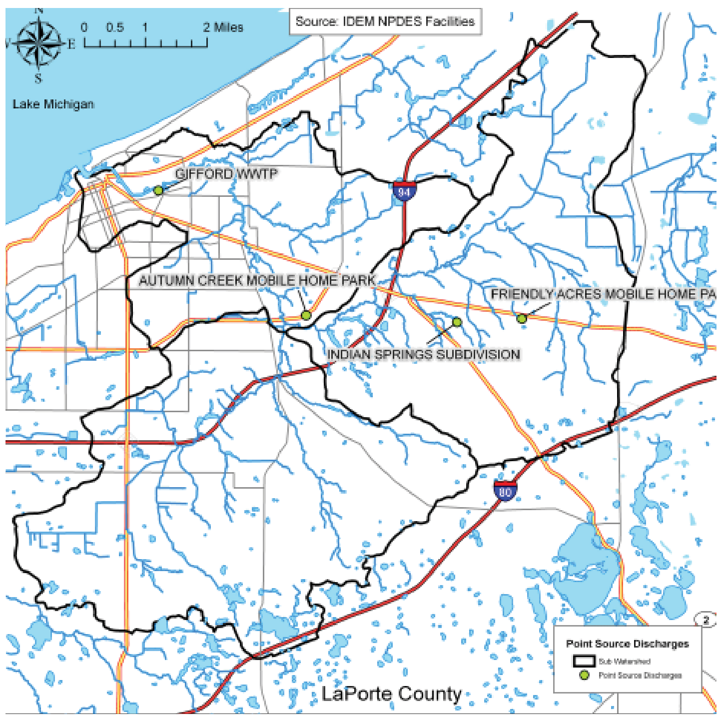


Figure 21: Point Source Discharges (see appendix page 83)

Non-point Sources of Pollution

The 1993 Trail Creek Watershed Management Plan indicated numerous non-point sources of pollutants within the watershed including rural sources, urban sources, stormwater runoff, landfills, CERCLIS (Comprehensive Environmental Response, Compensation and Liability Information System) or hazardous waste sites, Superfund sites, confined disposal sites, construction activities, and channel modifications. Many of these sources are still of concern within the watershed, particularly as development continues and the existing infrastructure ages.

Non-point sources of pollution exist everywhere and by definition are extremely difficult to locate and eliminate. As identified through the concerns expressed as part of the public involvement for this report and water quality testing, problems within the Trail Creek Watershed include excessive *E. coli*, sediment loading, nutrient loading, and hydromodifications. Many non-point sources found within the watershed can contribute to more than one pollutant of concern. For example, narrow riparian corridors can contribute to streambank erosion which leads to sedimentation and increased nutrient loading to the stream due to nutrients adhered to soil particles. Likewise, increased impervious surface in an urban area can contribute to increased storm flows leading to streambank erosion as well as *E. coli* and nutrient loading from urban stormwater. The following is a brief description of known and potential sources of pollutants within the Trail Creek Watershed.

E. coli

E. coli bacteria and other pathogens can have many sources of access to waterways, both natural and human influenced. Water quality issues related to human and animal waste include increased levels of nutrients, ammonia, and higher levels of *E. coli* and other bacteria in the watershed. Human and animal waste can either be introduced as a point source or a non-point source pollutant. This watershed management plan is primarily focused on non-point sources of pollutants to Trail Creek. Sources noted as part of this study include failing or ineffective septic tanks, livestock, pets, and natural sources.

Human and animal waste

Contribution of *E. coli* and other nutrients from septic systems, particularly septic systems either in areas with unsuitable soils or failing septic tanks is an identified problem within the watershed. The majority of both the East and West Branches of Trail Creek as well as the towns of Trail Creek and Pottawattomie Park do not currently have sanitary sewer service and therefore rely upon septic tanks. Many of these areas are located on soils which are not suited for septic tank placement, Figure 22. Unsuitable soils allow rapid movement of untreated biological waste from septic systems to enter into the waterway before it is able to be properly treated.

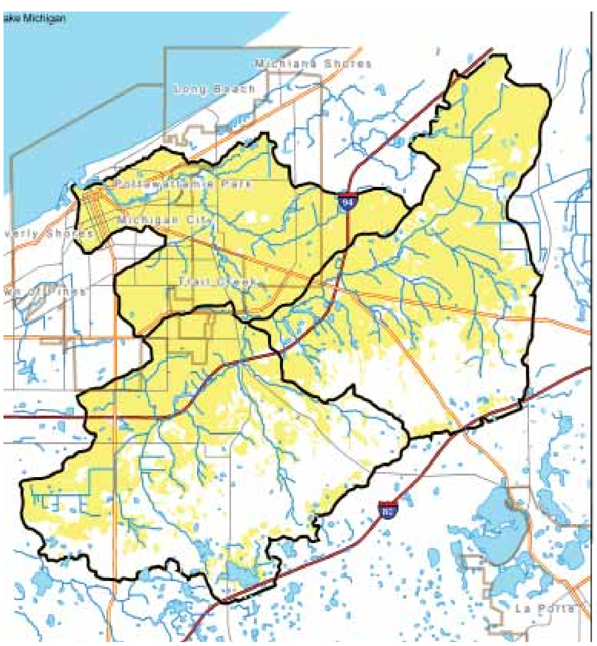


Figure 22: Soils Not Suited for Septic Tanks (see appendix page 84)

Failing Septic Systems in LaPorte County

Many of the septic tanks in place, particularly in older neighborhoods such as Trail Creek and Pottawattomie Park, are aging and with age the efficiency of

Watering hole for cattle within stream

the septic systems has declined. It is widely accepted that a 20-year lifespan is average for most septic tank systems. This lifespan varies depending upon usage and maintenance. As a septic tank ages and fails it begins to transport more untreated waste into the leaching field. This movement of solids clog the system, resulting in septic tank failure and release of untreated waste. These failing septic systems coupled with the location of the systems in soils not suited for use as septic fields allows rapid movement of the untreated waste to both ground water and the stream system.

Domestic pet waste is another source of pollution of concern for the Trail Creek Watershed. With the large number of homes in the urban and suburban areas of the watershed pet waste is easily transported to the adjacent waterways. Lack of riparian buffers in urban backyards, poor housekeeping, and inadequate removal of pet wastes can allow the waste into the water. Additionally, as Michigan City and other communities develop green spaces along Trail Creek the potential for pet waste to enter the waterway will increase.

Livestock production

Livestock production and unlimited access of livestock to the streams or runoff of manure to the stream is a recognized source for *E. coli*, nutrient loading, and erosion within the stream, whether from a production farm or hobby farm. No regulated confined animal feeding operations (CAFOs) are located within the Trail Creek Watershed; however, as part of this watershed management plan, several locations were identified as specific areas of concern within the East and West Branches of Trail Creek where livestock were either allowed direct access to the stream or where manure was allowed to run off into the stream channel, Figure 23. Water quality sampling within these areas confirm higher *E. coli* levels near or adjacent to pasture lands where livestock have unlimited access to the streams. It should be noted that Figure 23 is not intended to be an inclusive listing of areas of potential concern due to livestock in or near waterways nor to indicate that every designated area is a contributor to water quality problems within the watershed. Data including on this mapping was gathered from available land use mapping and through general observations and should be utilized for future planning and implementation purposes only.

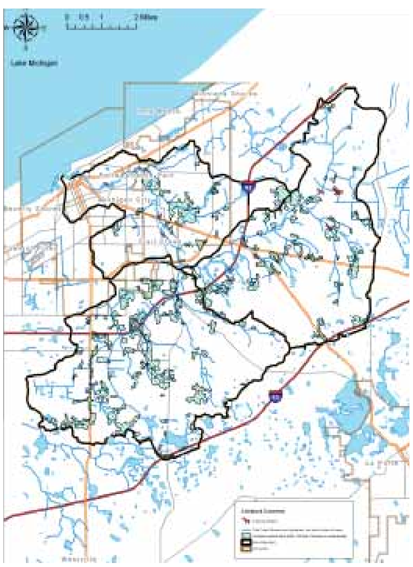


Figure 23: Areas of Livestock Production (see appendix page 87)

In addition to bacterial contamination, higher than normal levels of erosion, sedimentation, and nutrient loading were observed in areas where livestock were allowed access to the streams. Soil erosion occurs in these areas when large numbers of livestock are confined to small areas. The livestock can cause the erosion of the soil by overgrazing the land, trampling the streambank, exposing the soil to external means of erosion or by physically becoming covered in the soil and enabling it to be transported on the animal itself.

Erosion and Sedimentation

Erosion and sedimentation within the Trail Creek Watershed have been noted as a problem throughout the watershed although sediment transport and deposition of sediments in the navigable channel and downstream sections of the stream have received the majority of the focus. Sources of erosion and sedimentation within the watershed noted as part of this study include livestock in streams, agricultural practices, new and re-development, and roadway and roadside ditch maintenance.

Concurrently with the preparation of this Watershed Management Plan, the US Army Corps of Engineers has been preparing a sediment and erosion model for Trail Creek. This web-GIS based model is knows as the Burns Ditch and Trail Creek Watershed Management System. The model includes a number of very useful tools for watershed management including applicable BMPs, estimated sediment yields, estimated impervious cover, estimated peak runoff, estimated non-point pollution levels, and sediment and erosion control designs at specific locations. The model can be accessed at http://danpatch.ecn.purdue.edu/~eqip/erosion/. This model will be incorporated into the Trail Creek Watershed Management Plan and implementation.

Agricultural Practices

Agricultural practices have contributed to non-point source pollutant loading within the Trail Creek Watershed through lack of implementation of conservation practices and limitations on riparian buffers, Figure 24. Approximately 56 percent of all land in LaPorte County is used for agriculture, with 393 farms tilling 103,414 acres for grain production, according to the 2002 National Census of Agriculture. Of the land used for grain production, 71 farms farm with 18,773 acres of land were under irrigation. While farming practices have become more conservation minded, application of those practices within the Trail Creek Watershed is inconsistent.

Bank erosion due to cattle entering stream at Sample Point W1

Specific data on the farming practices for each farm within the watershed were not available however the NRCS indicated that approximately 40 percent of the farms in the watershed employed no-till practices, 40 percent employed reduced till practices and 20 percent employed conventional tillage. As defined by the NRCS, there are three main types of tillage practices for agricultural fields. Conservation tillage is any tillage and planting system in which at least 30 percent of the soil surface is covered by plant residue after planting to reduce soil erosion by water or wind. Conventional tillage includes tillage types that leave less than 15 percent residue cover after planting. Reduced tillage includes tillage types that leave 15-30 percent residue cover after planting.

Each tillage practice presents different benefits and problems to both the farmer and the watershed. The use of conservation tillage lowers the number of days in which soil is exposed and therefore lessens the potential for the soils to be eroded, thus lowering the amount of total suspended solids added to a watershed. However, conservation tillage is not suitable to all soil types or farming practices, especially in soils found in the East Branch of Trail Creek Watershed. As such, tillage practices in use throughout the watershed have been identified as a source of erosion and sedimentation.

In addition to conservation tillage practices, a wide variety of other conservation practices can be utilized on agricultural areas to reduce erosion and sedimentation as well as nutrient loading to streams. These include but are not limited to riparian buffers, wetland restoration or enhancement, and fencing of livestock from streams. The use of these practices within the Trail Creek Watershed is sporadic. The majority of the active farms in the East Branch of Trail Creek Watershed, particularly along streams maintained as legal drains, have no riparian buffers and row crops are planted to the top of the stream bank. General observations conducted during the watershed study indicated that these stream reaches were affected by sedimentation and algae growth more than downstream reaches with sufficient riparian buffers.

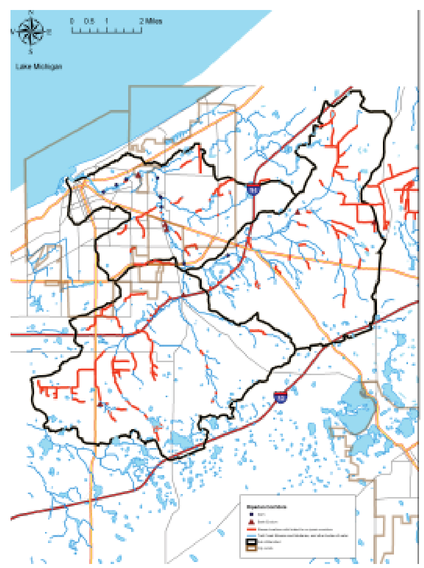


Figure 24: Areas with Limited Riparian Corridors (see appendix page 86)

New and Re-Development

Development of previously undeveloped land poses many threats to a watershed. With development comes disturbance of the soils surface, extended exposure of soils, removal of significant ecological areas (wetlands, forests, and natural riparian buffers), increased impervious surfaces, and increased pollution runoff. The effects of these actions include but are not limited to increased erosion, increased total suspended solids, increased runoff, greater flow variations, higher levels of pollutants in water, algal blooms, streambank erosion and channelization, loss of stream biodiversity, loss of stream canopy, and overall degradation of the water quality.

Photo Conservation tillage gives this central Iowa field the protection it needs from wind and water erosion (photo by Lynn Betts, USDA, Natural Resources Conservation Service).

Erosion from new and re-development (Figure 25) can be increased by a variety of reasons included construction activities, an increase in impervious surface, increased stormwater volumes, and lack of post-construction stormwater practices. Development exposes soils that would other wise be protected by vegetation to the natural processes of wind and water erosion. Recent state regulation mandates stormwater pollution prevention plans during construction for all developments greater than one acre under Rule 5 (Construction Stormwater Pollution Prevention). Sites less than one acre are not governed and the regulation of sites which are regulated is inconsistent. The West Branch of Trail Creek Watershed is the most rapidly developing of the three sub-watersheds. General observations with regard to implementation of construction stormwater practices indicate that construction activities are a source of erosion and sedimentation within the watershed. Within Trail Creek, sedimentation and the formation of sediment bars was noted at the confluence with smaller tributaries affected by new development.

Rule 5 applies to construction activities that result in the disturbance of one (1) or more acres of land. By definition in the rule, "land disturbing activity means any manmade change of the land surface, including removing vegetative cover that exposes the underlying soil, excavating, filling, transporting, and grading." If a developer or project site owner conducts a land disturbing activity that disturbs one (1) or more acres of land, the project site owner must apply for coverage under a Rule 5 general stormwater permit. As part of this, the project site owner must develop and implement a Stormwater Pollution Prevention Plan which is generally submitted to either the local MS4 or LaPorte County for review and approval.

In addition to construction stormwater pollution prevention, new and re-developments within urban areas must comply with Rule 13 which requires the implementation of best management practices in order to treat non-point source stormwater associated with runoff from Municipal Separate Storm Sewer Systems (MS4). Rule 13 governs urban stormwater within federal, state, municipal, county, public or private entity storm water conveyance systems that are not combined with sewage conveyances. A regulated conveyance system includes roads with drains, municipal streets, catch basins, curbs, gutters, storm drains, piping, channels, ditches, tunnels, and conduits. Within LaPorte County, Michigan City, the City of LaPorte, the town of Long Beach, the town of Trail Creek, and portions of LaPorte County between the two cities (Figure 26) are regulated MS4 communities and have formed a partnership to implement these regulations jointly. As the Stormwater Pollution Prevention Plan for LaPorte County is implemented, it will be vital that stormwater ordinances be adopted and implemented uniformly across the watershed.

The increased percentage of impervious surfaces associated with the development of new land increases runoff which in turn increases the flow of a stream and its load carrying capacity, Figure 27. The Center for Watershed Protection has documented that stream degradation begins to occur within a watershed when approximately 10% of the land surface is comprised of impervious cover. When impervious land cover ranges from 10 to 25% stream impairment becomes evident, from 25-60% streams become damaged, and with greater than 60% impervious cover streams are severely damaged. Using the impervious tool in the Burns Ditch and Trail Creek Watershed Management System, the Trail Creek Waters as a whole currently has an impervious surface of nearly 7% and some of the smaller tributaries in the developed area of the Trail Creek Watershed have impervious surface areas exceeding 20%. Based on these guidelines, the developed area tributaries would fall in the "stream impairment becomes evident" category.

Figure 25: Areas of Existing and Proposed Development (see appendix page 85)

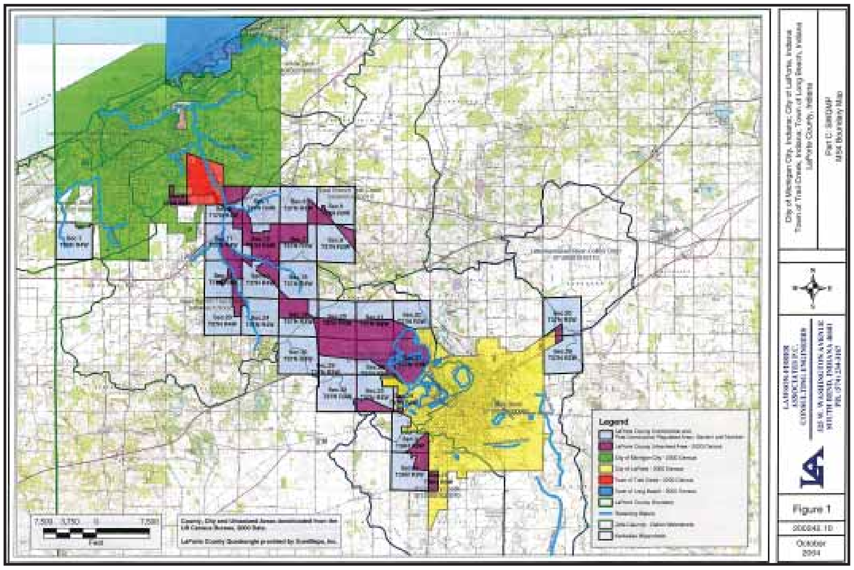


Figure 26: Area covered by MS4 (see appendix 88)

Roadway and Roadside Ditch Maintenance

LaPorte County and Michigan City generally maintain the roadways during the winter through the application of both sand and salt. During the watershed study, it was observed that sand from the roadways accumulated on and near bridges crossing the streams, contributing to sedimentation within the stream at those crossings. It was also noted during the watershed study that roadside ditches within the County are sometimes maintained by dredging and piling of dredged material adjacent to the ditch, contributing to sedimentation within the roadside ditches and waterways.

In addition to maintenance of the existing roadways and ditches, inappropriate placement of new roadways or expansion of existing roadways can contribute to water quality problems including streambank erosion, sedimentation, and increased nutrient loading. Attention to proper siting and design of new roadways and bridges as well as rehabilitation of existing roadways and bridges to protect water quality will be an important aspect of the Watershed Management Plan so that new sources of pollutants are not added to the watershed. As an example, during the reconstruction of the roadway into Washington Park during the summer of 2006, stormwater treatments basins were retrofitted into the project to treat stormwater prior to discharge to Trail Creek.

Roadway drainage as it enters Tributary to Trail Creek

Nutrient Loading

Nutrient loading within the Trail Creek Watershed has been noted as a problem and confirmed through water quality testing. Sources of nutrient loading to the watershed include a variety of sources previously mentioned including human and animal wastes, erosion and sedimentation, and agricultural practices, as well as application of lawn fertilizers.

Runoff from parking lot entering stormwater treatment basin at Washington Park

Lawn and garden practices

Varied lawn and garden practices are sources of water quality issues in the Trail Creek Watershed. Unregulated application of fertilizers, pesticides, and herbicides to yards and public areas such as golf courses inevitably move into the local waterways. Over application of these products or the use of them in close proximity to a body of water increases the possibility and rate at which these end up in the water system. Many of these products contain animal waste, ammonia, nitrogen, and possibly bacteria, all of which are of concern in the Trail Creek Watershed.

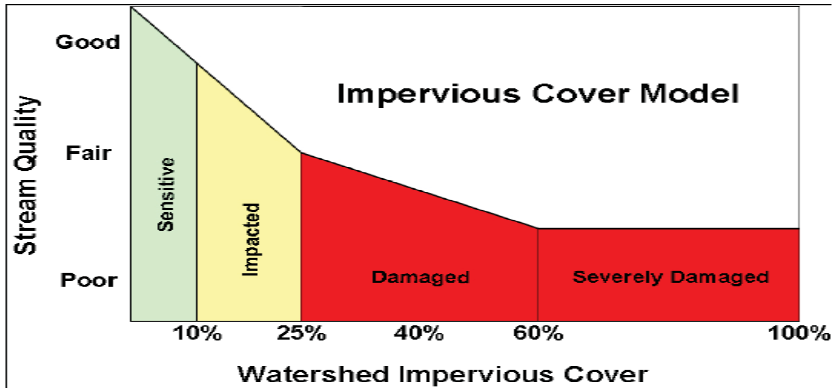


Figure 27: Watershed Impervious Cover

Vortechs Swirl Concentration stormwater BMP to be installed at Washington Park

Hydromodifications

As part of this study, hydromodifications, particularly those leading to streambank erosion, sedimentation, and changes in stream elevation and flow were noted as concerns. Hydromodification activities adversely affect stream flow, stream gradient, sediment load, channel width, and channel depth. Hydromodification activities which can contribute to these issues and which were noted within the Trail Creek Watershed include channelization, stream relocating, headwater stream and wetland fills, straightening, riparian encroachment, flow restriction through dams and bridges, and urbanization.

Channel Modification

Channel modification is generally used to describe channel engineering completed for flood control, navigation, and drainage improvement. Typically this type of hydromodification includes straightening, widening, deepening or relocation of stream channels. Within the Trail Creek Watershed there are approximately 158 linear miles of stream channel of which approximately 7.8 linear miles of stream channel are classified as legal drains subject to maintenance including riparian clearing, channelization and dredging by the County Drainage Board. The majority of streams classified as legal drains are located within the East Branch of Trail Creek sub-watershed. Additionally, responsibility for maintenance of all former legal drains within the Michigan City limits has been assumed by the Sanitary District of Michigan City. As these streams are maintained for drainage they can contribute to problems noted within the watershed including increased loading of *E. coli* and nutrients, streambank erosion and sedimentation.

Structures and Dams

Dams or structures which impound water within the stream channel beyond the normal capacity of the channel can contribute to a variety of non-point pollution problems including alterations to sediment transport within a stream system, impacts to wetlands and natural areas, nutrient loading, and alteration to the natural hydrology of a stream. As part of the Indiana Coastal Non-point Pollution Control Program, 16 dams were noted within the Little Calumet-Galien Watershed. A total of 9 dams were identified through review of available mapping and general observations within the watershed. These include the Dingler Lake dam which is approximately 16 feet in height, the Lakeside Estate dam which is 17.2 feet in height, the Michigan City Golf Course dam which is 12 feet in height, and the Siebert dam which is 6 feet in height.

Infiltration BMPs installed at Washington Park

Critical Areas

AS THE Trail Creek Watershed Management Plan was developed, three factors were examined to determine critical areas within the watershed. These include areas critical for preservation, areas with soils or land uses which may be sensitive for development and critical for implementation of best management and planning practices during that development; and areas critical for implementation of conservation and restoration strategies or enhancement of existing water quality treatment and strategies. These three factors can be found within the entire Trail Creek Watershed, Figure 28.

As part of this study, it was noted that the entirety of Michigan City is not included within the officially mapped watershed boundary for Trail Creek; however, storm sewers and urbanization within the city have altered the natural watershed boundary. As a result, for the purposes of this watershed management plan and future implementation, the entirety of Michigan City is included in the Trail Creek Watershed.

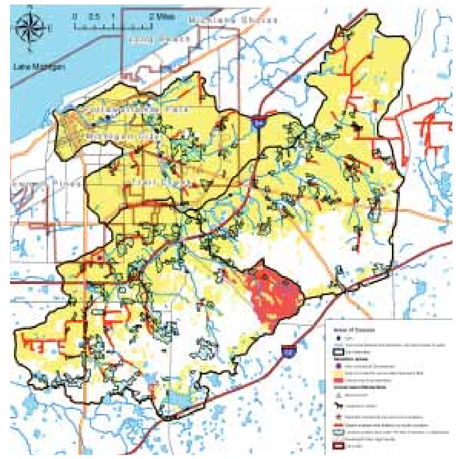


Figure 28: Critical Areas Mapping (see appendix page 89)

Preservation

As the watershed management plan was prepared, land use within the sub-watersheds of the West Branch of Trail Creek was noted to include a predominance of forested and natural areas. This sub-watershed is typified by Sample Point W3 (Figure 29). Water quality samples at this location indicated that water quality impairment was relatively low due in large part to the undeveloped nature of the watershed, large riparian buffers, and low density development. As such, two of the three sub-watersheds within the West Branch of Trail Creek were designated as critical areas for preservation in order to maintain or reduce the existing loading to the streams from these areas.

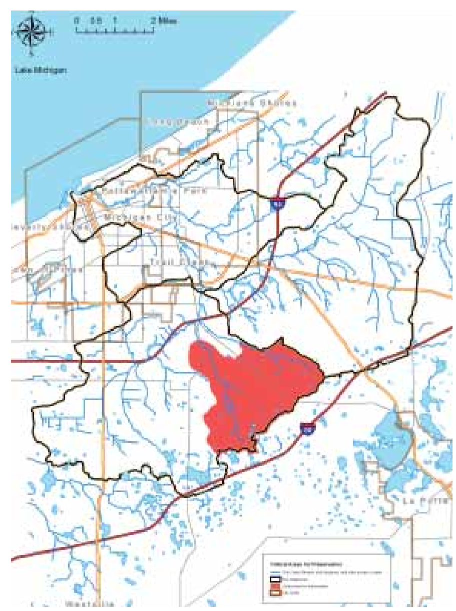


Figure 29: Areas Critical for Preservation (see appendix page 90)

Although preservation is not a typical water quality best management practice, the Steering Committee felt that within the Trail Creek Watershed preservation of the existing high quality areas and buffers was a critical component for the watershed in order to meet the established water quality goals. Water quality goals will be achieved by an overall reduction of pollutant loading to the stream both by reducing existing sources of pollutant loading to the stream and by minimizing new sources of pollutant loading to the stream. Now sources of pollutent loading to the stream include development of agricultural and natural area and increased imperious cover. The Trail Creek Watershed is anticipated to experience high development pressure over the next 10 to 15 years and as such, it will be critical to minimize any increase in pollutant loading to the streams from areas which are not currently significant contributors. The need for designation of the sub-watersheds for preservation is reflected in the Base Flow Loading calculations completed as part of this watershed study. The estimated load reduction necessary to meet the State Water Quality Standard for *E. coli* and the number of sampling days for which a load reduction was required were the lowest at Sample Point W3. The estimated mean load reduction for *E. coli* required at Sample Point W3 is 37%. The estimated mean load reduction for the remaining sample points for *E. coli* is more than 46% with most sample points requiring a load reduction of *E. coli* between 50% and 60%. At Sample Point W1, which is highly impacted by livestock access to the stream, the mean load reduction required for *E. coli* is 82%. For reference to the load reduction calculations see Table 9 (page 50) and Appendix R.

As previously stated, the West Branch of Trail Creek sub-watershed is the most rapidly developing of the three watersheds and each of the three sub-watersheds is anticipated to be subject to increasing development pressure in the future. The LaPorte County Comprehensive Plan is currently being developed; however, preliminary goals of the plan include encouraging development within the county to be concentrated within the Trail Creek Watershed. As such, preservation of existing natural areas and riparian buffers using smart growth and low impact development principles within these watersheds is critical to implementation of this watershed management plan and the pollutant load reductions required.

Sensitive Areas

Areas with soils or land uses deemed sensitive areas by the Steering Committee include those privately owned lands which are currently being developed or which are proposed for future development, areas which are not currently serviced by municipal utilities, and areas which are not subject to development restrictions such as riparian setbacks. For purposes of this study, these sensitive areas were mapped as those areas with soils not suitable for septic systems, streams with at least minimal existing riparian buffers, and those areas proposed for future development, Figure 29. It should be noted that the majority of the undeveloped portions of the Trail Creek Watershed are anticipated to be subject to development pressures over the next 10 to 15 years and therefore deemed as sensitive areas critical for implementation of best management practices during development. These areas are typified by Samples Points W1, W2, E1, E2, and E3.

Contribution of *E. coli* and other nutrients from septic systems was identified as a source of pollutant loading to Trail Creek, especially in areas with aging septic systems which may not have been properly maintained or areas with unsuitable soils. This includes the majority of both the East and West Branches of Trail Creek as well as the towns of Trail Creek and Pottawattomie Park. These areas were determined to be critical areas for installation of sanitary sewers and implementation of best management practices as part of the Trail Creek Watershed Management Plan. Extension of municipal utilities to the entire watershed is the long term implementation goal intended to reduce *E. coli* and nutrient loading; however, the installation of sanitary sewers to the entire watershed is anticipated to take longer than 15 years. As such, critical areas to be addressed in both the short and intermediate term include preparation of a Sanitary Sewer Master Plan and implementation of initial phases of that plan to provide sanitary sewer service to urban areas not currently serviced such as Pottawattomie Park and Trail Creek, thus reducing the pollutant loading of *E. coli* and other nutrients from these areas. Additionally, ensuring that existing septic systems in areas with unsuitable soils, which will not be serviced by municipal utilities in the short or intermediate time frames, are functioning properly is critical to addressing pollutant loading to Trail Creek.

Another sensitive area identified by the Steering Committee is cooridors of natural areas along existing riparian. As discussed previously, preservation of existing areas is critical to ensuring pollutant loading does not increase. A riparian buffer can decrease sediment and nutrient loading to a stream and therefore preservation of any existing buffers is critical to implementation of this plan. Areas particularly susceptible to encroachment on existing riparian buffers are those which are planned for future development.

In addition to the mapped sensitive areas, several areas within the watershed have been identified as sensitive land uses for preservation but were not individually included on the mapping. These include sensitive areas such as Pinhook Bog and other publicly or privately owned natural areas such as Trail Creek Fen and areas with unique or rare habitat or species. As one of the few cold water fisheries in the State of Indiana, Trail Creek itself is also considered a sensitive area.

The third sensitive area identified by the Steering Committee are those areas proposed for future development within the East and West Branch of Trail Creek. As indicated previously, these areas are not serviced by municipal utilities and have soils which are generally not suited for septic systems. The Steering Committee felt that identification of these areas as critical for implementation with the intent that these limitations were considered prior to development. As with preservation of existing natural areas, these proposed development areas are considered critical areas in order to ensure that future pollutant loading from these lands does not exceed the current levels and is ultimately reduced through the implementation of smart growth and low impact development concepts including restoration of riparian buffers, stream set-backs, and greenspaces.

Conservation and Restoration Areas

According to the IDNR Coastal Program, there are six categories of sensitive areas for preservation or restoration. These include areas of unique, scarce, fragile or vulnerable natural habitats; areas of historical significance, cultural value, or substantial recreational value or opportunity; areas of high natural productivity or essential habitat for living resources, including fish, wildlife, endangered species, and the various trophic levels in the food web critical to their well-being; areas needed to protect, maintain, or replenish coastal lands or resources including coastal flood plains, aquifers and their recharge areas, sand dunes, and offshore sand deposits; areas where development and facilities are dependent upon the use of, or access to, coastal waters or areas of unique features for industrial or commercial uses or dredge spoil disposal; and areas where if development were permitted, it might be subject to significant hazard due to storm, slides, floods, erosion, and settlement.

The Steering Committee determined that restoration of riparian buffers along Trail Creek and its tributaries was critical to implementation. Riparian buffers are areas or strips of permanent vegetation established along stream channels, predominately within agricultural areas but with increasing rural development, more frequently found in residential and commercial developments. Buffers are created to intercept sediment and nutrients and decrease the amount of soil erosion along waterways. Additionally, riparian buffers serve as greenways, greenspace, and habitat corridors linking fragmented natural areas. Assessment of the most recent aerial photography indicted that an estimated 40 miles of streams within the Trail Creek Watershed, 7.4 miles located within the Main Branch of Trail Creek Watershed, 18.4 miles within the East Branch of Trail Creek Watershed, and 14.2 miles within the West Branch of Trail Creek Watershed, have inadequate riparian buffers. For the purposes of this study inadequate buffers were determined to be those areas along Trail Creek and its tributaries without visible woody or natural vegetation adjacent to the streambank . Areas with inadequate buffers were generally agricultural or residential areas which were farmed to the stream edge or were residential yard . It should be noted that this assessment was completed through analysis of aerial photography and was not confirmed through ground proofing.

The lack of a riparian buffer can increase run-off to a stream and thus pollutant loading of nutrients and sediment, can contribute to streambank instability, and can lead to increased water temperature. Areas particularly susceptible are those agricultural areas in the East and West Branch of the watershed which do not currently have riparian buffers and are farmed with row crops to the top of bank.

Goals and Decisions

FOUR goals and a variety of objectives were identified within the 1993 Trail Creek Watershed Management Plan. Many of those goals and objectives remain valid with the current plan update. The goals from the 1993 Watershed Management Plan are as follows

1. Reduce potential health hazards due to poor water quality in the stream of Trail Creek.
2. Improve aquatic life support.
3. Increase quality/quantity of recreational opportunities to stimulate economic growth.
4. Develop a public awareness of the unique and diverse opportunities the stream of Trail Creek Provides.

As this plan was developed, the Steering Committee determined that the goals and objectives of the Watershed Management Plan for Lake, Porter, and LaPorte Counties prepared by the Northwestern Indiana Regional Planning Commission (October 2005) and the Indiana Coastal Non-point Pollution Control Program prepared by the Indiana Lake Michigan Coast Program (February 2005) would be incorporated by reference. Specific water quality goals for the Trail Creek Watershed Management Plan include the following.

1. Meet the State Water Quality Standard for *E. coli* of a monthly geometric mean of 125 cfu/100 ml and a maximum daily standard of 235 cfu/100 ml;
2. Decrease sedimentation and dredging of the navigable channel. Total Suspended Solid goal of 15 mg/l;
3. Decrease nutrient loading in Trail Creek to the target concentrations (0.05 mg/l ortho-phosphorus, 0.05 mg/l total phosphorus, 0.25 to 0.1 mg/l nitrogen ammonia, 1.0 mg/l TKN, and 10 mg/l nitrate-nitrite);
4. Maintain a natural stream channel and flow.

Measurable indicators of each of these goals include both qualitative and quantitative measurements. Qualitative measurements include the number of implementation projects constructed or realized as a result of the Watershed Management Plan and cooperative efforts in LaPorte County. Measurements can include riparian corridors preserved or enhanced, number of BMPs installed, planning conducted or programs implemented. The lead agency will track implementation projects and planning projects on an annual basis.

Quantitative measurements include water quality assessment of Trail Creek at each of the 12 sample locations discussed in this report. At the minimum, *E. coli*, TSS, turbidity, total phosphorus, nitrogen ammonia, TKN, nitrate-nitrate, and flow will be sampled. Sampling will occur at least twice annually during the growing season, once during base flow and once during peak flow. Additionally aquatic macroinvertebrate and habitat sampling will be conducted a minimum of every five years to access water quality trends in the Trail Creek Watershed. This data will be supplemented with data gathered by governmental agencies such as IDEM to determine water quality trends within Trail Creek. These trends will be used to quantitatively determine if pollutant load reductions are occurring within the watershed.

Table 9 summarizes the maximum, minimum, and mean calculated loading for the parameters of concern for each sample site and the pollutant reduction needed to reach the target water quality goal. The calculated base flow data was utilized as non-point source pollutants associated with stormwater runoff are generally the concern. For reference to how these loadings were calculated see the Appendix R.

Table 9: Trail Creek Watershed Sampling Data Analysis Results Using Calculated Peak Flow Data (Loads calculated in tons per year)

Sample Site E1	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	252.33	1716.35	8.20	3.12	17.96	4.97E+14	81.97	53.87
Min Load	97.35	23.06	1.17	0.78	0.78	4.85E+12	19.52	7.42
Mean Load	131.63	157.19	3.79	1.20	2.68	8.62E+13	31.75	23.54
Mean Target Load	89.66	192.13	5.37	1.95	2.93	4.06E+13	39.04	390.36
Mean Reduction Needed (%)	N/A	33.08	49.47	37.50	9.95	55.52	24.68	N/A
Sample Site E2	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	338.73	1334.39	4.28	1.03	5.47	7.85E+14	27.37	21.21
Min Load	136.86	30.79	0.51	0.34	0.34	3.10E+12	8.55	3.25
Mean Load	176.43	191.61	1.59	0.49	1.17	1.30E+14	13.09	10.21
Mean Target Load	119.75	256.61	2.35	0.86	1.28	5.20E+13	17.11	171.08
Mean Reduction Needed (%)	N/A	34.08	44.50	16.67	40.59	57.42	18.09	N/A
Sample Site E3	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	378.37	3443.36	4.00	1.60	9.61	9.17E+14	36.04	24.82
Min Load	156.15	36.04	0.60	0.40	0.40	3.63E+12	10.01	0.80
Mean Load	204.71	286.66	1.67	0.61	1.39	1.20E+14	14.78	11.46
Mean Target Load	140.14	300.29	2.56	1.00	1.50	6.08E+13	20.02	200.20
Mean Reduction Needed (%)	N/A	38.18	43.11	23.61	42.16	61.63	23.40	N/A
Sample Site M1	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	830.03	26331.84	11.45	2.39	44.84	2.79E+15	114.49	52.47
Min Load	357.77	85.86	1.91	0.95	0.95	2.81E+13	23.85	6.68
Mean Load	471.43	1235.50	4.67	1.23	4.15	3.40E+14	38.24	22.72
Mean Target Load	333.92	715.54	6.87	2.39	3.58	1.02E+14	47.70	477.03
Mean Reduction Needed (%)	N/A	40.95	39.44	N/A	47.14	59.49	25.85	N/A
Sample Site M2	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	1145.88	29416.65	11.97	3.99	57.01	2.81E+15	188.13	91.21
Min Load	421.87	102.62	1.14	1.14	1.14	2.07E+13	28.50	9.12
Mean Load	574.94	1504.80	5.78	1.56	5.28	3.72E+14	49.81	29.23
Mean Target Load	399.06	855.14	8.32	2.85	4.28	1.22E+14	57.01	570.09
Mean Reduction Needed (%)	N/A	42.41	37.56	28.57	50.11	63.20	32.76	N/A
Sample Site M3	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	1200.86	25444.06	16.65	3.57	52.31	4.91E+15	184.29	112.95
Min Load	416.14	107.01	2.38	1.19	1.19	2.16E+13	29.72	5.94
Mean Load	592.08	1480.65	6.90	1.53	5.39	4.86E+14	54.30	33.27
Mean Target Load	416.14	891.73	8.58	2.97	4.46	1.27E+14	59.30	594.49
Mean Reduction Needed (%)	N/A	46.08	47.18	16.67	45.43	60.13	38.57	N/A
Sample Site M4	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	1188.51	33206.65	14.93	1.79	53.75	1.92E+15	161.26	125.42
Min Load	388.21	107.50	2.99	1.19	1.19	2.87E+13	29.86	5.97
Mean Load	573.09	1701.88	6.57	1.42	7.19	3.25E+14	48.52	32.62
Mean Target Load	418.07	895.86	8.35	2.99	4.48	1.27E+14	59.72	597.24
Mean Reduction Needed (%)	N/A	51.18	47.38	N/A	48.57	54.55	27.95	N/A
Sample Site M5	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	1143.54	25519.10	16.25	12.64	44.54	3.33E+15	150.47	264.82
Min Load	397.23	108.34	2.41	1.81	3.01	8.19E+12	30.09	30.09
Mean Load	575.74	1218.84	7.20	5.04	9.43	3.74E+14	52.80	144.01
Mean Target Load	421.31	902.80	11.38	3.01	4.51	1.28E+14	60.19	601.87
Mean Reduction Needed (%)	N/A	43.42	42.77	48.38	60.15	54.87	29.00	N/A
Sample Site M6	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	1149.77	8853.86	23.98	7.38	9.22	1.14E+15	116.82	270.53
Min Load	393.50	110.67	2.46	1.23	1.23	5.58E+12	30.74	6.15
Mean Load	602.29	700.93	8.55	3.17	5.59	1.50E+14	49.43	116.03
Mean Target Load	430.40	922.28	4.66	3.07	4.61	1.31E+14	61.49	614.85
Mean Reduction Needed (%)	N/A	48.67	38.95	33.84	48.80	45.75	27.32	N/A

Table 9 (continued)

Sample Site W1	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load	276.87	3908.68	5.92	1.18	10.96	1.21E+15	39.98	25.61
Min Load	114.00	26.65	0.30	0.30	0.44	9.40E+12	7.40	1.42
148.06Mean Load	149.22	403.78	2.24	0.42	1.46	3.54E+14	13.92	6.56
Mean Target Load	103.64	222.08	2.06	0.74	1.11	3.16E+13	14.81	148.06
Mean Reduction Needed (%)	N/A	49.22	43.66	27.08	43.06	82.11	26.08	N/A
Sample Site W2	**Dissolved Oxygen**	**Total Suspended Solids**	**Ammonia**	**Ortho Phosphorus**	**Total Phosphorus**	***E. coli* (cfu/year)**	**TKN**	**Nitrate + Nitrite**
Max Load	73.95	2974.07	0.81	0.20	3.98	1.07E+14	11.78	3.78
Min Load	32.91	7.31	0.12	0.08	0.08	5.90E+11	2.03	0.41
Mean Load	42.25	137.67	0.31	0.09	0.30	1.48E+13	2.77	1.31
Mean Target Load	28.44	60.94	0.51	0.20	0.30	8.66E+12	4.06	40.63
Mean Reduction Needed (%)	N/A	40.64	33.26	N/A	92.01	53.94	56.44	N/A
Sample Site W3	**Dissolved Oxygen**	**Total Suspended Solids**	**Ammonia**	**Ortho Phosphorus**	**Total Phosphorus**	***E. coli* (cfu/year)**	**TKN**	**Nitrate + Nitrite**
Max Load	29.01	304.04	0.32	0.10	0.26	2.25E+13	2.19	0.85
Min Load	14.90	3.58	0.06	0.04	0.04	3.61E+10	0.99	0.08
Mean Load	17.97	42.36	0.12	0.05	0.08	3.69E+12	1.10	0.24
Mean Target Load	13.91	29.81	0.21	0.10	0.15	4.24E+12	1.99	19.87
Mean Reduction Needed (%)	N/A	45.28	35.02	N/A	38.18	36.65	9.09	N/A

Prioritization of Water Quality Problems and Implementation Goals

THE TRAIL Creek Watershed is a highly privately owned watershed, one in which the cooperation of the public is top priority in order to restore it to a clean waterway. In order to best manage the problems associated in the Trail Creek Watershed, prioritization of problems must occur on a basis of the willingness of landowners and organizations associated with the water quality problems to participate. With this in mind, the water quality problem of highest priority is participation, education, and cooperation of the general public. Once the public has become knowledgeable and involved through outreach programs, the prioritization of the water quality problem can occur on a site specific basis. Once a willing land owner participating party has been selected for implementation of one or more of the Best Management Practices the land or area can be examined and assessed with relation to the practicality, functionality, and necessity of the goals and problems to be addressed. Once willing land owner or participating parties have been identified and appropriate Best Management Practices selected, implementation will occur.

Implementation

SPECIFIC implementation goals, action items, required resources, estimated costs, funding sources, and the timeframe for implementation of the Trail Creek Watershed Management Plan have been determined by the Steering Committee. These Implementation Goals including realistic timeframes and success criteria were discussed in great length during Steering Committee meetings. All members of the Steering Committee were invited to contribute to the discussion and their comments were incorporated into the final implementation goals as set out in Table 11. These implementation goals were selected as measures which could be implemented within the Trail Creek Watershed in order to address the known water quality concerns and problems. In addition to the stated implementation goals and objectives included in this report, the goals and objectives of the Watershed Management Plan for Lake, Porter, and LaPorte Counties prepared by the Northwestern Indiana Regional Planning Commission (October 2005) and the Indiana Coastal Non-point Pollution Control Program prepared by the Indiana Lake Michigan Coast Program (February 2005) are incorporated by reference. For reference to additional Funding Sources see Appendix T, Funding Sources from Nonpoint Source Pollution Management Plan for Indiana, FFY 2000-2004, Indiana Department of Environmental Management - Office of Water Quality, October 1999.

Community education and involvement with regards to how enhanced water quality can affect and benefit the community, business, organizations, municipalities, families, developers and construction companies, outdoor enthusiasts including boaters, fisherman, and bicyclist, farmers, schools and teachers, students, legislators, and policy makers and how those groups can contribute to enhanced water quality within the Trail Creek Watershed is a primarily concern of the Steering Committee. As such, many of the Implementation Goals include a short term goal of education and outreach with the community as the first step to implementation. The Steering Committee believes that public education and outreach is a key factor to ensure that the 2007 Trail Creek Watershed Management Plan will be accepted by the pubic and to ensure significant action will be taken in the watershed to meet the established goals. Public education and outreach may include but is not limited to outreach to the agricultural community and farmers geared towards increasing participation in conservation management programs, outreach and education to property owners with septic system to encourage proper installation and maintenance of those systems, implementation of volunteer water quality monitoring programs, and outreach to developers and governmental agencies with regards to low impact development Opportunities for public education and outreach could also include distribution of education materials to residents within the watershed and to recreation users of Trail Creek.

Estimated pollutant load reduction through implementation of best management practices indicated below has been calculated through STEPL 4.0 Model provided by the US EPA, the Region 5 Model for Estimating Pollutant Loads, and data produced by the Center for Watershed Protection. For more detailed information on the load reduction calculations see the attached Appendix S.

For the purposes of determining BMPs to be implemented to meet the load reduction required, the maximum loading for each parameter of concern at Sample Site M6 for the calculated base flow condition was utilized. These reductions are as follows in Table 10. This sample site was utilized as it is the downstream sample site and levels at this location should reflect actual pollutant loading to Lake Michigan and from the entire Trail Creek Watershed. Additionally, the maximum values were utilized as a worst case scenario.

Table 10: Load Reduction for Sample Site M6 using the calculated base flow conditions

Sample Site M6	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	*E. coli* (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	8853.86	23.98	7.38	9.22	1.14E+15	116.82	270.53
Mean Target Load (tons/yr)	922.28	4.66	3.07	4.61	1.31E+14	61.49	614.85
Load Reduction Required (tons/yr)	7931.58	19.32	4.30	4.61	1.01E+15	55.34	None
Percentage Load Reduction Required	90%	81%	58%	50%	89%	47%	None
Implementation of Conservation Management on Agricultural Lands including Conservation Tillage							
Load Reduction Anticipated with Conservation Management	75%	25%	30%	30%	NA	25%	25%
Load Reduction from Practices (tons/yr)	6640.40	6.00	2.21	2.77	NA	29.21	67.63
Load Remaining (tons/yd)	2213.47	17.99	5.17	6.45	NA	87.62	202.90
Conservation and Restoration of Riparian Buffers							
Load Reduction Anticipated with Conservation and Restoration of Riparian Buffers	50%	50%	75%	75%	NA	50%	50%
Load Reduction from Practices (tons/yr)	4426.93	11.99	5.54	6.92	NA	58.41	135.27
Load Remaining (tons/yd)	-2213.47	6.00	-0.37	-0.46	NA	29.21	67.63
Installation of Sanitary Sewers							
Load Reduction Anticipated with Conservation and Restoration of Riparian Buffers	NA	55%	NA	NA	NA	55%	55%
Load Reduction from Practices (tons/yr)	NA	13.19	NA	NA	NA	64.25	148.79
Load Remaining (tons/yd)	NA	-7.19	NA	NA	NA	-35.05	-81.16

Within the Trail Creek Watershed, implementation of any single BMP is not anticipated to reduce the pollutant loading to the established goals. Implementation is anticipated to encompass a wide variety of BMPS. For the purposes of determining the minimum BMPs to be implemented to order to meet the load reduction goals, the load reduction anticipated as a result of each BMP was calculated. Additional BMPs were added until the load reduction goals were meet (Table 10). Implementation of multiple best management practices including agricultural conservation management practices, preservation, and restoration of riparian buffers, and expansion of sanitary sewer service as a combined program has been calculated to meet the watershed management goals for the reduction of total suspended solids, nitrogen, and phosphorus. For the purposes of these calculations, full implementation of each practice throughout the watershed was anticipated. Conservation management including conservation tillage within the Trail Creek Watershed is estimated to reduce total suspended solid loading by 75%, phosphorus loading by 30%, and nitrogen loading by 25%. Conservation and restoration of riparian buffers is estimated to reduce total suspended solid loading by 50-75%, phosphorus loading by 50-75%, and nitrogen loading by 17-57%. Implementation of conservation management on agricultural lands and conservation and restoration of riparian buffers throughout the watershed will meet the anticipated load reductions for total suspended solids and phosphorus. Installation of sanitary sewers and removal of septic tanks is anticipated to reduce nitrogen loading by 55%. Implementation of sanitary sewers throughout the watershed in addition to conservation management and conservation and restoration of riparian buffers will meet anticipated load reductions for nitrogen.

Implementation of conservation tillage and riparian buffers is anticipated to meet the total suspended solids and phosphorus goals at an estimated cost of $2,000,000. It should be noted that cost calculations associated with these implementation goals are rough estimations and should be used for planning purposes only. Implementation of these practices is anticipated to be the most costs efficient method for reduction of total suspended solids and nutrient loading.

Estimated cost to provide sanitary sewer service to the entire Trail Creek Watershed and meet the nitrogen loading goals is an estimated $99,000,000. Installation of sanitary sewers in the most densely populated areas can be completed for an estimated $5-10,000,000 and in conjunction with the conservation tillage and buffer goals is estimate will meet the pollutant loading goals for nitrogen.

In addition to total suspended solids, phosphorus and nitrogen, the implementation goals will also reduce *E. coli* within the stream. Additionally, exclusion of livestock from the stream will be an important implementation goal in order to meet the pollutant loading goal for *E. coli*.

In addition to the above implementation goals, a wide variety of other implementation practices were discussed by the Steering Committee members as appropriate goals within the Trail Creek Watershed to be implemented concurrently with the agricultural conservation management practices, preservation, and restoration of riparian buffers, and expansion of sanitary sewer service goals. These goals are summarized in Table 11 on following pages. Within the Trail Creek Watershed, *E. coli*, sedimentation and streambank erosion, nutrient loading, and hydromodification have been identified as areas of concern. With regards to implementation goals, these concerns are intertwined in that many of the implementation goals will address more than one concern. For example, exclusion of livestock from streams will reduce *E. coli* and nutrient loading, limit future streambank erosion due to livestock entering the stream, and reduce sedimentation from livestock in the stream and bank erosion. As a result, the Implementation Goals listed below are not tied to a specific water quality problem and pollutant loading reduction for several pollutants may have been calculated. Under each Implementation Goal the primary goals anticipated to be met by implementation are indicated.

Table 11: Implementation

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Eliminate livestock access to streams 1, 2, 3	Through observation and reporting, determine locations at which livestock have unlimited access to streams and tributaries. Potential sources include farms, boarding facilities, and small acreage farmsteads.	NRCS, MS4	No cost estimate included. Implementation of this task is anticipated to be through the normal operations of the MS4.		Short Term	Removal of livestock from streams will also reduce bank erosion and sedimentation and nutrient loading to stream.
	Coordinate with property owners and educate them on the importance of eliminating livestock access to streams and tributaries. Encourage property owners to eliminate access to streams for livestock. Enroll farmers in appropriate conservation programs.	NRCS, MS4, IDNR, IDEM	$.1 per unit per year	EQUIP, CRP	Short-Long Term	Implementation of Waste Management Plan can reduce Phosphorus load by 5 lbs/yr and nitrogen load by 40 lbs/yr per acre per animal.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Eliminate non-point source *E. coli* and nutrient loading to streams from livestock and not allow pets access to streams 1, 2	Through observation and reporting determine locations at which non-point sources of *E. coli* and nutrients are affecting the stream and tributaries. Potential sources include feedlots, boarding facilities, dog parks, nuisance birds, and small acreage farmsteads.	NRCS, MS4, IDNR, IDEM	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the MS4.		Short Term	
	Coordinate with property owners and educate them on the importance of eliminating *E. coli* and nutrient loading to streams from livestock. Encourage property owners to eliminate access to streams for livestock. Enroll farmers in appropriate conservation programs.	NRCS	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the MS4.		Short-Long Term	Implementation of Waste Management Plan can reduce Phosphorus load by 5 lbs/yr and nitrogen load by 40 lbs/yr per acre per animal.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
	Coordinate with parks and recreation facilities to ensure appropriate BMPs are installed at all parks including pet waste receptacles.	NRCS	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of MS4 and lead agency.		Short-Intermediate Term	
Encourage all farmers within watershed to implement Conservation Management Plans specific for each farm and farming practice 1, 2, 3, 4	Through NRCS and IDNR identify all farms within the watershed and evaluate current practices being implemented. Encourage the implementation of a Conservation Management Plan for all farms which do not currently one in place.	NRCS	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the NRCS and IDNR.		Short Term	
	Implement appropriate BMPs on each farm including riparian buffers, conservation tillage, and nutrient management.	NRCS	$20-50/farm	NRCS, private	Short-Long Term	Pollutant load reduction varies by practice. Conservation tillage practices are estimated to reduce nitrogen loading by 25%, phosphorus loading by 30%, and TSS loading by 75%.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Reduce erosion and sediment loading from row crops and agricultural lands 2, 3	Identify farms not currently enrolled in NRCS conservation programs or without a Conservation Management Plan.	NRCS, USDA, IDNR	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of NRCS.	IDNR	Short Term	
	Coordinate with property owners and encourage enrollment in appropriate conservation programs. Encourage Conservation Management Plan to be created for each farm. Potential conservation practices to be implemented may include riparian buffers, wetland restoration, nutrient management, fencing of streams.	NRCS, USDA, IDNR	$5-10 per acre	NRCS	Intermediate-Long Term	Conservation Management Plans will address all sources of potential runoff.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Eliminate discharges from septic tanks 1, 3	Coordinate with LaPorte County and other appropriate agencies to implement policies and procedures to eliminate the placement of new septic tanks in sensitive areas, including those areas adjacent to streams or with unsuitable soils.	LaPorte County Plan Commission, City governments,	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and local government.		Short Term	
	Coordinate with LaPorte County and other appropriate agencies to implement policies and procedures to inspect existing septic tanks and ensure they are functioning appropriately.	LaPorte County Health Department, NIRPC, Michigan City	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and local government.		Short Term	

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
	Coordinate with LaPorte County Health Department and NIRPC to promote educational program with regard to maintenance of septic systems. Identify potential incentives for property owners to have septic systems inspected and maintained.	LaPorte County Health Department, NIRPC, Michigan City	No cost estimate included. Implementation of this task is anticipated to be through the normal operations of the lead agency and local government.		Short-Intermediate Term	
	Prepare Sanitary Sewer Long Term Master Plan with the objective to provide sanitary sewer service to the majority of the Trail Creek Watershed. Plan shall recommend phased implementation plan. First phase of implementation plan is anticipated to include providing sanitary sewer service to Pottawatomi Park. Second phase of is anticipated to provide sanitary sewer service to the Town of Trail Creek.	Michigan City Sanitary District, County Plan Commission	$75	Local	Short Term	Septic connections and hookups are estimated to reduce nitrogen loading by 55%.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
	Implement Phase I of Sanitary Sewer Long Term Master Plan.	Michigan City Sanitary District	$18 per household	DOC grants, SRF loans	Intermediate Term	
	Implement Phase II of Sanitary Sewer Long Term Master Plan	Michigan City Sanitary District	$20 per household	DOC grants, SRF loans	Intermediate Term	
	Provide sanitary sewer service to entire Trail Creek Watershed.	Michigan City Sanitary District	$18-35 per household	DOC grants, SRF loans	Long Term	
Eliminate illicit discharges 1, 2, 3	Implement MS4 Plan and Illicit Discharge Detection Plan and support MS4 Program.	Michigan City, LaPorte County, MS4	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.	MS4	Short-Long Term	Elimination of illicit discharges will also potential influence nutrient loading to the stream.
Reduce discharges from stormwater runoff 1, 2, 3, 4	Implement and support MS4 Stormwater Pollution Prevision Plan.	Michigan City, LaPorte County, MS4	No cost estimate included. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.	MS4	Short-Long Term	Implementation of MS4 Stormwater Pollution Prevision Plan addresses all pollutant loadings to stream.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
	Implement relevant ordinances and stormwater quality guidance to maintain cold water habitat.	Michigan City, LaPorte County, MS4	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.	MS4	Short-Long Term	
Preserve existing riparian corridors and buffers 1, 2, 3, 4	Further refine critical area mapping and identify specific properties with existing riparian corridors and buffers for preservation	MS4, NRCS	$2.5 per acre	NRCS, MS4, local government, local conservation agencies	Short Term	Riparian buffers are estimated to reduce nitrogen loading by 17-57%, phosphorus loading by 50-75%, and TSS loading by 50-75%.
	Coordinate with LaPorte County and other appropriate agencies to implement policies and procedures to preserve existing riparian corridors including mandatory setbacks and easements.	Michigan City Sanitary District, County Plan Commission	$2.5 per acre	NRCS, MS4, local government, local conservation agencies	Intermediate-Long-Term	

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Protect, enhance and restore riparian corridors and wetlands, 2, 3, 4	Further refined critical area mapping and identify specific existing riparian corridors and buffers for restoration.	MS4, NRCS, private landowners, local conservations organizations	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.		Short Term	
	Coordinate with LaPorte County and other appropriate agencies to implement policies and procedures to encourage riparian buffer restoration including mandatory setbacks and easements.	Michigan City Sanitary District, County Plan Commission	$5 per acre	Section 319	Intermediate-Long Term	Stormwater wetlands are estimated to reduce nitrogen loading by 30%, phosphorus loading by 50%, and TSS loading by 80%.
	Identify significant areas of streambank erosion and instability.	MS4, NRCS	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.		Short Term	
	Implement streambank stabilization projects at priority locations.	MS4, Michigan City, NRCS	$.5 per linear foot	Local government, local conservation agencies	Intermediate-Long-Term	

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Restore natural hydrology to Trail Creek 1, 2, 3, 4	Identify critical areas of within watershed.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	No cost estimate included due to unknown costs associated with this task.		Short Term	
	Implement stormwater quantity ordinances which encourage the use of Best Management Practices such as infiltration and regional detention rather than “beat the peak” practices.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	$15	Local government	Short Term	
	Retrofit Best Management Practices and develop restoration projects such as Streuble Pond within the watershed.	MS4, Michigan City, NRCS	$ 10-25 per acre	Local government	Intermediate-Long Term	
Evaluate the potential effects of proposed channel modifications to the physical and chemical characteristics and instream and riparian habitat of Trail Creek Plan and design channel modifications to reduce/eliminate to the physical and chemical characteristics and instream and riparian habitat of Trail Creek 1, 2, 3, 4	Implement stormwater quantity ordinances which encourage the use of Best Management Practices such as infiltration and regional detention rather than “beat the peak” practices.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	Short Term	

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
	Develop model for Trail Creek. Coordinate with US Army Corps of Engineers regarding sediment model.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	No cost estimate included. Model already completed by US Army Corps of Engineers.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	Short-Intermediate Term	
	Locate potential sites for installation of channel modification BMPS. Modifications can include lamprey barriers, removal of log jams and blockages within the channel, or streambank restoration.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	Short-Long Term	
	Implement channel modification Project. Removal of logjams should be completed using the palmiter methodology if possible. Dredging and clearing of riparian buffer should be avoided.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor, local conservation agency	$50	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor, local conservation agency, IDNR	Short-Long Term	
Assess the impacts that dams located on Trail Creek have on water quality, instream and riparian habitat, fish passage and the potential for improvement 1, 2, 3, 4	Locate and evaluate dams within Watershed	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency and MS4.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	Short-Long Term	Dams along Trail Creek alter the natural flow of the stream and channel morphology, affecting the natural channel and potential ability of the channel to transport sediment and nutrients.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Implement channel modification Project. 1, 2, 3, 4	Implement dam project.	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	$50	MS4, Michigan City, NRCS, County Drainage Board, County Surveyor	Intermediate-Long Term	
Remove existing sediment deposits to restore natural channel and investigate the use of sediment traps for future use 2, 4	Investigate legacy program and partner with US Army Corps of Engineers to determine sustainable long term management plan for navigable channel.	Michigan City	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency.	Local government	Short Term	
	Support MS4 program and encourage the use of Best Management Practices to reduce urban non-point source sedimentation.	MS4, local governments	$5	Local government	Short-Long Term	
	Fully implement Construction and Post Construction Programs.	MS4, local governments	$5	Local government	Short-Long Term	
Increase recreational access for fishing and recreational use 2	Provide better access points through the acquisition of easements	Local government, IDNR, local conservation organizations, agricultural community	$ 5-40 per acre	Local government, IDNR, local conservation organizations	Short-Long Term	Better access will decrease trespassing on private lands and decrease damage to streambanks at existing access points. Increase in recreation access will also increase revenue due to recreational use.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
	Preservation and restoration of existing access points	Local government, IDNR, local conservation organizations	$ 0.5 per foot	Local government, IDNR, local conservation organizations	Short- Long Term	Streambank stabilization at existing access points.
	Creation of greenways and blueways/canoe trails	Local government, IDNR, local conservation organizations	$5-10 per acre land; $.05 per foot trail	Local government, IDNR, local conservation organizations	Short-Long Term	Increase recreational use of stream will increase community awareness. Increase in recreation access will also increase revenue due to recreational use.
Encourage Low Impact Development 1, 2, 3, 4	Coordinate with LaPorte County Comprehensive Plan regarding inclusion of low impact development guidance and ordinances	Local government	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency.	Local government	Short Term	Low impact development philosophy includes many of the previously mentioned implementation goals including riparian buffers and BMPS.
Coordinate Trail Creek Watershed Efforts with regional goals 1, 2, 3, 4	Lead agency shall coordinate with other local and regional watershed planners with regards to pollutant loads to Lake Michigan.	Local government, regional government, state government	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency.		Short Term	Regional planning and implementation of TMDLs and Watershed Plans will be required to ensure water quality within Lake Michigan.

Table 11 (continued)

Implementation Goal	Action/Indicator	Resources	Cost Estimate (in thousands)	Potential Funding sources	Timeframe	Additional benefit/ Estimated Load Reduction
Coordinate all data gathering and GIS gathering within County 1, 2, 3, 4	Lead agency shall coordinate with other local agencies to create a single point of contact for water quality data and GIS mapping.	Local Government, MS4	No cost estimate included due to unknown costs associated with this task. Implementation of this task is anticipated to be through the normal operations of the lead agency.	Local government, MS4	Short-Long Term	As part of the MS4 implementation, all point sources and storm sewer systems are to be mapped. A single point of contact and sharing of this data between municipalities and water quality organizations will facilitate future planning efforts.
Reduce or eliminate pollutant loading from marinas 1, 3	Implement Clean Marina initiatives	IDNR, marinas, local conservation agencies	No cost estimate included due to unknown costs associated with this task.	Marinas	Short-Intermediate Term	Implementation of Clean Marinas initiatives will reduce multiple sources of pollutant loading.
	Have at least one Designated Clean Marina in Michigan City	IDNR, marinas, local conservation agencies	No cost estimate included due to unknown costs associated with this task.	Marinas	Intermediate-Long Term	
	Encourage clean boating programs	IDNR, marinas, local conservation agencies	No cost estimate included due to unknown costs associated with this task.	Marinas	Short-Intermediate Term	

1. Implementation Goal which will reduce *E. coli* loading to stream
2. Implementation Goal which will reduce sediment loading to stream and streambank erosion
3. Implementation Goal which will reduce nutrient loading to stream
4. Implementation Goal which will restore the natural hydrology of Trail Creek

In addition to those Implementation Goals found in Table 11, the Indiana Department of Natural Resources, the Indiana Lake Michigan Coastal Program, and the National Oceanic and Atmospheric Administration have prepared several brochures with implementation strategies applicable to Trail Creek. These can be found in Appendix U.

Implementation of the Trail Creek Watershed Management Plan is anticipated to start in the Spring of 2007. Full implementation of the plan is anticipated to take 5 to 10 years at which time it is likely the plan should be re-visited and updated to current conditions within the watershed. Short term implementation goals are anticipated to be started in year 1 and 2 of the Trail Creek Watershed Management Plan. These goals include but are not limited to selection of a lead agency, forming partnerships and interagency agreements for plan implementation, community education and outreach, refinement of critical areas and building partnerships with property owners for implementation, and implementing the first projects. Intermediate term goals are anticipated to occur in years 2 through 5 of the Trail Creek Watershed Management Plan and include continuation of the plan implementation including sanitary sewer installation and implementation of conservation management projects. Long term goals are anticipated to occur in years 5 through 10+ of the Trail Creek Watershed Management Plan and include continuation of the plan implementation including sanitary sewer installation for as much of the watershed as is practical.

The first step in the implementation of the Trail Creek Watershed Management Plan will be selection of a lead agency and completion of any necessary interagency agreements necessary to fully implement the plan. It is anticipated that each of the Stakeholder agencies, including those which participated as Steering Committee members, will be active in the implementation of the Trail Creek Watershed Management Plan either in their area of expertise or in their jurisdictional area. For example, implementation of the agricultural conservation management plan on a single farm may take action by the MS4 Coordinator, NRCS, IDNR, and Soil and Water Conservation. Only though interagency cooperation and action, and undergraded by the voluntery participation of private land owners, will the Trail Creek Watershed Management Plan be fully implemented.

Appendices

Appendix A: List of Steering Committee Members and Stakeholders

Trail Creek Watershed Management Plan Steering Committee

Walus, Alan J. (Al) - General Manager
Sanitary District of Michigan City
1100 E. 8th Street
Michigan City, Indiana 46360-2567
Phone: 219.874.7799
Fax: 219.874.8053
alw@mcsan.org

Sky Schelle
Watershed Manager: NPS/TMDL Section
100 N. Senate Ave.
MC 64-44 IGCN 1255
Indianapolis, Indiana 46204-2251
Phone: 317.234.4094
Fax: 317.232.8406
SSCHELLE@idem.IN.gov

Steve West, Watershed Specialist
Indiana Department of Environmental Management
Office of Water Quality
Watershed Planning Branch
100 N. Senate Ave.
MC 64-44 IGCN 1255
Indianapolis, Indiana 46204-2251
Phone: 317.234.4094
Fax: 317.232.8406
lschmidt@idem.IN.gov

Maggi Spartz
The Unity Foundation of LaPorte County
P.O. Box 527
619 Franklin Street
Michigan City, Indiana 46361
Phone: 219.879.0327
Fax: 219.873.2416
mspartz@uflc.net

Tony Ekovich
Phone: 219.874.9901
afekovich@yahoo.com

Tom Anderson, Executive Director
Save the Dunes Council
444 Barker Road
Michigan City, Indiana 46360
Phone: 219.879.3937
Fax: 219.872.4875
std@savedunes.org

Joe Exl, Coastal Non-point Coordinator
Indiana Department of Natural Resources
Indiana Dunes State Park
1600 North 25 East
Chesterton, Indiana 46304
Phone: 219.983.9912
Fax: 219.926.9775
jexl@dnr.in.gov

Rick Brown, LaPorte County MS4 Coordinator
LaPorte County Soil and Water Conservation District
100 Legacy Plaza West
LaPorte, Indiana 46350
Phone: 219.362.6633 Ext. 3
Fax: 219.324.8317
rbrown@laportecounty.org

Theresa Wojkovich, District Conservationist
LaPorte Field Office
Natural Resource Conservation Services
LaPorte County Service Center
100 Legacy Plaza West
LaPorte, Indiana 46350
Phone: 219.362.6303
Fax: 219.324.8317

Gene Matzat, County Extension Director
Purdue University Cooperative Extension Service
LaPorte County Office
2358 N US Highway 35
LaPorte, Indiana 46350-8380
Phone: 219.324.9407
Fax: 219.326.7362
wsells@purdue.edu

Mary Beth Wiseman
Northwestern Indiana Regional Planning Commission
6100 Southport Road
Portage, Indiana 46368
Phone: 219.763.6060
Fax: 219.762.1653
nirpc@nirpc.org

Susan Claussen, Pretreatment Coordinator
Sanitary District of Michigan City
1100 E. 8th Street
Michigan City, Indiana 46360-2567
Phone: 219.874.7799
Fax: 219.874.8053
sckaysseb@mcsan.org

Christine Meador, Project Manager
American Consulting, Inc.
7260 Shadeland Station
Indianapolis, Indiana 46256

Phone: 317.547.5580
Fax: 317.543.0270
Cell: 317.459.3629
cmeador@amercons.com

Appendix B: Letter of Understanding

A LETTER OF UNDERSTANDING BETWEEN THE SANITARY DISTRICT OF MICHIGAN CITY ("DISTRICT") & THE MICHIGAN CITY BOARD OF PUBLIC WORKS & SAFETY ("BOARD") REGARDING WATER QUALITY ISSUES IN TRAIL CREEK RELATING TO: THE ADMINISTRATION OF THE MUNICIPAL SEPARATE STORM SEWER SYSTEM ("MS4") PROGRAM OF 327 IAC 15-13 (RULE 13) & TRAIL CREEK WATERSHED PLANNING EFFORTS

WHERAS, the City of Michigan City (herein after referred to as the "City") is a designated Municipal Separate Storm Sewer (MS4) entity resulting from the designation as a municipality mapped in the 2000 United States Census Bureau as an Urbanized Area and/or other criteria of 327 IAC 15-13-3; and,

WHEREAS, the City, as a designated MS4 entity, is required by the Indiana Department of Environmental Management (IDEM) to obtain a permit for, develop and operate a MS4 program under IAC 15-13 (Rule 13); and,

WHEREAS, the MS4 program includes, over time, among other requirements, the necessity for the development, passage, and enforcement of new zoning ordinances relating to construction site runoff and post-construction site monitoring; along with municipal operations pollution prevention pracitces by of other City Departments; and,

WHEREAS, the District has responsibility for storm sewer systems and discharges within District boundaries and has current involvement in other requirements of the MS4 program and District Staff has the personnel and experience to administer the MS4 program for the City; and,

WHEREAS, water quality problems in Trail Creek were identified in the 1988-89 Indiana 305(b) Report issued by the Indiana Department of Environmental Management; and,

WHEREAS, the "Horizon 2000 Michigan City Area Strategic Plan" issued on March 30, 1992, prepared for and in conjunction with the citizens of the Michigan City, identified a specific lakefront and Trail Creek water quality goal as follows: "Our goal is to have the highest quality of water for recreation and aquatic production in the area by eliminating debris, pollutants and sediment build-up in the creeks"; and,

WHEREAS, the "Trail Creek Watershed Management Plan" issued on September 30, 1993, proffered a multi-faceted and substantive plan focused on nonpoint sources of pollution with recommendations to reduce sedimentation and nutrient loading to the stream of Trail Creek; and,

WHEREAS, the Indiana Department of Environmental Management, Office of Water Quality, issued a "Draft Trail Creek Total Maximum Daily Load (TMDL) Report" in September 2003, with said report including draft nonpoint source E. coli pollutant limits and instructions that some "nonpoint sources will need to be monitored locally for implementation of BMP's or in providing access to watershed grants to assist in reducing nonpoint sources to meet the Load Allocation developed under this TMDL".

NOW, THEREFORE the District and Board agree as follows:

Section 1: The District will consider options and develop recommendations to ensure the City's compliance with the MS4 requirements of IAC 15-13 (Rule 13) and submit said recommendations to the Board for review; and,

Section 2: The District will act as the temporary "City Lead Agency", not necessarily as the implementer but as the facilitator, to coordinate activities that focus on nonpoint source water pollution abatement strategies among local, county, state and federal agencies, until such time as a partnership is established representing a variety of stakeholders including riparian owners, agricultural community, environmental community, commerce/industry, private citizens and local government entities located in the 59 square mile Trail Creek Watershed.

Approved by the **Sanitary District of Michigan City** Board of Commissioners
September 24, 2003

Boyd W. Phelps
President

ATTEST:
Roger J. McKee
Secretary

Approved by the **Michigan City Board of Public Works and Safety**
September 24, 2003

[signature]
President

ATTEST:
Thomas F. Fedder
City Clerk

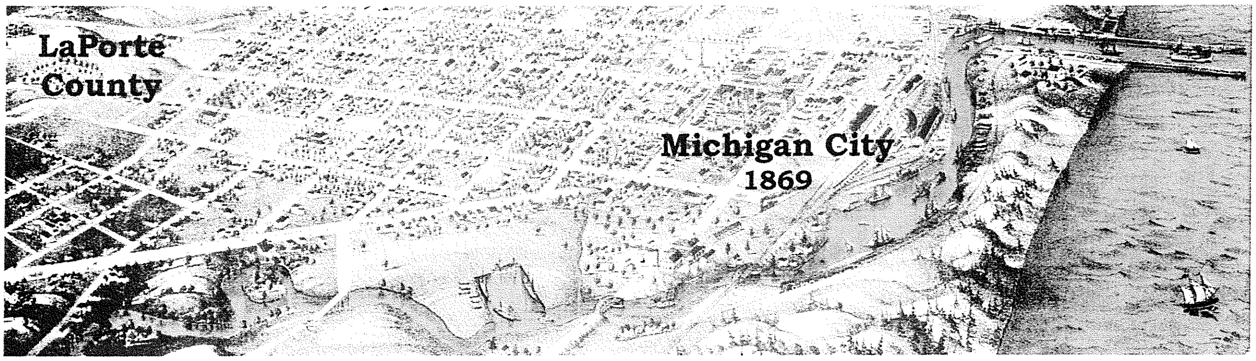
Appendix C: List of Acronyms

List of Acronyms

ACE	American Consulting, Inc.
BMP	Best management practices
cfs	Cubic feet per second
cfu/100 ml	Colony forming units per 100 milliliter
cm	Centimeter
CSO	Combined Sewer Overflow
E	East
W	West
N	North
S	south
E. coli	Escherichia coli
ERM	Environmental Resources Management
ESRI	Environmental Systems Research Institute
GIS	Geographic Information Systems
GPS	Global Positioning System
ha	Hectares
hr	hour
HydroQual	HydroQual, Inc.
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
LA	Load Allocation for non-point sources
LTCP	Long Term Control Plan
m/day	Meters per day
m^2/day	Meters squared per day
mg	Million gallons
mgd	Million gallons per day
mg/l	Milligrams per liter
mL	Milliliters
NIPSCO	Northern Indiana Public Service Company
NIRPC	Northwestern Indiana Regional Planning Commission
NOAA	National Oceanic and Atmospheric Administration
No.	Number
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCBs	Polychlorinated biphenyls
PCS	Permit Compliance System
SSURGO	Soil Survey Geographic Database
TMDL	Total Maximum Daily Load
Triad	Triad Engineering Incorporated

USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WASP	Water Quality Analysis Simulation Program
WLA	Wasteload Allocation for Point Sources
WWTP	Waste Water Treatment Plant

Appendix D: Invitation to Stakeholders and List of Agencies



The Trail Creek Watershed Management Plan

Creating a Legacy of Stewardship

Sponsors:
Indiana Department of Environmental Management
Unity Foundation of LaPorte County

Lead Agency:
Sanitary District of Michigan City

Supporting Entities:
City of Michigan City
Indiana Department of Natural Resources
LaPorte County Health Department
LaPorte County Soil & Water Conservation District
Michigan City Area Chamber of Commerce
Michigan City Area Schools
Michigan City Economic Development Corporation
Natural Resource Conservation Service
Northwestern Indiana Regional Planning Commission
Port Authority of Michigan City
Purdue University North Central
Save the Dunes Council
Town of Trail Creek
United States Geological Survey

Consultants:
American Consulting, Inc. (ACE)

January 31, 2006

Tom Alevizos
Potawatomi District Chairman
Lasalle Council
Boy Scouts of America

re: Trail Creek Watershed Management Plan Update

Dear Tom,

In the fall of 2003, the Sanitary District submitted a grant application funding request to IDEM for updating the 1993 Trail Creek Watershed Management Plan. The funding request was approved and the Sanitary District is moving forward with this critical project.

On Wednesday evening, February 8, 2006, at 7:00 p.m. in Michigan City's City Hall, we will be conducting the first Public Meeting for this project. After this initial Kickoff Meeting, future meetings will be held in the County at sites throughout the watershed. We invite you and any Boy Scout members to attend and participate. We will be issuing a Press Release to the media in advance of the meeting.

However, we do seek your guidance and cooperation for the entity of the Boy Scouts to specify a liaison that we can communicate with on a regular basis in order to ensure that the Boy Scouts are properly informed of the progress of these efforts throughout the year. Please consider an individual to designate as the Boy Scouts' Liaison to the Trail Creek Watershed Management Plan Update Project and return the desired contact information to us at the Sanitary District of Michigan City. We have included a simple Liaison Form and a stamped self-addressed envelope to return the form to us.

The many stakeholders that provided input during the original plan development in 1993 and other new stakeholders are encouraged to participate in this effort to update the Watershed Management Plan. An approved Watershed Management Plan will allow Michigan City, Trail Creek, LaPorte County and various other public and private agencies within the Trail Creek Watershed to apply to IDEM and IDNR for financial grants and technical assistance in seeking options to improve water quality and enhance the quality of life in the Trail Creek watershed area.

Sincerely,

Alan J. Walus, General Manager
Sanitary District of Michigan City

Christine Meador, Project Manager
American Consulting, Inc.

2-8-06 Public Meeting Stakeholder Invitees

Stakeholder Invitees:

1 City of Michigan City
2 LaPorte County Commissioners
3 Town of Trail Creek
4 Town of Pottawattomie Park
5 Coolspring Township Trustee
6 Springfield Township Trustee
7 Center Township Trustee
8 LaPorte County Health Department
9 NIRPC
10 USGS-Water Resources Division
11 Michigan City Area Chamber of Commerce
12 Michigan City Area Schools
13 Purdue University North Central
14 Michigan City Economic Development Corp.
15 Michigan City Parks Department
16 Michigan City Planning Department
17 Michigan City Port Authority
18 Northwest Indiana Steelheaders
19 Michigan City Fish & Game Club
20 International Friendship Gardens
21 League of Women Voters of LaPorte County
22 Boys & Girls Club of Michigan City
23 Boy Scouts
24 Girl Scouts
25 Farm Burea

Steering Committee:

1 IDEM
2 Unity Foundation
3 Sanitary District
4 DNR
5 MS4
6 NRCS
7 Purdue University Cooperative Extension
8 Save the Dunes
9 Landowner (Tony Ekovich)

34 Entities Invited

Rev. A
2/2/06
AJW

Appendix E: Summary from Steering Committee Meeting

Trail Creek Watershed Management Plan
Steering Committee Meeting
January 19, 2006

To: All attendees and members of the Steering Committee
From: Christine Meador, American Consulting, Inc.
Date: January 26, 2006

Attendees:

Al Walus, Sanitary District of Michigan City
Sky Schelle, IDEM
Linda Sneddon Schmidt, IDEM
Maggie Spartz, Unity Foundation of LaPorte County
Tony Ekovich, Property Owner
Tom Anderson, Save the Dunes Council
Joe Exl, Costal Non-point Coordinator - IDNR
Kevin Lackman, MS4 Coordinator - LaPorte County
Christine Meador, Project Manager - American Consulting, Inc.

Meeting Notes:

Al Walus began the meeting with introductions and asked each member to describe their background and role on the Steering Committee. Mr. Walus presented each member with a Trail Creek Watershed Management Plan Steering Committee Handbook, a Copy of the 1993 Trail Creek Watershed Management Plan, and a copy of the 2003 Trail Creek Escherichia coli TMDL Report.

Mr. Walus reviewed the history of planning within Michigan City and how planning around Trail Creek has been an unfulfilled focus of Michigan City since 1926. In 2003, the Unity Foundation of LaPorte County approached Michigan City and the Sanitary District of Michigan City with a grant proposal. The Michigan City Board of Public Works and Safety and the Sanitary District of Michigan City signed an agreement on September 24, 2003 designating the Sanitary District to act as the Temporary "City Lead Agency" with regards to watershed planning and non point water pollution abatement strategies. Following that proposal and agreement, the Sanitary District applied to the Indiana Department of Environmental Management to obtain a Section 319 Grant to update the 1993 Trail Creek Watershed Management Plan to the current standards.

The Sanitary District was awarded the Section 319 Grant and solicited consultant's proposals to update the Trail Creek Watershed Plan. American Consulting, Inc. was awarded this contract and will be the lead consultant preparing the Watershed Management Plan. Partial copies of the Contract for Services between IDEM and the Sanitary District of Michigan City and between the Sanitary District of Michigan City and American Consulting, Inc. were included in the Handbook for review. Additionally, the Watershed Plan Checklist was included for review.

Mr. Walus reviewed data collected to date by the Sanitary District of Michigan City and American Consulting, Inc. in support of the Trail Creek Watershed Management Plan. All data collected during the calendar year 2005 were included in the Handbook including mapping indicating sample locations within the watershed. Data collected by the Sanitary District has been collected twice monthly during the winter (November through March) and weekly during the summer (April through October) at 12 different sample locations throughout the watershed. Supplemental water quality, habitat, and biological data was collected at four sample points once on September 26, 2005 by American Consulting, Inc. Data collected by the Sanitary District to date has not been analyzed as yet and no clear trends in non-point pollution have been noted. *E. coli* exceeded the Daily Maximum Water Quality Standard of 235 at every sample location. Initial analysis of the macroinvertebrate sampling indicates that each branch of Trail Creek sampled is fully supporting for biological communities. Ms. Meador requested Steering Committee Members to provide her with any known historic data for the Trail Creek Watershed to be used to evaluate the watershed.

Mr. Walus reviewed the next steps to be completed. These include filing of the Quality Assurance Project Plan (QAPP), a draft of the Trail Creek Watershed Management Plan including the Introduction and Problem Identification, and an updated project schedule. All three items must be completed by February 3rd in order to comply with the schedule provided by IDEM. An Initial Stakeholder Public Meeting was discussed and scheduled for February 8, 2006, at 7 pm in the City Hall for Michigan City. This meeting will introduce the Watershed Management Plan to the public and other stakeholders. A second Stakeholder meeting was discussed for February 2, 2006. No meeting time or place was determined.

Respectfully submitted,

Christine Meador
American Consulting, Inc.

Appendix F: First Public Involvement and Stakeholder

PRESS RELEASE

Sanitary District of Michigan City · 1100 E. 8th Street · Michigan City, IN 46360

For more information contact:
Al Walus, General Manager
(219) 874-7799

FOR IMMEDIATE RELEASE
February 1, 2006

Public Meeting for Trail Creek Water Quality Improvements Announced

Michigan City, IN – The Sanitary District of Michigan City is moving forward with the planned update of the 1993 Trail Creek Watershed Plan. A public meeting has been scheduled to kickoff these efforts for Wednesday, February 8, 2006, at 7:00 p.m., at the City Hall Council Chambers in Michigan City. The public is encouraged to attend this first Public Involvement and Stakeholder Meeting and provide input on concerns regarding Trail Creek water quality issues.

"Because of the Sanitary District's daily involvement with Trail Creek water quality issues, the Michigan City Board of Public Works and Safety has designated the Sanitary District as the temporary 'City Lead Agency' to not only reconvene the 1993 Trail Creek Watershed Plan participants, but to reach out to new stakeholders and organizations in order to obtain broad input and consensus concerning our invaluable and critical water resource: Trail Creek," Mayor Chuck Oberlie said.

"The key to success in this watershed plan update is the participation and inclusion of local citizens and as many public and private institutions as possible. Recent cooperative efforts in stormwater management throughout all of LaPorte County have laid the foundation to begin tackling this difficult regional problem of pollution in Trail Creek. Pollution from Trail Creek has closed beaches in Washington Park and has resulted in the expenditure of Federal funds to continually dredge the navigable waterways of Trail Creek. These are regional issues and require input from residents throughout the 59 square mile Trail Creek watershed."

The Unity Foundation of LaPorte County is a sponsoring agency for this effort to create a watershed plan for Trail Creek which will address the current Indiana Department of Environmental Management classification of Trail Creek as an "impaired waterway" with respect to the levels of E. coli found in the stream's water. Maggi Spartz, President of the Unity Foundation said, "The environment is one of our areas of interest. We had the chance to make a larger grant and wanted to do something that would improve Trail Creek for generations to come. Working collaboratively with others is the only way to make that happen."

The current task involves updating the existing 1993 Trail Creek Watershed Management Plan and bringing the plan into compliance with current day watershed plan standards. The completion of the Trail Creek Watershed Plan update, scheduled for December of 2006, will allow Michigan City, LaPorte County, the Town of Trail Creek, and various public and private institutions to apply for additional grant money from the Indiana Department of Environmental Management and others to implement projects within the Trail Creek watershed aimed at reducing non-point source pollution and enhancing water quality.

The agenda of the first Public Involvement and Stakeholder meeting on February 8th will include an historical overview of Trail Creek watershed planning; a summary of water sampling results from the past year; the identification of problem issues affecting the Trail Creek watershed; and an open discussion with all attendees.

Subsequent meetings will be scheduled over the next several months at locations spread throughout the watershed in Springfield Township and Coolspring Township. These meetings will be open to the public and allow for many opportunities for public involvement with the plan development.

The Trail Creek watershed encompasses an area of 59 square miles throughout parts of Michigan Township, Coolspring Township, Springfield Township and Center Township. The watershed extends as far south as the I-80 Toll Road and as far east as State Road 39.

For questions regarding the project or participation, please contact Al Walus at the Sanitary District of Michigan City at 219-874-7799, or Christine Meador at American Consulting, Inc. at 317-547-5580.

###

STVILLE — A tip to
led to one arrest and
ly more in connection
burglary at a home
Vestville.
Saturday afternoon, a
ported to LaPorte Coun-
ce that he and his two
vent to a restaurant in
an City, and when they
d five hours later, the
oor to their home in the
lock of West County
50 North was wide open.
ce said a laptop com-
camera, several coins
er miscellaneous items
tolen. While tracking
nts in the snow that led
e home, police received
ation from a nearby res-
hat led them to a boy
Vestville.
vas charged as a juve-
th Class B felony bur-
The boy told police two
uveniles actually broke
home and he served as
out.
mpts to reach the oth-
pects were ongoing,
said.

ent charged with ing prescription to school to sell

ORTE — A 15-year-
y is accused of bring-
scription pills into La-
High School to sell to
ates.
bout 8 a.m. Monday, po-
re called to the princi-
ffice where the boy was
fter he was found with
in a prescription bottle.
did not disclose how the
s caught with the drugs.
ing questioning, police
e boy revealed he ob-
the pills from a friend
anned to sell them at
for $2 to $3 apiece. Ac-
to police, hydrocodone
proxen were among the
in his possession.
boy, from Kingsford
s, was charged as a ju-
with dealing in a Sched-
substance, a Class B
He is being held at the
e County Juvenile Ser-
Center.

Justin Rumbach/AP (Evansville Courier & Press)

Stockwell School third-grader Amira Morgan, 9, gets face-to-face with her work while constructing a replication of a Freedom Quilt in class in Evansville, Ind., on Feb. 1. While the real quilts were used by slaves as road maps to freedom during the Civil War, the student's versions were built with construction paper, fabric, markers and glue to give the children the opportunity to learn hands-on about black history.

Sanitary District seeks input on watershed plan update

■ Citizens can work to stop pollution in Trail Creek.

BY JASON MILLER
The News-Dispatch

The Michigan City Sanitary District will ask the public for input on a planned update of the 1993 Trail Creek Watershed Plan at a meeting at 7 p.m. today in the chambers of the Michigan City Common Council.

Officials hope to hear any public concerns that might exist about Trail Creek water issues as they begin the process of updating the 12-year-old plan.

"We're updating it not to reinvent the wheel, but to get an implementation strategy," Sanitary District General Manager Al Walus said Tuesday. "The plan will allow citizens to work together to stop pollution in Trail Creek."

Mayor Chuck Oberlie said the city's Board of Public Works and Safety has designated the Sanitary District as the temporary "lead agency" to reconvene the group that participated in the original plan and also to find new stakeholders and organizations.

The Unity Foundation is a sponsor of the project.

"The key to success in this watershed plan update is the participation and inclusion of local citizens and as many public and private institutions as possible," Oberlie said. "Recent cooperative efforts in stormwater management throughout all of LaPorte County have laid the foundation to begin tackling this difficult regional problem of pollution in Trail Creek. Pollution from Trail Creek has closed beaches in Washington Park and has resulted in the expenditure of federal funds to continually dredge the navigable waterways of Trail Creek."

Trail Creek is classified by the Indiana Department of Environmental Management as an "impaired waterway" because of the levels of the E. coli bacteria, said Maggi Spartz, president of the Unity Foundation.

Walus said the plan is designed to help pinpoint sources of E. coli and sedimentation — the main pollutants in the creek. He said the pollution comes from hard-to-determine areas scattered throughout the watershed.

Completion of the plan is slated for Dec., 2006. It will allow Michigan City, LaPorte County, the town of Trail Creek and other institutions to apply for additional grant money from IDEM and others to implement projects within the watershed.

Qualifying projects will be aimed at reducing non-point source pollution and enhancing water quality.

Tonight's meeting will include a look at the history of watershed planning, a summary of water sampling results from the past year, the identification of problems affecting the watershed and an open discussion with attendees.

The watershed area encompasses a 59-square-mile area through Michigan, Coolspring, Springfield and Center townships as far south as the Indiana Toll Road and as far east as Indiana 39.

❑

Contact reporter Jason Miller at jmiller@thenewsdispatch.com.

Shawn Polewsk
dead from a heroi
a Portage home o
He was a 2002 Po
graduate and an I
lege student.
Polewski's death
second overdose d
County blamed on
past week. Meagha
of Chesterton was
her home Jan. 30.
Robert Taylor, c
the Porter County
said he had ordere
tests to determine
deaths were conne
batch of heroin th
people in Chicago
three weeks.
Authorities susp
minated heroin wa
pain killer prescrib
patients. Investiga
comes within min
who used the taint

Northweste changes min Central time

2 WINAM
Officials
ern Indi
County want to di
zone change that t
federal governmen
months ago.
The County Co
and County Counc
unanimously Mon
"home rule" and st
time if a federal ag
grant an appeal to
time-zone ruling m
The meeting or
issue drew a crowd
dents that filled a
meeting room and
into the hallway a
stairs. Many peopl
the U.S. Departm
portation's decisio
county to Central
April 2, when day
time begins.

Consumers turning to c for heat

3 WALK
— Som
turning
corn-burning furn
saving alternative
Bryan Baker ins
systems to help he
apartment comple

Appendix G: First Public Involvement and Stakeholder Meeting

TRAIL CREEK
WATERSHED MANAGEMENT
PLAN UPDATE PROJECT

Public Meeting Number 1 of 4
February 8, 2006

AGENDA

1. Historical Summary

2. Unity Foundation

3. IDEM Perspective

4. Sanitary District

5. Watershed Definitions

6. Trail Creek Watershed

7. Plan Update Process

8. 2005 Watershed Testing

9. Watershed Problem Identification

10. Open Discussion

1. Historical Summary

STREAM USE in the 1800's:

"The stream of Trail Creek, as it is known today, was named River of the Trail by French Traders because the trails of the Potawatomi Indians converged along this Lake Michigan tributary. The first survey of Lake Michigan shores, in 1816, indicated Trail Creek was 30 feet wide at its mouth. Early harbor records show continuous petitions to Congress for dredging funds and frequent battles for appropriations with Chicago. By the 1840's, Trail Creek was a major outlet for farm goods and for passengers who came up the Michigan Road bound for ports on Lake Michigan." (1993 Trail Creek Watershed Management Plan)

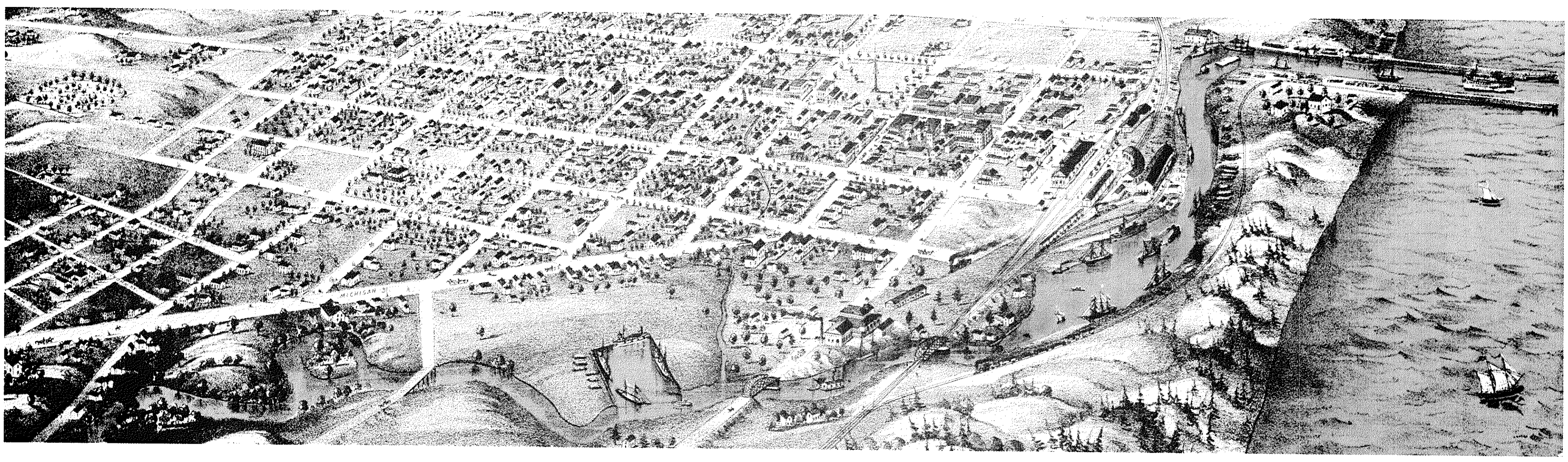
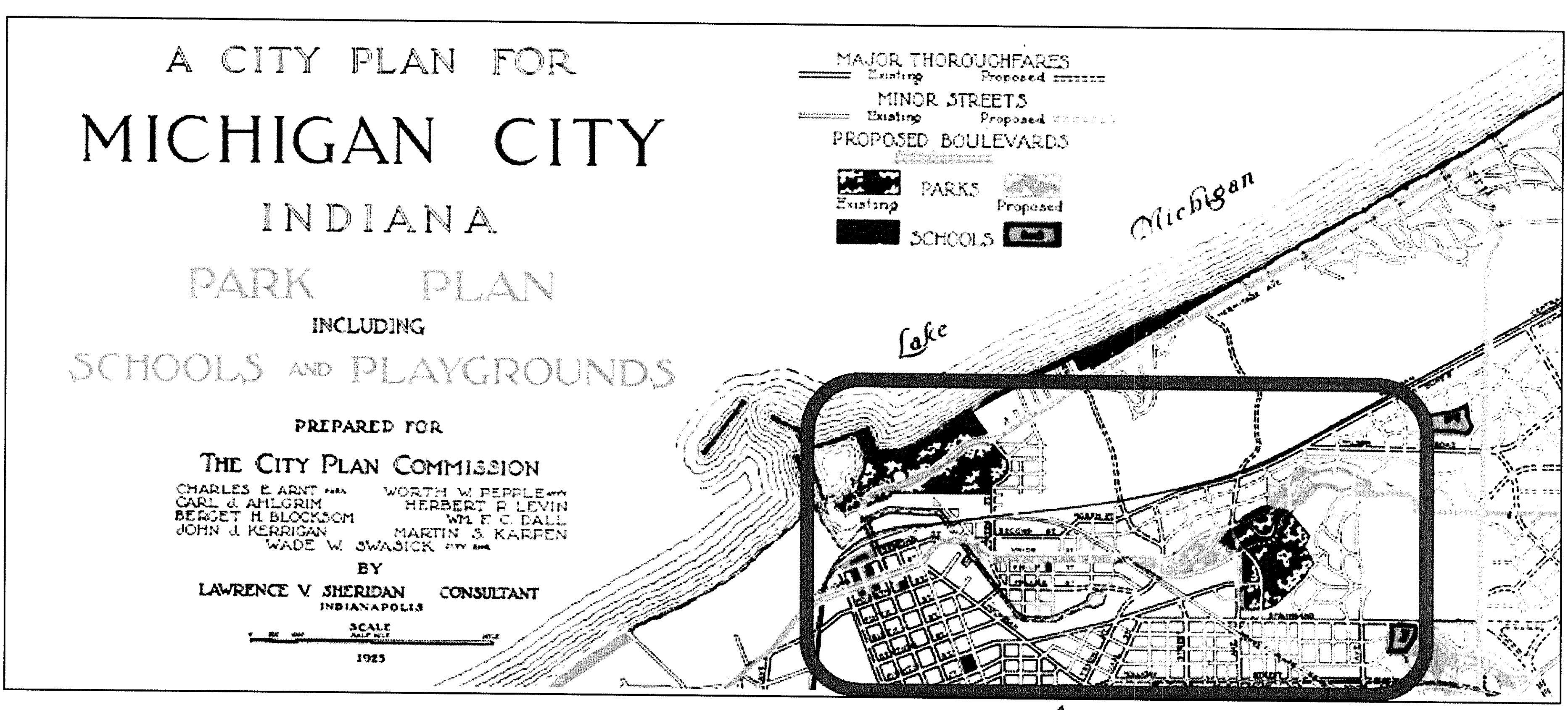


Illustration of Trail Creek in 1869

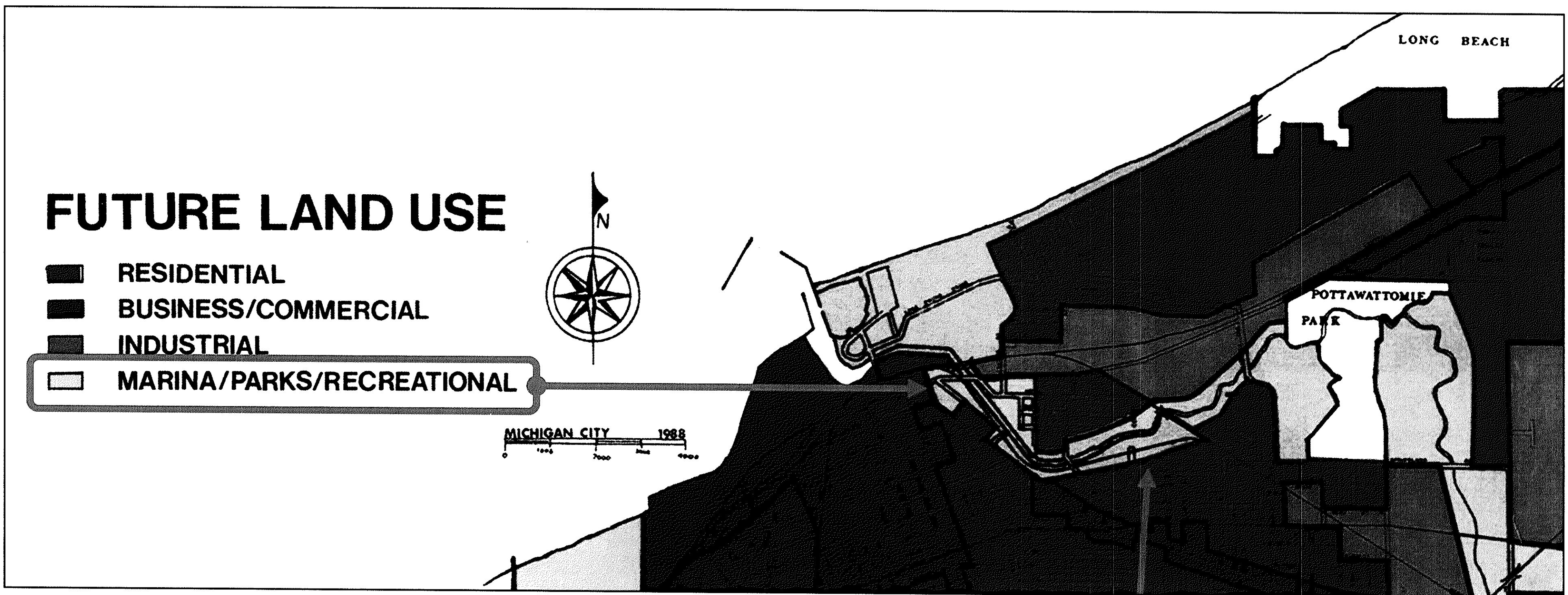
STREAM USE in the early 1900's:



Actual text from the 1926 "Michigan City Plan":

The most important element in the chain of parks which are indicated on the Park Plan is *Trail Creek Parkway*. Its origin is at the end of Union Street from which point it proceeds to the east through Memorial Park and Pottawattomie Park subdivision to the Country Club.

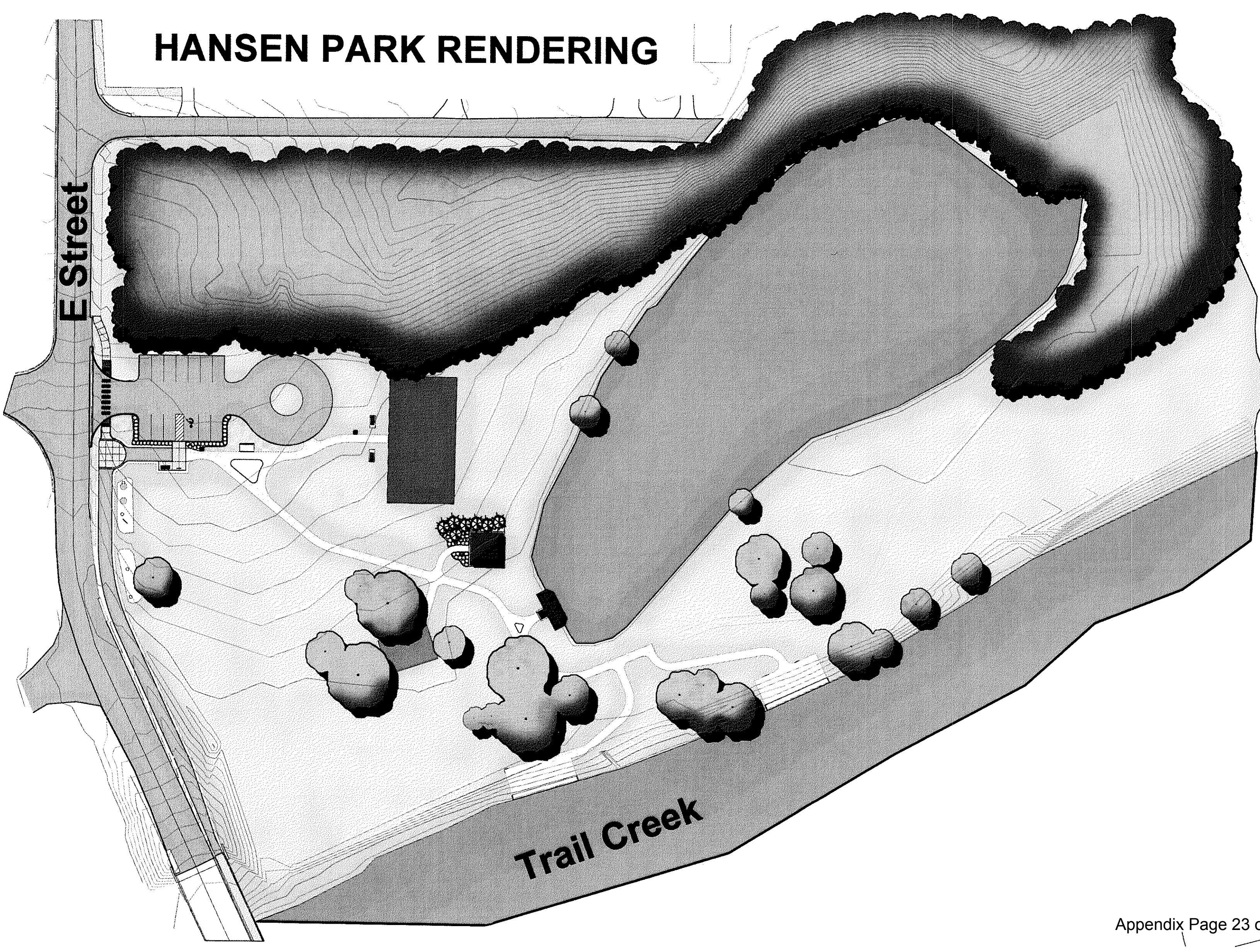
STREAM USE in the late 1900's:



Text from the 1988 "Michigan City Comprehensive Plan":

> Over the years the Michigan City lakefront and Trail Creek areas have received much planning emphasis. All of these plans contain valuable components and recommendations. Although each plan places a different type of emphasis on different aspects of Michigan City's water resources all of them agree on one basic principle: Michigan City has yet to fully realize the great potential of its lakefront and Trail Creek. The

STREAM USE in the early 2000's:



2. Unity Foundation

Mission

The Unity Foundation serves donors, non-profits and the community by building endowment funds to provide income for local charitable causes—now and forever.

Vision

The Unity Foundation strives to realize a vision of LaPorte County as a cohesive community that uses its diverse heritage to improve the quality of life for all through civic pride, service, and philanthropy.

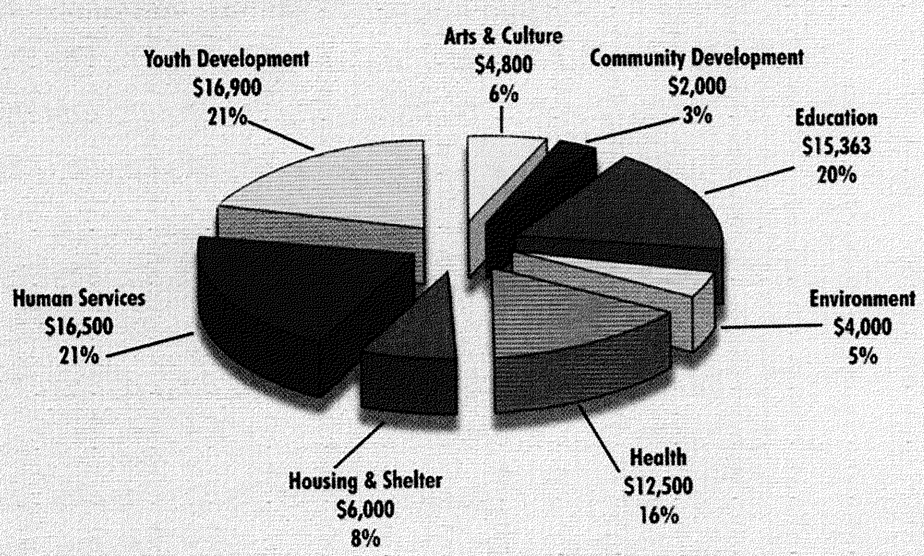
Unity's Core Values

The people of the Unity Foundation share a core set of values that guide and inspire our work now and for the future.

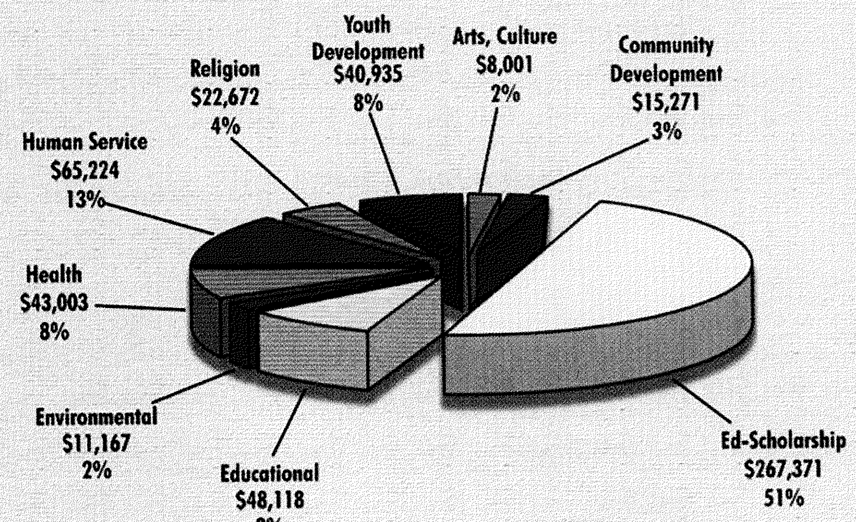
- Leadership and Vision:
  We strive to continually sharpen our vision of a better life for all in our community and to provide the leadership to make it happen.
- Integrity and Responsibility:
  We are dedicated to building and holding the trust of the community through independent governance, objectivity, and honesty.
- Permanence:
  We are committed to building a permanent endowment so we may address today's needs, while confident our successors can also address the needs of future generations.
- Education:
  We strive to educate our community on the value and methods of giving to create a culture of philanthropy to sustain a vibrant, healthy, caring community.
- Inclusiveness and Accessibility:
  We seek diverse perspectives when identifying community needs and finding ways to address them.
- Collaboration and Partnering:
  We believe the greatest possible good from our efforts will arise from closely cooperating with everyone committed to the improvement of our community.

Unity Foundation Grant Distribution

Community Fund Grants 2004 - $78,063



All Grants 2004 - $521,762



Does not include in-kind grants

Community Fund Grant Guidelines:

1. Grants will be made to nonprofit organizations and programs operating in LaPorte County, Indiana. Grants will be made for a wide variety of programs and purposes, while striving for geographical balance.

2. Grants will not be made to churches for sectarian religious programs, for operating budgets or for basic municipal or educational functions. No grants will be made for endowment campaigns or for old debts. Nor will grants provide long-term funding or dollars for after-the-fact situations.

3. The Foundation is particularly interested in funding projects not adequately serviced by existing resources, start-up costs for new programs, one-time projects or needs, projects that leverage other funds, and projects which facilitate cooperation and collaboration between organizations and the communities within LaPorte County, Indiana.

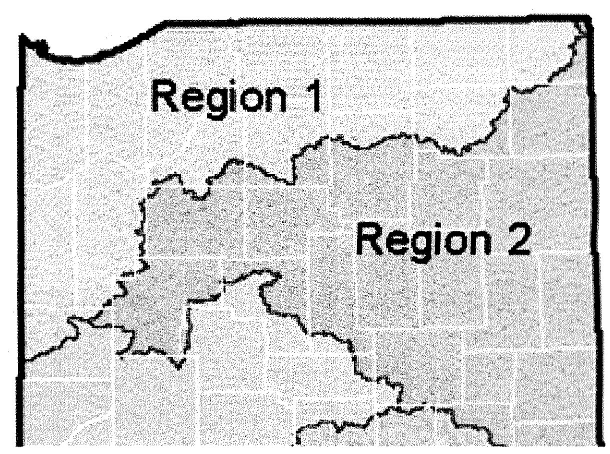
3. IDEM Perspective

SECTION 319 NONPOINT SOURCE PROGRAM:

The Federal Clean Water Act Section 319(h) provides funding for various types of projects that work to reduce nonpoint source water pollution. Funds may be used to conduct assessments, develop and implement TMDLs and watershed management plans, provide technical assistance, demonstrate new technology and provide education and outreach. Organizations eligible for funding include nonprofit organizations, universities, and local, State or Federal government agencies. A 40% (non-federal) in-kind or cash match of the total project cost must be provided, unless the project is a planning or implementation project in a watershed that includes waterbodies impaired by nonpoint sources of pollution as listed on the 2004 303(d) List of Impaired Waterbodies, in which case a 25% match is required. (IDEM websiteb http://www.in.gov/idem/water/planbr/wsm/319main.html)

WHAT 319 PROGRAMS HAVE BEEN FUNDED IN NORTHERN INDIANA?

REGION 1 PROGRAMS:



Dunes Creek Watershed Management Plan (03-750) (2003 Incremental Funds) - Save the Dunes Conservation Fund will be developing a watershed management plan for the Dunes Creek watershed. Steering committee meetings will be held bi-monthly and public meetings quarterly to solicit input on the watershed management plan. A chemical and biological water quality monitoring program will be conducted in the Dunes Creek watershed to help with the development of the plan. Also included in the project will be a study to assess the efficacy of a pilot wetland restoration site along a section of Dunes Creek. The study results will be included in the final written summary project report. Public outreach activities will include outreach brochures, news releases about the project, and quarterly newsletters, e-mail, or website articles.

Five Lakes Watershed Management Plan (03-752) (2003 Incremental Funds) - Five Lakes Conservation Association, Inc. is developing a comprehensive watershed management plan (WMP) for the Little Elkhart Creek-Messick-Oliver Lake, Little Elkhart Creek-Dallas Lake, and Little Elkhart Creek-Tamarack-Cree Lakes watersheds that make up the headwaters of the Elkhart River. To begin this process, the Association will identify and coordinate a Watershed Planning Team consisting of individuals from the three watersheds and technical support experts to identify issues and concerns to be considered during the planning process. Community outreach will include the development and distribution of quarterly newsletters or newspaper articles, and separate newspaper announcements of dates, times, and places of activities, meetings, and events scheduled within the watersheds. At least eight public meetings will be held to ensure that all stakeholder perspectives and comments are considered in the development of the WMP. The Association will also conduct water quality and macroinvertebrate monitoring to help with the development of the plan.

Pigeon Creek Watershed Plan Development (03-751) (2003 Incremental Funds) - The Steuben County Commissioners is using funds to develop a watershed management plan for the Pigeon Creek watershed within Steuben County. To begin this process the Commissioners will organize a Planning Committee consisting of Soil and Water Conservation District staff, local officials, landowners, representatives from cities and towns, and other interested parties in the watershed. A minimum of eight committee meetings will be conducted to identify issues and concerns to be considered during the planning process. A digital geographic information system (GIS) layer of soil types within the watershed will be developed and used for production rates, runoff calculations, and site recommendations. Site locations of conservation practices, potential practice implementation sites, tile outfalls, and waterway locations will be collected using a handheld Geographic Positioning System (GPS) unit. A watershed map will be produced containing at least planning and zoning areas, land use, and riparian zones collected from external resources. The Commissioners will hold a minimum of three additional public meetings to ensure that all stakeholder perspectives and comments are considered in the development of the WMP and to present the final plan. At least eight news releases will be submitted to local media to publicize, communicate, and encourage public participation in all meetings.

Landuse Changes and Nonpoint Source Pollution Prevention (01-252) (2001 Base Funds) - The Michiana Area Council of Governments (MACOG) will be developinga computer CD and corresponding printed material to educate builders anddevelopers regarding land use changes and relative impacts on nonpoint sourcepollution (NPS). The focus will be on construction site maintenance, sequencingof construction activities, erosion control, and general site design. MACOGwill consult with the homebuilders associations, planning departments, andlocal Soil and Water Conservation Districts before developing the material. MACOG will also be developing, in cooperation with local health departments, a video highlighting the care and maintenance of on-site sewage disposalsystems. The video will be distributed throughout the St. Joseph River Basinand Marshall County including libraries, health departments, title companies,real estate offices, and other agencies involved in land transfer and landdevelopment within the St. Joseph River basin.

Problematic Domestic Waste Disposal Systems (01-254) (2001 Base Funds) - Elkhart County Commissioners will be conducting water quality monitoring and engineering and geospatial analyses on 14-digit hydrologic unit code (HUC) watersheds in Elkhart County to prioritize watersheds according to levels of E. coli contamination. A public education campaign will be conducted in the three highest priority watersheds to educate the public on water quality issues relating to on-site sewage disposal systems, system maintenance, and alternative solutions. The SWCD will also develop a comprehensive watershed management plan for the watershed most threatened by E. coli contamination. At least four public meetings will be held in the watershed for the purposes of soliciting stakeholder input and support in the development of the watershed management plan.

Aquaculture Demonstration Project (00-204) (2001 Incremental Funds) - Lake County Solid Waste Management District is constructing an indoor stream approximately 100-feet in length within a Lake County Solid Waste Management District facility that will serve as a public outreach and demonstration project for emphasizing watershed management and nonpoint source pollution. The District will also construct a wetland adjacent to the indoor stream to serve as a public outreach and demonstration project for emphasizing the importance of naturally functioning wetlands and their role in watershed management. A demonstration based monitoring program for the indoor stream and wetland to demonstrate the physical and chemical filtering processes found within actual wetlands will be developed. The District will also produce an educational curriculum and printed educational materials specific to this project for use by the project's targeted audience.

Vegetative Restoration Water Quality Project (00-205) (2001 Incremental Funds) - Pheasants Forever will hire a seasonal Coordinator and develop a cost-share program to establish and maintain at least one hundred and fifty acres of tall grass prairie and twenty-five acres of woodland plots along riparian areas and upon soils susceptible to rill, sheet, and wind erosion. Another cost-share program will be developed to restore wetland vegetation at at least five sites. Pheasants Forever will work with the LaGrange County SWCD in identifying potential restoration sites, conducting habitat analyses, conducting environmental impact assessments, and conducting extensive soil investigations.

Lake Gilbraith & Flat Lake Watershed Improvement (00-211) (2001 Incremental Funds) - The Poor Handmaidens of Jesus Christ is using grant funds to develop a watershed management plan and implement best management practices (BMPs) aimed at reducing and controlling nutrient and sediment loading into Lake Gilbraith and Flat Lake. Stakeholder meetings to solicit input on the development of the watershed management plan will be conducted. The BMPs include rehabilitating the ditch and approximately six acres of an associated wetland downstream from the Ancilla Waste Water Treatment Plant finishing lagoon located on the south shore of Lake Gilbraith. A wastewater wetland cell for the Earthworks Ecological Center will also be constructed utilizing native wetland plants to purify septic tank effluent before it reaches the leach field. The Poor Handmaidens of Jesus Christ will hold at least three workshops for Friends of Earthworks and the public on watershed management issues, including a workshop with hands-on activity where the public may assist in the construction of the wastewater wetland cell.

Wolf Lake Conservation Area (99-390) (2000 Base Funds) - The City of Hammond Parks and Recreation Department is developing a conservation area at highly urbanized Wolf Lake. The City of Hammond is building a wetland area designed to filter road salts and other runoff borne pollutants coming from a nearby interstate highway system, before they enter the lake. In addition to the wetland, an education/ observation area is being constructed. Groups which the City of Hammond is partnering with to implement this project include the Boy Scouts of America, local schools, and stakeholders in the Wolf Lake Watershed.

Yellow River Water Quality Improvement (00-39) (2000 Incremental Funds) - The City of Plymouth is sponsoring a water quality study on the Yellow River. The Yellow River was cited in the 305(b) report as having degraded water quality due to unknown sources. A previous study sponsored by the City of Plymouth found that the river in Marshall County was seriously affected by *E. coli*, sedimentation from urban stormwater sources, and PAH contamination. To pinpoint and address the sources of pollution affecting the Yellow River, the City of Plymouth is partnering with the cities of Knox and Bremen to monitor eight sites on the Yellow River for *E. coli* contamination for the period of one year. A sterile sandbag technique is used to help pinpoint the sources of bacterial contamination identified by the 1997 water study. The Cities of Bremen and Plymouth are installing stormwater filters capable of removing both sediment and hydrocarbon contamination. Semi-permeable membrane devices are being installed upstream and downstream from the stormwater filters to help determine the effectiveness of the filters in removing PAH contamination.

Septic Demonstration (00-87) (2000 Incremental Funds) - The Arrowhead Country RC&D is addressing septic system failure in the Kankakee Iroquois watershed by demonstrating innovative septic technologies. Cost-share monies are provided to fund the installation of constructed wetland systems, sand filters, and aerobic package treatment systems to replace failing standard septic systems. In addition to creating the demonstration systems, the Arrowhead RC&D is developing and distributing a brochure highlighting proper septic system installation and maintenance.

Juday Creek Erosion Control (00-92) (2000 Incremental Funds) - The St. Joseph Drainage Board is demonstrating bank stabilization BMPs along Juday Creek. The Drainage Board is holding public meetings to advertise the project and a list of volunteer landowners is being compiled. After the available sites have been prioritized, bioengineering techniques are used to demonstrate effective streambank stabilization.

Gatlin Property Constructed Wetland (00-88) (2000 Incremental Funds) - The Gatlin Property NPS Pollution Control and Wetland Preservation Project is implementing several BMPs that will improve water quality within the Turkey Creek Watershed. These BMPs include vegetated swales and buffers, as well as wet-bottom detention basins. The Gatlin project is also constructing a large wetland that will trap sediment and nutrients before entering Turkey Creek.

Deep River/Turkey Creek (00-99) (2000 Incremental Funds) - The City of Hobart is performing a three-part diagnostic study of the Deep River/Turkey Creek watershed in order to assess and address NPS concerns. In the first part, the impacts of combined sewers, storm water runoff, and other nonpoint sources are determined. In part two, these concerns are identified and mapped. Finally, based on the findings of the study, recommendations for addressing the targeted water quality concerns are made.

Kankakee Restoration (00-78) (2000 Incremental Funds) - The Nature Conservancy is helping restore eleven square miles connecting a series of publicly-owned conservation areas, including Conrad Savanna (800+ acres) Beaver Lake Prairie (640 acres) and Willow Slough State Fish and Wildlife Area (12,000+ acres). The Conservancy has developed a detailed restoration plan designed to restore natural vegetation, establish riparian buffers to filter runoff, and minimize surface water flow off the property. In addition, a water quality-monitoring plan is being implemented to monitor the water as it both enters and leaves the restoration site. The site will provide both a habitat corridor for wildlife and also act as a filter for nutrients and sediment-laden waters entering the site.

Coffee Creek Watershed Management Plan (00-200) (2000 Incremental Funds) - The Coffee Creek Watershed Conservancy, Inc., is developing a watershed management plan. The comprehensive plan includes a historical perspective on land use and water quality issues, maps and data describing current water quality conditions, a model of nonpoint source pollution in the watershed, informational brochures, a watershed map, and a final report.

Livestock Management Planning (99-209) (1999 Incremental Funds) - The LaGrange County SWCD is spearheading a multi-county project providing assistance with livestock management. The district is employing a Livestock Management Specialist to provide educational, technical, and financial assistance to individual land users, and assist with the development of livestock management plans. Cost-share assistance is being offered to participants at a rate of fifty percent.

Cedar Lake Watershed Protection (99-221) (1999 Incremental Funds) - The Cedar Lake Enhancement Association is studying, restoring and educating stakeholders about Cedar Lake. This project is conducting a diagnostic feasibility study of the north and northeast inlets to Cedar Lake. In addition, a wetland treatment system and supplemental bank erosion protection are being installed along Sleepy Hollow Ditch. The Association is including outreach and education in their restoration efforts, including public meetings and workshops.

Revegetation and Restoration (99-205) (1999 Base Funds) - Pheasants Forever is establishing tall grass prairie and tree plots in the St. Joseph River watershed. In addition, wetlands are being restored through a cost-share program. Field days and presentations in the watershed are promoting the restoration work, as well as educating stakeholders in the watershed.

Juday Creek Stream Bank Stabilization (98-187) (1998 Funds) - The St. Joseph County Drainage Board used a cost-share program to reduce erosion and sedimentation into Juday Creek. Public meetings promoted the program, which focused on vegetative bank stabilization, sediment traps, and constructed wetlands.

Eller Creek Erosion Control (1997 Funds) - The Michiana Area Council of Governments (MACOG) addressed erosion control and educated the public in the Eller Creek watershed in St. Joseph County, Indiana. This project came on the heels of other successful projects in the St. Joseph River Watershed administered by MACOG, and will help counter the effects of urban impacts on water quality.

Mobile Education Unit (1997 Funds) - The LaGrange County SWCD hired a Water Quality Educator to coordinate activities of the Mobile Education Unit. The Educator's activities included teaching, curriculum development, and teacher follow-up workshops, as well as implementing Project WET and Volunteer Water Quality Monitoring activities.

Northwest Indiana Technical Assistance Partnership (1996 Funds) - The USDA/NRCS provided technical assistance to local organizations. Assistance focused on implementing recommended best management practices, and increasing local awareness of these efforts.

Restoration of Juday Creek (1995 Funds) - The Michiana Area Council of Governments implemented a public awareness program and incentive program to encourage riparian landowners to install BMPs along the Juday Creek corridor.

Quality of Precipitation (1994 Funds) - The USGS monitored the quality of precipitation at a monitoring site located at the Gary Regional Airport. This was a continuation of a previous project. The data collected was needed to evaluate possible sources of atmospheric NPS pollution in northwest Indiana.

Quality of Precipitation in the Grand Calumet (1994 Funds) - U.S. Geological Survey monitored the quality and quantity of precipitation, including trace metals, in the Grand Calumet River watershed at a precipitation monitoring station. Data was used to evaluate seasonal and annual changes in chemistry, and to evaluate the importance of wet-deposition as a source of pollutants in Lake County.

Evaluation of Constructed Wetlands (1993 Funds) - Indiana University/SPEA evaluated constructed wetlands in Marshall County. Persistent emergent vegetation was planted to more effectively reduce flow velocities and allow sediments and their associated nutrients to settle out. A model was developed to describe which features of constructed wetlands are most important in trapping nutrients and sediments in NPS runoff.

Urban NPS Public Education (1993 Funds) - The Grand Calumet Task Force worked with various state and local organizations to promote awareness of NPS problems and solutions on the Grand Calumet River/Indiana Harbor Ship Canal.

Area of Concern (1993 Funds) - The USDA/NRCS provided a program of technical assistance to the Lake County Area of Concern in order to help implement the NPS best management practices plan developed by the Lake County SWCD. Baseline data of the practices effects on water quality was collected to compliment the educational effort by the Grand Cal Task Force.

Indiana Dunes (1993 Funds) - The Indiana Geological Survey assessed the threat of pollution by human waste along the Indiana National Lakeshore. This helped to provide the Indiana State Department of Health with a basis for evaluating the appropriateness of on-site septic tank absorption fields as a method of household waste disposal in dune sand.

Restoration of Wetlands (1992 Funds) - The U.S. Fish and Wildlife Service (USFWS) restored wetlands within several watersheds, primarily within northwestern Indiana, to reduce the input of NPS pollutants.

Grand Calumet River Basin Demonstrations (1992 Funds) - The Lake County SWCD participated with local communities in the installation of best management practices throughout the Grand Calumet River watershed to reduce surface water runoff and associated pollutants.

Trail Creek (1991 Funds) - Michigan City designed and constructed erosion control measures on Trail Creek in Michigan City. An innovative septic system was also designed, installed and used for demonstration purposes.

Juday Creek (1991 Funds) - The St. Joseph River Basin Commission implemented a watershed protection plan for Juday Creek.

Indiana Dunes (1991 Funds) - The Indiana Geological Survey cooperate with the Indiana State Health Department in an evaluation of the performance of dry wells used for wastewater disposal in the Indiana Dunes region.

Quality of Precipitation (1991 Funds) - The U.S. Geological Survey (USGS) established the first year of a three-year monitoring program in the Grand Calumet River Basin to appraise the water quality impacts of atmospheric deposition.

Lake County Conservation (1991 Funds) - The USDA/NRCS used Great Lakes grant funding to provide an employee to assist for two years with conservation activities, including NPS activities, in Lake County.

LaGrange County (1990 Funds) - A study on the Oliver, Olin, and Martin Lakes watersheds was completed by a water quality technician paid with Section 319 funds through the LaGrange County SWCD. Cost-share payments were also made in LaGrange County to landowners for six various types of conservation practices. A model farm was also developed.

Urban Runoff Demonstration (1990 Funds) - The Lake County SWCD signed two subcontracts, one with Purdue University and the other with the Grand Cal Task Force. Purdue University compiled existing information to identify current land uses and their relative contributions to water quality problems in the Grand Calumet River basin and published the results under the title of "Urban Targeting of NPS Pollution in the Grand Calumet River Watershed". The Grand Calumet Task Force organized, promoted, and conducted two workshops used as a forum for explanation and discussions regarding storm water and urban NPS pollution problems and best management practices (BMPs) selection.

Mission of Sanitary District of Michigan City

The Sanitary District of Michigan City was created to provide the efficient…

- Collection, conveyance and treatment of wastewater;
- Management of biosolids and residuals;
- Collection and disposal of refuse, trash and garbage; and,
- Drainage of storm water through best management practices;

…in order to achieve the multiple goals of:

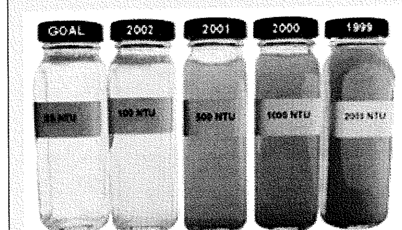
- Protecting the public health, safety and welfare of our community;
- Supporting economic and community growth; and,
- Protecting the designated uses for the Trail Creek Watershed and Lake Michigan through environmental stewardship.

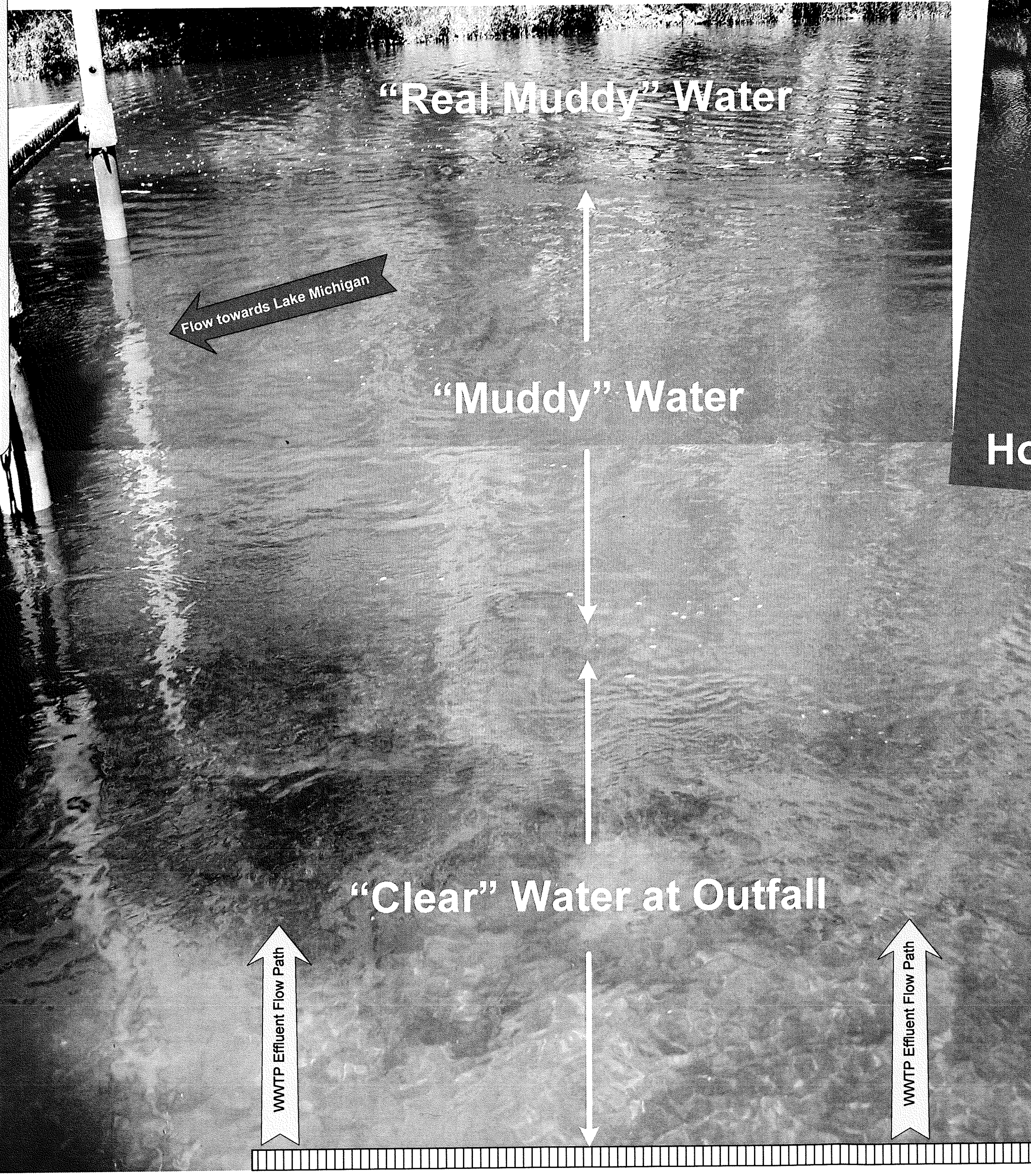
Northern Bank of Trail Creek at WWTP Outfall

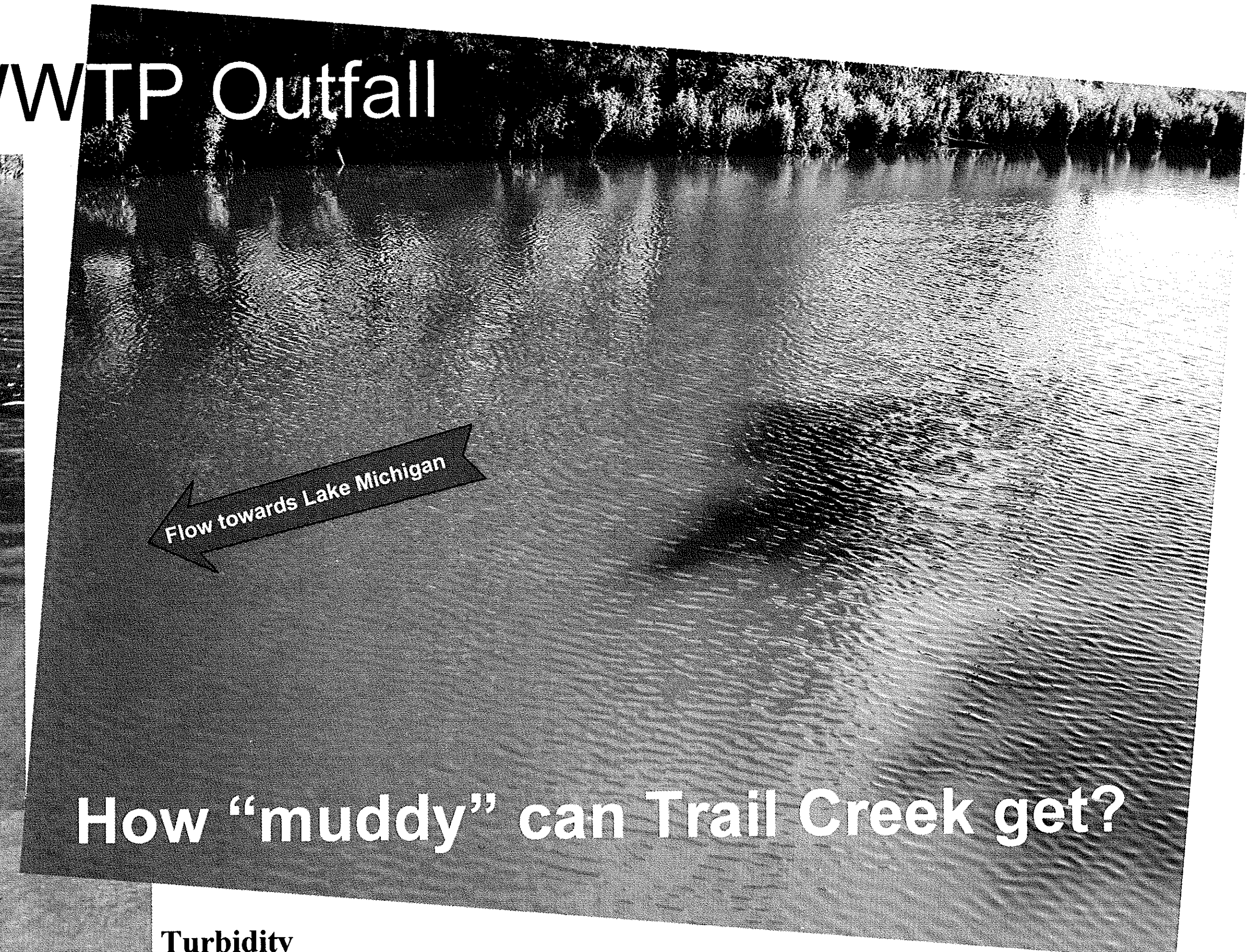
Polluted Runoff in Washington State

Sample of Success: Effective Irrigation Techniques Improve Turbidity on the Yakima River

A multi-agency effort helped local farmers improve irrigation techniques through education, loans, and technical assistance. The project decreased harmful turbidity levels in the Yakima River by 95% and more. Please visit www.svid.org for more information.







Turbidity

What is turbidity and why is it important?

Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Sources of turbidity include:

- Soil erosion
- Waste discharge
- Urban runoff
- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth

Source: USEPA

Southern Bank of Trail Creek at WWTP Outfall

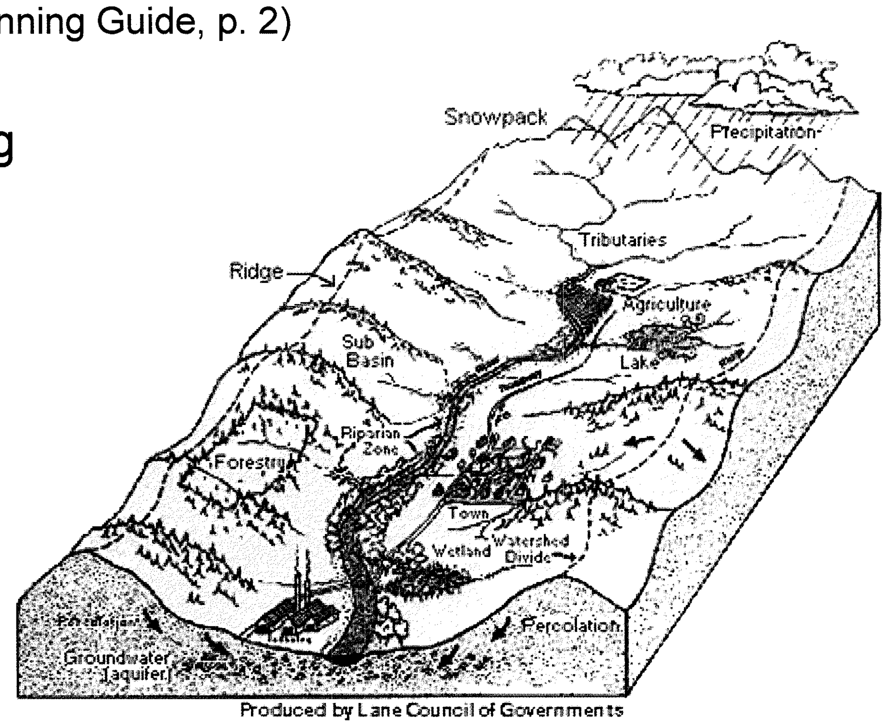
SANITARY DISTRICT OF MICHIGAN CITY

REV.	DESCRIPTION	DATE	BY
0	Visual Impact of Turbidity	11/10/05	A. J. Walus, Gen. Mgr.

5. Watershed Definitions

WATERSHED:

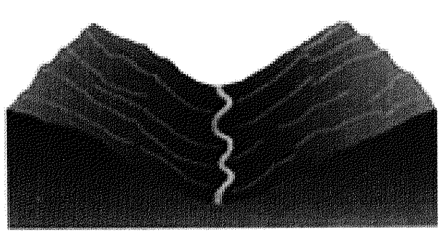
- "A watershed is all of a landscape that drains to a specific point. Depending on the scale of the discussion, you could refer to the watershed of the Mississippi River, or the watershed of a farm pond." (Indiana Watershed Planning Guide, p. 2)
- "An area of land that drains water, sediment and dissolved materials to a common receiving body or outlet. The term is not restricted to surface water runoff and includes interactions with subsurface water. Watersheds vary from the largest river basins to just acres or less in size." (http://www.epa.gov/watertrain/ecology/p2a.html)
- "Political boundaries usually do not coincide with the natural drainage boundaries of a watershed. Thus, the most effective watershed planning is developed in cooperation with other communities within the watershed." (NIRPC Water Resources Toolkit)



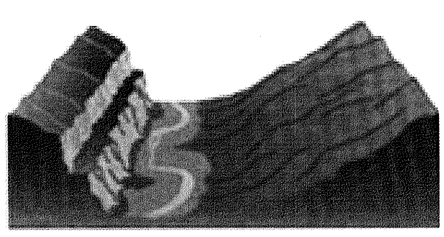
Source: EPA Watersheds website
http://www.epa.gov/owow/watershed/whatis.html

PHYSICAL TEMPLATE:

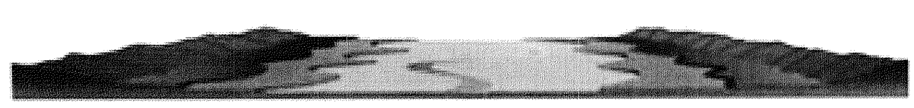
"The physical template of watershed structure is ultimately determined by varying combinations of climatic, geomorphic, and hydrologic processes. As a result of different combinations of these formative processes, different types of watersheds are created. Below are some examples that show how different from one another watersheds of different origin and physical template conditions can be." (US EPA Watershed Academy website: http://www.epa.gov/watertrain/ecology/ecology5.html)



"*Valley Type II:* moderately steep, gentle sloping side slopes often in colluvial valleys."



"*Valley Type VI:* moderately steep, fault controlled valleys."

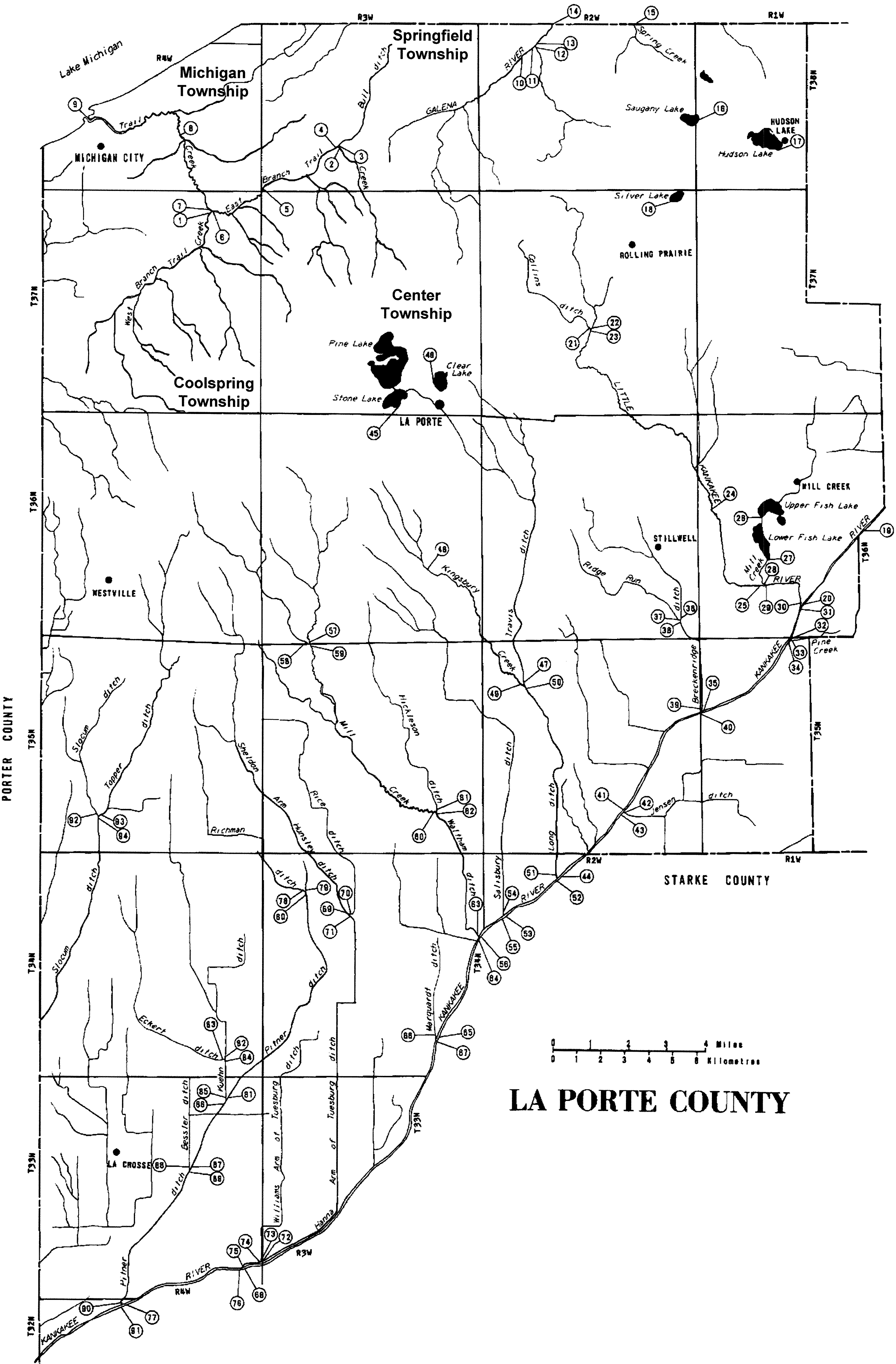


"*Valley Type VIII:* wide, gentle valley slope with well developed floodplain adjacent to river terraces."

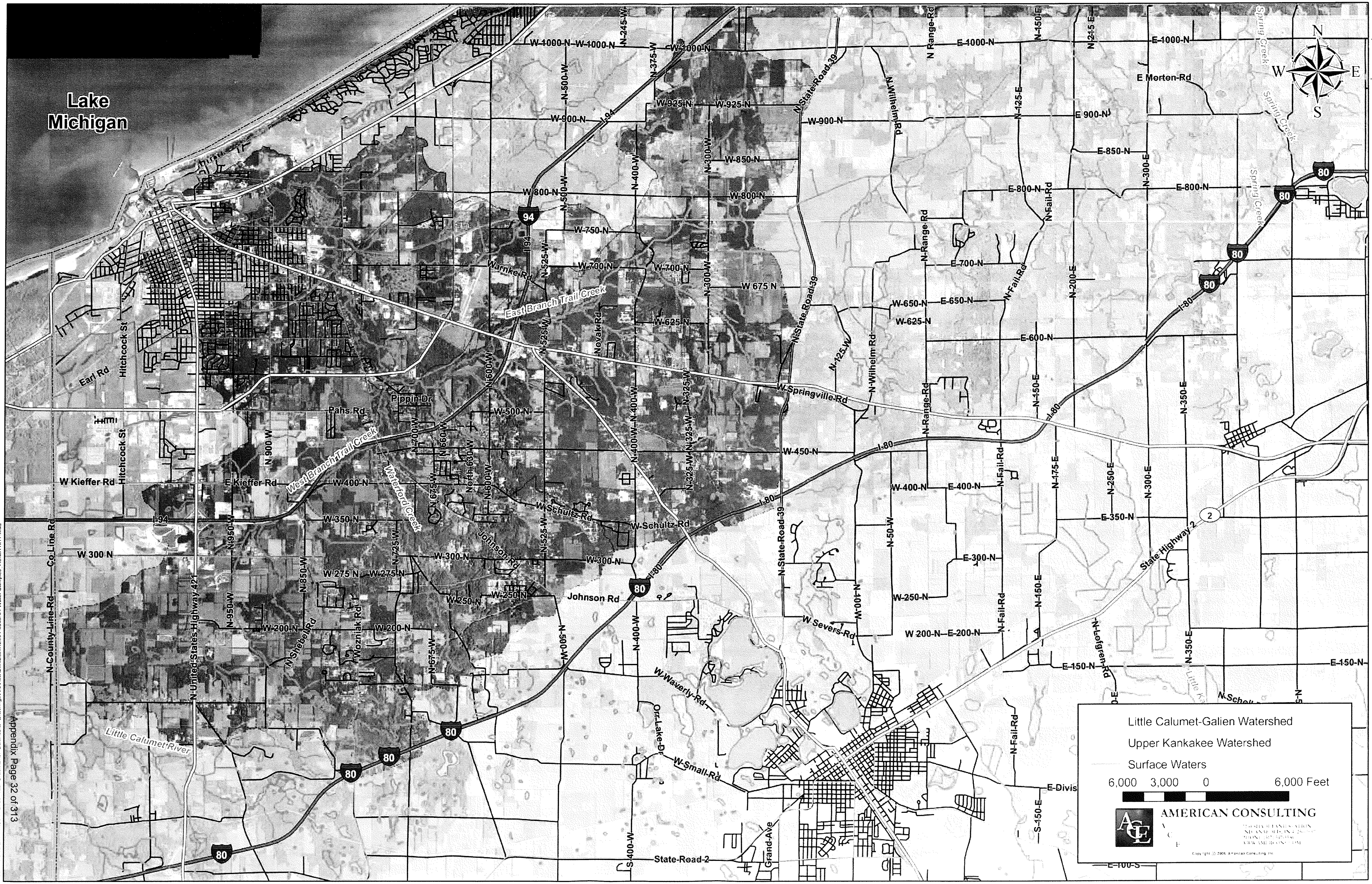
NONPOINT SOURCE POLLUTION or "NPS":

Nonpoint source pollution is the pollution of ground and surface water that results from the variety of ways that humans use the land. Unlike pollution from factories and sewage treatment plants ("point sources"), NPS comes from many diffuse widespread sources. Soil particles, fertilizers, animal manure, pesticides, oil, roadsalt, fecal material from failing septic systems, pet waste, and debris from paved areas are transported over the landscape by storm runoff, snow melt, and wind. Eventually entering streams, wetlands and lakes, or penetrating into ground water, these pollutants damage aquatic habitat, harm aquatic life, and reduce the capacity of water resources to be used for drinking water and recreation. Because NPS doesn't come out of a pipe that's easily located, it has to be managed differently than facilities with site-specific permits. That's why so many of the measures directed at controlling NPS are voluntary, and why so many people need to be involved." (Indiana Watershed Planning Guide, p. 3)

6. Trail Creek Watershed



Source: DNR website http://www.in.gov/dnr/water/surface_water/drainage_area/pdf/laporte.pdf



S:\2919\JNS\2004\N2004 0385 Trail Creek\Env Science\D Drawings\ArcView\Exhibits\N2004 0385 04 Water Samples Aerial11x17.mxd

The creation of the... *Trail Creek Watershed Management Plan* of 1993

TIP Membership
- Comprised of concerned businesspersons, residents, & government agents who volunteer their time to improve the water quality & usefulness of Trail Creek.
- Represent business, environment, government, private citizens & recreation.

Trail Creek Improvement Program Committee (TIP) 1990

TIP Purpose
- Formed in response to citizen's requests that the problems facing the stream be addressed.
- Dedicated to developing & implementing a whole ecosystem approach aimed at improving and restoring the water quality of the stream of Trail Creek.

Steering Committee

Five (5) Subcommittees
- Water Quality
- Shoreline Enhancement
- Navigability
- Funding
- Public Relations

OVERALL TIP GOALS:
- Maximize Trail Creek as a useable natural resource for the public & aquatic life
- Promote river-related activities as another improvement in the quality of Michigan City life
- Establish Trail Creek as a source of community pride

$100,000 Sect. 319 Grant Approved for M.C. for:
- $54,000 to construct 2 small sediment traps
- $30,000 to remove sediments
- $12,000 to monitor effectiveness
- $4,000 for legal services

CANNOT ACCESS WITHOUT WATERSHED MANAGEMENT PLAN!!

[redacted]

[redacted]

[redacted]

Trail Creek Watershed Management Resource Committee (Subcommittee of TIP)

Eight (8) Member Committee
- **Port Authority member, Resource Committee Coordinating Chairperson**
- PNC Chancellor
- Save the Dunes Council, Executive Director
- Mayor of Michigan City
- LaPorte County Soil & Water Conservation District, Board of Supervisors member
- Michigan City Area Chamber of Commerce
- LaPorte County Cooperative Extension, Extension Agent--Agriculture
- LaPorte County Commissioner

Technical Advisors
- IDEM, LaMP Coordinator
- IDEM, Northwest Indiana Office Director
- Sanitary District of Michigan City
- LaPorte County Soil & Water Conservation District, District Conservationist
- NIRPC Staff

Volunteers
- LaPorte County Surveyor's Office
- DNR, Division of Water
- Northwest Indiana Steelheaders
- DNR, Division of Fish & Wildlife
- LaPorte County Health Department

All meetings publicized & open to the public

Trail Creek Watershed Management Plan September 30, 1993

4 GOALS OF 1993 PLAN

Goal 1) Reduce potential health hazards due to poor water quality in the stream of Trail Creek.

Goal 2) Improve aquatic life support.

Goal 3) Increase quality/quantity of recreational opportunities to stimulate economic growth.

Goal 4) Develop a public awareness of the unique & diverse opportunities that the stream of Trail Creek provides.

2006 Update

✓ Re-Invite Original Stakeholders to Participate

✓ Re-Establish a Steering Committee

Nine (9) Member Steering Committee
- **Sanitary District of Michigan City, Temporary Lead Agency**
- Unity Foundation
- Local LaPorte County Landowner
- Save the Dunes Council
- Municipal Separate Storm Sewer System Coordinator
- LaPorte County Soil & Water Conservation District
- LaPorte County Cooperative Extension, Extension Agent—Agriculture
- DNR Coastal Nonpoint Coordinator
- American Consulting, Inc. (ACE)

✓ Re-Establish Sub-Committees
- E. coli
- Sedimentation
- Public Involvement
- Best Management practices
- Land Use & Landowners
- 1993 Survey Data & BMP Evaluation

→ **Project Implementation & Financing**

2006 Action Plan for Trail Creek: Start with Existing Plan

1993 Trail Creek Watershed Management Plan

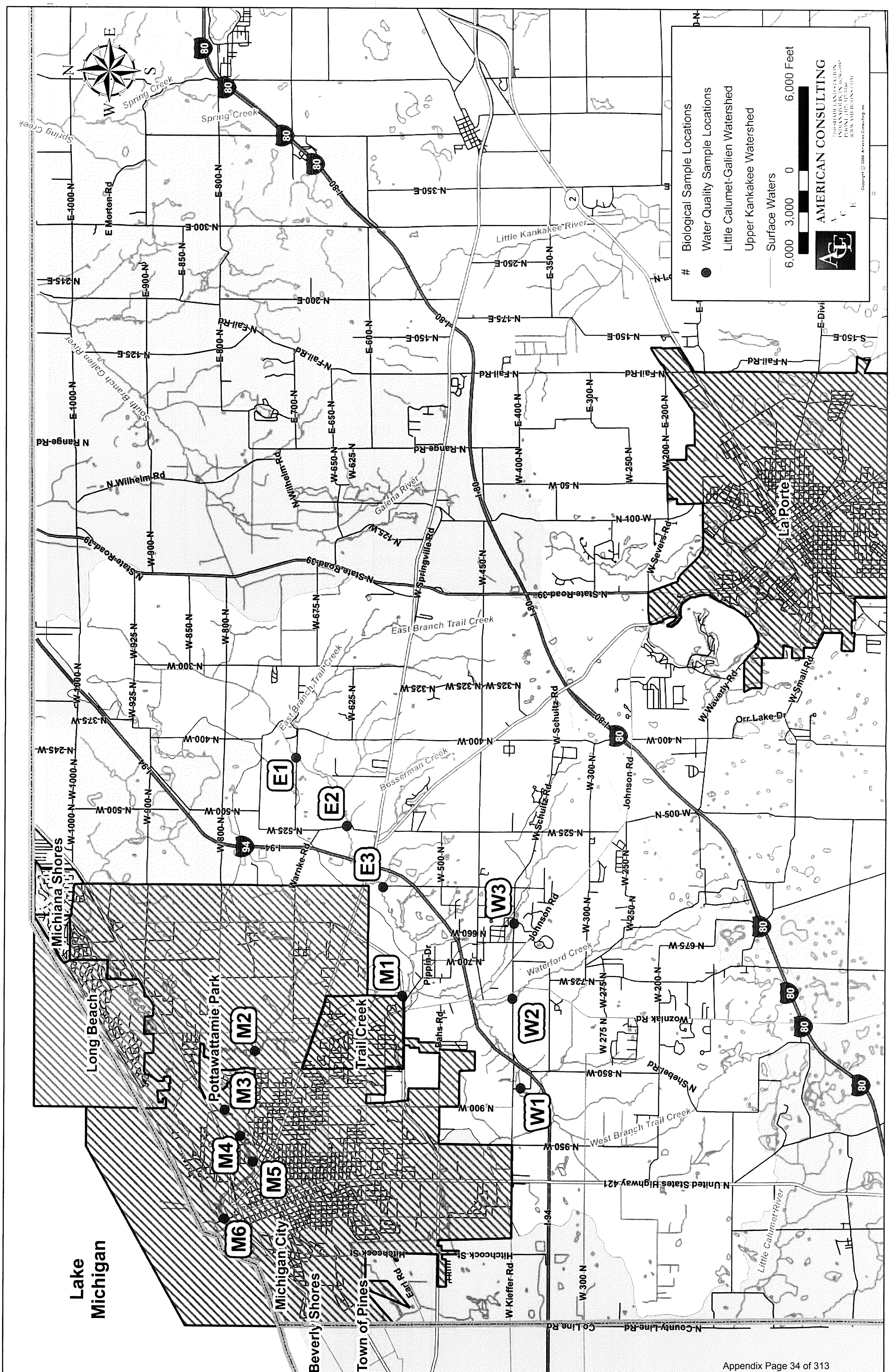
✓ Concerns → ✓ Stressors → ✓ Goals

Add: 2003 TMDL E. coli Info → ✓ Sources → ✓ Targets → Indicators

Add: Turbidity/Sedimentation → Sources → Targets → Indicators

Concerns → Stressors → Sources → Goals → Targets → Indicators

2006 Trail Creek Watershed Management Plan



Biological Sample Locations
Water Quality Sample Locations
Little Calumet-Galien Watershed
Upper Kankakee Watershed
Surface Waters
6,000 3,000 0 6,000 Feet
AMERICAN CONSULTING
Lake Michigan
Michiana Shores
Long Beach
Pottawattamie Park
Trail Creek
Michigan City
Beverly Shores
Town of Pines
La Porte
E1
E2
E3
M1
M2
M3
M4
M5
M6
W1
W2
W3
East Branch Trail Creek
West Branch Trail Creek
Galena River
Little Kankakee River
Little Calumet River
Spring Creek
Waterford Creek
Bosserman Creek

HOOSIER RIVERWATCH

VOLUNTEER STREAM MONITORING & ADOPT-A-RIVER PROGRAM

Volunteer Stream Monitoring

Adopt-A-River Program

HOOSIER RIVERWATCH

VOLUNTEER STREAM MONITORING

~Introduction~

Hoosier Riverwatch is a state-sponsored water quality monitoring initiative. The program was started in 1994 to increase public awareness of water quality issues and concerns by training volunteers to monitor stream water quality. Hoosier Riverwatch collaborates with agencies and volunteers to:

- Increase public involvement in water quality issues through hands-on training of volunteers in stream monitoring and cleanup activities.
- Educate local communities about the relationship between land use and water quality
- Provide water quality information to citizens and governmental agencies working to protect Indiana's rivers and streams.

Hoosier Riverwatch is sponsored by the Indiana Department of Natural Resources - Division of Fish and Wildlife. Funding is provided in part by the Federal Sport Fish Restoration Fund.

DNR Indiana Department of Natural Resources

INDIANA DIVISION OF FISH & WILDLIFE

SPORT FISH RESTORATION

Appendix H: Second Public Involvement and Stakeholder Press Release

PRESS RELEASE

Sanitary District of Michigan City · 1100 E. 8th Street · Michigan City, IN 46360

For more information contact:
Al Walus, General Manager
(219) 874-7799

FOR IMMEDIATE RELEASE
June 23, 2006

2nd Public Meeting Announced for the Trail Creek Watershed Management Plan Update

Michigan City, IN – The Second Public Involvement and Stakeholder Meeting for the Trail Creek Watershed Management Plan Update is scheduled for Thursday, June 29, 2006, at 7:00 p.m. in the gymnasium of Springfield Elementary School located at 3054 W 800 N in LaPorte County. Stakeholders and the general public are encouraged to attend and provide input into the Watershed Management Plan. Water quality data gathered to date will be presented and the public will have an opportunity to share their issues and observations with regards to water quality within the watershed.

The Sanitary District of Michigan City hosted its first Public Involvement and Stakeholder meeting earlier this year in February to introduce the Watershed Plan and process. Since the February meeting and with the assistance and input of local volunteers and agencies, the Sanitary District of Michigan City has made significant progress with the ongoing update of the 1993 Trail Creek Watershed Plan. The completion of the Trail Creek Watershed Plan update later this year will allow Michigan City, LaPorte County, the Town of Trail Creek and various public and private institutions to apply for additional grant money from the Indiana Department of Environmental Management and others to implement projects within the Trail Creek watershed to reduce non-point source pollution and enhance water quality.

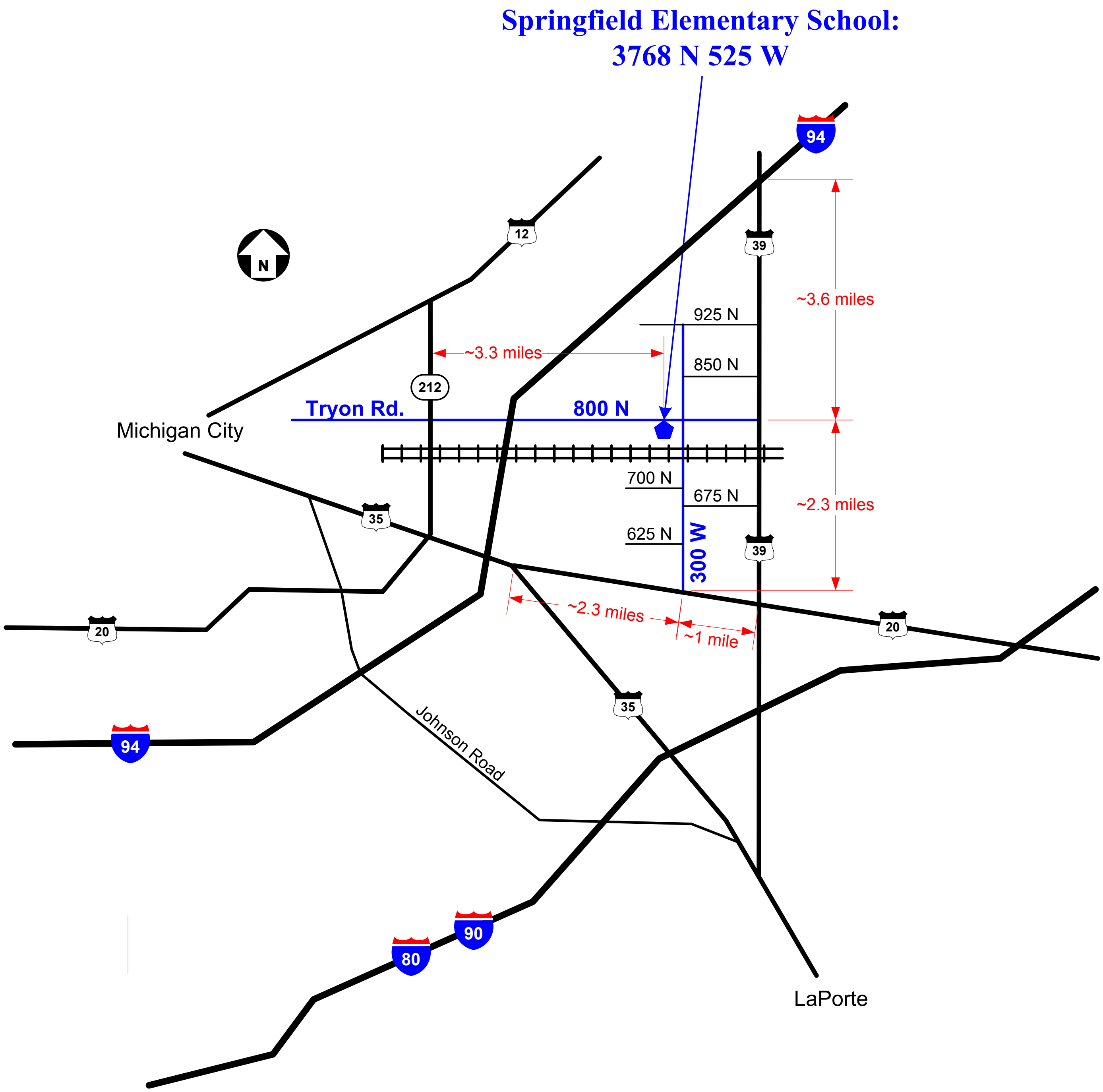
The study and design of the plan is partially funded by a grant from the Unity Foundation, a Section 319 grant from IDEM and in-kind services provided by the Sanitary District of Michigan City. The focus of these grant monies is to create a Watershed Plan for Trail Creek which will address the classification of Trail Creek as an "impaired waterway" and the Total Maximum Daily Load requirements for *E. coli*.

The Sanitary District of Michigan City has completed a year and a half of water quality sampling within the Trail Creek watershed and is preparing a list of issues and activities within the watershed which may affect water quality within Trail Creek. The list of issues is based on the water quality data and land use within the watershed.

For questions regarding the project or participation, please contact Al Walus of the Sanitary District of Michigan City at 219-874-7799, or Christine Meador of American Consulting at 317-547-5580.

The Trail Creek watershed encompasses an area of 59 square miles throughout parts of Michigan Township, Coolspring Township, Springfield Township and Center Township. The watershed extends as far south as the I-80 Toll Road and as far east as State Road 39.

###



2nd Public Meeting for the Trail Creek Watershed Management Plan Update

Thursday evening, June 29, 2006

7:00 p.m. at Springfield Elementary School

Appendix I: Second Public Involvement and Stakeholder Meeting

Trail Creek Watershed Management Plan
Public and Stakeholder Meeting
Agenda – Meeting 2 of 4
June 29, 2006

1. **Introduction – Alan Walus, Sanitary District of Michigan City**
2. **Review of the "The Basics"/Background**
3. **Watershed Sampling**
4. **Summary of TMDL for Trail Creek**
5. **Watershed Land-use and Mapping**
6. **Areas of Concern**
7. **Goals and Solutions**
8. **Future Meetings**

"The Basics"

Watershed:
A watershed is all of the landscape that drains to a specific point. Depending on the scale of the discussion, you could refer to the watershed of the Mississippi River or the watershed of a farm pond. You may hear terms like "river basin" or "drainage" used interchangeably with "watershed".

Hydrologic Unit or HUC:
Hydrologic unit codes were developed by the US Geological Survey in cooperation with the US Water Resource Council and the USDA Natural Resource Conservation Service. Most federal and state agencies use this coding system. HUCs are a way of cataloguing portions of the landscape according to their drainage. Landscape units are nested within each other and described as successively smaller units. The hydrologic code attached to a specific watershed is unique, enabling different agencies to have common terms of reference and agree on the boundaries of the watershed. These commonly understood boundaries foster understanding of how landscapes function, where water quality problems should be addressed, and who needs to be involved in the planning process.

Nonpoint source pollution or NPS:
Pollution of ground and surface water results from the variety of ways that humans use the land. Unlike pollution from factories and sewage treatment plans (point sources), NPS comes from many diffuse widespread sources. Soil particles, fertilizers, animal manure, pesticides, oil, road salt, fecal material from failing septic systems, pet waste, and debris from paved areas are transported over the landscape by storm runoff, snow melt, and wind. Eventually entering streams, wetlands and lakes, or penetrating into groundwater, these pollutants damage aquatic habitat, harm aquatic life, and reduce the capacity of water recourses to be used for drinking water and recreation. Because NPS does not come out of a pipe that is easily located, it has to be managed differently than facilities with site-specific permits. That is why so many of the measures directed at controlling NPS are voluntary, and why so many people are involved.

Planning:
An orderly, logical process by which a diverse group of people can reach defensible decisions based on objective data. Done right, planning prevents jumping from the problem directly to the solution without stopping at reality on the way. In the case of watershed planning, planning also means recording the decisions made by the group, along with enough information that the community at large can understand what the group is doing and why they are doing it.

Trail Creek Watershed Plan - Status:

The Sanitary District held the first Public Meeting in February to introduce the Watershed Plan. Water quality sampling was completed from January 2005 through May 2006 for 12 sample locations within the watershed. The Steering Committee and sub-committees have met several times to order to determine potential problem areas within the watershed, issues of concern, review the data collected, and recommend potential solutions to identified problems.

Draft Watershed Plan should be completed by early fall and submitted to IDEM by the end of the year. A third public meeting will be held to review the draft plan.

Watershed Sampling

Sampling Protocol and Testing

12 Sample Locations

- East Branch – 3 locations
- West Branch – 3 locations
- Main Branch – 6 locations

Sampling Protocol
Water Quality Analysis: Twice monthly during the winter (November through March) and weekly during the summer (April through October) at each of the 12 sample locations.

- conductivity,
- pH,
- temperature,
- dissolved oxygen,
- turbidity,
- total suspended solids (TSS),
- nitrogen ammonia,
- ortho phosphorus,
- total phosphorus,
- *E. coli,*
- biological oxygen demand (BOD) (once monthly)
- TKN,
- and nitrate/nitrite

Biological and Habitat Analysis: One late summer sampling; one storm event at 4 of the 12 sample locations.

Purpose:

The goal of this study is to closely identify potential sources of non-point pollutants (both biological and physical), quantify the extent of that pollution, and evaluate potential programs to effectively reduce pollutant loading within the Trail Creek watershed, as identified in the TMDL and other studies completed within the watershed. Data collected will be utilized to identify potential sources of pollutants and establish baseline conditions of the watershed against which the success of the prevention and remediation methodologies that will be developed may be measured.

Data:

Completed sampling from January 2005 through May 2006. Collected wet and dry weather samples.
Summary Tables are attached.

Sample Site	Field Analysis					Concentration Data Statistics For Trail Creek Watershed Sampleing Points (watersheds)							
	Conductivity	pH	Temperature	Dissolved Oxygen	Turbidity	TSS	Nitrogen Ammonia	Ortho Phosphorus	Total Phosphorus	e.Coli	BOD	TKN	Nitrate + Nitrite
	uS	I.U.	°C	(mg/l)	NTU	< TSS (mg/l) E1	< Nitrogen Ammonia (mg/l) E1	< Ortho Phosphorus (mg/l)	< Total Phosphorus (mg/l) E1	< E coli (col/100) E1	< BOD (mg/l) E1	< TKN (mg/l) E1	< Nitrate + Nitrite (mg/l) E1
E 1													
Averages	545.9361702	8.153191	12.00851	10.2766	12.18723	12.27234043	0.061914894	0.019574468	0.043829787	696	0.761702128	0.519148936	0.384893617
MAX	753.00	9.40	22.10	19.70	166.00	134.00	0.21	0.08	0.46	4100.00	4.90	2.10	1.38
MIN	261.00	7.00	1.90	7.60	2.90	1.80	0.03	0.02	0.02	40.00	2.00	0.50	0.19
E2													
Averages	510.8510638	8.178723	12.28936	10.31277	10.20213	11.2	0.059148936	0.018297872	0.043617021	837.212766	0.719148936	0.488510638	0.38106383
MAX	703.00	8.60	21.90	19.80	123.00	78.00	0.25	0.06	0.32	5060.00	3.80	1.60	1.24
MIN	269.00	7.80	0.90	8.00	3.30	1.80	0.03	0.02	0.02	20.00	2.00	0.50	0.19
E3													0.365319149
Averages	529	8.12766	12.09787	10.22553	11.75106	14.31914894	0.053404255	0.019361702	0.044255319	663.0851064	0.727659574	0.471276596	
MAX	725.00	8.50	20.90	18.90	192.00	172.00	0.20	0.08	0.48	5050.00	4.20	1.80	1.24
MIN	285.00	7.00	1.20	7.80	3.30	1.80	0.03	0.02	0.02	20.00	2.00	0.50	0.04
M1													
Averages	509.2765957	8.042553	12.87021	9.67234	22.20851	25.34893617	0.060425532	0.015957447	0.053617021	768.8723404	0.763829787	0.494680851	0.293829787
MAX	745.00	8.60	23.50	17.40	605.00	552.00	0.24	0.05	0.94	6440.00	5.80	2.40	1.10
MIN	279.00	7.60	1.30	7.50	3.40	1.80	0.04	0.02	0.02	65.00	2.00	0.50	0.14
M2													
Averages	541.3191489	8.187234	12.93617	10.08511	22.73404	26.39574468	0.064680851	0.017446809	0.059148936	719.7234043	0.846808511	0.557659574	0.333829787
MAX	758.00	8.50	23.60	20.10	553.00	516.00	0.21	0.07	1.00	5440.00	5.90	3.30	1.60
MIN	274.00	7.90	1.00	7.40	3.70	1.80	0.02	0.02	0.02	40.00	2.00	0.50	0.16
M3													
Averages	551.8085106	8.178723	13.14468	9.959574	21.22128	24.90638298	0.074042553	0.016382979	0.05787234	900.5531915	1.010638298	0.582978723	0.357234043
MAX	761.00	8.50	24.00	20.20	436.00	428.00	0.28	0.06	0.88	9100.00	8.20	3.10	1.90
MIN	298.00	7.90	0.20	7.00	3.40	1.80	0.04	0.02	0.02	40.00	2.00	0.50	0.10
M4													
Averages	546.6808511	7.989362	13.43617	9.391489	19.5766	27.8893617	0.06787234	0.014680851	0.074255319	586.9787234	0.785106383	0.501276596	0.337021277
MAX	758.00	8.70	23.80	19.90	425.00	556.00	0.25	0.03	0.90	3540.00	6.40	2.70	2.10
MIN	304.00	7.70	1.80	6.50	3.70	1.80	0.05	0.02	0.02	53.00	2.00	0.50	0.10
M5													
Averages	592.6808511	8.076596	13.88723	9.565957	17.77894	18.84680851	0.076382979	0.053404255	0.1	685.4680851	0.85106383	0.56	1.527234043
MAX	795	8.4	25	19	424	358	0.27	0.21	0.74	6100	5.9	2.5	4.4
MIN	331	6.8	2	6.6	3.4	1.8	0.04	0.03	0.05	15	2	0.5	0.5
M6													
Averages	557.1702128	8.104255	14.52553	9.795745	10.45745	11.4	0.09212766	0.037659574	0.07	293.1702128	0.757446809	0.574468085	1.370851064
MAX	801	8.7	26.5	18.7	158	144	0.39	0.12	0.32	2050	4.2	2.2	4.4
MIN	342	6.8	0.5	6.4	2	1.8	0.04	0.02	0.05	10	2	0.5	0.1
W1													
Averages	532.0638298	8.193617	16.28936	10.07872	27.51915	27.27234043	0.096382979	0.018297872	0.062978723	2637.085106	0.791489362	0.6	0.282765957
MAX	846	8.6	189.3	18.7	403	264	0.4	0.08	0.74	9000	5.6	2.7	1.73
MIN	237	7.6	1.5	7.7	4.4	1.8	0.02	0.02	0.03	70	2	0.5	0.1
W2													
Averages	468.0851064	8.234043	11.4617	10.4	28.59574	33.88510638	0.048085106	0.014255319	0.046808511	402.4893617	0.736170213	0.434468085	0.205531915
MAX	696	8.7	18.5	18.2	784	732	0.2	0.05	0.98	2900	3.6	2.9	0.93
MIN	255	7.8	2.8	8.1	3.2	1.8	0.03	0.02	0.02	16	2	0.5	0.1
W3													
Averages	477.3191489	7.942553	11.78936	9.042553	10.5766	21.31489362	0.03893617	0.015744681	0.027021277	204.9574468	0.680851064	0.354680851	0.078085106
MAX	674	8.3	18.2	14.6	46.3	153	0.16	0.05	0.13	1250	2	1.1	0.43
MIN	278	7	4.6	7.5	4.2	1.8	0.03	0.02	0.02	2	2	0.5	0.04

Total Maximum Daily Load

A TMDL (Total Maximum Daily Load), established under section 303(d) of the federal Clean Water Act, is a calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards, and allocates pollutant loadings among point and non-point sources. The calculation must include a margin of safety, which accounts for scientific uncertainty and future growth. Seasonal variations are also included. The TMDL is calculated using the following equation:

TMDL = WLA + LA + MOS + SV

Where:

WLA = Waste Load Allocations (point sources)

LA = Load Allocations (non-point sources)

MOS = Margin of Safety

SV = Seasonal Variation

What is the TMDL Process? A TMDL is a tool for implementing water quality standards and is based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL establishes the allowable loadings or other quantifiable parameters for a water body and thereby provides the basis to establish water quality-based controls. These controls should provide the pollutant reduction necessary for a water body to meet water quality standards.

The TMDL process provides a flexible assessment and planning framework for identifying load reductions or other actions needed to attain water quality standards (i.e. water quality goals to protect aquatic life, drinking water, and other water uses). The process has three steps:

1. Identify Quality Limited Waters - States must identify and prepare a list of waters that do not or are not expected to meet water quality standards after applying existing required controls (e.g. minimum sewage treatment technology).
2. Establish Priority Waters/Watersheds - States must prioritize waters/watersheds and target high priority waters/watersheds for TMDL development.
3. Develop TMDLs - For listed waters, States must develop TMDLs that will achieve water quality standards, allowing for seasonal variations and an appropriate margin of safety. A TMDL is a quantitative assessment of water quality problems, contributing sources, and load reductions or control actions needed to restore and protect individual water bodies.

States are responsible for implementing the TMDL process. EPA reviews and approves lists of quality-limited waters and specific TMDLs. If EPA disapproves lists or TMDLs, EPA is required to establish the lists and/or TMDLs. Landowners, other agencies, and other stakeholders can often assist States or EPA in developing TMDLs for specific watersheds.
http://www.state.in.us/idem/water/planbr/wqs/tmdl/documents.html

TMDL for E. coli in Trail Creek, December 2003
Permitted and Non-point Sources

Permitted Sources of E. coli
- J. B Gifford Wastewater Treatment Plant (Michigan City)
- Friendly Acres Mobile Home Park
- Autumn Creek Mobile Home Park
- Indian Springs Subdivision

Non-point Sources
- Agricultural drainage and run-off
- Livestock
- Failing septic systems
- Illicit connections/non-permitted discharges
- Urban stormwater runoff
- Natural sources

Non-point sources are a function of rainfall, land use, soil type, and source.

Target Concentrations for E. coli are (125 cfu/100 ml – monthly geometric mean and 235 cfu/100 ml – daily maximum).

Point Sources: Waste Load Allocation 5.72×10^{10}

If all permitted point sources operate within their permit limitations the waste load allocation will meet the TMDL.

Non-Point Sources: Load Allocation 9.18×10^{10} to 4.91×10^{10}

Exceeds Load Allocation

Total TMDL: 1.49×10^{11} to 5.48×10^{11}

Data Collected as part of Watershed Management Plan: 3.76×10^{10} to 9.57×10^{14}

East Branch Watershed Sampling Data Analysis Results

Sample Site E1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	263.18	1790.18	2.81	1.07	6.15	4.97E+14	28.06	18.44
Min Load (tons/yr)	14.28	24.05	0.00	0.27	0.27	4.85E+12	6.68	2.54
Median Load (tons/yr)	124.24	163.95	1.27	0.40	0.60	5.79E+13	9.42	6.55
Mean Target Load	93.52	400.79	2.00	0.67	1.00	4.06E+13	13.36	133.60
Median Reduction Needed (%)	N/a	71.76	56.65	37.50	28.57	61.05	16.67	No Reduction Needed

Sample Site E2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	353.36	1392.02	4.46	1.07	5.71	8.19E+14	28.55	22.13
Min Load (tons/yr)	142.77	32.12	0.54	0.36	0.36	3.24E+12	8.92	3.39
Median Load (tons/yr)	164.19	199.88	1.34	0.45	1.07	7.45E+13	12.94	8.57
Mean Target Load	124.93	535.39	2.67	0.89	1.34	5.42E+13	17.85	178.46
Median Reduction Needed (%)	N/a	29.99	45.86	16.67	40.97	56.77	12.88	No Reduction Needed

Sample Site E3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	394.71	3592.09	4.18	1.67	10.02	9.57E+14	37.59	25.90
Min Load (tons/yr)	162.90	37.59	0.63	0.42	0.42	3.79E+12	10.44	0.84
Median Load (tons/yr)	196.31	299.04	1.46	0.63	0.94	9.09E+13	14.41	10.02
Mean Target Load	146.19	626.53	3.12	1.04	1.57	6.35E+13	20.88	208.84
Median Reduction Needed (%)	N/a	47.91	41.51	16.67	44.44	51.36	16.67	No Reduction Needed

Main Branch Watershed Sampling Data Analysis Results

Sample Site M1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	263.18	1790.18	2.81	1.07	6.15	4.97E+14	28.06	18.44
Min Load (tons/yr)	14.28	24.05	0.00	0.27	0.27	4.85E+12	6.68	2.54
Median Load (tons/yr)	124.24	163.95	1.27	0.40	0.60	5.79E+13	9.42	6.55
Mean Target Load	93.52	400.79	2.00	0.67	1.00	4.06E+13	13.36	133.60
Median Reduction Needed (%)	N/a	71.76	56.65	37.50	28.57	61.05	16.67	No Reduction Needed

Sample Site M2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1195.49	30690.16	12.49	4.16	59.48	2.94E+15	196.27	95.16
Min Load (tons/yr)	440.13	107.06	1.19	1.19	1.19	2.16E+13	29.74	9.52
Median Load (tons/yr)	559.08	1569.94	5.35	1.19	2.97	2.27E+14	44.91	22.60
Mean Target Load	416.34	1784.31	8.90	2.97	4.46	1.81E+14	59.48	594.77
Median Reduction Needed (%)	N/a	36.98	56.73	28.57	47.22	56.31	28.57	No Reduction Needed

Sample Site M3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1252.91	26546.71	17.37	3.72	54.58	5.12E+15	192.28	117.85
Min Load (tons/yr)	434.18	111.65	2.48	1.24	1.24	2.25E+13	31.01	0.00
Median Load (tons/yr)	570.63	1544.82	5.58	1.24	3.10	2.03E+14	44.97	24.81
Mean Target Load	434.18	1860.75	9.28	3.10	4.65	1.89E+14	62.03	620.25
Median Reduction Needed (%)	N/a	38.46	53.30	16.67	47.22	60.12	39.34	No Reduction Needed

Sample Site M4 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1239.87	34641.61	15.58	1.87	56.07	2.00E+15	168.22	130.84
Min Load (tons/yr)	404.98	112.15	3.12	1.25	1.25	3.00E+13	31.15	0.00
Median Load (tons/yr)	551.40	1775.42	5.61	1.25	3.12	1.98E+14	44.24	16.82
Mean Target Load	436.14	1869.15	9.32	3.12	4.67	1.89E+14	62.31	623.05
Median Reduction Needed (%)	N/a	48.52	57.46	No Reduction Needed	44.44	49.99	19.87	No Reduction Needed

Sample Site M5 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1390.70	31034.59	19.76	15.37	54.16	4.05E+15	182.99	322.06
Min Load (tons/yr)	483.09	131.75	2.93	2.20	3.66	9.96E+12	36.60	36.60
Median Load (tons/yr)	644.11	1482.27	7.32	5.86	9.88	3.45E+14	58.19	175.67
Mean Target Load	512.36	2195.84	10.95	3.66	5.49	2.22E+14	73.19	731.95
Median Reduction Needed (%)	N/a	42.73	51.18	50.00	64.29	52.73	23.08	No Reduction Needed

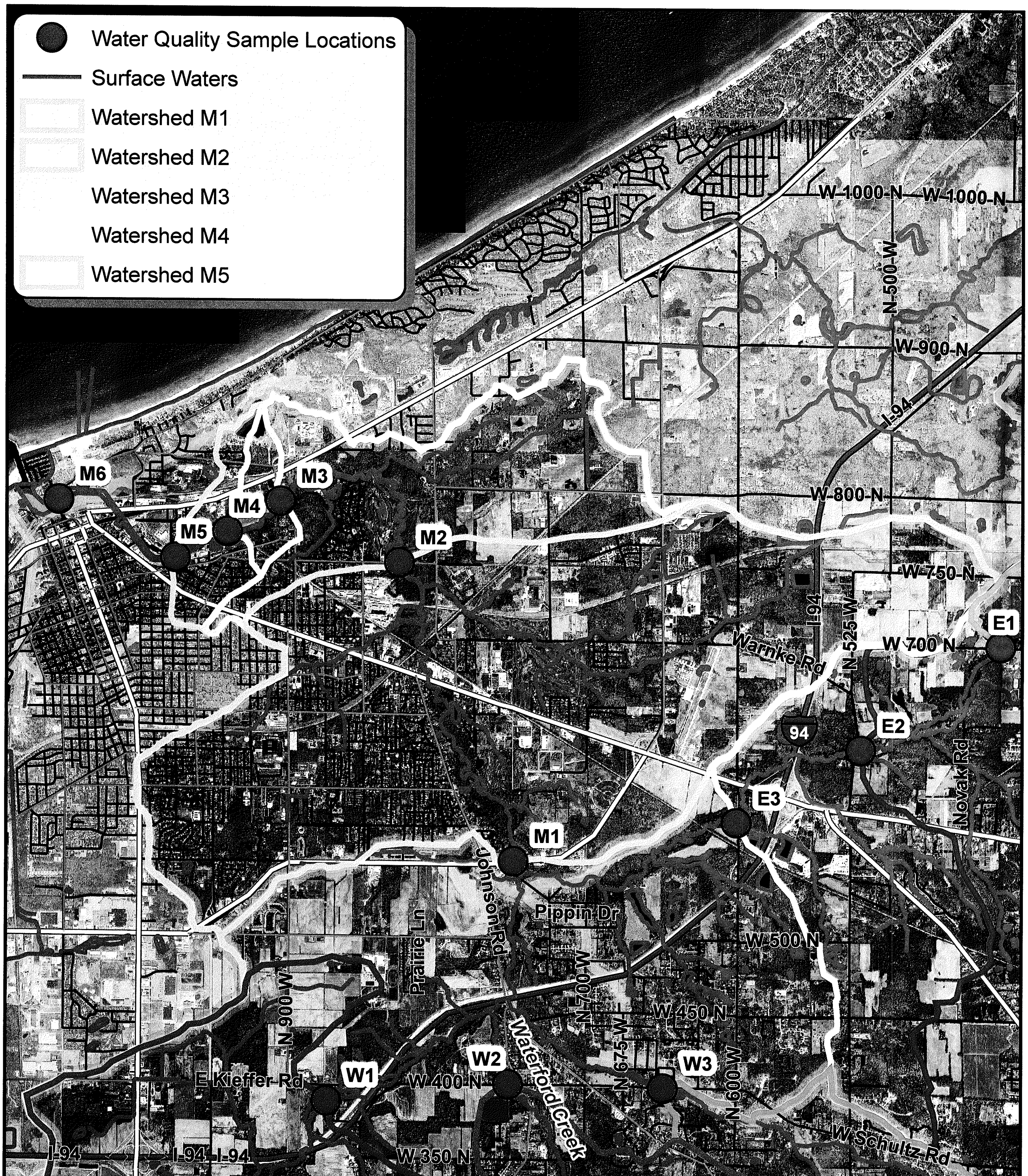
Sample Site M6 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2701.31	9801.22	54.98	9.56	31.08	2.15E+15	289.23	413.18
Min Load (tons/yr)	13.50	8.26	0.10	0.04	0.07	1.25E+11	0.69	0.69
Median Load (tons/yr)	451.25	790.37	6.28	2.48	6.20	5.08E+13	47.10	132.34
Mean Target Load	377.39	1617.38	6.92	2.70	15.49	1.64E+14	53.91	539.13
Median Reduction Needed (%)	N/a	26.83	60.11	28.57	52.27	57.70	22.62	No Reduction Needed

West Branch Watershed Sampling Data Analysis Results

Sample Site W1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	288.93	4079.03	6.18	1.24	11.43	1.26E+15	41.72	26.73
Min Load (tons/yr)	118.97	27.81	0.31	0.31	0.46	9.81E+12	7.73	1.55
Median Load (tons/yr)	142.15	421.38	2.47	0.39	0.93	2.97E+14	13.29	4.87
Mean Target Load	108.16	463.53	2.31	0.77	1.16	4.70E+13	15.45	154.51
Median Reduction Needed (%)	N/a	48.92	37.39	27.08	37.50	87.32	19.87	No Reduction Needed

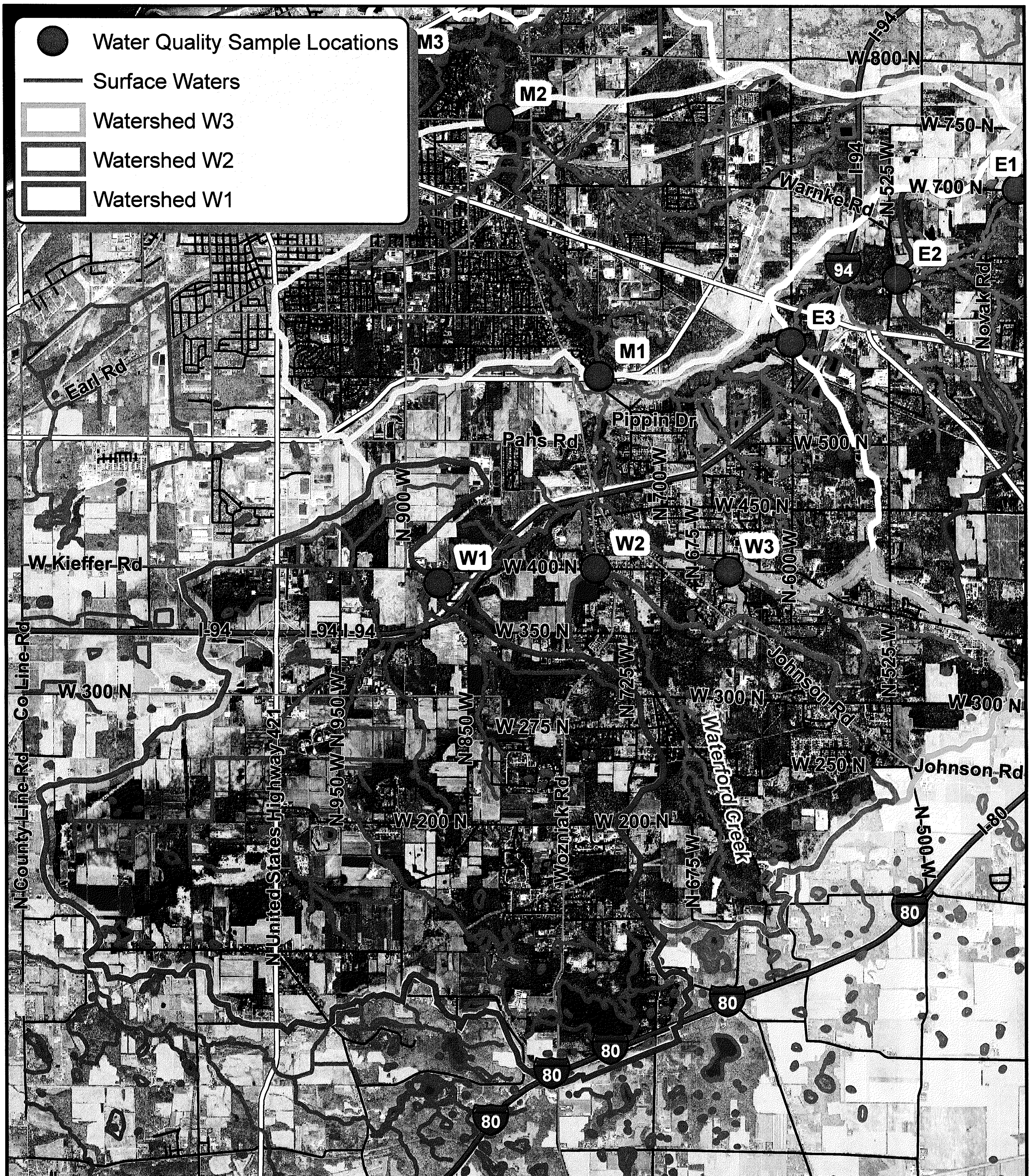
Sample Site W2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	77.08	1736.34	0.85	0.21	4.15	1.11E+14	12.28	3.94
Min Load (tons/yr)	34.30	7.62	0.13	0.08	0.08	6.15E+11	2.12	0.42
Median Load (tons/yr)	41.93	79.23	0.28	0.08	0.11	8.07E+12	2.14	1.23
Mean Target Load	29.64	127.05	0.63	0.21	0.32	1.29E+13	4.23	42.35
Median Reduction Needed (%)	N/a	68.42	41.69	#NUM!	92.01	34.65	56.44	No Reduction Needed

Sample Site W3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	30.26	317.10	0.33	0.10	0.27	2.35E+13	2.28	0.89
Min Load (tons/yr)	15.54	3.73	0.06	0.04	0.04	3.76E+10	1.04	0.08
Median Load (tons/yr)	17.82	44.18	0.12	0.04	0.06	2.63E+12	1.04	0.21
Mean Target Load	14.51	62.18	0.31	0.10	0.16	6.30E+12	2.07	20.73
Median Reduction Needed (%)	N/a	41.61	37.28	No Reduction Needed	37.50	22.87	9.09	No Reduction Needed



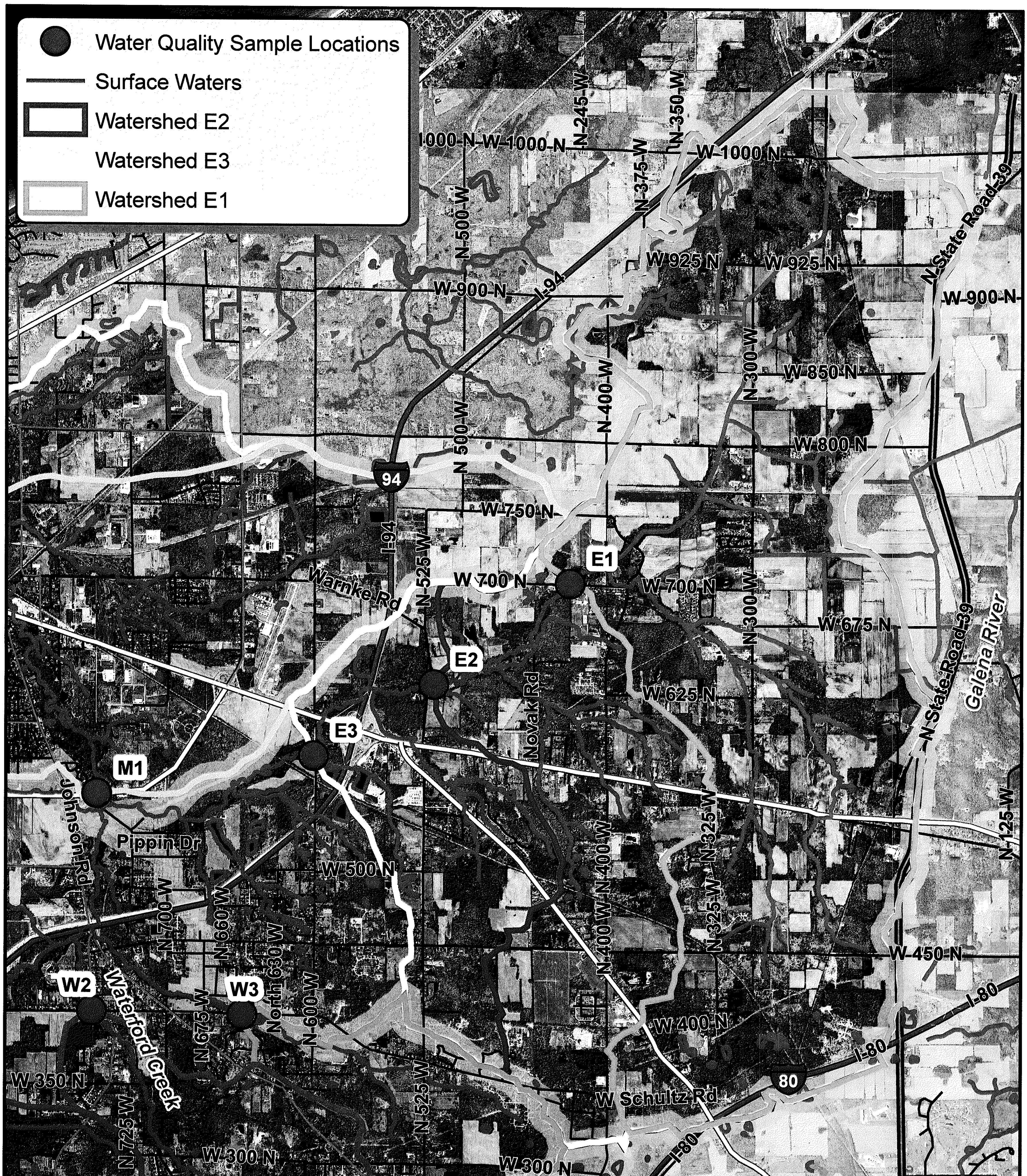
Trail Creek Watershed Plan	**Main Branch Trail Creek Watershed**	Watershed Location
AMERICAN CONSULTING Architects Consultants Engineers 7260 SHADELAND STATION INDIANAPOLIS, IN 46256-3957 PHONE (317) 547-5580 WWW.AMERCONS.COM	SCALE: **NOT TO SCALE**	County: La Porte State: Indiana Sheet: 2 Date: 06/29/06

N



Trail Creek Watershed Plan	West Branch Trail Creek Watershed	Watershed Location
AMERICAN CONSULTING Architects Consultants Engineers 7260 SHADELAND STATION INDIANAPOLIS, IN 46256-3957 PHONE (317) 547-5580 WWW.AMERCONS.COM	SCALE: NOT TO SCALE	County: La Porte State: Indiana Sheet: 3 Date: 06/29/06

N



Trail Creek Watershed Plan

AMERICAN CONSULTING

Architects Consultants Engineers

7260 SHADELAND STATION
INDIANAPOLIS, IN 46256-3957
PHONE (317) 547-5580
WWW.AMERCONS.COM

East Branch Trail Creek Watershed

SCALE:

NOT TO SCALE

Watershed Location

County: La Porte

State: Indiana

Sheet: 4 Date: 06/29/06

N

Trail Creek Land Use Data

Watershed		Land Use Type	Acres	% of watershed	Wetland Type	Acres	% of watershed
Trail Creek		Developed Agriculture Pasture/Grassland	4974.53	13.13%	Palustrine emergent	453.23	1.20%
		Developed Agriculture Row Crop	9657.30	25.48%	Palustrine forested	2804.27	7.40%
		Developed Non-Vegetated	533.94	1.41%	Palustrine scrub/shrub	209.90	0.55%
		Developed Urban High Density	1360.45	3.59%	Palustrine submergent	5.78	0.02%
		Developed Urban Low Density	1567.46	4.14%	Ponds	25.94	0.07%
		Palustrine Forest Deciduous	3470.64	9.16%	Riverine	9.31	0.02%
		Palustrine Herbaceous Deciduous	285.72	0.75%			
		Palustrine Shrubland Deciduous	20.37	0.05%			
		Palustrine Woodland Deciduous	3.15	0.01%			
		Terrestrial Forest Deciduous	14251.35	37.60%			
		Terrestrial Forest Evergreen	208.63	0.55%			
		Terrestrial Forest Mixed	82.46	0.22%			
		Terrestrial Shrubland Deciduous	684.48	1.81%			
		Terrestrial Woodland Deciduous	402.57	1.06%			
		Unclassified Cloud/Shadow	234.54	0.62%			
		Water	160.68	0.42%			
	Total Acres		**37898.27**			**3508.43**	
	Percentage of Trail Creek Watershed		**100.00%**		Percentage of Trail Creek Watershed Containing Wetlands	**9.26%**	
Main Branch of Trail Creek							
		Developed Agriculture Pasture/Grassland	896.65	10.43%	Palustrine emergent	60.99	0.71%
		Developed Agriculture Row Crop	1067.30	12.41%	Palustrine forested	654.17	7.61%
		Developed Non-Vegetated	173.34	2.02%	Palustrine scrub/shrub	36.96	0.43%
		Developed Urban High Density	1213.18	14.11%	Palustrine submergent	2.22	0.03%
		Developed Urban Low Density	1353.46	15.74%	Ponds	3.96	0.05%
		Palustrine Forest Deciduous	802.14	9.33%	Riverine	9.31	0.11%
		Palustrine Herbaceous Deciduous	21.02	0.24%			
		Palustrine Woodland Deciduous	3.15	0.04%			
		Terrestrial Forest Deciduous	2770.09	32.21%			
		Terrestrial Forest Mixed	2.86	0.03%			
		Terrestrial Shrubland Deciduous	97.69	1.14%			
		Terrestrial Woodland Deciduous	126.48	1.47%			
		Water	71.61	0.83%			
	Total Acres		**8598.97**			**767.70**	
	Percentage of Trail Creek Watershed		**22.69%**		Percentage Sub-Watershed containing Wetlands	**8.93%**	
West Branch Of Trail Creek							
		Developed Agriculture Pasture/Grassland	1521.60	10.91%	Palustrine emergent	210.47	1.51%
		Developed Agriculture Row Crop	3876.38	27.79%	Palustrine forested	1330.28	9.54%
		Developed Non-Vegetated	152.67	1.09%	Palustrine scrub/shrub	36.39	0.26%
		Developed Urban High Density	20.10	0.14%	Palustrine submergent	1.89	0.01%
		Developed Urban Low Density	63.10	0.45%	Ponds	6.80	0.05%
		Palustrine Forest Deciduous	1620.26	11.61%			
		Palustrine Herbaceous Deciduous	129.83	0.93%			
		Palustrine Shrubland Deciduous	6.42	0.05%			
		Terrestrial Forest Deciduous	5756.76	41.27%			
		Terrestrial Forest Evergreen	126.88	0.91%			
		Terrestrial Forest Mixed	29.66	0.21%			
		Terrestrial Shrubland Deciduous	254.80	1.83%			
		Terrestrial Woodland Deciduous	93.72	0.67%			
		Unclassified Cloud/Shadow	229.07	1.64%			
		Water	68.81	0.49%			
	Total Acres		**13950.08**			**1585.83**	
	Percentage of Trail Creek Watershed		**36.81%**		Percentage Sub-Watershed containing Wetlands	**11.37%**	
East Branch Of Trail Creek							
		Developed Agriculture Pasture/Grassland	2556.28	16.65%	Palustrine emergent	181.77	1.18%
		Developed Agriculture Row Crop	4713.62	30.71%	Palustrine forested	819.82	5.34%
		Developed Non-Vegetated	207.93	1.35%	Palustrine scrub/shrub	136.55	0.89%
		Developed Urban High Density	127.17	0.83%	Palustrine submergent	1.66	0.01%
		Developed Urban Low Density	150.90	0.98%	Ponds	15.19	0.10%
		Palustrine Forest Deciduous	1048.24	6.83%			
		Palustrine Herbaceous Deciduous	134.86	0.88%			
		Palustrine Shrubland Deciduous	13.95	0.09%			
		Terrestrial Forest Deciduous	5724.49	37.30%			
		Terrestrial Forest Evergreen	81.74	0.53%			
		Terrestrial Forest Mixed	49.94	0.33%			
		Terrestrial Shrubland Deciduous	332.00	2.16%			
		Terrestrial Woodland Deciduous	182.37	1.19%			
		Unclassified Cloud/Shadow	5.47	0.04%			
		Water	20.26	0.13%			
	Total Acres		**15349.21**			**1154.98**	
	Percentage of Trail Creek Watershed		**40.50%**		Percentage Sub-Watershed containing Wetlands	**7.52%**	

Trail Creek Land Use Data

Watershed		Land Use Type	Acres	% of Sampling Watershed	Wetland Type	Acres	% of Sampling Watershed
Trail Creek Watershed			37898.27				
East Branch							
		Developed Agriculture Pasture/Grassland	2556.28	16.65%	Palustrine emergent	181.77	1.18%
		Developed Agriculture Row Crop	4713.62	30.71%	Palustrine forested	819.82	5.34%
		Developed Non-Vegetated	207.93	1.35%	Palustrine scrub/shrub	136.55	0.89%
		Developed Urban High Density	127.17	0.83%	Palustrine submergent	1.66	0.01%
		Developed Urban Low Density	150.90	0.98%	Ponds	15.19	
		Palustrine Forest Deciduous	1048.24	6.83%			
		Palustrine Herbaceous Deciduous	134.86	0.88%			
		Palustrine Shrubland Deciduous	13.95	0.09%			
		Terrestrial Forest Deciduous	5724.49	37.30%			
		Terrestrial Forest Evergreen	81.74	0.53%			
		Terrestrial Forest Mixed	49.94	0.33%			
		Terrestrial Shrubland Deciduous	332.00	2.16%			
		Terrestrial Woodland Deciduous	182.37	1.19%			
		Unclassified Cloud/Shadow	5.47	0.04%			
		Water	20.26	0.13%			
	Total		**15349.21**			**1154.98**	
	Percentage	Of Trail Creek Watershed	**40.50%**		Of wetlands in Sampling Watershed	**7.52%**	
E1							
		Developed Agriculture Pasture/Grassland	828.98	10.51%	Palustrine emergent	148.10	1.88%
		Developed Agriculture Row Crop	2652.71	33.63%	Palustrine forested	1025.21	13.00%
		Developed Non-Vegetated	42.81	0.54%	Palustrine scrub/shrub	35.04	0.44%
		Developed Urban High Density	15.48	0.20%	Palustrine submergent	0.38	0.00%
		Developed Urban Low Density	23.66	0.30%	Ponds	3.93	0.05%
		Palustrine Forest Deciduous	1251.93	15.87%			
		Palustrine Herbaceous Deciduous	98.16	1.24%			
		Terrestrial Forest Deciduous	2436.82	30.89%			
		Terrestrial Forest Evergreen	57.85	0.73%			
		Terrestrial Forest Mixed	14.13	0.18%			
		Terrestrial Shrubland Deciduous	159.17	2.02%			
		Terrestrial Woodland Deciduous	65.31	0.83%			
		Unclassified Cloud/Shadow	228.78	2.90%			
		Water	11.98	0.15%			
	Total		**7887.77**			**1212.65**	
	Percentage	Of Trail Creek Watershed	**20.81%**		Of wetlands in Sampling Watershed	**15.37%**	
E2							
		Developed Agriculture Pasture/Grassland	1105.23	10.49%	Palustrine emergent	186.18	1.77%
		Developed Agriculture Row Crop	3385.58	32.13%	Palustrine forested	1152.19	10.93%
		Developed Non-Vegetated	67.27	0.64%	Palustrine scrub/shrub	35.08	0.33%
		Developed Urban High Density	15.29	0.15%	Palustrine submergent	1.89	0.02%
		Developed Urban Low Density	38.69	0.37%	Ponds	6.31	0.06%
		Palustrine Forest Deciduous	1418.45	13.46%			
		Palustrine Herbaceous Deciduous	111.33	1.06%			
		Terrestrial Forest Deciduous	3719.96	35.30%			
		Terrestrial Forest Evergreen	111.81	1.06%			
		Terrestrial Forest Mixed	19.62	0.19%			
		Terrestrial Shrubland Deciduous	219.87	2.09%			
		Terrestrial Woodland Deciduous	72.44	0.69%			
		Unclassified Cloud/Shadow	229.91	2.18%			
		Water	21.50	0.20%			
	Total		**10536.94**			**1381.66**	
	Percentage	Of Trail Creek Watershed	**27.80%**		Of wetlands in Sampling Watershed	**13.11%**	
E3							
		Developed Agriculture Pasture/Grassland	1310.14	10.63%	Palustrine emergent	205.60	1.67%
		Developed Agriculture Row Crop	3670.73	29.77%	Palustrine forested	1262.83	10.24%
		Developed Non-Vegetated	134.41	1.09%	Palustrine scrub/shrub	35.02	0.28%
		Developed Urban High Density	20.05	0.16%	Palustrine submergent	1.89	0.02%
		Developed Urban Low Density	42.39	0.34%	Ponds	6.78	0.05%
		Palustrine Forest Deciduous	1539.36	12.48%			
		Palustrine Herbaceous Deciduous	118.03	0.96%			
		Terrestrial Forest Deciduous	4767.94	38.67%			
		Terrestrial Forest Evergreen	111.81	0.91%			
		Terrestrial Forest Mixed	19.63	0.16%			
		Terrestrial Shrubland Deciduous	244.71	1.98%			
		Terrestrial Woodland Deciduous	87.20	0.71%			
		Unclassified Cloud/Shadow	229.11	1.86%			
		Water	35.01	0.28%			
	Total		**12330.51**			**1512.13**	
	Percentage	Of Trail Creek Watershed	**32.54%**		Of wetlands in Sampling Watershed	**12.26%**	

Trail Creek Land Use Data

Watershed		Land Use Type	Acres	% of Sampling Watershed	Wetland Type	Acres	% of Sampling Watershed
Trail Creek Watershed			37898.2678				
Main Branch (M6)							
		Developed Agriculture Pasture/Grassland	896.65	0.10	Palustrine emergent	60.99	0.01
		Developed Agriculture Row Crop	1067.30	0.12	Palustrine forested	654.17	0.08
		Developed Non-Vegetated	173.34	0.02	Palustrine scrub/shrub	36.96	0.00
		Developed Urban High Density	1213.18	0.14	Palustrine submergent	2.22	0.00
		Developed Urban Low Density	1353.46	0.16	Ponds	3.96	0.00
		Palustrine Forest Deciduous	802.14	0.09	Riverine	9.31	0.00
		Palustrine Herbaceous Deciduous	21.02	0.00			
		Palustrine Woodland Deciduous	3.15	0.00			
		Terrestrial Forest Deciduous	2770.09	0.32			
		Terrestrial Forest Mixed	2.86	0.00			
		Terrestrial Shrubland Deciduous	97.69	0.01			
		Terrestrial Woodland Deciduous	126.48	0.01			
		Water	71.61	0.01			
	Total		**8598.97**			**767.61**	
	Percentage	Of Trail Creek Watershed	**22.69%**		Of wetlands in Sub-watershed	**8.93%**	
M1							
		Developed Agriculture Pasture/Grassland	4081.96	0.14	Palustrine emergent	396.14	0.01
		Developed Agriculture Row Crop	8595.25	0.29	Palustrine forested	2170.83	0.07
		Developed Non-Vegetated	363.84	0.01	Palustrine scrub/shrub	172.90	0.01
		Developed Urban High Density	159.47	0.01	Palustrine submergent	3.55	0.00
		Developed Urban Low Density	219.97	0.01	Ponds	22.00	0.00
		Palustrine Forest Deciduous	2688.79	0.09			
		Palustrine Herbaceous Deciduous	268.88	0.01			
		Palustrine Shrubland Deciduous	20.37	0.00			
		Terrestrial Forest Deciduous	11509.67	0.39			
		Terrestrial Forest Evergreen	208.63	0.01			
		Terrestrial Forest Mixed	79.56	0.00			
		Terrestrial Shrubland Deciduous	586.65	0.02			
		Terrestrial Woodland Deciduous	276.25	0.01			
		Unclassified Cloud/Shadow	235.93	0.01			
		Water	89.05	0.00			
	Total		**29384.26**			**2765.43**	
	Percentage	Of Trail Creek Watershed	**77.53%**		Of wetlands in Sampling Watershed	**9.41%**	
M2							
		Developed Agriculture Pasture/Grassland	4822.53	0.14	Palustrine emergent	439.89	0.01
		Developed Agriculture Row Crop	9394.17	0.27	Palustrine forested	2601.71	0.07
		Developed Non-Vegetated	506.55	0.01	Palustrine scrub/shrub	183.61	0.01
		Developed Urban High Density	624.79	0.02	Palustrine submergent	5.78	0.00
		Developed Urban Low Density	1124.09	0.03	Ponds	22.79	0.00
		Palustrine Forest Deciduous	3224.77	0.09	Riverine	0.07	0.00
		Palustrine Herbaceous Deciduous	285.17	0.01			
		Palustrine Shrubland Deciduous	20.37	0.00			
		Terrestrial Forest Deciduous	13400.42	0.38			
		Terrestrial Forest Evergreen	208.69	0.01			
		Terrestrial Forest Mixed	82.43	0.00			
		Terrestrial Shrubland Deciduous	679.84	0.02			
		Terrestrial Woodland Deciduous	394.36	0.01			
		Unclassified Cloud/Shadow	234.88	0.01			
		Water	113.57	0.00			
	Total		**35116.63**			**3253.85**	
	Percentage	Of Trail Creek Watershed	**92.66%**		Of wetlands in Sampling Watershed	**9.27%**	
M3							
		Developed Agriculture Pasture/Grassland	4969.68	0.14	Palustrine emergent	452.95	0.01
		Developed Agriculture Row Crop	9639.38	0.26	Palustrine forested	2789.58	0.08
		Developed Non-Vegetated	525.28	0.01	Palustrine scrub/shrub	210.36	0.01
		Developed Urban High Density	694.79	0.02	Palustrine submergent	5.78	0.00
		Developed Urban Low Density	1196.95	0.03	Ponds	26.01	0.00
		Palustrine Forest Deciduous	3450.93	0.09	Riverine	9.31	0.00
		Palustrine Herbaceous Deciduous	286.00	0.01			
		Palustrine Shrubland Deciduous	20.37	0.00			
		Terrestrial Forest Deciduous	14113.54	0.39			
		Terrestrial Forest Evergreen	208.65	0.01			
		Terrestrial Forest Mixed	82.50	0.00			
		Terrestrial Shrubland Deciduous	684.18	0.02			
		Terrestrial Woodland Deciduous	400.21	0.01			
		Unclassified Cloud/Shadow	235.41	0.01			
		Water	113.15	0.00			
	Total		**36621.02**			**3493.98**	
	Percentage	Of Trail Creek Watershed	**96.63%**		Of wetlands in Sampling Watershed	**9.54%**	
M4		Developed Agriculture Pasture/Grassland	4970.84	0.14	Palustrine emergent	452.92	0.01
		Developed Agriculture Row Crop	9647.95	0.26	Palustrine forested	2804.72	0.08
		Developed Non-Vegetated	529.56	0.01	Palustrine scrub/shrub	210.21	0.01
		Developed Urban High Density	728.02	0.02	Palustrine submergent	5.78	0.00
		Developed Urban Low Density	1214.00	0.03	Ponds	25.90	0.00
		Palustrine Forest Deciduous	3470.65	0.09	Riverine	9.31	0.00
		Palustrine Herbaceous Deciduous	286.00	0.01			
		Palustrine Shrubland Deciduous	20.37	0.00			
		Palustrine Woodland Deciduous	1.53	0.00			
		Terrestrial Forest Deciduous	14185.82	0.39			
		Terrestrial Forest Evergreen	208.66	0.01			
		Terrestrial Forest Mixed	82.43	0.00			
		Terrestrial Shrubland Deciduous	684.40	0.02			
		Terrestrial Woodland Deciduous	400.23	0.01			
		Unclassified Cloud/Shadow	236.21	0.01			
		Water	119.67	0.00			
	Total		**36786.35**			**3508.84**	
	Percentage	Of Trail Creek Watershed	**97.07%**		Of wetlands in Sampling Watershed	**9.54%**	
M5		Developed Agriculture Pasture/Grassland	4975.51	0.13	Palustrine emergent	453.10	0.01
		Developed Agriculture Row Crop	9652.57	0.26	Palustrine forested	2804.86	0.08
		Developed Non-Vegetated	532.53	0.01	Palustrine scrub/shrub	210.05	0.01
		Developed Urban High Density	822.61	0.02	Palustrine submergent	5.78	0.00
		Developed Urban Low Density	1328.33	0.04	Ponds	25.99	0.00
		Palustrine Forest Deciduous	3471.01	0.09	Riverine	9.31	0.00
		Palustrine Herbaceous Deciduous	285.57	0.01			
		Palustrine Shrubland Deciduous	20.37	0.00			
		Palustrine Woodland Deciduous	3.15	0.00			
		Terrestrial Forest Deciduous	14227.88	0.38			
		Terrestrial Forest Evergreen	208.59	0.01			
		Terrestrial Forest Mixed	82.45	0.00			
		Terrestrial Shrubland Deciduous	684.42	0.02			
		Terrestrial Woodland Deciduous	402.71	0.01			
		Unclassified Cloud/Shadow	235.17	0.01			
		Water	141.82	0.00			
	Total		**37074.69**			**3509.09**	
	Percentage	Of Trail Creek Watershed	**97.83%**		Of wetlands in Sampling Watershed	**9.46%**	

Trail Creek Land Use Data

Watershed		Land Use Type	Acres	% of Sampling Watershed	Wetland Type	Acres	% of Sampling Watershed
Trail Creek Watershed			37898.27				
West Branch							
		Developed Agriculture Pasture/Grassland	1521.60	10.91%	Palustrine emergent	210.47	1.51%
		Developed Agriculture Row Crop	3876.38	27.79%	Palustrine forested	1330.28	9.54%
		Developed Non-Vegetated	152.67	1.09%	Palustrine scrub/shrub	36.39	0.26%
		Developed Urban High Density	20.10	0.14%	Palustrine submergent	1.89	0.01%
		Developed Urban Low Density	63.10	0.45%	Ponds	6.80	0.05%
		Palustrine Forest Deciduous	1620.26	11.61%			
		Palustrine Herbaceous Deciduous	129.83	0.93%			
		Palustrine Shrubland Deciduous	6.42	0.05%			
		Terrestrial Forest Deciduous	5756.76	41.27%			
		Terrestrial Forest Evergreen	126.88	0.91%			
		Terrestrial Forest Mixed	29.66	0.21%			
		Terrestrial Shrubland Deciduous	254.80	1.83%			
		Terrestrial Woodland Deciduous	93.72	0.67%			
		Unclassified Cloud/Shadow	229.07	1.64%			
		Water	68.81	0.49%			
	Total		**13950.08**			**1585.83**	
	Percentage	Of Trail Creek Watershed	**36.81%**		Of wetlands in Sub-watershed	**11.37%**	
W1							
		Developed Agriculture Pasture/Grassland	1534.44	16.82%	Palustrine emergent	120.87	1.32%
		Developed Agriculture Row Crop	3520.36	38.59%	Palustrine forested	639.64	7.01%
		Developed Non-Vegetated	159.08	1.74%	Palustrine scrub/shrub	112.35	1.23%
		Developed Urban High Density	49.24	0.54%	Palustrine submergent	1.49	0.02%
		Developed Urban Low Density	20.51	0.22%	Ponds	13.22	0.14%
		Palustrine Forest Deciduous	793.83	8.70%			
		Palustrine Herbaceous Deciduous	99.45	1.09%			
		Palustrine Shrubland Deciduous	13.95	0.15%			
		Terrestrial Forest Deciduous	2535.43	27.79%			
		Terrestrial Forest Evergreen	28.37	0.31%			
		Terrestrial Forest Mixed	44.41	0.49%			
		Terrestrial Shrubland Deciduous	182.17	2.00%			
		Terrestrial Woodland Deciduous	115.65	1.27%			
		Unclassified Cloud/Shadow	5.44	0.06%			
		Water	20.26	0.22%			
	Total		**9122.58**			**887.58**	
	Percentage	Of Trail Creek Watershed	**24.07%**		Of wetlands in Sampling Watershed	**9.73%**	
W2							
		Developed Agriculture Pasture/Grassland	317.39	12.69%	Palustrine emergent	20.33	0.81%
		Developed Agriculture Row Crop	311.30	12.45%	Palustrine forested	112.25	4.49%
		Developed Urban Low Density	18.26	0.73%	Palustrine scrub/shrub	3.88	0.16%
		Palustrine Forest Deciduous	128.00	5.12%	Palustrine submergent	0.16	0.01%
		Palustrine Herbaceous Deciduous	9.49	0.38%	Ponds	0.78	0.03%
		Terrestrial Forest Deciduous	1618.08	64.71%			
		Terrestrial Forest Evergreen	22.80	0.91%			
		Terrestrial Forest Mixed	2.26	0.09%			
		Terrestrial Shrubland Deciduous	42.82	1.71%			
		Terrestrial Woodland Deciduous	30.05	1.20%			
	Total		**2500.43**			**137.40**	
	Percentage	Of Trail Creek Watershed	**6.60%**		Of wetlands in Sampling Watershed	**5.49%**	
W3							
		Developed Agriculture Pasture/Grassland	139.74	11.42%	Palustrine emergent	0.95	0.08%
		Developed Agriculture Row Crop	267.38	21.85%	Palustrine scrub/shrub	11.33	0.93%
		Developed Urban Low Density	2.12	0.17%	Ponds	1.00	0.08%
		Palustrine Forest Deciduous	16.40	1.34%			
		Terrestrial Forest Deciduous	724.04	59.17%			
		Terrestrial Forest Evergreen	19.97	1.63%			
		Terrestrial Forest Mixed	3.28	0.27%			
		Terrestrial Shrubland Deciduous	45.15	3.69%			
		Terrestrial Woodland Deciduous	5.62	0.46%			
	Total		**1223.69**			**13.28**	
	Percentage	Of Trail Creek Watershed	**3.23%**		Of wetlands in Sampling Watershed	**1.09%**	

Appendix J: Third Public Involvement and Stakeholder Meeting Press Release

PRESS RELEASE

Sanitary District of Michigan City · 1100 E. 8th Street · Michigan City, IN 46360

For more information contact:
Al Walus, General Manager
(219) 874-7799

FOR IMMEDIATE RELEASE
September 29, 2006

3rd Public Meeting Announced for the Trail Creek Watershed Management Plan Update

Michigan City, IN – The third of four Public Involvement and Stakeholder Meetings for the Trail Creek Watershed Management Plan Update is scheduled for Monday, October 16, 2006, at 7:00 p.m. in the City Hall Council Chambers in Michigan City. The general public is encouraged to attend and provide input regarding the goals and objectives of the Watershed Management Plan.

During the Public Meeting on October 16th, public input will be solicited on draft goals and objectives targeting both the reduction of *E. coli.* and sedimentation within the Trail Creek waterway. Specific options will be offered with short-term outcomes expected within 1-2 years; mid-term outcomes within 3-5 years; and long-term outcomes within 10 years.

With a diversity of land uses throughout the watershed ranging from urban to rural and agricultural, a wide variety of measures will need to be implemented over time in order to achieve measurable water quality improvements throughout the entire watershed. Different pollutant reduction measures will be proposed for each of the different land use zones of the watershed.

The Trail Creek watershed encompasses an area of 59 square miles throughout parts of Michigan Township, Coolspring Township, Springfield Township and Center Township; extending as far south as the I-80 Toll Road and as far east as State Road 39.

For questions regarding the project or participation, please contact Al Walus of the Sanitary District of Michigan City at 219-874-7799, or Christine Meador of American Consulting at 317-547-5580.

###

Appendix K: Third Public Involvement and Stakeholder Meeting Agenda and Information Materials

<u>**Agenda for Public Meeting #3, Monday, October 16, 2006**</u>

<u>**Opportunities to Improve Water Quality Across the ENTIRE Trail Creek Watershed**</u>

Who has helped improve water quality since 1993?

Promote agricultural best management practices: wildlife watering areas, grass waterways & filter strips.

Restore ecological integrity through restoration: j-hooks and lunkers.

Diminish priority pollutant loads: storm sewer separation, sanitary sewer extension & CSO disinfection.

Enhance public access & preservation: Hansen Park, Peanut Bridge, Trail Creek Greenways & Karwick Nature Park.

What are concerns of 2006? **High levels of E. coli bacteria; sedimentation; excessive nutrient loading; and hydromodification (hydromodification--changing the natural hydrology of the creek).**

Where are the problem areas? **From the Trail Creek headwaters to Lake Michigan: E. coli, sedimentation, nutrient loading and hydromodification are *EVERYWHERE* to a certain extent.**

How can we help?

Vision: Through collaborative efforts, we can provide the stewardship and leadership required now in order for future generations to enjoy the natural beauty and prosperity of a clean Trail Creek.

Misison: Citizens of the Trail Creek Watershed will assess water quality issues and develop meaningful implementation strategies targeted to improve the quality of life within the watershed through water quality enhancement and realization of the long term goals with regard to the environmental, recreational and aesthetic use of our Lake Michigan lakefront and Trail Creek.

Stop making things worse		Reduce existing E. coli pollution, sedimentation & nutrient loading				Preservation
Opportunity: New Development	**Opportunity: Planning**	**Opportunity: Human Waste**	**Opportunity: Animal Waste**	**Opportunity: Stormwater Drainage**	**Opportunity: Human Habits**	**Opportunity: Preservation**
Pursue education and outreach to developers and contractors	Support the Countywide Land Development Plan	Develop sanitary sewer extension options for high-priority un-sewered urban areas along Trail Creek	Identify sources of livestock waste deposited directly to waterways & begin eliminating this practice	Convert to 2-tier ditch construction to minimize erosion and the transport of sedimentation	Promote lawn fertilization practices that minimize nutrient-laden storm runoff	Work with existing local groups to preserve high-priority wetland areas that are critical natural resources
Support existing programs (MS4) that regulate erosion control and stormwater drainage	Ensure consistency with NIRPC, MS4 & 6217 (Coastal Nonpoint Pollution Control) plans	Conduct public education and outreach on the care and operation of septic systems	Reduce runoff from manure piles and pastures near Trail Creek tributaries	In high priority areas, retrofit existing storm water sewer systems to include water quality features	Modify ditch maintenance procedures to conform with current sediment reduction methods	Create greenway areas and trails that connect sensitive areas and increase public access
Promote the use of proven Low Impact Development (LID) methods	Implement countywide stormwater quantity ordinance to minimize wet weather creek flow increases	Support existing programs that identify and eliminate illicit discharges of human waste	Conduct education and outreach to assist farmers with Conservation Management Plans	For row crop fields adjacent to water bodies, seek buffers and Conservation Management Plans	Re-evaluate wintertime salt & sand road applications to reduce salt & sand runoff into Trail Creek	Identify high priority areas for stream bank restoration to preserve the creek's natural hydrograph
Encourage on-site infiltration basins and constructed wetlands for stormwater treatment	Create setback standards (buffer zones) for stream bank protection and sediment/nutrient reduction	Implement the "Clean Marinas" program in all Trail Creek marinas	Educate public regarding impacts of pet waste	Install a sediment trap in Trail Creek as an interim stop gap measure	Promote the use of rain barrels to capture water for garden use	Coordinate efforts by stakeholders and communicate local successes
		Goals for E. coli reduction				

Progress towards reaching these goals will improve Trail Creek water quality by: lowering E. coli. levels; reducing sedimentation; minimizing nutrient loading; and reversing the effects of hydromodification

Why should we help?

IDEM issued a detailed study in 2003 regarding E. coli pollution in the 59 square mile Trail Creek watershed. IDEM concluded that "nonpoint sources will need to be monitored locally for implementation of Best Management Practices or in providing access to watershed grants to assist in reducing nonpoint sources to meet the Load Allocations developed under this TMDL (Total Maximum Daily Load report). In other words, solving the E. coli pollution problem is up to us.

When do we start?

We must start now, with a three-tier level of goal achievement: Short-Term goals in 1-2 years; Mid-Term goals in 5 years; & attainment of Water Quality Standards in 10 years.

2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017

Attainment of Water Quality Standards in Trail Creek

Short-Term Goals (2007–2009) — Mid-Term Goals (2009–2012) — Long-Term Goals (2012–2017)

1993 Watershed Management Plan Goals

Four goals were identified for the watershed management plan for the stream of Trail Creek. These goals were approved by the Trail Creek Watershed Management Resource Committee and subsequent meetings, which focused on the different goals, were conducted to develop specific objectives in accomplishing each goal.

Goal 1: Reduce potential health hazards due to poor water quality in the stream of Trail Creek.

Objective 1: Diminish priority pollutant loads delivered to the stream of Trail Creek to improve water quality conditions.

a. Develop a priority pollutant list into three categories: historic, present and stormwater.

b. Identify areas or sources of pollutants.

c. Establish target parameters for turbidity, dissolved oxygen, biological oxygen demand, sedimentation rates, and chemical contamination.

d. Analyze the discharge from each outfall and assess the risk to the stream of Trail Creek.

e. Educate the public about the consequences of dumping solvent down household or street drains.

f. Coordinate a "Tox-away" day to collect hazardous household chemicals and educate the public on proper disposal for common household products and nontoxic substitutions.

Objective 2: Encourage proper Stormwater and erosion control management in developing areas, and retrofit developed areas where feasible.

a. Identify locations for wetland restoration and development within the watershed.

b. Construct sediment ponds or French drains at Stormwater outfalls to allow pollutants to settle out of the discharge before entering the stream of Trail Creek.

c. Encourage Michigan City; Pottawattomie Park, the Town of Trail Creek and LaPorte County to adopt local ordinances that support already existing State and Federal laws that regulate wetlands.

d. Encourage Michigan City, Pottawattomie Park, the Town of Trail Creek and LaPorte County to adopt local ordinances that support existing State and Federal laws that control soil erosion on construction sites.

e. Encourage Michigan City, Pottawattomie Park, the Town of Trail Creek and LaPorte County to adopt local ordinances that support existing State and Federal laws that require storm water management on commercial, industrial and residential developments.

Objective 3: Secure funding to install sanitary sewers .and a collector line so that the Town of Trail Creek and Pottawattomie Park can discharge to the Michigan City Sanitary District. At a minimum, provide service to the homes along the stream of Trail Creek and those residents who are experiencing septic system failures.

Goal 2: Improve aquatic life support.

Objective 1: Promote agricultural best management practices.

a. Encourage farmers to use integrated crop management practices such as scouting the fields for insects before pesticides are applied and testing the soils to avoid over fertilizing the fields.

b. Persuade one landowner to participate in the Section 319 grant awarded to the LaPorte County Soil and Water Conservation District for one demonstration project to restrict livestock access to the stream of Trail Creek while providing an alternate water source such as a well or artesian spring.

c. Coordinate a "Chemical Container Disposal" day to collect for agricultural product containers and educate the agricultural community on the proper storing and application of agricultural products.

Objective 2: Protect and restore the ecological integrity of Trail Creek utilizing natural streambank restoration methods to stabilize eroding banks.

a. Demonstrate and monitor the effectiveness of the IDNR Division of Fish and Wildlife recommended streambank restoration methods at the eight selected sites.

b. Develop ordinances for excavating and maintaining legal drains to minimize bank erosion downstream.

Objective 3: Establish a baseline study on the benthic communities that inhibit the stream of Trail Creek.

a. Involve the local municipal and county schools in obtaining the baseline data.

b. Use the benthic organism study as an assessment tool for the watershed management plan.

Goal 3: Increase quality/quantity of recreational opportunities to stimulate economic growth.

Objective 1: Prompt the USACE to construct a sediment trap upstream of "E" Street bridge to reduce the occurrence of dredging and prevent clean sediments form being contaminated within the Federal Navigation channel.

a. Establish a funding source for maintaining the sediment trap.

b. Identify the type of dewatering structure to be used during the maintenance activity.

c. Identify a market for the clean sediment.

Objective 2: Coordinate the dredging of the Federal Channel with the adjacent property owners.

a. Identify an environmentally sound disposal facility to contain the contaminated sediments.

Objective 3: Enhance existing public access to the stream of Trail Creek to discourage trespassing on private property.

a. Create an inventory of riparian owners along the stream of Trail Creek.
b. Construct a trail from Hansen Park to Friendship Gardens with various amenities including lights, observation/fishing piers, shelters, outdoor cooking facilities and washrooms.
c. Develop bicycle, jogging and walking paths along this Michigan City trail to accommodate the various recreational interest. Connect the Michigan City trail to Washington Park and existing bike trails on local streets.

Objective 4: Control debris, litter, and obstructions from entering Trail Creek.

Goal 4: Develop a public awareness of the unique and diverse opportunities that the stream of Trail Creek provides.

Objective 1: Increase awareness of citizens and local decision makers as to the sources and impacts of nonpoint source pollution and the concept of watershed management.

a. Create a quarterly newsletter explaining the issues and highlighting the progress of the watershed management plan.

Objective 2: Stimulate participation ion maintenance and restoration activities within the watershed.

a. Create a LaPorte County Civilian Conservation Corps that would instill work ethics and teach construction skills in youths while providing environmental experiences.

b. Initiate an "Adopt a Stream" program.

Objective 3: Cultivate community appreciation for the uniqueness of Trail Creek and its diverse wildlife and plant species.

a. Develop a visual and oral presentation of the stream of Trail Creek to be presented at schools and various civic organizations and interest groups meetings.

b. Sponsor educational "Field" days and walks along the stream of Trail Creek.

Agricultural Best Management Practices

Wildlife Watering Area

Problematic (wet) farmland converted to permanent open water ~18" in depth

1

2

3

Grassed Waterway

Problematic surface drainage solved with grassed waterway to drain ~72 acres

4

5

6

Filter Strips

Buffer zone area between row crops and adjacent roadside drainage ditches

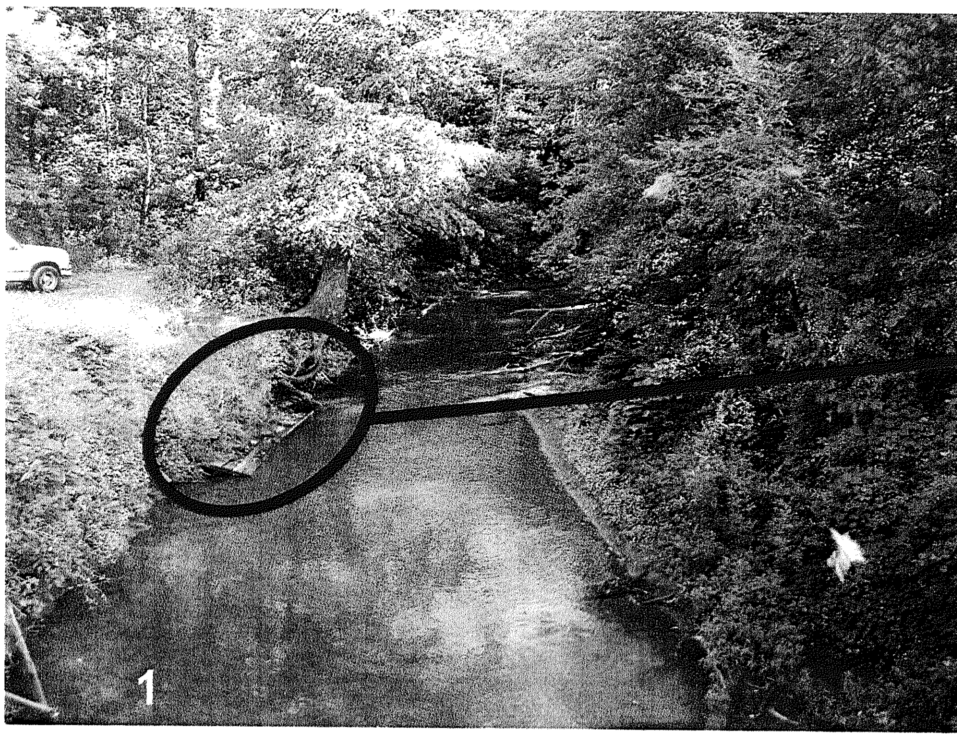
7

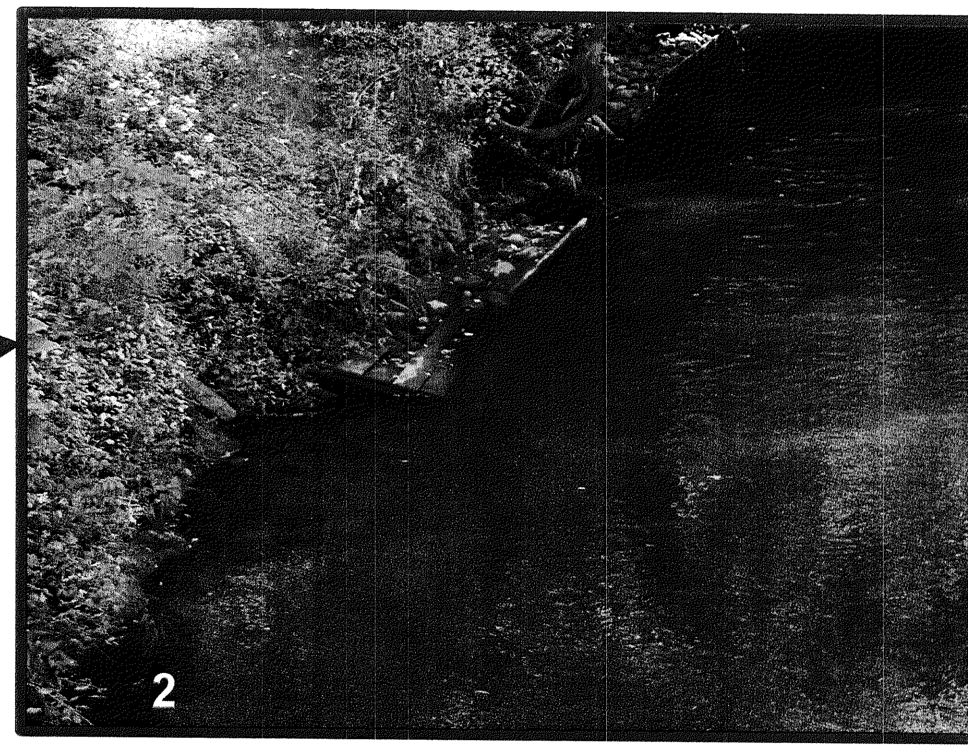
8

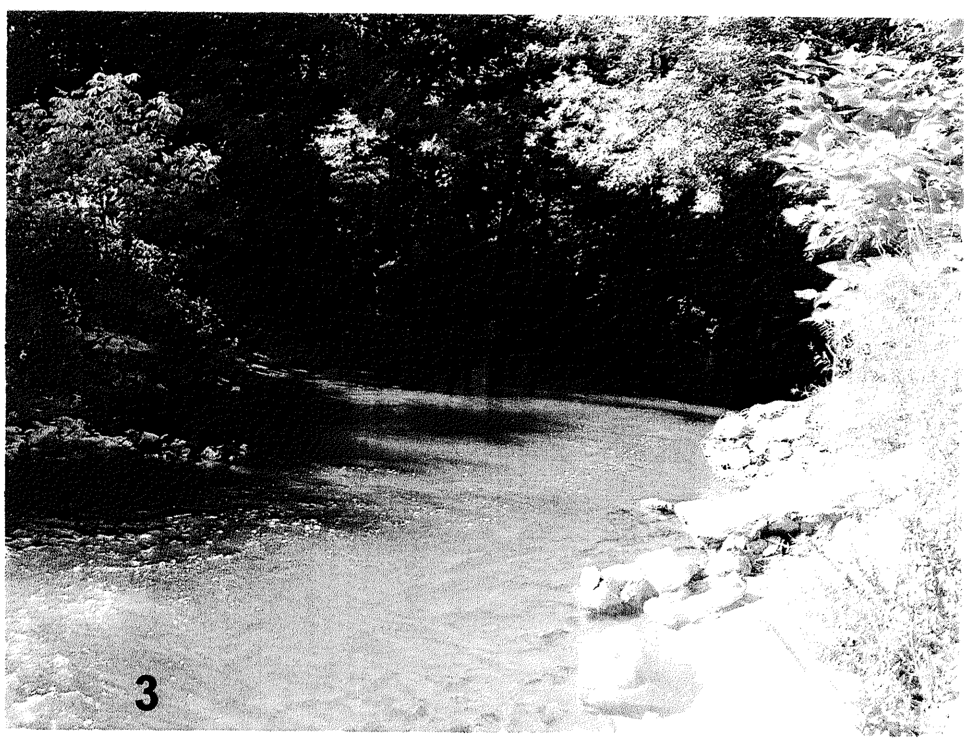
9

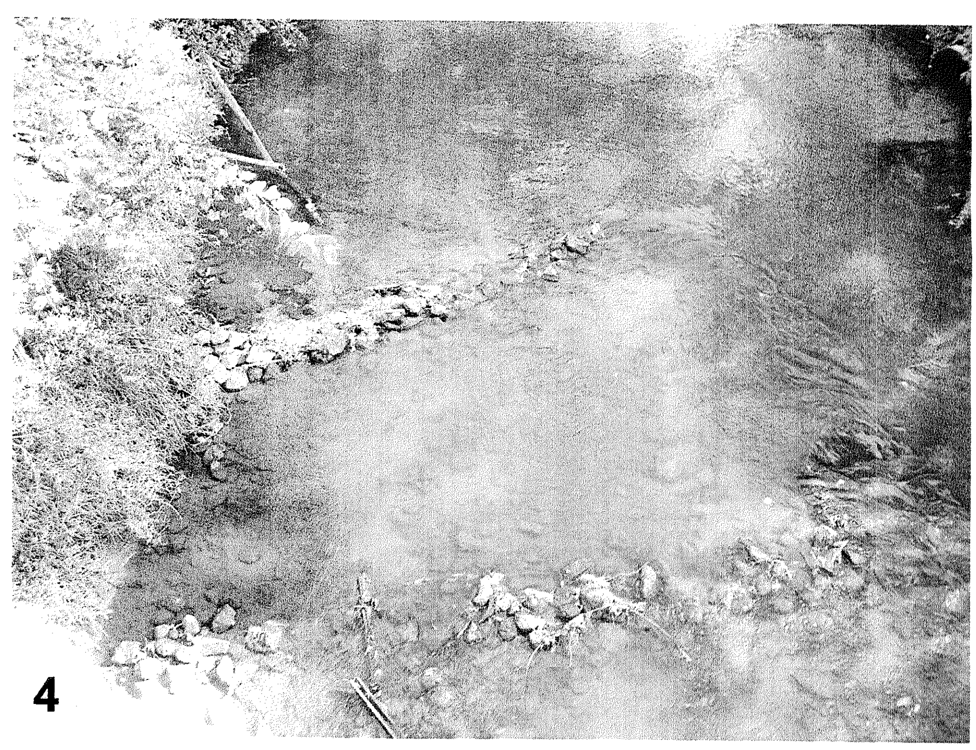
Creek Best Management Practices

Examples of Enhancements within Trail Creek

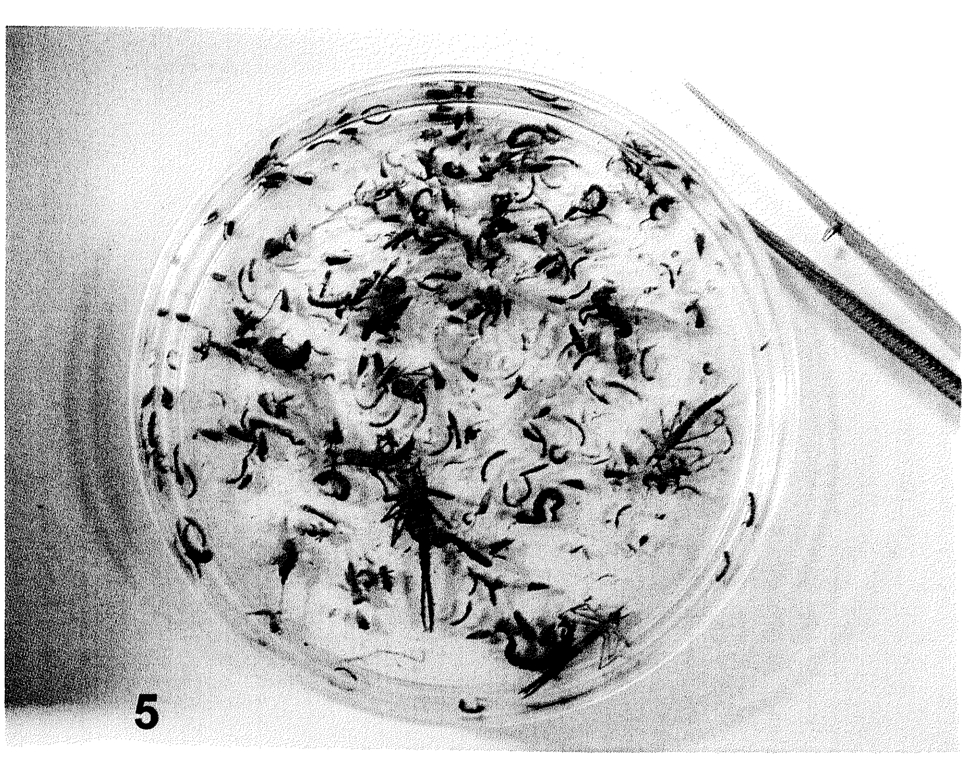


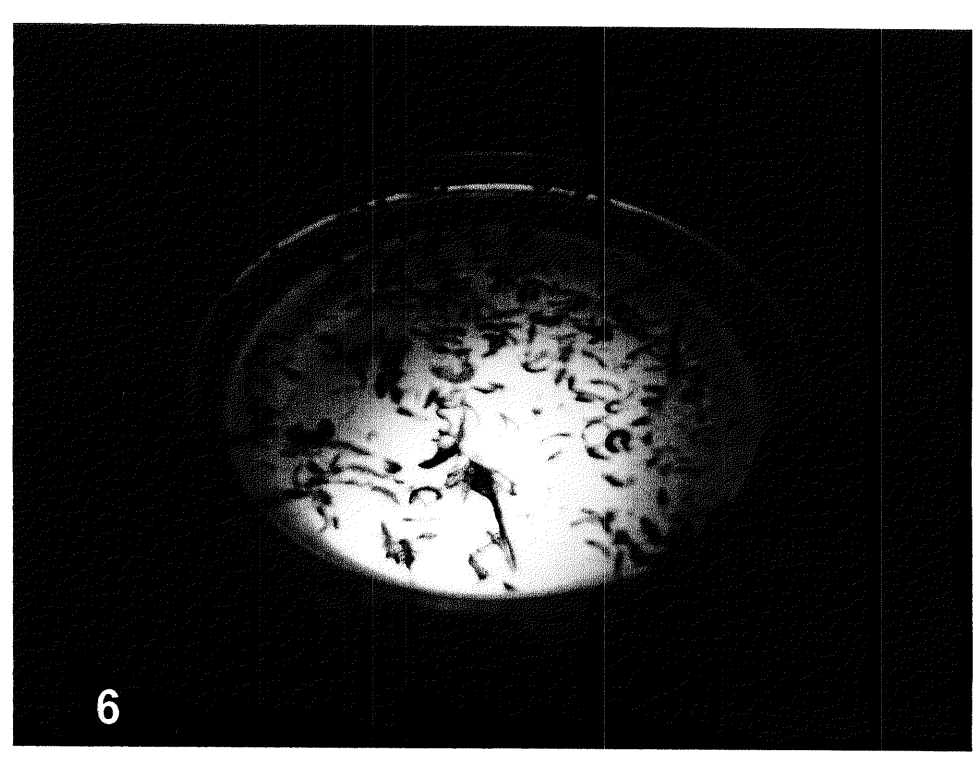






Results: Improved Ecological Integrity





Diminish E. coli Loading

Do Combined Sewer Overflow discharges from the Michigan City Wastewater Treatment Plant contribute to sustained elevated E. coli levels in Trail Creek?

Not since 1998 when there have been no more than 1 overflow in a given year and beginning on April 1, 2006, any future CSO discharge will be disinfected with chlorine to kill E. coli.

Historical Summary

Progress thru 1983	Progress thru 1990	Progress thru 1996	Progress thru 2003	Progress thru 2006
35% of original combined sewers were separated	A 54" relief sewer was constructed in the city's north end	60% of original combined sewers were separated	91% of original combined sewers were separated	94% of original combined sewers were separated
Sewer system had 18 CSO points into Trail Creek	18 sewer system CSO points **RE-DUCED** to only 6	Investment in sewer separation since 1962 was >$50 mill.	Investment in sewer separation since 1962 was >$80 mill.	Investment in sewer separation since 1962 was >$85 mill.
41 million gallons of CSO discharge yearly to Trail Creek	6.15 mill. gal. Storm Retention Basin built at WWTP	All 6 sewer system CSO points were **ELIMINATED**	From 1990-1997, the Storm Basin CSO rate was 19 events per yr.; from 1998-2003 the Storm Basin CSO rate was 1 per yr.; a **95% REDUCTION**	Headworks upgrade achieves **15 MGD** wet weather flow
CSO's during rain events **VIOLATE** the >7.0 mg/l DO criteria in Trail Creek for salmon	Coll. Sys. CSO flow **REDUCED** by 75%; strength of CSO reduced by 70%	The **ONLY** CSO point in Michigan City is the Storm Basin overflow; the Storm Basin provides the equivalent of primary & secondary treatment; thus, the only CSO Water Quality impairment is E. Coli		Storm Basin Disin-fection Project leads to **ATTAINMENT** of acute Water Qual. Standards for CSO
	WWTP CSO flow **REDUCED** by 95%; strength of CSO reduced by 75%		WWTP wet weather flow rating is 15 MGD, but due to equip. wear the max. wet weath. flow is only 13.9 MGD	Watershed approach leads to >500 homes removed from a floodplain; marina, urban & rural BMPs planned for the creek
			For Oct. 2001 CSO, creek DO was 9.6!	**For Jan. 2005 CSO, creek DO was 10.6!**

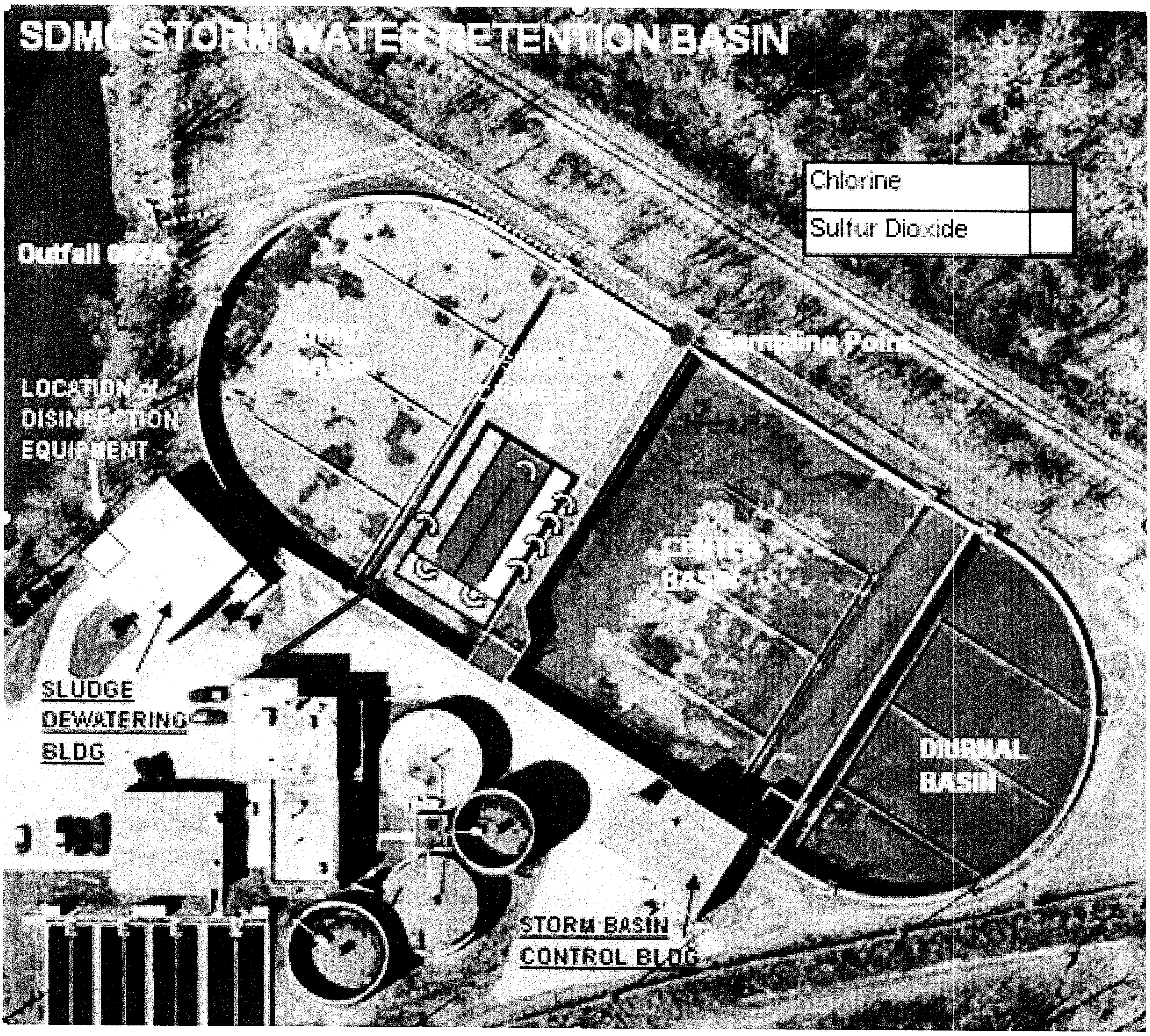
A comprehensive, multi-part strategy for improved stormwater controls at the J.B. Gifford WWTP has led to dramatic success in reducing CSO events in Michigan City as one can see from the following table:

Historical Number of CSO Events per Year

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
47	**24**	2	**32**	3	0	**19**	**14**	**1**	**0**	**0**	**1**	**1**	**0**	**0**	**1**

In 2002, Michigan City's WWTP was awarded the US EPA First Place National Award for best Combined Sewer Overflow Control in the United States.

Storm Basin Disinfection



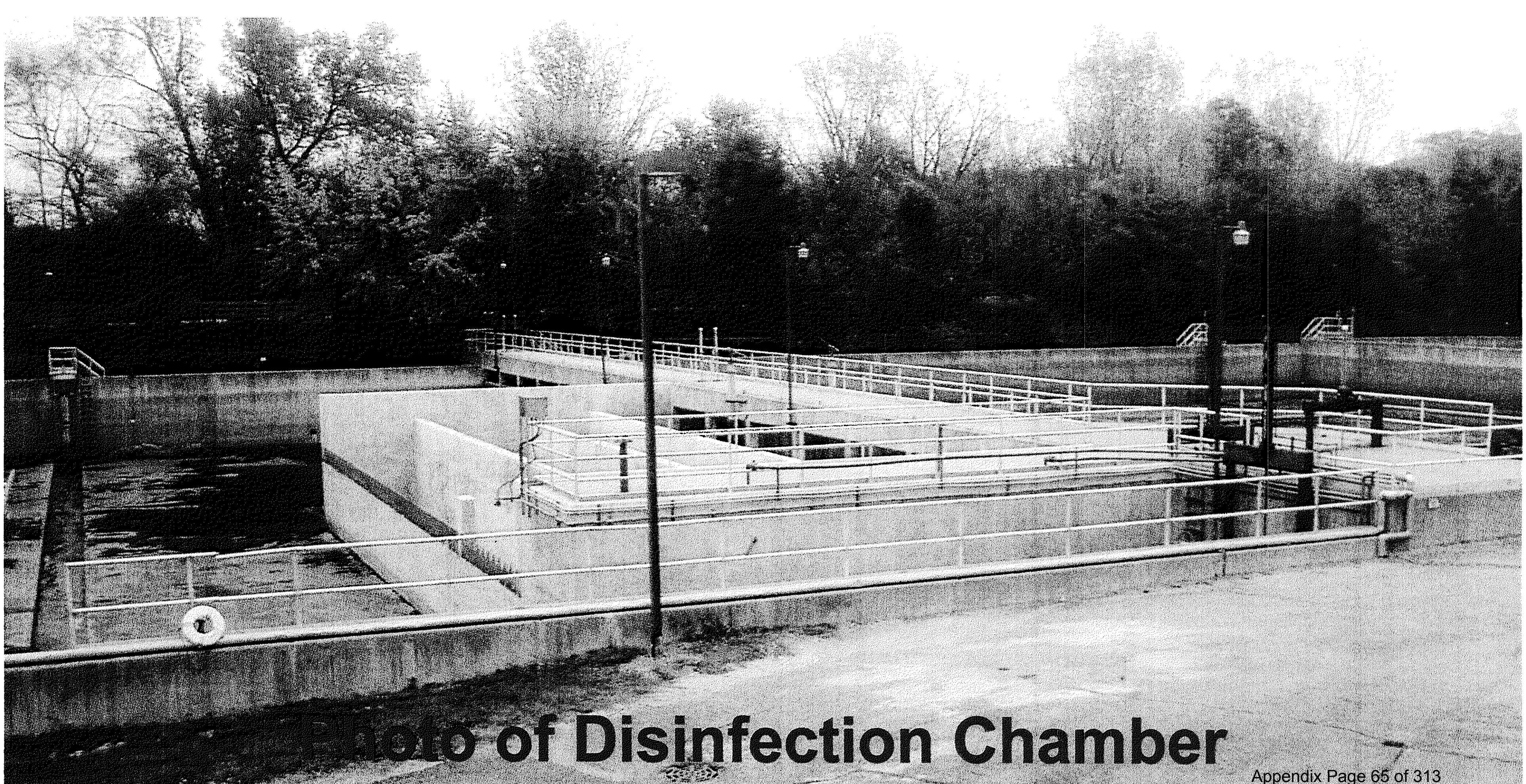
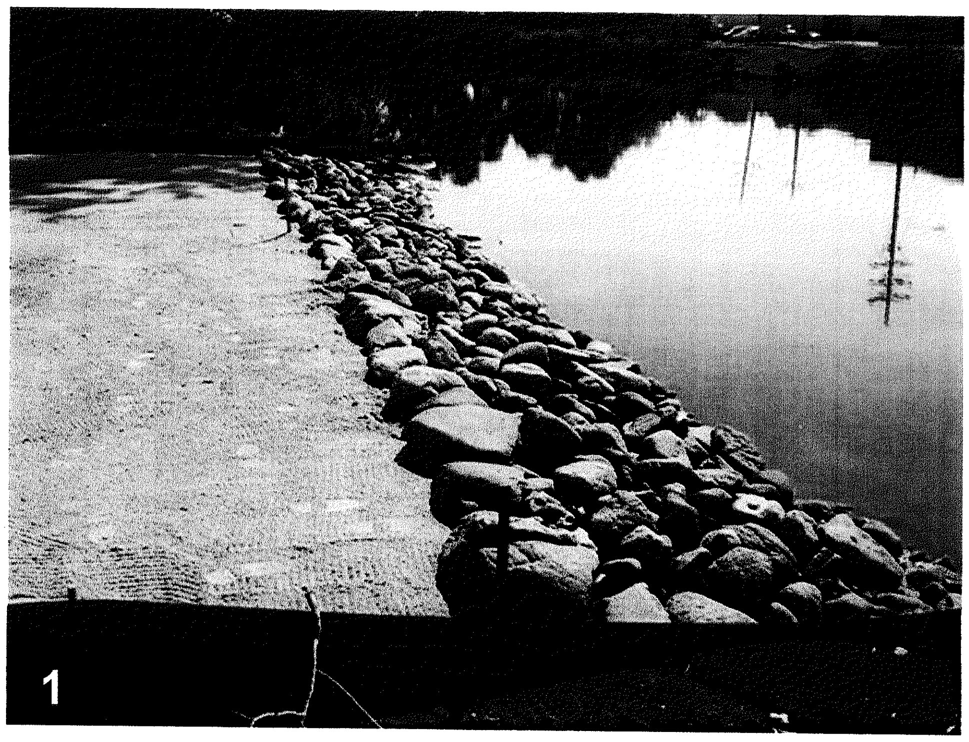


Photo of Disinfection Chamber

Public Access & Preservation

Hansen Park



1

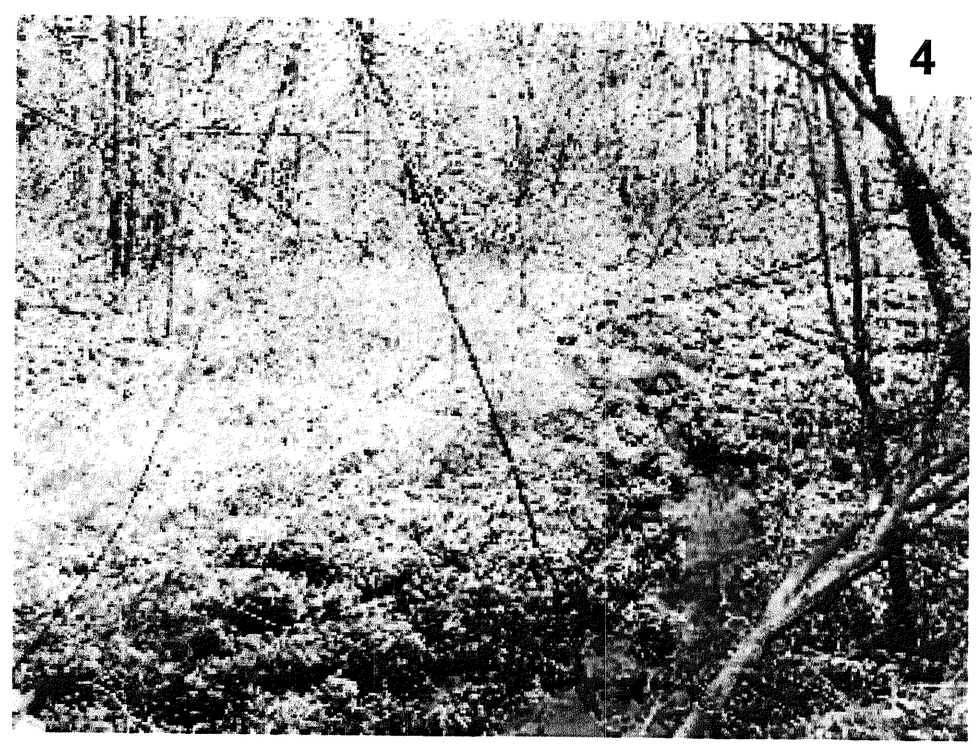
2

Preservation

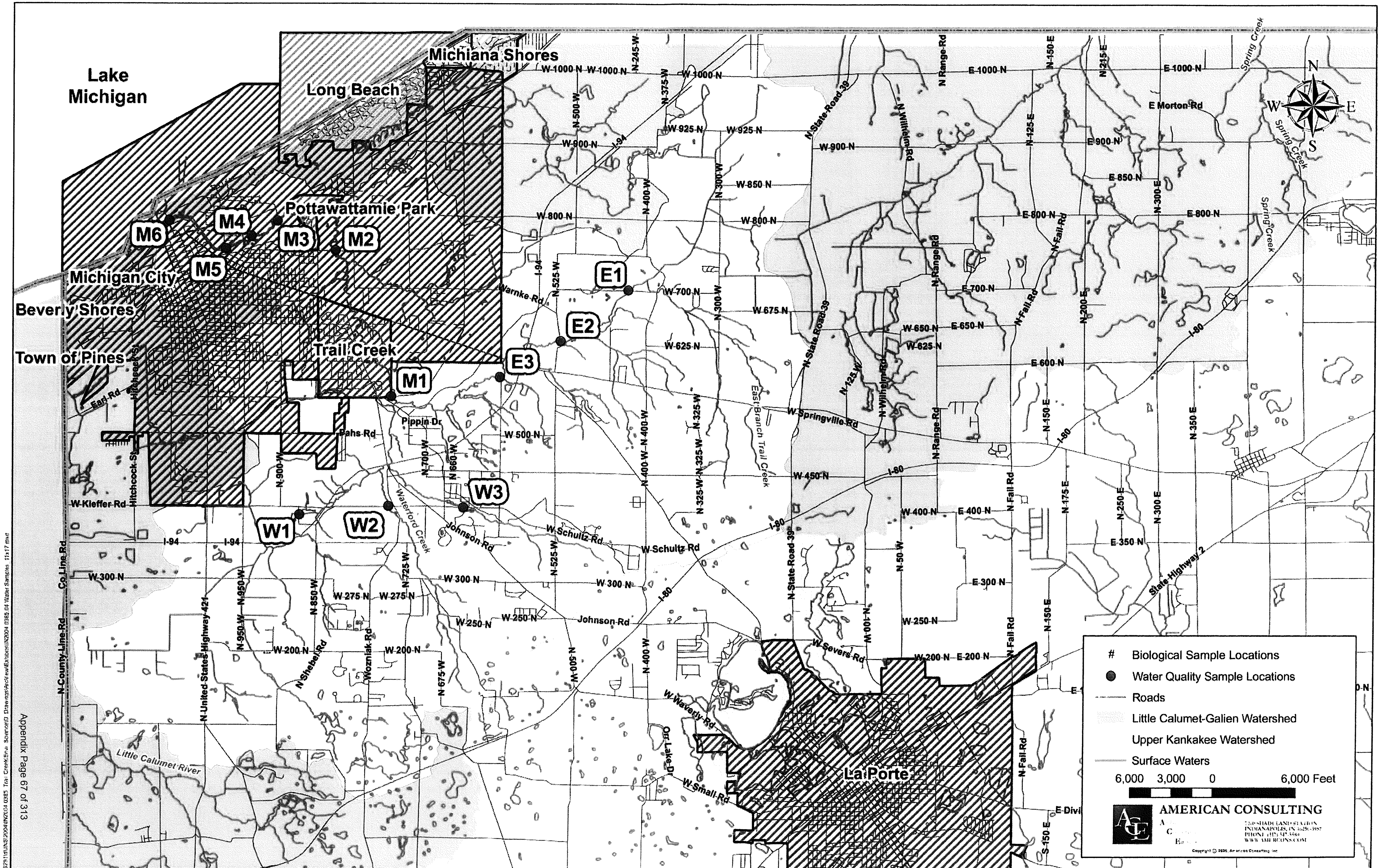
3

Tamarack tree in Trail Creek Fen

4



Sebert Forks property at 400 W and 700 N in Springfield Township.


Lake Michigan
Michiana Shores
Long Beach
Pottawattamie Park
Michigan City
Beverly Shores
Town of Pines
Trail Creek
La Porte
M1
M2
M3
M4
M5
M6
E1
E2
E3
W1
W2
W3
East Branch Trail Creek
Waterford Creek
Little Calumet River
Spring Creek
I-94
I-80
N State Road 39
W Springville Rd
State Highway 2
N United States Highway 421
N County Line Rd
Johnson Rd
W Schultz Rd
N Wilhelm Rd
N Range Rd
N Fail Rd
E Morton Rd
W Severs Rd
W Waverly Rd
W Small Rd
Orr Lake Dr
Warnke Rd
Pippin Dr
Pahs Rd
Hitchcock St
Earl Rd
W Kieffer Rd
N Shebel Rd
Wozniak Rd
Biological Sample Locations
Water Quality Sample Locations
Roads
Little Calumet-Galien Watershed
Upper Kankakee Watershed
Surface Waters
6,000 3,000 0 6,000 Feet
AMERICAN CONSULTING

Pollution Concerns of 2006

E. coli.

The E. coli is a bacteria found in the gut of warm blooded animals and acts to aid in digestion of food. Target Concentrations for E. coli are (125 cfu/100 ml – monthly geometric mean and 235 cfu/100 ml – daily maximum).

Sources

- Permitted point sources
  - J. B Gifford Wastewater Treatment Plant (Michigan City)
  - Friendly Acres Mobile Home Park
  - Autumn Creek Mobile Home Park
- Non-point sources
  - Failing septic systems
  - Illicit discharges
  - Marinas/ boats
  - Livestock and/or pet waste
  - Stormwater Run-off

Sedimentation

Continued dredging of navigable channel

Streambank erosion

Water clarity

Contributes to nutrient loading

No regulatory criteria

Nutrient loading

High levels of nitrogen and phosphorus

Contribute to decreased water quality

Algae and macrophyte growth

No regulatory criteria

Effects on Lake Michigan

Hydro-modification

Sources

- Dams
- Detention basins
- Increased impervious surface

Streambank erosion and stream instability

Alteration of natural water levels

Increased sedimentation

Next Steps

November: Complete Draft Report

December: Final Public Meeting

December 25, 2006: Final Report due to IDEM

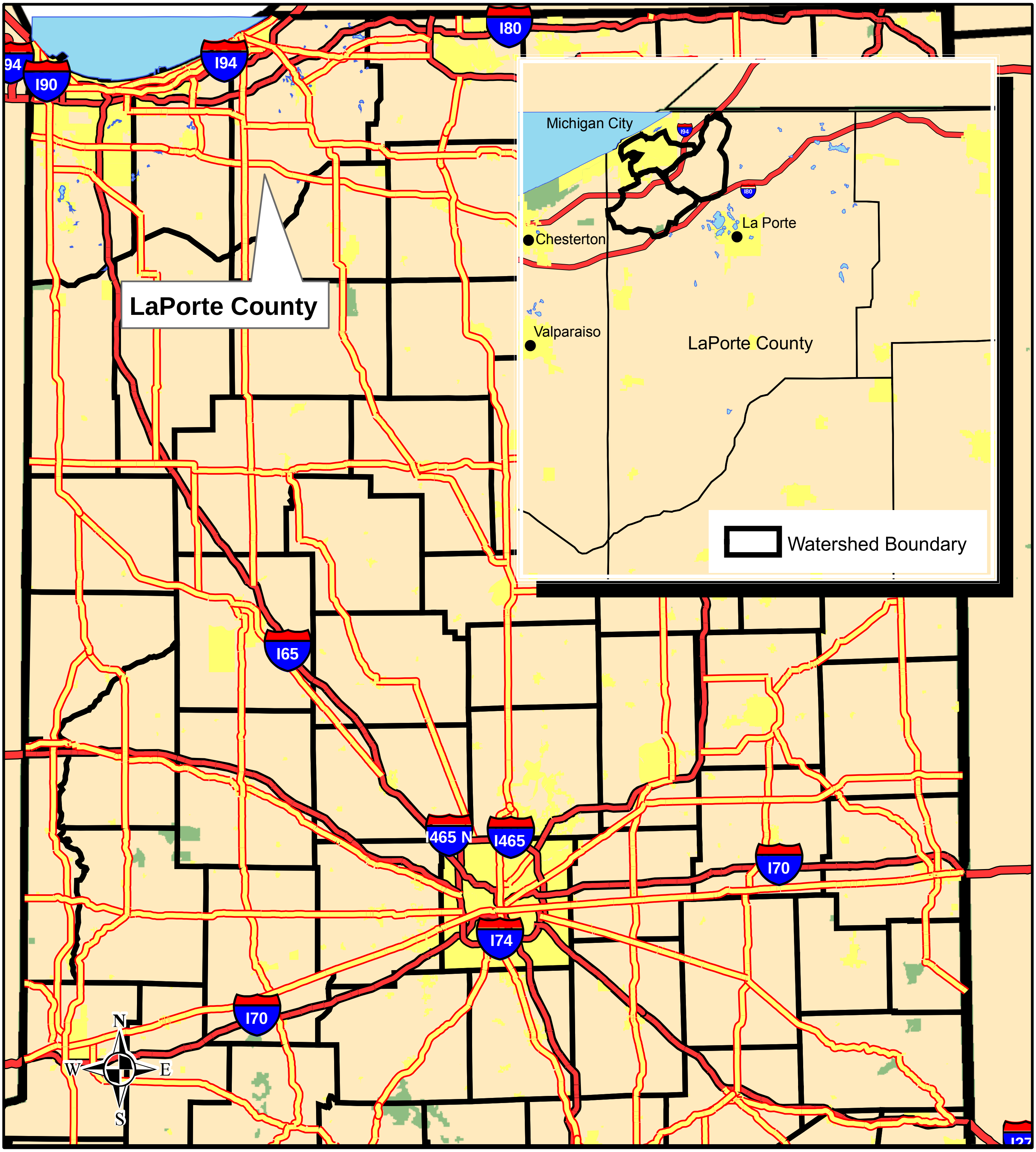
Contact for comments:

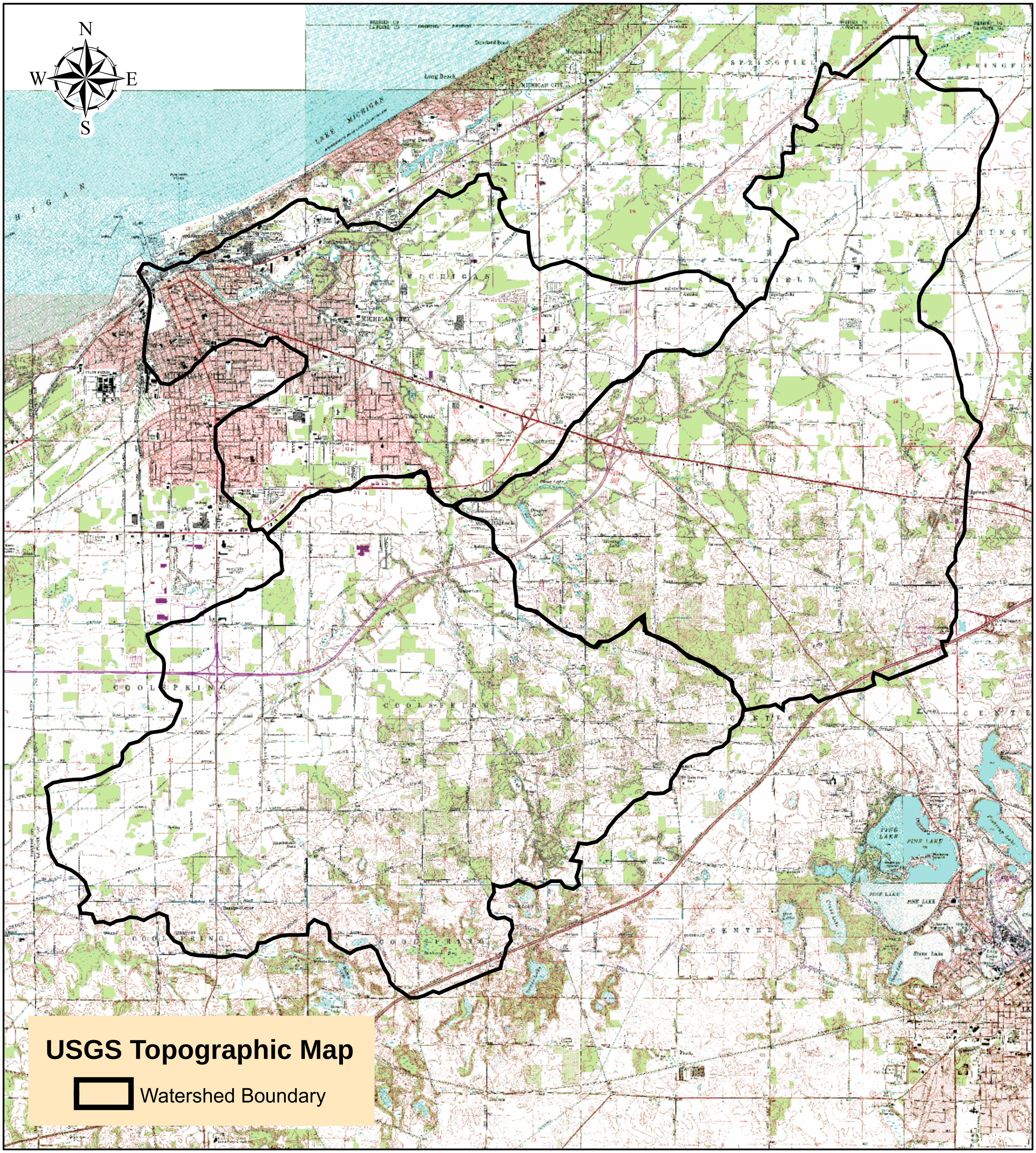
Christine Meador, American Consulting

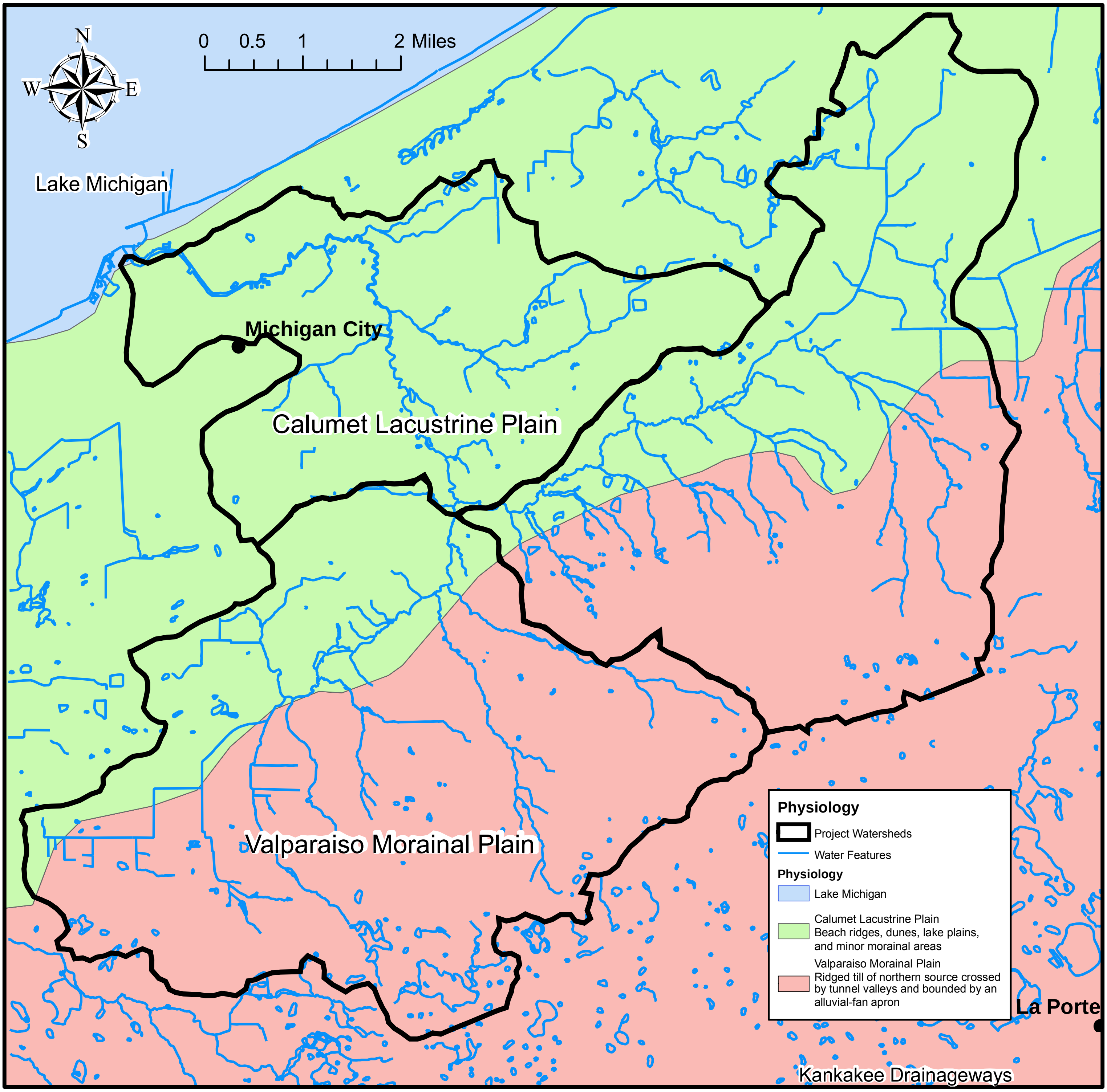
CMeador@amercons.com

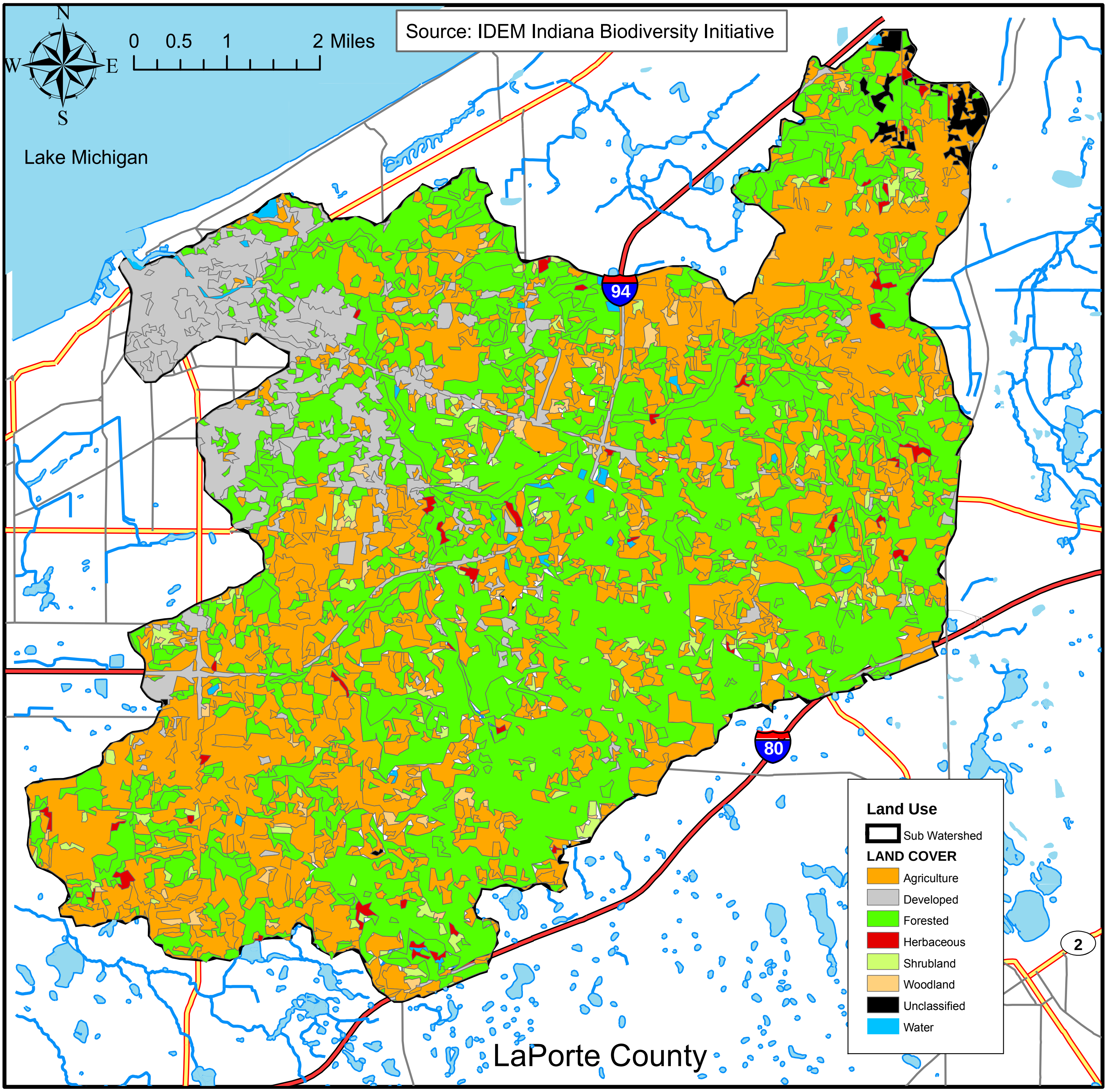
317-547-5580

Appendix L: Full Size Figures from Report

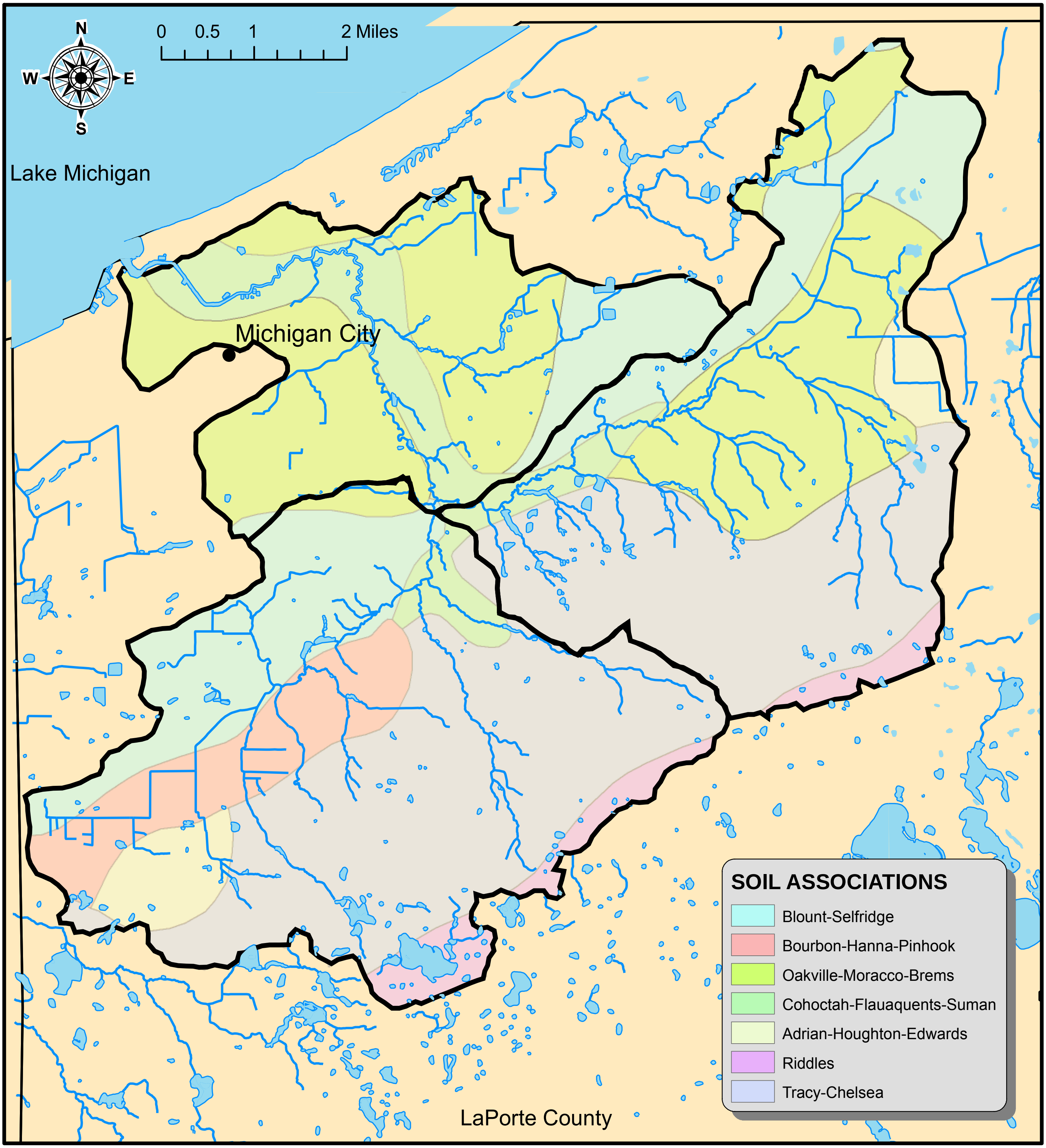

I80
I94
I90
94
LaPorte County
Michigan City
Chesterton
La Porte
Valparaiso
LaPorte County
Watershed Boundary
I65
I465 N
I465
I70
I74
I70
N
W
E
S

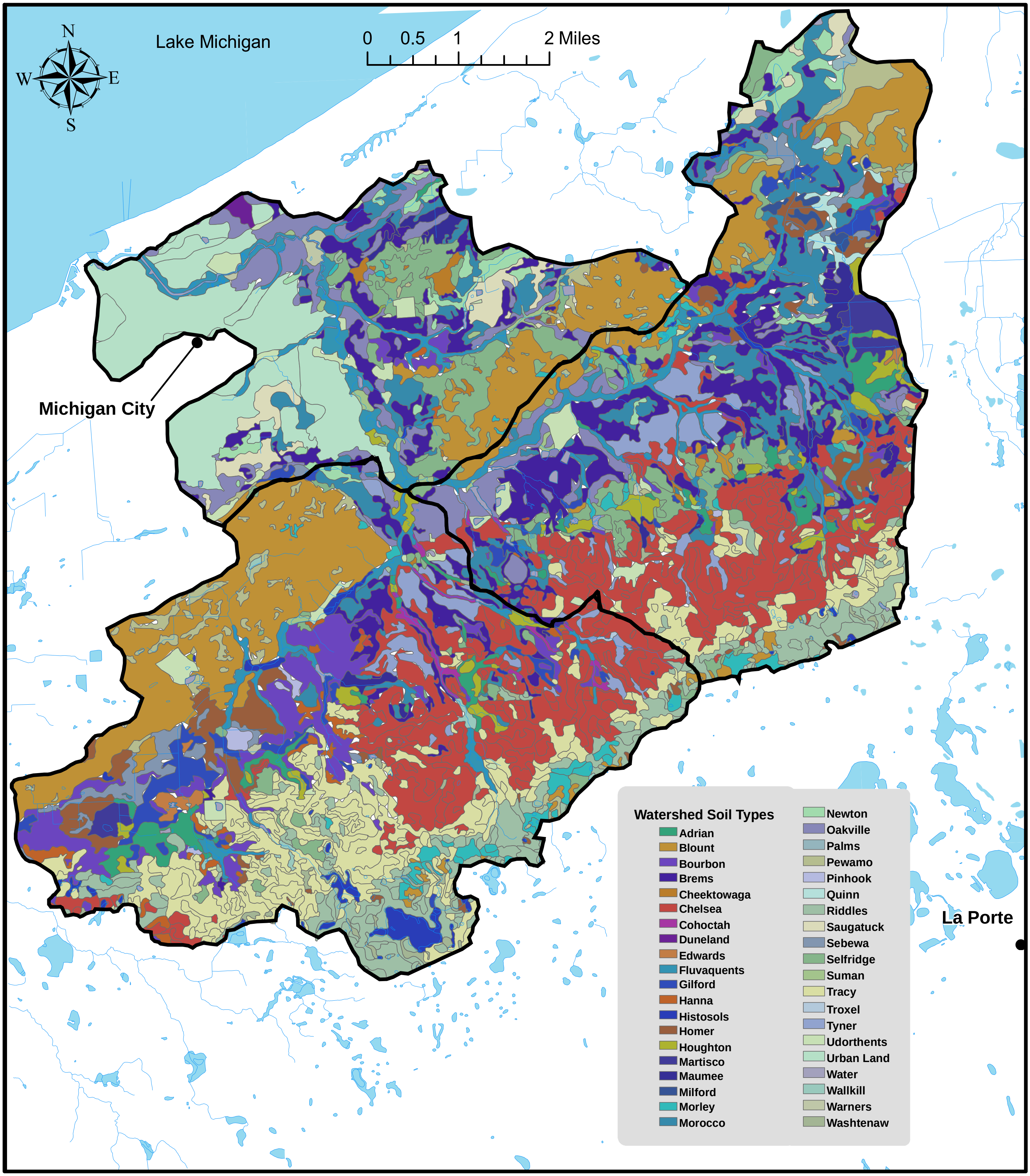

N
S
W
E
USGS Topographic Map
Watershed Boundary

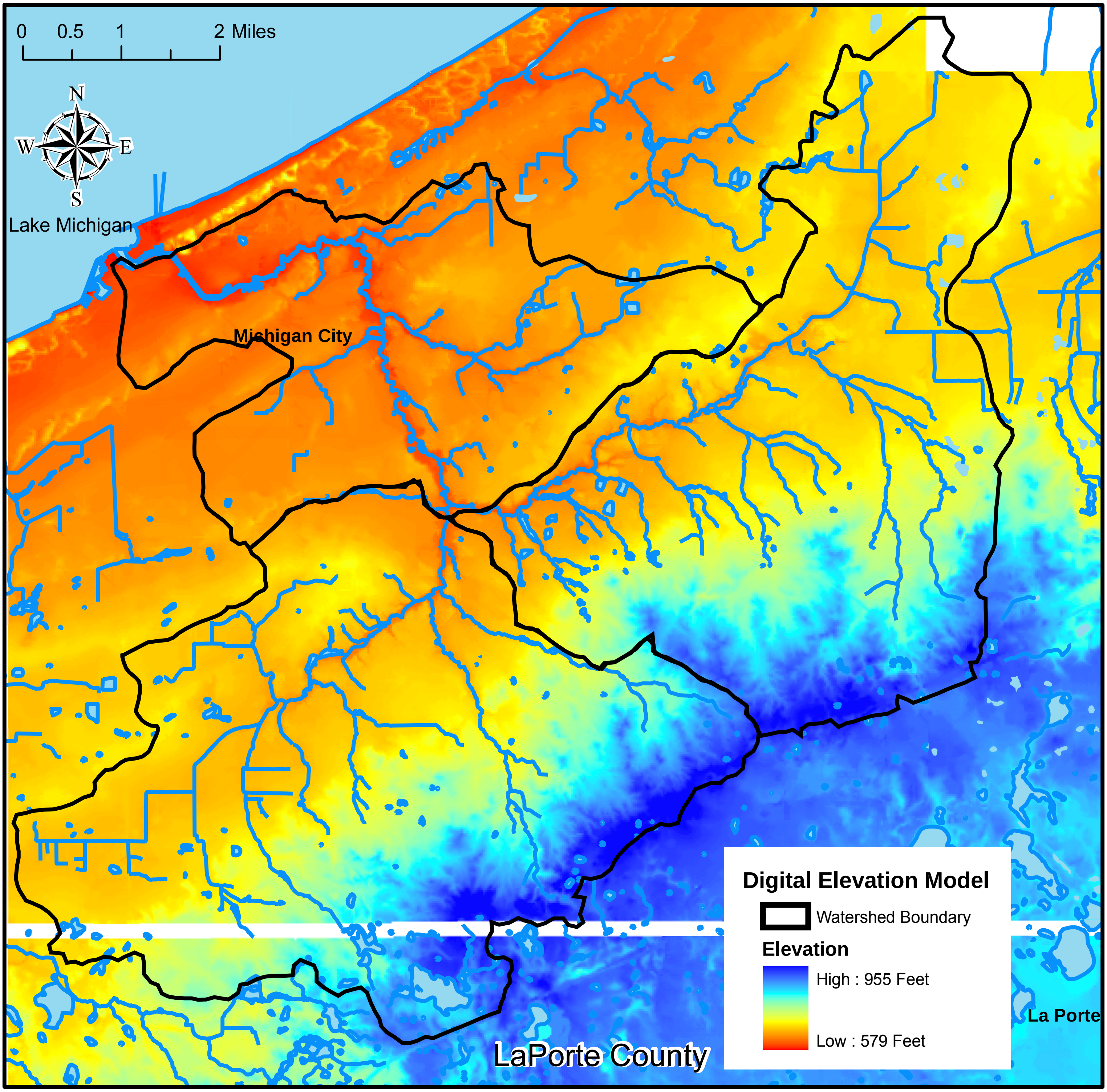

N
W
E
S
0 0.5 1 2 Miles
Lake Michigan
Michigan City
Calumet Lacustrine Plain
Valparaiso Morainal Plain
La Porte
Kankakee Drainageways
Physiology
Project Watersheds
Water Features
Physiology
Lake Michigan
Calumet Lacustrine Plain
Beach ridges, dunes, lake plains, and minor morainal areas
Valparaiso Morainal Plain
Ridged till of northern source crossed by tunnel valleys and bounded by an alluvial-fan apron

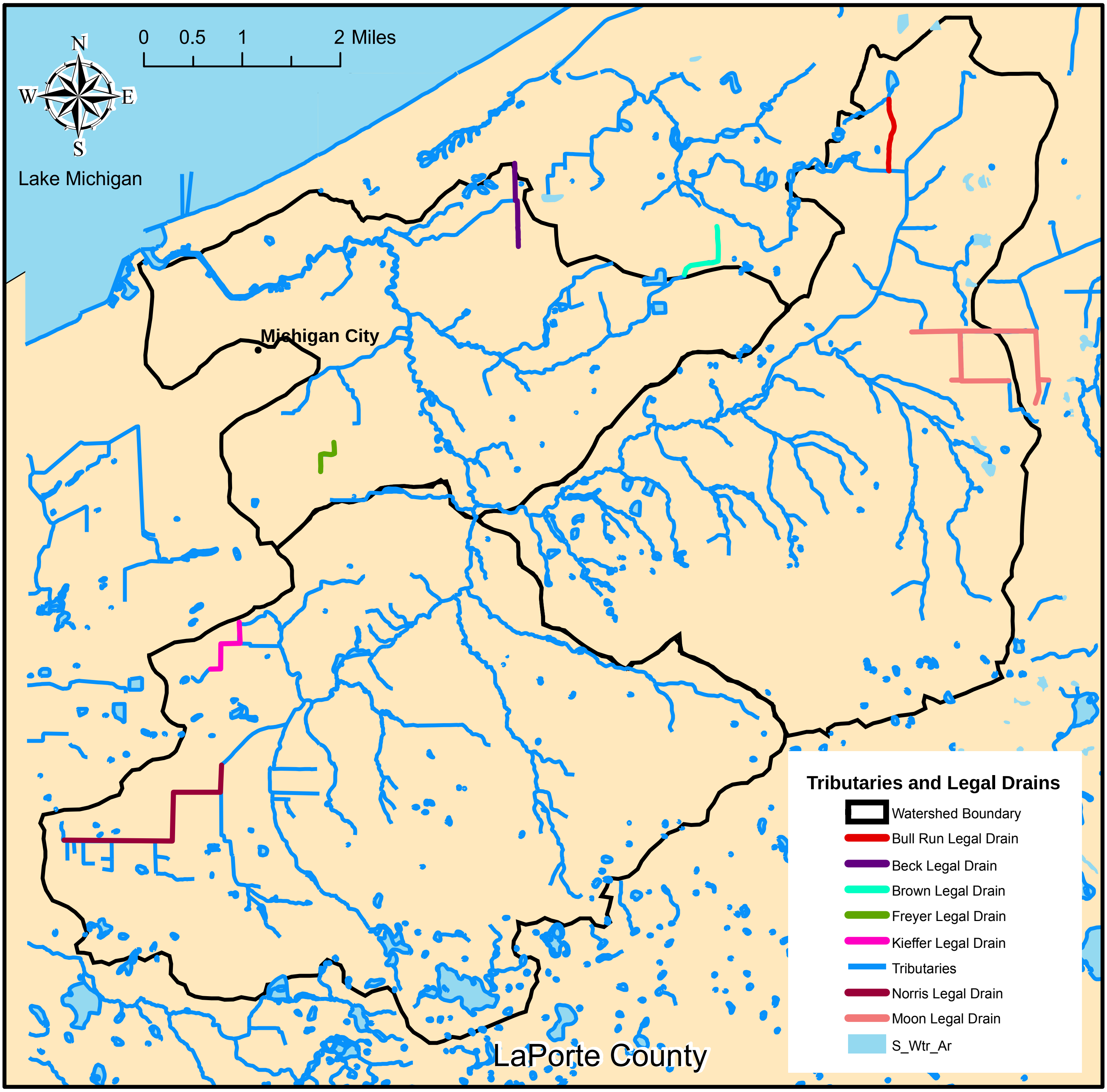


N
S
W
E
0 0.5 1 2 Miles
Source: IDEM Indiana Biodiversity Initiative
Lake Michigan
94
80
2
LaPorte County
Land Use
Sub Watershed
LAND COVER
Agriculture
Developed
Forested
Herbaceous
Shrubland
Woodland
Unclassified
Water

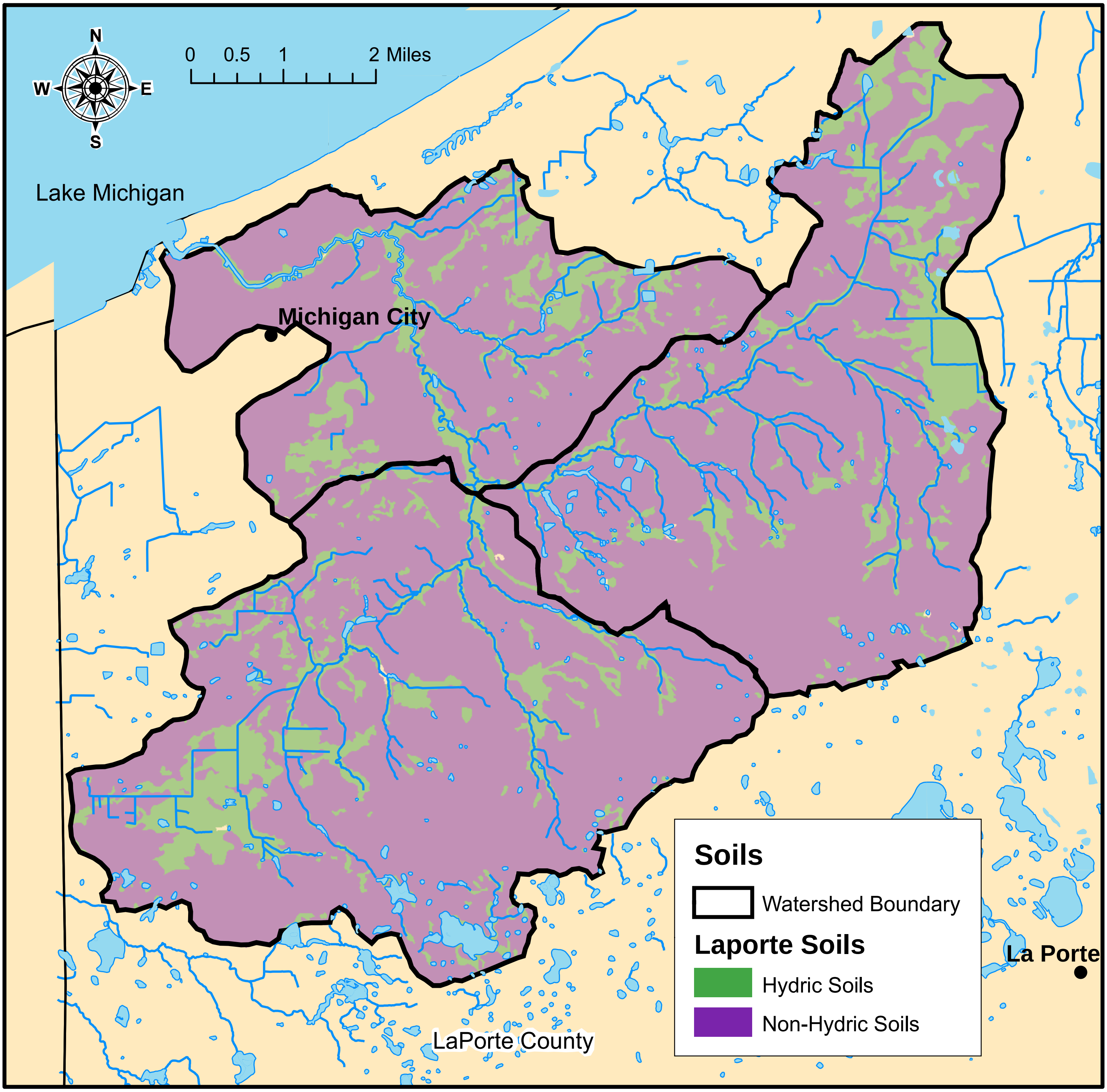

N
W
E
S
0
0.5
1
2 Miles
Lake Michigan
Michigan City
LaPorte County
SOIL ASSOCIATIONS
Blount-Selfridge
Bourbon-Hanna-Pinhook
Oakville-Moracco-Brems
Cohoctah-Flauaquents-Suman
Adrian-Houghton-Edwards
Riddles
Tracy-Chelsea

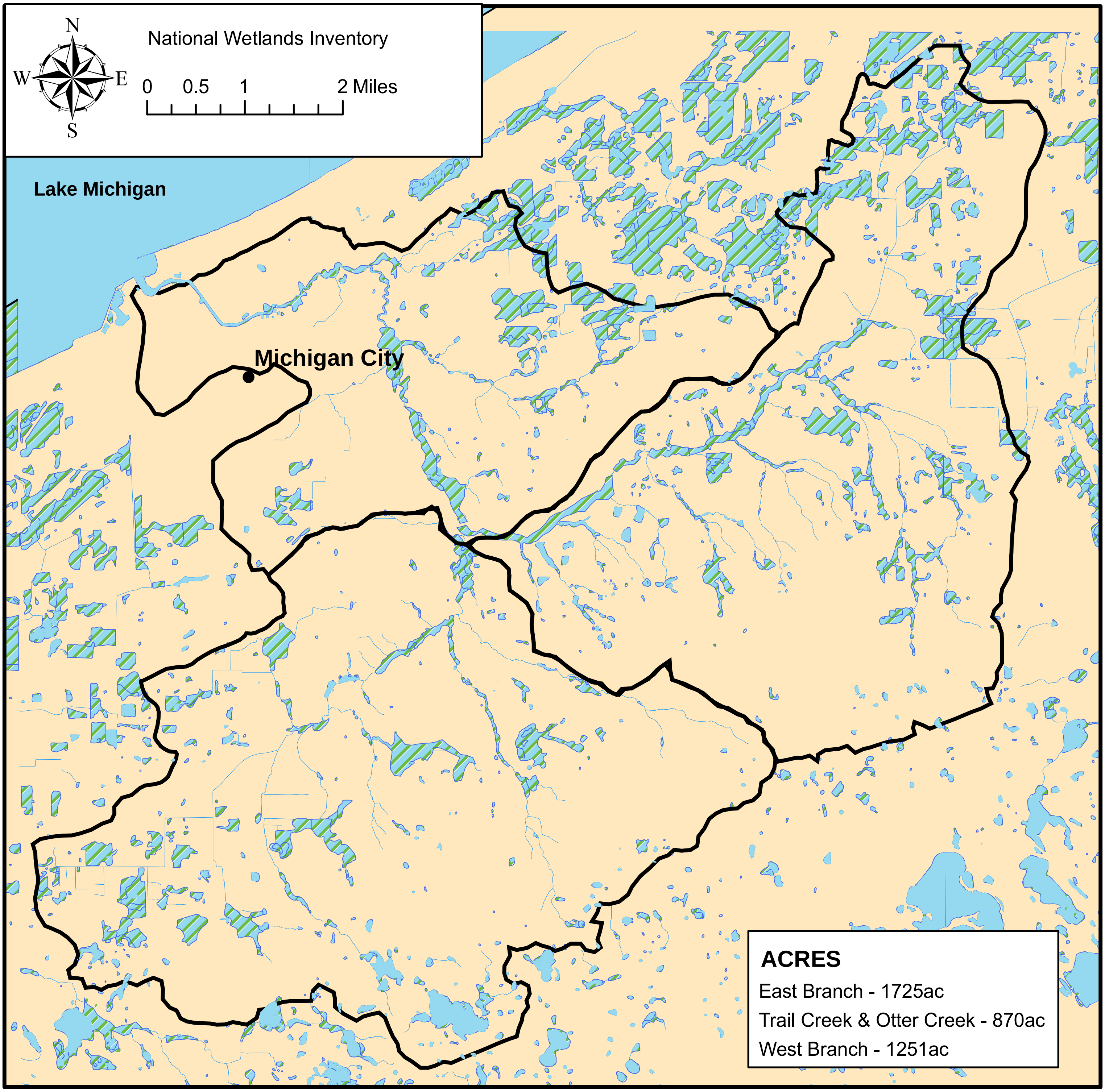

N
S
W
E
Lake Michigan
0 0.5 1 2 Miles
Michigan City
La Porte
Watershed Soil Types
Adrian
Blount
Bourbon
Brems
Cheektowaga
Chelsea
Cohoctah
Duneland
Edwards
Fluvaquents
Gilford
Hanna
Histosols
Homer
Houghton
Martisco
Maumee
Milford
Morley
Morocco
Newton
Oakville
Palms
Pewamo
Pinhook
Quinn
Riddles
Saugatuck
Sebewa
Selfridge
Suman
Tracy
Troxel
Tyner
Udorthents
Urban Land
Water
Wallkill
Warners
Washtenaw

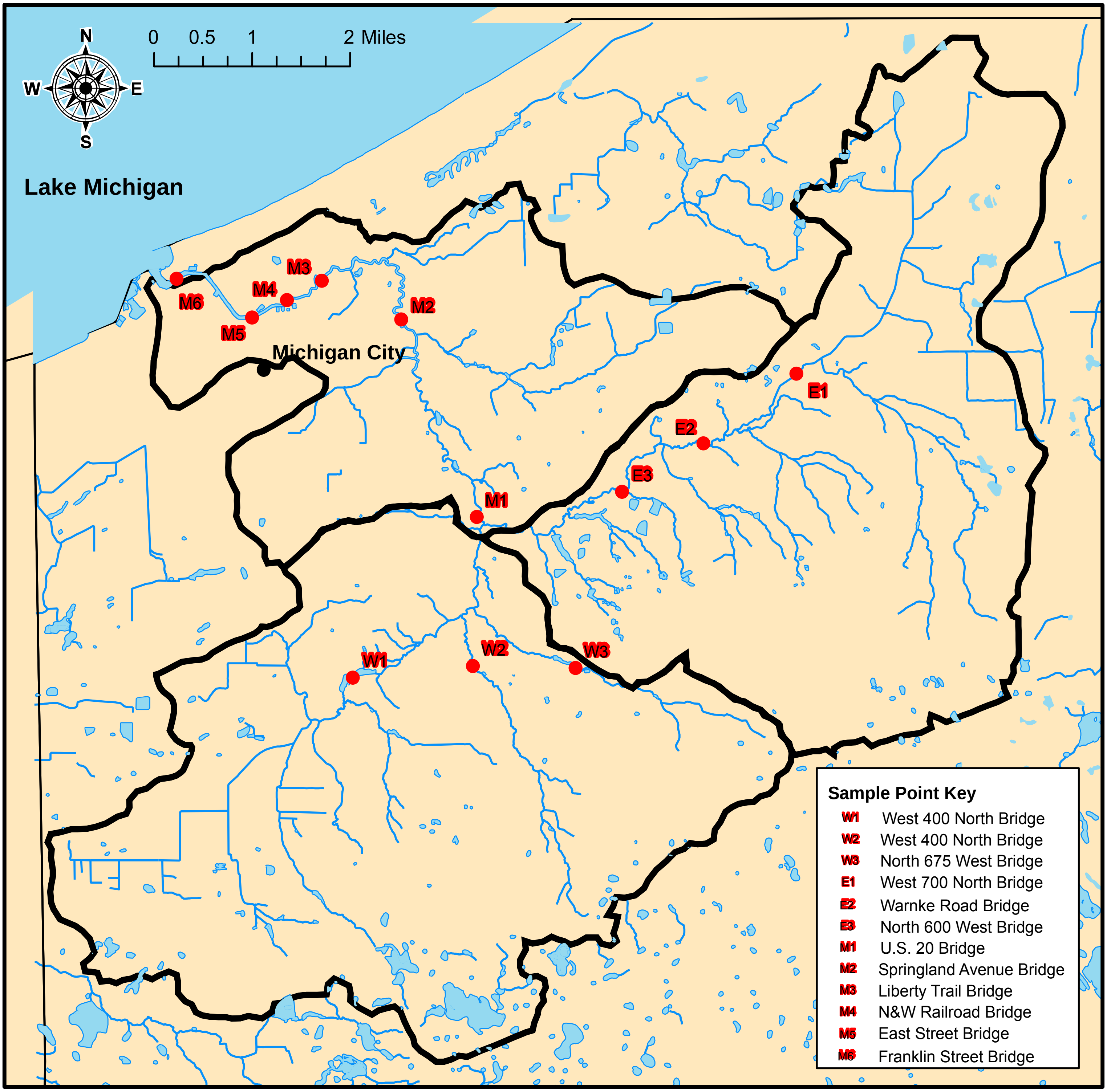

0 0.5 1 2 Miles
N
W
E
S
Lake Michigan
Michigan City
La Porte
LaPorte County
Digital Elevation Model
Watershed Boundary
Elevation
High : 955 Feet
Low : 579 Feet


N
S
W
E
0
0.5
1
2 Miles
Lake Michigan
Michigan City
LaPorte County
Tributaries and Legal Drains
Watershed Boundary
Bull Run Legal Drain
Beck Legal Drain
Brown Legal Drain
Freyer Legal Drain
Kieffer Legal Drain
Tributaries
Norris Legal Drain
Moon Legal Drain
S_Wtr_Ar

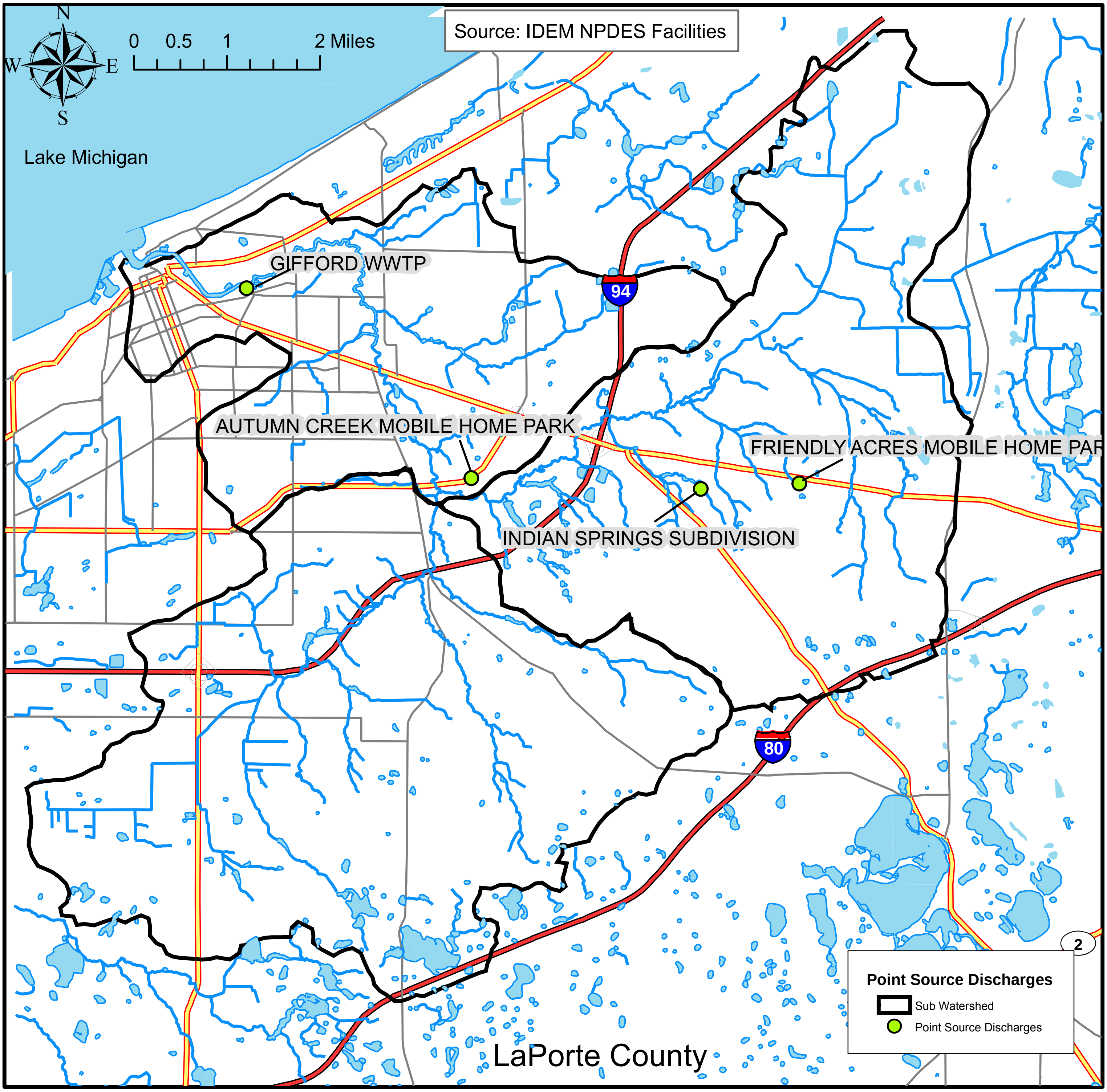
Lake Michigan
N
W
E
S
Lighthouse and Pier
Washington Park
Michigan City Lighthouse
0
0.5
1
2 Miles
HISTORICAL STRUCTURES
Historical Structure
Watershed Boundary

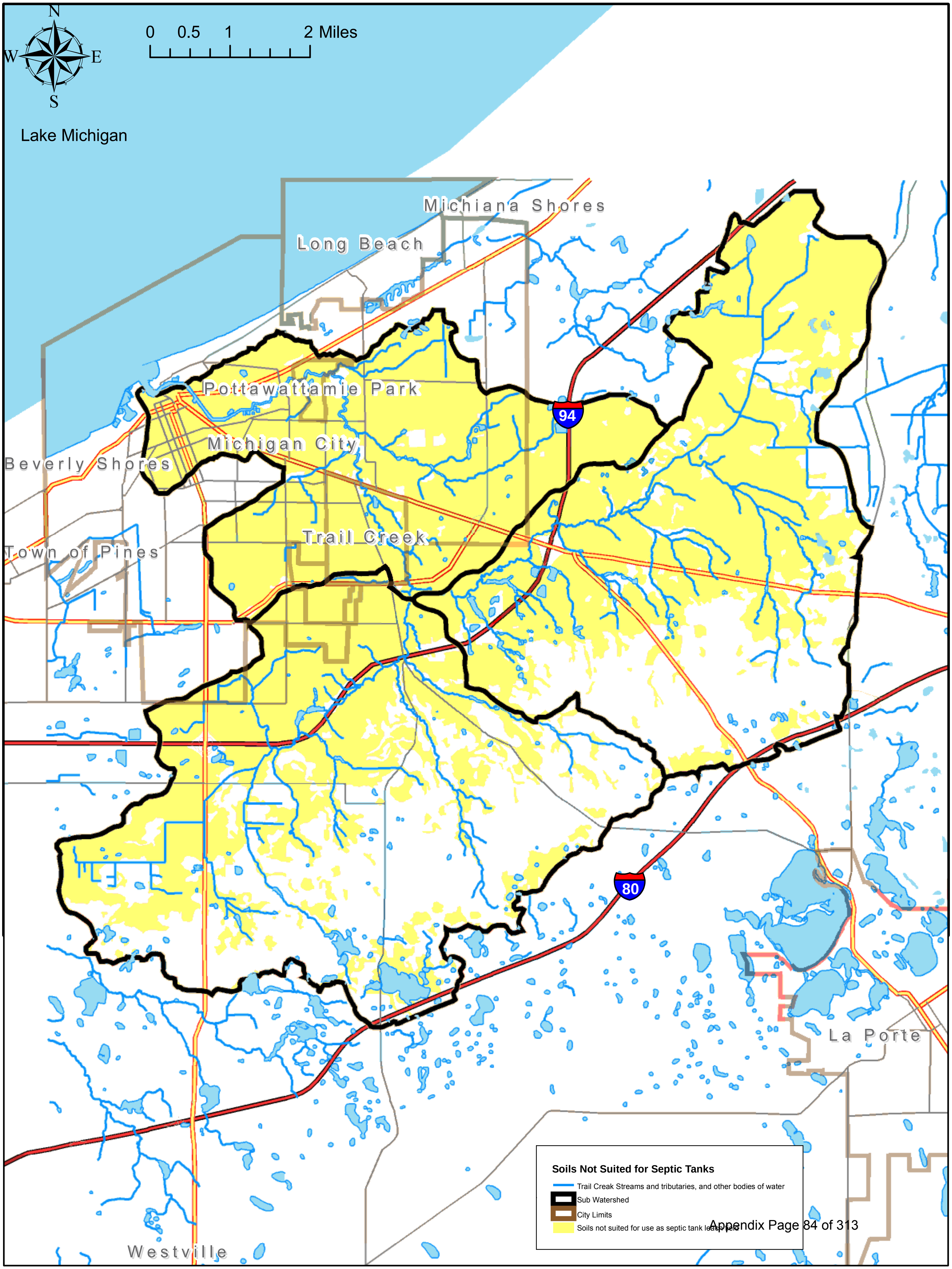

N
W
E
S
0 0.5 1 2 Miles
Lake Michigan
Michigan City
La Porte
LaPorte County
Soils
Watershed Boundary
Laporte Soils
Hydric Soils
Non-Hydric Soils

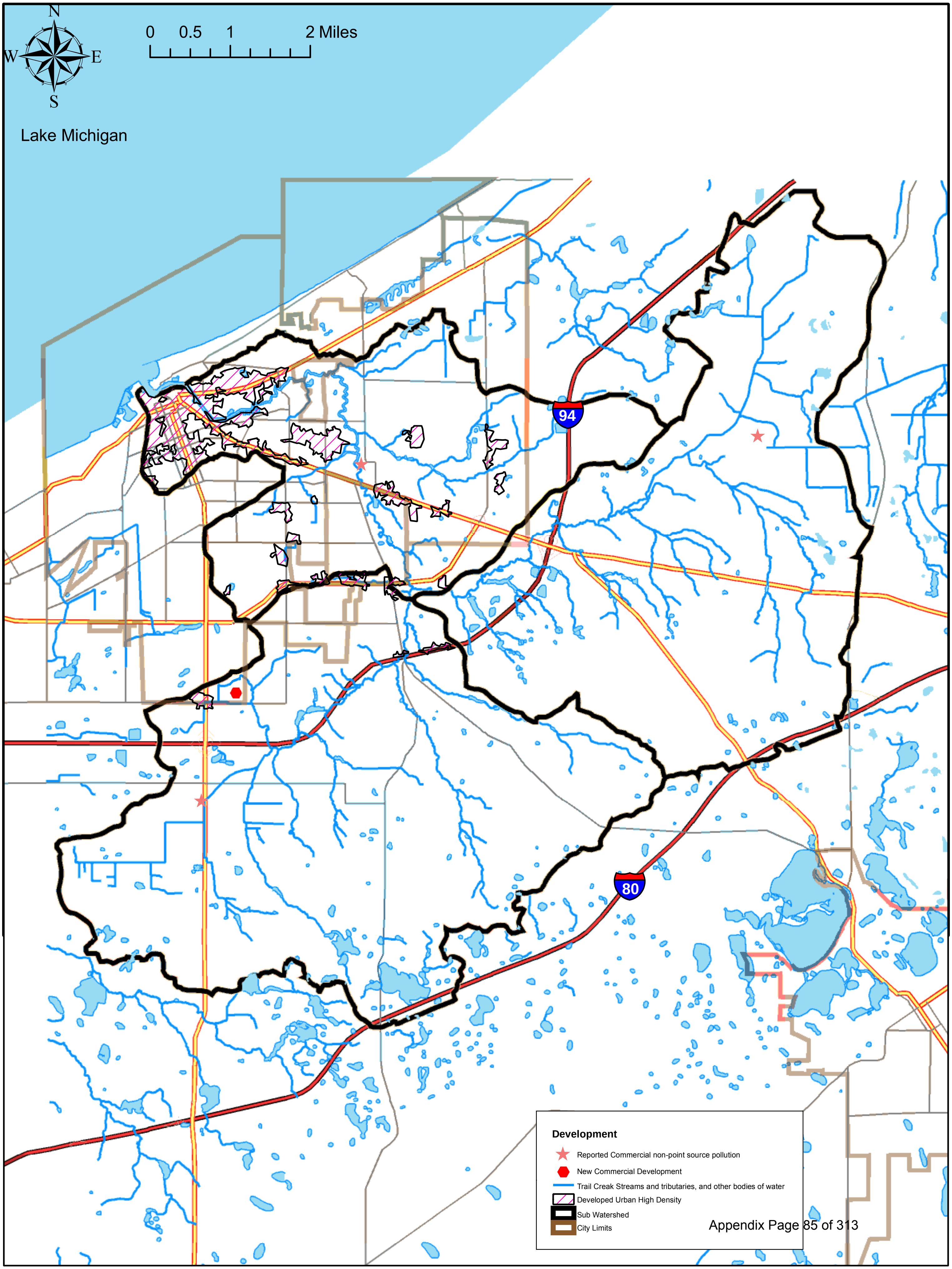

National Wetlands Inventory
N
W
E
S
0
0.5
1
2 Miles
Lake Michigan
Michigan City
ACRES
East Branch - 1725ac
Trail Creek & Otter Creek - 870ac
West Branch - 1251ac

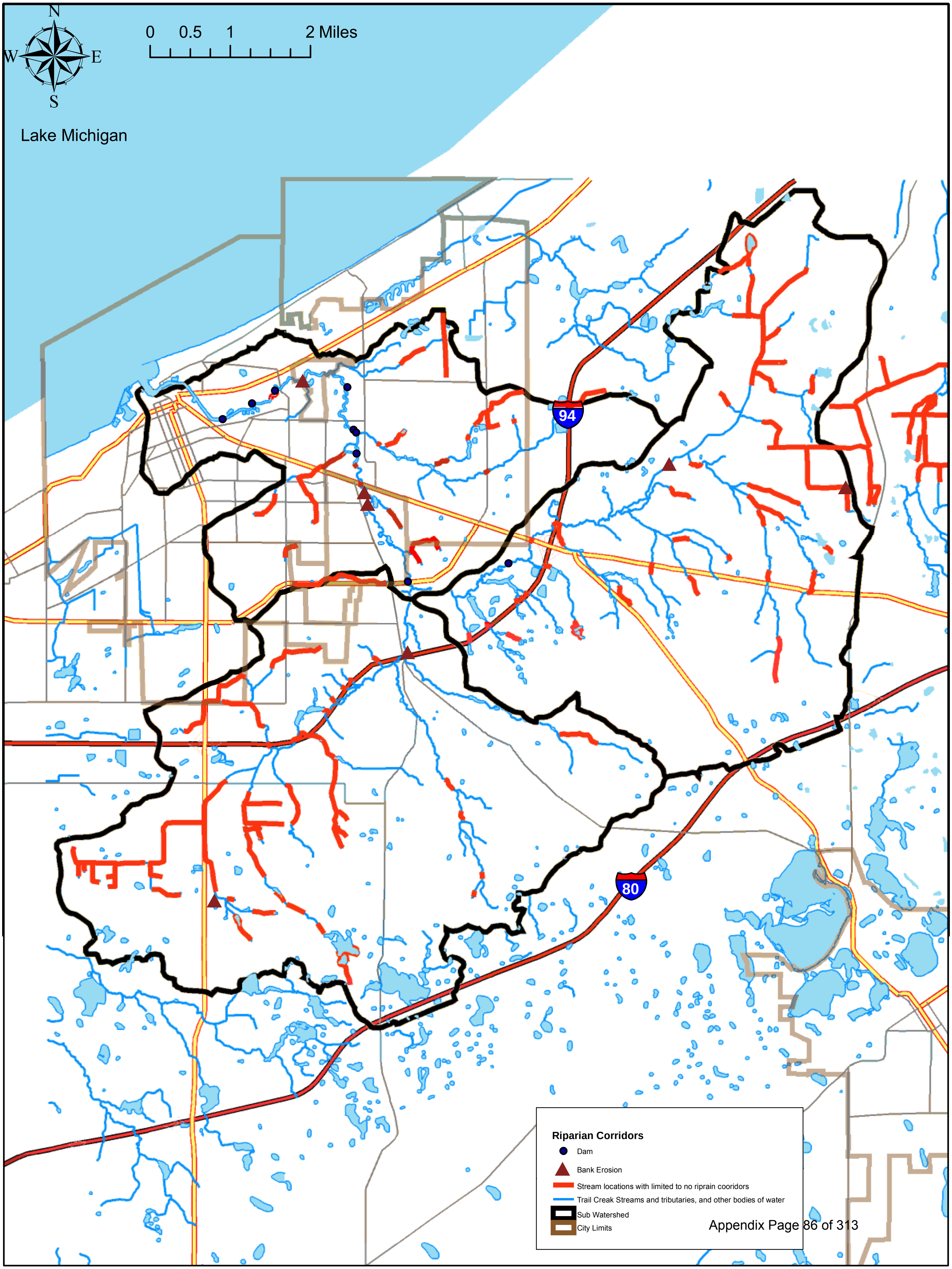


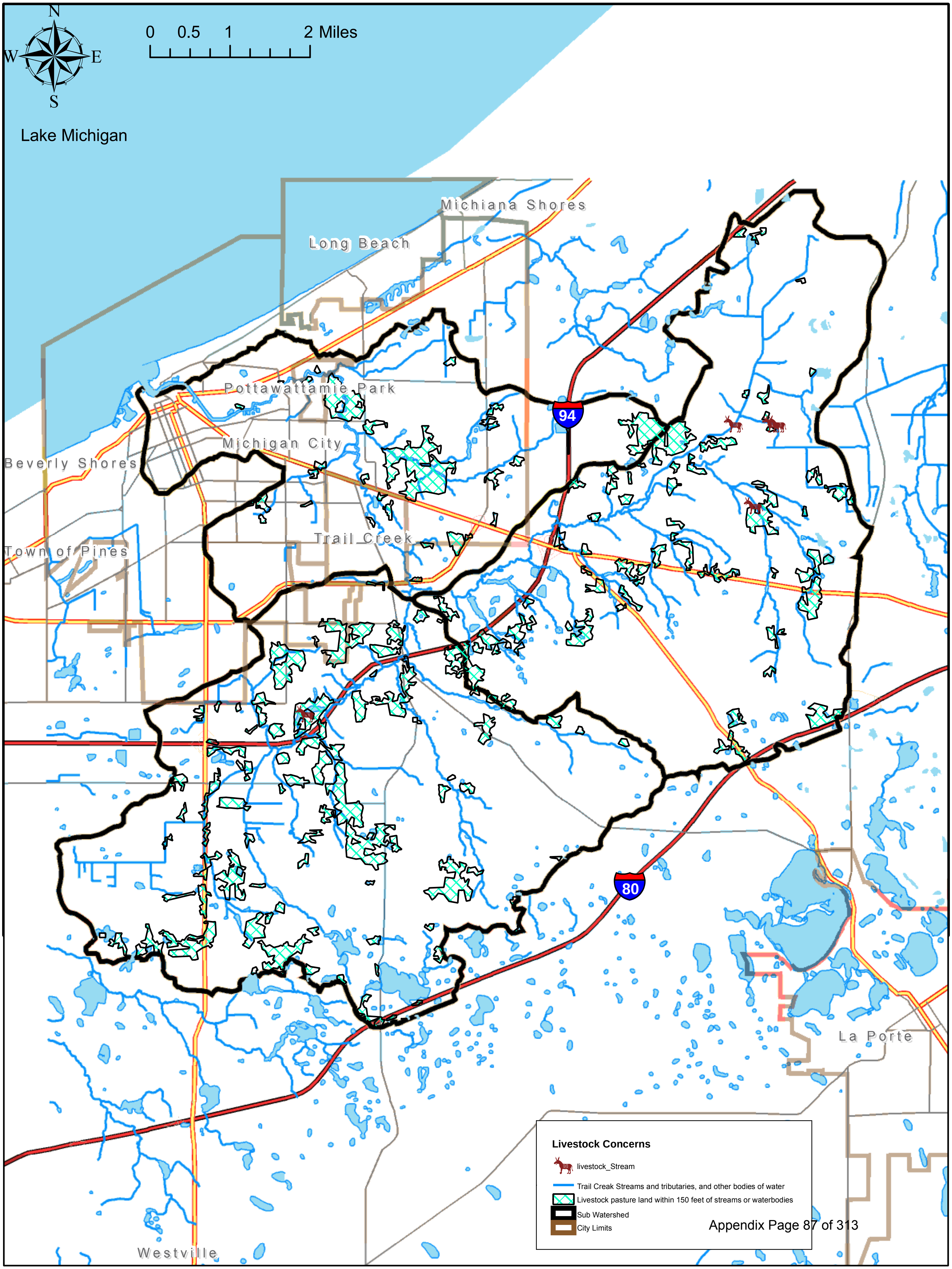
N
W
E
S
0 0.5 1 2 Miles
Lake Michigan
Michigan City
M1
M2
M3
M4
M5
M6
E1
E2
E3
W1
W2
W3
Sample Point Key
W1 West 400 North Bridge
W2 West 400 North Bridge
W3 North 675 West Bridge
E1 West 700 North Bridge
E2 Warnke Road Bridge
E3 North 600 West Bridge
M1 U.S. 20 Bridge
M2 Springland Avenue Bridge
M3 Liberty Trail Bridge
M4 N&W Railroad Bridge
M5 East Street Bridge
M6 Franklin Street Bridge

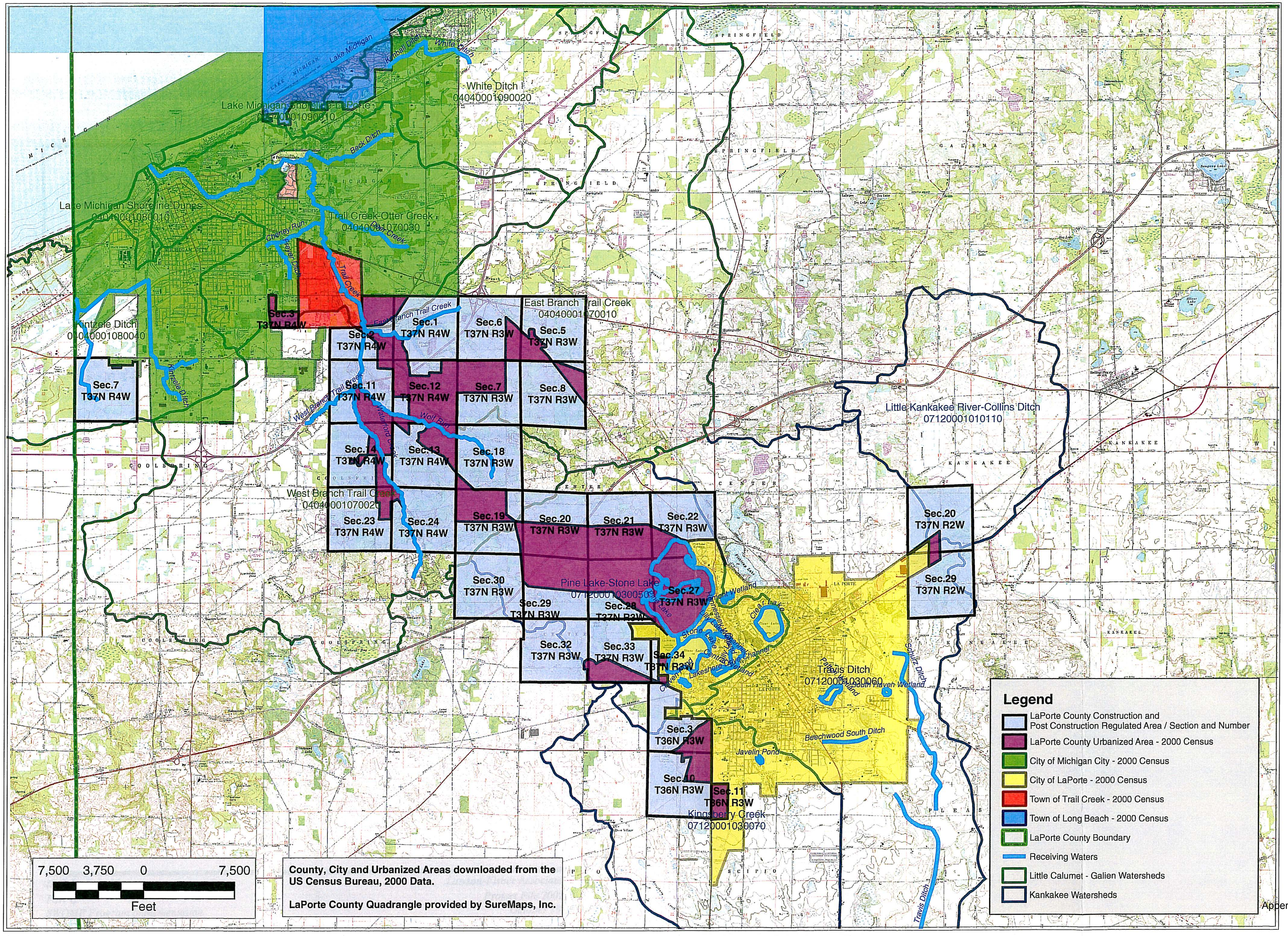

N
S
W
E
0 0.5 1 2 Miles
Source: IDEM NPDES Facilities
Lake Michigan
GIFFORD WWTP
94
AUTUMN CREEK MOBILE HOME PARK
FRIENDLY ACRES MOBILE HOME PAR
INDIAN SPRINGS SUBDIVISION
80
2
Point Source Discharges
Sub Watershed
Point Source Discharges
LaPorte County


N
S
W
E
0 0.5 1 2 Miles
Lake Michigan
Michiana Shores
Long Beach
Pottawattamie Park
Michigan City
Beverly Shores
Trail Creek
Town of Pines
94
80
La Porte
Westville
Soils Not Suited for Septic Tanks
Trail Creek Streams and tributaries, and other bodies of water
Sub Watershed
City Limits
Soils not suited for use as septic tank


N
W
E
S
0
0.5
1
2 Miles
Lake Michigan
94
80
Development
Reported Commercial non-point source pollution
New Commercial Development
Trail Creek Streams and tributaries, and other bodies of water
Developed Urban High Density
Sub Watershed
City Limits


N
W
E
S
0
0.5
1
2 Miles
Lake Michigan
94
80
Riparian Corridors
Dam
Bank Erosion
Stream locations with limited to no riprain cooridors
Trail Creak Streams and tributaries, and other bodies of water
Sub Watershed
City Limits


N
S
W
E
0 0.5 1 2 Miles
Lake Michigan
Michiana Shores
Long Beach
Pottawattamie Park
Michigan City
Beverly Shores
Trail Creek
Town of Pines
94
80
La Porte
Westville
Livestock Concerns
livestock_Stream
Trail Creak Streams and tributaries, and other bodies of water
Livestock pasture land within 150 feet of streams or waterbodies
Sub Watershed
City Limits



City of Michigan City, Indiana; City of LaPorte, Indiana
Town of Trail Creek, Indiana; Town of Long Beach, Indiana
LaPorte County, Indiana

Part C: SWQMP
MS4 Boundary Map

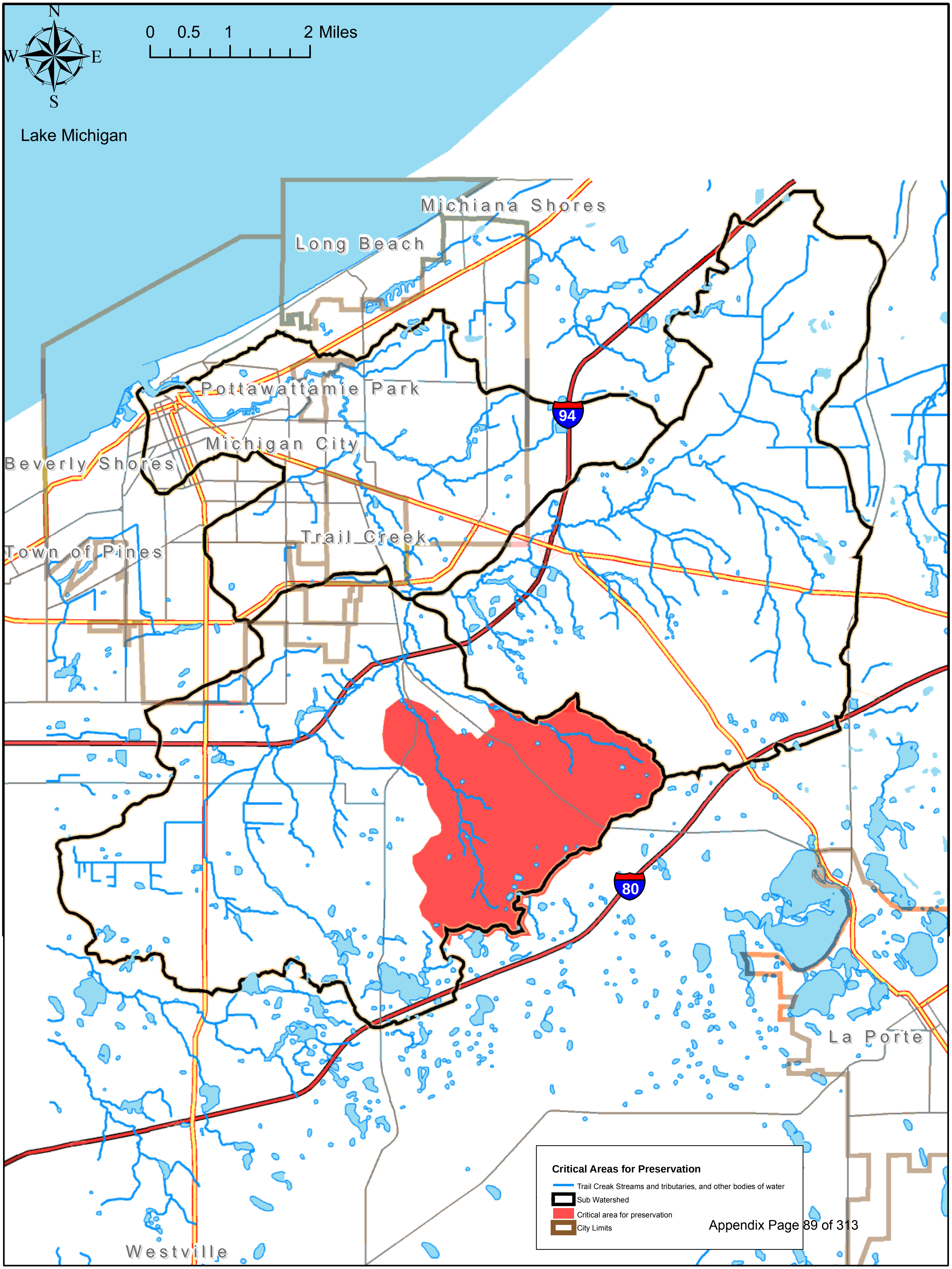
LAWSON-FISHER ASSOCIATES P.C.
CONSULTING ENGINEERS
525 W. WASHINGTON AVENUE
SOUTH BEND, INDIANA 46601
PH. (574) 234-3167

Figure 1

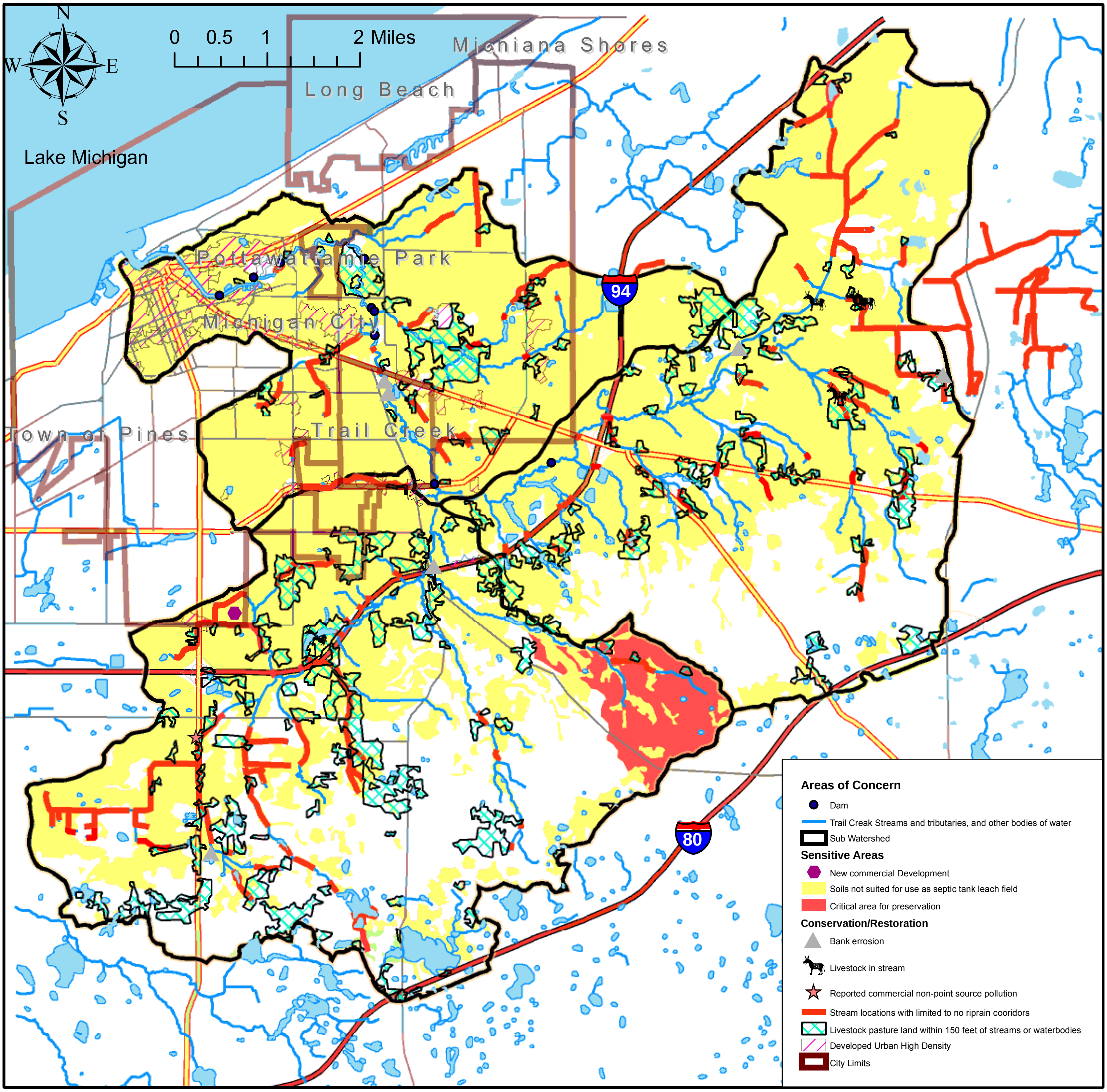
200242.10

October 2004

Map Document: (Z:\200242\PartC\11x17-township-urban.mxd)
10/18/2004 -- 3:43:45 PM



N
S
E
W
0 0.5 1 2 Miles
Lake Michigan
Michiana Shores
Long Beach
Pottawattamie Park
Michigan City
Beverly Shores
Trail Creek
Town of Pines
94
80
La Porte
Westville
Critical Areas for Preservation
Trail Creek Streams and tributaries, and other bodies of water
Sub Watershed
Critical area for preservation
City Limits


N
S
W
E
0 0.5 1 2 Miles
Lake Michigan
Michiana Shores
Long Beach
Pottawattamie Park
Michigan City
Town of Pines
Trail Creek
94
80
Areas of Concern
Dam
Trail Creak Streams and tributaries, and other bodies of water
Sub Watershed
Sensitive Areas
New commercial Development
Soils not suited for use as septic tank leach field
Critical area for preservation
Conservation/Restoration
Bank errosion
Livestock in stream
Reported commercial non-point source pollution
Stream locations with limited to no riprain cooridors
Livestock pasture land within 150 feet of streams or waterbodies
Developed Urban High Density
City Limits

Appendix M: Endangered, Threatened, and Rare Species Documented

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

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
VASCULAR PLANT					
ANDROMEDA GLAUCOPHYLLA	BOG ROSEMARY	SR	**	S2	G5
ARABIS GLABRA	TOWER-MUSTARD	ST	**	S2	G5
ARALIA HISPIDA	BRISTLY SARSAPARILLA	SE	**	S1	G5
ARCTOSTAPHYLOS UVA-URSI	BEARBERRY	SR	**	S2	G5
ARENARIA STRICTA	MICHAUX'S STITCHWORT	SR	**	S2	G5
ARISTIDA INTERMEDIA	SLIM-SPIKE THREE-AWN GRASS	SR	**	S2	G?
ARISTIDA TUBERCULOSA	SEABEACH NEEDLEGRASS	SR	**	S2	G5
ASTER BOREALIS	RUSHLIKE ASTER	SR	**	S2	G5
BETULA POPULIFOLIA	GRAY BIRCH	SX	**	SX	G5
BIDENS BECKII	BECK WATER-MARIGOLD	SE	**	S1	G4G5T4
CALLA PALUSTRIS	WILD CALLA	SE	**	S1	G5
CAREX ARCTATA	BLACK SEDGE	SE	**	S1	G5?
CAREX ATHERODES	AWNED SEDGE	SE	**	S1	G5
CAREX ATLANTICA SSP CAPILLACEA	HOWE SEDGE	SE	**	S1	G5T5?
CAREX CHORDORRHIZA	CREEPING SEDGE	SE	**	S1	G5
CAREX DEBILIS VAR RUDGEI	WHITE-EDGE SEDGE	ST	**	S2	G5T5
CAREX ECHINATA	LITTLE PRICKLY SEDGE	SE	**	S1	G5
CAREX FLAVA	YELLOW SEDGE	ST	**	S2	G5
CAREX FOLLICULATA	LONG SEDGE	ST	**	S2	G4G5
CAREX LEPTONERVIA	FINELY-NERVED SEDGE	SE	**	S1	G4
CAREX LIMOSA	MUD SEDGE	SE	**	S1	G5
CAREX PEDUNCULATA	LONGSTALK SEDGE	SR	**	S2	G5
CAREX SCABRATA	ROUGH SEDGE	SE	**	S1	G5
CAREX SEORSA	WEAK STELLATE SEDGE	SR	**	S2	G4
CAREX SPARGANIOIDES VAR CEPHALOIDEA	THINLEAF SEDGE	ST	**	S2	G5
CHRYSOSPLENIUM AMERICANUM	AMERICAN GOLDEN-SAXIFRAGE	ST	**	S2	G5
CIRCAEA ALPINA	SMALL ENCHANTER'S NIGHTSHADE	SX	**	SX	G5
CONIOSELINUM CHINENSE	HEMLOCK PARSLEY	SE	**	S1	G5
CORNUS RUGOSA	ROUNDLEAF DOGWOOD	SR	**	S2	G5
CORYDALIS SEMPERVIRENS	PALE CORYDALIS	SE	**	S1	G4G5
CYPERUS DENTATUS	TOOTHED SEDGE	SE	**	S1	G4
CYPRIPEDIUM CALCEOLUS VAR PARVIFLORUM	SMALL YELLOW LADY'S-SLIPPER	SR	**	S2	G5
CYPRIPEDIUM CANDIDUM	SMALL WHITE LADY'S-SLIPPER	SR	**	S2	G4
DESCHAMPSIA CESPITOSA	TUFTED HAIRGRASS	SR	**	S2	G5
DIERVILLA LONICERA	NORTHERN BUSH-HONEYSUCKLE	SR	**	S2	G5
DROSERA INTERMEDIA	SPOON-LEAVED SUNDEW	SR	**	S2	G5
DRYOPTERIS CLINTONIANA	CLINTON WOODFERN	SX	**	SX	G5
ELEOCHARIS MELANOCARPA	BLACK-FRUITED SPIKE-RUSH	ST	**	S2	G4
EQUISETUM VARIEGATUM	VARIEGATED HORSETAIL	SE	**	S1	G5
ERIOCAULON AQUATICUM	PIPEWORT	SE	**	S1	G5
ERIOPHORUM ANGUSTIFOLIUM	NARROW-LEAVED COTTON-GRASS	SR	**	S2	G5
ERIOPHORUM SPISSUM	DENSE COTTON-GRASS	SX	**	SX	G5T5

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

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

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
ERIOPHORUM VIRIDICARINATUM	GREEN-KEELED COTTON-GRASS	SR	**	S2	G5
FRAGARIA VESCA VAR AMERICANA	WOODLAND STRAWBERRY	SE	**	S1	G5T?
GENTIANA PUBERULENTA	DOWNY GENTIAN	ST	**	S2	G4G5
GERANIUM ROBERTIANUM	HERB-ROBERT	ST	**	S2	G5
JUNCUS BALTICUS VAR LITTORALIS	BALTIC RUSH	SR	**	S2	G5T5
JUNCUS PELOCARPUS	BROWN-FRUITED RUSH	ST	**	S2	G5
JUNCUS SCIRPOIDES	SCIRPUS-LIKE RUSH	ST	**	S2	G5
JUNIPERUS COMMUNIS	GROUND JUNIPER	SR	**	S2	G5
LATHYRUS MARITIMUS VAR GLABER	BEACH PEAVINE	SE	**	S1	G5T4T5
LATHYRUS VENOSUS	SMOOTH VEINY PEA	ST	**	S2	G5
LONICERA CANADENSIS	AMERICAN FLY-HONEYSUCKLE	SX	**	SX	G5
LUZULA ACUMINATA	HAIRY WOODRUSH	SE	**	S1	G5
LYCOPODIELLA INUNDATA	NORTHERN BOG CLUBMOSS	SE	**	S1	G5
LYCOPODIUM HICKEYI	HICKEY'S CLUBMOSS	SR	**	S2	G5
LYCOPODIUM OBSCURUM	TREE CLUBMOSS	SR	**	S2	G5
LYCOPODIUM TRISTACHYUM	DEEP-ROOT CLUBMOSS	ST	**	S2	G5
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	SE	**	S1	G5
MATTEUCCIA STRUTHIOPTERIS	OSTRICH FERN	SR	**	S2	G5
MELAMPYRUM LINEARE	AMERICAN COW-WHEAT	SR	**	S2	G5
MILIUM EFFUSUM	TALL MILLET-GRASS	SR	**	S2	G5
MYRIOPHYLLUM PINNATUM	CUTLEAF WATER-MILFOIL	SE	**	S1	G5
OENOTHERA PERENNIS	SMALL SUNDROPS	ST	**	S2	G5
ORYZOPSIS ASPERIFOLIA	WHITE-GRAINED MOUNTAIN-RICEGRASS	SE	**	S1	G5
ORYZOPSIS PUNGENS	SLENDER MOUNTAIN-RICEGRASS	SX	**	SX	G5
PANICUM BOREALE	NORTHERN WITCHGRASS	SR	**	S2	G5
PANICUM LEIBERGII	LEIBERG'S WITCHGRASS	ST	**	S2	G5
PANICUM VERRUCOSUM	WARTY PANIC-GRASS	ST	**	S2	G4
PINUS BANKSIANA	JACK PINE	SR	**	S2	G5
PINUS STROBUS	EASTERN WHITE PINE	SR	**	S2	G5
PLATANTHERA CILIARIS	YELLOW-FRINGE ORCHIS	SE	**	S1	G5
PLATANTHERA HYPERBOREA	LEAFY NORTHERN GREEN ORCHIS	ST	**	S2	G5
PLATANTHERA LEUCOPHAEA	PRAIRIE WHITE-FRINGED ORCHID	SE	LT	S1	G2
PLATANTHERA PSYCODES	SMALL PURPLE-FRINGE ORCHIS	SR	**	S2	G5
POA ALSODES	GROVE MEADOW GRASS	SR	**	S2	G4G5
POA PALUDIGENA	BOG BLUEGRASS	WL	**	S3	G3
POLYGONELLA ARTICULATA	EASTERN JOINTWEED	SR	**	S2	G5
POLYGONUM CAREYI	CAREY'S SMARTWEED	ST	**	S2	G4
POLYGONUM CILINODE	FRINGED BLACK BINDWEED	SE	**	S1	G5
POLYTAENIA NUTTALLII	PRAIRIE PARSLEY	SE	**	S1	G5
POTAMOGETON EPIHYDRUS	NUTTALL PONDWEED	SE	**	S1	G5
POTAMOGETON FRIESII	FRIES' PONDWEED	SE	**	S1	G4
POTAMOGETON PUSILLUS	SLENDER PONDWEED	SR	**	S2	G5
POTAMOGETON ROBBINSII	FLATLEAF PONDWEED	ST	**	S2	G5

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

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

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
POTENTILLA ANSERINA	SILVERWEED	ST	**	S2	G5
PRENANTHES ASPERA	ROUGH RATTLESNAKE-ROOT	SR	**	S2	G4?
PRUNUS PENSYLVANICA	FIRE CHERRY	SR	**	S2	G5
PSILOCARYA SCIRPOIDES	LONG-BEAKED BALDRUSH	ST	**	S2	G4
PYROLA ROTUNDIFOLIA VAR AMERICANA	AMERICAN WINTERGREEN	SR	**	S2	G5
PYROLA SECUNDA	ONE-SIDED WINTERGREEN	SX	**	SX	G5
RHYNCHOSPORA GLOBULARIS VAR RECOGNITA	GLOBE BEAKED-RUSH	SE	**	S1	G5T5?
RUBUS ALUMNUS	A BRAMBLE	SX	**	SX	G5
SATUREJA GLABELLA VAR ANGUSTIFOLIA	CALAMINT	SE	**	S1	G5
SCHEUCHZERIA PALUSTRIS SSP AMERICANA	AMERICAN SCHEUCHZERIA	SE	**	S1	G5T5
SILENE REGIA	ROYAL CATCHFLY	ST	**	S2	G3
SISYRINCHIUM MONTANUM	STRICT BLUE-EYED-GRASS	SE	**	S1	G5
SOLIDAGO SIMPLEX VAR GILLMANII	STICKY GOLDENROD	ST	**	S2	G5T3?
SORBUS DECORA	NORTHERN MOUNTAIN-ASH	SX	**	SX	G4G5
SPARGANIUM ANDROCLADUM	BRANCHING BUR-REED	ST	**	S2	G4G5
SPIRANTHES LUCIDA	SHINING LADIES'-TRESSES	SR	**	S2	G5
STIPA AVENACEA	BLACKSEED NEEDLEGRASS	ST	**	S2	G5
TOFIELDIA GLUTINOSA	FALSE ASPHODEL	SR	**	S2	G5
TRIGLOCHIN PALUSTRE	MARSH ARROW-GRASS	ST	**	S2	G5
UTRICULARIA GEMINISCAPA	HIDDEN-FRUITED BLADDERWORT	SE	**	S1	G4G5
UTRICULARIA MINOR	LESSER BLADDERWORT	SE	**	S1	G5
VACCINIUM OXYCOCCOS	SMALL CRANBERRY	ST	**	S2	G5
VALERIANA EDULIS	HAIRY VALERIAN	SE	**	S1	G5
VALERIANA ULIGINOSA	MARSH VALERIAN	SE	**	S1	G4Q
VALERIANELLA CHENOPODIIFOLIA	GOOSE-FOOT CORN-SALAD	SE	**	S1	G5
XYRIS DIFFORMIS	CAROLINA YELLOW-EYED GRASS	ST	**	S2	G5
ZIGADENUS ELEGANS VAR GLAUCUS	WHITE CAMAS	SR	**	S2	G5T4T5
MOLLUSCA: GASTROPODA					
LYMNAEA STAGNALIS	SWAMP LYMNAEA	SSC	**	S2	G5
ARTHROPODA: INSECTA: ODONATA (DRAGONFLIES; DAMSELFLIES)					
AESHNA MUTATA	SPATTERDOCK DARNER	**	**	S1S2	G3G4
SYMPETRUM SEMICINCTUM	BAND-WINGED MEADOWFLY	**	**	S2S3	G5
ARTHROPODA: INSECTA: LEPIDOPTERA (BUTTERFLIES; SKIPPERS)					
EUPHYDRYAS PHAETON	BALTIMORE	**	**	S2S4	G4
NEONYMPHA MITCHELLII MITCHELLII	MITCHELL'S SATYR	SE	LE	S1	G2T2
FISH					
ACIPENSER FULVESCENS	LAKE STURGEON	SE	**	S1	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

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

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
AMPHIBIANS					
RANA PIPIENS	NORTHERN LEOPARD FROG	SSC	**	S2	G5
REPTILES					
CLEMMYS GUTTATA	SPOTTED TURTLE	SE	**	S2	G5
CLONOPHIS KIRTLANDII	KIRTLAND'S SNAKE	SE	**	S2	G2
EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	SE	**	S2	G4
LIOCHLOROPHIS VERNALIS	SMOOTH GREEN SNAKE	SE	**	S2	G5
SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	SE	**	S2	G3G4T3T4
TERRAPENE ORNATA	ORNATE BOX TURTLE	SE	**	S2	G5
BIRDS					
ACCIPITER COOPERII	COOPER'S HAWK	**	**	S3B,SZN	G5
ARDEA HERODIAS	GREAT BLUE HERON	**	**	S4B,SZN	G5
BARTRAMIA LONGICAUDA	UPLAND SANDPIPER	SE	**	S3B	G5
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	SE	**	S2B	G4
BUTEO LINEATUS	RED-SHOULDERED HAWK	SSC	**	S3	G5
BUTEO PLATYPTERUS	BROAD-WINGED HAWK	SSC	**	S3B,SRFN	G5
CERTHIA AMERICANA	BROWN CREEPER	**	**	S2B,SZN	G5
CHLIDONIAS NIGER	BLACK TERN	SE	**	S1B,SZN	G4
CIRCUS CYANEUS	NORTHERN HARRIER	SE	**	S2	G5
CISTOTHORUS PALUSTRIS	MARSH WREN	SE	**	S3B,SZN	G5
CISTOTHORUS PLATENSIS	SEDGE WREN	SE	**	S3B,SZN	G5
DENDROICA CERULEA	CERULEAN WARBLER	SSC	**	S3B	G4
FALCO PEREGRINUS	PEREGRINE FALCON	SE	E(S/A)	S2B,SZN	G4
IXOBRYCHUS EXILIS	LEAST BITTERN	SE	**	S3B	G5
LANIUS LUDOVICIANUS	LOGGERHEAD SHRIKE	SE	**	S3B,SZN	G5
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	SE	**	S1B,SAN	G5
PHALACROCORAX AURITUS	DOUBLE-CRESTED CORMORANT	SX	**	SHB,SZN	G5
RALLUS LIMICOLA	VIRGINIA RAIL	SSC	**	S3B,SZN	G5
STURNELLA NEGLECTA	WESTERN MEADOWLARK	SSC	**	S2B	G5
XANTHOCEPHALUS XANTHOCEPHALUS	YELLOW-HEADED BLACKBIRD	SE	**	S1B	G5
MAMMALS					
CONDYLURA CRISTATA	STAR-NOSED MOLE	SSC	**	S2?	G5
LYNX RUFUS	BOBCAT	SE	**	S1	G5
MUSTELA NIVALIS	LEAST WEASEL	SSC	**	S2?	G5
MYOTIS SODALIS	INDIANA BAT OR SOCIAL MYOTIS	SE	LE	S1	G2
SPERMOPHILUS FRANKLINII	FRANKLIN'S GROUND SQUIRREL	SE	**	S2	G5
TAXIDEA TAXUS	AMERICAN BADGER	SE	**	S2	G5
HIGH QUALITY NATURAL COMMUNITY					
FOREST - FLATWOODS BOREAL	BOREAL FLATWOODS	SG	**	S2	G2?

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

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

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
FOREST - FLOODPLAIN WET-MESIC	WET-MESIC FLOODPLAIN FOREST	SG	**	S3	G3?
FOREST - UPLAND DRY	DRY UPLAND FOREST	SG	**	S4	G4
FOREST - UPLAND DRY-MESIC	DRY-MESIC UPLAND FOREST	SG	**	S4	G4
FOREST - UPLAND MESIC	MESIC UPLAND FOREST	SG	**	S3	G3?
LAKE - LAKE	LAKE	SG	**	S2	
PRAIRIE - DRY-MESIC	DRY-MESIC PRAIRIE	SG	**	S2	G3
PRAIRIE - MESIC	MESIC PRAIRIE	SG	**	S2	G2
PRAIRIE - SAND DRY	DRY SAND PRAIRIE	SG	**	S2	G3
PRAIRIE - SAND DRY-MESIC	DRY-MESIC SAND PRAIRIE	SG	**	S3	G3
PRAIRIE - SAND WET-MESIC	WET-MESIC SAND PRAIRIE	SG	**	S2	G1?
PRAIRIE - WET	WET PRAIRIE	SG	**	S1	G3
WETLAND - BOG ACID	ACID BOG	SG	**	S2	G3
WETLAND - BOG CIRCUMNEUTRAL	CIRCUMNEUTRAL BOG	SG	**	S3	G3
WETLAND - FEN	FEN	SG	**	S3	G3
WETLAND - FEN FORESTED	FORESTED FEN	SG	**	S1	G3
WETLAND - MARSH	MARSH	SG	**	S4	GU
WETLAND - MEADOW SEDGE	SEDGE MEADOW	SG	**	S1	G3?
WETLAND - SEEP CIRCUMNEUTRAL	CIRCUMNEUTRAL SEEP	SG	**	S1	GU
WETLAND - SWAMP SHRUB	SHRUB SWAMP	SG	**	S2	GU

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

Appendix N: Natural Heritage Database

Natural Heritage Database

Species Located in Trail Creek Watershed from the Natural Heritage Database

Species located in Trail Creek Watershed not listed as site-specific			
Type	Species Name	Common Name	State status
Bird	*Buteo platypterus*	Broad-winged Hawk	SSC
Bird	*Dendrocia cerulea*	Cerulean warbler	SSC
Bird	*Wilsonia citrina*	Hooded warbler	SSC
Mammal	*Taxidea taxus*	American badger	
Reptile	*Terrapene ornata*	Ornate box turtle	SE
Reptile	*Clemmys guttata*	Spotted turtle	SE
Plant	*Cornus rugosa*	Roundleaf dogwood	SR
Plant	*Panax trifolius*	Dwarf ginseng	WL
Plant	*Hydrastis canadensis*	Golden seal	WL
Plant	*Platanthera hyperborea*	Leafy northern green orchids	ST
Plant	*Spiranthes lucida*	Shining Ladies-tresses	SR
Plant	*Carex folliculata*	Long sedge	SR
Plant	*Aristida intermedia*	Slim-spike Three-awn Grass	SR
Plant	*Milium effusum*	Tall Millet-grass	SR
Plant	*Luzula acuminata*	Hairy woodrush	SE
Plant	*Stipa avenacea*	Blackseed needlegrass	SR
Plant	*Aristida tuberculosa*	Seabeach needlegrass	SR
Plant	*Poa alsodes*	Grove meadow grass	SR
Plant	*Matteuccia struthiopteris*	Ostrich fern	SR
Plant	*Lycopodium obscurum*	Tree clubmoss	SR
Plant	*Lycopodium hickeyi*	Hickey's clubmoss	SR
Plant	*Carex pedunculata*	Longstalk sedge	SR
Plant	*Juncus scirpoides*	Scirpus-like Rush	ST
Plant	*Eriophorum virdicarnatum*	Green-keeled Cotton-grass	SR
Plant	*Lonicera canadensis*	American Flay-honeysuckle	SX
Plant	*Epigaea repens*	Trailing arbutus	WL
Plant	*Circaea alpina*	Small enchanters nightshade	SX
Plant	*Polygonella articulata*	Eastern jointweed	SR
Plant	*Carex arctata*	Black sedge	SE
Plant	*Pyrola rotundifolia var. americana*	American wintergreen	SR
Plant	*Prunus pennsylvanica*	Fire cherry	SR
Plant	*Melampyrum lineare*	American Cow-wheat	SR
Plant	*Pinus banksiana*	Jack pine	SR
Plant	*Pinus strobus*	Eastern white pine	SR
Plant	*Polygonum careyi*	Carey's smartweed	ST
Plant	*Carex seorsa*	Weak stellate sedge	SR

Site specific Species located in Trail Creek Watershed listed as site specific				
Type	Species Name	Common Name	State Status	Location
Plant	*Carex arctata*	Black sedge	SE	Barker Woods Nature Preserve
Plant	*Carex folliculata*	Long sedge	SR	Barker Woods Nature Preserve
Plant	*Melampyrum lineare*	American Cow-wheat	SR	Barker Woods Nature Preserve
Plant	*Pyrola rotundifolia var. americana*	American wintergreen	SR	Barker Woods Nature Preserve
Plant	*Epigaea repens*	Trailing arbutus	WL	Barker Woods Nature Preserve
Plant	*Lathyus venosus*	Smooth veiny pea	ST	IDNL-Pinhook Bog Unit
Plant	*Calla palustris*	Wild calla	SE	IDNL-Pinhook Bog Unit
Plant	*Xyris difformis*	Carolina Yellow-eyed Grass	ST	IDNL-Pinhook Bog Unit
Plant	*Platanthera ciliaris*	Yellow-fringe Orchids	SE	IDNL-Pinhook Bog Unit
Plant	*Pinus stobus*	Eastern white pine	SR	IDNL-Pinhook Bog Unit
Insect	*Aeshna mutata*	Canada warbler	ST	IDNL-Pinhook Bog Unit
Plant	*Juncus balticus var. littoralis*	Baltic rush	SR	IDNL-Pinhook Bog Unit
Plant	*Lycododiella inundata*	Northern bog clubmoss	SE	IDNL-Pinhook Bog Unit
Plant	*Carex atlantica spp. Capillacea*	Howe sedge	SE	IDNL-Pinhook Bog Unit
Plant	*Carex Chordorrhiza*	Creeping sedge	SE	Indiana Dunes National Lakeshore
Reptile	*Clemmys guttata*	Spotted turtle	SE	Indiana Dunes National Lakeshore
Plant	*Carex seorsa*	Weak stellate sedge	SR	Indiana Dunes National Lakeshore
Plant	*Uticularia geminiscapa*	Hidden-fruited Bladderwort	SE	Indiana Dunes National Lakeshore
Plant	*Eriophorum spissum*	Dense Cotton-grass	SX	Indiana Dunes National Lakeshore
Plant	*Maxlais unifolia*	Green Adder's-mouth	SE	Indiana Dunes National Lakeshore
Plant	*Scheuchzeria palustris ssp. Americana*	American scheuchzeria	SE	Indiana Dunes National Lakeshore
Reptile	*Emydoidea blandingii*	Blanding's turtle	SE	Indiana Dunes National Lakeshore
Plant	*Drosera intermedia*	Spoon-leaved Sundew	SE	Indiana Dunes National Lakeshore
Plant	*Valerianella*	Goose-foot Corn-salas	SE	Trail Creek Fen (IDNR)
Reptile	*Clemmys guttata*	Spotted turtle	SE	Trail Creek Fen (TNC)
Plant	*Betula populifolia*	Gray birch	SE	Trail Creek Fen (TNC)
Mammal	*Condylura cristata*	Star-nosed mole	SG	Trail Creek Fen (TNC)
Insect	*Euphydras phaeton*	Baltimore	SR	Trail Creek Fen (TNC)
Plant	*Lycopodium obsurum*	Tree clubmoss	SR	Wintergreen Woods Nature Preserve
Plant	*Carex debilis var. rudgei*	White-edge Sedge	SR	Wintergreen Woods Nature Preserve

High Quality Natural Communities			
Community scientific Name	Common Name	State status	Location
Wetland-swamp shrub	Shrub Swamp	SG	N/A
Forest-flatwoods boreal	Boreal Flatwoods	SG	N/A
Forest-floodplain wet-mesic	Wet-mesic Floodplain Forest	SG	N/A
Forest-upland dry-mesic	Dry-mesic Upland Forest	SG	N/A

Forest-upland mesic	Mesic Upland Forest	SG	N/A
Forest-flatwoods boreal	Boreal Flatwoods	SG	Baker Woods Nature Preserve
Forest-upland dry-mesic	Dry-mesic Upland Forest	SG	Baker Woods Nature Preserve
Wetland - bog acid	Acid Bog	SG	IDNL-Pinhook Bog Unit
Wetland -Fen	Fen	SG	Trail Creek Fen (TNC)
Forest-upland dry-mesic	Dry-mesic Upland Forest	SG	Washington Park
Forest-upland dry	Dry Upland Forest	SG	Washington Park
Prairie- sand dry	Dry Sand Prairie	SG	Washington Park

Appendix O: Trail Creek Flow Study

Watershed Land Use Types and the Corresponding Cover Type Assumptions for Curve Number Calculations

Developed Agriculture Pasture/Grassland	Pasture, grassland, or range with continuous forage for grazing
Developed Agriculture Row Crop	Pasture, grassland, or range with continuous forage for grazing
Developed Non-Vegetated	Urban: Commercial and Business
Developed Urban High Density	Urban: Commercial and Business
Developed Urban Low Density	Residential: 1 acre
Palustrine Forest Deciduous	Wood or Forest Land: good cover
Palustrine Herbaceous Deciduous	Wood or Forest Land: good cover
Palustrine Shrubland Deciduous	Meadow
Palustrine Woodland Deciduous	Wood or Forest Land: good cover
Terrestrial Forest Deciduous	Wood or Forest Land: good cover
Terrestrial Forest Evergreen	Wood or Forest Land: good cover
Terrestrial Forest Mixed	Wood or Forest Land: thin stand
Terrestrial Shrubland Deciduous	Meadow
Terrestrial Woodland Deciduous	Wood or Forest Land: good cover
Unclassified Cloud/Shadow	Highest % (Wood or Forest for E1)
Water	Dirt

E1 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
2742.45	3619.9	1309.01	182.28	34.04

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of E1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	828.98	10.51%	288.22	380.44	137.57	19.16
Developed Agriculture Row Crop	2652.71	33.63%	922.30	1217.40	440.23	61.30
Developed Non-Vegetated	42.81	0.54%	14.88	19.65	7.10	0.99
Developed Urban High Density	15.48	0.20%	5.38	7.10	2.57	0.36
Developed Urban Low Density	23.66	0.30%	8.23	10.86	3.93	0.55
Palustrine Forest Deciduous	1251.93	15.87%	435.28	574.54	207.76	28.93
Palustrine Herbaceous Deciduous	98.16	1.24%	34.13	45.05	16.29	2.27
Terrestrial Forest Deciduous	2436.82	30.89%	847.24	1118.32	404.40	56.31
Terrestrial Forest Evergreen	57.85	0.73%	20.11	26.55	9.60	1.34
Terrestrial Forest Mixed	14.13	0.18%	4.91	6.48	2.34	0.33
Terrestrial Shrubland Deciduous	159.17	2.02%	55.34	73.05	26.42	3.68
Terrestrial Woodland Deciduous	65.31	0.83%	22.71	29.97	10.84	1.51
Unclassified Cloud/Shadow	228.78	2.90%	79.54	104.99	37.97	5.29
Water	11.98	0.15%	4.16	5.50	1.99	0.28
TOTAL	7887.77	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

~~Flow Rates are for a~~

Flow Rate are avg flows for a 1 yr 24 hr storm

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	14122.90	26250.32	10868.24	1609.19	52850.64
Developed Agriculture Row Crop	45192.87	84000.29	34778.05	5149.36	169120.57
Developed Non-Vegetated	1324.73	1807.53	667.84	93.99	3894.08
Developed Urban High Density	478.93	653.48	241.44	33.98	1407.83
Developed Urban Low Density	419.48	738.26	310.15	45.92	1513.81
Palustrine Forest Deciduous	10881.92	31599.92	14543.46	2227.70	59252.99
Palustrine Herbaceous Deciduous	853.23	2477.70	1140.33	174.67	4645.93
Terrestrial Forest Deciduous	21181.11	61507.67	28308.12	4336.10	115333.00
Terrestrial Forest Evergreen	502.83	1460.17	672.03	102.94	2737.97
Terrestrial Forest Mixed	221.05	427.95	180.54	27.10	856.64
Terrestrial Shrubland Deciduous	1660.23	4236.75	1875.47	286.91	8059.35
Terrestrial Woodland Deciduous	567.72	1648.60	758.75	116.22	3091.29
Unclassified Cloud/Shadow	1988.58	5774.61	2657.69	407.09	10827.97
Water	299.83	450.72	172.93	24.63	948.11

Total Sum	434540.19
Total Acres	7853.73
Composite Number	55.33
Flow	10.936 cfs

E2 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
4259.63	4505.23	1518.2	213.37	40.39

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of E2	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	1105.23	10.49%	446.80	472.56	159.24	22.38
Developed Agriculture Row Crop	3385.58	32.13%	1368.64	1447.56	487.81	68.56
Developed Non-Vegetated	67.27	0.64%	27.19	28.76	9.69	1.36
Developed Urban High Density	15.29	0.15%	6.18	6.54	2.20	0.31
Developed Urban Low Density	38.69	0.37%	15.64	16.54	5.58	0.78
Palustrine Forest Deciduous	1418.45	13.46%	573.42	606.48	204.38	28.72
Palustrine Herbaceous Deciduous	111.33	1.06%	45.00	47.60	16.04	2.25
Terrestrial Forest Deciduous	3719.96	35.30%	1503.82	1590.52	535.98	75.33
Terrestrial Forest Evergreen	111.81	1.06%	45.20	47.81	16.11	2.26
Terrestrial Forest Mixed	19.62	0.19%	7.93	8.39	2.83	0.40
Terrestrial Shrubland Deciduous	219.87	2.09%	88.88	94.01	31.68	4.45
Terrestrial Woodland Deciduous	72.44	0.69%	29.28	30.97	10.44	1.47
Unclassified Cloud/Shadow	229.91	2.18%	92.94	98.30	33.13	4.66
Water	21.50	0.20%	8.69	9.19	3.10	0.44
TOTAL	10536.94	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	21892.96	32606.38	12580.35	1879.96	68959.65
Developed Agriculture Row Crop	67063.49	99881.32	38536.68	5758.78	211240.27
Developed Non-Vegetated	2420.22	2646.05	911.07	129.40	6106.74
Developed Urban High Density	550.14	601.48	207.10	29.42	1388.13
Developed Urban Low Density	797.77	1125.02	440.44	65.82	2429.05
Palustrine Forest Deciduous	14335.44	33356.36	14306.26	2211.68	64209.74
Palustrine Herbaceous Deciduous	1125.12	2617.97	1122.83	173.58	5039.50
Terrestrial Forest Deciduous	37595.44	87478.83	37518.92	5800.26	168393.46
Terrestrial Forest Evergreen	1129.98	2629.29	1127.68	174.33	5061.27
Terrestrial Forest Mixed	356.98	553.76	217.71	32.98	1161.43
Terrestrial Shrubland Deciduous	2666.55	5452.57	2249.28	347.28	10715.68
Terrestrial Woodland Deciduous	732.08	1703.44	730.59	112.95	3279.06
Unclassified Cloud/Shadow	2323.60	5406.66	2318.87	358.49	10407.61
Water	625.75	753.75	269.49	38.75	1687.74

Total Sum:	560079.32
Total Acres:	10496.55
Composite Number:	53.36
Flow Rate:	7.75

E3 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
5186.29	4988.59	1696.77	287.33	171.4

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M2	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	1310.14	10.63%	551.05	530.05	180.28	30.53
Developed Agriculture Row Crop	3670.73	29.77%	1543.93	1485.08	505.12	85.54
Developed Non-Vegetated	134.41	1.09%	56.53	54.38	18.50	3.13
Developed Urban High Density	20.05	0.16%	8.43	8.11	2.76	0.47
Developed Urban Low Density	42.39	0.34%	17.83	17.15	5.83	0.99
Palustrine Forest Deciduous	1539.36	12.48%	647.46	622.78	211.83	35.87
Palustrine Herbaceous Deciduous	118.03	0.96%	49.65	47.75	16.24	2.75
Terrestrial Forest Deciduous	4767.94	38.67%	2005.42	1928.98	656.10	111.10
Terrestrial Forest Evergreen	111.81	0.91%	47.03	45.24	15.39	2.61
Terrestrial Forest Mixed	19.63	0.16%	8.26	7.94	2.70	0.46
Terrestrial Shrubland Deciduous	244.71	1.98%	102.92	99.00	33.67	5.70
Terrestrial Woodland Deciduous	87.20	0.71%	36.68	35.28	12.00	2.03
Unclassified Cloud/Shadow	229.11	1.86%	96.37	92.69	31.53	5.34
Water	35.01	0.28%	14.73	14.16	4.82	0.82
TOTAL	12330.51	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	27001.60	36573.24	14242.51	2564.47	80381.82
Developed Agriculture Row Crop	75652.56	102470.22	39904.40	7185.07	225212.25
Developed Non-Vegetated	5031.34	5002.68	1738.55	297.54	12070.11
Developed Urban High Density	750.42	746.14	259.30	44.38	1800.24
Developed Urban Low Density	909.35	1166.25	460.85	82.98	2619.43
Palustrine Forest Deciduous	16186.58	34253.00	14827.88	2762.04	68029.50
Palustrine Herbaceous Deciduous	1241.15	2626.45	1136.97	211.79	5216.37
Terrestrial Forest Deciduous	50135.58	106093.74	45927.23	8555.02	210711.58
Terrestrial Forest Evergreen	1175.71	2487.96	1077.02	200.62	4941.30
Terrestrial Forest Mixed	371.61	524.25	208.03	37.97	1141.86
Terrestrial Shrubland Deciduous	3087.75	5742.08	2390.81	444.77	11665.41
Terrestrial Woodland Deciduous	916.93	1940.36	839.97	156.46	3853.72
Unclassified Cloud/Shadow	2409.17	5098.13	2206.95	411.10	10125.34
Water	1060.23	1161.46	419.13	72.61	2713.43

Total Sum:	640482.36
Total Acres:	12159.11
Composite Number:	52.68
Flow Rate:(cfs)	6.63

6.89

W1 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
1119.78	5541.2	2013.24	320.18	128.1

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of W1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	1534.4425	16.82%	188.35	932.05	338.63	53.86
Developed Agriculture Row Crop	3520.3564	38.59%	432.12	2138.32	776.90	123.56
Developed Non-Vegetated	159.0765	1.74%	19.53	96.63	35.11	5.58
Developed Urban High Density	49.2400	0.54%	6.04	29.91	10.87	1.73
Developed Urban Low Density	20.5138	0.22%	2.52	12.46	4.53	0.72
Palustrine Forest Deciduous	793.8318	8.70%	97.44	482.19	175.19	27.86
Palustrine Herbaceous Deciduous	99.4471	1.09%	12.21	60.41	21.95	3.49
Palustrine Shrubland Deciduous	13.9458	0.15%	1.71	8.47	3.08	0.49
Terrestrial Forest Deciduous	2535.4325	27.79%	311.22	1540.06	559.54	88.99
Terrestrial Forest Evergreen	28.3698	0.31%	3.48	17.23	6.26	1.00
Terrestrial Forest Mixed	44.4067	0.49%	5.45	26.97	9.80	1.56
Terrestrial Shrubland Deciduous	182.1681	2.00%	22.36	110.65	40.20	6.39
Terrestrial Woodland Deciduous	115.6529	1.27%	14.20	70.25	25.52	4.06
Unclassified Cloud/Shadow	5.4352	0.06%	0.67	3.30	1.20	0.19
Water	20.2571	0.22%	2.49	12.30	4.47	0.71
TOTAL	9122.5762	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	9229.15	64311.11	26751.97	4523.83	104816.07
Developed Agriculture Row Crop	21173.76	147544.17	61375.04	10378.69	240471.66
Developed Non-Vegetated	1737.85	8889.56	3299.98	530.40	14457.79
Developed Urban High Density	537.93	2751.64	1021.47	164.18	4475.22
Developed Urban Low Density	128.42	847.31	357.64	60.48	1393.85
Palustrine Forest Deciduous	2436.04	26520.24	12263.22	2145.34	43364.84
Palustrine Herbaceous Deciduous	305.17	3322.32	1536.27	268.76	5432.52
Palustrine Shrubland Deciduous	51.35	491.31	218.51	38.18	799.36
Terrestrial Forest Deciduous	7780.50	84703.44	39167.71	6852.03	138503.68
Terrestrial Forest Evergreen	87.06	947.78	438.26	76.67	1549.76
Terrestrial Forest Mixed	245.29	1780.24	754.60	129.36	2909.49
Terrestrial Shrubland Deciduous	670.82	6417.81	2854.36	498.70	10441.70
Terrestrial Woodland Deciduous	354.90	3863.72	1786.62	312.55	6317.80
Unclassified Cloud/Shadow	16.68	181.58	83.96	14.69	296.91
Water	179.03	1008.97	388.93	63.28	1640.21

Total Sum:	576870.85
Total Acres:	8994.48
Composite Number:	64.14
Flow Rate (cfs)	57.49

72.44

W2 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
1275.1	939	227.15	54.65	4.51

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of W2	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	317.39	12.69%	161.85	119.19	28.83	6.94
Developed Agriculture Row Crop	311.30	12.45%	158.75	116.90	28.28	6.80
Developed Urban Low Density	18.26	0.73%	9.31	6.86	1.66	0.40
Palustrine Forest Deciduous	128.00	5.12%	65.27	48.07	11.63	2.80
Palustrine Herbaceous Deciduous	9.49	0.38%	4.84	3.56	0.86	0.21
Terrestrial Forest Deciduous	1618.08	64.71%	825.14	607.65	146.99	35.37
Terrestrial Forest Evergreen	22.80	0.91%	11.63	8.56	2.07	0.50
Terrestrial Forest Mixed	2.26	0.09%	1.15	0.85	0.20	0.05
Terrestrial Shrubland Deciduous	42.82	1.71%	21.83	16.08	3.89	0.94
Terrestrial Woodland Deciduous	30.05	1.20%	15.32	11.28	2.73	0.66
TOTAL	2500.43	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	7930.77	8224.12	2277.80	582.70	19015.38
Developed Agriculture Row Crop	7778.54	8066.26	2234.07	571.51	18650.39
Developed Urban Low Density	474.99	466.39	131.07	33.53	1105.99
Palustrine Forest Deciduous	1631.81	2643.70	813.95	215.41	5304.87
Palustrine Herbaceous Deciduous	120.93	195.92	60.32	15.96	393.13
Terrestrial Forest Deciduous	20628.61	33420.57	10289.55	2723.12	67061.85
Terrestrial Forest Evergreen	290.70	470.97	145.00	38.37	945.05
Terrestrial Forest Mixed	51.75	55.90	15.78	4.09	127.51
Terrestrial Shrubland Deciduous	655.04	932.60	276.17	72.99	1936.80
Terrestrial Woodland Deciduous	383.04	620.57	191.06	50.56	1245.24

Total Sum:	115786.22
Total Acres:	2495.92
Composite Number:	46.39
Flow Rate (cfs)	0.25

W3 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
680.6	475.51	40.2	27.15	0.22

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of W3	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	139.74	11.42%	77.72	54.30	4.59	3.10
Developed Agriculture Row Crop	267.38	21.85%	148.71	103.90	8.78	5.93
Developed Urban Low Density	2.12	0.17%	1.18	0.82	0.07	0.05
Palustrine Forest Deciduous	16.40	1.34%	9.12	6.37	0.54	0.36
Terrestrial Forest Deciduous	724.04	59.17%	402.70	281.35	23.79	16.06
Terrestrial Forest Evergreen	19.97	1.63%	11.10	7.76	0.66	0.44
Terrestrial Forest Mixed	3.28	0.27%	1.82	1.27	0.11	0.07
Terrestrial Shrubland Deciduous	45.15	3.69%	25.11	17.54	1.48	1.00
Terrestrial Woodland Deciduous	5.62	0.46%	3.12	2.18	0.18	0.12
TOTAL	1223.69	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	3808.45	3746.87	362.67	260.44	8178.43
Developed Agriculture Row Crop	7286.99	7169.17	693.93	498.32	15648.41
Developed Urban Low Density	60.10	55.99	5.50	3.95	125.54
Palustrine Forest Deciduous	228.01	350.46	37.71	28.01	644.19
Terrestrial Forest Deciduous	10067.54	15474.40	1665.00	1236.95	28443.89
Terrestrial Forest Evergreen	277.61	426.70	45.91	34.11	784.33
Terrestrial Forest Mixed	82.06	84.09	8.29	6.04	180.48
Terrestrial Shrubland Deciduous	753.32	1017.54	105.30	78.13	1954.29
Terrestrial Woodland Deciduous	78.10	120.04	12.92	9.60	220.64

Total Sum:	56180.19
Total Acres:	1223.47
Composite Number:	45.92
Flow Rate:	0.19

M1 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
10238.88	12941.01	4933.59	799.9	470.6

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M1	A	B	C	D
Developed Agriculture Pasture/Grassland	4081.96	13.89%	1422.35	1797.72	685.36	111.12
Developed Agriculture Row Crop	8595.25	29.25%	2994.99	3785.40	1443.13	233.98
Developed Non-Vegetated	363.84	1.24%	126.78	160.24	61.09	9.90
Developed Urban High Density	159.47	0.54%	55.57	70.23	26.78	4.34
Developed Urban Low Density	219.97	0.75%	76.65	96.88	36.93	5.99
Palustrine Forest Deciduous	2688.79	9.15%	936.90	1184.16	451.45	73.19
Palustrine Herbaceous Deciduous	268.88	0.92%	93.69	118.42	45.14	7.32
Palustrine Shrubland Deciduous	20.37	0.07%	7.10	8.97	3.42	0.55
Terrestrial Forest Deciduous	11509.67	39.17%	4010.52	5068.93	1932.46	313.32
Terrestrial Forest Evergreen	208.63	0.71%	72.70	91.88	35.03	5.68
Terrestrial Forest Mixed	79.56	0.27%	27.72	35.04	13.36	2.17
Terrestrial Shrubland Deciduous	586.65	2.00%	204.42	258.36	98.50	15.97
Terrestrial Woodland Deciduous	276.25	0.94%	96.26	121.66	46.38	7.52
Unclassified Cloud/Shadow	235.93	0.80%	82.21	103.90	39.61	6.42
Water	89.05	0.30%	31.03	39.22	14.95	2.42
TOTAL	29384.26	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A	B	C	D	Sums
Developed Agriculture Pasture/Grassland	69695.10	124042.64	54143.19	9334.02	257214.95
Developed Agriculture Row Crop	146754.73	261192.58	114007.58	19654.34	541609.24
Developed Non-Vegetated	11283.33	14741.80	5742.30	940.92	32708.35
Developed Urban High Density	4945.58	6461.46	2516.90	412.41	14336.36
Developed Urban Low Density	3909.11	6587.67	2917.73	503.00	13917.51
Palustrine Forest Deciduous	23422.62	65128.91	31601.23	5635.98	125788.73
Palustrine Herbaceous Deciduous	2342.26	6512.90	3160.13	563.60	12578.89
Palustrine Shrubland Deciduous	212.89	520.21	242.77	43.24	1019.11
Terrestrial Forest Deciduous	100262.99	278791.20	135272.43	24125.41	538452.04
Terrestrial Forest Evergreen	1817.39	5053.43	2451.98	437.30	9760.10
Terrestrial Forest Mixed	1247.51	2312.56	1028.57	179.76	4768.40
Terrestrial Shrubland Deciduous	6132.50	14985.12	6993.35	1245.65	29356.62
Terrestrial Woodland Deciduous	2406.47	6691.43	3246.75	579.05	12923.70
Unclassified Cloud/Shadow	2055.19	5714.66	2772.81	494.52	11037.19
Water	2233.99	3215.71	1300.70	215.74	6966.14

Total Sum:	1612437.32
Total Acres:	28913.66
Composite Number:	55.77
Flow Rate: cfs	45.86 92

M2 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
11353.19	14478.22	6413.83	886.84	1984.22

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M2	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	4822.53	13.73%	1559.12	1988.28	880.80	121.79
Developed Agriculture Row Crop	9394.17	26.75%	3037.13	3873.12	1715.79	237.24
Developed Non-Vegetated	506.55	1.44%	163.77	208.85	92.52	12.79
Developed Urban High Density	624.79	1.78%	202.00	257.60	114.11	15.78
Developed Urban Low Density	1124.09	3.20%	363.42	463.45	205.31	28.39
Palustrine Forest Deciduous	3224.77	9.18%	1042.57	1329.54	588.98	81.44
Palustrine Herbaceous Deciduous	285.17	0.81%	92.20	117.57	52.09	7.20
Palustrine Shrubland Deciduous	20.37	0.06%	6.58	8.40	3.72	0.51
Terrestrial Forest Deciduous	13400.42	38.16%	4332.35	5524.86	2447.50	338.42
Terrestrial Forest Evergreen	208.69	0.59%	67.47	86.04	38.12	5.27
Terrestrial Forest Mixed	82.43	0.23%	26.65	33.99	15.06	2.08
Terrestrial Shrubland Deciduous	679.84	1.94%	219.79	280.29	124.17	17.17
Terrestrial Woodland Deciduous	394.36	1.12%	127.50	162.59	72.03	9.96
Unclassified Cloud/Shadow	234.88	0.67%	75.94	96.84	42.90	5.93
Water	113.57	0.32%	36.72	46.82	20.74	2.87
Total	35116.63	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	76396.95	137191.21	69583.55	10230.26	293401.97
Developed Agriculture Row Crop	148819.37	267245.09	135547.03	19928.29	571539.78
Developed Non-Vegetated	14575.28	19213.74	8696.70	1215.28	43701.00
Developed Urban High Density	17977.63	23698.86	10726.79	1498.97	53902.25
Developed Urban Low Density	18534.27	31514.58	16219.30	2384.58	68652.73
Palustrine Forest Deciduous	26064.13	73124.55	41228.81	6270.78	146688.28
Palustrine Herbaceous Deciduous	2304.91	6466.57	3645.96	554.54	12971.98
Palustrine Shrubland Deciduous	197.52	487.00	264.09	40.12	988.73
Terrestrial Forest Deciduous	108308.77	303867.03	171325.18	26058.04	609559.02
Terrestrial Forest Evergreen	1686.77	4732.33	2668.17	405.82	9493.09
Terrestrial Forest Mixed	1199.24	2243.04	1159.27	172.78	4774.34
Terrestrial Shrubland Deciduous	6593.75	16256.85	8815.95	1339.16	33005.71
Terrestrial Woodland Deciduous	3187.38	8942.41	5041.87	766.85	17938.52
Unclassified Cloud/Shadow	1898.45	5326.22	3003.01	456.75	10684.43
Water	2643.56	3839.44	1804.58	255.25	8542.83

Total Sum:	1885844.65
Total Acres:	33132.41
Composite Number:	56.92
Flow Rate:	72.29

M3 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
12100.21	14932.42	6472.92	913.2	2201.92

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M3	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	4969.68	13.57%	1642.07	2026.41	878.41	123.93
Developed Agriculture Row Crop	9639.38	26.32%	3185.02	3930.51	1703.80	240.37
Developed Non-Vegetated	525.28	1.43%	173.56	214.18	92.84	13.10
Developed Urban High Density	694.79	1.90%	229.57	283.31	122.81	17.33
Developed Urban Low Density	1196.95	3.27%	395.49	488.06	211.57	29.85
Palustrine Forest Deciduous	3450.93	9.42%	1140.25	1407.13	609.97	86.05
Palustrine Herbaceous Deciduous	286.00	0.78%	94.50	116.62	50.55	7.13
Palustrine Shrubland Deciduous	20.37	0.06%	6.73	8.30	3.60	0.51
Terrestrial Forest Deciduous	14113.54	38.54%	4663.35	5754.87	2494.63	351.94
Terrestrial Forest Evergreen	208.65	0.57%	68.94	85.08	36.88	5.20
Terrestrial Forest Mixed	82.50	0.23%	27.26	33.64	14.58	2.06
Terrestrial Shrubland Deciduous	684.18	1.87%	226.07	278.98	120.93	17.06
Terrestrial Woodland Deciduous	400.21	1.09%	132.24	163.19	70.74	9.98
Unclassified Cloud/Shadow	235.41	0.64%	77.78	95.99	41.61	5.87
Water	113.15	0.31%	37.39	46.14	20.00	2.82
Total	36621.02	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	80461.31	139822.60	69394.56	10409.82	300088.29
Developed Agriculture Row Crop	156065.79	271205.21	134600.31	20191.28	582062.59
Developed Non-Vegetated	15446.84	19704.92	8727.40	1244.36	45123.52
Developed Urban High Density	20431.83	26064.08	11543.90	1645.94	59685.74
Developed Urban Low Density	20170.21	33188.40	16713.78	2507.22	72579.60
Palustrine Forest Deciduous	28506.13	77392.37	42697.61	6626.16	155222.27
Palustrine Herbaceous Deciduous	2362.46	6413.93	3538.58	549.15	12864.12
Palustrine Shrubland Deciduous	201.87	481.64	255.58	39.61	978.70
Terrestrial Forest Deciduous	116583.84	316517.93	174623.91	27099.55	634825.23
Terrestrial Forest Evergreen	1723.55	4679.33	2581.60	400.63	9385.12
Terrestrial Forest Mixed	1226.68	2220.24	1122.84	170.75	4740.52
Terrestrial Shrubland Deciduous	6781.95	16180.75	8586.16	1330.76	32879.63
Terrestrial Woodland Deciduous	3305.94	8975.41	4951.76	768.45	18001.56
Unclassified Cloud/Shadow	1944.58	5279.41	2912.67	452.01	10588.67
Water	2691.92	3783.39	1740.03	251.13	8466.46

Total Sum:	1947492.03
Total Acres:	34419.10
Composite Number:	56.58
Flow Rate:	70.02

70.78

M4 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
12162.98	14943.69	6478.04	913.29	2288.01

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M4	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	4970.84	13.51%	1643.55	2019.30	875.36	123.41
Developed Agriculture Row Crop	9647.95	26.23%	3189.98	3919.28	1698.99	239.53
Developed Non-Vegetated	529.56	1.44%	175.09	215.12	93.26	13.15
Developed Urban High Density	728.02	1.98%	240.71	295.74	128.20	18.07
Developed Urban Low Density	1214.00	3.30%	401.40	493.16	213.78	30.14
Palustrine Forest Deciduous	3470.65	9.43%	1147.53	1409.88	611.18	86.17
Palustrine Herbaceous Deciduous	286.00	0.78%	94.56	116.18	50.36	7.10
Palustrine Shrubland Deciduous	20.37	0.06%	6.73	8.27	3.59	0.51
Palustrine Woodland Deciduous	1.53	0.00%	0.51	0.62	0.27	0.04
Terrestrial Forest Deciduous	14185.82	38.56%	4690.38	5762.69	2498.11	352.19
Terrestrial Forest Evergreen	208.66	0.57%	68.99	84.76	36.74	5.18
Terrestrial Forest Mixed	82.43	0.22%	27.25	33.49	14.52	2.05
Terrestrial Shrubland Deciduous	684.40	1.86%	226.29	278.02	120.52	16.99
Terrestrial Woodland Deciduous	400.23	1.09%	132.33	162.59	70.48	9.94
Unclassified Cloud/Shadow	236.21	0.64%	78.10	95.96	41.60	5.86
Water	119.67	0.33%	39.57	48.61	21.07	2.97
TOTAL	36786.35	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Palustrine Woodland Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	80534.03	139331.81	69153.48	10366.48	299385.80
Developed Agriculture Row Crop	156309.18	270430.31	134220.59	20120.39	581080.47
Developed Non-Vegetated	15583.40	19791.46	8766.04	1249.01	45389.90
Developed Urban High Density	21423.45	27208.53	12051.22	1717.08	62400.29
Developed Urban Low Density	20471.18	33535.09	16888.98	2531.75	73427.00
Palustrine Forest Deciduous	28688.24	77543.32	42782.43	6634.73	155648.72
Palustrine Herbaceous Deciduous	2364.06	6389.96	3525.49	546.74	12826.25
Palustrine Shrubland Deciduous	202.01	479.84	254.63	39.44	975.91
Palustrine Woodland Deciduous	12.64	34.15	18.84	2.92	68.55
Terrestrial Forest Deciduous	117259.40	316948.13	174867.59	27118.59	636193.71
Terrestrial Forest Evergreen	1724.74	4661.93	2572.09	398.88	9357.64
Terrestrial Forest Mixed	1226.47	2210.07	1117.74	169.86	4724.14
Terrestrial Shrubland Deciduous	6788.68	16125.39	8557.09	1325.34	32796.51
Terrestrial Woodland Deciduous	3308.31	8942.25	4933.64	765.11	17949.32
Unclassified Cloud/Shadow	1952.53	5277.62	2911.79	451.56	10593.50
Water	2848.88	3986.33	1833.43	264.42	8933.06

Total Sum:	1951750.77
Total Acres:	34498.34
Composite Number:	56.58
Flow Rate:	69.55

70.34

M5 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
12179.95	14977.19	6478.17	913	2526.04

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M5	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	4975.51	13.42%	1634.58	2009.97	869.38	122.53
Developed Agriculture Row Crop	9652.57	26.04%	3171.11	3899.38	1686.62	237.70
Developed Non-Vegetated	532.53	1.44%	174.95	215.13	93.05	13.11
Developed Urban High Density	822.61	2.22%	270.25	332.31	143.74	20.26
Developed Urban Low Density	1328.33	3.58%	436.39	536.61	232.10	32.71
Palustrine Forest Deciduous	3471.01	9.36%	1140.31	1402.20	606.50	85.48
Palustrine Herbaceous Deciduous	285.57	0.77%	93.82	115.36	49.90	7.03
Palustrine Shrubland Deciduous	20.37	0.05%	6.69	8.23	3.56	0.50
Palustrine Woodland Deciduous	3.15	0.01%	1.03	1.27	0.55	0.08
Terrestrial Forest Deciduous	14227.88	38.38%	4674.21	5747.69	2486.08	350.38
Terrestrial Forest Evergreen	208.59	0.56%	68.53	84.27	36.45	5.14
Terrestrial Forest Mixed	82.45	0.22%	27.09	33.31	14.41	2.03
Terrestrial Shrubland Deciduous	684.42	1.85%	224.85	276.49	119.59	16.85
Terrestrial Woodland Deciduous	402.71	1.09%	132.30	162.69	70.37	9.92
Unclassified Cloud/Shadow	235.17	0.63%	77.26	95.00	41.09	5.79
Water	141.82	0.38%	46.59	57.29	24.78	3.49
TOTAL	37074.69	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Palustrine Woodland Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	80094.24	138688.08	68681.40	10292.24	297755.96
Developed Agriculture Row Crop	155384.24	269057.31	133243.12	19967.12	577651.79
Developed Non-Vegetated	15570.39	19791.66	8746.70	1245.83	45354.58
Developed Urban High Density	24052.01	30572.71	13511.27	1924.47	70060.45
Developed Urban Low Density	22255.81	36489.42	18336.11	2747.75	79829.10
Palustrine Forest Deciduous	28507.83	77120.83	42455.02	6581.73	154665.42
Palustrine Herbaceous Deciduous	2345.43	6344.99	3492.92	541.50	12724.84
Palustrine Shrubland Deciduous	200.72	477.17	252.66	39.12	969.66
Palustrine Woodland Deciduous	25.86	69.97	38.52	5.97	140.33
Terrestrial Forest Deciduous	116855.25	316122.73	174025.58	26978.90	633982.45
Terrestrial Forest Evergreen	1713.19	4634.60	2551.35	395.53	9294.67
Terrestrial Forest Mixed	1218.98	2198.43	1109.38	168.53	4695.32
Terrestrial Shrubland Deciduous	6745.45	16036.24	8490.92	1314.65	32587.27
Terrestrial Woodland Deciduous	3307.53	8947.70	4925.71	763.62	17944.57
Unclassified Cloud/Shadow	1931.52	5225.24	2876.49	445.94	10479.19
Water	3354.54	4697.86	2155.89	310.83	10519.12

Total Sum:	1958654.72
Total Acres:	34548.65
Composite Number:	56.69
Flow Rate:	72.~~54~~ 49

M6 Curve Number Calculations
Calculations performed June 29-30, 2006
Calculations checked/edited July 7, 2006

Acres of Each Soil Type in Watershed

A	B	C	D	Null
12188.18	15012.27	6476.8	912.86	3308.4

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M6	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	4974.53	13.13%	1599.82	1970.51	850.15	119.82
Developed Agriculture Row Crop	9657.30	25.48%	3105.81	3825.45	1650.43	232.62
Developed Non-Vegetated	533.94	1.41%	171.72	211.50	91.25	12.86
Developed Urban High Density	1360.45	3.59%	437.52	538.90	232.50	32.77
Developed Urban Low Density	1567.46	4.14%	504.10	620.90	267.88	37.76
Palustrine Forest Deciduous	3470.64	9.16%	1116.17	1374.79	593.13	83.60
Palustrine Herbaceous Deciduous	285.72	0.75%	91.89	113.18	48.83	6.88
Palustrine Shrubland Deciduous	20.37	0.05%	6.55	8.07	3.48	0.49
Palustrine Woodland Deciduous	3.15	0.01%	1.01	1.25	0.54	0.08
Terrestrial Forest Deciduous	14251.35	37.60%	4583.27	5645.25	2435.55	343.27
Terrestrial Forest Evergreen	208.63	0.55%	67.10	82.64	35.65	5.03
Terrestrial Forest Mixed	82.46	0.22%	26.52	32.66	14.09	1.99
Terrestrial Shrubland Deciduous	684.48	1.81%	220.13	271.14	116.98	16.49
Terrestrial Woodland Deciduous	402.57	1.06%	129.47	159.47	68.80	9.70
Unclassified Cloud/Shadow	234.54	0.62%	75.43	92.91	40.08	5.65
Water	160.68	0.42%	51.68	63.65	27.46	3.87
TOTAL	37898.27	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Palustrine Woodland Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A	B	C	D	Sums
Developed Agriculture Pasture/Grassland	78391.30	135965.39	67161.52	10065.06	291583.27
Developed Agriculture Row Crop	152184.86	263956.26	130383.94	19539.79	566064.85
Developed Non-Vegetated	15282.74	19458.37	8577.50	1221.80	44540.41
Developed Urban High Density	38939.71	49579.03	21855.07	3113.09	113486.90
Developed Urban Low Density	25709.01	42221.29	21162.35	3171.46	92264.11
Palustrine Forest Deciduous	27904.16	75613.47	41519.17	6437.02	151473.82
Palustrine Herbaceous Deciduous	2297.20	6224.85	3418.05	529.93	12470.03
Palustrine Shrubland Deciduous	196.49	467.90	247.11	38.26	949.76
Palustrine Woodland Deciduous	25.32	68.61	37.67	5.84	137.44
Terrestrial Forest Deciduous	114581.74	310488.57	170488.50	26432.09	621990.90
Terrestrial Forest Evergreen	1677.38	4545.29	2495.81	386.94	9105.41
Terrestrial Forest Mixed	1193.38	2155.85	1085.13	164.86	4599.22
Terrestrial Shrubland Deciduous	6603.96	15726.02	8305.45	1286.01	31921.44
Terrestrial Woodland Deciduous	3236.67	8770.58	4815.90	746.64	17569.80
Unclassified Cloud/Shadow	1885.71	5109.82	2805.79	435.00	10236.32
Water	3720.70	5219.31	2389.09	344.47	11673.56

Total Sum:	1980067.24
Total Acres:	34589.87
Composite Number:	57.24
Flow Rate:	83.83

Soil Type Acreages for Watershed E1
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	169.91	A	2742.45
BtA	843.63	A	
ChB	384.29	A	
ChC	348.21	A	
ChD	242.61	A	
Ho	78.61	A	
Mm	180.28	A	
Nf	219.49	A	
OaC	166.55	A	
OaE	7.46	A	
Pa	25.21	A	
TyA	76.20	A	
Br	78.85	B	3619.90
Ck	0.98	B	
Ed	10.65	B	
Fh	187.11	B	
Gf	155.08	B	
HaA	17.68	B	
Hk	300.82	B	
Md	183.20	B	
Mp	69.72	B	
Mx	1297.90	B	
Qu	105.83	B	
RIA	7.93	B	
RIB2	226.54	B	
RIC2	129.91	B	
RID2	63.63	B	
Sb	124.57	B	
SeA	252.62	B	
SeB	60.22	B	
So	5.50	B	
TcA	10.90	B	
TcB	126.77	B	
TcC2	95.09	B	
TcD2	105.93	B	
Wa	2.48	B	
BaA	841.62	C	1309.01
MrB2	71.25	C	
MrC2	1.88	C	
MrD2	9.90	C	
Pe	229.51	C	
Sa	98.44	C	
We	7.58	C	
Wh	48.82	C	
Cd	47.28	D	182.28
Hh	55.03	D	
Hm	79.98	D	
Ua	23.73	Null	34.04
W	10.31	Null	
	7887.68		7887.68

Soil Type Acreages for Watershed E2
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	213.65	A	4259.63
BtA	1129.44	A	
ChB	815.67	A	
ChC	672.68	A	
ChD	271.73	A	
Ho	78.93	A	
Mm	197.78	A	
Nf	241.30	A	
OaC	196.08	A	
OaE	7.46	A	
Pa	25.12	A	
TyA	409.80	A	
Br	81.87	B	4505.23
Ck	4.24	B	
Ed	10.65	B	
Fh	296.34	B	
Gf	162.12	B	
HaA	27.91	B	
Hk	303.15	B	
Md	182.50	B	
Mp	69.72	B	
Mx	1464.86	B	
Ph	4.21	B	
Qu	105.73	B	
RIA	7.93	B	
RIB2	270.71	B	
RIC2	147.30	B	
RID2	68.94	B	
Sb	124.57	B	
SeA	456.04	B	
SeB	140.86	B	
So	5.50	B	
TcA	60.25	B	
TcB	172.94	B	
TcC2	226.61	B	
TcD2	105.93	B	
Wa	4.34	B	
BaA	982.55	C	1518.20
MrB2	97.65	C	
MrC2	27.75	C	
MrD2	23.34	C	
Pe	232.40	C	
Sa	98.62	C	
We	7.58	C	
Wh	48.30	C	
Cd	50.38	D	213.37
Hh	67.96	D	
Hm	95.04	D	
Ua	30.03	Null	40.39
W	10.36	Null	
	10536.82		10536.82

Soil Type Acreages for Watershed E3
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	229.82	A	5186.29
BtA	1370.49	A	
ChB	1039.41	A	
ChC	810.64	A	
ChD	297.21	A	
Ho	78.80	A	
Mm	215.45	A	
Nf	244.41	A	
OaC	375.30	A	
OaE	7.46	A	
Pa	25.18	A	
TyA	492.13	A	
Br	92.91	B	4988.59
Ck	4.24	B	
Ed	10.65	B	
Fh	395.97	B	
Gf	171.17	B	
HaA	27.68	B	
Hk	302.77	B	
Md	182.97	B	
Mp	69.72	B	
Mx	1504.37	B	
Ph	4.21	B	
Qu	105.79	B	
RlA	9.51	B	
RlB2	273.46	B	
RlC2	147.31	B	
RlD2	69.26	B	
Sb	124.57	B	
SeA	586.99	B	
SeB	260.67	B	
So	14.99	B	
TcA	60.25	B	
TcB	186.22	B	
TcC2	272.63	B	
TcD2	105.94	B	
Wa	4.35	B	
BaA	1097.05	C	1696.77
MrB2	120.27	C	
MrC2	34.45	C	
MrD2	29.57	C	
Pe	241.04	C	
Sa	98.50	C	
We	14.04	C	
Wh	61.85	C	
Cd	60.95	D	287.33
Hh	68.05	D	
Hm	158.33	D	
Ua	142.30	Null	171.40
W	29.09	Null	
	12330.38		12330.38

Soil Type Acreages for Watershed W1
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	255.62	A	1119.78
BtA	48.89	A	
ChB	422.84	A	
ChC	285.50	A	
ChD	48.91	A	
Mm	50.18	A	
TyA	7.83	A	
Br	816.53	B	5541.20
Ed	63.04	B	
Fh	163.51	B	
Gf	367.31	B	
HaA	176.33	B	
Hk	476.72	B	
Md	76.27	B	
Mx	75.74	B	
Ph	66.25	B	
RIA	7.46	B	
RIB2	294.03	B	
RIC2	255.20	B	
RID2	255.88	B	
RIF	11.16	B	
Sb	260.81	B	
SeA	3.20	B	
SeB	111.00	B	
So	0.96	B	
TcA	137.01	B	
TcB	808.31	B	
TcC2	671.32	B	
TcD2	395.21	B	
TcF	16.02	B	
Wa	31.92	B	
BaA	1569.25	C	2013.24
MrB2	46.03	C	
MrC2	14.02	C	
MrD2	11.33	C	
Pe	262.73	C	
We	8.02	C	
Wh	101.86	C	
Hh	240.25	D	320.18
Hm	79.93	D	
Ua	99.19	Null	128.10
W	28.91	Null	
	9122.50		9122.50

Soil Type Acreages for Watershed W2
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	54.72	A	1275.10
BtA	72.54	A	
ChB	546.58	A	
ChC	361.13	A	
ChD	134.33	A	
Mm	3.94	A	
TyA	101.86	A	
Br	18.62	B	939.00
Ck	54.97	B	
Fh	44.45	B	
Gf	33.65	B	
HaA	8.03	B	
Hk	6.40	B	
Mx	25.45	B	
RlA	0.02	B	
RlB2	98.88	B	
RlC2	101.37	B	
RlD2	36.52	B	
RlF	84.02	B	
SeA	4.99	B	
SeB	35.05	B	
TcA	3.53	B	
TcB	142.79	B	
TcC2	129.07	B	
TcD2	70.60	B	
TcF	15.89	B	
Wa	24.71	B	
BaA	26.61	C	227.15
MrB2	123.18	C	
MrC2	41.67	C	
Pe	16.12	C	
Wh	19.57	C	
Hh	4.77	D	54.65
Hm	49.88	D	
Ua	4.51	Null	4.51
	2500.41		2500.41

Soil Type Acreages for Watershed W3
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
BtA	23.06	A	680.60
ChB	254.12	A	
ChC	266.81	A	
ChD	64.54	A	
Mm	7.14	A	
TyA	64.93	A	
Br	42.92	B	475.51
Ck	30.76	B	
Fh	26.73	B	
Gf	11.91	B	
HaA	13.09	B	
Hk	12.68	B	
Mx	7.06	B	
RIB2	87.49	B	
RIC2	73.86	B	
RID2	15.20	B	
SeA	2.14	B	
SeB	19.33	B	
TcB	58.37	B	
TcC2	41.86	B	
TcD2	26.35	B	
Tr	5.73	B	
BaA	13.26	C	40.20
MrB2	9.64	C	
MrC2	14.49	C	
Pe	1.73	C	
Wh	1.07	C	
Hh	1.10	D	27.15
Hm	26.05	D	
Ua	0.22	Null	0.22
	1223.67		1223.67

Soil Type Acreages for Watershed M1
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	588.17	A	10238.88
BtA	2210.12	A	
ChB	2676.02	A	
ChC	1842.73	A	
ChD	561.95	A	
Ho	82.66	A	
Mm	277.39	A	
Nf	271.21	A	
OaC	784.47	A	
OaE	7.46	A	
Pa	25.17	A	
TyA	911.54	A	
Br	1162.11	B	12941.01
Ck	130.83	B	
Ed	73.69	B	
Fh	802.45	B	
Gf	627.14	B	
HaA	247.61	B	
Hk	799.03	B	
Md	259.90	B	
Mp	69.72	B	
Mx	1919.11	B	
Ph	70.47	B	
Qu	105.65	B	
RlA	16.97	B	
RlB2	754.33	B	
RlC2	579.50	B	
RlD2	377.88	B	
RlF	94.75	B	
Sb	397.18	B	
SeA	674.97	B	
SeB	486.10	B	
So	42.49	B	
TcA	200.84	B	
TcB	1226.30	B	
TcC2	1124.66	B	
TcD2	598.67	B	
TcF	32.07	B	
Tr	5.73	B	
Wa	60.89	B	
BaA	3567.19	C	4933.59
MrB2	322.06	C	
MrC2	104.85	C	
MrD2	40.90	C	
Pe	582.00	C	
Sa	98.65	C	
We	22.06	C	
Wh	195.87	C	
Cd	63.27	D	799.90
Hh	361.48	D	
Hm	375.14	D	

Map Symbol	Total Acres	Type	Acres
Ua	348.09	Null	470.60
UoC	8.32	Null	
W	114.19	Null	
	29383.97		29383.97

Soil Type Acreages for Watershed M2
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	587.76	A	11353.19
BtA	2755.89	A	
ChB	2675.03	A	
ChC	1842.19	A	
ChD	561.52	A	
Ho	82.98	A	
Mm	277.39	A	
Nf	441.69	A	
OaC	1177.68	A	
OaE	7.46	A	
Pa	25.13	A	
TyA	918.47	A	
Br	1243.97	B	14478.22
Ck	130.83	B	
Ed	73.69	B	
Fh	1119.18	B	
Gf	649.94	B	
HaA	258.50	B	
Hk	807.12	B	
Md	260.15	B	
Mp	69.72	B	
Mx	2260.94	B	
Ph	70.47	B	
Qu	105.64	B	
RIA	16.81	B	
RIB2	756.46	B	
RIC2	580.82	B	
RID2	377.39	B	
RIF	94.59	B	
Sb	408.74	B	
SeA	1218.74	B	
SeB	606.98	B	
So	114.20	B	
TcA	201.12	B	
TcB	1227.30	B	
TcC2	1125.12	B	
TcD2	599.11	B	
TcF	32.10	B	
Tr	5.73	B	
Wa	62.90	B	
BaA	4556.64	C	6413.83
MrB2	355.39	C	
MrC2	109.24	C	
MrD2	40.90	C	
Pe	678.03	C	
Sa	455.12	C	
We	22.06	C	
Wh	196.45	C	
Cd	129.55	D	886.84
Hh	367.26	D	
Hm	390.03	D	

Map Symbol	Total Acres	Type	Acres
Ua	512.85	Null	1984.22
UoC	700.08	Null	
Uv	623.06	Null	
W	148.23	Null	
	35116.30		35116.30

Soil Type Acreages for Watershed M3
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	598.10	A	12100.21
BtA	2923.19	A	
ChB	2674.40	A	
ChC	1841.56	A	
ChD	561.48	A	
Ho	82.54	A	
Mm	374.33	A	
Nf	513.44	A	
OaC	1580.07	A	
OaE	7.46	A	
Pa	25.18	A	
TyA	918.47	A	
Br	1244.00	B	14932.42
Ck	130.83	B	
Ed	73.69	B	
Fh	1208.19	B	
Gf	649.90	B	
HaA	258.49	B	
Hk	808.21	B	
Md	259.50	B	
Mp	69.72	B	
Mx	2414.49	B	
Ph	70.47	B	
Qu	105.94	B	
RlA	16.87	B	
RlB2	755.87	B	
RlC2	580.15	B	
RlD2	381.77	B	
RlF	94.58	B	
Sb	408.54	B	
SeA	1371.15	B	
SeB	663.34	B	
So	117.11	B	
TcA	200.70	B	
TcB	1226.14	B	
TcC2	1123.24	B	
TcD2	598.29	B	
TcF	32.09	B	
Tr	5.73	B	
Wa	63.42	B	
BaA	4558.01	C	6472.92
MrB2	365.36	C	
MrC2	109.46	C	
MrD2	40.90	C	
Pe	680.83	C	
Sa	462.14	C	
We	60.68	C	
Wh	195.54	C	
Cd	154.83	D	913.21
Hh	367.16	D	
Hm	391.22	D	

Map Symbol	Total Acres	Type	Acres
Du	23.64	Null	2201.92
Ua	523.48	Null	
UoC	821.00	Null	
Uv	669.97	Null	
W	163.83	Null	
	36620.68		36620.68

Soil Type Acreages for Watershed M4
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	597.99	A	12162.98
BtA	2922.85	A	
ChB	2674.84	A	
ChC	1841.64	A	
ChD	561.49	A	
Ho	82.64	A	
Mm	374.22	A	
Nf	512.89	A	
OaC	1643.28	A	
OaE	7.46	A	
Pa	25.22	A	
TyA	918.47	A	
Br	1243.98	B	14943.69
Ck	130.83	B	
Ed	73.69	B	
Fh	1219.91	B	
Gf	649.99	B	
HaA	258.35	B	
Hk	808.22	B	
Md	260.48	B	
Mp	69.72	B	
Mx	2412.75	B	
Ph	70.47	B	
Qu	105.75	B	
RlA	16.90	B	
RlB2	754.77	B	
RlC2	581.02	B	
RlD2	381.44	B	
RlF	94.89	B	
Sb	408.32	B	
SeA	1371.93	B	
SeB	663.35	B	
So	117.11	B	
TcA	200.59	B	
TcB	1225.99	B	
TcC2	1124.07	B	
TcD2	597.98	B	
TcF	32.06	B	
Tr	5.73	B	
Wa	63.41	B	
BaA	4558.85	C	6478.04
MrB2	364.29	C	
MrC2	109.38	C	
MrD2	40.90	C	
Pe	680.68	C	
Sa	462.05	C	
We	65.75	C	
Wh	196.14	C	
Cd	154.87	D	913.29
Hh	367.55	D	
Hm	390.87	D	

Map Symbol	Total Acres	Type	Acres
Du	35.54	Null	2288.01
Ua	549.31	Null	
UoC	864.34	Null	
Uv	670.42	Null	
W	168.39	Null	
	36786.00		36786.00

Soil Type Acreages for Watershed M5
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	598.16	A	12179.95
BtA	2922.31	A	
ChB	2674.24	A	
ChC	1842.26	A	
ChD	561.50	A	
Ho	82.88	A	
Mm	374.02	A	
Nf	513.10	A	
OaC	1660.38	A	
OaE	7.46	A	
Pa	25.21	A	
TyA	918.47	A	
Br	1244.20	B	14977.19
Ck	130.83	B	
Ed	73.69	B	
Fh	1252.36	B	
Gf	650.28	B	
HaA	258.26	B	
Hk	808.13	B	
Md	260.00	B	
Mp	69.72	B	
Mx	2414.01	B	
Ph	70.47	B	
Qu	105.80	B	
RlA	17.04	B	
RlB2	755.08	B	
RlC2	579.91	B	
RlD2	381.86	B	
RlF	94.87	B	
Sb	408.51	B	
SeA	1371.38	B	
SeB	663.40	B	
So	117.11	B	
TcA	200.36	B	
TcB	1226.08	B	
TcC2	1124.27	B	
TcD2	598.48	B	
TcF	31.97	B	
Tr	5.73	B	
Wa	63.41	B	
BaA	4558.28	C	6478.17
MrB2	364.70	C	
MrC2	109.39	C	
MrD2	40.90	C	
Pe	680.30	C	
Sa	462.63	C	
We	65.75	C	
Wh	196.23	C	
Cd	154.82	D	913.00
Hh	367.11	D	
Hm	391.08	D	

Map Symbol	Total Acres	Type	Acres
Du	44.28	Null	2526.04
Ua	565.63	Null	
UoC	1062.88	Null	
Uv	679.00	Null	
W	174.26	Null	
	37074.35		37074.35

Soil Type Acreages for Watershed M6
June 23 & 29, 2006

Map Symbol	Total Acres	Type	Acres
Ad	597.78	A	12188.18
BtA	2922.93	A	
ChB	2674.58	A	
ChC	1842.23	A	
ChD	561.54	A	
Ho	82.85	A	
Mm	374.18	A	
Nf	512.98	A	
OaC	1660.45	A	
OaE	14.97	A	
Pa	25.22	A	
TyA	918.48	A	
Br	1243.98	B	15012.27
Ck	130.83	B	
Ed	73.69	B	
Fh	1286.99	B	
Gf	649.91	B	
Hk	807.87	B	
Md	259.37	B	
Mp	69.72	B	
Mx	2413.61	B	
Ph	70.47	B	
Qu	105.81	B	
RIB2	755.24	B	
RIC2	580.36	B	
RID2	382.36	B	
RIF	95.01	B	
RIA	16.98	B	
Sb	408.71	B	
SeA	1371.14	B	
SeB	662.93	B	
So	117.11	B	
TcB	1226.26	B	
TcC2	1124.99	B	
TcD2	598.87	B	
TcA	200.62	B	
TcF	31.97	B	
Tr	5.73	B	
Wa	63.33	B	
HaA	258.41	B	
BaA	4556.57	C	6476.80
MrB2	365.29	C	
MrC2	109.54	C	
MrD2	40.90	C	
Pe	680.00	C	
Sa	462.37	C	
We	65.75	C	
Wh	196.38	C	

Map Symbol	Total Acres	Type	Acres
Cd	154.90	D	912.86
Hh	366.88	D	
Hm	391.09	D	
Du	45.28	Null	3308.40
Ua	565.13	Null	
UoC	1686.75	Null	
Uv	819.20	Null	
W	192.04	Null	
	37898.52		37898.52

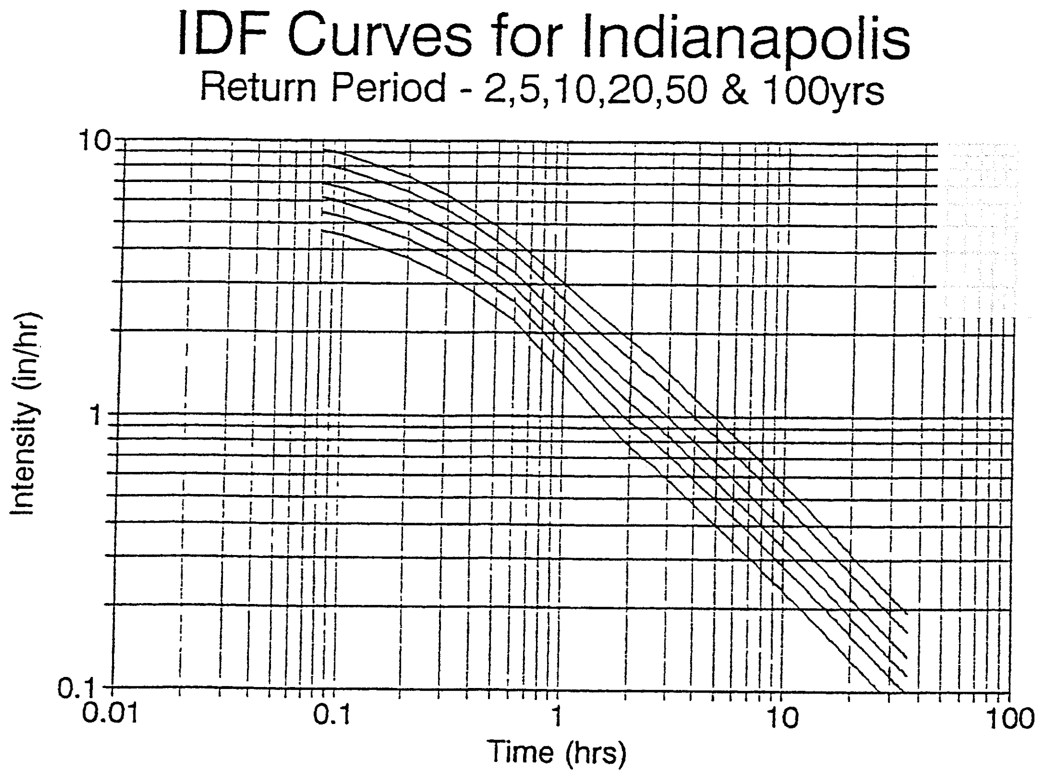


Figure 2.2.2
Intensity - Duration - Frequency Relationship for Indianapolis by IDF Equation
(adapted from Purdue et al., 1992)

2.2.5 Chen's Method

The coefficients and exponents in Table 2.2.3 are not available for all locations of interest to a drainage engineer. In such cases the rainfall intensity-duration-frequency data for a site will have to be estimated. An accurate method to generate this intensity-duration-frequency information has been developed by Chen (FHWA, 1976). This method has been shown to be valid across the United States. Maps showing rainfall depth curves across the entire continental United States are located at the end of Appendix A. Figures 2.2.4 through 2.2.6 enable rainfall depths in Indiana to be determined for Chen's method. The procedure is as follows:

1. From the rainfall atlases in Figures 2.2.4-2.2.6, estimate the following:
   a. The 10-year, 1-hour rainfall depth, p_1^{10}
   b. The 10-year, 24-hour rainfall depth, p_{24}^{10}
   c. The 100-year, 1-hour rainfall depth, p_1^{100}

2. Compute the following parameters:
   a. $(p_1^{10}) / (p_{24}^{10})$
   b. $X = (p_1^{100}) / (p_1^{10})$

3. Estimate a_1, d', and n' from Figure 2.2.3.

4. Determine the intensity corresponding to the 10-year, 1-hr rainfall depth, i_1^{10}, which is equal to p_1^{10}.

5. Calculate the parameter a', where a' is defined below:

$$a' = a_1 \; i_1^{10} \; \log(10^{(2 - X)} \; T_r^{(X - 1)})$$

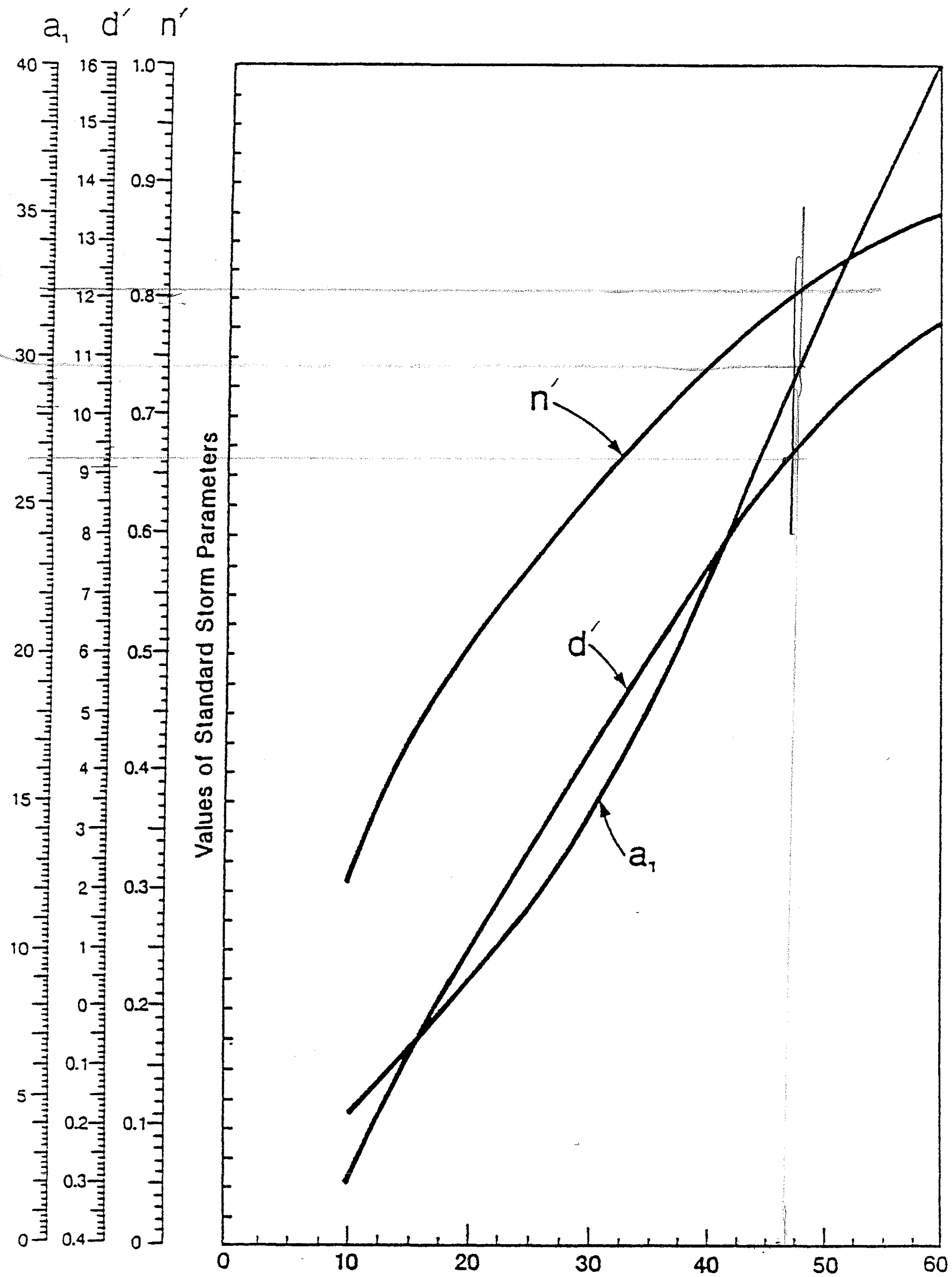
where T_r is the recurrence interval in years.

6. Determine the rainfall intensity-duration-frequency formula:

$$i_t^{T_r} = \frac{a'}{(60t + d')^{n'}} \qquad (inches/hour) \qquad (2.2.14)$$

$$i_t^{T_r} = \frac{2.54 \; a'}{(60t + d')^{n'}} \qquad (cm/hr) \qquad (2.2.15)$$

where the time, t, has units of hours and the intensity is i_t^{Tr}.



Ratio of 1-Hour to Corresponding 24-Hour Rainfall Depth (p_1^{Tr} / p_{24}^{Tr}), in Percent

Figure 2.2.3
Chen's Method Parameters as a Function of p_1^{10}/p_{24}^{10}

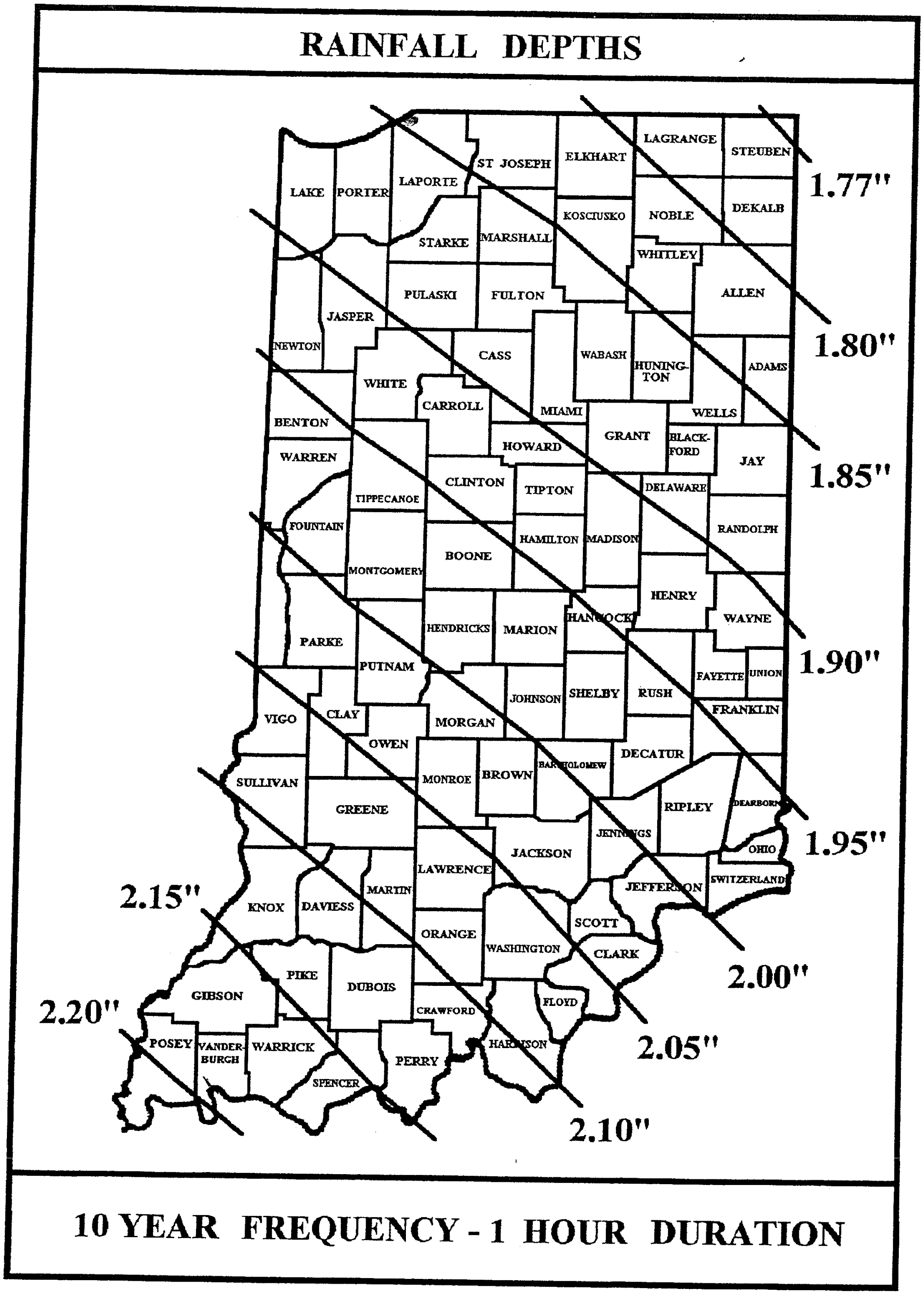
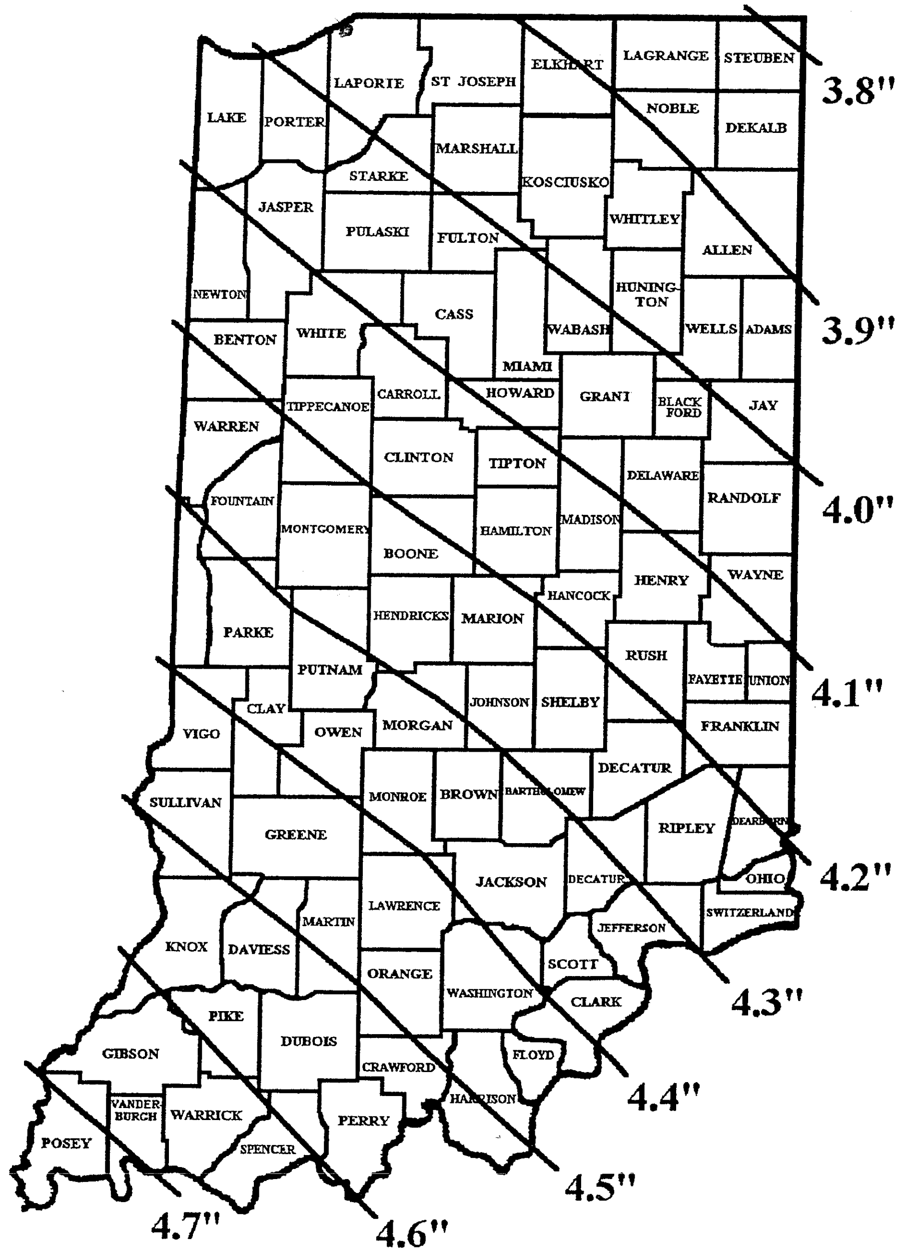


Figure 2.2.4
Depth - Duration - Frequency Curves
(adapted from Technical Paper 40, 1961)

RAINFALL DEPTHS



10 YEAR FREQUENCY - 24 HOUR DURATION

Figure 2.2.5
Depth - Duration - Frequency Curves
(adapted from Technical Paper 40, 1961)

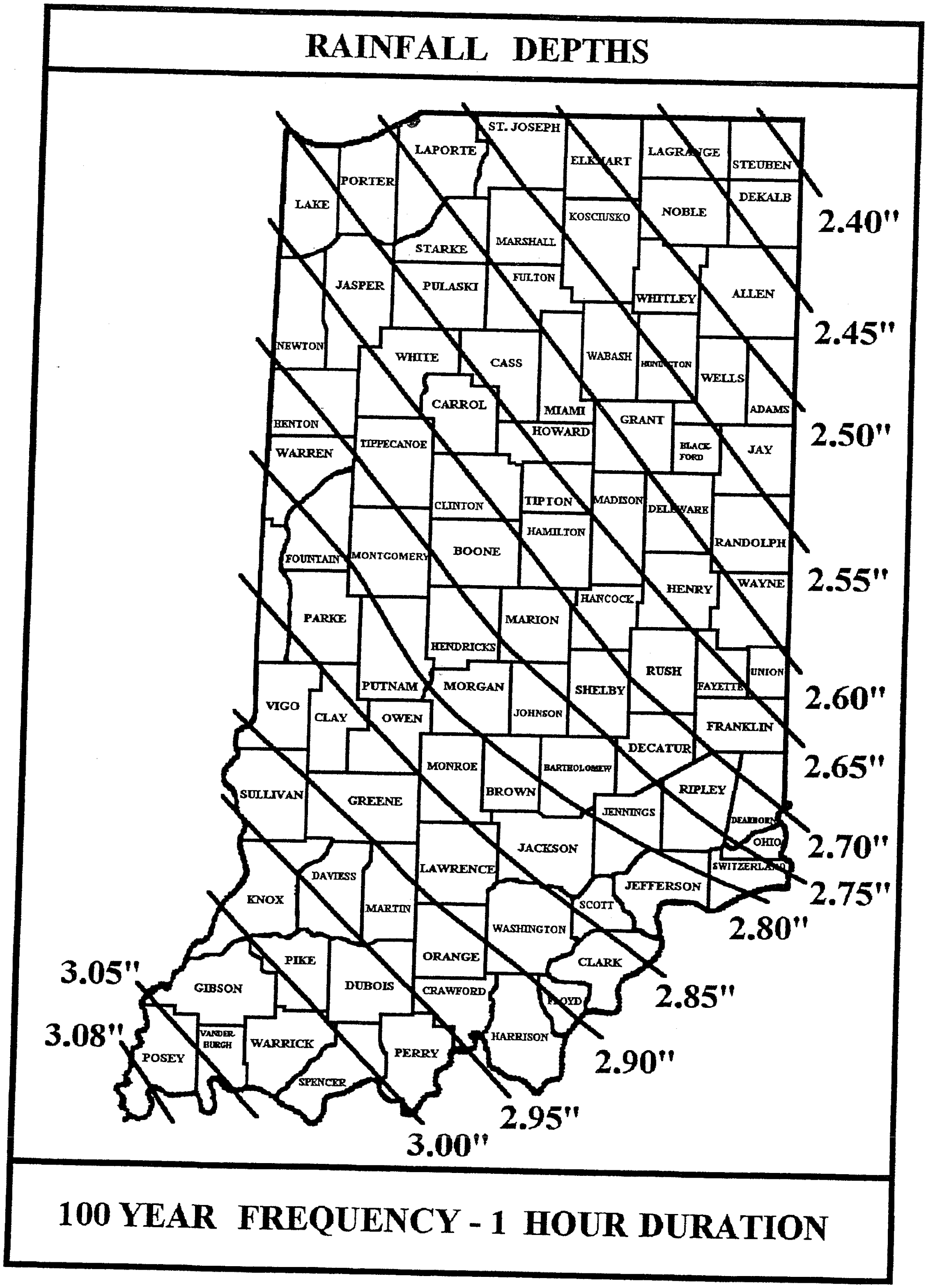


Figure 2.2.6
Depth - Duration - Frequency Curves
(adapted from Technical Paper 40, 1961)

AMERICAN CONSULTING, INC.

BY KEG	DATE 7-13-06	SUBJECT Clean Up of 6/06 Calcs	SHEET NO. 1 OF 3
CHKD. BY	DATE	Trail Creek Watershed	JOB NO. IN20040385
		Flow Calculations (see attached)	

- 1 year, 24 hr storm

$a_1 = 29.6 \quad d' = 9.2 \quad n' = 0.81$

$P_1^{10} = 1.84'' \quad P_{24}^{10} = 3.97'' \quad P_1^{100} = 2.58''$

$$\frac{P_1^{10}}{P_{24}^{10}} = \frac{1.84}{3.97} = 46.35\%$$

$$X = \frac{P_1^{100}}{P_1^{10}} = \frac{2.58}{1.84} = 1.402$$

$t = 24$ hr

$T_r = 1$ yr

$i_1^{10} = P_1^{10} = 1.84''/hr$

$$a' = a_1 i_1^{10} \log\left(10^{(2-X)} T_r^{(X-1)}\right)$$

$$= (29.6)(1.84)\log\left(10^{(2-1.402)} T_r^{(1.402-1)}\right)$$

$$a' = 54.46 \log\left(3.96\, T_r^{0.402}\right)$$

$$i_t^{T_r} = \frac{a'}{(60t + d')^{n'}}$$

$$= \frac{54.46 \log\left(3.96\, T_r^{0.402}\right)}{(60t + 9.2)^{0.81}}$$

$$i_{24}^{1} = \frac{54.46 \log(3.96 \times 1)}{(60(24) + 9.2)^{0.81}} = 0.0895 \text{ in/hr}$$

$$\left(\frac{0.0895 \text{ in}}{\text{hr}}\right)(24 \text{ hr}) = \boxed{2.148'' = P(t)}$$

Use for all watersheds

Other Equations Used For All Watersheds:

$$S = \frac{1000}{CN} - 10 \qquad R(t) = \frac{(P(t) - 0.2S)^2}{P(t) + 0.8S} = \frac{(2.148 - 0.2S)^2}{2.148 + 0.8S}$$

Watershed E1

$$S = \frac{1000}{53.33} - 10 = \boxed{8.0734'' = S}$$

$$R(t) = \frac{(2.148 - (0.2)(8.0734))^2}{2.148 + (0.8)(8.0734)} = \boxed{0.033'' = R(t)}$$

Watershed E2

$$S = \frac{1000}{53.36} - 10 = \boxed{8.7406'' = S}$$

$$R(t) = \frac{(2.148 - (0.2)(8.7406))^2}{2.148 + (0.8)(8.7406)} = \boxed{0.0175'' = R(t)}$$

Watershed E3

$$S = \frac{1000}{52.68} - 10 = \boxed{8.98'' = S}$$

$$R(t) = \frac{(2.148 - (0.2)(8.98))^2}{(2.148 + 0.8(8.98))} = \boxed{0.0133'' = R(t)}$$

Watershed W1

$$S = \frac{1000}{64.14} - 10 = \boxed{5.59'' = S}$$

$$R(t) = \frac{(2.148 - (0.2)(5.59))^2}{2.148 + (0.8)(5.59)} = \boxed{0.189'' = R(t)}$$

Watershed W2

$$S = \frac{1000}{46.39} - 10 = \boxed{11.56'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(11.56))^2}{2.148 + 0.8(11.56)} = \boxed{0.00236'' = R}$$

Watershed W3

$$S = \frac{1000}{45.92} - 10 = \boxed{11.78 = S}$$

$$R(t) = \frac{(2.148 - 0.2(11.78))^2}{2.148 + 0.8(11.78)} = \boxed{0.0037'' = R(t)}$$

Watershed m1

$$S = \frac{1000}{55.77} - 10 = \boxed{7.93'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(7.93))^2}{2.148 + 0.8(7.93)} = \boxed{0.037'' = R(t)}$$

Watershed m2

$$S = \frac{1000}{56.92} - 10 = \boxed{7.57'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(7.57))^2}{2.148 + 0.8(7.57)} = \boxed{0.049'' = R(t)}$$

Watershed m3

$$S = \frac{1000}{56.58} - 10 = \boxed{7.67'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(7.67))^2}{2.148 + 0.8(7.67)} = \boxed{0.046'' = R(t)}$$

Watershed m4

$$S = \frac{1000}{56.58} - 10 = \boxed{7.67'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(7.67))^2}{2.148 + 0.8(7.67)} = \boxed{0.046'' = R(t)}$$

Watershed m5

$$S = \frac{1000}{56.69} - 10 = \boxed{7.64'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(7.64))^2}{2.148 + 0.8(7.64)} = \boxed{0.047'' = R(t)}$$

Watershed m6

$$S = \frac{1000}{57.24} - 10 = \boxed{7.47'' = S}$$

$$R(t) = \frac{(2.148 - 0.2(7.47))^2}{2.148 + 0.8(7.47)} = \boxed{0.053'' = R(t)}$$

Watershed E1

Acres of Each Soil Type in Watershed = Values from "Soil Type Acreages for Watershed E1" spreadsheet

Acres of Given Land Use for Each Soil Type Table:

Acres = ArcView calculated acreages for each landuse based on the delineated watershed

$$\% \text{ of } E1 = \frac{\text{Acres Column}}{\text{Total Acres in Watershed}} = \frac{828.98}{7887.77} = 10.51\%$$

A (ac) = (% of E1)(Acres of A in the Watershed)

= (0.1051)(2742.45 ac) = 288.22 ac

B (ac), C (ac), D (ac) calc'd same way

Curve Number for Each Land Use:

Land Use Type = Land use given in ArcView data

Curve Numbers for A, B, C, D = Estimated curve numbers for each landuse based on Table 3.3.3 + Table 3.3.4 of the HERPICC Stormwater Drainage Manual (assumptions listed below)

Meadow Good Condition - Palustrine Shrubland Deciduous, Terrestrial Shrubland Deciduous

Wood or Forest Land

Thin stand, poor cover, no mulch - Terrestrial Forest Mixed

Good Cover - Palustrine Herbacious Deciduous, Palustrine Woodland Deciduous, Terrestrial Forest Deciduous, Terrestrial Forest Evergreen, Terrestrial Woodland Deciduous, Unclassified Cloud/Shadow

Streets + Roads

Dirt - Water (b/c channel looks to be mainly dirt or gravel)

Urban Districts

Commercial + business - Developed non-vegetated, Developed Urban High Density

Residential

1 acre - Developed Urban Low Density

Pasture, grassland or range w/continuous forage for grazing

Fair - Developed agriculture Pastureland/Grassland, Developed agriculture Row Crop

Curve Number x Acres of Land Use for Each Soil Type Table:

A (ac) = (CN from Curve Number for Each Land Use Table) X (A (ac) cell from Area of Given Land Use for Each Soil Type Table)

= (49)(288.22)

= 14122.90 ac

B(ac), C(ac), D(ac) calc'd same way

Sums = A (ac) + B(ac) + C(ac) + D(ac)

= 14122.90 + 26250.32 + 10868.24 + 1609.19 = 52850.64 ac

Total Sum = Sum of the Sums Column = 434540.19 ac

Total Acres = Total Watershed Acres − Null Acres

= 7887.77 − 34.04

= 7853.73 ac

$$\text{Composite CN} = \frac{\text{Total Sum}}{\text{Total Acres}} = \frac{434540.19}{7853.73} = 55.33$$

- For simplification purposes, these calculations assume that whatever percentage of the given watershed a specific land use occupies, the same percentage of each soil type A-D is located within the specified land use (i.e. 10.51% of Watershed E1 is Developed Agriculture Pastureland/Grassland. Therefore 10.51% of Soil Type A or 288.22 ac of 2742.45 ac is located in the Developed Agriculture Pastureland/Grassland land use)

Table 3.3.3
Runoff Curve Numbers for Urban Areas (SCS, 1986)

Cover Type and Hydrologic Condition	Curve Numbers for Hydrologic Soil Group A	B	C	D
Undeveloped Areas				
Cultivated Land				
Without conservation treatment	72	81	88	91
With conservation treatment	62	71	78	81
Pasture or range land				
Poor condition	68	79	86	89
Good condition	39	61	74	80
Meadow				
Good condition	30	58	71	78
Wood or forest land				
Thin stand, poor cover, no mulch	45	66	77	83
Good cover	25	55	70	77
Fully developed urban areas (with established vegetation)				
Open space (lawns, parks, golf courses, cemeteries)				
Poor condition (grass cover < 50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover > 75%)	39	61	74	80
Impervious areas:				
Paved parking lots, roofs, driveways, etc (excluding right-of-way)	98	98	98	98
Streets and roads				
Paved curb and storm sewers (excluding right-of-way)	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Urban Districts				
Commercial and business (85% impervious)	89	92	94	95
Industrial (72% impervious)	81	88	91	93
Residential				
1/8 acre or less, townhouses (65% impervious)	77	85	90	92
1/4 acre (38% impervious)	61	75	83	87
1/3 acre (30% impervious)	57	72	81	86
1/2 acre (25% impervious)	54	70	80	85
1 acre (20% impervious)	51	68	79	84
2 acre	46	65	77	82
Developing Urban Areas				
Newly graded areas (no vegetation)	77	86	91	94

Table 3.3.4
Runoff Curve Numbers for Agricultural Lands (SCS, 1986)

Cover Type and Hydrologic Condition	Curve Numbers for Hydrologic Soil Group A	B	C	D
Pasture, grassland, or range with continous forage for grazing				
Poor	68	79	86	89
Fair	49	69	79	84
Good	39	61	74	80
Meadow with continuous grass, protected from grazing and generally mowed for hay	30	58	71	78
Brush/brush-weed-grass mixture with brush being the major element				
Poor	48	67	77	83
Fair	35	56	70	77
Good	30	48	65	73
Woods and grass combination (orchard or tree farm)				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods				
Poor	45	66	77	83
Fair	36	60	73	79
Good	30	55	70	77
Farmsteads	59	74	82	86

The curve number method may also be used in determining the time distribution of the runoff. In this manual, the CN method is used in conjunction with the synthetic dimensionless and triangular unit hydrograph methods to determine the storm hydrograph. The procedure used in this operation is outlined below.

1. Determine the basin curve number.

2. Given the rainfall depth and storm duration, determine the time distribution of the rainfall This distribution can be the SCS Type II or Huff Distributions discussed in Chapter 2.

Trail Creek Watershed Study
July 11, 2006
IN20040385
Hydrograph Calculations

Watershed	Travel Length, L (ft)	Beginning Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	*Velocity, v (ft/s)	Area, A_m (mi^2)	Time of Concentr-ation, t_c (hr)	ΔD (hr)	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
E1	26,706	905	630	0.010	1.6	12.33	4.64	0.62	3.09	1,932	8.25	5.16
E2	33,283	905	625	0.0084	1.5	16.48	6.16	0.82	4.11	1,941	10.97	6.86
E3	39,270	905	610	0.0075	1.4	19.28	7.79	1.04	5.19	1,797	13.87	8.67
W1	24,687	670	625	0.002	0.5	14.26	13.72	1.82	9.14	755	24.41	15.27
W2	16,524	925	635	0.018	2.19	3.91	2.10	0.28	1.40	1,355	3.73	2.33
W3	13,403	910	670	0.018	2.19	1.91	1.70	0.23	1.13	817	3.03	1.89
M1	48,133	905	605	0.006	1.21	45.95	11.05	1.47	7.36	3,020	19.66	12.30
M2	61,431	905	590	0.005	1.0	54.91	17.06	2.27	11.37	2,337	30.37	18.99
M3	70,693	905	590	0.004	0.8	57.26	24.55	3.26	16.36	1,694	43.68	27.32
M4	73,874	905	590	0.004	0.8	57.52	25.65	3.41	17.10	1,628	45.65	28.55
M5	76,531	905	585	0.004	0.8	57.97	26.57	3.53	17.71	1,584	47.29	29.58
M6	81,853	905	585	0.004	0.8	59.22	28.42	3.78	18.94	1,513	50.58	31.63

*Any watershed with a slop less than 0.005 has a velocity less than 1 ft/s. It was assumed that slope = 0.004 has a velocity of 0.8 ft/s and slope = 0.002 has a velocity of 0.5 ft/s.

Equations:

Travel Length, Beginning Elevation, Ending Elevation - measured in ArcView

Slope = (Beginning Elevation - Ending Elevation) / Travel Length

Velocity - read off of Figure 3.4.5 in the HERPICC manual

Area - Calculated previously for CN calculations

$\Delta D = 0.133 \times t_c$ (duration of unit excess rainfall)

$t_c = L/(3600 \times v)$

$t_p = \Delta D/2 + 0.6t_c$

$q_p = 484 \times A_m \times Q' / t_p$

$Q' = 1''$

$t_b = 2.67 \times t_p$

$t_r = 1.67 \times t_p$

Trail Creek Watershed Study
July 11, 2006
IN20040385
Triangular Unit Hydrograph Calculations

Watershed	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
E1	3.09	1,932	8.25	5.16
E2	4.11	1,941	10.97	6.86
E3	5.19	1,797	13.87	8.67
W1	9.14	755	24.41	15.27
W2	1.40	1,355	3.73	2.33
W3	1.13	817	3.03	1.89
M1	7.36	3,020	19.66	12.30
M2	11.37	2,337	30.37	18.99
M3	16.36	1,694	43.68	27.32
M4	17.10	1,628	45.65	28.55
M5	17.71	1,584	47.29	29.58
M6	18.94	1,513	50.58	31.63

Watershed E1

Time (hr)	Flow (cfs)
0	0
3.09	1,932
8.25	0

Watershed E2

Time (hr)	Flow (cfs)
0	0
4.11	1,941
10.97	0

Watershed E3

Time (hr)	Flow (cfs)
0	0
5.19	1,797
13.87	0

Watershed W1

Time (hr)	Flow (cfs)
0	0
9.14	755
24	0

Watershed W2

Time (hr)	Flow (cfs)
0	0
1.40	1,355
3.73	0

Watershed W3

Time (hr)	Flow (cfs)
0	0
1.13	817
3.03	0

Watershed M1

Time (hr)	Flow (cfs)
0	0
7.36	3,020
19.66	0

Watershed M2

Time (hr)	Flow (cfs)
0	0
11.37	2,337
30.37	0

Watershed M3

Time (hr)	Flow (cfs)
0	0
16.36	1,694
43.68	0

Watershed M4

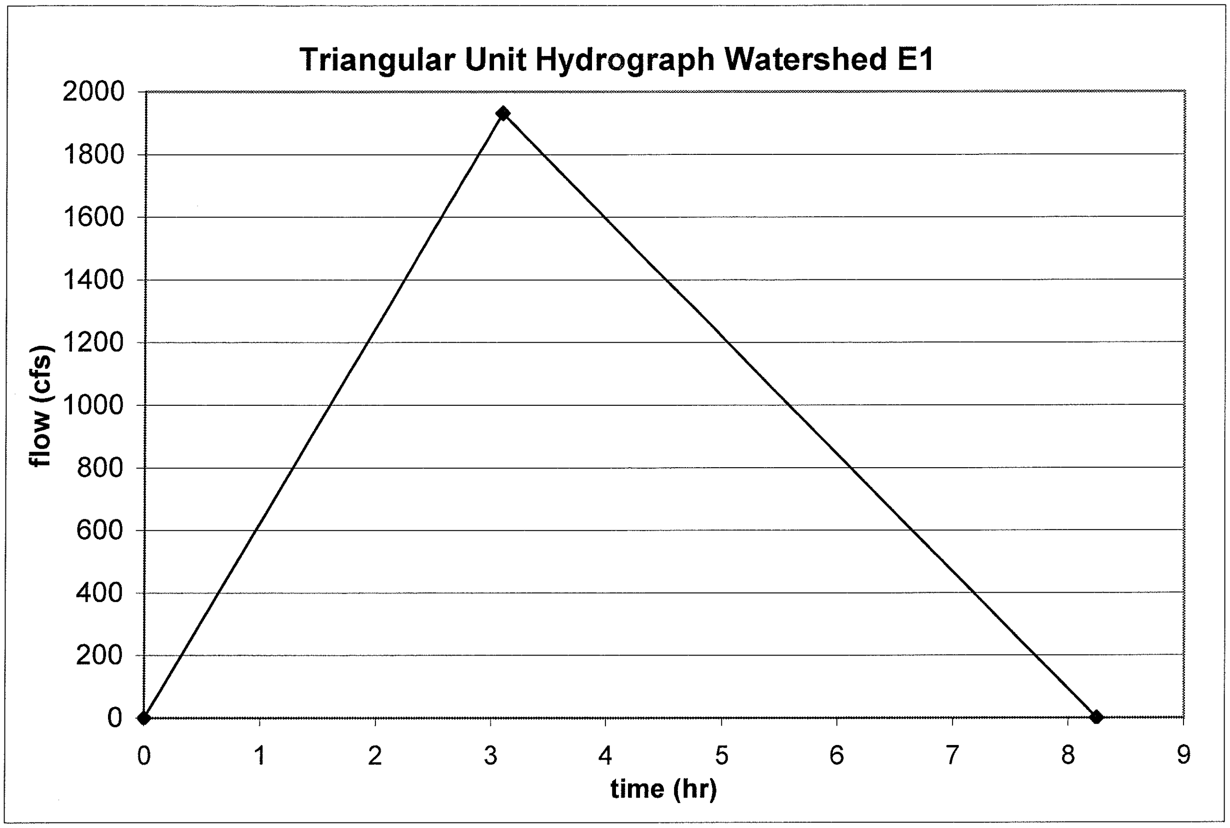
Time (hr)	Flow (cfs)
0	0
17.10	1,628
45.65	0

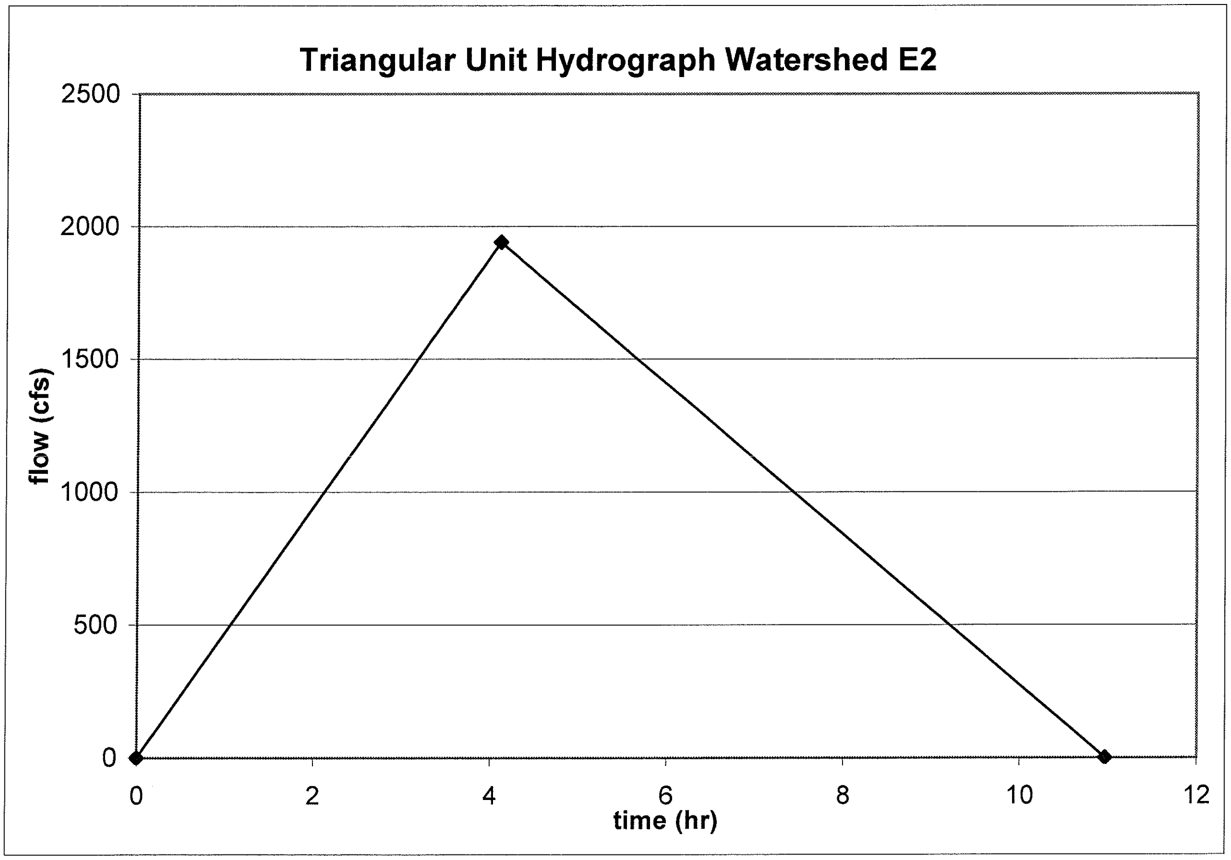
Watershed M5

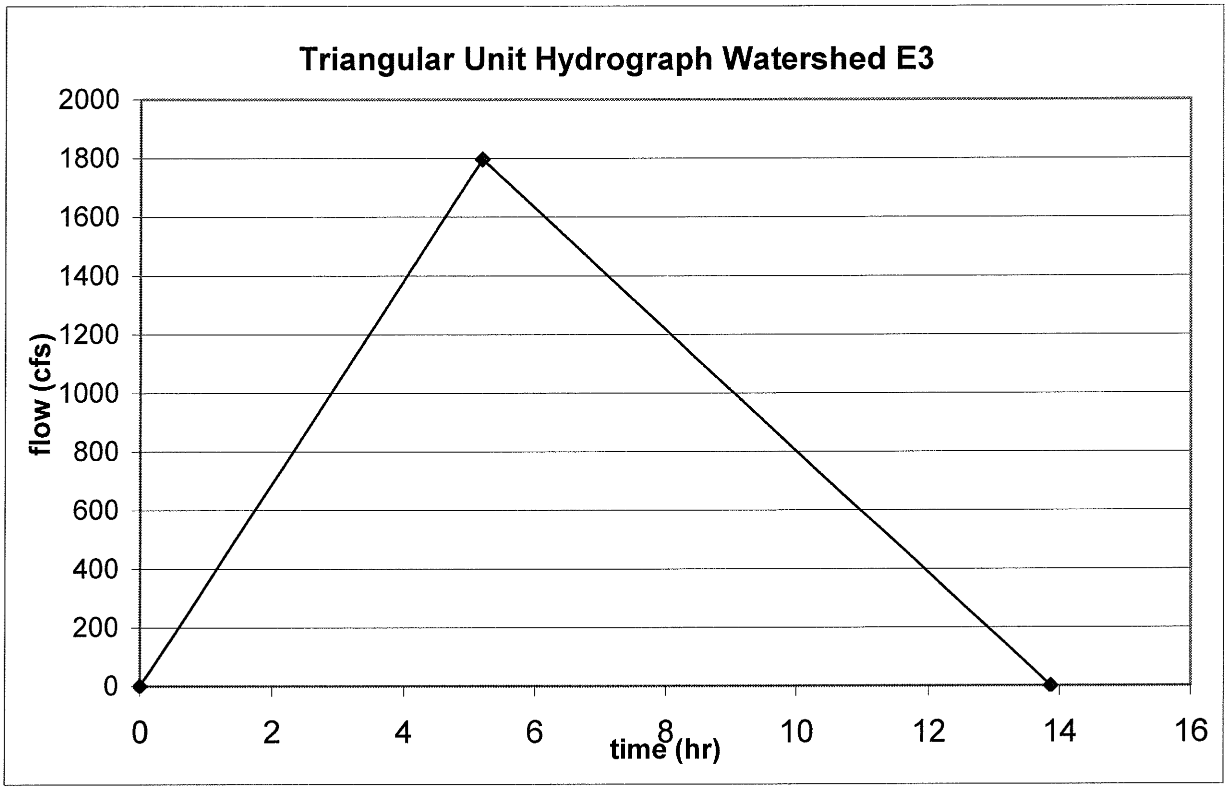
Time (hr)	Flow (cfs)
0	0
17.71	1,584
47.29	0

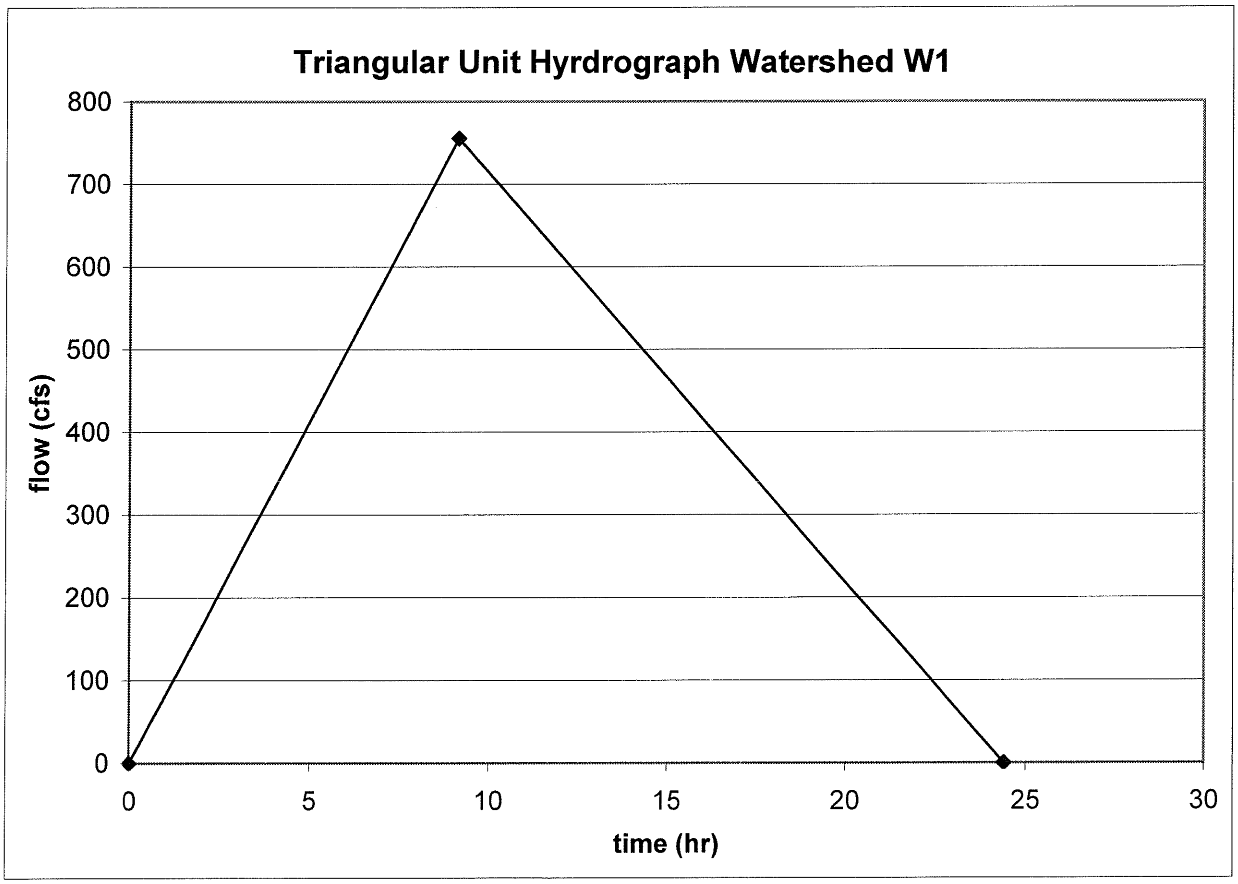
Watershed M6

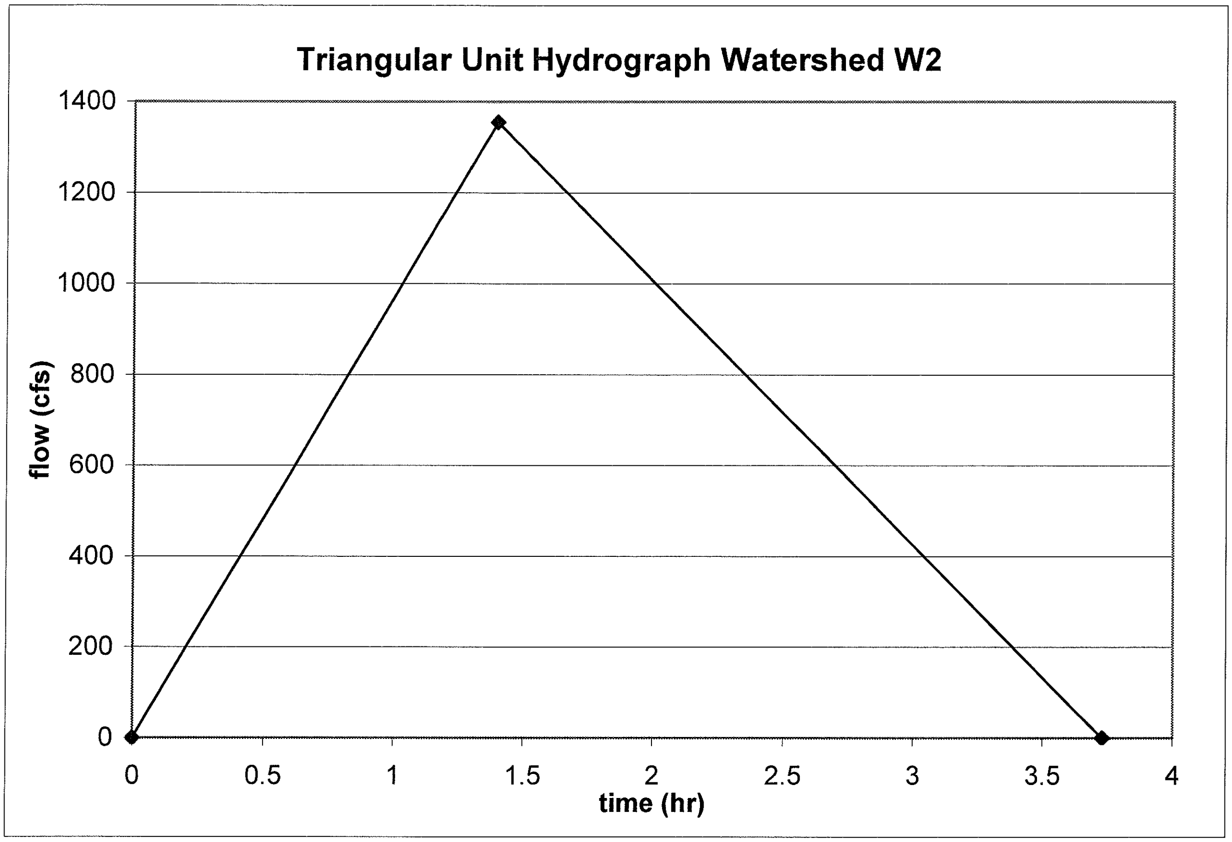
Time (hr)	Flow (cfs)
0	0
18.94	1,513
50.58	0

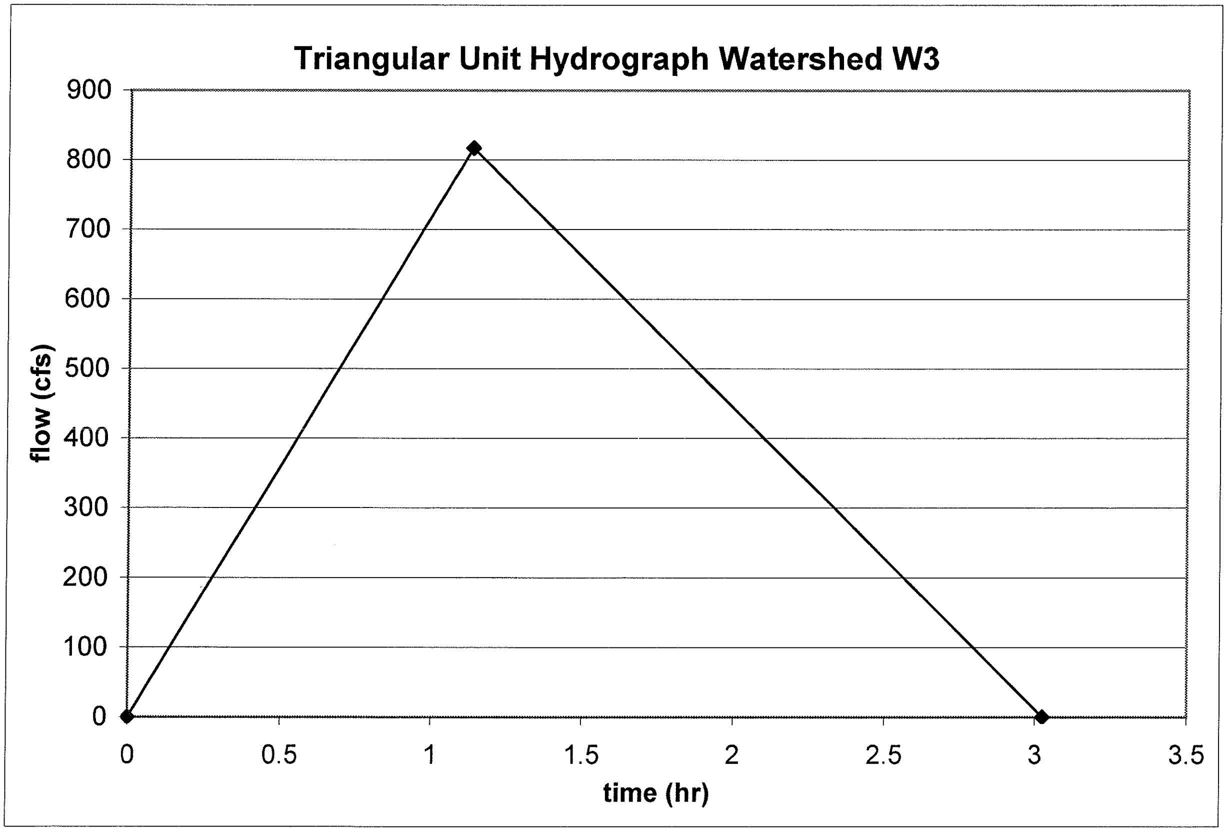

Triangular Unit Hydrograph Watershed E1
flow (cfs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
9
time (hr)


Triangular Unit Hydrograph Watershed E2
flow (cfs)
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
time (hr)


Triangular Unit Hydrograph Watershed E3
flow (cfs)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
16
time (hr)


Triangular Unit Hyrdrograph Watershed W1
flow (cfs)
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
time (hr)


Triangular Unit Hydrograph Watershed W2
1400
1200
1000
800
600
400
200
0
flow (cfs)
0
0.5
1
1.5
2
2.5
3
3.5
4
time (hr)


Triangular Unit Hydrograph Watershed W3
900
800
700
600
500
400
300
200
100
0
flow (cfs)
0
0.5
1
1.5
2
2.5
3
3.5
time (hr)

Trail Creek Watershed Study
SCS Type II Distribution
July 11, 2006
IN20040385

R(t) = 0 if P(t) < 0.2S

Watershed E1, S = 8.07, 0.2S = 1.615

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	----
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0	0
0.520	12.48	0.730	1.568	0	0
0.530	12.72	0.750	1.611	0	0
0.540	12.96	0.770	1.654	0.0002	0.0002
0.550	13.20	0.780	1.675	0.0005	0.0003
0.560	13.44	0.800	1.718	0.0013	0.001
0.570	13.68	0.810	1.740	0.0019	0.001
0.580	13.92	0.820	1.761	0.0026	0.001
0.600	14.40	0.835	1.794	0.0039	0.001
0.630	15.12	0.860	1.847	0.0066	0.003
0.650	15.60	0.870	1.869	0.0078	0.001
0.670	16.08	0.880	1.890	0.0091	0.001
0.700	16.80	0.895	1.922	0.0114	0.002
0.720	17.28	0.910	1.955	0.0138	0.002
0.750	18.00	0.920	1.976	0.0156	0.002
0.770	18.48	0.930	1.998	0.0174	0.002
0.800	19.20	0.940	2.019	0.0194	0.002
0.830	19.92	0.950	2.041	0.0214	0.002
0.850	20.40	0.960	2.062	0.0236	0.002
0.870	20.88	0.970	2.084	0.0258	0.002
0.900	21.60	0.980	2.105	0.0282	0.002
0.950	22.80	0.990	2.127	0.0306	0.002
1.000	24.00	1.000	2.148	0.0331	0.003

Watershed E2, S = 8.74, 0.2S = 1.748

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	----
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0	0
0.520	12.48	0.730	1.568	0	0
0.530	12.72	0.750	1.611	0	0
0.540	12.96	0.770	1.654	0	0
0.550	13.20	0.780	1.675	0	0
0.560	13.44	0.800	1.718	0	0
0.570	13.68	0.810	1.740	0	0
0.580	13.92	0.820	1.761	2.04E-05	2.04E-05
0.600	14.40	0.835	1.794	0.0002	0.0002
0.630	15.12	0.860	1.847	0.0011	0.0009
0.650	15.60	0.870	1.869	0.0016	0.0005
0.670	16.08	0.880	1.890	0.0023	0.0006
0.700	16.80	0.895	1.922	0.0034	0.0011
0.720	17.28	0.910	1.955	0.0048	0.0014
0.750	18.00	0.920	1.976	0.0058	0.0010
0.770	18.48	0.930	1.998	0.0069	0.0011
0.800	19.20	0.940	2.019	0.0082	0.0012
0.830	19.92	0.950	2.041	0.0095	0.0013
0.850	20.40	0.960	2.062	0.0109	0.0014
0.870	20.88	0.970	2.084	0.0124	0.0015
0.900	21.60	0.980	2.105	0.0140	0.0016
0.950	22.80	0.990	2.127	0.0157	0.0017
1.000	24.00	1.000	2.148	0.0175	0.0018

Watershed E3, S = 8.98, 0.2S = 1.796

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0	0
0.520	12.48	0.730	1.568	0	0
0.530	12.72	0.750	1.611	0	0
0.540	12.96	0.770	1.654	0	0
0.550	13.20	0.780	1.675	0	0
0.560	13.44	0.800	1.718	0	0
0.570	13.68	0.810	1.740	0	0
0.580	13.92	0.820	1.761	0	0
0.600	14.40	0.835	1.794	0	0
0.630	15.12	0.860	1.847	0.0003	0.0003
0.650	15.60	0.870	1.869	0.0006	0.0003
0.670	16.08	0.880	1.890	0.0010	0.0004
0.700	16.80	0.895	1.922	0.0018	0.0008
0.720	17.28	0.910	1.955	0.0028	0.0010
0.750	18.00	0.920	1.976	0.0035	0.0008
0.770	18.48	0.930	1.998	0.0044	0.0009
0.800	19.20	0.940	2.019	0.0054	0.0010
0.830	19.92	0.950	2.041	0.0065	0.0011
0.850	20.40	0.960	2.062	0.0077	0.0012
0.870	20.88	0.970	2.084	0.0089	0.0013
0.900	21.60	0.980	2.105	0.0103	0.0014
0.950	22.80	0.990	2.127	0.0117	0.0015
1.000	24.00	1.000	2.148	0.0133	0.0015

Watershed W1, S = 5.59, 0.2S = 1.118

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0.0113	0.0113
0.520	12.48	0.730	1.568	0.0335	0.0223
0.530	12.72	0.750	1.611	0.0400	0.0064
0.540	12.96	0.770	1.654	0.0469	0.0069
0.550	13.20	0.780	1.675	0.0505	0.0037
0.560	13.44	0.800	1.718	0.0582	0.0077
0.570	13.68	0.810	1.740	0.0623	0.0040
0.580	13.92	0.820	1.761	0.0664	0.0041
0.600	14.40	0.835	1.794	0.0728	0.0064
0.630	15.12	0.860	1.847	0.0842	0.0113
0.650	15.60	0.870	1.869	0.0889	0.0047
0.670	16.08	0.880	1.890	0.0937	0.0048
0.700	16.80	0.895	1.922	0.1012	0.0075
0.720	17.28	0.910	1.955	0.1089	0.0077
0.750	18.00	0.920	1.976	0.1142	0.0053
0.770	18.48	0.930	1.998	0.1196	0.0054
0.800	19.20	0.940	2.019	0.1251	0.0055
0.830	19.92	0.950	2.041	0.1307	0.0056
0.850	20.40	0.960	2.062	0.1364	0.0057
0.870	20.88	0.970	2.084	0.1422	0.0058
0.900	21.60	0.980	2.105	0.1481	0.0059
0.950	22.80	0.990	2.127	0.1541	0.0060
1.000	24.00	1.000	2.148	0.1603	0.0061

Watershed W2, S = 11.56, 0.2S = 2.312

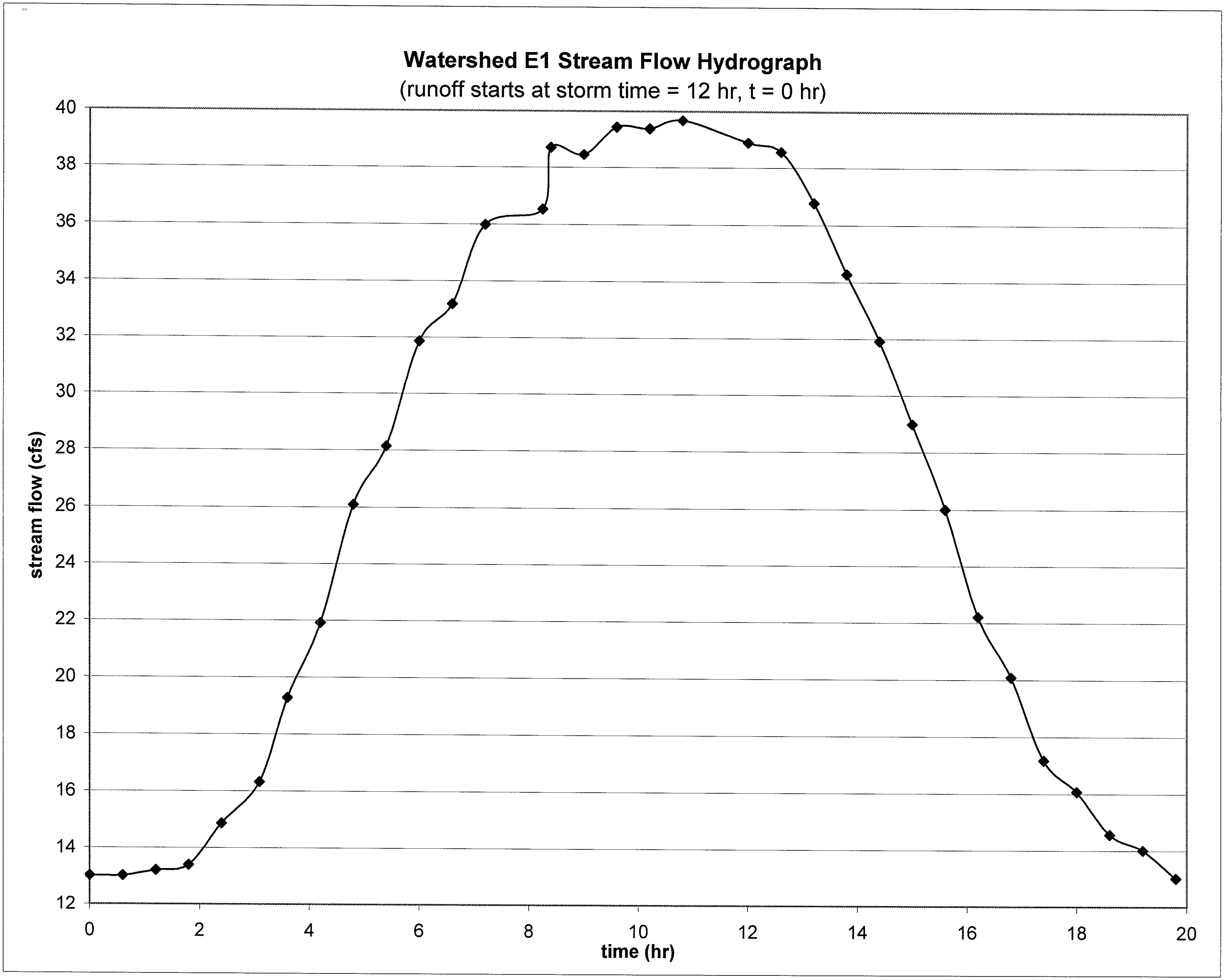
Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0	0
0.520	12.48	0.730	1.568	0	0
0.530	12.72	0.750	1.611	0	0
0.540	12.96	0.770	1.654	0	0
0.550	13.20	0.780	1.675	0	0
0.560	13.44	0.800	1.718	0	0
0.570	13.68	0.810	1.740	0	0
0.580	13.92	0.820	1.761	0	0
0.600	14.40	0.835	1.794	0	0
0.630	15.12	0.860	1.847	0	0
0.650	15.60	0.870	1.869	0	0
0.670	16.08	0.880	1.890	0	0
0.700	16.80	0.895	1.922	0	0
0.720	17.28	0.910	1.955	0	0
0.750	18.00	0.920	1.976	0	0
0.770	18.48	0.930	1.998	0	0
0.800	19.20	0.940	2.019	0	0
0.830	19.92	0.950	2.041	0	0
0.850	20.40	0.960	2.062	0	0
0.870	20.88	0.970	2.084	0	0
0.900	21.60	0.980	2.105	0	0
0.950	22.80	0.990	2.127	0	0
1.000	24.00	1.000	2.148	0	0

Watershed W3, S = 11.78, 0.2S = 2.356

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0	0
0.520	12.48	0.730	1.568	0	0
0.530	12.72	0.750	1.611	0	0
0.540	12.96	0.770	1.654	0	0
0.550	13.20	0.780	1.675	0	0
0.560	13.44	0.800	1.718	0	0
0.570	13.68	0.810	1.740	0	0
0.580	13.92	0.820	1.761	0	0
0.600	14.40	0.835	1.794	0	0
0.630	15.12	0.860	1.847	0	0
0.650	15.60	0.870	1.869	0	0
0.670	16.08	0.880	1.890	0	0
0.700	16.80	0.895	1.922	0	0
0.720	17.28	0.910	1.955	0	0
0.750	18.00	0.920	1.976	0	0
0.770	18.48	0.930	1.998	0	0
0.800	19.20	0.940	2.019	0	0
0.830	19.92	0.950	2.041	0	0
0.850	20.40	0.960	2.062	0	0
0.870	20.88	0.970	2.084	0	0
0.900	21.60	0.980	2.105	0	0
0.950	22.80	0.990	2.127	0	0
1.000	24.00	1.000	2.148	0	0

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed E1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (starts at storm time x hr so Time = 0 is Storm Time = 12 hr when runoff											Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8	12		
		0	0.0005	0.0034	0.0039	0.0036	0.0042	0.0038	0.0042	0.0046	0.0024	0.0025		
0	0.00	0.000											0.000	13.020
0.6	375.15	0.000	0.000										0.000	13.020
1.2	750.29	0.000	0.188	0.000									0.188	13.208
1.8	1125.44	0.000	0.375	0.000									0.375	13.395
2.4	1500.58	0.000	0.563	1.275	0.000								1.838	14.858
3.09	1932.00	0.000	0.750	2.551	0.000								3.301	16.321
3.6	1741.05	0.000	0.966	3.826	1.463	0.000							6.256	19.276
4.2	1516.39	0.000	0.871	5.102	2.926	0.000							8.899	21.919
4.8	1291.74	0.000	0.758	6.569	4.389	1.351	0.000						13.067	26.087
5.4	1067.09	0.000	0.646	5.920	5.852	2.701	0.000						15.119	28.139
6	842.44	0.000	0.534	5.156	7.535	4.052	1.576	0.000					18.851	31.871
6.6	617.79	0.000	0.421	4.392	6.790	5.402	3.151	0.000					20.157	33.177
7.2	393.14	0.000	0.309	3.628	5.914	6.955	4.727	1.426	0.000				22.959	35.979
8.25	0.00	0.000	0.197	2.864	5.038	6.268	6.302	2.851	0.000				23.520	36.540
8.4		0.000	0.000	2.100	4.162	5.459	8.114	4.277	1.576	0.000			25.688	38.708
9			0.000	1.337	3.286	4.650	7.312	5.702	3.151	0.000			25.438	38.458
9.6				0.000	2.409	3.842	6.369	7.342	4.727	1.726	0.000		26.414	39.434
10.2				0.000	1.533	3.033	5.425	6.616	6.302	3.451	0.000		26.361	39.381
10.8					0.000	2.224	4.482	5.762	8.114	5.177	0.900	0.000	26.660	39.680
12					0.000	1.415	3.538	4.909	7.312	6.903	1.801	0.000	25.878	38.898
12.6						0.000	2.595	4.055	6.369	8.887	2.701	0.938	25.545	38.565
13.2						0.000	1.651	3.201	5.425	8.009	3.601	1.876	23.764	36.784
13.8							0.000	2.348	4.482	6.975	4.637	2.814	21.255	34.275
14.4							0.000	1.494	3.538	5.942	4.179	3.751	18.904	31.924
15								0.000	2.595	4.909	3.639	4.830	15.973	28.993
15.6								0.000	1.651	3.875	3.100	4.353	12.979	25.999
16.2									0.000	2.842	2.561	3.791	9.194	22.214
16.8									0.000	1.808	2.022	3.229	7.060	20.080
17.4										0.000	1.483	2.668	4.150	17.170
18										0.000	0.944	2.106	3.050	16.070
18.6											0.000	1.544	1.544	14.564
19.2											0.000	0.983	0.983	14.003
19.8												0.000	0.000	13.020
												SUM =	**435.368**	**865.028**

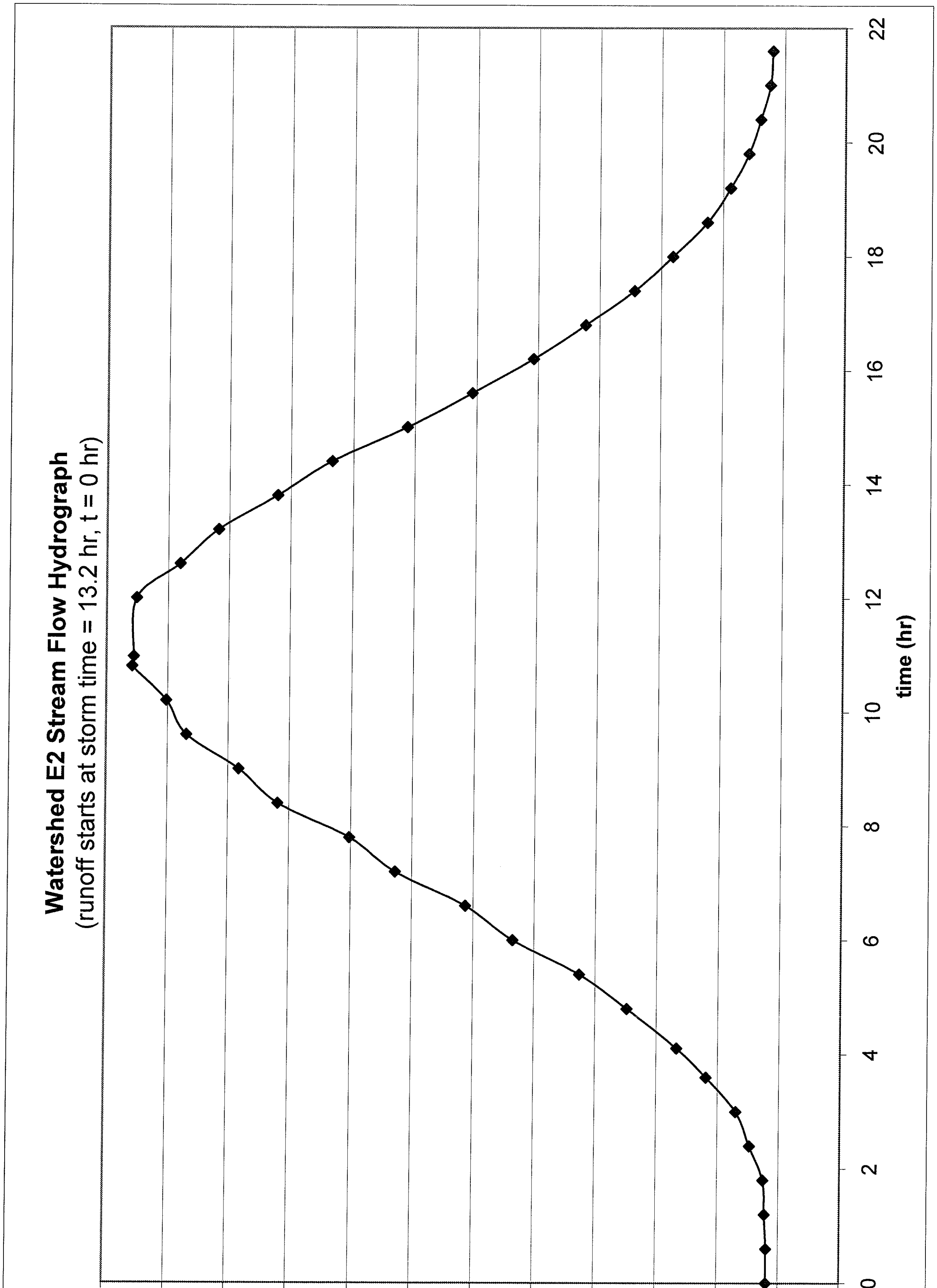


Watershed E1 Stream Flow Hydrograph
(runoff starts at storm time = 12 hr, t = 0 hr)
stream flow (cfs)
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
0
2
4
6
8
10
12
14
16
18
20
time (hr)

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed E2 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 13.2 hr)										Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8		
		0	0.0002	0.0014	0.0018	0.0024	0.0024	0.0027	0.0031	0.0017	0.0018		
0.0	0.00	0.000										0.000	17.390
0.6	283.36	0.000	0.000									0.000	17.390
1.2	566.72	0.000	0.057	0.000								0.057	17.447
1.8	850.07	0.000	0.113	0.000								0.113	17.503
2.4	1133.43	0.000	0.170	0.397	0.000							0.567	17.957
3.0	1416.79	0.000	0.227	0.793	0.000							1.020	18.410
3.6	1700.15	0.000	0.283	1.190	0.510	0.000						1.984	19.374
4.11	1941.00	0.000	0.340	1.587	1.020	0.000						2.947	20.337
4.8	1745.77	0.000	0.388	1.984	1.530	0.680	0.000					4.582	21.972
5.4	1576.00	0.000	0.349	2.380	2.040	1.360	0.000					6.130	23.520
6.0	1406.24	0.000	0.315	2.717	2.550	2.040	0.680	0.000				8.303	25.693
6.6	1236.47	0.000	0.281	2.444	3.060	2.720	1.360	0.000				9.866	27.256
7.2	1066.70	0.000	0.247	2.206	3.494	3.400	2.040	0.765	0.000			12.153	29.543
7.8	896.94	0.000	0.213	1.969	3.142	4.080	2.720	1.530	0.000			13.655	31.045
8.4	727.17	0.000	0.179	1.731	2.837	4.658	3.400	2.295	0.878	0.000		15.980	33.370
9.0	557.40	0.000	0.145	1.493	2.531	4.190	4.080	3.060	1.757	0.000		17.257	34.647
9.6	387.64	0.000	0.111	1.256	2.226	3.782	4.658	3.825	2.635	0.482	0.000	18.976	36.366
10.2	217.87	0.000	0.078	1.018	1.920	3.375	4.190	4.590	3.514	0.963	0.000	19.648	37.038
10.8	48.10	0.000	0.044	0.780	1.614	2.968	3.782	5.241	4.392	1.445	0.510	20.776	38.166
10.97	0.00	0.000	0.010	0.543	1.309	2.560	3.375	4.714	5.270	1.927	1.020	20.727	38.117
12.0			0.000	0.305	1.003	2.153	2.968	4.255	6.017	2.409	1.530	20.639	38.029
12.6			0.000	0.067	0.698	1.745	2.560	3.797	5.412	2.890	2.040	19.210	36.600
13.2				0.000	0.392	1.338	2.153	3.338	4.886	3.300	2.550	17.957	35.347
13.8				0.000	0.087	0.930	1.745	2.880	4.359	2.968	3.060	16.030	33.420
14.4					0.000	0.523	1.338	2.422	3.833	2.679	3.494	14.288	31.678
15.0					0.000	0.115	0.930	1.963	3.307	2.391	3.142	11.849	29.239
15.6						0.000	0.523	1.505	2.781	2.102	2.837	9.747	27.137
16.2						0.000	0.115	1.047	2.254	1.813	2.531	7.761	25.151
16.8							0.000	0.588	1.728	1.525	2.226	6.067	23.457

17.4							0.000	0.130	1.202	1.236	1.920	4.488	21.878
18.0								0.000	0.675	0.948	1.614	3.237	20.627
18.6								0.000	0.149	0.659	1.309	2.117	19.507
19.2									0.000	0.370	1.003	1.374	18.764
19.8									0.000	0.082	0.698	0.780	18.170
20.4										0.000	0.392	0.392	17.782
21.0										0.000	0.087	0.087	17.477
21.6											0.000	0.000	17.390
											SUM =	**310.762**	**954.192**

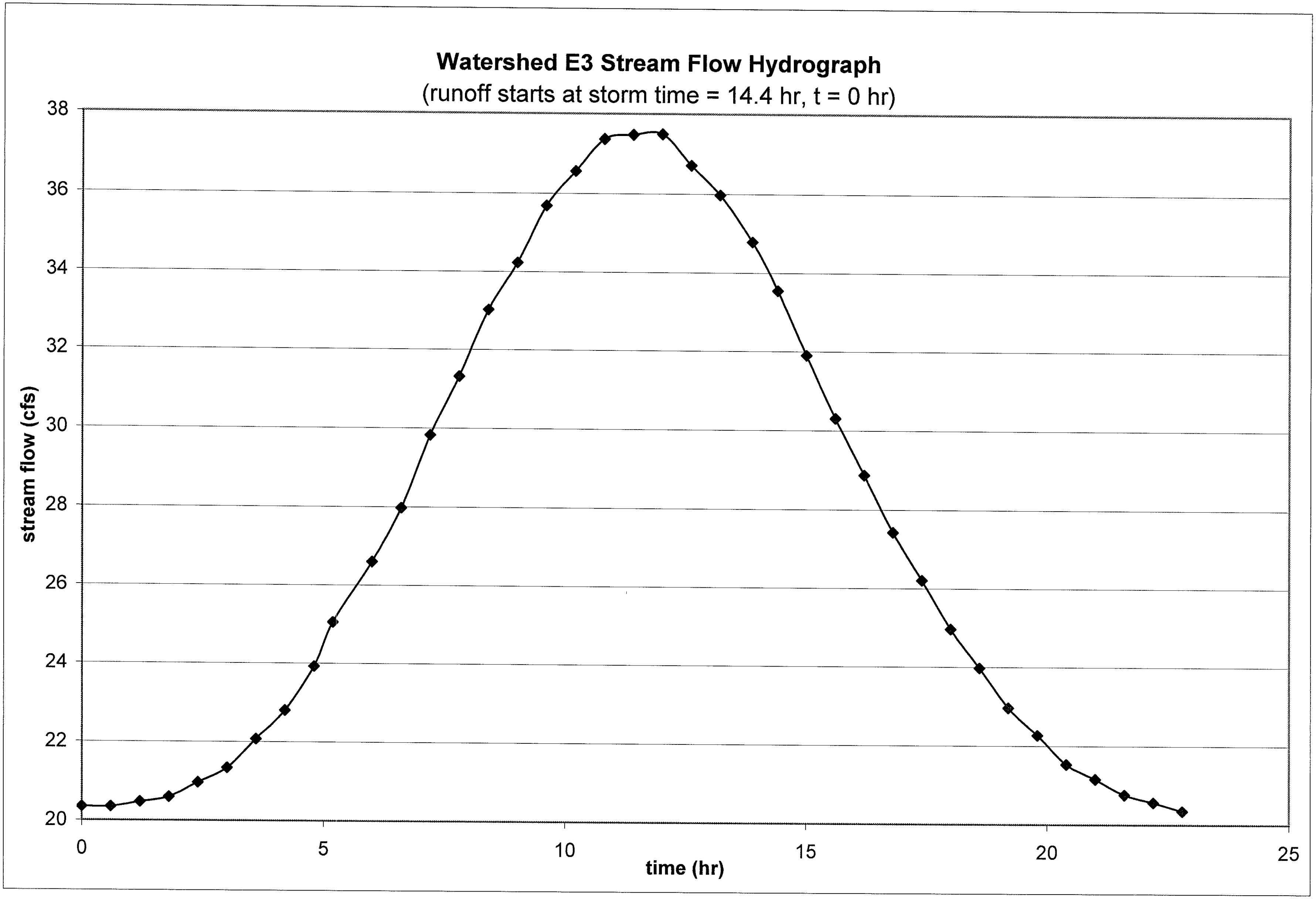


Watershed E2 Stream Flow Hydrograph
(runoff starts at storm time = 13.2 hr, t = 0 hr)
stream flow (cfs)
time (hr)
39
37
35
33
31
29
27
25
23
21
19
17
15
0
2
4
6
8
10
12
14
16
18
20
22

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed E3 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 14.4 hr)									Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0 0	1.2 0.0006	2.4 0.0012	3.6 0.0017	4.8 0.0019	6 0.0023	7.2 0.0026	8.4 0.0014	9.6 0.0016		
0	0	0.000									0.000	20.350
0.6	207.75	0.000	0.000								0.000	20.350
1.2	415.49	0.000	0.125	0.000							0.125	20.475
1.8	623.24	0.000	0.249	0.000							0.249	20.599
2.4	830.98	0.000	0.374	0.249	0.000						0.623	20.973
3.0	1038.73	0.000	0.499	0.499	0.000						0.997	21.347
3.6	1246.47	0.000	0.623	0.748	0.353	0.000					1.724	22.074
4.2	1454.22	0.000	0.748	0.997	0.706	0.000					2.451	22.801
4.8	1661.97	0.000	0.873	1.246	1.060	0.395	0.000				3.573	23.923
5.19	1797.00	0.000	0.997	1.496	1.413	0.789	0.000				4.695	25.045
6.0	1629.31	0.000	1.078	1.745	1.766	1.184	0.478	0.000			6.251	26.601
6.6	1505.09	0.000	0.978	1.994	2.119	1.579	0.956	0.000			7.625	27.975
7.2	1380.87	0.000	0.903	2.156	2.472	1.974	1.433	0.540	0.000		9.479	29.829
7.8	1256.66	0.000	0.829	1.955	2.825	2.368	1.911	1.080	0.000		10.969	31.319
8.4	1132.44	0.000	0.754	1.806	3.055	2.763	2.389	1.620	0.291	0.000	12.678	33.028
9.0	1008.22	0.000	0.679	1.657	2.770	3.158	2.867	2.161	0.582	0.000	13.873	34.223
9.6	884.01	0.000	0.605	1.508	2.559	3.414	3.345	2.701	0.873	0.332	15.336	35.686
10.2	759.79	0.000	0.530	1.359	2.347	3.096	3.823	3.241	1.163	0.665	16.224	36.574
10.8	635.57	0.000	0.456	1.210	2.136	2.860	4.133	3.781	1.454	0.997	17.027	37.377
11.4	511.36	0.000	0.381	1.061	1.925	2.624	3.747	4.321	1.745	1.330	17.134	37.484
12.0	387.14	0.000	0.307	0.912	1.714	2.388	3.462	4.672	2.036	1.662	17.152	37.502
12.6	262.93	0.000	0.232	0.763	1.503	2.152	3.176	4.236	2.327	1.994	16.383	36.733
13.2	138.71	0.000	0.158	0.614	1.292	1.916	2.890	3.913	2.516	2.327	15.625	35.975
13.87	0.00	0.000	0.083	0.465	1.080	1.680	2.605	3.590	2.281	2.659	14.443	34.793
14.4			0.000	0.316	0.869	1.444	2.319	3.267	2.107	2.875	13.197	33.547
15.0			0.000	0.166	0.658	1.208	2.033	2.944	1.933	2.607	11.550	31.900
15.6				0.000	0.447	0.972	1.748	2.621	1.759	2.408	9.955	30.305
16.2				0.000	0.236	0.736	1.462	2.298	1.585	2.209	8.526	28.876
16.8					0.000	0.500	1.176	1.975	1.412	2.011	7.073	27.423

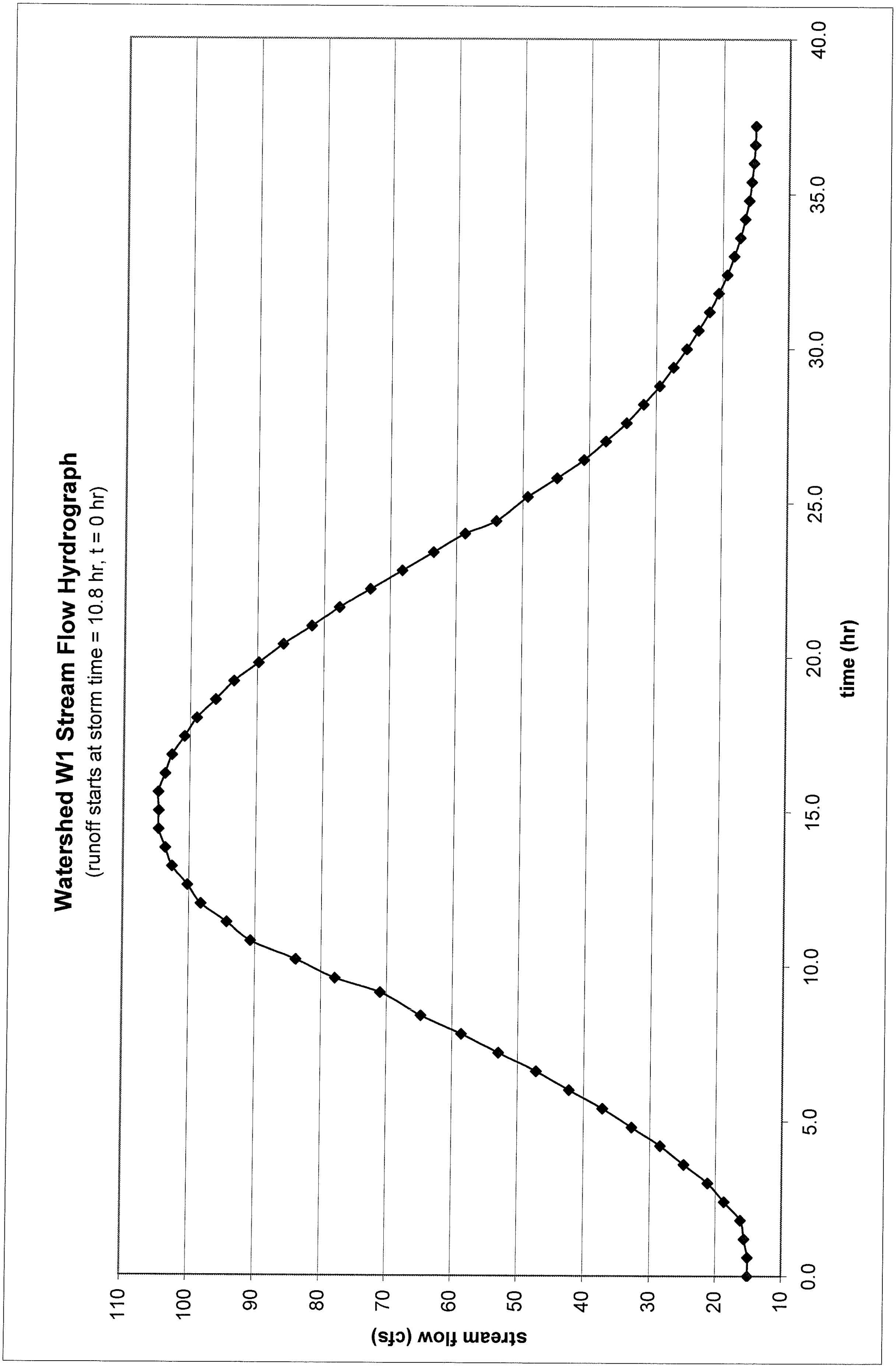
17.4					0.000	0.264	0.890	1.652	1.238	1.812	5.856	26.206
18.0						0.000	0.605	1.330	1.064	1.613	4.611	24.961
18.6						0.000	0.319	1.007	0.890	1.414	3.630	23.980
19.2							0.000	0.684	0.716	1.216	2.615	22.965
19.8							0.000	0.361	0.542	1.017	1.920	22.270
20.4								0.000	0.368	0.818	1.186	21.536
21.0								0.000	0.194	0.619	0.814	21.164
21.6									0.000	0.421	0.421	20.771
22.2									0.000	0.222	0.222	20.572
22.8										0.000	0.000	20.350
										SUM =	**276.214**	**1069.864**


Watershed E3 Stream Flow Hydrograph
(runoff starts at storm time = 14.4 hr, t = 0 hr)
stream flow (cfs)
38
36
34
32
30
28
26
24
22
20
0
5
10
15
20
25
time (hr)

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed W1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 10.8 hr)												Storm Hydrograph (cfs)	Stream Flow Hyrdrograph (cfs)
		0 0	1.2 0.0113	2.4 0.0392	3.6 0.0223	4.8 0.0161	6 0.0123	7.2 0.013	8.4 0.0109	9.6 0.0113	10.8 0.0117	12 0.006	13.2 0.0062		
0.0	0.00	0.000												0.000	15.050
0.6	49.56	0.000	0.000											0.000	15.050
1.2	99.12	0.000	0.560	0.000										0.560	15.610
1.8	148.69	0.000	1.120	0.000										1.120	16.170
2.4	198.25	0.000	1.680	1.943	0.000									3.623	18.673
3.0	247.81	0.000	2.240	3.886	0.000									6.126	21.176
3.6	297.37	0.000	2.800	5.829	1.105	0.000								9.734	24.784
4.2	346.94	0.000	3.360	7.771	2.210	0.000								13.342	28.392
4.8	396.50	0.000	3.920	9.714	3.316	0.798	0.000							17.748	32.798
5.4	446.06	0.000	4.480	11.657	4.421	1.596	0.000							22.154	37.204
6.0	495.62	0.000	5.040	13.600	5.526	2.394	0.610	0.000						27.170	42.220
6.6	545.19	0.000	5.601	15.543	6.631	3.192	1.219	0.000						32.186	47.236
7.2	594.75	0.000	6.161	17.486	7.737	3.990	1.829	0.644	0.000					37.846	52.896
7.8	644.31	0.000	6.721	19.428	8.842	4.788	2.438	1.289	0.000					43.506	58.556
8.4	693.87	0.000	7.281	21.371	9.947	5.586	3.048	1.933	0.540	0.000				49.706	64.756
9.14	755.00	0.000	7.841	23.314	11.052	6.384	3.658	2.577	1.080	0.000				55.906	70.956
9.6	732.26	0.000	8.531	25.257	12.158	7.182	4.267	3.222	1.621	0.560	0.000			62.797	77.847
10.2	702.59	0.000	8.275	27.200	13.263	7.980	4.877	3.866	2.161	1.120	0.000			68.741	83.791
10.8	672.92	0.000	7.939	29.596	14.368	8.777	5.487	4.510	2.701	1.680	0.580	0.000		75.639	90.689
11.4	643.26	0.000	7.604	28.704	15.473	9.575	6.096	5.154	3.241	2.240	1.160	0.000		79.249	94.299
12.0	613.59	0.000	7.269	27.542	16.836	10.373	6.706	5.799	3.782	2.800	1.740	0.297	0.000	83.144	98.194
12.6	583.93	0.000	6.934	26.379	16.329	11.171	7.315	6.443	4.322	3.360	2.320	0.595	0.000	85.168	100.218
13.2	554.26	0.000	6.598	25.216	15.668	12.155	7.925	7.087	4.862	3.920	2.899	0.892	0.307	87.531	102.581
13.8	524.59	0.000	6.263	24.053	15.006	11.789	8.535	7.732	5.402	4.480	3.479	1.189	0.615	88.544	103.594
14.4	494.93	0.000	5.928	22.890	14.345	11.312	9.286	8.376	5.943	5.040	4.059	1.487	0.922	89.588	104.638
15.0	465.26	0.000	5.593	21.727	13.683	10.834	9.007	9.020	6.483	5.601	4.639	1.784	1.229	89.600	104.650
15.6	435.60	0.000	5.257	20.564	13.022	10.356	8.642	9.815	7.023	6.161	5.219	2.082	1.536	89.677	104.727
16.2	405.93	0.000	4.922	19.401	12.360	9.879	8.277	9.519	7.563	6.721	5.799	2.379	1.844	88.664	103.714
16.8	376.26	0.000	4.587	18.238	11.698	9.401	7.912	9.134	8.229	7.281	6.379	2.676	2.151	87.687	102.737

17.4	346.60	0.000	4.252	17.075	11.037	8.924	7.547	8.748	7.982	7.841	6.959	2.974	2.458	85.796	100.846
18.0	316.93	0.000	3.917	15.912	10.375	8.446	7.182	8.362	7.658	8.531	7.538	3.271	2.766	83.960	99.010
18.6	287.27	0.000	3.581	14.750	9.714	7.968	6.817	7.977	7.335	8.275	8.118	3.568	3.073	81.176	96.226
19.2	257.60	0.000	3.246	13.587	9.052	7.491	6.453	7.591	7.012	7.939	8.833	3.866	3.380	78.450	93.500
19.8	227.93	0.000	2.911	12.424	8.391	7.013	6.088	7.205	6.688	7.604	8.567	4.163	3.687	74.742	89.792
20.4	198.27	0.000	2.576	11.261	7.729	6.535	5.723	6.820	6.365	7.269	8.220	4.530	3.995	71.022	86.072
21.0	168.60	0.000	2.240	10.098	7.068	6.058	5.358	6.434	6.041	6.934	7.873	4.394	4.302	66.800	81.850
21.6	138.94	0.000	1.905	8.935	6.406	5.580	4.993	6.048	5.718	6.598	7.526	4.216	4.681	62.607	77.657
22.2	109.27	0.000	1.570	7.772	5.744	5.103	4.628	5.663	5.395	6.263	7.179	4.038	4.540	57.894	72.944
22.8	79.60	0.000	1.235	6.609	5.083	4.625	4.263	5.277	5.071	5.928	6.832	3.860	4.356	53.139	68.189
23.4	49.94	0.000	0.900	5.446	4.421	4.147	3.898	4.891	4.748	5.593	6.485	3.682	4.172	48.383	63.433
24.0	20.27	0.000	0.564	4.283	3.760	3.670	3.533	4.506	4.425	5.257	6.138	3.504	3.988	43.628	58.678
24.41	0.00	0.000	0.229	3.120	3.098	3.192	3.168	4.120	4.101	4.922	5.791	3.326	3.804	38.873	53.923
25.2			0.000	1.958	2.437	2.714	2.804	3.734	3.778	4.587	5.444	3.148	3.620	34.223	49.273
25.8			0.000	0.795	1.775	2.237	2.439	3.349	3.455	4.252	5.096	2.970	3.436	29.803	44.853
26.4				0.000	1.114	1.759	2.074	2.963	3.131	3.917	4.749	2.792	3.252	25.751	40.801
27.0				0.000	0.452	1.282	1.709	2.577	2.808	3.581	4.402	2.614	3.069	22.494	37.544
27.6					0.000	0.804	1.344	2.192	2.484	3.246	4.055	2.436	2.885	19.446	34.496
28.2					0.000	0.326	0.979	1.806	2.161	2.911	3.708	2.258	2.701	16.850	31.900
28.8						0.000	0.614	1.421	1.838	2.576	3.361	2.080	2.517	14.406	29.456
29.4						0.000	0.249	1.035	1.514	2.240	3.014	1.902	2.333	12.287	27.337
30.0							0.000	0.649	1.191	1.905	2.667	1.724	2.149	10.285	25.335
30.6							0.000	0.264	0.868	1.570	2.320	1.546	1.965	8.532	23.582
31.2								0.000	0.544	1.235	1.973	1.368	1.781	6.900	21.950
31.8								0.000	0.221	0.900	1.626	1.190	1.597	5.533	20.583
32.4									0.000	0.564	1.278	1.012	1.413	4.268	19.318
33.0									0.000	0.229	0.931	0.834	1.229	3.223	18.273
33.6										0.000	0.584	0.656	1.045	2.285	17.335
34.2										0.000	0.237	0.478	0.861	1.576	16.626
34.8											0.000	0.300	0.677	0.977	16.027
35.4											0.000	0.122	0.494	0.615	15.665
36.0												0.000	0.310	0.310	15.360
36.6												0.000	0.126	0.126	15.176
37.2													0.000	0.000	15.050
													SUM =	**2463.114**	**3411.264**

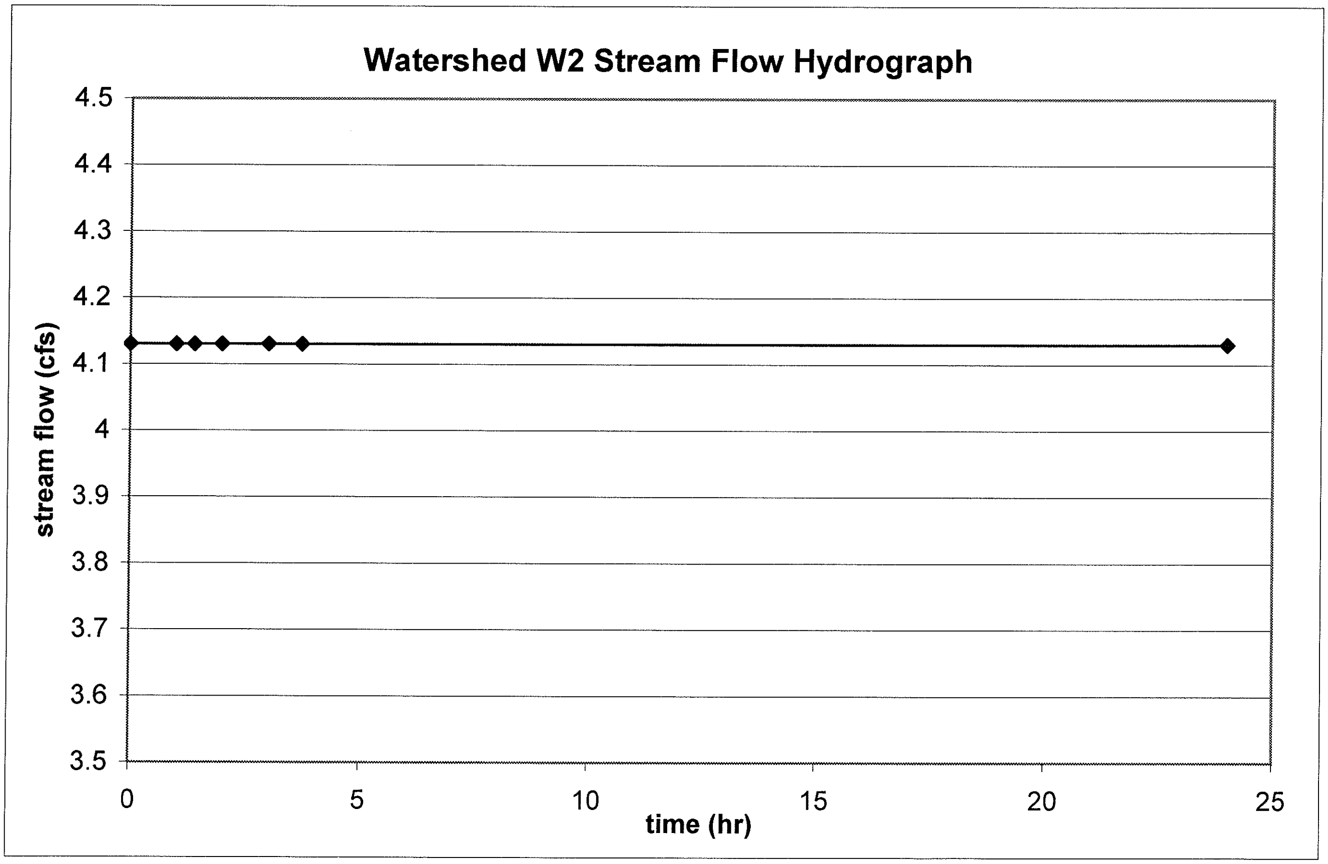


Watershed W1 Stream Flow Hyrdrograph
(runoff starts at storm time = 10.8 hr, t = 0 hr)
stream flow (cfs)
110
100
90
80
70
60
50
40
30
20
10
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
time (hr)

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed W2 Hydrograph Calculations

**There is no run off in this watershed and therefore no storm hydrograph. The stream hydrograph for for the storm is simply the base flow of the stream.*

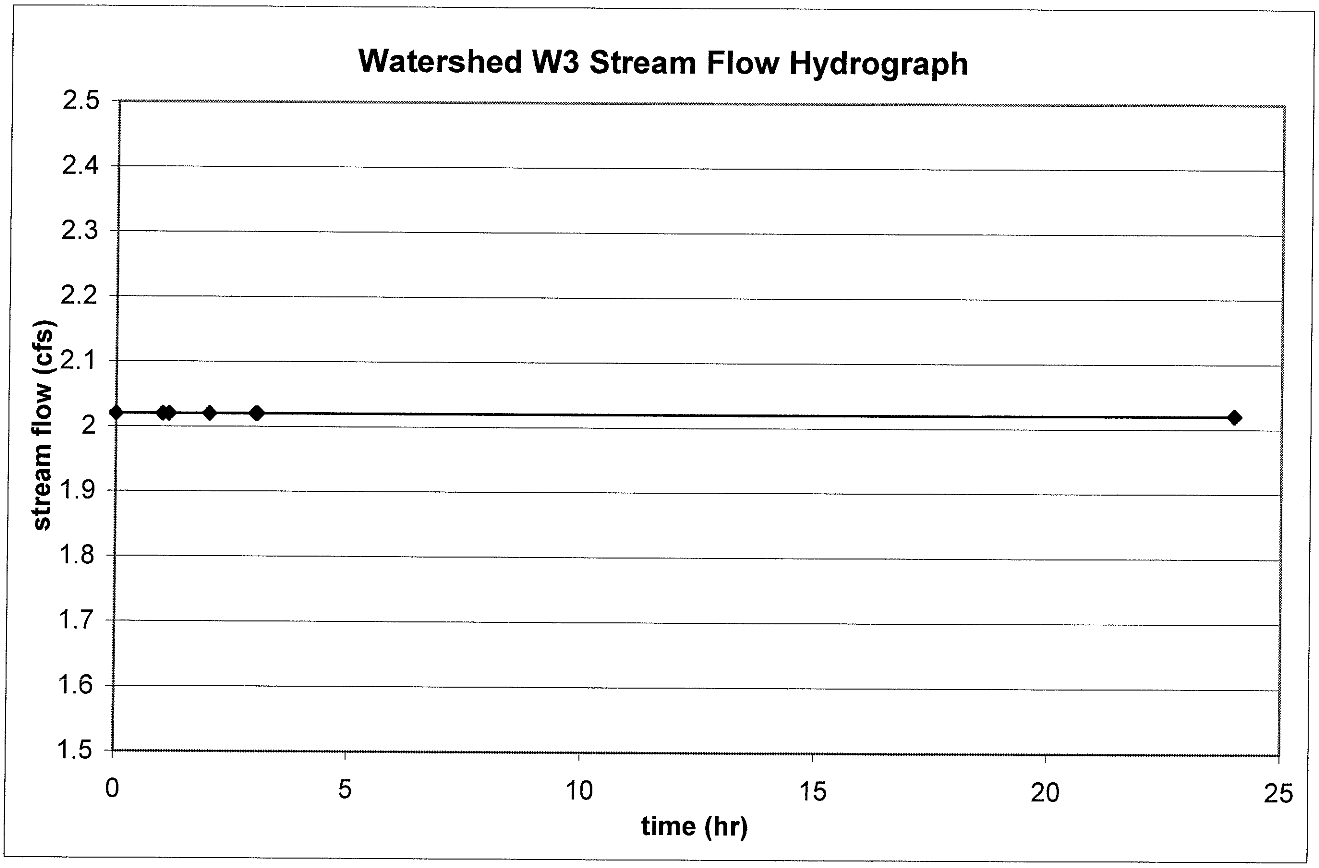
Time (hr)	Unit Hydrograph (cfs)	Storm Hydrograph (cfs)	Stream Hydrograph (cfs)
0	0.00	0	4.13
1	967.86	0	4.13
1.4	1355.00	0	4.13
2	1006.07	0	4.13
3	424.53	0	4.13
3.73	0.00	0	4.13
24		0	4.13



Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed W3 Hydrograph Calculations

**There is no run off in this watershed and therefore no storm hydrograph. The stream hydrograph for for the storm is simply the base flow of the stream.*

Time (hr)	Unit Hydrograph (cfs)	Storm Hydrograph (cfs)	Stream Hydrograph (cfs)
0	0.00	0	2.02
1	723.01	0	2.02
1.13	817.00	0	2.02
2	442.90	0	2.02
3	12.90	0	2.02
3.03	0.00	0	2.02
24		0	2.02



From HERPICC Manual:

(1) $t_t = \frac{L}{3600V}$, t_t = travel time, V = velocity from Fig. 3.4.5

(2) $t_c = \Sigma t_{t_n}$, t_c = time of concentration

(3) $q_p = \frac{484 A_m Q'}{t_p}$ (4) $t_p = \frac{\Delta D}{2} + L' = \frac{\Delta D}{2} + 0.6 t_c$

t_p = time to peak, hr A_m = area, mi²

q_p = peak flow, cfs Q' = volume, in

See attached sheet for variable values

$Q' = 1''$ for unit hydrograph

Use Table 3.4.1 to determine Unit Hydrograph Coordinates

Unit Hydrograph Check

$V = A_m \times 645.33 = 59.22 \times 645.33 = 38216.44$ cfs-hr

$V_{UH} = \Delta D \sum_{i=1}^{5t_p/\Delta D} q_t = (226.8\,min)\left(\frac{18850.47\,ft^3}{s}\right)\left(\frac{hr}{60\,min}\right) = 71254.78$ cfs-hr

Try Triangular Unit Hydrograph

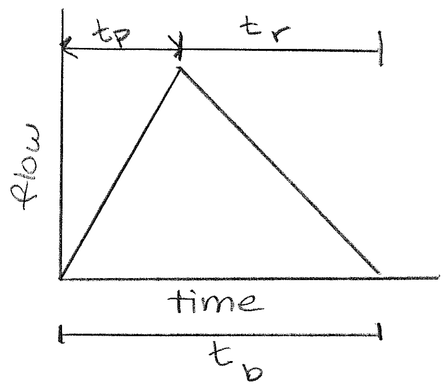
(5) $t_b = 2.67 t_p$

(6) $t_r = 1.67 t_p$

t_p = time to peak

t_b = base time

t_r = recession time



NOT TO SCALE

Unit Hydrograph Check

$V_{m6} = 38216.44$ cfs-hr

$V_{UH} = \frac{1}{2}(18.94)(1513) + \frac{1}{2}(31.63)(1513) = 38256.21$ cfs-hr

Triangular UH is an estimate. Therefore, OK.

Linear relationships since they are triangular ; $y = mx + b$

$b = 0$ since all times start at 0 for start to peak

$\therefore y = mx$

- All have 2 → one to peak, one from peak to end

E1

$m_1 = \frac{1932-0}{3.09-0} = 625.243$; $y = 625.243x$

$m_2 = \frac{0-1932}{8.25-3.09} = -374.4186$; $y = -374.4186x + b$; $y = -374.42x + 3088.95$

$0 = -374.4186(8.25) + b$

$b = 3088.95$

E2

$m_1 = \frac{1941-0}{4.11-0} = 472.2628$, $y = 472.2628x$

$m_2 = \frac{0-1941}{10.97-4.11} = -282.945$, $y = -282.945x + b$; $y = -282.945x + 3103.907$

$0 = -282.94(10.97) + b$

$b = 3103.907$

E3

$m_1 = \frac{1797-0}{5.19-0} = 346.2428$; $y = 346.2428x$

$m_2 = \frac{0-1797}{13.87-5.19} = -207.0276$; $y = -207.0276x + b$; $y = -207.0276x + 2871.4728$

$0 = -207.0276(13.87) + b$

$b = 2871.4728$

W1

$m_1 = \frac{755-0}{9.14-0} = 82.6039$; $y = 82.6039x$

$m_2 = \frac{0-755}{24.41-9.14} = -49.4434$; $y = -49.4434x + b$; $y = -49.4434x + 1206.9134$

$0 = -49.4434(24.41) + b$

$b = 1206.9134$

W2

$m_1 = \frac{1355-0}{1.4-0} = 967.8571$; $y = 967.8571x$

$m_2 = \frac{0-1355}{3.73-1.4} = -581.5451$; $y = -581.5451x + b$; $y = -581.5451x + 2169.1632$

$0 = -581.5451(3.73) + b$

$b = 2169.1632$

AMERICAN CONSULTING, INC.

BY KEG DATE 7-12-06 SUBJECT Unit Hydrograph Equation SHEET NO. 3 OF 4

CHKD. BY .... DATE .... JOB NO. IN2004038S

W3

$m_1 = \frac{817-0}{1.13-0} = 723.0088$; $y = 723.0088$

$m_2 = \frac{0-817}{3.03-1.13} = -430$; $y = -430x + b$; $y = -430x + 1302.9$

$0 = -430(3.03) + b$

$b = 1302.9$

M1

$m_1 = \frac{3020-0}{7.36-0} = 410.3261$; $y = 410.3261x$

$m_2 = \frac{0-3020}{19.66-7.36} = -245.5285$; $y = -245.5285x + b$; $y = -245.5285x + 4827.0903$

$0 = -245.5285(19.66) + b$

$b = 4827.0903$

M2

$m_1 = \frac{2337-0}{11.37-0} = 205.5409$; $y = 205.5409x$

$m_2 = \frac{0-2337}{30.37-11.37} = -123$; $y = -123x + b$; $y = -123x + 3735.51$

$0 = -123(30.37) + b$

$b = 3735.51$

M3

$m_1 = \frac{1694-0}{16.36-0} = 103.5452$; $y = 103.5452x$

$m_2 = \frac{0-1694}{43.68-16.36} = -62.0059$; $y = -62.0059x + b$; $y = -62.0059x + 2708.4177$

$0 = -62.0059(43.68) + b$

$b = 2708.4177$

M4

$m_1 = \frac{1628-0}{17.10-0} = 95.2047$; $y = 95.2047x$

$m_2 = \frac{0-1628}{45.65-17.10} = -57.0228$; $y = -57.0228x + b$; $y = -57.0228x + 2603.0908$

$0 = -57.0228(45.65) + b$

$b = 2603.0908$

m5

$$m_1 = \frac{1584-0}{17.71-0} = 89.441 \; ; \quad y = 89.441x$$

$$m_2 = \frac{0-1584}{47.29-17.71} = -53.5497 \; ; \quad y = -53.5497x + b \; ; \quad y = -53.5497x + 2532.3653$$

$$0 = -53.5497(47.29) + b$$

$$b = 2532.3653$$

m6

$$m_1 = \frac{1513-0}{18.94-0} = 79.8838 \; ; \quad y = 79.8838x$$

$$m_2 = \frac{0-1513}{50.58-18.94} = -47.8192 \; ; \quad y = -47.8192x + b \; ; \quad y = -47.8192x + 2418.6951$$

$$0 = -47.8192(50.58) + b$$

$$b = 2418.6951$$

AMERICAN CONSULTING, INC.

BY: KEG DATE 7-13-06 SUBJECT Trail Creek Watershed Sample Calculations SHEET NO. 1 OF 3

CHKD. BY........ DATE .... JOB NO. IN20040385

1. File: P:/IN2004/0385/C. Calcs _ Data/Studies and Background information/Drainage Calcs/Land Use For Drainage Calcs Hayley Calcs. xls

Land Use Type – from ArcView Data

Acres – Acres of each land use in the given watershed calculated in ArcView

A, B, C, D – Curve numbers for each soil type A-D based on the land use designation. Assumptions for each land use based on attached Table 3.3.3 from the HERPICC manual are shown at the bottom of the page.

2. File: P:/IN2004/0385/C. Calcs _ Data/Studies and background information/Drainage Calcs/Soil Types. xls

Map Symbol – from ArcView Data

Total Acres – Acres of each soil in the given watershed calculated in ArcView

Type – Soil classification A-D

Acres – Sum of acreage of each soil type A-D in the watershed

3. File: P/IN2004/0385/C. Calcs _ Data/Studies and background information/Base + Peak Flows. xls

Values were obtained from other spreadsheet files. No calculations performed on this sheet.

4. File: P/IN2004/0385/C. Calcs _ Data/Studies and background information/Drainage Calcs/Base Flow Estimates. xls

$$\text{Area (mi}^2) = \text{Area (ac)} \times \frac{43560\text{ ft}^2}{\text{ac}} \times \left(\frac{\text{mi}}{5280\text{ ft}}\right)^2$$

$$= (7893.62\text{ ac})\left(\frac{43560\text{ ft}^2}{\text{ac}}\right)\left(\frac{\text{mi}}{5280\text{ ft}}\right)^2 = 12.33\text{ mi}^2$$

$$\text{Annual Runoff (ft}^3) = 18.85'' \times \text{Area (mi}^2) \times \frac{1\text{ ft}}{12''} \times \left(\frac{5280\text{ ft}}{\text{mi}}\right)^2$$

$$= (18.85'')(12.33\text{ mi}^2)\left(\frac{1\text{ ft}}{12''}\right)\left(\frac{5280\text{ ft}}{\text{mi}}\right)^2 = 540{,}125{,}088\text{ ft}^3$$

- 18.85" is the annual runoff in Michigan City and was assumed to apply to the entire Trail Creek Watershed

$$\text{Annual Flow (cfs)} = \frac{\text{Annual Runoff (ft}^3)}{31{,}536{,}000\text{ s}} = 17.13\text{ cfs}$$

- There are 31,536,000 s in 1 year

Base Flow = 0.76 x Annual Flow

= 0.76 (17.13)

= 13.02 cfs

5. File: P/IN2004/0385/C. Calcs_Data/Studies and background information/Drainage Calcs/Hydrograph Calculations.xls

Sheet: Hydrograph Calculations

Travel Length - measured in ArcView
Beginning/Ending Elevation - identified in ArcView

$$\text{Slope} = \frac{\text{Beginning Elev} - \text{Ending Elev}}{\text{Travel Length}}$$

$$= \frac{905-630}{26706} = 0.010$$

Velocity - read off of figure 3.4.5 from HERPICC manual. Figure attached.

Area (mi²) - calculated under Base Flow Estimates file

$$\text{Time of Concentration} = \frac{L}{3600V} = \frac{26706\text{ft}}{(3600)(1.6\text{ft/s})} = 4.64\text{ hr}$$

$$\Delta D = 0.133 t_c = (0.133)(4.64\text{ hr}) = 0.62\text{ hr}$$

$$\text{Time to Peak} = \frac{\Delta D}{2} + 0.6t_c = \frac{0.62}{2} + 0.6(4.64) = 3.09\text{ hr}$$

$$\text{Peak flow} = 484 \times A_m \times \frac{Q'}{t_p} = \frac{(484)(12.33)(1'')}{3.09} = 1932\text{ cfs}$$

$$\text{Base time} = 2.67t_p = 2.67(3.09) = 8.25\text{ hr}$$

$$\text{Recession time} = 1.67t_p = 1.67(3.09) = 5.16\text{ hr}$$

$Q' = 1''$ (rainfall depth for unit hydrograph)

Sheet: Triangular Unit Hydrograph Calculations

t_p, q_p, t_p, t_r - from previous spreadsheet
Unit Hydrograph E1 - graph points at $t=0$, $t=t_p$, & $t=t_b$ to form triangular unit hydrograph. Slope calculation for each line are attached.

Sheet: SCS Type II Distribution

Time/Total Time - ratio from attached Soil Conservation Service Type II Storm Distribution sheet

Time (hr) - (24 hr)(Time/Total Time) = (24)(0.040) = 0.96 hr

- Looking at 7yr, 24hr storm → duration is 24 hr

Rainfall/Total Rainfall - ratio from same sheet as Time/Total Time

Cummulative Depth (in) = (2.148'')(Rainfall/Total Rainfall)
= (2.148)(0.010) = 0.021''

- 2.148'' & S values are from separate rainfall calculations

Cummulative Runoff = 0 if P(t) < 0.2S (P(t) = Cummulative Depth)

$$= \frac{(P(t) - 0.2S)^2}{(P(t) + 0.8S)}$$

$$= \frac{(1.654 - 0.2(8.07))^2}{1.654 + 0.8(8.07)} = 0.0002''$$

Incremental Runoff = Cummulative Runoff$_n$ − Cummulative Runoff$_{n-1}$
= 0.0005 − 0.0002 = 0.0003″

Sheets: Watershed XX Hydrograph Calculations

- see attached sheet for colum explanations. Sample calcs shown here

Row: Time = 2.4 hr

Unit Hydrograph = 1500.58 cfs

(0.0005)(1125.44) = 0.563
(0.0034)(375.15) = 1.275

Storm Hydrograph = 0. + 0.563 + 1.275 + 0 = 1.838 cfs

Stream Flow Hydrograph = Storm Hydrograph + Base Flow
= 1.838 + 13.020 = 14.858 cfs

Trail Creek Watershed Study
REVISED Calculated Flows
IN20040385
July 19, 2006

**Watershed	Base Flow (cfs)		Peak Flow (cfs)		*With WWTP Flows (cfs) Base Flow (cfs)		*With WWTP Flows (cfs) Peak Flow (cfs)	
	Original	Revised	Original	Revised	Original	Revised	Original	Revised
E1	13.02	----	39.68	----	----	----	----	----
E2	17.39	----	38.17	----	----	----	----	----
E3	20.35	----	37.50	----	----	----	----	----
W1	15.05	----	104.73	----	----	----	----	----
W2	4.13	----	4.13	----	----	----	----	----
W3	2.02	----	2.02	----	----	----	----	----
M1	48.49	----	139.29	----	----	----	----	----
M2	57.95	57.94	151.59	184.07	----	----	----	----
M3	60.43	60.42	127.87	165.28	----	----	----	----
M4	60.71	60.70	125.97	164.24	----	----	----	----
M5	61.18	62.17	126.35	169.71	72.01	73.00	144.92	188.28
M6	62.50	62.53	141.06	181.22	73.33	73.36	159.63	199.79

*WWTP located between M4 and M5. Average daily flow is +/- 7 MGD (10.83 cfs) and peak wet weather flows are +/- 12 MGD (18.57 cfs).
Equations for Stream Flow when WWTP flow is added:

Base Flow + 10.83 cfs = Base Stream Flow w/WWTP cfs
Peak Flow + 18.57 cfs = Peak Stream Flow w/WWTP cfs

**Only flows for Watersheds M2, M3, M4, M5, & M6 have been revised. Base flow changed +/- 0.01 cfs with the exception of M5, which cahnged 1 cfs. Peak flow changed +/- 40 cfs.

Change in flows due to July 18, 2006 revisions (Revised - Original = Change in Flow, cfs)

Watershed	Base Δ	Peak Δ
M2	-0.01	32.48
M3	-0.01	37.41
M4	-0.01	38.27
M5	0.99	43.36
M6	0.03	40.16

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M2 - Watershed M1
Curve Number & Runoff Check for Michigan City

Acres of Each Soil Type in Watershed

A	B	C	D	Null
1114.31	1537.21	1480.24	86.94	1513.62

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M2-M1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	740.57	12.92%	143.93	198.56	191.20	11.23
Developed Agriculture Row Crop	798.92	13.93%	155.27	214.20	206.26	12.11
Developed Non-Vegetated	142.71	2.49%	27.74	38.26	36.84	2.16
Developed Urban High Density	465.32	8.12%	90.44	124.76	120.14	7.06
Developed Urban Low Density	904.11	15.77%	175.72	242.41	233.42	13.71
Palustrine Forest Deciduous	535.97	9.35%	104.17	143.70	138.38	8.13
Palustrine Herbaceous Deciduous	16.29	0.28%	3.17	4.37	4.21	0.25
Palustrine Shrubland Deciduous	0.00	0.00%	0.00	0.00	0.00	0.00
Terrestrial Forest Deciduous	1890.75	32.98%	367.47	506.94	488.15	28.67
Terrestrial Forest Evergreen	0.07	0.00%	0.01	0.02	0.02	0.00
Terrestrial Forest Mixed	2.87	0.05%	0.56	0.77	0.74	0.04
Terrestrial Shrubland Deciduous	93.19	1.63%	18.11	24.99	24.06	1.41
Terrestrial Woodland Deciduous	118.11	2.06%	22.95	31.67	30.49	1.79
Unclassified Cloud/Shadow	0.00	0.00%	0.00	0.00	0.00	0.00
Water	24.52	0.43%	4.77	6.57	6.33	0.37
TOTAL	5733.41	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	7052.71	13700.50	15104.74	943.31	36801.25
Developed Agriculture Row Crop	7608.40	14779.96	16294.85	1017.63	39700.84
Developed Non-Vegetated	2468.53	3520.17	3463.40	205.58	9657.67
Developed Urban High Density	8048.88	11477.84	11292.74	670.32	31489.77
Developed Urban Low Density	8961.62	16483.61	18440.37	1151.62	45037.22
Palustrine Forest Deciduous	2604.20	7903.59	9686.31	625.80	20819.90
Palustrine Herbaceous Deciduous	79.17	240.27	294.47	19.02	632.93
Palustrine Shrubland Deciduous	0.00	0.00	0.00	0.00	0.00
Terrestrial Forest Deciduous	9186.87	27881.58	34170.53	2207.66	73446.63
Terrestrial Forest Evergreen	0.33	0.99	1.22	0.08	2.61
Terrestrial Forest Mixed	25.11	50.80	57.07	3.61	136.60
Terrestrial Shrubland Deciduous	543.35	1449.16	1708.22	110.22	3810.95
Terrestrial Woodland Deciduous	573.86	1741.63	2134.47	137.90	4587.87
Unclassified Cloud/Shadow	0.00	0.00	0.00	0.00	0.00
Water	343.14	539.12	550.79	33.09	1466.15

Total Sum:	267590.40
Total Acres:	4219.79
Composite Number:	63.41
Flow Rate (cfs):	

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M2 - Watershed M1
Curve Number & Runoff Check for Michigan City

Base Flow

Watershed	Area (ac)	Area (mi^2)	Annual Runoff (ft^3)	Annual Flow (cfs)	Base Flow (cfs)
M5-M1	5733.41	8.96	392,311,699	12.44	9.45

Hydrograph Calculations

Watershed	Travel Length, L (ft)	Beginning Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	*Velocity, v (ft/s)	Area, A_m (mi^2)	Time of Concentr-ation, t_c (hr)	ΔD (hr)	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M2-M1	24,100	695	590	0.004	0.8	8.96	8.37	1.11	5.58	777	14.89	9.31

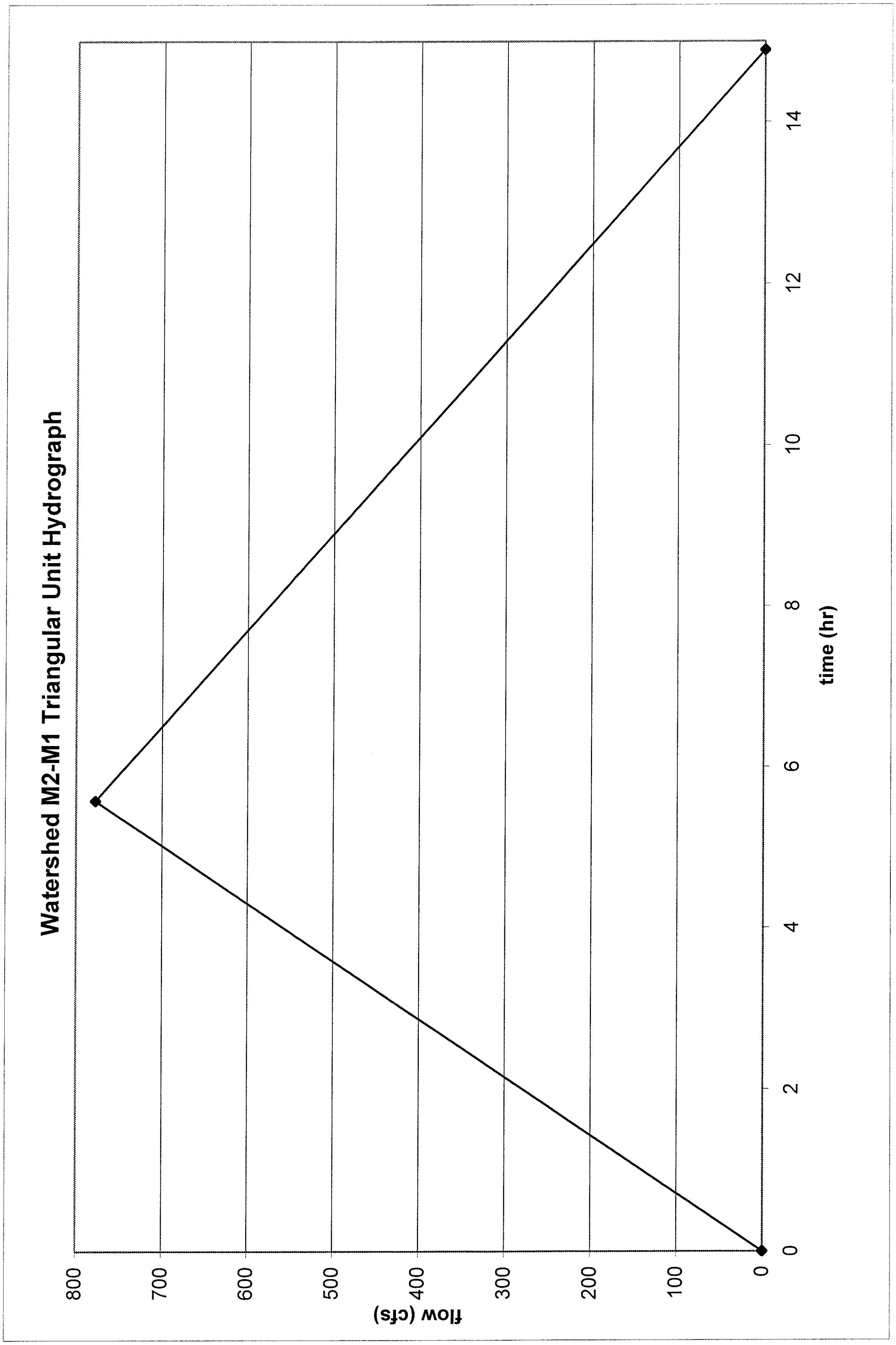
*Any watershed with a slop less than 0.005 has a velocity less than 1 ft/s. It was assumed that slope = 0.004 has a velocity of 0.8 ft/s and slope = 0.002 has a velocity of 0.5 ft/s.

Unit Hydrograph Calculations

Watershed	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M2-M1	5.58	777	14.89	9.31

Watershed M2-M1

Time (hr)	Flow (cfs)
0	0
5.58	777
14.89	0



Watershed M2-M1 Triangular Unit Hydrograph
flow (cfs)
0
100
200
300
400
500
600
700
800
time (hr)
0
2
4
6
8
10
12
14

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M2 - Watershed M1
SCS Type II Distribution

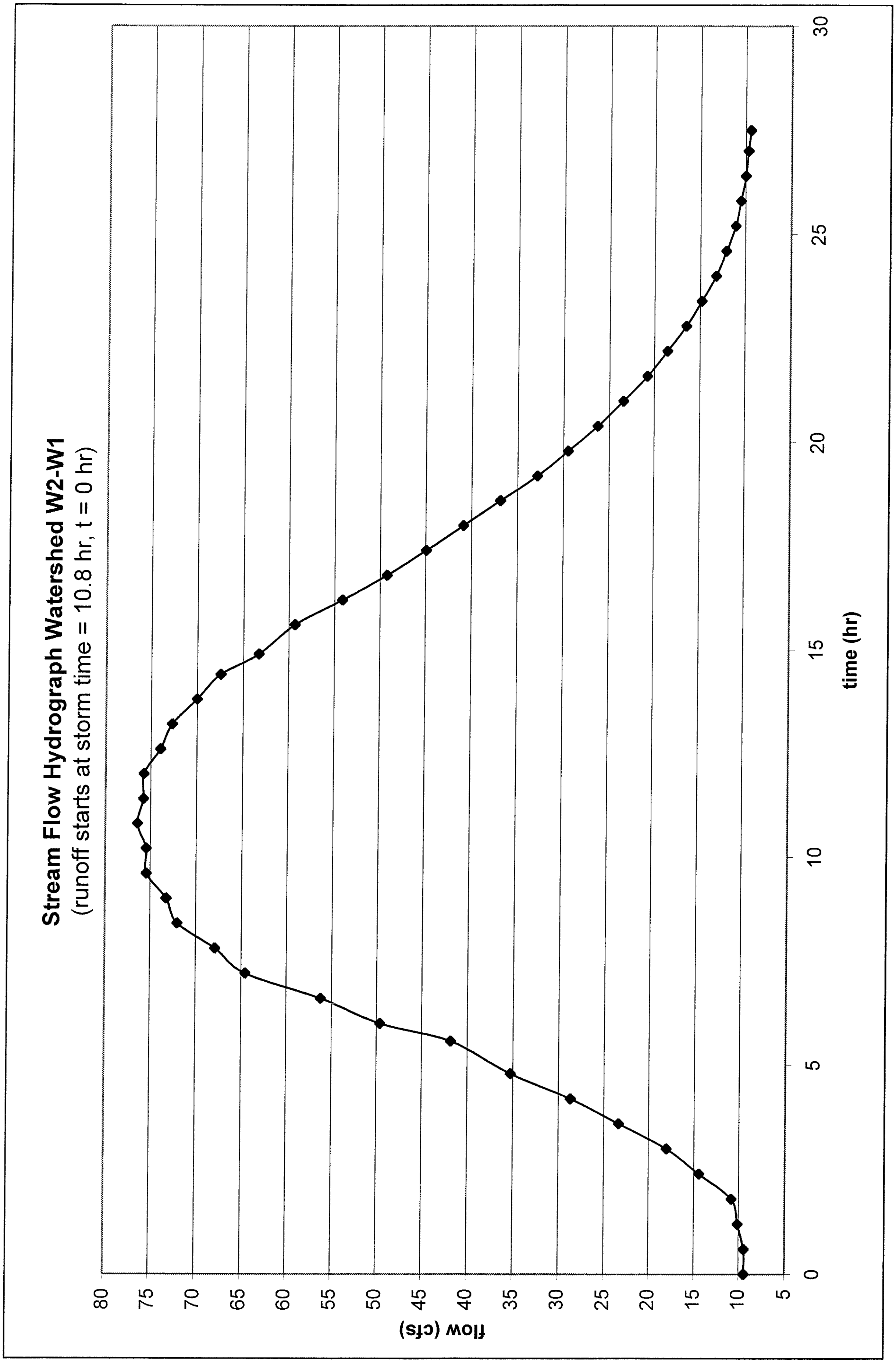
Watershed M2-M1, S = 5.77, 0.2S = 1.154

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0.0081	0.0081
0.520	12.48	0.730	1.568	0.0277	0.0196
0.530	12.72	0.750	1.611	0.0335	0.0058
0.540	12.96	0.770	1.654	0.0399	0.0063
0.550	13.20	0.780	1.675	0.0432	0.0034
0.560	13.44	0.800	1.718	0.0503	0.0071
0.570	13.68	0.810	1.740	0.0540	0.0037
0.580	13.92	0.820	1.761	0.0578	0.0038
0.600	14.40	0.835	1.794	0.0638	0.0060
0.630	15.12	0.860	1.847	0.0744	0.0105
0.650	15.60	0.870	1.869	0.0788	0.0044
0.670	16.08	0.880	1.890	0.0833	0.0045
0.700	16.80	0.895	1.922	0.0903	0.0070
0.720	17.28	0.910	1.955	0.0976	0.0073
0.750	18.00	0.920	1.976	0.1025	0.0050
0.770	18.48	0.930	1.998	0.1076	0.0051
0.800	19.20	0.940	2.019	0.1128	0.0052
0.830	19.92	0.950	2.041	0.1181	0.0053
0.850	20.40	0.960	2.062	0.1235	0.0054
0.870	20.88	0.970	2.084	0.1290	0.0055
0.900	21.60	0.980	2.105	0.1346	0.0056
0.950	22.80	0.990	2.127	0.1403	0.0057
1.000	24.00	1.000	2.148	0.1461	0.0058

Trail Creek Watershed Study
July 18, 2006
IN20040385
Watershed M2-M1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 10.8 hr)												Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0 0	1.2 0.0081	2.4 0.0351	3.6 0.0206	4.8 0.015	6 0.0115	7.2 0.0122	8.4 0.0103	9.6 0.0107	10.8 0.0111	12 0.0057	13.2 0.0058		
0	0.00	0.000												0.000	9.450
0.6	83.55	0.000	0.000											0.000	9.450
1.2	167.10	0.000	0.677	0.000										0.677	10.127
1.8	250.65	0.000	1.353	0.000										1.353	10.803
2.4	334.19	0.000	2.030	2.933	0.000									4.963	14.413
3.0	417.74	0.000	2.707	5.865	0.000									8.572	18.022
3.6	501.29	0.000	3.384	8.798	1.721	0.000								13.902	23.352
4.2	584.84	0.000	4.060	11.730	3.442	0.000								19.233	28.683
4.8	668.39	0.000	4.737	14.663	5.163	1.253	0.000							25.816	35.266
5.58	777.00	0.000	5.414	17.595	6.884	2.506	0.000							32.400	41.850
6.0	741.95	0.000	6.294	20.528	8.605	3.760	0.961	0.000						40.148	49.598
6.6	691.87	0.000	6.010	23.460	10.327	5.013	1.922	0.000						46.731	56.181
7.2	641.80	0.000	5.604	27.273	12.048	6.266	2.882	1.019	0.000					55.092	64.542
7.8	591.72	0.000	5.199	26.042	13.769	7.519	3.843	2.039	0.000					58.411	67.861
8.4	541.65	0.000	4.793	24.285	16.006	8.773	4.804	3.058	0.861	0.000				62.579	72.029
9.0	491.57	0.000	4.387	22.527	15.284	10.026	5.765	4.077	1.721	0.000				63.787	73.237
9.6	441.50	0.000	3.982	20.769	14.253	11.655	6.726	5.096	2.582	0.894	0.000			65.956	75.406
10.2	391.42	0.000	3.576	19.012	13.221	11.129	7.686	6.116	3.442	1.788	0.000			65.970	75.420
10.8	341.35	0.000	3.171	17.254	12.189	10.378	8.935	7.135	4.303	2.682	0.927	0.000		66.975	76.425
11.4	291.27	0.000	2.765	15.497	11.158	9.627	8.532	8.154	5.163	3.576	1.855	0.000		66.327	75.777
12.0	241.20	0.000	2.359	13.739	10.126	8.876	7.957	9.479	6.024	4.470	2.782	0.476	0.000	66.288	75.738
12.6	191.12	0.000	1.954	11.981	9.095	8.125	7.381	9.052	6.884	5.364	3.710	0.952	0.000	64.497	73.947
13.2	141.05	0.000	1.548	10.224	8.063	7.374	6.805	8.441	8.003	6.258	4.637	1.429	0.485	63.265	72.715
13.8	90.97	0.000	1.142	8.466	7.032	6.622	6.229	7.830	7.642	7.152	5.564	1.905	0.969	60.554	70.004
14.4	40.89	0.000	0.737	6.708	6.000	5.871	5.653	7.219	7.126	8.314	6.492	2.381	1.454	57.955	67.405
14.89	0.00	0.000	0.331	4.951	4.969	5.120	5.077	6.608	6.611	7.939	7.419	2.857	1.938	53.820	63.270
15.6			0.000	3.193	3.937	4.369	4.501	5.997	6.095	7.403	8.625	3.334	2.423	49.877	59.327
16.2			0.000	1.435	2.906	3.618	3.925	5.386	5.579	6.867	8.236	3.810	2.907	44.670	54.120
16.8				0.000	1.874	2.867	3.350	4.775	5.063	6.331	7.680	4.429	3.392	39.761	49.211

17.4				0.000	0.842	2.116	2.774	4.164	4.547	5.796	7.124	4.229	3.877	35.469	44.919
18.0					0.000	1.365	2.198	3.554	4.032	5.260	6.568	3.944	4.507	31.426	40.876
18.6					0.000	0.613	1.622	2.943	3.516	4.724	6.012	3.658	4.303	27.392	36.842
19.2						0.000	1.046	2.332	3.000	4.188	5.456	3.373	4.013	23.408	32.858
19.8						0.000	0.470	1.721	2.484	3.652	4.901	3.087	3.722	20.038	29.488
20.4							0.000	1.110	1.969	3.117	4.345	2.802	3.432	16.774	26.224
21.0							0.000	0.499	1.453	2.581	3.789	2.517	3.142	13.979	23.429
21.6								0.000	0.937	2.045	3.233	2.231	2.851	11.297	20.747
22.2								0.000	0.421	1.509	2.677	1.946	2.561	9.114	18.564
22.8									0.000	0.973	2.121	1.660	2.270	7.025	16.475
23.4									0.000	0.438	1.566	1.375	1.980	5.358	14.808
24.0										0.000	1.010	1.089	1.689	3.789	13.239
24.6										0.000	0.454	0.804	1.399	2.657	12.107
25.2											0.000	0.519	1.108	1.627	11.077
25.8											0.000	0.233	0.818	1.051	10.501
26.4												0.000	0.528	0.528	9.978
27.0												0.000	0.237	0.237	9.687
27.49													0.000	0.000	9.450
													SUM =	**1410.750**	**1854.900**

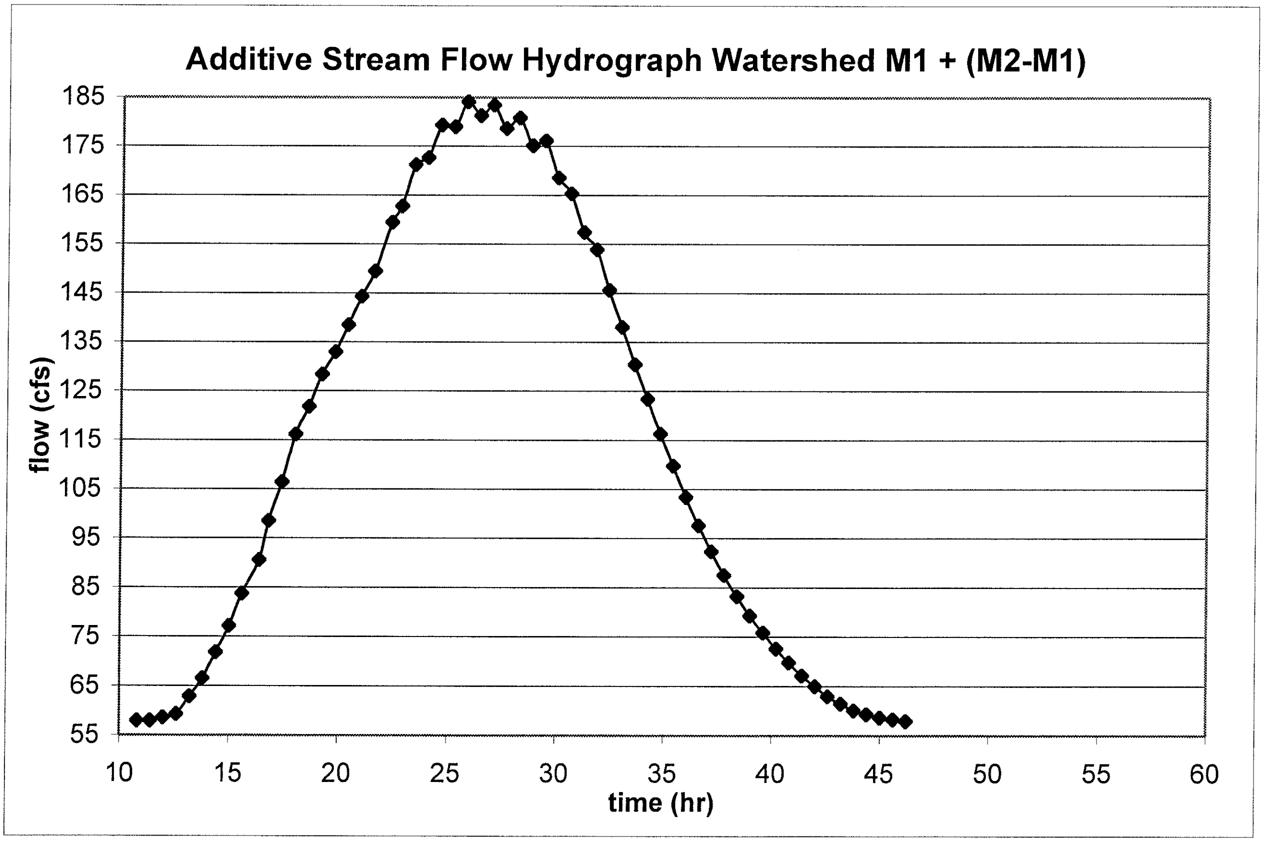


Stream Flow Hydrograph Watershed W2-W1
(runoff starts at storm time = 10.8 hr, t = 0 hr)
flow (cfs)
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
time (hr)
0
5
10
15
20
25
30

Trail Creek Watershed Study
Additive Stream Flow Hydrograph
Watershed M1 + (M2-M1)
July 18, 2006
IN20040385

Storm Time (hr)	M1 Time (hr)	M1 Time Actual (hr)	Stream Flow from M1 (cfs)	M2-M1 Time (hr)	Stream Flow M2-M1 (cfs)	Sum (cfs) M1 + (M2-M1)
10.8	0		48.490	0	9.450	57.940
11.4	0		48.490	0.6	9.450	57.940
12.0	0		48.490	1.2	10.127	58.617
12.6	0.6		48.490	1.8	10.803	59.293
13.2	1.2		48.490	2.4	14.413	62.903
13.8	1.8		48.490	3.0	18.022	66.512
14.4	2.4		48.490	3.6	23.352	71.842
15.0	3.0	0.0	48.490	4.2	28.683	77.173
15.6	3.6	0.6	48.490	4.8	35.266	83.756
16.2	4.2	1.2	48.736			
16.38	4.38			5.58	41.850	90.586
16.8	4.8	1.8	48.982	6.0	49.598	98.580
17.4	5.4	2.4	50.287	6.6	56.181	106.468
18.0	6.0	3.0	51.592	7.2	64.542	116.134
18.6	6.6	3.6	53.980	7.8	67.861	121.841
19.2	7.2	4.2	56.368	8.4	72.029	128.397
19.8	7.8	4.8	59.741	9.0	73.237	132.979
20.4	8.4	5.4	63.114	9.6	75.406	138.520
21.0	9.0	6.0	68.905	10.2	75.420	144.325
21.6	9.6	6.6	73.017	10.8	76.425	149.442
22.2	10.2	7.2		11.4	75.777	
22.36	10.36	7.36	83.666	11.56		159.442
22.8	10.8	7.8	87.055	12.0	75.738	162.794
23.4	11.4	8.4	97.312	12.6	73.947	171.260
24.0	12.0	9.0	99.974	13.2	72.715	172.689
24.6	12.6	9.6	109.321	13.8	70.004	179.325
25.2	13.2	10.2	111.611	14.4	67.405	179.016
25.69	13.69			14.89	63.270	
25.8	13.8	10.8	120.799	15.0		184.070
26.4	14.4	11.4	121.935	15.6	59.327	181.261
27.0	15.0	12.0	129.320	16.2	54.120	183.439
27.6	15.6	12.6	129.483	16.8	49.211	178.694
28.2	16.2	13.2	135.920	17.4	44.919	180.839
28.8	16.8	13.8	134.293	18.0	40.876	175.169
29.4	17.4	14.4	139.286	18.6	36.842	176.128
30.0	18.0	15.0	135.711	19.2	32.858	168.569
30.6	18.6	15.6	135.840	19.8	29.488	165.328
31.2	19.2	16.2	131.229	20.4	26.224	157.453
31.8	19.8	16.8	130.475	21.0	23.429	153.904
32.4	20.4	17.4	124.893	21.6	20.747	145.640
33.0	21.0	18.0	119.515	22.2	18.564	138.079
33.6	21.6	18.6	113.928	22.8	16.475	130.404
34.2	22.2	19.2	108.554	23.4	14.808	123.362
34.66	22.66	19.66	103.074	23.86		

34.8	22.8			24.0	13.239	116.312
35.4	23.4	20.4	97.628	24.6	12.107	109.735
36.0	24.0	21.0	92.295	25.2	11.077	103.372
36.6	24.6	21.6	87.110	25.8	10.501	97.611
37.2	25.2	22.2	82.411	26.4	9.978	92.388
37.8	25.8	22.8	77.863	27.0	9.687	87.550
38.4	26.4	23.4	73.811	27.49	9.450	83.261
39.0	27.0	24.0	69.898	27.49	9.450	79.348
39.6	27.6	24.6	66.436	27.49	9.450	75.886
40.2	28.2	25.2	63.132	27.49	9.450	72.582
40.8	28.8	25.8	60.348	27.49	9.450	69.798
41.4	29.4	26.4	57.704	27.49	9.450	67.154
42.0	30.0	27.0	55.524	27.49	9.450	64.974
42.6	30.6	27.6	53.502	27.49	9.450	62.952
43.2	31.2	28.2	51.999	27.49	9.450	61.449
43.8	31.8	28.8	50.665	27.49	9.450	60.115
44.4	32.4	29.4	49.884	27.49	9.450	59.334
45.0	33.0	30.0	49.193	27.49	9.450	58.643
45.6	33.6	30.6	48.795	27.49	9.450	58.245
46.2	34.2	31.2	48.490	27.49	9.450	57.940



Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M3 - Watershed M1
Curve Number & Runoff Check for Michigan City

Acres of Each Soil Type in Watershed

A	B	C	D	Null
1861.33	1991.41	1539.33	113.3	1731.32

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M3-M1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	887.72	12.27%	228.31	244.27	188.81	13.90
Developed Agriculture Row Crop	1044.14	14.43%	268.54	287.30	222.08	16.35
Developed Non-Vegetated	161.44	2.23%	41.52	44.42	34.34	2.53
Developed Urban High Density	535.32	7.40%	137.68	147.30	113.86	8.38
Developed Urban Low Density	976.98	13.50%	251.27	268.83	207.80	15.29
Palustrine Forest Deciduous	762.13	10.53%	196.01	209.71	162.10	11.93
Palustrine Herbaceous Deciduous	17.12	0.24%	4.40	4.71	3.64	0.27
Palustrine Shrubland Deciduous	0.00	0.00%	0.00	0.00	0.00	0.00
Terrestrial Forest Deciduous	2603.87	35.98%	669.68	716.48	553.83	40.76
Terrestrial Forest Evergreen	0.02	0.00%	0.01	0.01	0.01	0.00
Terrestrial Forest Mixed	2.94	0.04%	0.76	0.81	0.63	0.05
Terrestrial Shrubland Deciduous	97.53	1.35%	25.08	26.84	20.74	1.53
Terrestrial Woodland Deciduous	123.96	1.71%	31.88	34.11	26.37	1.94
Unclassified Cloud/Shadow	0.00	0.00%	0.00	0.00	0.00	0.00
Water	24.11	0.33%	6.20	6.63	5.13	0.38
TOTAL	7237.28	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	11187.22	16854.37	14916.31	1167.38	44125.28
Developed Agriculture Row Crop	13158.34	19824.01	17544.48	1373.06	51899.90
Developed Non-Vegetated	3695.21	4086.72	3227.64	240.09	11249.67
Developed Urban High Density	12253.21	13551.43	10702.77	796.14	37303.54
Developed Urban Low Density	12814.58	18280.18	16416.09	1284.75	48795.62
Palustrine Forest Deciduous	4900.25	11533.95	11347.09	918.70	28700.00
Palustrine Herbaceous Deciduous	110.06	259.05	254.85	20.63	644.60
Palustrine Shrubland Deciduous	0.00	0.00	0.00	0.00	0.00
Terrestrial Forest Deciduous	16741.97	39406.39	38767.97	3138.80	98055.13
Terrestrial Forest Evergreen	0.16	0.37	0.37	0.03	0.93
Terrestrial Forest Mixed	34.03	53.40	48.16	3.82	139.42
Terrestrial Shrubland Deciduous	752.51	1556.53	1472.85	119.10	3900.99
Terrestrial Woodland Deciduous	797.04	1876.04	1845.65	149.43	4668.16
Unclassified Cloud/Shadow	0.00	0.00	0.00	0.00	0.00
Water	446.42	543.96	446.11	33.59	1470.08

Total Sum:	330953.30
Total Acres:	5505.96
Composite Number:	60.11
Flow Rate (cfs):	

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M3 - Watershed M1
Curve Number & Runoff Check for Michigan City

Base Flow

Watershed	Area (ac)	Area (mi^2)	Annual Runoff (ft^3)	Annual Flow (cfs)	Base Flow (cfs)
M3-M1	7237.28	11.31	495,214,503	15.70	11.93

Hydrograph Calculations

Watershed	Travel Length, L (ft)	Beginning Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	*Velocity, v (ft/s)	Area, A_m (mi^2)	Time of Concentr-ation, t_c (hr)	ΔD (hr)	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M3-M1	33,362	695	590	0.003	0.6	11.31	15.45	2.05	10.29	532	27.49	17.19

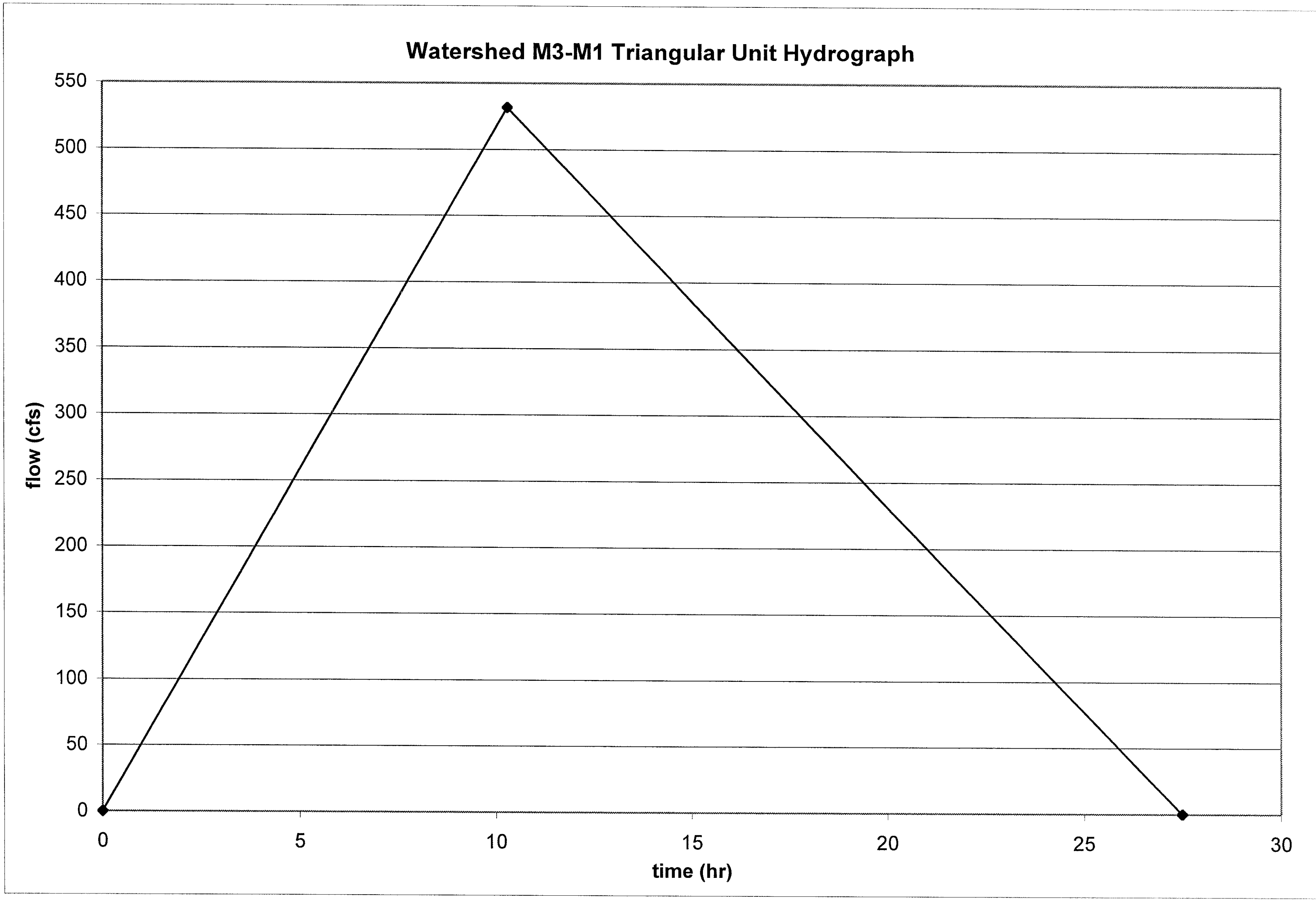
*Any watershed with a slop less than 0.005 has a velocity less than 1 ft/s. It was assumed that slope = 0.004 has a velocity of 0.8 ft/s and slope = 0.002 has a velocity of 0.5 ft/s.

Unit Hydrograph Calculations

Watershed	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M3-M1	10.29	532	27.49	17.19

Watershed M3-M1

Time (hr)	Flow (cfs)
0	0
10.29	532
27.49	0


Watershed M3-M1 Triangular Unit Hydrograph
flow (cfs)
550
500
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
time (hr)

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M3 - Watershed M1
SCS Type II Distribution

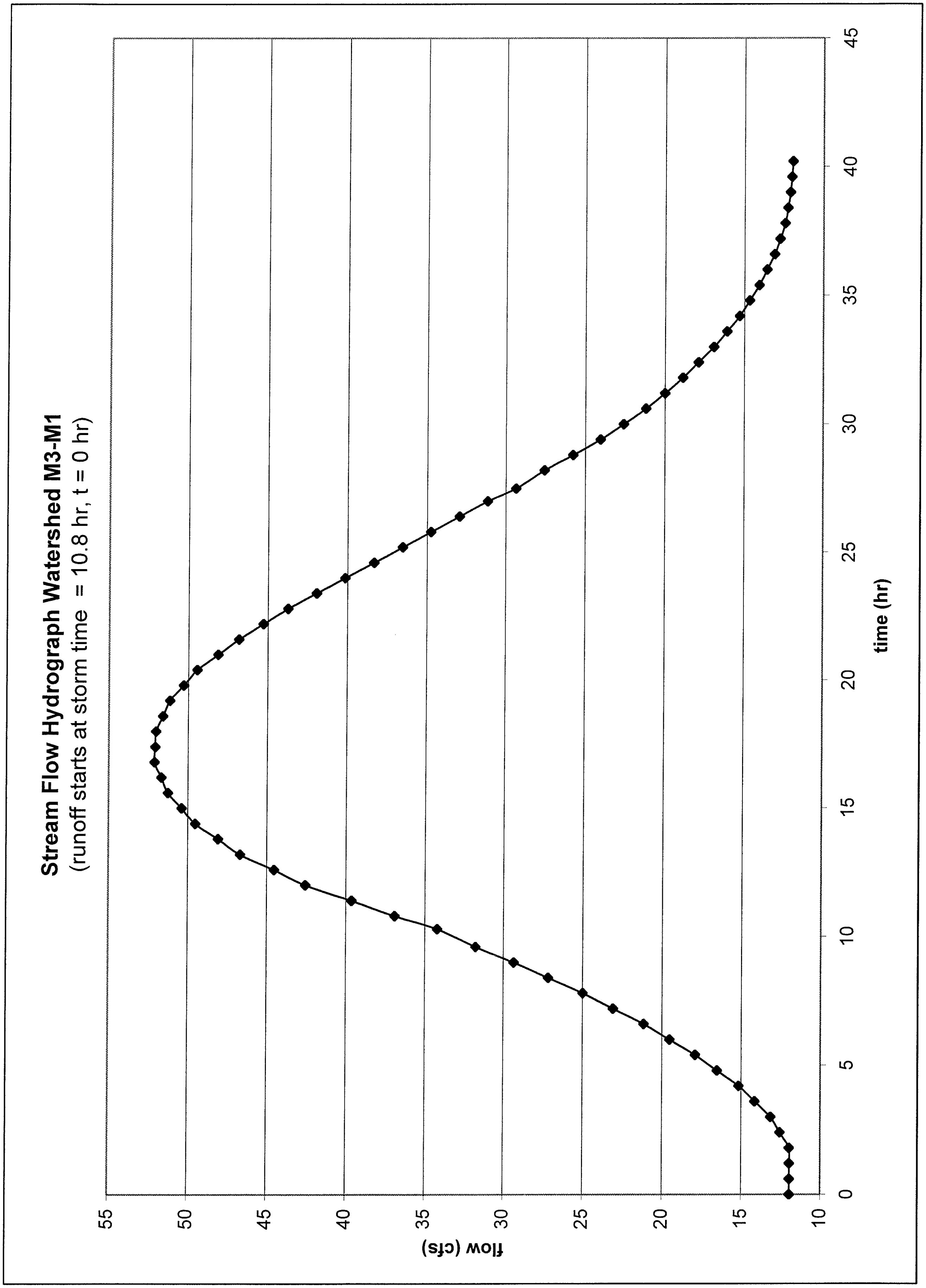
Watershed M3-M1, S = 6.64, 0.2S = 1.327

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0.0004	0.0004
0.520	12.48	0.730	1.568	0.0091	0.0087
0.530	12.72	0.750	1.611	0.0125	0.0034
0.540	12.96	0.770	1.654	0.0165	0.0040
0.550	13.20	0.780	1.675	0.0187	0.0022
0.560	13.44	0.800	1.718	0.0234	0.0047
0.570	13.68	0.810	1.740	0.0260	0.0026
0.580	13.92	0.820	1.761	0.0287	0.0027
0.600	14.40	0.835	1.794	0.0329	0.0043
0.630	15.12	0.860	1.847	0.0406	0.0077
0.650	15.60	0.870	1.869	0.0439	0.0033
0.670	16.08	0.880	1.890	0.0473	0.0034
0.700	16.80	0.895	1.922	0.0526	0.0053
0.720	17.28	0.910	1.955	0.0582	0.0056
0.750	18.00	0.920	1.976	0.0621	0.0039
0.770	18.48	0.930	1.998	0.0660	0.0040
0.800	19.20	0.940	2.019	0.0701	0.0041
0.830	19.92	0.950	2.041	0.0743	0.0042
0.850	20.40	0.960	2.062	0.0786	0.0043
0.870	20.88	0.970	2.084	0.0830	0.0044
0.900	21.60	0.980	2.105	0.0875	0.0045
0.950	22.80	0.990	2.127	0.0922	0.0046
1.000	24.00	1.000	2.148	0.0969	0.0047

Trail Creek Watershed Study
July 18, 2006
IN20040385
Watershed M3-M1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 10.8 hr)												Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8	12	13.2		
		0	0.0004	0.0183	0.0142	0.011	0.0087	0.0095	0.008	0.0085	0.0089	0.0047	0.0047		
0	0.00	0.000												0.000	11.930
0.6	31.02	0.000	0.000											0.000	11.930
1.2	62.04	0.000	0.012	0.000										0.012	11.942
1.8	93.06	0.000	0.025	0.000										0.025	11.955
2.4	124.08	0.000	0.037	0.568	0.000									0.605	12.535
3.0	155.10	0.000	0.050	1.135	0.000									1.185	13.115
3.6	186.12	0.000	0.062	1.703	0.440	0.000								2.206	14.136
4.2	217.14	0.000	0.074	2.271	0.881	0.000								3.226	15.156
4.8	248.16	0.000	0.087	2.838	1.321	0.341	0.000							4.588	16.518
5.4	279.18	0.000	0.099	3.406	1.762	0.682	0.000							5.950	17.880
6.0	310.20	0.000	0.112	3.974	2.202	1.024	0.270	0.000						7.581	19.511
6.6	341.22	0.000	0.124	4.541	2.643	1.365	0.540	0.000						9.213	21.143
7.2	372.25	0.000	0.136	5.109	3.083	1.706	0.810	0.295	0.000					11.139	23.069
7.8	403.27	0.000	0.149	5.677	3.524	2.047	1.080	0.589	0.000					13.066	24.996
8.4	434.29	0.000	0.161	6.244	3.964	2.389	1.349	0.884	0.248	0.000				15.240	27.170
9.0	465.31	0.000	0.174	6.812	4.405	2.730	1.619	1.179	0.496	0.000				17.415	29.345
9.6	496.33	0.000	0.186	7.380	4.845	3.071	1.889	1.473	0.744	0.264	0.000			19.853	31.783
10.29	532.00	0.000	0.199	7.947	5.286	3.412	2.159	1.768	0.993	0.527	0.000			22.291	34.221
10.8	516.23	0.000	0.213	8.515	5.726	3.753	2.429	2.063	1.241	0.791	0.276	0.000		25.007	36.937
11.4	497.67	0.000	0.206	9.083	6.167	4.095	2.699	2.358	1.489	1.055	0.552	0.000		27.703	39.633
12.0	479.11	0.000	0.199	9.736	6.607	4.436	2.969	2.652	1.737	1.318	0.828	0.146	0.000	30.628	42.558
12.6	460.55	0.000	0.192	9.447	7.048	4.777	3.239	2.947	1.985	1.582	1.104	0.292	0.000	32.612	44.542
13.2	441.99	0.000	0.184	9.107	7.554	5.118	3.508	3.242	2.233	1.846	1.380	0.437	0.146	34.757	46.687
13.8	423.43	0.000	0.177	8.768	7.330	5.460	3.778	3.536	2.482	2.109	1.656	0.583	0.292	36.171	48.101
14.4	404.88	0.000	0.169	8.428	7.067	5.852	4.048	3.831	2.730	2.373	1.933	0.729	0.437	37.597	49.527
15.0	386.32	0.000	0.162	8.088	6.803	5.678	4.318	4.126	2.978	2.637	2.209	0.875	0.583	38.457	50.387
15.6	367.76	0.000	0.155	7.749	6.540	5.474	4.628	4.420	3.226	2.900	2.485	1.021	0.729	39.327	51.257
16.2	349.20	0.000	0.147	7.409	6.276	5.270	4.491	4.715	3.474	3.164	2.761	1.166	0.875	39.749	51.679
16.8	330.64	0.000	0.140	7.070	6.013	5.066	4.330	5.054	3.722	3.428	3.037	1.312	1.021	40.192	52.122
17.4	312.09	0.000	0.132	6.730	5.749	4.862	4.168	4.904	3.971	3.691	3.313	1.458	1.166	40.145	52.075
18.0	293.53	0.000	0.125	6.390	5.486	4.658	4.007	4.728	4.256	3.955	3.589	1.604	1.312	40.109	52.039
18.6	274.97	0.000	0.117	6.051	5.222	4.454	3.845	4.552	4.130	4.219	3.865	1.750	1.458	39.662	51.592

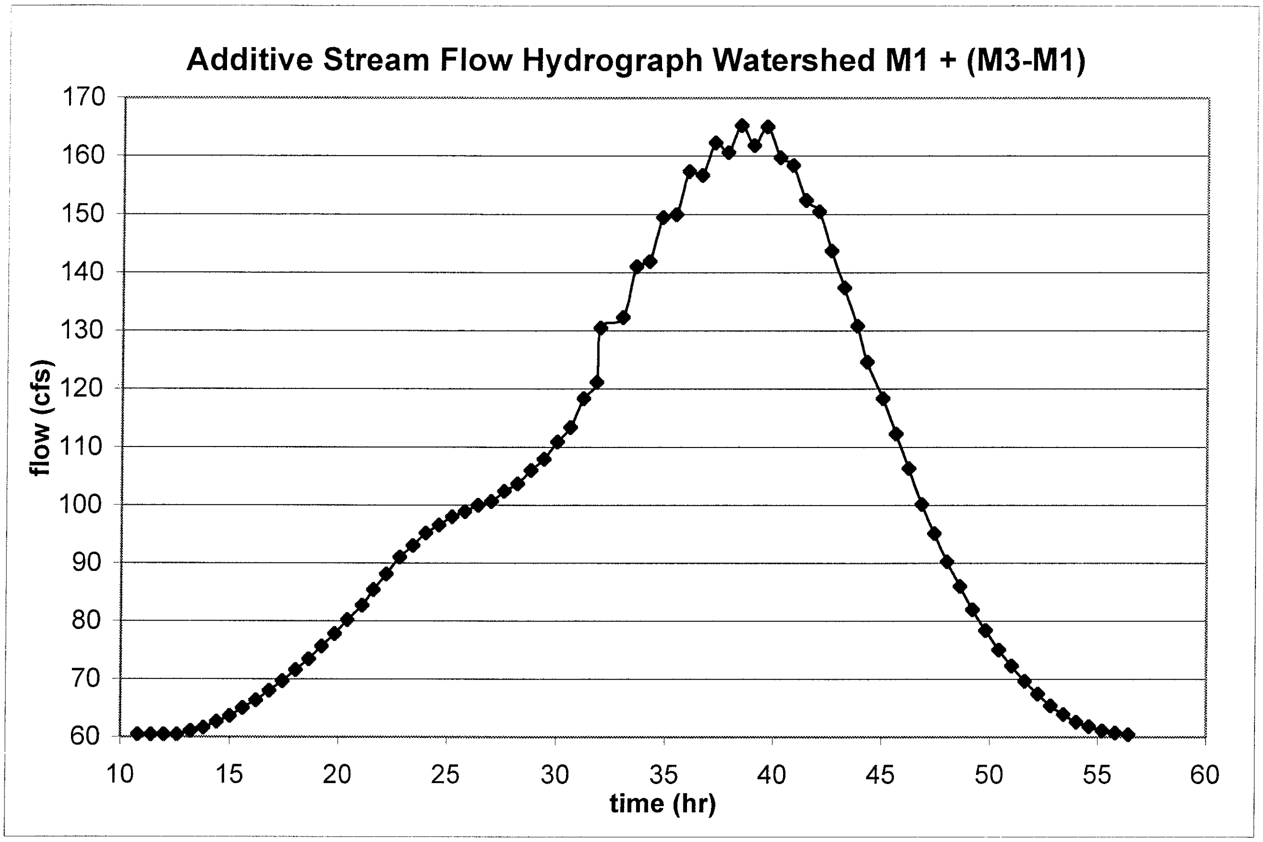
19.2	256.41	0.000	0.110	5.711	4.959	4.250	3.684	4.375	3.981	4.522	4.141	1.895	1.604	39.232	51.162
19.8	237.85	0.000	0.103	5.372	4.695	4.045	3.522	4.199	3.833	4.388	4.417	2.041	1.750	38.365	50.295
20.4	219.30	0.000	0.095	5.032	4.432	3.841	3.361	4.023	3.684	4.230	4.735	2.187	1.895	37.515	49.445
21.0	200.74	0.000	0.088	4.692	4.168	3.637	3.200	3.846	3.536	4.072	4.594	2.333	2.041	36.208	48.138
21.6	182.18	0.000	0.080	4.353	3.905	3.433	3.038	3.670	3.387	3.915	4.429	2.500	2.187	34.897	46.827
22.2	163.62	0.000	0.073	4.013	3.641	3.229	2.877	3.494	3.239	3.757	4.264	2.426	2.333	33.345	45.275
22.8	145.06	0.000	0.065	3.673	3.378	3.025	2.715	3.317	3.091	3.599	4.099	2.339	2.500	31.802	43.732
23.4	126.50	0.000	0.058	3.334	3.114	2.821	2.554	3.141	2.942	3.441	3.934	2.252	2.426	30.017	41.947
24.0	107.95	0.000	0.051	2.994	2.850	2.616	2.392	2.965	2.794	3.284	3.769	2.165	2.339	28.218	40.148
24.6	89.39	0.000	0.043	2.655	2.587	2.412	2.231	2.789	2.645	3.126	3.603	2.077	2.252	26.420	38.350
25.2	70.83	0.000	0.036	2.315	2.323	2.208	2.069	2.612	2.497	2.968	3.438	1.990	2.165	24.622	36.552
25.8	52.27	0.000	0.028	1.975	2.060	2.004	1.908	2.436	2.348	2.810	3.273	1.903	2.077	22.823	34.753
26.4	33.71	0.000	0.021	1.636	1.796	1.800	1.746	2.260	2.200	2.653	3.108	1.816	1.990	21.025	32.955
27.0	15.16	0.000	0.013	1.296	1.533	1.596	1.585	2.083	2.051	2.495	2.943	1.728	1.903	19.227	31.157
27.49	0.00	0.000	0.006	0.957	1.269	1.392	1.424	1.907	1.903	2.337	2.778	1.641	1.816	17.429	29.359
28.2			0.000	0.617	1.006	1.187	1.262	1.731	1.754	2.179	2.612	1.554	1.728	15.632	27.562
28.8			0.000	0.277	0.742	0.983	1.101	1.554	1.606	2.022	2.447	1.467	1.641	13.841	25.771
29.4				0.000	0.479	0.779	0.939	1.378	1.457	1.864	2.282	1.380	1.554	12.112	24.042
30.0				0.000	0.215	0.575	0.778	1.202	1.309	1.706	2.117	1.292	1.467	10.661	22.591
30.6					0.000	0.371	0.616	1.025	1.161	1.549	1.952	1.205	1.380	9.258	21.188
31.2					0.000	0.167	0.455	0.849	1.012	1.391	1.787	1.118	1.292	8.070	20.000
31.8						0.000	0.293	0.673	0.864	1.233	1.621	1.031	1.205	6.920	18.850
32.4						0.000	0.132	0.497	0.715	1.075	1.456	0.943	1.118	5.936	17.866
33.0							0.000	0.320	0.567	0.918	1.291	0.856	1.031	4.982	16.912
33.6							0.000	0.144	0.418	0.760	1.126	0.769	0.943	4.160	16.090
34.2								0.000	0.270	0.602	0.961	0.682	0.856	3.371	15.301
34.8								0.000	0.121	0.444	0.796	0.595	0.769	2.725	14.655
35.4									0.000	0.287	0.630	0.507	0.682	2.106	14.036
36.0									0.000	0.129	0.465	0.420	0.595	1.609	13.539
36.6										0.000	0.300	0.333	0.507	1.140	13.070
37.2										0.000	0.135	0.246	0.420	0.801	12.731
37.8											0.000	0.158	0.333	0.491	12.421
38.4											0.000	0.071	0.246	0.317	12.247
39.0												0.000	0.158	0.158	12.088
39.6												0.000	0.071	0.071	12.001
40.2													0.000	0.000	11.930
													SUM =	**1181.222**	**1992.462**


Stream Flow Hydrograph Watershed M3-M1
(runoff starts at storm time = 10.8 hr, t = 0 hr)
flow (cfs)
time (hr)
55
50
45
40
35
30
25
20
15
10
0
5
10
15
20
25
30
35
40
45

Trail Creek Watershed Study
Additive Stream Flow Hydrograph
Watershed M1 + (M3-M1)
July 18, 2006
IN20040385

Storm Time (hr)	M1 Time (hr)	M1 Time Actual (hr)	Stream Flow from M1 (cfs)	M3-M1 Time (hr)	Stream Flow M3-M1 (cfs)	Sum (cfs) M1 + (M3-M1)
10.8	0		48.490	0	11.930	60.420
11.4	0		48.490	0.6	11.930	60.420
12.0	0		48.490	1.2	11.942	60.432
12.6	0.6		48.490	1.8	11.955	60.445
13.2	1.2		48.490	2.4	12.535	61.025
13.8	1.8		48.490	3.0	13.115	61.605
14.4	2.4		48.490	3.6	14.136	62.626
15.0	3.0		48.490	4.2	15.156	63.646
15.6	3.6		48.490	4.8	16.518	65.008
16.2	4.2		48.490	5.4	17.880	66.370
16.8	4.8		48.490	6.0	19.511	68.001
17.4	5.4		48.490	6.6	21.143	69.633
18.0	6.0		48.490	7.2	23.069	71.559
18.6	6.6		48.490	7.8	24.996	73.486
19.2	7.2		48.490	8.4	27.170	75.660
19.8	7.8		48.490	9.0	29.345	77.835
20.4	8.4		48.490	9.6	31.783	80.273
21.0	9.0		48.490	10.2		
21.09	9.09			10.29	34.221	82.711
21.6	9.6		48.490	10.8	36.937	85.427
22.2	10.2		48.490	11.4	39.633	88.123
22.8	10.8		48.490	12.0	42.558	91.048
23.4	11.4		48.490	12.6	44.542	93.032
24.0	12.0		48.490	13.2	46.687	95.177
24.6	12.6		48.490	13.8	48.101	96.591
25.2	13.2	0	48.490	14.4	49.527	98.017
25.8	13.8	0.6	48.490	15.0	50.387	98.877
26.4	14.4	1.2	48.736	15.6	51.257	99.993
27.0	15.0	1.8	48.982	16.2	51.679	100.662
27.6	15.6	2.4	50.287	16.8	52.122	102.409
28.2	16.2	3.0	51.592	17.4	52.075	103.667
28.8	16.8	3.6	53.980	18.0	52.039	106.020
29.4	17.4	4.2	56.368	18.6	51.592	107.960
30.0	18.0	4.8	59.741	19.2	51.162	110.903
30.6	18.6	5.4	63.114	19.8	50.295	113.409
31.2	19.2	6.0	68.905	20.4	49.445	118.350
31.8	19.8	6.6	73.017	21.0	48.138	121.154
32.4	20.4	7.2		21.6	46.827	
31.96	19.96	7.36	83.666			130.493
33.0	21.0	7.8	87.055	22.2	45.275	132.331
33.6	21.6	8.4	97.312	22.8	43.732	141.044
34.2	22.2	9.0	99.974	23.4	41.947	141.920
34.8	22.8	9.6	109.321	24.0	40.148	149.469
35.4	23.4	10.2	111.611	24.6	38.350	149.961

36.0	24.0	10.8	120.799	25.2	36.552	157.351
36.6	24.6	11.4	121.935	25.8	34.753	156.688
37.2	25.2	12.0	129.320	26.4	32.955	162.275
37.8	25.8	12.6	129.483	27.0	31.157	160.640
38.29	26.29			27.49	29.359	
38.4	26.4	13.2	135.920	27.6		165.279
39.0	27.0	13.8	134.293	28.2	27.562	161.855
39.6	27.6	14.4	139.286	28.8	25.771	165.057
40.2	28.2	15.0	135.711	29.4	24.042	159.753
40.8	28.8	15.6	135.840	30.0	22.591	158.431
41.4	29.4	16.2	131.229	30.6	21.188	152.417
42.0	30.0	16.8	130.475	31.2	20.000	150.475
42.6	30.6	17.4	124.893	31.8	18.850	143.743
43.2	31.2	18.0	119.515	32.4	17.866	137.381
43.8	31.8	18.6	113.928	33.0	16.912	130.841
44.4	32.4	19.2		33.6	16.090	
44.26	32.26	19.66	108.554			124.644
45.0	33.0	19.8	103.074	34.2	15.301	118.374
45.6	33.6	20.4	97.628	34.8	14.655	112.283
46.2	34.2	21.0	92.295	35.4	14.036	106.331
46.8	34.8	21.6	87.110	36.0	13.070	100.180
47.4	35.4	22.2	82.411	36.6	12.731	95.141
48.0	36.0	22.8	77.863	37.2	12.421	90.284
48.6	36.6	23.4	73.811	37.8	12.247	86.058
49.2	37.2	24.0	69.898	38.4	12.088	81.986
49.8	37.8	24.6	66.436	39.0	12.001	78.437
50.4	38.4	25.2	63.132	39.6	11.930	75.062
51.0	39.0	25.8	60.348	40.2	11.930	72.278
51.6	39.6	26.4	57.704	40.8	11.930	69.634
52.2	40.2	27.0	55.524	41.4	11.930	67.454
52.8	40.8	27.6	53.502	42.0	11.930	65.432
53.4	41.4	28.2	51.999	42.6	11.930	63.929
54.0	42.0	28.8	50.665	43.2	11.930	62.595
54.6	42.6	29.4	49.884	43.8	11.930	61.814
55.2	43.2	30.0	49.193	44.4	11.930	61.123
55.8	43.8	30.6	48.795	45.0	11.930	60.725
56.4	44.4	31.2	48.490	45.6	11.930	60.420



Additive Stream Flow Hydrograph Watershed M1 + (M3-M1)
flow (cfs)
170
160
150
140
130
120
110
100
90
80
70
60
10
15
20
25
30
35
40
45
50
55
60
time (hr)

IN20040385 Trail Creek Watershed
July 18, 2006
Watershed M4 - Watershed M1
Curve Number & Runoff Check for Michigan City

Acres of Each Soil Type in Watershed

A	B	C	D	Null
1924.1	2002.68	1544.45	113.39	1817.41

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M4-M1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	888.89	12.01%	231.06	240.49	185.47	13.62
Developed Agriculture Row Crop	1052.71	14.22%	273.64	284.82	219.65	16.13
Developed Non-Vegetated	165.73	2.24%	43.08	44.84	34.58	2.54
Developed Urban High Density	568.55	7.68%	147.79	153.82	118.63	8.71
Developed Urban Low Density	994.03	13.43%	258.39	268.94	207.40	15.23
Palustrine Forest Deciduous	781.85	10.56%	203.23	211.53	163.13	11.98
Palustrine Herbaceous Deciduous	17.12	0.23%	4.45	4.63	3.57	0.26
Palustrine Shrubland Deciduous	0.00	0.00%	0.00	0.00	0.00	0.00
Palustrine Woodland Deciduous	1.53	0.02%	0.40	0.41	0.32	0.02
Terrestrial Forest Deciduous	2676.15	36.15%	695.64	724.05	558.38	40.99
Terrestrial Forest Evergreen	0.03	0.00%	0.01	0.01	0.01	0.00
Terrestrial Forest Mixed	2.87	0.04%	0.75	0.78	0.60	0.04
Terrestrial Shrubland Deciduous	97.75	1.32%	25.41	26.45	20.40	1.50
Terrestrial Woodland Deciduous	123.98	1.67%	32.23	33.54	25.87	1.90
Unclassified Cloud/Shadow	0.29	0.00%	0.07	0.08	0.06	0.00
Water	30.63	0.41%	7.96	8.29	6.39	0.47
TOTAL	7402.09	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Palustrine Woodland Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	11321.79	16594.04	14651.84	1143.79	43711.46
Developed Agriculture Row Crop	13408.38	19652.29	17352.16	1354.59	51767.42
Developed Non-Vegetated	3834.00	4125.09	3250.39	241.18	11450.66
Developed Urban High Density	13153.23	14151.88	11151.07	827.40	39283.58
Developed Urban Low Density	13177.78	18287.95	16384.96	1279.08	49129.78
Palustrine Forest Deciduous	5080.87	11634.42	11419.38	922.22	29056.90
Palustrine Herbaceous Deciduous	111.25	254.74	250.04	20.19	636.22
Palustrine Shrubland Deciduous	0.00	0.00	0.00	0.00	0.00
Palustrine Woodland Deciduous	9.93	22.75	22.33	1.80	56.81
Terrestrial Forest Deciduous	17390.93	39822.59	39086.53	3156.61	99456.66
Terrestrial Forest Evergreen	0.19	0.44	0.43	0.03	1.10
Terrestrial Forest Mixed	33.59	51.27	46.13	3.65	134.63
Terrestrial Shrubland Deciduous	762.29	1533.95	1448.12	116.80	3861.15
Terrestrial Woodland Deciduous	805.70	1844.94	1810.83	146.24	4607.72
Unclassified Cloud/Shadow	1.87	4.29	4.21	0.34	10.71
Water	573.18	679.45	555.94	41.75	1850.32

Total Sum:	335015.11
Total Acres:	5584.68
Composite Number:	59.99
Flow Rate (cfs):	

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M4 - Watershed M1
Curve Number & Runoff Check for Michigan City

Base Flow

Watershed	Area (ac)	Area (mi^2)	Annual Runoff (ft^3)	Annual Flow (cfs)	Base Flow (cfs)
M5-M1	7402.09	11.57	506,491,819	16.06	12.21

Hydrograph Calculations

Watershed	Travel Length, L (ft)	Beginning Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	*Velocity, v (ft/s)	Area, A_m (mi^2)	Time of Concentr-ation, t_c (hr)	ΔD (hr)	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M4-M1	36,543	695	590	0.003	0.6	11.57	16.92	2.25	11.28	496	30.11	18.83

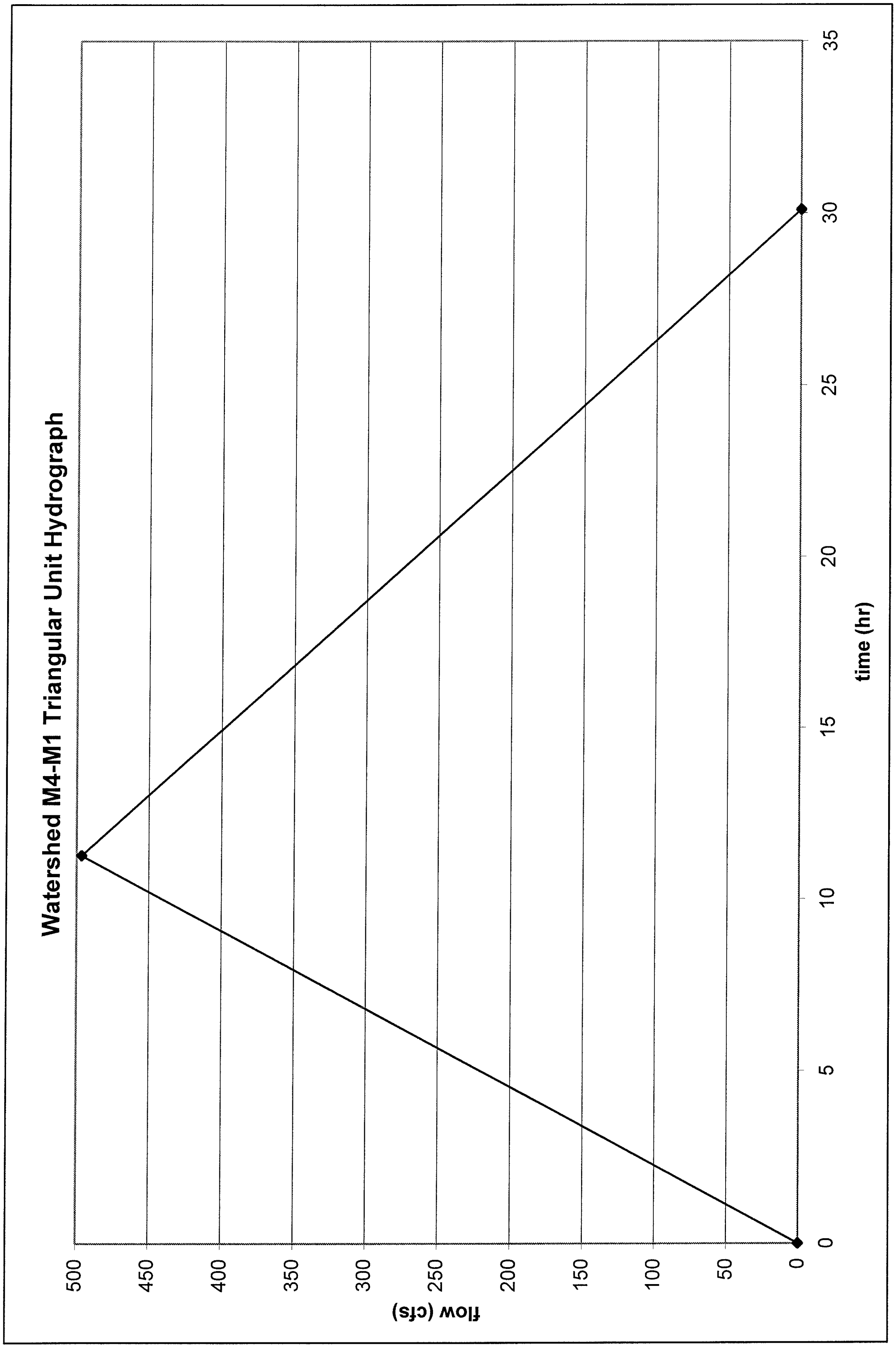
*Any watershed with a slop less than 0.005 has a velocity less than 1 ft/s. It was assumed that slope = 0.004 has a velocity of 0.8 ft/s and slope = 0.002 has a velocity of 0.5 ft/s.

Unit Hydrograph Calculations

Watershed	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M4-M1	11.28	496	30.11	18.83

Watershed M4-M1

Time (hr)	Flow (cfs)
0	0
11.28	496
30.11	0


Watershed M4-M1 Triangular Unit Hydrograph
flow (cfs)
0
50
100
150
200
250
300
350
400
450
500
time (hr)
0
5
10
15
20
25
30
35

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M4 - Watershed M1
SCS Type II Distribution

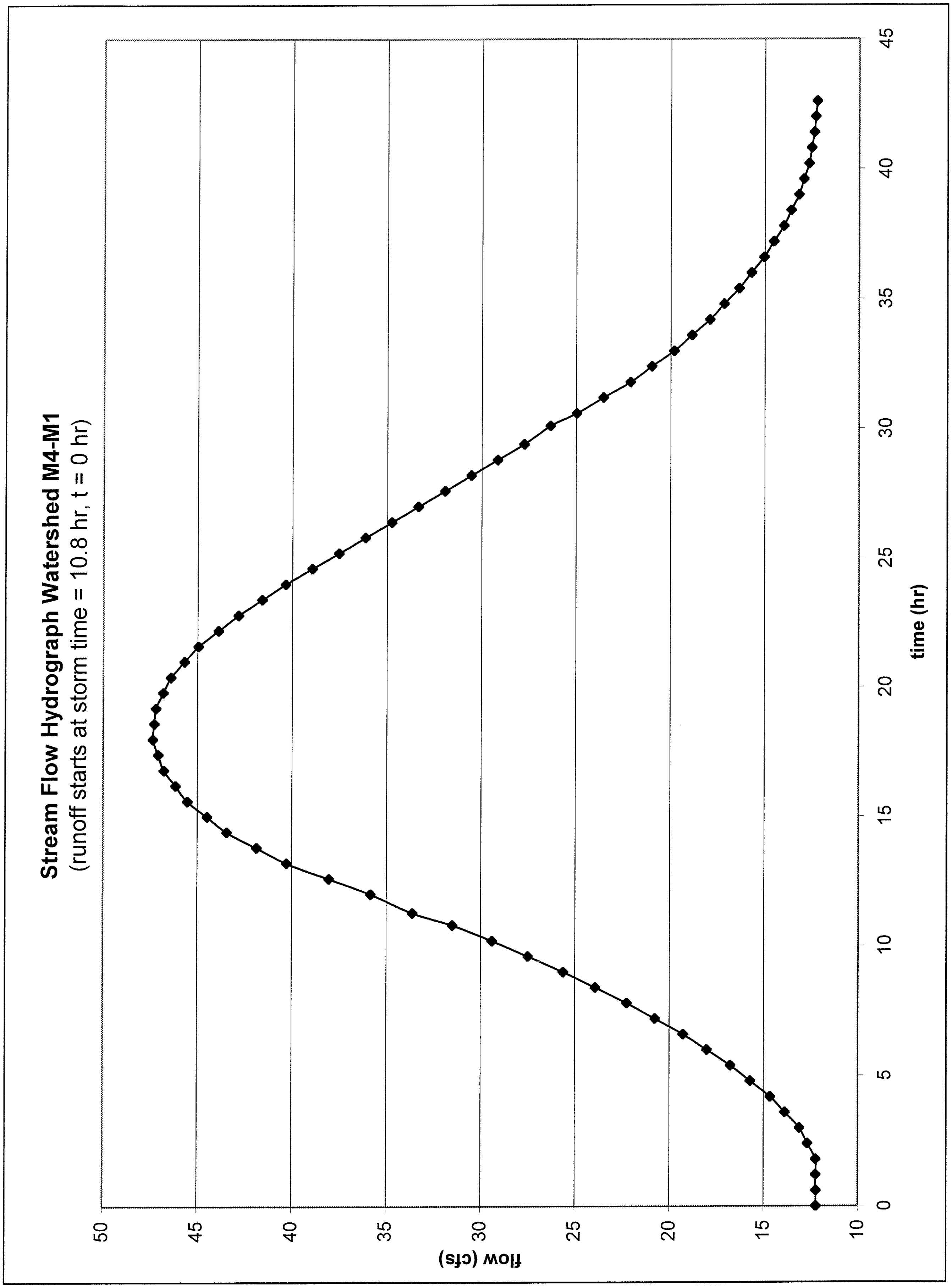
Watershed M4-M1, S = 6.67, 0.2S = 1.334

Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0.0002	0.0002
0.520	12.48	0.730	1.568	0.0079	0.0077
0.530	12.72	0.750	1.611	0.0110	0.0031
0.540	12.96	0.770	1.654	0.0146	0.0036
0.550	13.20	0.780	1.675	0.0166	0.0020
0.560	13.44	0.800	1.718	0.0209	0.0043
0.570	13.68	0.810	1.740	0.0233	0.0023
0.580	13.92	0.820	1.761	0.0257	0.0025
0.600	14.40	0.835	1.794	0.0296	0.0039
0.630	15.12	0.860	1.847	0.0367	0.0071
0.650	15.60	0.870	1.869	0.0397	0.0030
0.670	16.08	0.880	1.890	0.0428	0.0031
0.700	16.80	0.895	1.922	0.0477	0.0049
0.720	17.28	0.910	1.955	0.0528	0.0051
0.750	18.00	0.920	1.976	0.0564	0.0036
0.770	18.48	0.930	1.998	0.0601	0.0037
0.800	19.20	0.940	2.019	0.0638	0.0038
0.830	19.92	0.950	2.041	0.0677	0.0039
0.850	20.40	0.960	2.062	0.0717	0.0040
0.870	20.88	0.970	2.084	0.0757	0.0041
0.900	21.60	0.980	2.105	0.0799	0.0042
0.950	22.80	0.990	2.127	0.0842	0.0043
1.000	24.00	1.000	2.148	0.0885	0.0044

Trail Creek Watershed Study
July 18, 2006
IN20040385
Watershed M4-M1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 10.8 hr)												Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8	12	13.2		
		0	0.0002	0.0164	0.013	0.0101	0.008	0.0087	0.0074	0.0079	0.0082	0.0043	0.0043		
0	0.00	0.000												0.000	12.210
0.6	26.38	0.000	0.000											0.000	12.210
1.2	52.77	0.000	0.005	0.000										0.005	12.215
1.8	79.15	0.000	0.011	0.000										0.011	12.221
2.4	105.53	0.000	0.016	0.433	0.000									0.449	12.659
3.0	131.91	0.000	0.021	0.865	0.000									0.886	13.096
3.6	158.30	0.000	0.026	1.298	0.343	0.000								1.667	13.877
4.2	184.68	0.000	0.032	1.731	0.686	0.000								2.448	14.658
4.8	211.06	0.000	0.037	2.163	1.029	0.266	0.000							3.496	15.706
5.4	237.45	0.000	0.042	2.596	1.372	0.533	0.000							4.543	16.753
6.0	263.83	0.000	0.047	3.029	1.715	0.799	0.211	0.000						5.802	18.012
6.6	290.21	0.000	0.053	3.461	2.058	1.066	0.422	0.000						7.060	19.270
7.2	316.60	0.000	0.058	3.894	2.401	1.332	0.633	0.230	0.000					8.548	20.758
7.8	342.98	0.000	0.063	4.327	2.744	1.599	0.844	0.459	0.000					10.036	22.246
8.4	369.36	0.000	0.069	4.759	3.087	1.865	1.055	0.689	0.195	0.000				11.719	23.929
9.0	395.74	0.000	0.074	5.192	3.430	2.132	1.266	0.918	0.390	0.000				13.403	25.613
9.6	422.13	0.000	0.079	5.625	3.773	2.398	1.477	1.148	0.586	0.208	0.000			15.294	27.504
10.2	448.51	0.000	0.084	6.058	4.116	2.665	1.689	1.377	0.781	0.417	0.000			17.186	29.396
10.8	474.89	0.000	0.090	6.490	4.459	2.931	1.900	1.607	0.976	0.625	0.216	0.000		19.294	31.504
11.28	496.00	0.000	0.095	6.923	4.802	3.198	2.111	1.836	1.171	0.834	0.433	0.000		21.402	33.612
12.0	477.04	0.000	0.099	7.356	5.145	3.464	2.322	2.066	1.367	1.042	0.649	0.113	0.000	23.622	35.832
12.6	461.23	0.000	0.095	7.788	5.488	3.731	2.533	2.295	1.562	1.251	0.865	0.227	0.000	25.835	38.045
13.2	445.43	0.000	0.092	8.134	5.831	3.997	2.744	2.525	1.757	1.459	1.082	0.340	0.113	28.075	40.285
13.8	429.62	0.000	0.089	7.823	6.174	4.263	2.955	2.754	1.952	1.667	1.298	0.454	0.227	29.657	41.867
14.4	413.82	0.000	0.086	7.564	6.448	4.530	3.166	2.984	2.148	1.876	1.514	0.567	0.340	31.223	43.433
15.0	398.01	0.000	0.083	7.305	6.201	4.796	3.377	3.213	2.343	2.084	1.731	0.681	0.454	32.268	44.478
15.6	382.21	0.000	0.080	7.046	5.996	5.010	3.588	3.443	2.538	2.293	1.947	0.794	0.567	33.301	45.511
16.2	366.40	0.000	0.076	6.787	5.791	4.818	3.799	3.673	2.733	2.501	2.163	0.908	0.681	33.929	46.139
16.8	350.60	0.000	0.073	6.527	5.585	4.658	3.968	3.902	2.929	2.710	2.380	1.021	0.794	34.547	46.757
17.4	334.79	0.000	0.070	6.268	5.380	4.499	3.816	4.132	3.124	2.918	2.596	1.134	0.908	34.844	47.054
18.0	318.99	0.000	0.067	6.009	5.174	4.339	3.690	4.315	3.319	3.126	2.812	1.248	1.021	35.121	47.331
18.6	303.19	0.000	0.064	5.750	4.969	4.180	3.563	4.150	3.514	3.335	3.029	1.361	1.134	35.049	47.259
19.2	287.38	0.000	0.061	5.491	4.763	4.020	3.437	4.013	3.670	3.543	3.245	1.475	1.248	34.966	47.176

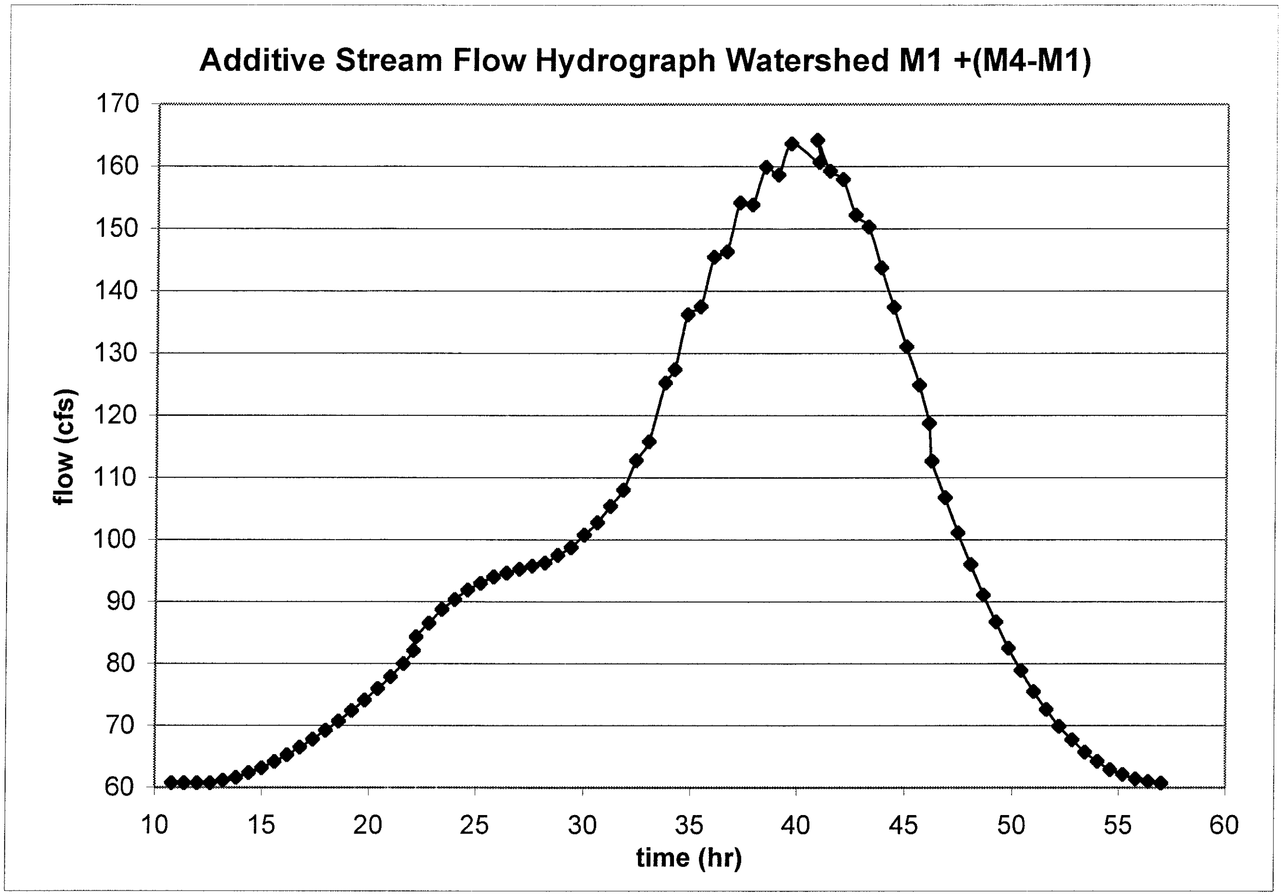
19.8	271.58	0.000	0.057	5.231	4.558	3.860	3.311	3.875	3.530	3.752	3.461	1.588	1.361	34.586	46.796
20.4	255.77	0.000	0.054	4.972	4.352	3.701	3.184	3.738	3.413	3.918	3.678	1.702	1.475	34.187	46.397
21.0	239.97	0.000	0.051	4.713	4.147	3.541	3.058	3.600	3.296	3.769	3.894	1.815	1.588	33.472	45.682
21.6	224.16	0.000	0.048	4.454	3.941	3.381	2.931	3.463	3.179	3.644	4.067	1.929	1.702	32.739	44.949
22.2	208.36	0.000	0.045	4.195	3.736	3.222	2.805	3.325	3.062	3.519	3.912	2.042	1.815	31.677	43.887
22.8	192.55	0.000	0.042	3.935	3.530	3.062	2.678	3.188	2.945	3.394	3.782	2.133	1.929	30.619	42.829
23.4	176.75	0.000	0.039	3.676	3.325	2.903	2.552	3.050	2.828	3.269	3.652	2.051	2.042	29.388	41.598
24.0	160.94	0.000	0.035	3.417	3.120	2.743	2.425	2.913	2.711	3.144	3.523	1.983	2.133	28.148	40.358
24.6	145.14	0.000	0.032	3.158	2.914	2.583	2.299	2.775	2.594	3.019	3.393	1.915	2.051	26.735	38.945
25.2	129.34	0.000	0.029	2.899	2.709	2.424	2.173	2.638	2.477	2.895	3.264	1.847	1.983	25.337	37.547
25.8	113.53	0.000	0.026	2.639	2.503	2.264	2.046	2.500	2.361	2.770	3.134	1.779	1.915	23.938	36.148
26.4	97.73	0.000	0.023	2.380	2.298	2.104	1.920	2.363	2.244	2.645	3.005	1.711	1.847	22.539	34.749
27.0	81.92	0.000	0.020	2.121	2.092	1.945	1.793	2.225	2.127	2.520	2.875	1.643	1.779	21.141	33.351
27.6	66.12	0.000	0.016	1.862	1.887	1.785	1.667	2.088	2.010	2.395	2.745	1.576	1.711	19.742	31.952
28.2	50.31	0.000	0.013	1.603	1.681	1.626	1.540	1.950	1.893	2.270	2.616	1.508	1.643	18.343	30.553
28.8	34.51	0.000	0.010	1.344	1.476	1.466	1.414	1.813	1.776	2.145	2.486	1.440	1.576	16.945	29.155
29.4	18.70	0.000	0.007	1.084	1.270	1.306	1.288	1.675	1.659	2.021	2.357	1.372	1.508	15.546	27.756
30.11	0.00	0.000	0.004	0.825	1.065	1.147	1.161	1.538	1.542	1.896	2.227	1.304	1.440	14.147	26.357
30.6			0.000	0.566	0.860	0.987	1.035	1.400	1.425	1.771	2.097	1.236	1.372	12.748	24.958
31.2			0.000	0.307	0.654	0.827	0.908	1.263	1.308	1.646	1.968	1.168	1.304	11.352	23.562
31.8				0.000	0.449	0.668	0.782	1.125	1.191	1.521	1.838	1.100	1.236	9.909	22.119
32.4				0.000	0.243	0.508	0.655	0.988	1.074	1.396	1.709	1.032	1.168	8.773	20.983
33.0					0.000	0.349	0.529	0.850	0.957	1.271	1.579	0.964	1.100	7.599	19.809
33.6					0.000	0.189	0.403	0.713	0.840	1.147	1.449	0.896	1.032	6.668	18.878
34.2						0.000	0.276	0.575	0.723	1.022	1.320	0.828	0.964	5.708	17.918
34.8						0.000	0.150	0.438	0.606	0.897	1.190	0.760	0.896	4.937	17.147
35.4							0.000	0.300	0.489	0.772	1.061	0.692	0.828	4.142	16.352
36.0							0.000	0.163	0.372	0.647	0.931	0.624	0.760	3.497	15.707
36.6								0.000	0.255	0.522	0.801	0.556	0.692	2.827	15.037
37.2								0.000	0.138	0.397	0.672	0.488	0.624	2.320	14.530
37.8									0.000	0.273	0.542	0.420	0.556	1.791	14.001
38.4									0.000	0.148	0.413	0.352	0.488	1.401	13.611
39.0										0.000	0.283	0.284	0.420	0.988	13.198
39.6										0.000	0.153	0.216	0.352	0.722	12.932
40.2											0.000	0.148	0.284	0.433	12.643
40.8											0.000	0.080	0.216	0.297	12.507
41.4												0.000	0.148	0.148	12.358
42.0												0.000	0.080	0.080	12.290
42.6													0.000	0.000	12.210
													SUM =	**1101.256**	**1980.376**


Stream Flow Hydrograph Watershed M4-M1
(runoff starts at storm time = 10.8 hr, t = 0 hr)
flow (cfs)
50
45
40
35
30
25
20
15
10
0
5
10
15
20
25
30
35
40
45
time (hr)

Trail Creek Watershed Study
Additive Stream Flow Hydrograph
Watershed M1 + (M4-M1)
July 18, 2006
IN20040385

Storm Time (hr)	M1 Time (hr)	M1 Time Actual (hr)	Stream Flow from M1 (cfs)	M4-M1 Time (hr)	Stream Flow M4-M1 (cfs)	Sum (cfs) M1 + (M4-M1)
10.8	0		48.490	0	12.210	60.700
11.4	0		48.490	0.6	12.210	60.700
12.0	0		48.490	1.2	12.215	60.705
12.6	0.6		48.490	1.8	12.221	60.711
13.2	1.2		48.490	2.4	12.659	61.149
13.8	1.8		48.490	3.0	13.096	61.586
14.4	2.4		48.490	3.6	13.877	62.367
15.0	3.0		48.490	4.2	14.658	63.148
15.6	3.6		48.490	4.8	15.706	64.196
16.2	4.2		48.490	5.4	16.753	65.243
16.8	4.8		48.490	6.0	18.012	66.502
17.4	5.4		48.490	6.6	19.270	67.760
18.0	6.0		48.490	7.2	20.758	69.248
18.6	6.6		48.490	7.8	22.246	70.736
19.2	7.2		48.490	8.4	23.929	72.419
19.8	7.8		48.490	9.0	25.613	74.103
20.4	8.4		48.490	9.6	27.504	75.994
21.0	9.0		48.490	10.2	29.396	77.886
21.6	9.6		48.490	10.8	31.504	79.994
22.08	10.08		48.490	11.28	33.612	82.102
22.2	10.2		48.490	12.0	35.832	84.322
22.8	10.8		48.490	12.6	38.045	86.535
23.4	11.4		48.490	13.2	40.285	88.775
24.0	12.0		48.490	13.8	41.867	90.357
24.6	12.6		48.490	14.4	43.433	91.923
25.2	13.2		48.490	15.0	44.478	92.968
25.8	13.8		48.490	15.6	45.511	94.001
26.4	14.4	0	48.490	16.2	46.139	94.629
27.0	15.0	0.6	48.490	16.8	46.757	95.247
27.6	15.6	1.2	48.736	17.4	47.054	95.791
28.2	16.2	1.8	48.982	18.0	47.331	96.313
28.8	16.8	2.4	50.287	18.6	47.259	97.546
29.4	17.4	3.0	51.592	19.2	47.176	98.768
30.0	18.0	3.6	53.980	19.8	46.796	100.776
30.6	18.6	4.2	56.368	20.4	46.397	102.765
31.2	19.2	4.8	59.741	21.0	45.682	105.423
31.8	19.8	5.4	63.114	21.6	44.949	108.063
32.4	20.4	6.0	68.905	22.2	43.887	112.792
33.0	21.0	6.6	73.017	22.8	42.829	115.845
33.6	21.6	7.2		23.4	41.598	
33.76	21.76	7.36	83.666			125.263
34.2	22.2	7.8	87.055	24.0	40.358	127.413
34.8	22.8	8.4	97.312	24.6	38.945	136.258
35.4	23.4	9.0	99.974	25.2	37.547	137.521

36.0	24.0	9.6	109.321	25.8	36.148	145.469
36.6	24.6	10.2	111.611	26.4	34.749	146.360
37.2	25.2	10.8	120.799	27.0	33.351	154.150
37.8	25.8	11.4	121.935	27.6	31.952	153.887
38.4	26.4	12.0	129.320	28.2	30.553	159.873
39.0	27.0	12.6	129.483	28.8	29.155	158.637
39.6	27.6	13.2	135.920	29.4	27.756	163.676
40.2	28.2	13.8	134.293			
40.91	28.91			30.11	26.357	160.650
40.8	28.8	14.4	139.286	30.6	24.958	164.244
41.4	29.4	15.0	135.711	31.2	23.562	159.274
42.0	30.0	15.6	135.840	31.8	22.119	157.959
42.6	30.6	16.2	131.229	32.4	20.983	152.212
43.2	31.2	16.8	130.475	33.0	19.809	150.284
43.8	31.8	17.4	124.893	33.6	18.878	143.771
44.4	32.4	18.0	119.515	34.2	17.918	137.432
45.0	33.0	18.6	113.928	34.8	17.147	131.075
45.6	33.6	19.2	108.554	35.4	16.352	124.906
46.06	34.06	19.66	103.074			
46.2	34.2	19.8		36.0	15.707	118.781
46.8	34.8	20.4	97.628	36.6	15.037	112.665
47.4	35.4	21.0	92.295	37.2	14.530	106.825
48.0	36.0	21.6	87.110	37.8	14.001	101.111
48.6	36.6	22.2	82.411	38.4	13.611	96.022
49.2	37.2	22.8	77.863	39.0	13.198	91.060
49.8	37.8	23.4	73.811	39.6	12.932	86.743
50.4	38.4	24.0	69.898	40.2	12.643	82.540
51.0	39.0	24.6	66.436	40.8	12.507	78.942
51.6	39.6	25.2	63.132	41.4	12.358	75.490
52.2	40.2	25.8	60.348	42.0	12.290	72.638
52.8	40.8	26.4	57.704	42.6	12.210	69.914
53.4	41.4	27.0	55.524	43.2	12.210	67.734
54.0	42.0	27.6	53.502	43.8	12.210	65.712
54.6	42.6	28.2	51.999	44.4	12.210	64.209
55.2	43.2	28.8	50.665	45.0	12.210	62.875
55.8	43.8	29.4	49.884	45.6	12.210	62.094
56.4	44.4	30.0	49.193	46.2	12.210	61.403
57.0	45.0	30.6	48.795	46.8	12.210	61.005
57.6	45.6	31.2	48.490	47.4	12.210	60.700



Additive Stream Flow Hydrograph Watershed M1 +(M4-M1)
flow (cfs)
170
160
150
140
130
120
110
100
90
80
70
60
10
15
20
25
30
35
40
45
50
55
60
time (hr)

IN20040385 Trail Creek Watershed
July 18, 2006
Watershed M5 - Watershed M1
Curve Number & Runoff Check for Michigan City

Acres of Each Soil Type in Watershed

A	**B**	**C**	**D**	**Null**
1941.07	2036.18	1544.58	113.1	2055.44

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M5-M1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	893.55	11.62%	225.51	236.56	179.45	13.14
Developed Agriculture Row Crop	1057.32	13.75%	266.84	279.92	212.34	15.55
Developed Non-Vegetated	168.69	2.19%	42.57	44.66	33.88	2.48
Developed Urban High Density	663.14	8.62%	167.36	175.56	133.17	9.75
Developed Urban Low Density	1108.35	14.41%	279.72	293.43	222.58	16.30
Palustrine Forest Deciduous	782.22	10.17%	197.41	207.09	157.09	11.50
Palustrine Herbaceous Deciduous	16.69	0.22%	4.21	4.42	3.35	0.25
Palustrine Shrubland Deciduous	0.00	0.00%	0.00	0.00	0.00	0.00
Palustrine Woodland Deciduous	3.15	0.04%	0.79	0.83	0.63	0.05
Terrestrial Forest Deciduous	2718.21	35.34%	686.01	719.62	545.88	39.97
Terrestrial Forest Evergreen	0.00	0.00%	0.00	0.00	0.00	0.00
Terrestrial Forest Mixed	2.89	0.04%	0.73	0.77	0.58	0.04
Terrestrial Shrubland Deciduous	97.77	1.27%	24.67	25.88	19.63	1.44
Terrestrial Woodland Deciduous	126.46	1.64%	31.92	33.48	25.40	1.86
Unclassified Cloud/Shadow	0.00	0.00%	0.00	0.00	0.00	0.00
Water	52.77	0.69%	13.32	13.97	10.60	0.78
TOTAL	7691.22	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Palustrine Woodland Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	11049.95	16322.56	14176.22	1103.74	42652.47
Developed Agriculture Row Crop	13075.25	19314.26	16774.53	1306.03	50470.08
Developed Non-Vegetated	3788.96	4108.59	3184.39	235.65	11317.59
Developed Urban High Density	14894.90	16151.41	12518.28	926.39	44490.99
Developed Urban Low Density	14265.76	19953.01	17584.13	1369.07	53171.97
Palustrine Forest Deciduous	4935.30	11389.68	10996.16	885.70	28206.85
Palustrine Herbaceous Deciduous	105.32	243.05	234.65	18.90	601.91
Palustrine Shrubland Deciduous	0.00	0.00	0.00	0.00	0.00
Palustrine Woodland Deciduous	19.87	45.85	44.27	3.57	113.56
Terrestrial Forest Deciduous	17150.19	39579.17	38211.70	3077.81	98018.87
Terrestrial Forest Evergreen	0.00	0.00	0.00	0.00	0.00
Terrestrial Forest Mixed	32.87	50.58	44.76	3.53	131.75
Terrestrial Shrubland Deciduous	740.23	1501.24	1394.04	112.14	3747.65
Terrestrial Woodland Deciduous	797.90	1841.40	1777.78	143.19	4560.27
Unclassified Cloud/Shadow	0.00	0.00	0.00	0.00	0.00
Water	958.95	1145.65	922.04	69.07	3095.70

Total Sum:	340579.66
Total Acres:	5635.78
Composite Number:	60.43
Flow Rate (cfs):	

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M5 - Watershed M1
Curve Number & Runoff Check for Michigan City

Base Flow

Watershed	Area (ac)	Area (mi^2)	Annual Runoff (ft^3)	Annual Flow (cfs)	Base Flow (cfs)
M5-M1	7691.22	12.02	526,275,820	16.69	12.68

Hydrograph Calculations

Watershed	Travel Length, L (ft)	Beginning Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	*Velocity, v (ft/s)	Area, A_m (mi^2)	Time of Concentration, t_c (hr)	ΔD (hr)	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M5-M1	39,200	695	585	0.003	0.6	12.02	18.15	2.41	12.10	481	32.30	20.20

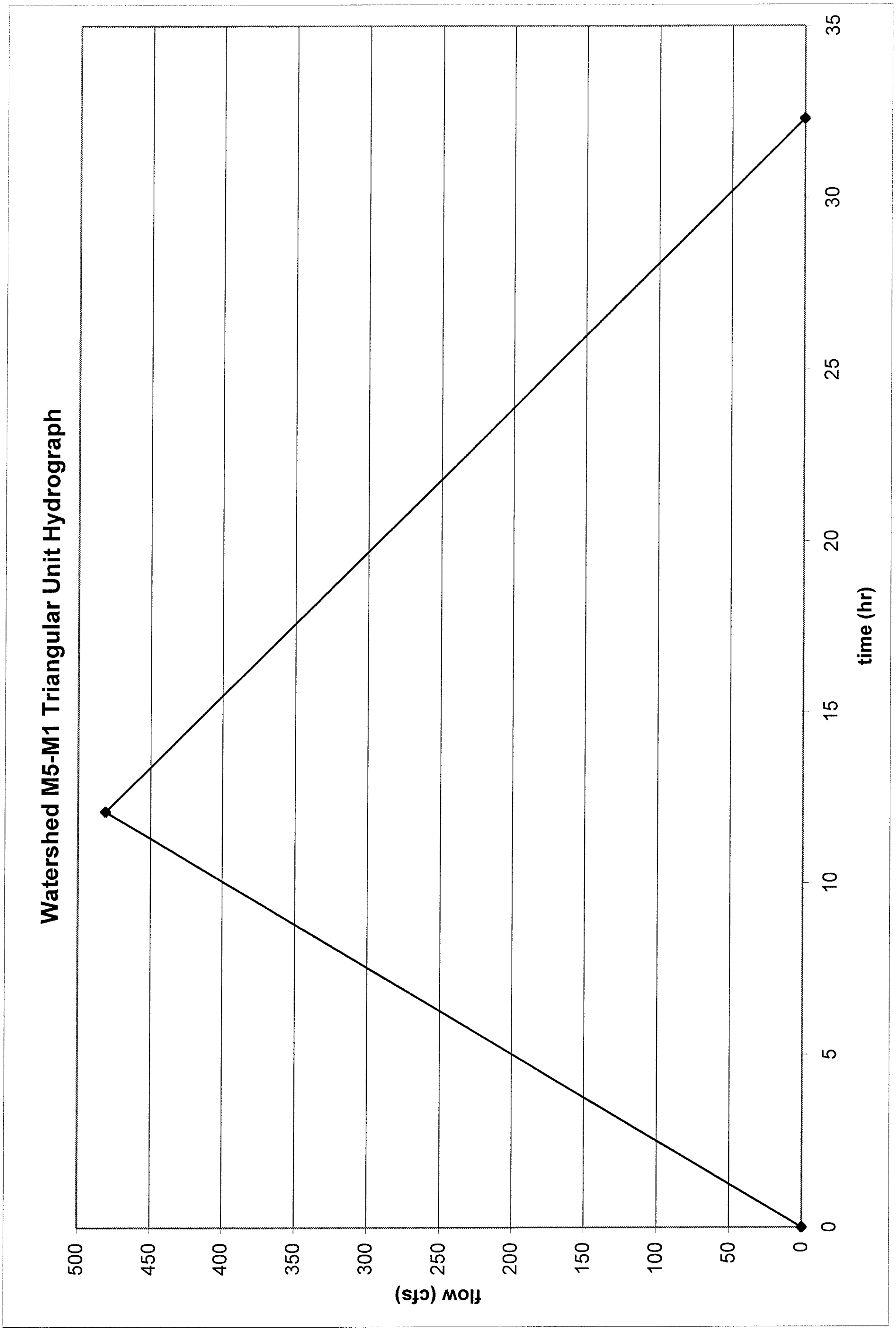
*Any watershed with a slop less than 0.005 has a velocity less than 1 ft/s. It was assumed that slope = 0.004 has a velocity of 0.8 ft/s and slope = 0.002 has a velocity of 0.5 ft/s.

Unit Hydrograph Calculations

Watershed	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M5-M1	12.10	481	32.30	20.20

Watershed M5-M1

Time (hr)	Flow (cfs)
0	0
12.10	481
32.30	0


Watershed M5-M1 Triangular Unit Hydrograph
flow (cfs)
0
50
100
150
200
250
300
350
400
450
500
time (hr)
0
5
10
15
20
25
30
35

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M5 - Watershed M1
SCS Type II Distribution

Watershed M5-M1, S = 6.55, 0.2S = 1.31

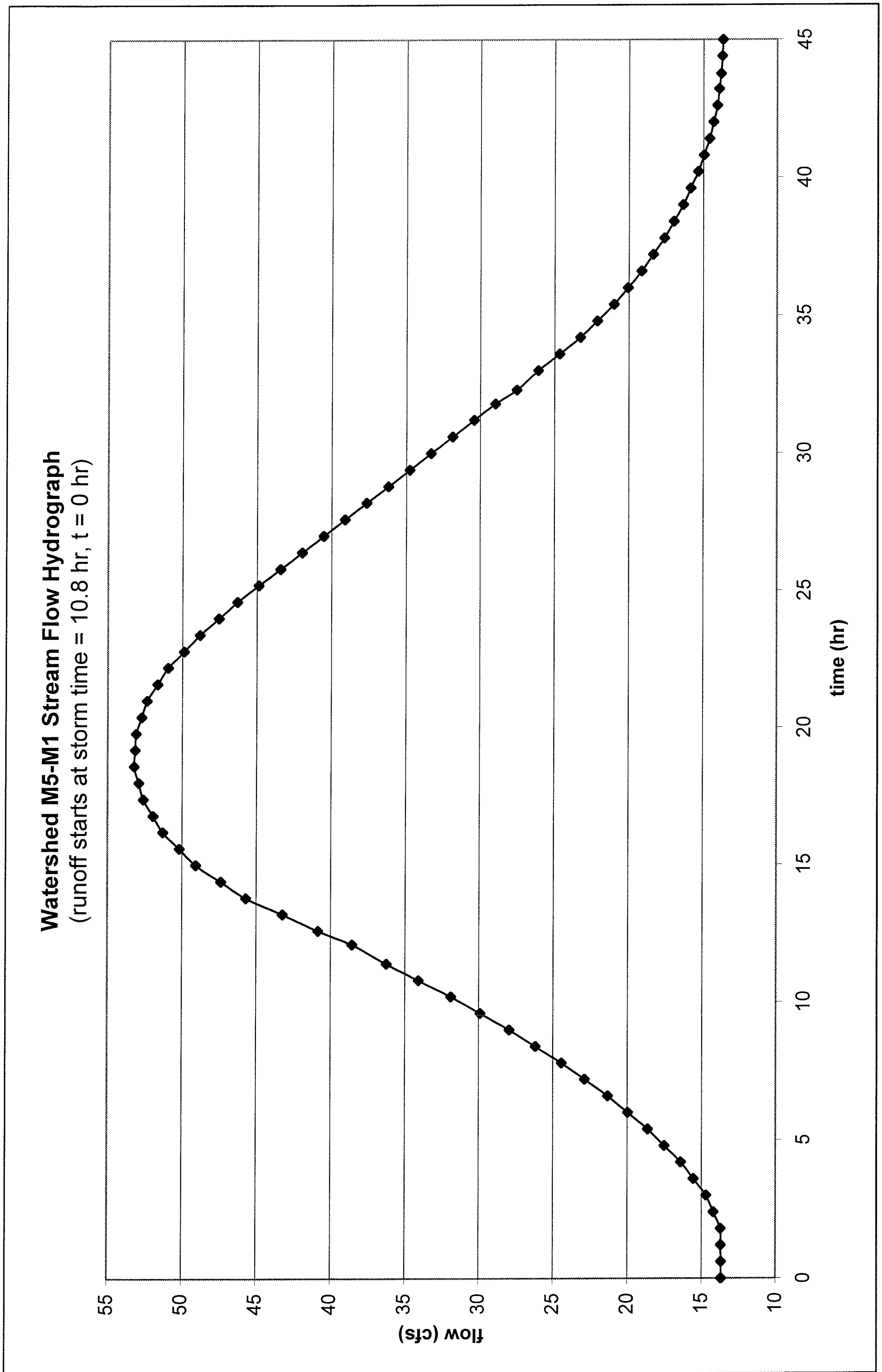
Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0.0007	0.0007
0.520	12.48	0.730	1.568	0.0105	0.0098
0.530	12.72	0.750	1.611	0.0141	0.0037
0.540	12.96	0.770	1.654	0.0184	0.0042
0.550	13.20	0.780	1.675	0.0206	0.0023
0.560	13.44	0.800	1.718	0.0256	0.0050
0.570	13.68	0.810	1.740	0.0283	0.0027
0.580	13.92	0.820	1.761	0.0311	0.0028
0.600	14.40	0.835	1.794	0.0355	0.0044
0.630	15.12	0.860	1.847	0.0435	0.0080
0.650	15.60	0.870	1.869	0.0469	0.0034
0.670	16.08	0.880	1.890	0.0504	0.0035
0.700	16.80	0.895	1.922	0.0559	0.0055
0.720	17.28	0.910	1.955	0.0616	0.0057
0.750	18.00	0.920	1.976	0.0656	0.0040
0.770	18.48	0.930	1.998	0.0696	0.0041
0.800	19.20	0.940	2.019	0.0738	0.0042
0.830	19.92	0.950	2.041	0.0781	0.0043
0.850	20.40	0.960	2.062	0.0825	0.0044
0.870	20.88	0.970	2.084	0.0870	0.0045
0.900	21.60	0.980	2.105	0.0916	0.0046
0.950	22.80	0.990	2.127	0.0964	0.0047
1.000	24.00	1.000	2.148	0.1012	0.0048

Trail Creek Watershed Study
July 18, 2006
IN20040385
Watershed M5-M1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 10.8 hr)												Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0 0	1.2 0.0007	2.4 0.0199	3.6 0.0149	4.8 0.0114	6 0.009	7.2 0.0097	8.4 0.0082	9.6 0.0087	10.8 0.0091	12 0.0048	13.2 0.0048		
0	0.00	0.000												0.000	13.680
0.6	23.85	0.000	0.000											0.000	13.680
1.2	47.70	0.000	0.017	0.000										0.017	13.697
1.8	71.55	0.000	0.033	0.000										0.033	13.713
2.4	95.41	0.000	0.050	0.475	0.000									0.525	14.205
3.0	119.26	0.000	0.067	0.949	0.000									1.016	14.696
3.6	143.11	0.000	0.083	1.424	0.355	0.000								1.863	15.543
4.2	166.96	0.000	0.100	1.899	0.711	0.000								2.710	16.390
4.8	190.81	0.000	0.117	2.373	1.066	0.272	0.000							3.828	17.508
5.4	214.66	0.000	0.134	2.848	1.422	0.544	0.000							4.947	18.627
6.0	238.51	0.000	0.150	3.322	1.777	0.816	0.215	0.000						6.280	19.960
6.6	262.36	0.000	0.167	3.797	2.132	1.088	0.429	0.000						7.613	21.293
7.2	286.22	0.000	0.184	4.272	2.488	1.360	0.644	0.231	0.000					9.178	22.858
7.8	310.07	0.000	0.200	4.746	2.843	1.631	0.859	0.463	0.000					10.743	24.423
8.4	333.92	0.000	0.217	5.221	3.198	1.903	1.073	0.694	0.196	0.000				12.503	26.183
9.0	357.77	0.000	0.234	5.696	3.554	2.175	1.288	0.925	0.391	0.000				14.263	27.943
9.6	381.62	0.000	0.250	6.170	3.909	2.447	1.503	1.157	0.587	0.208	0.000			16.231	29.911
10.2	405.47	0.000	0.267	6.645	4.265	2.719	1.717	1.388	0.782	0.415	0.000			18.199	31.879
10.8	429.32	0.000	0.284	7.120	4.620	2.991	1.932	1.620	0.978	0.623	0.217	0.000		20.383	34.063
11.4	453.17	0.000	0.301	7.594	4.975	3.263	2.147	1.851	1.173	0.830	0.434	0.000		22.568	36.248
12.10	481.00	0.000	0.317	8.069	5.331	3.535	2.361	2.082	1.369	1.038	0.651	0.114	0.000	24.867	38.547
12.6	469.09	0.000	0.337	8.544	5.686	3.807	2.576	2.314	1.565	1.245	0.868	0.229	0.000	27.169	40.849
13.2	454.81	0.000	0.328	9.018	6.042	4.079	2.791	2.545	1.760	1.453	1.085	0.343	0.114	29.558	43.238
13.8	440.52	0.000	0.318	9.572	6.397	4.350	3.005	2.776	1.956	1.660	1.302	0.458	0.229	32.024	45.704
14.4	426.23	0.000	0.308	9.335	6.752	4.622	3.220	3.008	2.151	1.868	1.519	0.572	0.343	33.700	47.380
15.0	411.95	0.000	0.298	9.051	7.167	4.894	3.435	3.239	2.347	2.075	1.736	0.687	0.458	35.387	49.067
15.6	397.66	0.000	0.288	8.766	6.989	5.166	3.649	3.470	2.543	2.283	1.953	0.801	0.572	36.482	50.162
16.2	383.37	0.000	0.278	8.482	6.777	5.483	3.864	3.702	2.738	2.490	2.170	0.916	0.687	37.587	51.267
16.8	369.08	0.000	0.268	8.198	6.564	5.348	4.079	3.933	2.934	2.698	2.388	1.030	0.801	38.240	51.920

17.4	354.80	0.000	0.258	7.913	6.351	5.185	4.329	4.164	3.129	2.905	2.605	1.145	0.916	38.901	52.581
18.0	340.51	0.000	0.248	7.629	6.138	5.022	4.222	4.396	3.325	3.113	2.822	1.259	1.030	39.204	52.884
18.6	326.22	0.000	0.238	7.345	5.925	4.859	4.093	4.666	3.520	3.320	3.039	1.374	1.145	39.524	53.204
19.2	311.94	0.000	0.228	7.060	5.712	4.696	3.965	4.550	3.716	3.528	3.256	1.488	1.259	39.459	53.139
19.8	297.65	0.000	0.218	6.776	5.499	4.533	3.836	4.412	3.944	3.735	3.473	1.603	1.374	39.404	53.084
20.4	283.36	0.000	0.208	6.492	5.286	4.370	3.708	4.273	3.847	3.943	3.690	1.717	1.488	39.022	52.702
21.0	269.07	0.000	0.198	6.208	5.074	4.208	3.579	4.134	3.729	4.185	3.907	1.832	1.603	38.656	52.336
21.6	254.79	0.000	0.188	5.923	4.861	4.045	3.450	3.996	3.612	4.081	4.124	1.946	1.717	37.944	51.624
22.2	240.50	0.000	0.178	5.639	4.648	3.882	3.322	3.857	3.495	3.957	4.377	2.061	1.832	37.247	50.927
22.8	226.21	0.000	0.168	5.355	4.435	3.719	3.193	3.719	3.378	3.833	4.269	2.175	1.946	36.189	49.869
23.4	211.93	0.000	0.158	5.070	4.222	3.556	3.065	3.580	3.261	3.708	4.139	2.309	2.061	35.129	48.809
24.0	197.64	0.000	0.148	4.786	4.009	3.393	2.936	3.442	3.144	3.584	4.009	2.252	2.175	33.877	47.557
24.6	183.35	0.000	0.138	4.502	3.796	3.230	2.807	3.303	3.026	3.460	3.879	2.183	2.309	32.634	46.314
25.2	169.06	0.000	0.128	4.217	3.583	3.067	2.679	3.164	2.909	3.335	3.749	2.114	2.252	31.199	44.879
25.8	154.78	0.000	0.118	3.933	3.371	2.905	2.550	3.026	2.792	3.211	3.619	2.046	2.183	29.753	43.433
26.4	140.49	0.000	0.108	3.649	3.158	2.742	2.422	2.887	2.675	3.087	3.489	1.977	2.114	28.308	41.988
27.0	126.20	0.000	0.098	3.364	2.945	2.579	2.293	2.749	2.558	2.962	3.359	1.909	2.046	26.862	40.542
27.6	111.92	0.000	0.088	3.080	2.732	2.416	2.164	2.610	2.441	2.838	3.229	1.840	1.977	25.416	39.096
28.2	97.63	0.000	0.078	2.796	2.519	2.253	2.036	2.471	2.324	2.714	3.099	1.772	1.909	23.970	37.650
28.8	83.34	0.000	0.068	2.511	2.306	2.090	1.907	2.333	2.206	2.590	2.969	1.703	1.840	22.524	36.204
29.4	69.05	0.000	0.058	2.227	2.093	1.927	1.779	2.194	2.089	2.465	2.839	1.634	1.772	21.078	34.758
30.0	54.77	0.000	0.048	1.943	1.880	1.764	1.650	2.056	1.972	2.341	2.709	1.566	1.703	19.632	33.312
30.6	40.48	0.000	0.038	1.658	1.668	1.602	1.522	1.917	1.855	2.217	2.579	1.497	1.634	18.187	31.867
31.2	26.19	0.000	0.028	1.374	1.455	1.439	1.393	1.779	1.738	2.092	2.449	1.429	1.566	16.741	30.421
31.8	11.91	0.000	0.018	1.090	1.242	1.276	1.264	1.640	1.621	1.968	2.319	1.360	1.497	15.295	28.975
32.3	0.00	0.000	0.008	0.806	1.029	1.113	1.136	1.501	1.503	1.844	2.189	1.292	1.429	13.849	27.529
33.0			0.000	0.521	0.816	0.950	1.007	1.363	1.386	1.719	2.059	1.223	1.360	12.405	26.085
33.6			0.000	0.237	0.603	0.787	0.879	1.224	1.269	1.595	1.929	1.154	1.292	10.969	24.649
34.2				0.000	0.390	0.624	0.750	1.086	1.152	1.471	1.799	1.086	1.223	9.580	23.260
34.8				0.000	0.177	0.461	0.621	0.947	1.035	1.347	1.668	1.017	1.154	8.429	22.109
35.4					0.000	0.299	0.493	0.808	0.918	1.222	1.538	0.949	1.086	7.313	20.993
36.0					0.000	0.136	0.364	0.670	0.801	1.098	1.408	0.880	1.017	6.374	20.054
36.6						0.000	0.236	0.531	0.683	0.974	1.278	0.812	0.949	5.463	19.143
37.2						0.000	0.107	0.393	0.566	0.849	1.148	0.743	0.880	4.687	18.367
37.8							0.000	0.254	0.449	0.725	1.018	0.674	0.812	3.933	17.613
38.4							0.000	0.115	0.332	0.601	0.888	0.606	0.743	3.285	16.965
39.0								0.000	0.215	0.476	0.758	0.537	0.674	2.661	16.341

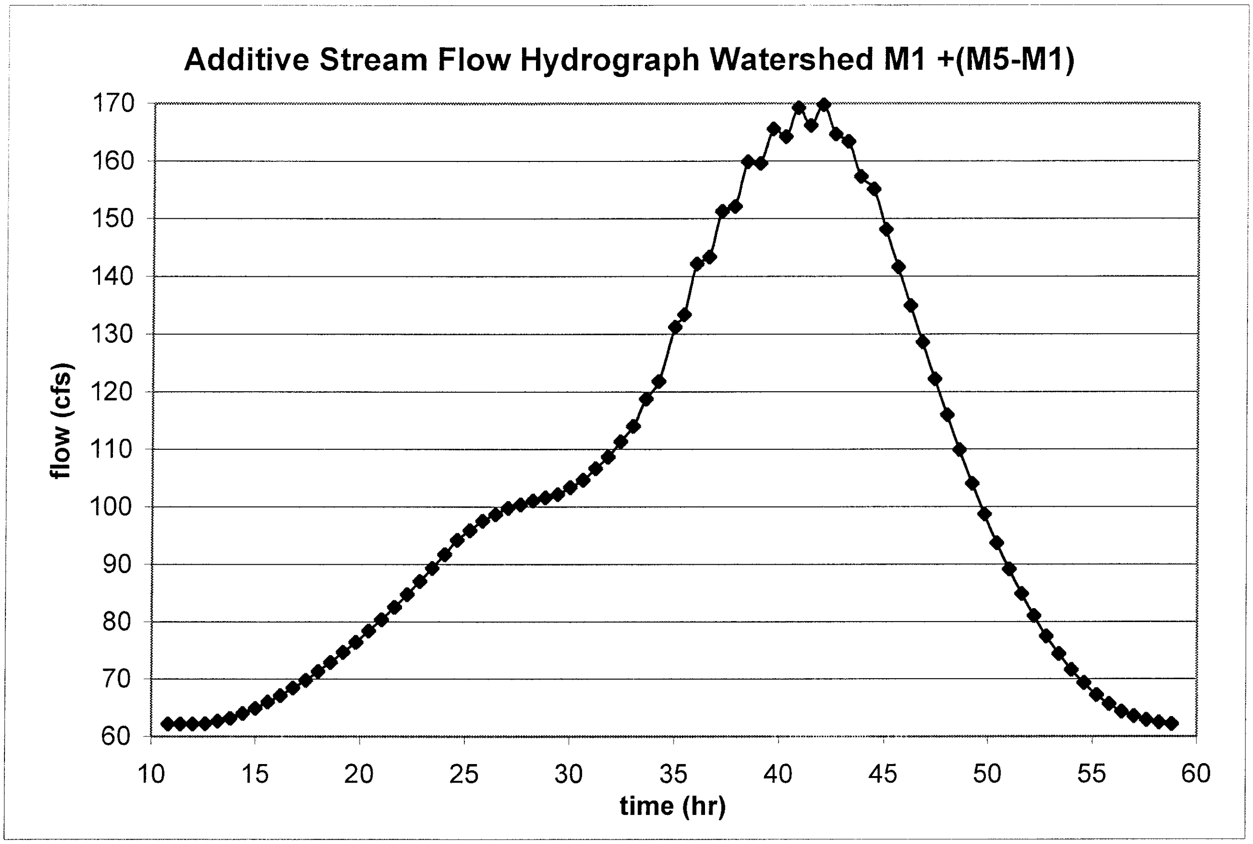
39.6								0.000	0.098	0.352	0.628	0.469	0.606	2.153	15.833
40.2									0.000	0.228	0.498	0.400	0.537	1.663	15.343
40.8									0.000	0.104	0.368	0.331	0.469	1.272	14.952
41.4										0.000	0.238	0.263	0.400	0.901	14.581
42.0										0.000	0.108	0.194	0.331	0.634	14.314
42.6											0.000	0.126	0.263	0.389	14.069
43.2											0.000	0.057	0.194	0.251	13.931
43.75												0.000	0.126	0.126	13.806
44.4												0.000	0.057	0.057	13.737
45.0													0.000	0.000	13.680
													SUM =	**1310.462**	**2350.142**


Watershed M5-M1 Stream Flow Hydrograph
(runoff starts at storm time = 10.8 hr, t = 0 hr)
flow (cfs)
time (hr)
55
50
45
40
35
30
25
20
15
10
0
5
10
15
20
25
30
35
40
45

Trail Creek Watershed Study
Additive Stream Flow Hydrograph
Watershed M1 + (M5-M1)
July 18, 2006
IN20040385

Storm Time (hr)	M1 Time (hr)	M1 Time Actual (hr)	Stream Flow from M1 (cfs)	M5-M1 Time (hr)	Stream Flow M5-M1 (cfs)	Sum (cfs) M1 + (M5-M1)
10.8	0		48.490	0	13.680	62.170
11.4	0		48.490	0.6	13.680	62.170
12.0	0		48.490	1.2	13.697	62.187
12.6	0.6		48.490	1.8	13.713	62.203
13.2	1.2		48.490	2.4	14.205	62.695
13.8	1.8		48.490	3.0	14.696	63.186
14.4	2.4		48.490	3.6	15.543	64.033
15.0	3.0		48.490	4.2	16.390	64.880
15.6	3.6		48.490	4.8	17.508	65.998
16.2	4.2		48.490	5.4	18.627	67.117
16.8	4.8		48.490	6.0	19.960	68.450
17.4	5.4		48.490	6.6	21.293	69.783
18.0	6.0		48.490	7.2	22.858	71.348
18.6	6.6		48.490	7.8	24.423	72.913
19.2	7.2		48.490	8.4	26.183	74.673
19.8	7.8		48.490	9.0	27.943	76.433
20.4	8.4		48.490	9.6	29.911	78.401
21.0	9.0		48.490	10.2	31.879	80.369
21.6	9.6		48.490	10.8	34.063	82.553
22.2	10.2		48.490	11.4	36.248	84.738
22.8	10.8		48.490	12.10	38.547	87.037
23.4	11.4		48.490	12.6	40.849	89.339
24.0	12.0		48.490	13.2	43.238	91.728
24.6	12.6		48.490	13.8	45.704	94.194
25.2	13.2		48.490	14.4	47.380	95.870
25.8	13.8		48.490	15.0	49.067	97.557
26.4	14.4		48.490	15.6	50.162	98.652
27.0	15.0		48.490	16.2	51.267	99.757
27.6	15.6	0	48.490	16.8	51.920	100.410
28.2	16.2	0.6	48.490	17.4	52.581	101.071
28.8	16.8	1.2	48.736	18.0	52.884	101.620
29.4	17.4	1.8	48.982	18.6	53.204	102.187
30.0	18.0	2.4	50.287	19.2	53.139	103.426
30.6	18.6	3.0	51.592	19.8	53.084	104.676
31.2	19.2	3.6	53.980	20.4	52.702	106.682
31.8	19.8	4.2	56.368	21.0	52.336	108.704
32.4	20.4	4.8	59.741	21.6	51.624	111.365
33.0	21.0	5.4	63.114	22.2	50.927	114.041
33.6	21.6	6.0	68.905	22.8	49.869	118.774
34.2	22.2	6.6	73.017	23.4	48.809	121.826
34.8	22.8	7.2			47.557	
34.96	23.0	7.36	83.666	24.0		131.223
35.4	23.4	7.8	87.055	24.6	46.314	133.369
36.0	24.0	8.4	97.312	25.2	44.879	142.192

36.6	24.6	9.0	99.974	25.8	43.433	143.407
37.2	25.2	9.6	109.321	26.4	41.988	151.309
37.8	25.8	10.2	111.611	27.0	40.542	152.152
38.4	26.4	10.8	120.799	27.6	39.096	159.895
39.0	27.0	11.4	121.935	28.2	37.650	159.585
39.6	27.6	12.0	129.320	28.8	36.204	165.524
40.2	28.2	12.6	129.483	29.4	34.758	164.241
40.8	28.8	13.2	135.920	30.0	33.312	169.233
41.4	29.4	13.8	134.293	30.6	31.867	166.159
42.0	30.0	14.4	139.286	31.2	30.421	169.707
42.6	30.6	15.0	135.711	31.8	28.975	164.686
43.10				32.3	27.529	
43.20	31.2	15.6	135.840			163.368
43.80	31.8	16.2	131.229	33.0	26.085	157.314
44.4	32.4	16.8	130.475	33.6	24.649	155.124
45.0	33.0	17.4	124.893	34.2	23.260	148.153
45.6	33.6	18.0	119.515	34.8	22.109	141.623
46.2	34.2	18.6	113.928	35.4	20.993	134.921
46.8	34.8	19.2	108.554	36.0	20.054	128.608
47.26	35.26	19.66	103.074			
47.4	35.4	19.8		36.6	19.143	122.217
48.0	36.0	20.4	97.628	37.2	18.367	115.995
48.6	36.6	21.0	92.295	37.8	17.613	109.908
49.2	37.2	21.6	87.110	38.4	16.965	104.075
49.8	37.8	22.2	82.411	39.0	16.341	98.752
50.4	38.4	22.8	77.863	39.6	15.833	93.695
51.0	39.0	23.4	73.811	40.2	15.343	89.155
51.6	39.6	24.0	69.898	40.8	14.952	84.850
52.2	40.2	24.6	66.436	41.4	14.581	81.017
52.8	40.8	25.2	63.132	42.0	14.314	77.446
53.4	41.4	25.8	60.348	42.6	14.069	74.416
54.0	42.0	26.4	57.704	43.2	13.931	71.636
54.6	42.6	27.0	55.524	43.75	13.806	69.330
55.2	43.2	27.6	53.502	44.4	13.737	67.239
55.8	43.8	28.2	51.999	45.0	13.680	65.679
56.4	44.4	28.8	50.665	45.6	13.680	64.345
57.0	45.0	29.4	49.884	46.2	13.680	63.564
57.6	45.6	30.0	49.193	46.8	13.680	62.873
58.2	46.2	30.6	48.795	47.4	13.680	62.475
58.8	46.8	31.2	48.490	48.0	13.680	62.170


Additive Stream Flow Hydrograph Watershed M1 +(M5-M1)
flow (cfs)
170
160
150
140
130
120
110
100
90
80
70
60
10
15
20
25
30
35
40
45
50
55
60
time (hr)

IN20040385 Trail Creek Watershed
July 18, 2006
Watershed M6 - Watershed M1
Curve Number & Runoff Check for Michigan City

Acres of Each Soil Type in Watershed

A	B	C	D	Null
1949.3	2071.26	1543.21	112.96	2837.8

Acres of Given Land Use for Each Soil Type

Land Use Type	Acres	% of M6-M1	A (ac)	B (ac)	C (ac)	D (ac)
Developed Agriculture Pasture/Grassland	892.58	10.48%	204.32	217.11	161.76	11.84
Developed Agriculture Row Crop	1062.06	12.47%	243.12	258.33	192.47	14.09
Developed Non-Vegetated	170.10	2.00%	38.94	41.37	30.83	2.26
Developed Urban High Density	1200.98	14.10%	274.92	292.12	217.65	15.93
Developed Urban Low Density	1347.48	15.82%	308.46	327.76	244.20	17.87
Palustrine Forest Deciduous	781.84	9.18%	178.98	190.17	141.69	10.37
Palustrine Herbaceous Deciduous	16.84	0.20%	3.85	4.10	3.05	0.22
Palustrine Shrubland Deciduous	0.00	0.00%	0.00	0.00	0.00	0.00
Palustrine Woodland Deciduous	3.15	0.04%	0.72	0.77	0.57	0.04
Terrestrial Forest Deciduous	2741.68	32.20%	627.61	666.88	496.86	36.37
Terrestrial Forest Evergreen	0.00	0.00%	0.00	0.00	0.00	0.00
Terrestrial Forest Mixed	2.90	0.03%	0.66	0.71	0.53	0.04
Terrestrial Shrubland Deciduous	97.84	1.15%	22.40	23.80	17.73	1.30
Terrestrial Woodland Deciduous	126.32	1.48%	28.92	30.73	22.89	1.68
Unclassified Cloud/Shadow	0.00	0.00%	0.00	0.00	0.00	0.00
Water	71.64	0.84%	16.40	17.43	12.98	0.95
TOTAL	8515.40	100.00%				

Curve Number for Each Land Use

Land Use Type	A	B	C	D
Developed Agriculture Pasture/Grassland	49	69	79	84
Developed Agriculture Row Crop	49	69	79	84
Developed Non-Vegetated	89	92	94	95
Developed Urban High Density	89	92	94	95
Developed Urban Low Density	51	68	79	84
Palustrine Forest Deciduous	25	55	70	77
Palustrine Herbaceous Deciduous	25	55	70	77
Palustrine Shrubland Deciduous	30	58	71	78
Palustrine Woodland Deciduous	25	55	70	77
Terrestrial Forest Deciduous	25	55	70	77
Terrestrial Forest Evergreen	25	55	70	77
Terrestrial Forest Mixed	45	66	77	83
Terrestrial Shrubland Deciduous	30	58	71	78
Terrestrial Woodland Deciduous	25	55	70	77
Unclassified Cloud/Shadow	25	55	70	77
Water	72	82	87	89

Curve Number x Acres of Land Use for Each Soil Type

Land Use Type	A (ac)	B (ac)	C (ac)	D (ac)	Sums
Developed Agriculture Pasture/Grassland	10011.86	14980.41	12778.86	994.59	38765.73
Developed Agriculture Row Crop	11912.91	17824.89	15205.31	1183.44	46126.56
Developed Non-Vegetated	3465.52	3806.47	2897.69	214.36	10384.04
Developed Urban High Density	24468.02	26875.26	20458.94	1513.49	73315.70
Developed Urban Low Density	15731.40	22287.54	19291.71	1501.49	58812.15
Palustrine Forest Deciduous	4474.39	10459.55	9918.33	798.60	25650.87
Palustrine Herbaceous Deciduous	96.37	225.28	213.62	17.20	552.47
Palustrine Shrubland Deciduous	0.00	0.00	0.00	0.00	0.00
Palustrine Woodland Deciduous	18.02	42.13	39.95	3.22	103.32
Terrestrial Forest Deciduous	15690.25	36678.25	34780.38	2800.44	89949.32
Terrestrial Forest Evergreen	0.00	0.01	0.01	0.00	0.02
Terrestrial Forest Mixed	29.88	46.57	40.48	3.19	120.13
Terrestrial Shrubland Deciduous	671.88	1380.23	1258.85	101.23	3412.19
Terrestrial Woodland Deciduous	722.90	1689.88	1602.44	129.02	4144.23
Unclassified Cloud/Shadow	0.00	0.00	0.00	0.00	0.00
Water	1180.74	1428.87	1129.50	84.58	3823.68

Total Sum:	355160.42
Total Acres:	5677.60
Composite Number:	62.55
Flow Rate:	

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M6 - Watershed M1
Curve Number & Runoff Check for Michigan City

Base Flow

Watershed	Area (ac)	Area (mi^2)	Annual Runoff (ft^3)	Annual Flow (cfs)	Base Flow (cfs)
M6-M1	8515.40	13.31	582,670,503	18.48	14.04

Hydrograph Calculations

Watershed	Travel Length, L (ft)	Beginning Elevation (ft)	Ending Elevation (ft)	Slope (ft/ft)	*Velocity, v (ft/s)	Area, A_m (mi^2)	Time of Concentr-ation, t_c (hr)	ΔD (hr)	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M6-M1	44,251	695	585	0.002	0.5	13.31	24.58	3.27	16.39	393	43.75	27.36

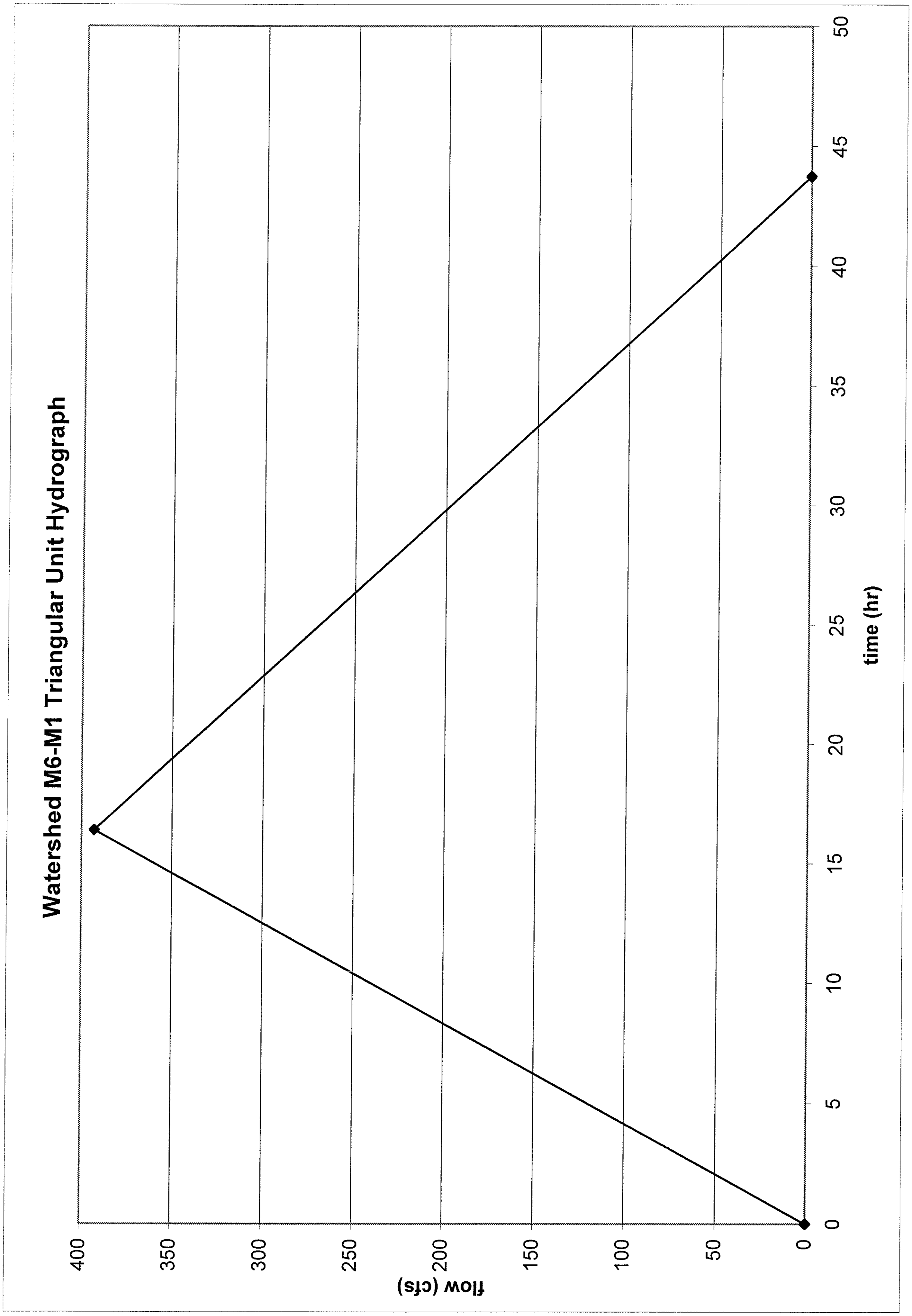
*Any watershed with a slop less than 0.005 has a velocity less than 1 ft/s. It was assumed that slope = 0.004 has a velocity of 0.8 ft/s and slope = 0.002 has a velocity of 0.5 ft/s.

Unit Hydrograph Calculations

Watershed	Time to Peak, t_p (hr)	Peak Flow, q_p (cfs)	Base Time, t_b (hr)	Recession Time, t_r (hr)
M6-M1	16.39	393	43.75	27.36

Watershed M6-M1

Time (hr)	Flow (cfs)
0	0
16.39	393
43.75	0


Watershed M6-M1 Triangular Unit Hydrograph
flow (cfs)
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
50
time (hr)

Trail Creek Watershed
July 18, 2006
IN20040385
Watershed M6 - Watershed M1
SCS Type II Distribution

Watershed M6-M1, S = 5.99, 0.2S = 1.20

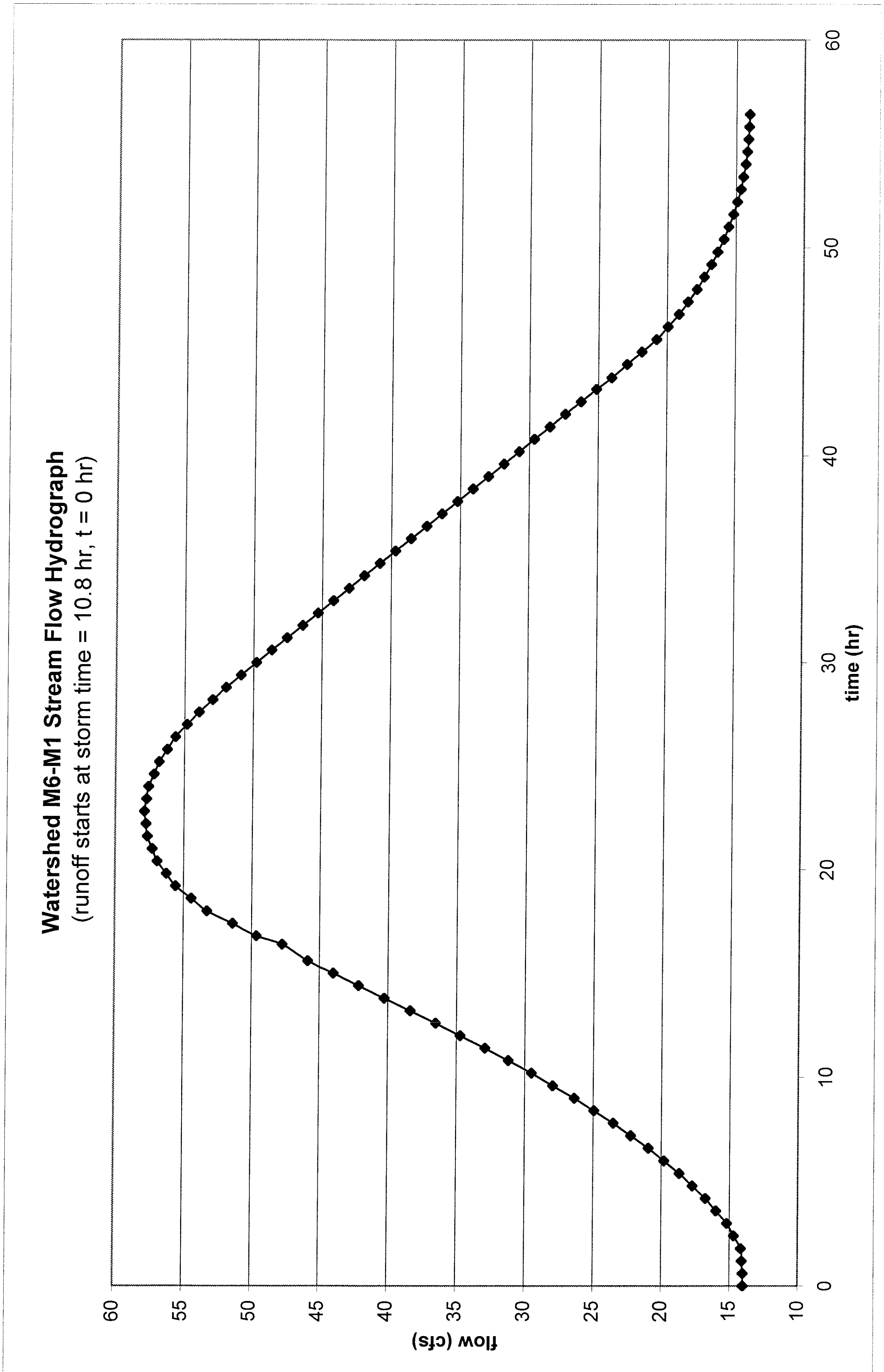
Time/Total Time	Time (hr)	Rainfall/Total Rainfall	Cummulative Depth (in)	Cummulative Runoff (in)	Incremental Runoff (in)
0.000	0.00	0.000	0.000	0	0
0.040	0.96	0.010	0.021	0	0
0.100	2.40	0.025	0.054	0	0
0.150	3.60	0.040	0.086	0	0
0.200	4.80	0.060	0.129	0	0
0.250	6.00	0.080	0.172	0	0
0.300	7.20	0.100	0.215	0	0
0.330	7.92	0.120	0.258	0	0
0.350	8.40	0.130	0.279	0	0
0.380	9.12	0.150	0.322	0	0
0.400	9.60	0.165	0.354	0	0
0.420	10.08	0.190	0.408	0	0
0.430	10.32	0.200	0.430	0	0
0.440	10.56	0.210	0.451	0	0
0.450	10.80	0.220	0.473	0	0
0.460	11.04	0.230	0.494	0	0
0.470	11.28	0.260	0.558	0	0
0.480	11.52	0.300	0.644	0	0
0.485	11.64	0.340	0.730	0	0
0.487	11.69	0.370	0.795	0	0
0.490	11.76	0.500	1.074	0	0
0.500	12.00	0.640	1.375	0.0051	0.0051
0.520	12.48	0.730	1.568	0.0215	0.0165
0.530	12.72	0.750	1.611	0.0266	0.0051
0.540	12.96	0.770	1.654	0.0323	0.0056
0.550	13.20	0.780	1.675	0.0352	0.0030
0.560	13.44	0.800	1.718	0.0416	0.0064
0.570	13.68	0.810	1.740	0.0450	0.0034
0.580	13.92	0.820	1.761	0.0484	0.0035
0.600	14.40	0.835	1.794	0.0539	0.0054
0.630	15.12	0.860	1.847	0.0635	0.0096
0.650	15.60	0.870	1.869	0.0675	0.0041
0.670	16.08	0.880	1.890	0.0717	0.0042
0.700	16.80	0.895	1.922	0.0782	0.0065
0.720	17.28	0.910	1.955	0.0849	0.0067
0.750	18.00	0.920	1.976	0.0895	0.0046
0.770	18.48	0.930	1.998	0.0942	0.0047
0.800	19.20	0.940	2.019	0.0990	0.0048
0.830	19.92	0.950	2.041	0.1039	0.0049
0.850	20.40	0.960	2.062	0.1089	0.0050
0.870	20.88	0.970	2.084	0.1141	0.0051
0.900	21.60	0.980	2.105	0.1193	0.0052
0.950	22.80	0.990	2.127	0.1246	0.0053
1.000	24.00	1.000	2.148	0.1300	0.0054

Trail Creek Watershed Study
July 18, 2006
IN20040385
Watershed M6-M1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 10.8 hr)												Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0 0	1.2 0.0051	2.4 0.0301	3.6 0.0187	4.8 0.0136	6 0.0107	7.2 0.0113	8.4 0.0095	9.6 0.0099	10.8 0.0104	12 0.0053	13.2 0.0054		
0	0.00	0.000												0.000	14.040
0.6	14.39	0.000	0.000											0.000	14.040
1.2	28.77	0.000	0.073	0.000										0.073	14.113
1.8	43.16	0.000	0.147	0.000										0.147	14.187
2.4	57.55	0.000	0.220	0.433	0.000									0.653	14.693
3.0	71.93	0.000	0.293	0.866	0.000									1.160	15.200
3.6	86.32	0.000	0.367	1.299	0.269	0.000								1.935	15.975
4.2	100.71	0.000	0.440	1.732	0.538	0.000								2.710	16.750
4.8	115.09	0.000	0.514	2.165	0.807	0.196	0.000							3.682	17.722
5.4	129.48	0.000	0.587	2.598	1.076	0.391	0.000							4.653	18.693
6.0	143.87	0.000	0.660	3.031	1.345	0.587	0.154	0.000						5.778	19.818
6.6	158.25	0.000	0.734	3.464	1.614	0.783	0.308	0.000						6.903	20.943
7.2	172.64	0.000	0.807	3.897	1.883	0.978	0.462	0.163	0.000					8.190	22.230
7.8	187.03	0.000	0.880	4.330	2.152	1.174	0.616	0.325	0.000					9.478	23.518
8.4	201.42	0.000	0.954	4.763	2.421	1.370	0.770	0.488	0.137	0.000				10.902	24.942
9.0	215.80	0.000	1.027	5.197	2.690	1.565	0.924	0.650	0.273	0.000				12.327	26.367
9.6	230.19	0.000	1.101	5.630	2.959	1.761	1.078	0.813	0.410	0.142	0.000			13.893	27.933
10.2	244.58	0.000	1.174	6.063	3.228	1.957	1.232	0.975	0.547	0.285	0.000			15.460	29.500
10.8	258.96	0.000	1.247	6.496	3.497	2.152	1.385	1.138	0.683	0.427	0.150	0.000		17.176	31.216
11.4	273.35	0.000	1.321	6.929	3.766	2.348	1.539	1.301	0.820	0.570	0.299	0.000		18.893	32.933
12.0	287.74	0.000	1.394	7.362	4.035	2.544	1.693	1.463	0.957	0.712	0.449	0.076	0.000	20.685	34.725
12.6	302.12	0.000	1.467	7.795	4.305	2.739	1.847	1.626	1.093	0.855	0.598	0.153	0.000	22.478	36.518
13.2	316.51	0.000	1.541	8.228	4.574	2.935	2.001	1.788	1.230	0.997	0.748	0.229	0.078	24.348	38.388
13.8	330.90	0.000	1.614	8.661	4.843	3.131	2.155	1.951	1.367	1.139	0.898	0.305	0.155	26.219	40.259
14.4	345.28	0.000	1.688	9.094	5.112	3.326	2.309	2.113	1.503	1.282	1.047	0.381	0.233	28.089	42.129
15.0	359.67	0.000	1.761	9.527	5.381	3.522	2.463	2.276	1.640	1.424	1.197	0.458	0.311	29.959	43.999
15.6	374.06	0.000	1.834	9.960	5.650	3.718	2.617	2.439	1.777	1.567	1.347	0.534	0.388	31.829	45.869
16.39	393.00	0.000	1.908	10.393	5.919	3.913	2.771	2.601	1.913	1.709	1.496	0.610	0.466	33.700	47.740
16.8	387.11	0.000	2.004	10.826	6.188	4.109	2.925	2.764	2.050	1.852	1.646	0.686	0.544	35.593	49.633

17.4	378.49	0.000	1.974	11.259	6.457	4.305	3.079	2.926	2.187	1.994	1.795	0.763	0.622	37.360	51.400
18.0	369.87	0.000	1.930	11.829	6.726	4.500	3.233	3.089	2.323	2.136	1.945	0.839	0.699	39.250	53.290
18.6	361.25	0.000	1.886	11.652	6.995	4.696	3.387	3.251	2.460	2.279	2.095	0.915	0.777	40.393	54.433
19.2	352.64	0.000	1.842	11.393	7.349	4.892	3.541	3.414	2.597	2.421	2.244	0.991	0.855	41.538	55.578
19.8	344.02	0.000	1.798	11.133	7.239	5.087	3.695	3.577	2.733	2.564	2.394	1.068	0.932	42.220	56.260
20.4	335.40	0.000	1.754	10.874	7.078	5.345	3.848	3.739	2.870	2.706	2.544	1.144	1.010	42.912	56.952
21.0	326.78	0.000	1.711	10.614	6.917	5.265	4.002	3.902	3.007	2.849	2.693	1.220	1.088	43.267	57.307
21.6	318.16	0.000	1.667	10.355	6.755	5.147	4.205	4.064	3.144	2.991	2.843	1.296	1.165	43.633	57.673
22.2	309.54	0.000	1.623	10.096	6.594	5.030	4.142	4.227	3.280	3.133	2.992	1.373	1.243	43.733	57.773
22.8	300.93	0.000	1.579	9.836	6.433	4.913	4.050	4.441	3.417	3.276	3.142	1.449	1.321	43.856	57.896
23.4	292.31	0.000	1.535	9.577	6.272	4.796	3.958	4.374	3.554	3.418	3.292	1.525	1.398	43.698	57.738
24.0	283.69	0.000	1.491	9.317	6.111	4.679	3.865	4.277	3.733	3.561	3.441	1.601	1.476	43.553	57.593
24.6	275.07	0.000	1.447	9.058	5.950	4.561	3.773	4.180	3.678	3.703	3.591	1.678	1.554	43.171	57.211
25.2	266.45	0.000	1.403	8.798	5.788	4.444	3.681	4.082	3.596	3.891	3.741	1.754	1.631	42.809	56.849
25.8	257.83	0.000	1.359	8.539	5.627	4.327	3.589	3.985	3.514	3.832	3.890	1.830	1.709	42.201	56.241
26.4	249.22	0.000	1.315	8.280	5.466	4.210	3.497	3.887	3.432	3.747	4.087	1.906	1.787	41.614	55.654
27.0	240.60	0.000	1.271	8.020	5.305	4.093	3.404	3.790	3.350	3.662	4.026	1.983	1.865	40.768	54.808
27.6	231.98	0.000	1.227	7.761	5.144	3.975	3.312	3.693	3.268	3.576	3.936	2.083	1.942	39.918	53.958
28.2	223.36	0.000	1.183	7.501	4.983	3.858	3.220	3.595	3.186	3.491	3.847	2.052	2.020	38.936	52.976
28.8	214.74	0.000	1.139	7.242	4.821	3.741	3.128	3.498	3.104	3.406	3.757	2.006	2.122	37.965	52.005
29.4	206.12	0.000	1.095	6.983	4.660	3.624	3.035	3.400	3.023	3.320	3.667	1.960	2.090	36.859	50.899
30.0	197.51	0.000	1.051	6.723	4.499	3.507	2.943	3.303	2.941	3.235	3.578	1.915	2.044	35.738	49.778
30.6	188.89	0.000	1.007	6.464	4.338	3.389	2.851	3.206	2.859	3.150	3.488	1.869	1.997	34.618	48.658
31.2	180.27	0.000	0.963	6.204	4.177	3.272	2.759	3.108	2.777	3.064	3.399	1.823	1.951	33.498	47.538
31.8	171.65	0.000	0.919	5.945	4.016	3.155	2.667	3.011	2.695	2.979	3.309	1.778	1.904	32.377	46.417
32.4	163.03	0.000	0.875	5.685	3.855	3.038	2.574	2.914	2.613	2.894	3.219	1.732	1.858	31.257	45.297
33.0	154.41	0.000	0.831	5.426	3.693	2.920	2.482	2.816	2.531	2.809	3.130	1.686	1.811	30.137	44.177
33.6	145.79	0.000	0.788	5.167	3.532	2.803	2.390	2.719	2.449	2.723	3.040	1.641	1.765	29.016	43.056
34.2	137.18	0.000	0.744	4.907	3.371	2.686	2.298	2.621	2.368	2.638	2.950	1.595	1.718	27.896	41.936
34.8	128.56	0.000	0.700	4.648	3.210	2.569	2.206	2.524	2.286	2.553	2.861	1.549	1.672	26.775	40.815
35.4	119.94	0.000	0.656	4.388	3.049	2.452	2.113	2.427	2.204	2.467	2.771	1.504	1.625	25.655	39.695
36.0	111.32	0.000	0.612	4.129	2.888	2.334	2.021	2.329	2.122	2.382	2.681	1.458	1.578	24.535	38.575
36.6	102.70	0.000	0.568	3.870	2.726	2.217	1.929	2.232	2.040	2.297	2.592	1.412	1.532	23.414	37.454
37.2	94.08	0.000	0.524	3.610	2.565	2.100	1.837	2.134	1.958	2.211	2.502	1.367	1.485	22.294	36.334
37.8	85.47	0.000	0.480	3.351	2.404	1.983	1.744	2.037	1.876	2.126	2.413	1.321	1.439	21.173	35.213
38.4	76.85	0.000	0.436	3.091	2.243	1.866	1.652	1.940	1.794	2.041	2.323	1.275	1.392	20.053	34.093
39.0	68.23	0.000	0.392	2.832	2.082	1.748	1.560	1.842	1.713	1.955	2.233	1.229	1.346	18.933	32.973

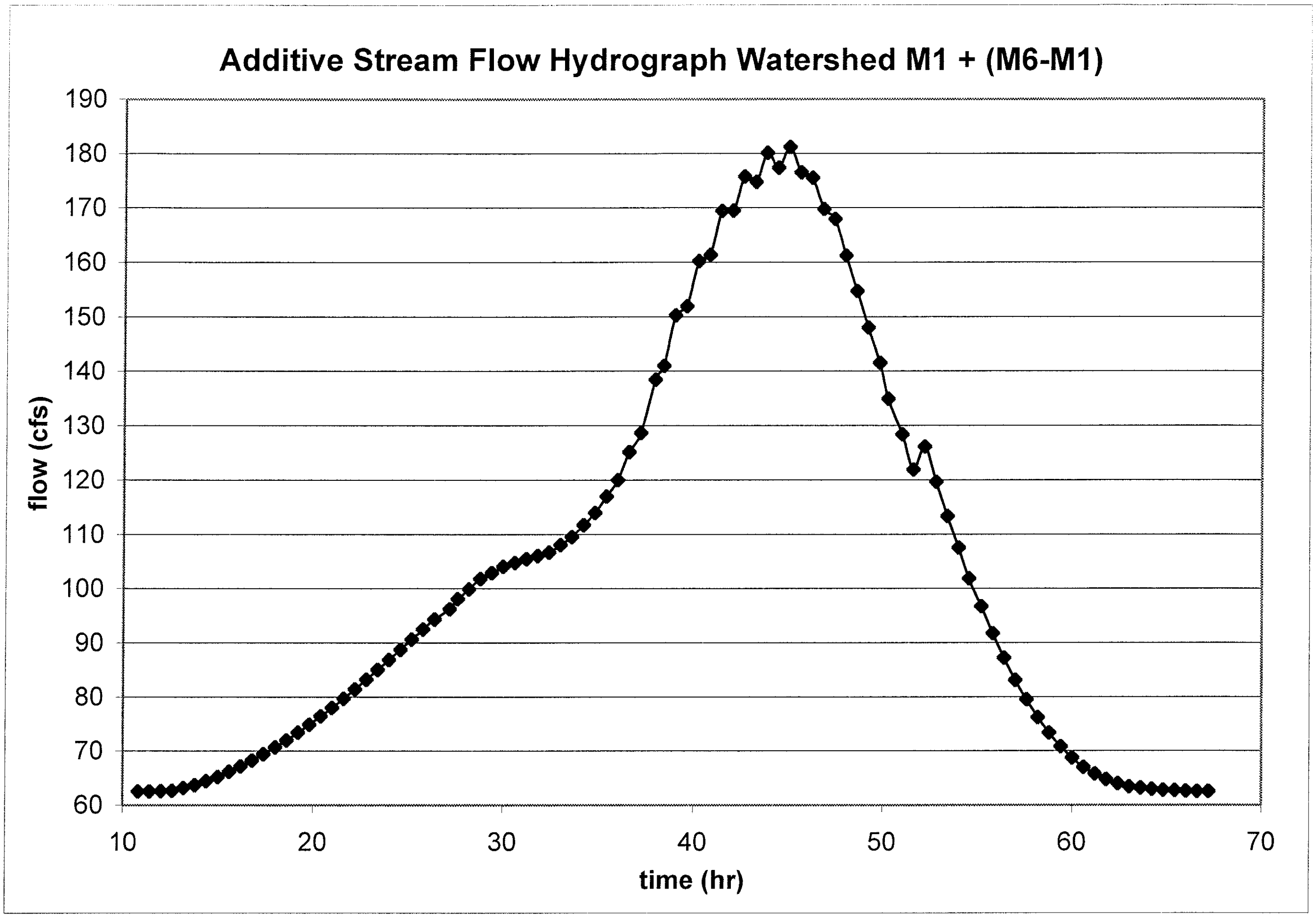
39.6	59.61	0.000	0.348	2.573	1.921	1.631	1.468	1.745	1.631	1.870	2.144	1.184	1.299	17.812	31.852
40.2	50.99	0.000	0.304	2.313	1.759	1.514	1.376	1.647	1.549	1.785	2.054	1.138	1.253	16.692	30.732
40.8	42.37	0.000	0.260	2.054	1.598	1.397	1.283	1.550	1.467	1.699	1.964	1.092	1.206	15.571	29.611
41.4	33.76	0.000	0.216	1.794	1.437	1.280	1.191	1.453	1.385	1.614	1.875	1.047	1.160	14.451	28.491
42.0	25.14	0.000	0.172	1.535	1.276	1.162	1.099	1.355	1.303	1.529	1.785	1.001	1.113	13.331	27.371
42.6	16.52	0.000	0.128	1.275	1.115	1.045	1.007	1.258	1.221	1.443	1.696	0.955	1.067	12.210	26.250
43.2	7.90	0.000	0.084	1.016	0.954	0.928	0.914	1.161	1.139	1.358	1.606	0.910	1.020	11.090	25.130
43.75	0.00	0.000	0.040	0.757	0.792	0.811	0.822	1.063	1.058	1.273	1.516	0.864	0.973	9.969	24.009
44.4			0.000	0.497	0.631	0.693	0.730	0.966	0.976	1.187	1.427	0.818	0.927	8.853	22.893
45.0			0.000	0.238	0.470	0.576	0.638	0.868	0.894	1.102	1.337	0.773	0.880	7.776	21.816
45.6				0.000	0.309	0.459	0.546	0.771	0.812	1.017	1.247	0.727	0.834	6.721	20.761
46.2				0.000	0.148	0.342	0.453	0.674	0.730	0.931	1.158	0.681	0.787	5.904	19.944
46.8					0.000	0.225	0.361	0.576	0.648	0.846	1.068	0.636	0.741	5.101	19.141
47.4					0.000	0.107	0.269	0.479	0.566	0.761	0.978	0.590	0.694	4.445	18.485
48.0						0.000	0.177	0.381	0.484	0.675	0.889	0.544	0.648	3.799	17.839
48.6						0.000	0.085	0.284	0.403	0.590	0.799	0.499	0.601	3.260	17.300
49.2							0.000	0.187	0.321	0.505	0.710	0.453	0.555	2.729	16.769
49.8							0.000	0.089	0.239	0.420	0.620	0.407	0.508	2.283	16.323
50.4								0.000	0.157	0.334	0.530	0.362	0.462	1.845	15.885
51.0								0.000	0.075	0.249	0.441	0.316	0.415	1.496	15.536
51.6									0.000	0.164	0.351	0.270	0.368	1.153	15.193
52.2									0.000	0.078	0.261	0.225	0.322	0.886	14.926
52.8										0.000	0.172	0.179	0.275	0.626	14.666
53.4										0.000	0.082	0.133	0.229	0.444	14.484
54.0											0.000	0.088	0.182	0.270	14.310
54.6											0.000	0.042	0.136	0.178	14.218
55.2												0.000	0.089	0.089	14.129
55.8												0.000	0.043	0.043	14.083
56.4													0.000	0.000	14.040
													SUM =	**1862.964**	**3196.764**


Watershed M6-M1 Stream Flow Hydrograph
(runoff starts at storm time = 10.8 hr, t = 0 hr)
flow (cfs)
time (hr)
10
15
20
25
30
35
40
45
50
55
60
0
10
20
30
40
50
60

Trail Creek Watershed Study
Additive Stream Flow Hydrograph
Watershed M1 + (M6-M1)
July 18, 2006
IN20040385

Storm Time (hr)	M1 Time (hr)	M1 Time Actual (hr)	Stream Flow from M1 (cfs)	M6-M1 Time (hr)	Stream Flow M6-M1 (cfs)	Sum (cfs) M1 + (M6-M1)
10.8	0.0		48.490	0	14.040	62.530
11.4	0.0		48.490	0.6	14.040	62.530
12.0	0.0		48.490	1.2	14.113	62.603
12.6	0.6		48.490	1.8	14.187	62.677
13.2	1.2		48.490	2.4	14.693	63.183
13.8	1.8		48.490	3.0	15.200	63.690
14.4	2.4		48.490	3.6	15.975	64.465
15.0	3.0		48.490	4.2	16.750	65.240
15.6	3.6		48.490	4.8	17.722	66.212
16.2	4.2		48.490	5.4	18.693	67.183
16.8	4.8		48.490	6.0	19.818	68.308
17.4	5.4		48.490	6.6	20.943	69.433
18.0	6.0		48.490	7.2	22.230	70.720
18.6	6.6		48.490	7.8	23.518	72.008
19.2	7.2		48.490	8.4	24.942	73.432
19.8	7.8		48.490	9.0	26.367	74.857
20.4	8.4		48.490	9.6	27.933	76.423
21.0	9.0		48.490	10.2	29.500	77.990
21.6	9.6		48.490	10.8	31.216	79.706
22.2	10.2		48.490	11.4	32.933	81.423
22.8	10.8		48.490	12.0	34.725	83.215
23.4	11.4		48.490	12.6	36.518	85.008
24.0	12.0		48.490	13.2	38.388	86.878
24.6	12.6		48.490	13.8	40.259	88.749
25.2	13.2		48.490	14.4	42.129	90.619
25.8	13.8		48.490	15.0	43.999	92.489
26.4	14.4		48.490	15.6	45.869	94.359
27.19	15.19		48.490	16.39	47.740	96.230
27.6	15.6		48.490	16.8	49.633	98.123
28.2	16.2		48.490	17.4	51.400	99.890
28.8	16.8		48.490	18.0	53.290	101.780
29.4	17.4		48.490	18.6	54.433	102.923
30.0	18.0		48.490	19.2	55.578	104.068
30.6	18.6	0.0	48.490	19.8	56.260	104.750
31.2	19.2	0.6	48.490	20.4	56.952	105.442
31.8	19.8	1.2	48.736	21.0	57.307	106.043
32.4	20.4	1.8	48.982	21.6	57.673	106.655
33.0	21.0	2.4	50.287	22.2	57.773	108.060
33.6	21.6	3.0	51.592	22.8	57.896	109.488
34.2	22.2	3.6	53.980	23.4	57.738	111.718
34.8	22.8	4.2	56.368	24.0	57.593	113.961
35.4	23.4	4.8	59.741	24.6	57.211	116.953
36.0	24.0	5.4	63.114	25.2	56.849	119.963
36.6	24.6	6.0	68.905	25.8	56.241	125.146
37.2	25.2	6.6	73.017	26.4	55.654	128.670
37.8	25.8	7.2		27.0	54.808	
37.96	25.96	7.36	83.666			138.473

38.4	26.4	7.8	87.055	27.6	53.958	141.013
39.0	27.0	8.4	97.312	28.2	52.976	150.289
39.6	27.6	9.0	99.974	28.8	52.005	151.978
40.2	28.2	9.6	109.321	29.4	50.899	160.220
40.8	28.8	10.2	111.611	30.0	49.778	161.389
41.4	29.4	10.8	120.799	30.6	48.658	169.458
42.0	30.0	11.4	121.935	31.2	47.538	169.473
42.6	30.6	12.0	129.320	31.8	46.417	175.737
43.2	31.2	12.6	129.483	32.4	45.297	174.780
43.8	31.8	13.2	135.920	33.0	44.177	180.097
44.4	32.4	13.8	134.293	33.6	43.056	177.349
45.0	33.0	14.4	139.286	34.2	41.936	181.222
45.6	33.6	15.0	135.711	34.8	40.815	176.527
46.2	34.2	15.6	135.840	35.4	39.695	175.535
46.8	34.8	16.2	131.229	36.0	38.575	169.804
47.4	35.4	16.8	130.475	36.6	37.454	167.929
48.0	36.0	17.4	124.893	37.2	36.334	161.226
48.6	36.6	18.0	119.515	37.8	35.213	154.728
49.2	37.2	18.6	113.928	38.4	34.093	148.021
49.8	37.8	19.2	108.554	39.0	32.973	141.527
50.26	38.26	19.66	103.074			
50.4	38.4	19.8		39.6	31.852	134.926
51.0	39.0	20.4	97.628	40.2	30.732	128.360
51.6	39.6	21.0	92.295	40.8	29.611	121.907
52.2	40.2	21.6	97.628	41.4	28.491	126.119
52.8	40.8	22.2	92.295	42.0	27.371	119.666
53.4	41.4	22.8	87.110	42.6	26.250	113.360
54.0	42.0	23.4	82.411	43.2	25.130	107.541
54.55				43.75	24.009	
54.6	66.6	24.0	77.863			101.872
55.2	43.2	24.6	73.811	44.4	22.893	96.704
55.8	43.8	25.2	69.898	45.0	21.816	91.714
56.4	44.4	25.8	66.436	45.6	20.761	87.197
57.0	45.0	26.4	63.132	46.2	19.944	83.076
57.6	45.6	27.0	60.348	46.8	19.141	79.488
58.2	46.2	27.6	57.704	47.4	18.485	76.189
58.8	46.8	28.2	55.524	48.0	17.839	73.363
59.4	47.4	28.8	53.502	48.6	17.300	70.802
60.0	48.0	29.4	51.999	49.2	16.769	68.768
60.6	48.6	30.0	50.665	49.8	16.323	66.988
61.2	49.2	30.6	49.884	50.4	15.885	65.769
61.8	49.8	31.2	49.193	51.0	15.536	64.728
62.4	50.4	31.8	48.795	51.6	15.193	63.988
63.0	51.0	32.4	48.490	52.2	14.926	63.416
63.6	51.6	33.0	48.490	52.8	14.666	63.156
64.2	52.2	33.6	48.490	53.4	14.484	62.974
64.8	52.8	34.2	48.490	54.0	14.310	62.800
65.4	53.4	34.8	48.490	54.6	14.218	62.708
66.0	54.0	35.4	48.490	55.2	14.129	62.619
66.6	54.6	36.0	48.490	55.8	14.083	62.573
67.2	55.2	36.6	48.490	56.4	14.040	62.530


Additive Stream Flow Hydrograph Watershed M1 + (M6-M1)
flow (cfs)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
10
20
30
40
50
60
70
time (hr)

Curve Number for the M6-M1 area: 62.55

$P(t) = 2.148''$

$S = \frac{1000}{62.55} - 10 = 5.99$

$0.2S = 1.20$

$R(t) = \frac{(2.148 - 0.2(5.99))^2}{2.148 + 0.8(5.99)} = 0.13''$

Triangular Unit Hydrograph $y = mx + b$

<u>M6-M1</u>

$m_1 = \frac{393-0}{16.39-0} = 23.978; \quad y = 23.978x$

$m_2 = \frac{0-393}{43.75-16.39} = {}^-14.364; \quad y = {}^-14.364x + b \quad ; \quad y = {}^-14.364x + 628.425$

$0 = {}^-14.364(43.75) + b$

$b = 628.425$

Base Flow at M6 = Base Flow at M1 + Base Flow for M6-M1
= 48.49 + 14.04
= 62.53 cfs

Peak Flow M1: t = 14.4 hr
storm t = 14.4 + 12 = 26.4 hr

Peak Flow M6-M1: t = 22.8 hr
storm t = 22.8 + 10.8 = 33.6 hr

Time for M1 to reach M6:

d = 81853 - 48133 LF = 33720 LF

Δelev = 605 - 585 = 20'

$S = \frac{20}{33720} = 0.000593$

V = 0.5 ft/s (assumed)

$t = \frac{d}{V} = \frac{33720 \text{ ft}}{0.5 \text{ ft/s}} = (67440 s)\left(\frac{min}{60 s}\right)\left(\frac{hr}{60 min}\right) = 18.73 \text{ hr}$

M1 peak flow reaches M6 at storm t = 26.4 + 18.73 = 45.13 hr (45 hr)

$CN = 60.43$

$P(t) = 2.148''$

$S = \frac{1000}{60.43} - 10 = 6.55$

$0.2S = 1.31$

$R(t) = \frac{(2.148 - 0.2(6.55))^2}{2.148 + 0.8(6.55)} = 0.095$

Triangular Unit Hydrograph $y = mx + b$

$m_1 = \frac{481 - 0}{12.10 - 0} = 39.7521$; $y = 39.7521x$

$m_2 = \frac{0 - 481}{32.3 - 12.1} = -23.8119$; $y = -23.8119x + b$; $y = -23.8119x + 769.1238$

$0 = -23.8119(32.3) + b$

$b = 769.1238$

Base Flow at M5 = Base Flow at M1 + Base Flow for M5-M1

= 48.49 + 12.68

= 61.17 cfs

Peak Flow M1: t = 14.4 hr

storm t = 14.4 + 12 = 26.4 hr

Peak Flow M5-M1: t = 19.2 hr

storm t = 19.2 + 10.8 = 30 hr

Time for M1 to reach M5

$d = 76531 - 48133 = 28398$ LF

$\Delta elev = 605 - 585 = 20'$

$S = \frac{20}{28398} = 0.000704$

$V = 0.5$ ft/s (assumed)

$t = \frac{d}{V} = \frac{28398}{0.5} = (56796 \text{ ft/s})\left(\frac{\text{min} \cdot \text{hr}}{3600 \text{ s} \cdot \text{min}}\right) = 15.78$ hr

M1 peak flow reaches M5 at storm t = 26.4 + 15.78 = 42.18 hr (42 hr)

CN = 59.99

P(t) = 2.148"

$S = \frac{1000}{59.99} - 10 = 6.67$

0.2S = 1.334

$R(t) = \frac{(2.148 - 0.2(6.67))^2}{2.148 - 0.8(6.67)} = 0.089"$

Triangular Unit Hydrograph y = mx + b

$m_1 = \frac{496-0}{11.28-0} = 43.9716$; y = 43.9716x

$m_2 = \frac{0-496}{30.11-11.28} = {}^{-}26.3409$; $y = {}^{-}26.3409x + b$; $y = {}^{-}26.3409x + 793.1259$

$0 = {}^{-}26.3409(30.11) + b$

$b = 793.1259$

Base Flow at M4 = Base Flow at M1 + Base Flow for M4-M1

= 48.49 + 12.21

= 60.70 cfs

Peak Flow M1: t = 14.4 hr

storm t = 14.4 + 12 = 26.4 hr

Peak Flow M4-M1: t = 18.0 hr

storm t = 18.0 + 10.8 = 28.8 hr

Time for M1 to reach M4

d = 73874 - 48133 = 25741 LF

Δelev = 605 - 590 = 15'

s = 15/25741 = 0.000583

V = 0.5 ft/s (assumed)

$t = \frac{d}{V} = \frac{25741}{0.5} = (51482\ s)\left(\frac{hr}{3600\ s}\right) = 14.30\ hr$

M1 peak flow reaches M4 at storm t = 26.4 + 14.30 = 40.7 hr (40.8)

$CN = 60.11$ $P(t) = 2.148''$

$S = \frac{1000}{60.11} - 10 = 6.64$

$0.2S = 1.327$

$R(t) = \frac{(2.148 - 0.2(6.64))^2}{2.148 + 0.8(6.64)} = 0.09''$

Triangular Unit Hydrograph

$m_1 = \frac{532-0}{10.29-0} = 51.7007$; $y = 51.7007X$

$m_2 = \frac{0-532}{27.49-10.29} = -30.9302$; $y = -30.9302x + b$; $y = -30.9302x + 850.2712$

$0 = (-30.9302)(27.49) + b$

$b = 850.2712$

Base Flow at m3 = Base Flow at m1 + Base Flow from m1-m3

= 48.49 + 11.93

= 60.42 cfs

Peak Flow m1 : t = 14.4 hr

storm t = 14.4 + 12 = 26.4 hr

Peak Flow m3-m1 : t = 16.8 hr

storm t = 16.8 + 10.8 = 27.6 hr

Time for m1 to reach m3:

$d = 70693 - 48133 = 22560$

$\Delta elev = 605 - 590 = 15'$

$s = \frac{15}{22560} = 0.000665$

v = 0.5 ft/s (assumed)

$t = \frac{d}{v} = \frac{22560 LF}{0.5 ft/s} = (45120s)\left(\frac{hr}{3600s}\right) = 12.53\ hr\ (12.6\ hr)$

m1 values start at storm t = 12 + 12.6 = 24.6 hr

peak = 24.6 + 14.4 = 39 hr

$CN = 63.41$ $P(t) = 2.148''$

$S = \frac{1000}{63.41} - 10 = 5.77$

$0.2S = 1.154$

$R(t) = \frac{(2.148 - 0.2(5.77))^2}{2.148 - 0.8(5.77)} = 0.146''$

Triangular Unit Hydrograph

$m_1 = \frac{772-0}{5.58-0} = 139.2473$; $y = 139.2473x$

$m_2 = \frac{0-772}{14.89-5.58} = -83.4586$; $y = -83.4586x + b$; $y = -83.4586x + 1242.6986$

$0 = -83.4586(14.89) + b$

$b = 1242.6986$

Base Flow at M2 = Base Flow at M1 + Base Flow from M1-M2
= 48.49 + 9.45
= 57.94 cfs

Peak Flow M1: t = 14.4 hr
storm t = 14.4 + 12 = 26.4 hr

Peak Flow M2: t = 10.8 hr
storm t = 10.8 + 10.8 = 21.6 hr

Time for M1 to reach M2:

d = 61431 - 48133 = 13298 LF

Δelev = 605 - 590 = 15'

$s = \frac{15}{13298} = 0.0011$

v = 1.6 ft/s

$t = \frac{d}{v} = \frac{13298}{1.6} = (10229\ s)\left(\frac{hr}{3600\ s}\right) = 2.84\ hr$ (3 hr)

M1 values start at storm t = 12 + 3 = 15 hr
peak = 15 + 14.4 = 29.4 hr

WWTP flows

$$\left(\frac{7.0\times10^6\ gal}{day}\right)\left(\frac{day}{24\ hr}\right)\left(\frac{hr}{60 min}\right)\left(\frac{1\ cfs}{448.831\ gpm}\right) = 10.83\ cfs$$

$$\left(\frac{12\times10^6\ gal}{day}\right)\left(\frac{day}{24\ hr}\right)\left(\frac{hr}{60 min}\right)\left(\frac{1\ cfs}{448.831\ gpm}\right) = 18.57\ cfs$$

Base Flow + WWTP Flow = Base Stream Flow w/WWTP included (base WWTP)
Peak Flow + WWTP Flow = Peak Stream Flow w/WWTP included (peak WWTP)

62.17 + 10.83 = 73.00 cfs
169.71 + 18.57 = 188.28 cfs

Sample Calcs apply to the following files:

P:/IN2004/0385/C. Calcs_Data/Studies and background information/Drainage Calcs/m2-m1.xls ← Used for sample calcs
m3-m1.xls
m4-m1.xls
m5-m1.xls
m6-m1.xls

Sheet m2-m1 calcs:

Land Use Type – from ArcView Data
Acres – Acres of each land use in the given watershed calculated in ArcView
A(ac), B(ac), C(ac), D(ac) = Acres of each soil type X % of watershed
A(ac) = 1114.31 X 0.1292 = 143.93 ac

A, B, C, D, Null – Acres of each soil type in watershed
For m2-m1 → A in m2 – A in m1 = A in m2-m1

Curve Numbers for Each Land Use A, B, C, D – Curve numbers for each soil type based on the land use designation. Assumptions for each land use based on attached Table 3.3.3 from the HERPICC Manual. A sheet is also attached with each assumption listed

Curve Number X Acres of Land use for each soil type
A(ac) = A(ac) from Acres of Given Land Use for Each Soil Type X Curve Number for the Land use
= 143.93 X 49 = 7052.71 ac
Sums = sum across the row
= 7052.71 + 13700.50 + 15104.74 + 943.31 = 36801.25 ac
Total sum = Sum of Sums Column
Total Acres = TOTAL from Acres of Given Land Use for Each Soil Type – Null acres
= 5733.41 – 1513.62 = 4219.79

Composite Number = $\frac{\text{Total Sum}}{\text{Total Acres}} = \frac{267590.40}{4219.79} = 63.41$

Sheet: M2-M1 calcs cont.

Base Flow

Area (ac) – from M2-M1 calcs

Area (mi²) = Area (ac) × $\frac{43560\ ft^2}{ac} \times \left(\frac{mi}{5280\ ft}\right)^2$

$= (5733.41\ ac)\left(\frac{43560\ ft^2}{ac}\right)\left(\frac{mi}{5280\ ft}\right)^2 = 8.96\ mi^2$

Annual Runoff (ft^3) = 18.85" × Area (mi^2) × 1'/12" × $(5280\ ft/mi)^2$

$= (18.85'')(8.96\ mi^2)\left(\frac{1'}{12''}\right)\left(\frac{5280\ ft}{mi}\right)^2 = 392{,}311{,}699\ ft^3$

- 18.85" is the annual runoff in Michigan City + was assumed to apply for the entire Trail Creek watershed

Annua Flow (cfs) = $\frac{\text{Annual runoff } (ft^3)}{31{,}536{,}000\ s} = \frac{392{,}311{,}699\ ft^3}{31{,}536{,}000\ s} = 12.44$ cfs

Base Flow = 0.76 × Annual Flow

= 0.76 × 12.44 = 9.45 cfs

- There are 31,536,000 s in 1 year
- The 1994 DNR Basin Study report p. 88 states that 76% of annual flow is base flow for Trail Creek. Also states the annual runoff is 18.85".
- 76% was assumed to apply to the entire watershed

Hydrograph Calculations

Travel length – measured in ArcView

Beginning/Ending elevation – identified in ArcView

Slope = $\frac{\text{Beginning} - \text{Ending elev.}}{\text{Travel Length}} = \frac{695' - 590'}{24{,}100\ LF} = 0.004$

Velocity – read off of Figure 3.4.5 from HERPICC manual. Figure attached. Assumptions on spreadsheet apply.

Area (mi²) – from Base Flow table

Time of Concentration, $t_c = \frac{L}{3600V} = \frac{24100\ LF}{(3600)(0.8\ ft/s)} = 8.37\ hr$

$\Delta D = 0.133\ t_c = 0.133(8.37) = 1.11\ hr$

$t_p = \frac{\Delta D}{2} + 0.6t_c = \frac{1.11}{2} + (0.6)(8.37) = 5.58\ hr$

$$q_p = 484 \times A_m \times \frac{Q'}{t_p} = \frac{(484)(8.96\,mi^2)(1'')}{5.58\,hr} = 777\ cfs$$

Q' = 1" (rainfall depth for unit hydrograph)

$t_b = 2.67\,t_p = 2.67(5.58) = 14.89$ hr

$t_r = 1.67\,t_p = 1.67(5.58) = 9.31$ hr

Unit Hydrograph Calculations – read from Hydrograph Calculations Table

Watershed M2-M1 – points for Hydrograph graph

Sheet: SCS Type II

Time/Total Time – ratio from attached Soil Conservation Service Type II storm distribution sheet

Time (hr) = (24 hr)(Time/Total Time) = (24)(0.040) = 0.96 hr

• Looking at 1yr 24 hr storm → duration is 24 hr

Rainfall/Total Rainfall – see Time/Total Time

Cummulative Depth (in) = (2.148")(Rainfall/Total Rainfall)
= (2.148)(0.010) = 0.021"

• 2.148" + S values are from separate rainfall calculations

Cummulative Runoff (in) = 0 if $P(t) < 0.2S$; P(t) = Cummulative Depth

$$= \frac{(P(t) - 0.2S)^2}{(P(t) + 0.8S)} \text{ if } P(t) > 0.2S$$

Incremental Runoff = Cummulative Runoff$_n$ – Cummulative Runoff$_{n-1}$
= 0.0277 – 0.0081 = 0.0196"

Sheet: M2-M1

see attached sheet for column explanations. Sample Calcs shown here

Row: Time = 2.4 hr

Unit Hydrograph = 334.19 cfs

(0.0081)(250.66) = 2.030 cfs

(0.0351)(83.55) = 2.933 cfs

Storm Hydrograph = 0 + 2.030 + 2.933 + 0 = 4.963 cfs

Stream Flow Hydrograph = Storm Hydrograph + Base Flow
= 4.963 + 9.450 = 14.413 cfs

Sheet: M1 + (M2-M1)

Storm time = hr since the storm has started

M1 time – M1 runoff starts at storm time = 10.8 hr so this is the time runoff has been flowing in M1
(Storm time – 12 hr)

M1 time actual = time that M1 runoff has reached M2. There is a delay b/c it takes time for M1 flows to reach sample point M2.
= M1 runoff start time + time for M1 to reach M2

= 12 + 3 = 15 hr

Stream flow from M1 – M1 stream flow hydrograph

M2-M1 time = time of runoff from M2-M1 which starts at storm time = 10.8 hr

Stream Flow M2-M1 → from M2-M1 Hydrograph

Sum M1 + (M2-M1) = Stream Flow M1 + Stream Flow M2-M1
= 48.490 + 10.127 = 58.617 cfs

Additive Stream Flow Hydrograph

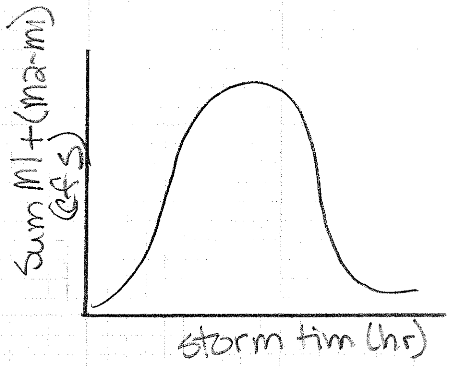


Table 3.3.3
Runoff Curve Numbers for Urban Areas (SCS, 1986)

Cover Type and Hydrologic Condition	Curve Numbers for Hydrologic Soil Group			
	A	B	C	D
Undeveloped Areas				
Cultivated Land				
Without conservation treatment	72	81	88	91
With conservation treatment	62	71	78	81
Pasture or range land				
Poor condition	68	79	86	89
Good condition	39	61	74	80
Meadow				
Good condition	30	58	71	78
Wood or forest land				
Thin stand, poor cover, no mulch	45	66	77	83
Good cover	25	55	70	77
Fully developed urban areas (with established vegetation)				
Open space (lawns, parks, golf courses, cemeteries)				
Poor condition (grass cover < 50%)	68	79	86	89
Fair condition (grass cover 50% to 75%)	49	69	79	84
Good condition (grass cover > 75%)	39	61	74	80
Impervious areas:				
Paved parking lots, roofs, driveways, etc (excluding right-of-way)	98	98	98	98
Streets and roads				
Paved curb and storm sewers (excluding right-of-way)	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Urban Districts				
Commercial and business (85% impervious)	89	92	94	95
Industrial (72% impervious)	81	88	91	93
Residential				
1/8 acre or less, townhouses (65% impervious)	77	85	90	92
1/4 acre (38% impervious)	61	75	83	87
1/3 acre (30% impervious)	57	72	81	86
1/2 acre (25% impervious)	54	70	80	85
1 acre (20% impervious)	51	68	79	84
2 acre	46	65	77	82
Developing Urban Areas				
Newly graded areas (no vegetation)	77	86	91	94

Table 3.3.4
Runoff Curve Numbers for Agricultural Lands (SCS, 1986)

Cover Type and Hydrologic Condition	Curve Numbers for Hydrologic Soil Group A	B	C	D
Pasture, grassland, or range with continous forage for grazing				
Poor	68	79	86	89
Fair	49	69	79	84
Good	39	61	74	80
Meadow with continuous grass, protected from grazing and generally mowed for hay	30	58	71	78
Brush/brush-weed-grass mixture with brush being the major element				
Poor	48	67	77	83
Fair	35	56	70	77
Good	30	48	65	73
Woods and grass combination (orchard or tree farm)				
Poor	57	73	82	86
Fair	43	65	76	82
Good	32	58	72	79
Woods				
Poor	45	66	77	83
Fair	36	60	73	79
Good	30	55	70	77
Farmsteads	59	74	82	86

The curve number method may also be used in determining the time distribution of the runoff. In this manual, the CN method is used in conjunction with the synthetic dimensionless and triangular unit hydrograph methods to determine the storm hydrograph. The procedure used in this operation is outlined below.

1. Determine the basin curve number.

2. Given the rainfall depth and storm duration, determine the time distribution of the rainfall This distribution can be the SCS Type II or Huff Distributions discussed in Chapter 2.

Watershed Land Use Types and the Corresponding Cover Type Assumptions for Curve Number Calculations

Developed Agriculture Pasture/Grassland	Pasture, grassland, or range with continuous forage for grazing
Developed Agriculture Row Crop	Pasture, grassland, or range with continuous forage for grazing
Developed Non-Vegetated	Urban: Commercial and Business
Developed Urban High Density	Urban: Commercial and Business
Developed Urban Low Density	Residential: 1 acre
Palustrine Forest Deciduous	Wood or Forest Land: good cover
Palustrine Herbaceous Deciduous	Wood or Forest Land: good cover
Palustrine Shrubland Deciduous	Meadow
Palustrine Woodland Deciduous	Wood or Forest Land: good cover
Terrestrial Forest Deciduous	Wood or Forest Land: good cover
Terrestrial Forest Evergreen	Wood or Forest Land: good cover
Terrestrial Forest Mixed	Wood or Forest Land: thin stand
Terrestrial Shrubland Deciduous	Meadow
Terrestrial Woodland Deciduous	Wood or Forest Land: good cover
Unclassified Cloud/Shadow	Highest % (Wood or Forest for E1)
Water	Dirt

- assume all unpaved
- W1, M3-M6 off of chart

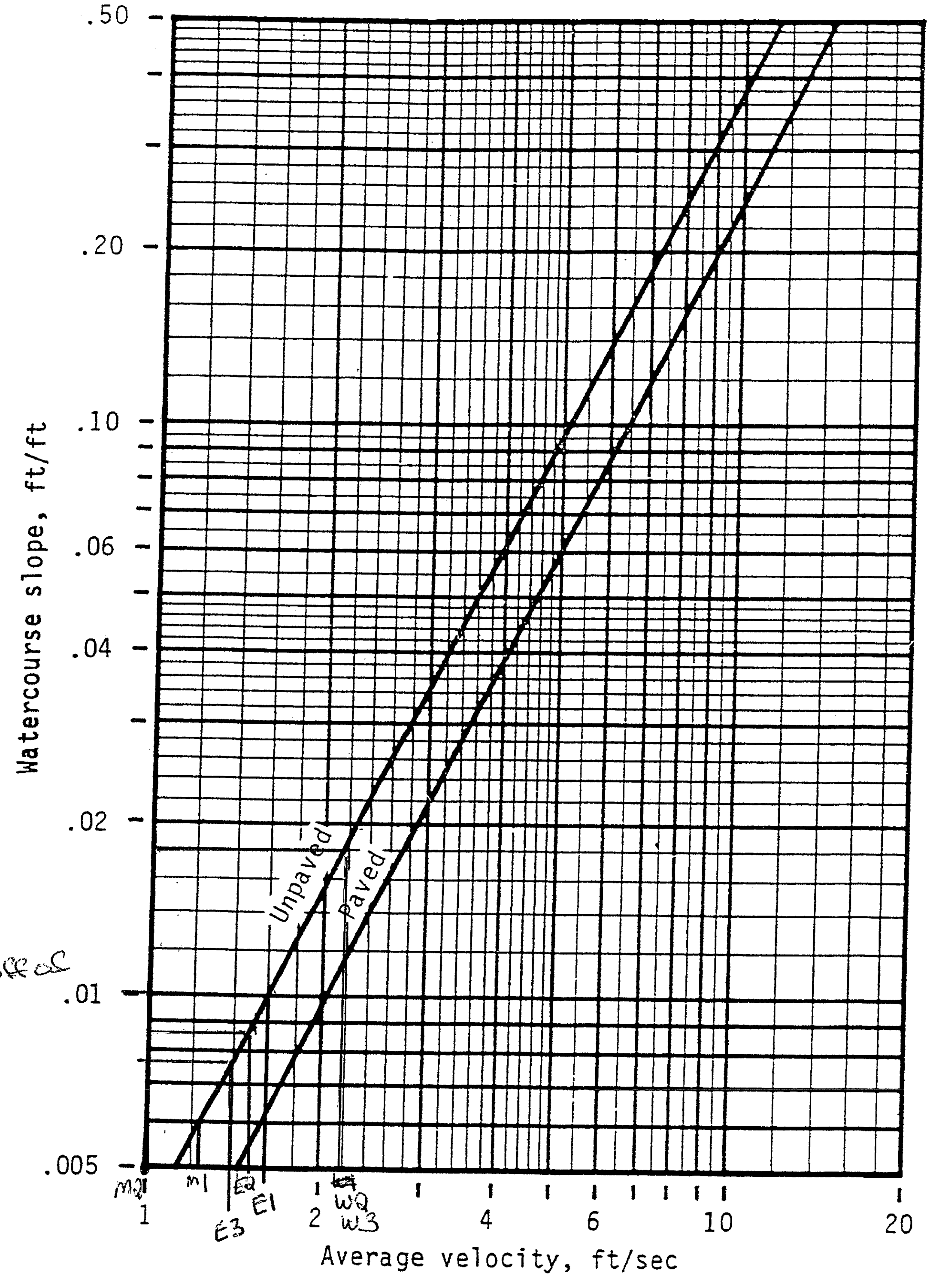
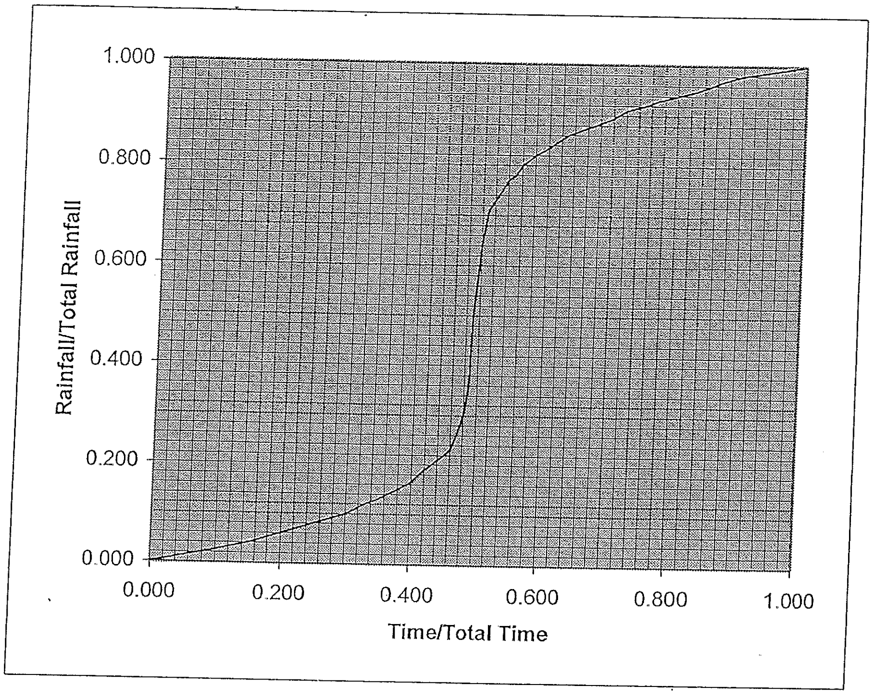


Figure 3.4.5
Average Velocities for Estimating Travel Time (SCS, 1986)

Soil Conservation Service Type II Storm Distribution



Time/Total Time	Rainfall/Total Rainfall	Time/Total Time	Rainfall/Total Rainfall
0.000	0.000	0.520	0.730
0.040	0.010	0.530	0.750
0.100	0.025	0.540	0.770
0.150	0.040	0.550	0.780
0.200	0.060	0.560	0.800
0.250	0.080	0.570	0.810
0.300	0.100	0.580	0.820
0.330	0.120	0.600	0.835
0.350	0.130	0.630	0.860
0.380	0.150	0.650	0.870
0.400	0.165	0.670	0.880
0.420	0.190	0.700	0.895
0.430	0.200	0.720	0.910
0.440	0.210	0.750	0.920
0.450	0.220	0.770	0.930
0.460	0.230	0.800	0.940
0.470	0.260	0.830	0.950
0.480	0.300	0.850	0.960
0.485	0.340	0.870	0.970
0.487	0.370	0.900	0.980
0.490	0.500	0.950	0.990
0.500	0.640	1.000	1.000

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed E1 Hydrograph Calculations

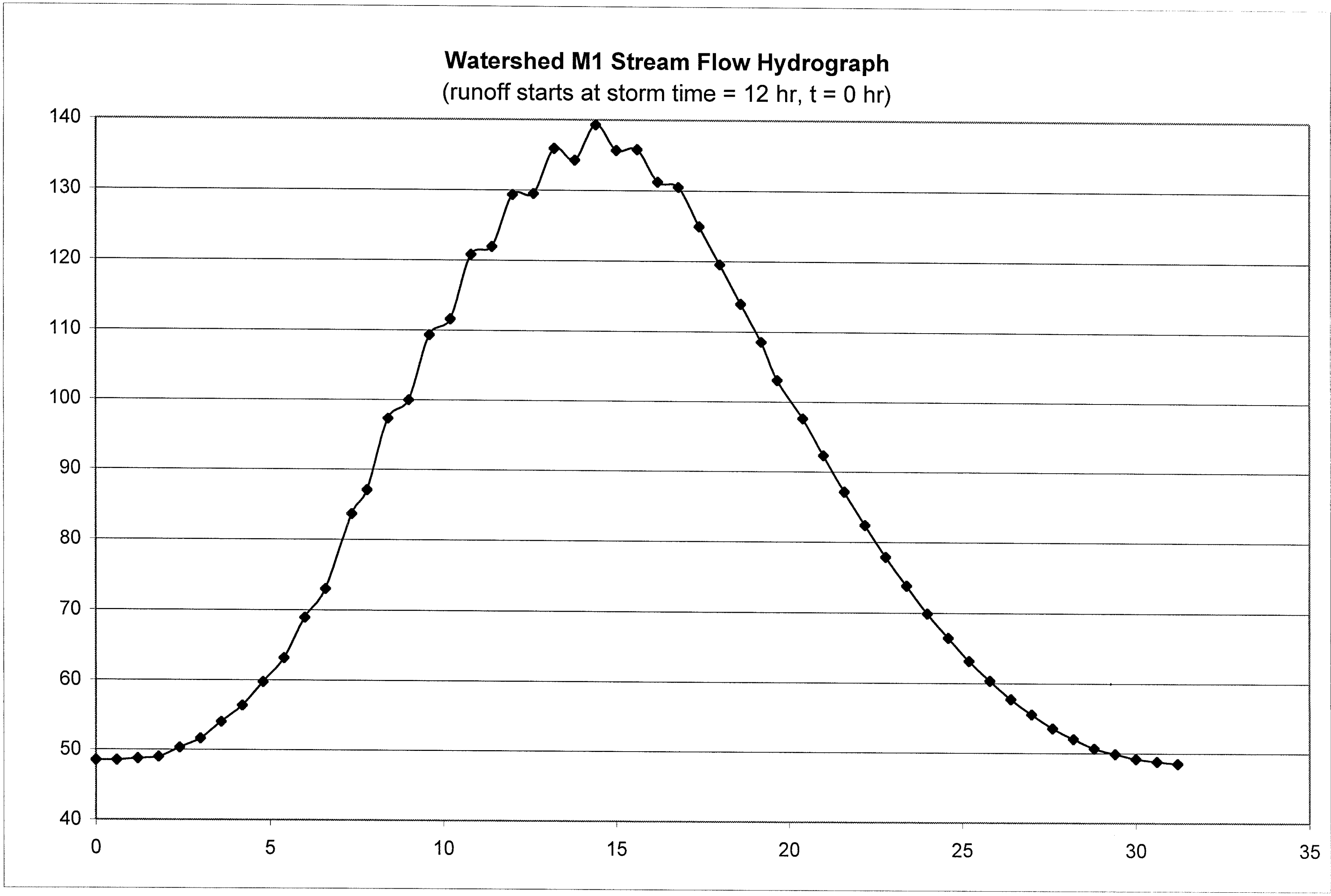
Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (starts at storm time x hr so Time = 0 is Storm Time = 12 hr when runoff											Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8	12		
		0	0.0005	0.0034	0.0039	0.0036	0.0042	0.0038	0.0042	0.0046	0.0024	0.0025		
0	0.00	0.000											0.000	13.020
0.6	375.15	0.000	0.000										0.000	13.020
1.2	750.29	0.000	0.188	0.000									0.188	13.208
1.8	1125.44	0.000	0.375	0.000									0.375	13.395
2.4	1500.58	0.000	0.563	1.275	0.000								1.838	14.858
3.09	1932.00	0.000	0.750	2.551	0.000								3.301	16.321
3.6	1741.05	0.000	0.966	3.826	1.463	0.000							6.256	19.276
4.2	1516.39	0.000	0.871	5.102	2.926	0.000							8.899	21.919
4.8	1291.74	0.000	0.758	6,569	4.389	1.351	0.000						13.067	26.087
5.4	1067.09	0.000	0.646	5.920	5.852	2.701	0.000						15.119	28.139
6	842.44	0.000	0.534	5.156	7.535	4.052	1.576	0.000					18.851	31.871
6.6	617.79	0.000	0.421	4.392	6.790	5.402	3.151	0.000					20.157	33.177
7.2	393.14	0.000	0.309	3:628	5.914	6.955	4.727	1.426	0.000				22.959	35.979
8.25	0.00	0.000	0.197	2.864	5.038	6.268	6.302	2.851	0.000				23.520	36.540
8.4		0.000	0.000	2,100	4.162	5.459	8.114	4.277	1.576	0.000			25.688	38.708
9			0.000	1.337	3.286	4.650	7.312	5.702	3.151	0.000			25.438	38.458
9.6				0.000	2.409	3.842	6.369	7.342	4.727	1.726	0.000		26.414	39.434
10.2				0.000	1.533	3.033	5.425	6.616	6.302	3.451	0.000		26.361	39.381
10.8					0.000	2.224	4.482	5.762	8.114	5.177	0.900	0.000	26.660	39.680
12					0.000	1.415	3.538	4.909	7.312	6.903	1.801	0.000	25.878	38.898
12.6						0.000	2.595	4.055	6.369	8.887	2.701	0.938	25.545	38.565
13.2						0.000	1.651	3.201	5.425	8.009	3.601	1.876	23.764	36.784
13.8							0.000	2.348	4.482	6.975	4.637	2.814	21.255	34.275
14.4							0.000	1.494	3.538	5.942	4.179	3.751	18.904	31.924
15								0.000	2.595	4.909	3.639	4.830	15.973	28.993
15.6								0.000	1.651	3.875	3.100	4.353	12.979	25.999
16.2									0.000	2.842	2.561	3.791	9.194	22.214
16.8									0.000	1.808	2.022	3.229	7.060	20.080
17.4										0.000	1.483	2.668	4.150	17.170
18										0.000	0.944	2.106	3.050	16.070
18.6											0.000	1.544	1.544	14.564
19.2											0.000	0.983	0.983	14.003
19.8												0.000	0.000	13.020
												SUM =	435.368	865.028

12 hr into storm when runoff starts →
interval is about hr
end of 24 hr storm →
0.0005 x 375.15
0.0005 x 750.29
0.0034 x 375.15
0.0034 x 750.29
0.0034 x 393.14
interval = 1.2 hr
interval is 1.2 hr b/c constant interval is needed
Σ across row
storm flow + base flow
← peak flow

Trail Creek Watershed Study
July 12, 2006
IN20040385
Watershed M1 Hydrograph Calculations

Time (hr)	Unit Hydrograph (cfs)	Excess Precipitation (in) (Time = 0 is when runoff starts at 12 hr)											Storm Hydrograph (cfs)	Stream Flow Hydrograph (cfs)
		0	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8	12		
		0	0.001	0.0043	0.0044	0.004	0.0046	0.0041	0.0046	0.0049	0.0026	0.0027		
0	0.00	0.000											0.000	48.490
0.6	246.20	0.000	0.000										0.000	48.490
1.2	492.39	0.000	0.246	0.000									0.246	48.736
1.8	738.59	0.000	0.492	0.000									0.492	48.982
2.4	984.78	0.000	0.739	1.059	0.000								1.797	50.287
3.0	1230.98	0.000	0.985	2.117	0.000								3.102	51.592
3.6	1477.17	0.000	1.231	3.176	1.083	0.000							5.490	53.980
4.2	1723.37	0.000	1.477	4.235	2.167	0.000							7.878	56.368
4.8	1969.57	0.000	1.723	5.293	3.250	0.985	0.000						11.251	59.741
5.4	3501.24	0.000	1.970	6.352	4.333	1.970	0.000						14.624	63.114
6.0	3353.92	0.000	3.501	7.410	5.416	2.954	1.133	0.000					20.415	68.905
6.6	3206.60	0.000	3.354	8.469	6.500	3.939	2.265	0.000					24.527	73.017
7.36	3020.00	0.000	3.207	15.055	7.583	4.924	3.398	1.009	0.000				35.176	83.666
7.8	2911.97	0.000	3.020	14.422	8.666	5.909	4.530	2.019	0.000				38.565	87.055
8.4	2764.65	0.000	2.912	13.788	15.405	6.893	5.663	3.028	1.133	0.000			48.822	97.312
9.0	2617.33	0.000	2.765	12.986	14.757	7.878	6.795	4.038	2.265	0.000			51.484	99.974
9.6	2470.02	0.000	2.617	12.521	14.109	14.005	7.928	5.047	3.398	1.206	0.000		60.831	109.321
10.2	2322.70	0.000	2.470	11.888	13.288	13.416	9.060	6.056	4.530	2.413	0.000		63.121	111.611
10.8	2175.38	0.000	2.323	11.255	12.813	12.826	16.106	7.066	5.663	3.619	0.640	0.000	72.309	120.799
11.4	2028.07	0.000	2.175	10.621	12.164	12.080	15.428	8.075	6.795	4.825	1.280	0.000	73.445	121.935
12.0	1880.75	0.000	2.028	9.988	11.516	11.648	14.750	14.355	7.928	6.032	1.920	0.665	80.830	129.320
12.6	1733.43	0.000	1.881	9.354	10.868	11.059	13.892	13.751	9.060	7.238	2.560	1.329	80.993	129.483
13.2	1586.11	0.000	1.733	8.721	10.220	10.469	13.395	13.147	16.106	8.445	3.201	1.994	87.430	135.920
13.8	1438.80	0.000	1.586	8.087	9.572	9.880	12.717	12.382	15.428	9.651	3.841	2.659	85.803	134.293
14.4	1291.48	0.000	1.439	7.454	8.923	9.291	12.040	11.939	14.750	17.156	4.481	3.324	90.796	139.286
15.0	1144.16	0.000	1.291	6.820	8.275	8.702	11.362	11.335	13.892	16.434	5.121	3.988	87.221	135.711
15.6	996.85	0.000	1.144	6.187	7.627	8.112	10.684	10.731	13.395	15.712	9.103	4.653	87.350	135.840
16.2	849.53	0.000	0.997	5.553	6.979	7.523	10.007	10.127	12.717	14.798	8.720	5.318	82.739	131.229
16.8	702.21	0.000	0.850	4.920	6.331	6.934	9.329	9.523	12.040	14.269	8.337	9.453	81.985	130.475

17.4	554.89	0.000	0.702	4.286	5.683	6.344	8.651	8.919	11.362	13.547	7.852	9.056	76.403	124.893
18.0	407.58	0.000	0.555	3.653	5.034	5.755	7.974	8.315	10.684	12.825	7.571	8.658	71.025	119.515
18.6	260.26	0.000	0.408	3.020	4.386	5.166	7.296	7.711	10.007	12.103	7.188	8.154	65.438	113.928
19.2	112.94	0.000	0.260	2.386	3.738	4.577	6.618	7.107	9.329	11.381	6.805	7.862	60.064	108.554
19.66	0.00	0.000	0.113	1.753	3.090	3.987	5.941	6.503	8.651	10.659	6.422	7.465	54.584	103.074
20.4			0.000	1.119	2.442	3.398	5.263	5.899	7.974	9.938	6.039	7.067	49.138	97.628
21.0			0.000	0.486	1.793	2.809	4.585	5.295	7.296	9.216	5.656	6.669	43.805	92.295
21.6				0.000	1.145	2.220	3.908	4.691	6.618	8.494	5.273	6.271	38.620	87.110
22.2				0.000	0.497	1.630	3.230	4.087	5.941	7.772	4.890	5.874	33.921	82.411
22.8					0.000	1.041	2.553	3.483	5.263	7.050	4.507	5.476	29.373	77.863
23.4					0.000	0.452	1.875	2.879	4.585	6.328	4.124	5.078	25.321	73.811
24.0						0.000	1.197	2.275	3.908	5.606	3.741	4.680	21.408	69.898
24.6						0.000	0.520	1.671	3.230	4.885	3.358	4.283	17.946	66.436
25.2							0.000	1.067	2.553	4.163	2.975	3.885	14.642	63.132
25.8							0.000	0.463	1.875	3.441	2.592	3.487	11.858	60.348
26.4								0.000	1.197	2.719	2.209	3.089	9.214	57.704
27.0								0.000	0.520	1.997	1.826	2.691	7.034	55.524
27.6									0.000	1.275	1.443	2.294	5.012	53.502
28.2									0.000	0.553	1.060	1.896	3.509	51.999
28.8										0.000	0.677	1.498	2.175	50.665
29.4										0.000	0.294	1.100	1.394	49.884
30.0											0.000	0.703	0.703	49.193
30.6											0.000	0.305	0.305	48.795
31.2												0.000	0.000	48.490
												SUM =	**1941.614**	**4511.584**


Watershed M1 Stream Flow Hydrograph
(runoff starts at storm time = 12 hr, t = 0 hr)
140
130
120
110
100
90
80
70
60
50
40
0
5
10
15
20
25
30
35

Appendix P: Biological Sampling Data

Trail Creek E3

		Life Stage	No. of Species	Tolerance Value	HBI
Oligochaeta					
					0.00
Hirudinea					
					0.00
Isopoda					
	Isopoda	Adult	2		0.00
Amphipoda					
	Amphipoda	Adult	14		0.00
Decapoda					
					0.00
Ephmeroptera					
	Baetidae	Immature	16	4	0.19
	Leptophlediidae	Immature	25	2	0.15
	Heptageniidae	Immature	18	4	0.21
Plecoptera					
					0.00
Trichoptera					
	Lepidostomatid	Immature	1	1	0.00
	Hydropsychidae	Immature	43	4	0.51
Hemiptera					
					0.00
Coleoptera					
	Elmidae	Immature	1	4	0.01
Megaloptera					
					0.00
Diptera					
	Chironomidae	Immature	78	5	1.15
	Simuliidae	Pupa	76	6	1.35
	Simuliidae	Immature	78	6	1.38
Gastropoda					
					0.00
Pelecypoda					
					0.00
Other					
	Odonata - Calopterygidae	Immature	3	5	0.04
		TOTAL	339	**HBI TOTAL**	4.65

		Mertic Score
Famly Level HBI	4.65	4
Number of Taxa	11.00	4
Number of Individuals	339.00	8
Percent Dominant Taxa	23.01	6
EPT Index	5.00	4
EPT Count	103.00	6
EPT Count to Total Number of Individuals	0.30	4
EPT Count to Chironomid Count	1.32	2
Chironomid Count	78.00	2
	mIBI Metric Score	**4.44**

	A	B	C	D	E	F
1	**Trail Creek E3**					
2						
3			**Life Stage**	**No. of Species**	**Tolerance Value**	**HBI**
4	**Oligochaeta**					
5						=(D5*E5)/$D$40
6	**Hirudinea**					
7						=(D7*E7)/$D$40
8	**Isopoda**					
9		Isopoda	Adult	2		=(D9*E9)/$D$40
10	**Amphipoda**					
11		Amphipoda	Adult	14		=(D11*E11)/$D$40
12	**Decapoda**					
13						=(D13*E13)/$D$40
14	**Ephmeroptera**					
15		Baetidae	Immature	16	4	=(D15*E15)/$D$40
16		Leptophlediidae	Immature	25	2	=(D16*E16)/$D$40
17		Heptageniidae	Immature	18	4	=(D17*E17)/$D$40
18	**Plecoptera**					
19						=(D19*E19)/$D$40
20	**Trichoptera**					
21		Lepidostomatid	Immature	1	1	=(D21*E21)/$D$40
22		Hydropsychidae	Immature	43	4	=(D22*E22)/$D$40
23	**Hemiptera**					
24						=(D24*E24)/$D$40
25	**Coleoptera**					
26		Elmidae	Immature	1	4	=(D26*E26)/$D$40
27	**Megaloptera**					
28						=(D28*E28)/$D$40
29	**Diptera**					
30		Chironomidae	Immature	78	5	=(D30*E30)/$D$40
31		Simuliidae	Pupa	76	6	=(D31*E31)/$D$40
32		Simuliidae	Immature	78	6	=(D32*E32)/$D$40
33	**Gastropoda**					
34						=(D34*E34)/$D$40
35	**Pelecypoda**					
36						=(D36*E36)/$D$40
37	**Other**					
38		Odonata - Calopterygidae	Immature	3	5	=(D38*E38)/$D$40
39						
40			**TOTAL**	=SUM(D13:D38)	**HBI TOTAL**	=SUM(F17:F38)
41						
42					**Mertic Score**	
43	**Famly Level HBI**			=F40	4	
44	**Number of Taxa**			11	4	
45	**Number of Individuals**			=D40	8	
46	**Percent Dominant Taxa**			=(D30/D40)*100	6	
47	**EPT Index**			5	4	
48	**EPT Count**			=SUM(D14:D22)	6	
49	**EPT Count to Total Number of Individuals**			=D48/D45	4	
50	**EPT Count to Chironomid Count**			=D48/D30	2	
51	**Chironomid Count**			=D30	2	
52				**mIBI Metric Score**	**=SUM(E43:E51)/9**	

Trail Creek M2

		Life Stage	No. of Species	Tolerance Value	HBI
Oligochaeta					
					0.00
Hirudinea					
					0.00
Isopoda					
	Isopoda	Adult	22		0.00
Amphipoda					
	Amphipoda	Adult	9		0.00
Decapoda					
					0.00
Ephmeroptera					
	Baetidae	Immature	11	4	0.36
	Heptageniidae	Immature	12	4	0.39
Plecoptera					
					0.00
Trichoptera					
	Hydropsychidae	Immature	80	4	2.60
Hemiptera					
					0.00
Coleoptera					
					0.00
Megaloptera					
					0.00
Diptera					
	Chironomidae	Immature	2	5	0.08
	Tipulidae	Immature	8	3	0.20
	Simuliidae	Immature	1	6	0.05
Gastropoda					
					0.00
Pelecypoda					
					0.00
Other					
	Odonata - Calopter	Immature	9	5	0.37
		TOTAL	123	**HBI TOTAL**	3.68

		Mertic Score
Famly Level HBI	3.68	8
Number of Taxa	9.00	2
Number of Individuals	123.00	2
Percent Dominant Taxa	65.04	0
EPT Index	3.00	2
EPT Count	103.00	6
EPT Count to Total Number of Individuals	0.84	8
EPT Count to Chironomid Count	51.50	8
Chironomid Count	2.00	8
	mIBI Metric Score	**4.89**

	A	B	C	D	E	F
1	**Trail Creek M2**					
2						
3			**Life Stage**	**No. of Species**	**Tolerance Value**	**HBI**
4	**Oligochaeta**					
5						=(D5*E5)/$D$38
6	**Hirudinea**					
7						=(D7*E7)/$D$38
8	**Isopoda**					
9		Isopoda	Adult	22		=(D9*E9)/$D$38
10	**Amphipoda**					
11		Amphipoda	Adult	9		=(D11*E11)/$D$38
12	**Decapoda**					
13						=(D13*E13)/$D$38
14	**Ephmeroptera**					
15		Baetidae	Immature	11	4	=(D15*E15)/$D$38
16		Heptageniidae	Immature	12	4	=(D16*E16)/$D$38
17	**Plecoptera**					
18						=(D18*E18)/$D$38
19	**Trichoptera**					
20		Hydropsychidae	Immature	80	4	=(D20*E20)/$D$38
21	**Hemiptera**					
22						=(D22*E22)/$D$38
23	**Coleoptera**					
24						=(D24*E24)/$D$38
25	**Megaloptera**					
26						=(D26*E26)/$D$38
27	**Diptera**					
28		Chironomidae	Immature	2	5	=(D28*E28)/$D$38
29		Tipulidae	Immature	8	3	=(D29*E29)/$D$38
30		Simuliidae	Immature	1	6	=(D30*E30)/$D$38
31	**Gastropoda**					
32						=(D32*E32)/$D$38
33	**Pelecypoda**					
34						=(D34*E34)/$D$38
35	**Other**					
36		Odonata - Calopter	Immature	9	5	=(D36*E36)/$D$38
37						
38			**TOTAL**	=SUM(D13:D36)	**HBI TOTAL**	=SUM(F16:F36)
39						
40					**Mertic Score**	
41	**Famly Level HBI**			=F38	8	
42	**Number of Taxa**			9	2	
43	**Number of Individuals**			=D38	2	
44	**Percent Dominant Taxa**			=(D20/D38)*100	0	
45	**EPT Index**			3	2	
46	**EPT Count**			=SUM(D14:D20)	6	
47	**EPT Count to Total Number of Individuals**			=D46/D43	8	
48	**EPT Count to Chironomid Count**			=D46/D28	8	
49	**Chironomid Count**			=D28	8	
50				**mIBI Metric Score**	**=SUM(E41:E49)/9**	

Trail Creek W1 - New Site

		Life Stage	No. of Species	Tolerance Value	HBI
Oligochaeta					
					0.00
Hirudinea					
			5	0	0.00
Isopoda					
					0.00
Amphipoda					
	Amphipoda	Adult	10	0	0.00
Decapoda					
					0.00
Ephmeroptera					
	Baetidae	Immature	1	4	0.07
Plecoptera					
					0.00
Trichoptera					
					0.00
Hemiptera					
	Corixidae	Adult	1	0	0.00
Coleoptera					
	Dytiscidae	Adult	2	0	0.00
		Immature	1	0	0.00
	Hydrophilidae	Adult	2	0	0.00
		Immature	1	0	0.00
	Elimidae	Adult	2	4	0.14
Megaloptera					
					0.00
Diptera					
	Chironomidae	Pupa	2	5	0.18
		Immature	24	5	2.14
	Simuliidae	Immature	5	6	0.54
Gastropoda					
					0.00
Pelecypoda					
					0.00
Other					
		TOTAL	56	**HBI TOTAL**	3.00

		Mertic Score
Famly Level HBI	3.00	8
Number of Taxa	8.00	2
Number of Individuals	56.00	0
Percent Dominant Taxa	42.86	4
EPT Index	1.00	0
EPT Count	1.00	0
EPT Count to Total Number of Individuals	0.02	2
EPT Count to Chironomid Count	0.04	0
Chironomid Count	26.00	4
	mIBI Metric Score	**2.22**

Trail Creek W1 - New Site

		Life Stage	No. of Species	Tolerance Value	HBI
Oligochaeta					
					=(D5*E5)/$D$40
Hirudinea					
			5	0	=(D7*E7)/$D$40
Isopoda					
					=(D9*E9)/$D$40
Amphipoda					
	Amphipoda	Adult	10	0	=(D11*E11)/$D$40
Decapoda					
					=(D13*E13)/$D$40
Ephmeroptera					
	Baetidae	Immature	1	4	=(D15*E15)/$D$40
Plecoptera					
					=(D17*E17)/$D$40
Trichoptera					
					=(D19*E19)/$D$40
Hemiptera					
	Corixidae	Adult	1	0	=(D21*E21)/$D$40
Coleoptera					
	Dytiscidae	Adult	2	0	=(D23*E23)/$D$40
		Immature	1	0	=(D24*E24)/$D$40
	Hydrophilidae	Adult	2	0	=(D25*E25)/$D$40
		Immature	1	0	=(D26*E26)/$D$40
	Elimidae	Adult	2	4	=(D27*E27)/$D$40
Megaloptera					
					=(D29*E29)/$D$40
Diptera					
	Chironomidae	Pupa	2	5	=(D31*E31)/$D$40
		Immature	24	5	=(D32*E32)/$D$40
	Simuliidae	Immature	5	6	=(D33*E33)/$D$40
Gastropoda					
					=(D35*E35)/$D$40
Pelecypoda					
					=(D37*E37)/$D$40
Other					
		TOTAL	=SUM(D5:D38)	**HBI TOTAL**	=SUM(F16:F38)

		Mertic Score
Famly Level HBI	=F40	8
Number of Taxa	8	2
Number of Individuals	=D40	0
Percent Dominant Taxa	=(D32/D40)*100	4
EPT Index	1	0
EPT Count	=SUM(D15:D19)	0
EPT Count to Total Number of Individuals	=D48/D45	2
EPT Count to Chironomid Count	=D48/(D31+D32)	0
Chironomid Count	=D31+D32	4
	mIBI Metric Score	**=SUM(E43:E51)/9**

Trail Creek W1

	Life Stage	No. of Species	Tolerance Value	HBI
Oligochaeta				
				0.00
Hirudinea				
				0.00
Isopoda				
Isopoda	Adult	5		0.00
Amphipoda				
Amphipoda	Adult	110		0.00
Decapoda				
				0.00
Ephmeroptera				
Baetidae	Immature	4	4	0.12
Leptophlebiidae	Immature	1	2	0.02
Plecoptera				
Plecoptera	Immature	1		0.00
Trichoptera				
Phryganeidae	Immature	1	4	0.03
Hydropsychidae	Immature	2	4	0.06
Hemiptera				
				0.00
Coleoptera				
				0.00
Megaloptera				
				0.00
Diptera				
Chironomidae	Immature	2	5	0.08
Tipulidae	Immature	3	3	0.07
Culicidae	Immature	1		0.00
Gastropoda				
				0.00
Pelecypoda				
				0.00
Other				
Odonata - Aeshnidae	Immature	1	3	0.02
	TOTAL	131	**HBI TOTAL**	0.27

		Mertic Score
Famly Level HBI	0.27	8
Number of Taxa	11.00	4
Number of Individuals	131.00	2
Percent Dominant Taxa	83.97	0
EPT Index	5.00	4
EPT Count	9.00	0
EPT Count to Total Number of Individuals	0.07	0
EPT Count to Chironomid Count	4.50	4
Chironomid Count	2.00	8
	mIBI Metric Score	**3.33**

	A	B	C	D	E	F
1	**Trail Creek W1**					
2						
3			**Life Stage**	**No. of Species**	**Tolerance Value**	**HBI**
4	**Oligochaeta**					
5						=(D5*E5)/$D$39
6	**Hirudinea**					
7						=(D7*E7)/$D$39
8	**Isopoda**					
9		Isopoda	Adult	5		=(D9*E9)/$D$39
10	**Amphipoda**					
11		Amphipoda	Adult	110		=(D11*E11)/$D$39
12	**Decapoda**					
13						=(D13*E13)/$D$39
14	**Ephmeroptera**					
15		Baetidae	Immature	4	4	=(D15*E15)/$D$39
16		Leptophlebiidae	Immature	1	2	=(D16*E16)/$D$39
17	**Plecoptera**					
18		Plecoptera	Immature	1		=(D18*E18)/$D$39
19	**Trichoptera**					
20		Phryganeidae	Immature	1	4	=(D20*E20)/$D$39
21		Hydropsychidae	Immature	2	4	=(D21*E21)/$D$39
22	**Hemiptera**					
23						=(D23*E23)/$D$39
24	**Coleoptera**					
25						=(D25*E25)/$D$39
26	**Megaloptera**					
27						=(D27*E27)/$D$39
28	**Diptera**					
29		Chironomidae	Immature	2	5	=(D29*E29)/$D$39
30		Tipulidae	Immature	3	3	=(D30*E30)/$D$39
31		Culicidae	Immature	1		=(D31*E31)/$D$39
32	**Gastropoda**					
33						=(D33*E33)/$D$39
34	**Pelecypoda**					
35						=(D35*E35)/$D$39
36	**Other**					
37		Odonata - Aeshnidae	Immature	1	3	=(D37*E37)/$D$39
38						
39			**TOTAL**	=SUM(D5:D37)	**HBI TOTAL**	=SUM(F16:F37)
40						
41					**Mertic Score**	
42	**Famly Level HBI**			=F39	8	
43	**Number of Taxa**			11	4	
44	**Number of Individuals**			=D39	2	
45	**Percent Dominant Taxa**			=(D11/D39)*100	0	
46	**EPT Index**			5	4	
47	**EPT Count**			=SUM(D15:D21)	0	
48	**EPT Count to Total Number of Individuals**			=D47/D44	0	
49	**EPT Count to Chironomid Count**			=D47/D29	4	
50	**Chironomid Count**			=D29	8	
51				**mIBI Metric Score**	**=SUM(E42:E50)/9**	

Trail Creek M1

		Life Stage	No. of Species	Tolerance Value	HBI
Oligochaeta					
					0.00
Hirudinea					
					0.00
Isopoda					
					0.00
Amphipoda					
	Amphipoda	Adult	1		0.00
Decapoda					
					0.00
Ephmeroptera					
	Baetidae	Immature	16	4	0.32
	Heptageniidae	Immature	9	4	0.18
Plecoptera					
	Plecoptera	Immature	2		0.00
Trichoptera					
	Hydropsychidae	Immature	129	4	2.62
Hemiptera					
					0.00
Coleoptera					
					0.00
Megaloptera					
					0.00
Diptera					
	Chironomidae	Immature	4	5	0.10
	Tipulidae	Immature	1	3	0.02
	Simuliidae	Immature	35	6	1.07
Gastropoda					
					0.00
Pelecypoda					
					0.00
Other					
					0.00
		TOTAL	197	**HBI TOTAL**	3.98

		Mertic Score
Famly Level HBI	3.98	8
Number of Taxa	8.00	2
Number of Individuals	197.00	4
Percent Dominant Taxa	65.48	0
EPT Index	4.00	4
EPT Count	156.00	6
EPT Count to Total Number of Individuals	0.79	8
EPT Count to Chironomid Count	39.00	8
Chironomid Count	4.00	8
	mIBI Metric Score	**5.33**

	A	B	C	D	E	F
1	**Trail Creek M1**					
2						
3			**Life Stage**	**No. of Species**	**Tolerance Value**	**HBI**
4	**Oligochaeta**					
5						=(D5*E5)/$D$38
6	**Hirudinea**					
7						=(D7*E7)/$D$38
8	**Isopoda**					
9						=(D9*E9)/$D$38
10	**Amphipoda**					
11		Amphipoda	Adult	1		=(D11*E11)/$D$38
12	**Decapoda**					
13						=(D13*E13)/$D$38
14	**Ephmeroptera**					
15		Baetidae	Immature	16	4	=(D15*E15)/$D$38
16		Heptageniidae	Immature	9	4	=(D16*E16)/$D$38
17	**Plecoptera**					
18		Plecoptera	Immature	2		=(D18*E18)/$D$38
19	**Trichoptera**					
20		Hydropsychidae	Immature	129	4	=(D20*E20)/$D$38
21	**Hemiptera**					
22						=(D22*E22)/$D$38
23	**Coleoptera**					
24						=(D24*E24)/$D$38
25	**Megaloptera**					
26						=(D26*E26)/$D$38
27	**Diptera**					
28		Chironomidae	Immature	4	5	=(D28*E28)/$D$38
29		Tipulidae	Immature	1	3	=(D29*E29)/$D$38
30		Simuliidae	Immature	35	6	=(D30*E30)/$D$38
31	**Gastropoda**					
32						=(D32*E32)/$D$38
33	**Pelecypoda**					
34						=(D34*E34)/$D$38
35	**Other**					
36						=(D36*E36)/$D$38
37						
38			**TOTAL**	=SUM(D5:D36)	**HBI TOTAL**	=SUM(F16:F36)
39						
40					**Mertic Score**	
41	**Famly Level HBI**			=F38	8	
42	**Number of Taxa**			8	2	
43	**Number of Individuals**			=D38	4	
44	**Percent Dominant Taxa**			=(D20/D38)*100	0	
45	**EPT Index**			4	4	
46	**EPT Count**			=SUM(D14:D20)	6	
47	**EPT Count to Total Number of Individuals**			=D46/D43	8	
48	**EPT Count to Chironomid Count**			=D46/D28	8	
49	**Chironomid Count**			=D28	8	
50				**mIBI Metric Score**	**=SUM(E41:E49)/9**	

Appendix Q: Qualitative Habitat Evaluation Index

Ohio EPA Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 73

River Code: ______ **RM:** ______ **Stream:** TRAIL CREEK - M1
Date: ______ **Location:** ______
Scorers Full Name: ______ **Affiliation:** American Consulting

1] SUBSTRATE (Check ONLY Two SubstrateTYPE BOXES; Estimate % present

TYPE — POOL RIFFLE — POOL RIFFLE — SUBSTRATE ORIGIN — SUBSTRATE QUALITY

- ☐☐-BLDR /SLBS[10] ☐☐-GRAVEL [7] — Check ONE (OR 2 & AVERAGE) — Check ONE (OR 2 & AVERAGE)
- ☐☐-BOULDER [9] ☑☐-SAND [6] ☐-LIMESTONE [1] SILT: ☐- SILT HEAVY [-2]
- ☑☐-COBBLE [8] ☐☐-BEDROCK[5] ☑-TILLS [1] ☑-SILT MODERATE [-1]
- ☐☐-HARDPAN [4] ☐☐-DETRITUS[3] ☐-WETLANDS[0] ☐-SILT NORMAL [0]
- ☐☐-MUCK [2] ☐☐-ARTIFICIAL[0] ☐-HARDPAN [0] ☐-SILT FREE [1]
- ☐☐-SILT [2] NOTE: Ignore Sludge Originating From Point Sources ☐-SANDSTONE [0] EMBEDDEDNESS: ☐-EXTENSIVE [-2]
- ☐-RIP/RAP [0] ☑-MODERATE [-1]

NUMBER OF SUBSTRATE TYPES: ☑-4 or More [2] ☐-LACUSTRINE [0] ☐-NORMAL [0]
(High Quality Only, Score 5 or >) ☐-3 or Less [0] ☐-SHALE [-1] ☐-NONE [1]
COMMENTS: Created Structure ☐-COAL FINES [-2]

Substrate: 13 (Max 20)

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions) (Structure) TYPE: Score All That Occur

- 1 UNDERCUT BANKS [1] — 2 POOLS> 70 cm [2] — ___OXBOWS, BACKWATERS [1]
- 1 OVERHANGING VEGETATION [1] — ___ROOTWADS [1] — ___AQUATIC MACROPHYTES [1]
- ___SHALLOWS (IN SLOW WATER) [1] — 2 BOULDERS [1] — 1 LOGS OR WOODY DEBRIS [1]
- ___ROOTMATS [1] COMMENTS: ______

AMOUNT: (Check ONLY One or check 2 and AVERAGE)
- ☐- EXTENSIVE > 75% [11]
- ☑- MODERATE 25-75% [7]
- ☐- SPARSE 5-25% [3]
- ☐- NEARLY ABSENT < 5%[1]

Cover: 14 (Max 20)

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
☐- HIGH [4]	☐- EXCELLENT [7]	☑-NONE [6]	☐- HIGH [3]	☐- SNAGGING	☐- IMPOUND.
☑- MODERATE [3]	☑-GOOD [5]	☐- RECOVERED [4]	☑-MODERATE [2]	☐- RELOCATION	☐- ISLANDS
☐- LOW [2]	☐- FAIR [3]	☐- RECOVERING [3]	☐- LOW [1]	☐- CANOPY REMOVAL	☐- LEVEED
☐- NONE [1]	☐- POOR [1]	☐- RECENT OR NO RECOVERY [1]		☐- DREDGING	☑- BANK SHAPING
				☑- ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS: ______

Channel: 16 (Max 20)

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH L R (Per Bank)	FLOOD PLAIN QUALITY (PAST 100 Meter RIPARIAN) L R (Most Predominant Per Bank)	L R	BANK EROSION L R (Per Bank)
☐☐- WIDE > 50m [4]	☑☑-FOREST, SWAMP [3]	☐☐-CONSERVATION TILLAGE [1]	☐☐-NONE/LITTLE [3]
☑☑-MODERATE 10-50m [3]	☐☐-SHRUB OR OLD FIELD [2]	☑☑-URBAN OR INDUSTRIAL [0]	☑☑-MODERATE [2]
☐☐- NARROW 5-10 m [2]	☐☐-RESIDENTIAL,PARK,NEW FIELD [1]	☐☐-OPEN PASTURE,ROWCROP [0]	☐☐-HEAVY/SEVERE[1]
☐☐- VERY NARROW <5 m[1]	☐☐-FENCED PASTURE [1]	☐☐-MINING/CONSTRUCTION [0]	
☐☐- NONE [0]			

COMMENTS: ______

Riparian: 8 (Max 10)

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)	MORPHOLOGY (Check 1 or 2 & AVERAGE)	CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)	
☑- >1m [6]	☐-POOL WIDTH > RIFFLE WIDTH [2]	☑-EDDIES[1]	☐-TORRENTIAL[-1]
☐- 0.7-1m [4]	☑-POOL WIDTH = RIFFLE WIDTH [1]	☐-FAST[1]	☐-INTERSTITIAL[-1]
☐- 0.4-0.7m [2]	☐-POOL WIDTH < RIFFLE W. [0]	☑-MODERATE [1]	☐-INTERMITTENT[-2]
☐- 0.2- 0.4m [1]		☐-SLOW [1]	☐-VERY FAST[1]
☐- < 0.2m [POOL=0]			

COMMENTS: ______

Pool/Current: 9 (Max 12)

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH	RUN DEPTH	RIFFLE/RUN SUBSTRATE	RIFFLE/RUN EMBEDDEDNESS
☑- Best Areas >10 cm [2]	☐- MAX > 50 [2]	☑-STABLE (e.g.,Cobble, Boulder) [2]	☐- NONE [2]
☐- Best Areas 5-10 cm[1]	☑- MAX < 50[1]	☐-MOD. STABLE (e.g.,Large Gravel) [1]	☐- LOW [1]
☐- Best Areas < 5 cm [RIFFLE=0]		☐-UNSTABLE (Fine Gravel,Sand) [0]	☑-MODERATE [0]
			☐- EXTENSIVE [-1]

COMMENTS: Created Riffle ☐- NO RIFFLE [Metric=0]

Riffle/Run: 5 (Max 8)

Gradient: 8 (Max 10)

6] GRADIENT (ft/mi): 5.7 DRAINAGE AREA (sq.mi.): 45.8

%POOL: ___ %GLIDE: ___
%RIFFLE: ___ %RUN: ___

*- Best areas must be large enough to support a population of riffle-obligate species

Is Sampling Reach Representative of the Stream (Y/N)___ If Not, Explain:

Major Suspected Sources of Impacts (Check All That Apply):
- None ☐
- Industrial ☐
- WWTP ☐
- Ag ☐
- Livestock ☐
- Silviculture ☐
- Construction ☐
- Urban Runoff ☐
- CSOs ☐
- Suburban Impacts ☐
- Mining ☐
- Channelization ☐
- Riparian Removal ☐
- Landfills ☐
- Natural ☐
- Dams ☐
- Other Flow Alteration ☐
- Other:

Subjective Rating (1-10)

Aesthetic Rating (1-10)

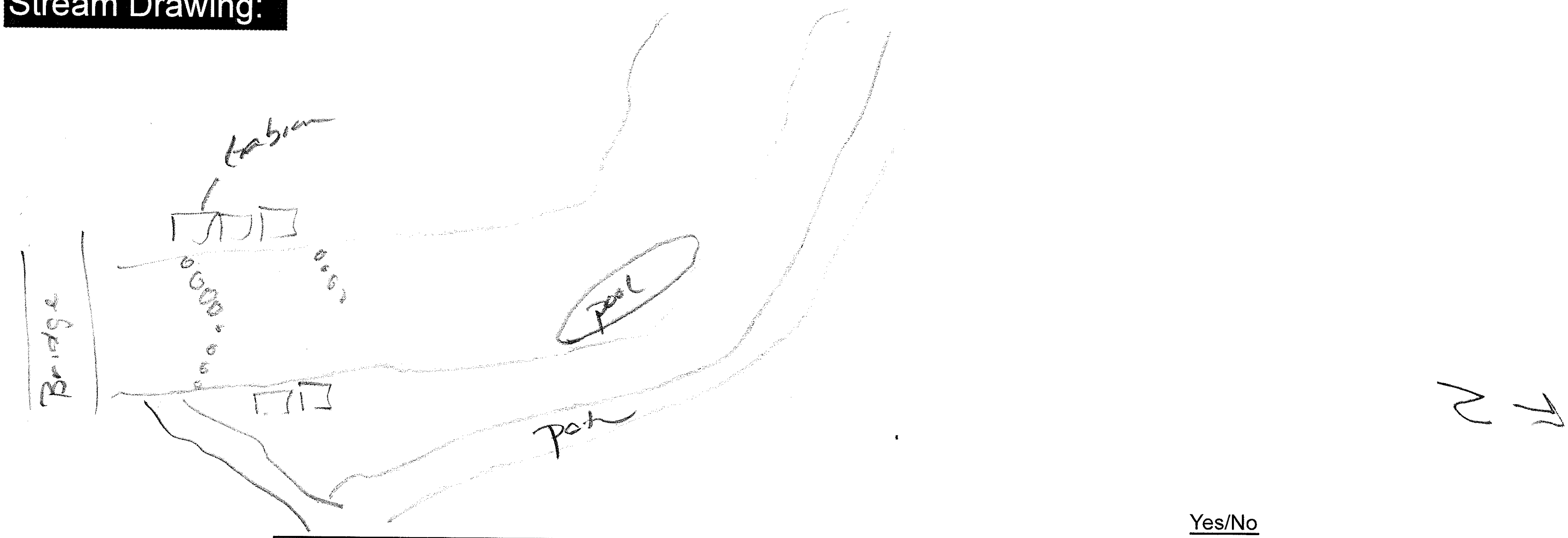
Gradient: ☐ - Low, ☐ - Moderate, ☐ -High

	Gear:	Distance:	Water Clarity:	Water Stage:	Canopy -% Open
First Sampling Pass					

Stream Measurements:

Average Width	Average Depth	Maximum Depth	Av. Bankfull Width	Bankfull Mean Depth	W/D Ratio	Bankfull Max Depth	Floodprone Area Width	Entrench. Ratio

Stream Drawing:



Instructions for scoring the alternate cover metric: Each cover type should receive a score of between 0 and 3, Where: 0 - Cover type absent; 1 - Cover type present in very small amounts or if more common of marginal quality; 2 - Cover type present in moderate amounts, but not of highest quality or in small amounts of highest quality; 3 - Cover type of highest quality in moderate or greater amounts. Examples of highest quality include very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

Yes/No	
☐ ☐	Is Stream Ephemeral (no pools, totally dry or only damp spots)?
☐ ☐	Is there water upstream? How Far:______
☐ ☐	Is There Water Close Downstream? How Far:______
☐ ☐	Is Dry Channel Mostly Natural?

2/8

Ohio EPA Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 63

River Code: ______ **RM:** ______ **Stream:** TRAIL CREEK – M2
Date: ______ **Location:** ______
Scorers Full Name: ______ **Affiliation:** American Consulting

1] SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % present)

TYPE — POOL RIFFLE / POOL RIFFLE

- ☐ ☐ -BLDR /SLBS[10]
- ☐ ☐ -BOULDER [9]
- ☐ ☐ -COBBLE [8]
- ☐ ☐ -HARDPAN [4]
- ☐ ☐ -MUCK [2]
- ☑ ☐ -SILT [2]
- ☐ ☑ -GRAVEL [7]
- ☐ ☐ -SAND [6]
- ☐ ☐ -BEDROCK[5]
- ☐ ☐ -DETRITUS[3]
- ☐ ☐ -ARTIFICIAL[0]

NOTE: Ignore Sludge Originating From Point Sources

NUMBER OF SUBSTRATE TYPES: ☑ 4 or More [2] ☐ 3 or Less [0]
(High Quality Only, Score 5 or >)

SUBSTRATE ORIGIN — Check ONE (OR 2 & AVERAGE)
- ☐ -LIMESTONE [1]
- ☑ -TILLS [1]
- ☐ -WETLANDS[0]
- ☐ -HARDPAN [0]
- ☐ -SANDSTONE [0]
- ☐ -RIP/RAP [0]
- ☐ -LACUSTRINE [0]
- ☐ -SHALE [-1]
- ☐ -COAL FINES [-2]

SUBSTRATE QUALITY — Check ONE (OR 2 & AVERAGE)

SILT:
- ☐ - SILT HEAVY [-2]
- ☑ -SILT MODERATE [-1]
- ☐ -SILT NORMAL [0]
- ☐ -SILT FREE [1]

EMBEDDEDNESS:
- ☐ -EXTENSIVE [-2]
- ☑ -MODERATE [-1]
- ☐ -NORMAL [0]
- ☐ -NONE [1]

COMMENTS______

Substrate: 10 (Max 20)

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)
(Structure) **TYPE:** Score All That Occur

- 2 UNDERCUT BANKS [1]
- 1 OVERHANGING VEGETATION [1]
- 1 SHALLOWS (IN SLOW WATER) [1]
- __ ROOTMATS [1]
- 2 POOLS> 70 cm [2]
- __ ROOTWADS [1]
- 1 BOULDERS [1]
- __ OXBOWS, BACKWATERS [1]
- __ AQUATIC MACROPHYTES [1]
- 2 LOGS OR WOODY DEBRIS [1]

COMMENTS:______

AMOUNT: (Check ONLY One or check 2 and AVERAGE)
- ☐ - EXTENSIVE > 75% [11]
- ☑ - MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

Cover: 14 (Max 20)

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY
- ☐ - HIGH [4]
- ☑ - MODERATE [3]
- ☐ - LOW [2]
- ☐ - NONE [1]

DEVELOPMENT
- ☐ - EXCELLENT [7]
- ☑ - GOOD [5]
- ☐ - FAIR [3]
- ☐ - POOR [1]

CHANNELIZATION
- ☑ - NONE [6]
- ☐ - RECOVERED [4]
- ☐ - RECOVERING [3]
- ☐ - RECENT OR NO RECOVERY [1]

STABILITY
- ☐ - HIGH [3]
- ☑ - MODERATE [2]
- ☐ - LOW [1]

MODIFICATIONS/OTHER
- ☐ - SNAGGING
- ☐ - RELOCATION
- ☐ - CANOPY REMOVAL
- ☐ - DREDGING
- ☐ - ONE SIDE CHANNEL MODIFICATIONS
- ☐ - IMPOUND.
- ☐ - ISLANDS
- ☐ - LEVEED
- ☐ - BANK SHAPING

COMMENTS:______

Channel: 14 (Max 20)

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH — L R (Per Bank)
- ☑ ☑ - WIDE > 50m [4]
- ☐ ☐ - MODERATE 10-50m [3]
- ☐ ☐ - NARROW 5-10 m [2]
- ☐ ☐ - VERY NARROW <5 m[1]
- ☐ ☐ - NONE [0]

FLOOD PLAIN QUALITY (*PAST 100 Meter RIPARIAN*) — L R (Most Predominant Per Bank)
- ☐ ☐ -FOREST, SWAMP [3]
- ☐ ☐ -SHRUB OR OLD FIELD [2]
- ☐ ☐ -RESIDENTIAL,PARK,NEW FIELD [1]
- ☐ ☐ -FENCED PASTURE [1]
- ☐ ☐ -CONSERVATION TILLAGE [1]
- ☑ ☑ -URBAN OR INDUSTRIAL [0]
- ☐ ☐ -OPEN PASTURE,ROWCROP [0]
- ☐ ☐ -MINING/CONSTRUCTION [0]

BANK EROSION — L R (Per Bank)
- ☐ ☐ -NONE/LITTLE [3]
- ☐ ☐ -MODERATE [2]
- ☑ ☑ -HEAVY/SEVERE[1]

COMMENTS:______

Riparian: 5 (Max 10)

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)
- ☑ - >1m [6]
- ☐ - 0.7-1m [4]
- ☐ - 0.4-0.7m [2]
- ☐ - 0.2- 0.4m [1]
- ☐ - < 0.2m [POOL=0]

MORPHOLOGY (Check 1 or 2 & AVERAGE)
- ☐ -POOL WIDTH > RIFFLE WIDTH [2]
- ☑ -POOL WIDTH = RIFFLE WIDTH [1]
- ☐ -POOL WIDTH < RIFFLE W. [0]

CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)
- ☑ -EDDIES[1]
- ☐ -FAST[1]
- ☑ -MODERATE [1]
- ☐ -SLOW [1]
- ☐ -TORRENTIAL[-1]
- ☐ -INTERSTITIAL[-1]
- ☐ -INTERMITTENT[-2]
- ☐ -VERY FAST[1]

COMMENTS:______

Pool/Current: 9 (Max 12)

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH
- ☑ - Best Areas >10 cm [2]
- ☐ - Best Areas 5-10 cm[1]
- ☐ - Best Areas < 5 cm [RIFFLE=0]

RUN DEPTH
- ☐ - MAX > 50 [2]
- ☑ - MAX < 50[1]

RIFFLE/RUN SUBSTRATE
- ☑ -STABLE (e.g.,Cobble, Boulder) [2]
- ☐ -MOD. STABLE (e.g.,Large Gravel) [1]
- ☐ -UNSTABLE (Fine Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ - NONE [2]
- ☐ - LOW [1]
- ☑ - MODERATE [0]
- ☐ - EXTENSIVE [-1]

COMMENTS:______ ☐ - NO RIFFLE [Metric=0]

Riffle/Run: 5 (Max 8)

Gradient: 4 (Max 10)

6] GRADIENT (ft/mi): 2.12 DRAINAGE AREA (sq.mi.): 54.7

%POOL: ______ %GLIDE: ______
%RIFFLE: ______ %RUN: ______

*Best areas must be large enough to support a population of riffle-obligate species

EPA 4520 06/24/01

3/8

Is Sampling Reach Representative of the Stream (Y/N)___ If Not, Explain:

First Sampling Pass	Gear:	Distance:	Water Clarity:	Water Stage:	Canopy -% Open

Subjective Rating (1-10)

Aesthetic Rating (1-10)

Gradient: ☐ - Low, ☐ - Moderate, ☐ -High

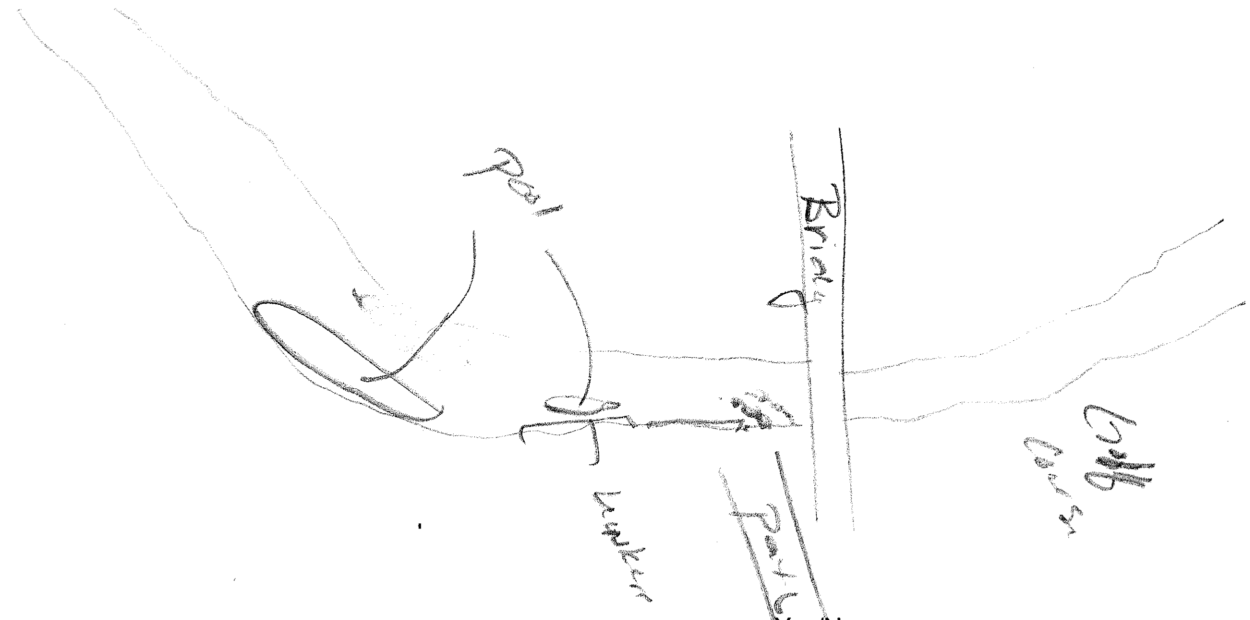
Stream Measurements:

Average Width	Average Depth	Maximum Depth	Av. Bankfull Width	Bankfull Mean Depth	W/D Ratio	Bankfull Max Depth	Floodprone Area Width	Entrench. Ratio

Major Suspected Sources of Impacts (Check All That Apply):

- None ☐
- Industrial ☐
- WWTP ☐
- Ag ☐
- Livestock ☐
- Silviculture ☐
- Construction ☐
- Urban Runoff ☐
- CSOs ☐
- Suburban Impacts ☐
- Mining ☐
- Channelization ☐
- Riparian Removal ☐
- Landfills ☐
- Natural ☐
- Dams ☐
- Other Flow Alteration ☐
- Other:________

Stream Drawing:



Instructions for scoring the alternate cover metric: Each cover type should receive a score of between 0 and 3, Where: 0 - Cover type absent; 1 - Cover type present in very small amounts or if more common of marginal quality; 2 - Cover type present in moderate amounts, but not of highest quality or in small amounts of highest quality; 3 - Cover type of highest quality in moderate or greater amounts. Examples of highest quality include very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

Yes	No	
☐	☐	Is Stream Ephemeral (no pools, totally dry or only damp spots)?
☐	☐	Is there water upstream? How Far:________
☐	☐	Is There Water Close Downstream? How Far:______
☐	☐	Is Dry Channel Mostly Natural?

Ohio EPA Qualitative Habitat Evaluation Index Field Sheet — QHEI Score: 41.5

River Code: ______ **RM:** ______ **Stream:** West Branch Trail Creek - W1
Date: ______ **Location:** ______
Scorers Full Name: ______ **Affiliation:** ______

1] SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % present)

TYPE — POOL RIFFLE

- ☐☐-BLDR /SLBS[10]
- ☐☐-BOULDER [9]
- ☐☐-COBBLE [8]
- ☐☐-HARDPAN [4]
- ☑☑-MUCK [2]
- ☑☐-SILT [2]
- ☐☐-GRAVEL [7]
- ☐☐-SAND [6]
- ☐☐-BEDROCK[5]
- ☐☐-DETRITUS[3]
- ☐☐-ARTIFICIAL[0]

NOTE: Ignore Sludge Originating From Point Sources

SUBSTRATE ORIGIN — Check ONE (OR 2 & AVERAGE)

- ☐ -LIMESTONE [1]
- ☑ -TILLS [1]
- ☐ -WETLANDS[0]
- ☐ -HARDPAN [0]
- ☐ -SANDSTONE [0]
- ☐ -RIP/RAP [0]
- ☐ -LACUSTRINE [0]
- ☐ -SHALE [-1]
- ☐ -COAL FINES [-2]

SUBSTRATE QUALITY — Check ONE (OR 2 & AVERAGE)

SILT:
- ☑ -SILT HEAVY [-2]
- ☐ -SILT MODERATE [-1]
- ☐ -SILT NORMAL [0]
- ☐ -SILT FREE [1]

EMBEDDEDNESS:
- ☐ -EXTENSIVE [-2]
- ☑ -MODERATE [-1]
- ☐ -NORMAL [0]
- ☐ -NONE [1]

NUMBER OF SUBSTRATE TYPES: ☐ 4 or More [2] ☑ 3 or Less [0]
(High Quality Only, Score 5 or >)

COMMENTS: ______

Substrate: **3** (Max 20)

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)
(Structure) TYPE: Score All That Occur

- 1 UNDERCUT BANKS [1]
- ___ OVERHANGING VEGETATION [1]
- ___ SHALLOWS (IN SLOW WATER) [1]
- ___ ROOTMATS [1]
- ___ POOLS> 70 cm [2]
- ___ ROOTWADS [1]
- ___ BOULDERS [1]
- ___ OXBOWS, BACKWATERS [1]
- 1 AQUATIC MACROPHYTES [1]
- 1 LOGS OR WOODY DEBRIS [1]

COMMENTS: Cows in stream

AMOUNT: (Check ONLY One or check 2 and AVERAGE)

- ☐ - EXTENSIVE > 75% [11]
- ☐ - MODERATE 25-75% [7]
- ☑ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

Cover: **6** (Max 20)

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY
- ☐ - HIGH [4]
- ☐ - MODERATE [3]
- ☑ - LOW [2]
- ☐ - NONE [1]

DEVELOPMENT
- ☐ - EXCELLENT [7]
- ☑ - GOOD [5]
- ☐ - FAIR [3]
- ☐ - POOR [1]

CHANNELIZATION
- ☐ - NONE [6]
- ☑ - RECOVERED [4]
- ☐ - RECOVERING [3]
- ☐ - RECENT OR NO RECOVERY [1]

STABILITY
- ☐ - HIGH [3]
- ☑ - MODERATE [2]
- ☐ - LOW [1]

MODIFICATIONS/OTHER
- ☐ - SNAGGING
- ☐ - RELOCATION
- ☑ - CANOPY REMOVAL
- ☐ - DREDGING
- ☐ - ONE SIDE CHANNEL MODIFICATIONS
- ☐ - IMPOUND.
- ☐ - ISLANDS
- ☐ - LEVEED
- ☐ - BANK SHAPING

COMMENTS: - opportunity for Restoration

Channel: **13** (Max 20)

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH — L R (Per Bank)
- ☐☐ - WIDE > 50m [4]
- ☑☐ - MODERATE 10-50m [3]
- ☐☑ - NARROW 5-10 m [2]
- ☐☐ - VERY NARROW <5 m[1]
- ☐☐ - NONE [0]

FLOOD PLAIN QUALITY (*PAST 100 Meter RIPARIAN*) — L R (Most Predominant Per Bank)
- ☐☐-FOREST, SWAMP [3]
- ☐☐-SHRUB OR OLD FIELD [2]
- ☐☐-RESIDENTIAL,PARK,NEW FIELD [1]
- ☑☑-FENCED PASTURE [1]
- ☐☐-CONSERVATION TILLAGE [1]
- ☐☐-URBAN OR INDUSTRIAL [0]
- ☑☑-OPEN PASTURE,ROWCROP [0]
- ☐☐-MINING/CONSTRUCTION [0]

BANK EROSION — L R (Per Bank)
- ☐☐-NONE/LITTLE [3]
- ☐☐-MODERATE [2]
- ☑☑-HEAVY/SEVERE[1]

COMMENTS: ______

Riparian: **4.5** (Max 10)

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)
- ☐ - >1m [6]
- ☐ - 0.7-1m [4]
- ☑ - 0.4-0.7m [2]
- ☐ - 0.2- 0.4m [1]
- ☐ - < 0.2m [POOL=0]

MORPHOLOGY (Check 1 or 2 & AVERAGE)
- ☐ -POOL WIDTH > RIFFLE WIDTH [2]
- ☑ -POOL WIDTH = RIFFLE WIDTH [1]
- ☐ -POOL WIDTH < RIFFLE W. [0]

CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)
- ☐ -EDDIES[1]
- ☐ -FAST[1]
- ☑ -MODERATE [1]
- ☑ -SLOW [1]
- ☐ -TORRENTIAL[-1]
- ☐ -INTERSTITIAL[-1]
- ☐ -INTERMITTENT[-2]
- ☐ -VERY FAST[1]

COMMENTS: ______

Pool/Current: **5** (Max 12)

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH
- ☐ - Best Areas >10 cm [2]
- ☐ - Best Areas 5-10 cm[1]
- ☑ - Best Areas < 5 cm [RIFFLE=0]

RUN DEPTH
- ☐ - MAX > 50 [2]
- ☑ - MAX < 50[1]

RIFFLE/RUN SUBSTRATE
- ☐ -STABLE (e.g.,Cobble, Boulder) [2]
- ☐ -MOD. STABLE (e.g.,Large Gravel) [1]
- ☑ -UNSTABLE (Fine Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ - NONE [2]
- ☐ - LOW [1]
- ☐ - MODERATE [0]
- ☑ - EXTENSIVE [-1]

COMMENTS: ______ ☐ - NO RIFFLE [Metric=0]

Riffle/Run: **0** (Max 8)

6] GRADIENT (ft/mi): 7.75 DRAINAGE AREA (sq.mi.) : 14.7

%POOL: ____ %GLIDE: ____
%RIFFLE: ____ %RUN: ____

Gradient: **10** (Max 10)

*- *Best areas must be large enough to support a population of riffle-obligate species*

EPA 4520 06/24/01

Is Sampling Reach Representative of the Stream (Y/N)___ If Not, Explain:

Subjective Rating (1-10)	Aesthetic Rating (1-10)	First Sampling Pass	Gear:	Distance:	Water Clarity:	Water Stage:	Canopy -% Open

Gradient: ☐ - Low, ☐ - Moderate, ☐ -High

Stream Measurements:

Average Width	Average Depth	Maximum Depth	Av. Bankfull Width	Bankfull Mean Depth	W/D Ratio	Bankfull Max Depth	Floodprone Area Width	Entrench. Ratio

Major Suspected Sources of Impacts (Check All That Apply):
- None ☐
- Industrial ☐
- WWTP ☐
- Ag ☐
- Livestock ☐
- Silviculture ☐
- Construction ☐
- Urban Runoff ☐
- CSOs ☐
- Suburban Impacts ☐
- Mining ☐
- Channelization ☐
- Riparian Removal ☐
- Landfills ☐
- Natural ☐
- Dams ☐
- Other Flow Alteration ☐
- Other:______

Stream Drawing:

Instructions for scoring the alternate cover metric: Each cover type should receive a score of between 0 and 3, Where: 0 - Cover type absent; 1 - Cover type present in very small amounts or if more common of marginal quality; 2 - Cover type present in moderate amounts, but not of highest quality or in small amounts of highest quality; 3 - Cover type of highest quality in moderate or greater amounts. Examples of highest quality include very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

Yes/No		
☐	☐	Is Stream Ephemeral (no pools, totally dry or only damp spots)?
☐	☐	Is there water upstream? How Far:______
☐	☐	Is There Water Close Downstream? How Far:______
☐	☐	Is Dry Channel Mostly Natural?

6/8

OhioEPA Qualitative Habitat Evaluation Index Field Sheet QHEI Score: 58.5

River Code: ____ **RM:** ____ **Stream:** East Branch Trall Creek - E3

Date: ____ **Location:** ____

Scorers Full Name: ____ **Affiliation:** ____

1] SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % present)

TYPE — POOL RIFFLE

- ☐☐-BLDR /SLBS[10]
- ☐☐-BOULDER [9]
- ☐☐-COBBLE [8]
- ☐☐-HARDPAN [4]
- ☐☐-MUCK [2]
- ☐☑-SILT [2]
- ☐☑-GRAVEL [7]
- ☑☑-SAND [6] — 90
- ☐☐-BEDROCK[5]
- ☐☐-DETRITUS[3]
- ☐☐-ARTIFICIAL[0]

NOTE: Ignore Sludge Originating From Point Sources

NUMBER OF SUBSTRATE TYPES: (High Quality Only, Score 5 or >) ☐-4 or More [2] ☑-3 or Less [0]

COMMENTS____

SUBSTRATE ORIGIN — Check ONE (OR 2 & AVERAGE)

- ☐ -LIMESTONE [1]
- ☑ -TILLS [1]
- ☐ -WETLANDS[0]
- ☐ -HARDPAN [0]
- ☐ -SANDSTONE [0]
- ☐ -RIP/RAP [0]
- ☐ -LACUSTRINE [0]
- ☐ -SHALE [-1]
- ☐ -COAL FINES [-2]

SUBSTRATE QUALITY — Check ONE (OR 2 & AVERAGE)

SILT:
- ☐ - SILT HEAVY [-2]
- ☐ -SILT MODERATE [-1]
- ☑ -SILT NORMAL [0]
- ☐ -SILT FREE [1]

EMBEDDEDNESS:
- ☐ -EXTENSIVE [-2]
- ☑ -MODERATE [-1]
- ☐ -NORMAL [0]
- ☐ -NONE [1]

Substrate: 8 (Max 20)

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions) (Structure) TYPE: Score All That Occur

- 2 UNDERCUT BANKS [1]
- 2 OVERHANGING VEGETATION [1]
- ___ SHALLOWS (IN SLOW WATER) [1]
- ___ ROOTMATS [1]
- 1 POOLS> 70 cm [2]
- ___ ROOTWADS [1]
- ___ BOULDERS [1]
- 1 OXBOWS, BACKWATERS [1]
- 1 AQUATIC MACROPHYTES [1]
- 1 LOGS OR WOODY DEBRIS [1]

COMMENTS:____

AMOUNT: (Check ONLY One or check 2 and AVERAGE)

- ☐ - EXTENSIVE > 75% [11]
- ☑ - MODERATE 25-75% [7]
- ☐ - SPARSE 5-25% [3]
- ☐ - NEARLY ABSENT < 5%[1]

Cover: 15 (Max 20)

3] CHANNEL MORPHOLOGY: (Check ONLY One PER Category OR check 2 and AVERAGE)

SINUOSITY
- ☐ - HIGH [4]
- ☑ - MODERATE [3]
- ☐ - LOW [2]
- ☐ - NONE [1]

DEVELOPMENT
- ☐ - EXCELLENT [7]
- ☑ - GOOD [5]
- ☐ - FAIR [3]
- ☐ - POOR [1]

CHANNELIZATION
- ☑ - NONE [6]
- ☐ - RECOVERED [4]
- ☐ - RECOVERING [3]
- ☐ - RECENT OR NO RECOVERY [1]

STABILITY
- ☐ - HIGH [3]
- ☑ - MODERATE [2]
- ☐ - LOW [1]

MODIFICATIONS/OTHER
- ☐ - SNAGGING
- ☐ - RELOCATION
- ☐ - CANOPY REMOVAL
- ☐ - DREDGING
- ☐ - ONE SIDE CHANNEL MODIFICATIONS
- ☐ - IMPOUND.
- ☐ - ISLANDS
- ☐ - LEVEED
- ☐ - BANK SHAPING

COMMENTS:____

Channel: 17 (Max 20)

4]. RIPARIAN ZONE AND BANK EROSION (check ONE box per bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH — L R (Per Bank)
- ☐☐ - WIDE > 50m [4]
- ☑☐ - MODERATE 10-50m [3]
- ☐☑ - NARROW 5-10 m [2]
- ☐☐ - VERY NARROW <5 m[1]
- ☐☐ - NONE [0]

FLOOD PLAIN QUALITY (*PAST 100 Meter RIPARIAN*) — L R (Most Predominant Per Bank)
- ☑☑-FOREST, SWAMP [3]
- ☐☐-SHRUB OR OLD FIELD [2]
- ☐☐-RESIDENTIAL,PARK,NEW FIELD [1]
- ☐☐-FENCED PASTURE [1]
- ☐☐-CONSERVATION TILLAGE [1]
- ☐☐-URBAN OR INDUSTRIAL [0]
- ☑☑-OPEN PASTURE,ROWCROP [0]
- ☐☐-MINING/CONSTRUCTION [0]

BANK EROSION — L R (Per Bank)
- ☐☐-NONE/LITTLE [3]
- ☑☑-MODERATE [2]
- ☐☐-HEAVY/SEVERE[1]

Riparian: 5.5 (Max 10)

COMMENTS:____

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH (Check 1 ONLY!)
- ☐ - >1m [6]
- ☐ - 0.7-1m [4]
- ☑ - 0.4-0.7m [2]
- ☐ - 0.2- 0.4m [1]
- ☐ - < 0.2m [POOL=0]

MORPHOLOGY (Check 1 or 2 & AVERAGE)
- ☐ -POOL WIDTH > RIFFLE WIDTH [2]
- ☑ -POOL WIDTH = RIFFLE WIDTH [1]
- ☐ -POOL WIDTH < RIFFLE W. [0]

COMMENTS:____

CURRENT VELOCITY [POOLS & RIFFLES!] (Check All That Apply)
- ☐ -EDDIES[1]
- ☐ -FAST[1]
- ☑ -MODERATE [1]
- ☑ -SLOW [1]
- ☐ -TORRENTIAL[-1]
- ☐ -INTERSTITIAL[-1]
- ☐ -INTERMITTENT[-2]
- ☐ -VERY FAST[1]

Pool/Current: 5 (Max 12)

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH
- ☐ - *Best Areas >10 cm [2]
- ☑ - Best Areas 5-10 cm[1]
- ☐ - Best Areas < 5 cm [RIFFLE=0]

RUN DEPTH
- ☐ - MAX > 50 [2]
- ☑ - MAX < 50[1]

RIFFLE/RUN SUBSTRATE
- ☐ -STABLE (e.g.,Cobble, Boulder) [2]
- ☐ -MOD. STABLE (e.g.,Large Gravel) [1]
- ☑ -UNSTABLE (Fine Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
- ☐ - NONE [2]
- ☐ - LOW [1]
- ☑ - MODERATE [0]
- ☐ - EXTENSIVE [-1]

Riffle/Run: 2 (Max 8)

COMMENTS:____ ☐ - NO RIFFLE [Metric=0]

Gradient: 6 (Max 10)

6] GRADIENT (ft/mi): ____ DRAINAGE AREA (sq.mi.) : ____

%POOL: ____ %GLIDE: ____

%RIFFLE: ____ %RUN: ____

*- *Best areas must be large enough to support a population of riffle-obligate species*

EPA 4520 06/24/01

7/8

Is Sampling Reach Representative of the Stream (Y/N)____ If Not, Explain:

Subjective Rating (1-10)	Aesthetic Rating (1-10)

Gradient: ☐ - Low, ☐ - Moderate, ☐ -High

First Sampling Pass	Gear:	Distance:	Water Clarity:	Water Stage:	Canopy -% Open

Stream Measurements:

Average Width	Average Depth	Maximum Depth	Av. Bankfull Width	Bankfull Mean Depth	W/D Ratio	Bankfull Max Depth	Floodprone Area Width	Entrench. Ratio

Major Suspected Sources of Impacts (Check All That Apply):
- None ☐
- Industrial ☐
- WWTP ☐
- Ag ☐
- Livestock ☐
- Silviculture ☐
- Construction ☐
- Urban Runoff ☐
- CSOs ☐
- Suburban Impacts ☐
- Mining ☐
- Channelization ☐
- Riparian Removal ☐
- Landfills ☐
- Natural ☐
- Dams ☐
- Other Flow Alteration ☐
- Other:________

Stream Drawing:

Instructions for scoring the alternate cover metric: Each cover type should receive a score of between 0 and 3, Where: 0 - Cover type absent; 1 - Cover type present in very small amounts or if more common of marginal quality; 2 - Cover type present in moderate amounts, but not of highest quality or in small amounts of highest quality; 3 - Cover type of highest quality in moderate or greater amounts. Examples of highest quality include very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

Yes/No		
☐	☐	Is Stream Ephemeral (no pools, totally dry or only damp spots)?
☐	☐	Is there water upstream? How Far:________
☐	☐	Is There Water Close Downstream? How Far:______
☐	☐	Is Dry Channel Mostly Natural?

Appendix R: Load Calculations

Trail Creek Watershed Sampling Data Analysis Results Using Calculated Base Flow Data

Sample Site E1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	252.33	1716.35	8.20	3.12	17.96	4.97E+14	81.97	53.87
Min Load (tons/yr)	97.35	23.06	1.17	0.78	0.78	4.85E+12	19.52	7.42
Mean Load (tons/yr)	131.63	157.19	3.79	1.20	2.68	8.62E+13	31.75	23.54
Mean Target Load	89.66	192.13	5.84	1.95	2.93	4.06E+13	39.04	390.36
Mean Reduction Needed (%)	N/A	33.08	55.98	37.50	9.95	55.52	24.68	N/A

Sample Site E2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	338.73	1334.39	4.28	1.03	5.47	7.85E+14	27.37	21.21
Min Load (tons/yr)	136.86	30.79	0.51	0.34	0.34	3.10E+12	8.55	3.25
Mean Load (tons/yr)	176.43	191.61	1.59	0.49	1.17	1.30E+14	13.09	10.21
Mean Target Load	119.75	256.61	2.35	0.86	1.28	5.20E+13	17.11	171.08
Mean Reduction Needed (%)	N/A	34.08	44.50	16.67	40.59	57.42	18.09	N/A

Sample Site E3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	378.37	3443.36	4.00	1.60	9.61	9.17E+14	36.04	24.82
Min Load (tons/yr)	156.15	36.04	0.60	0.40	0.40	3.63E+12	10.01	0.80
Mean Load (tons/yr)	204.71	286.66	1.67	0.61	1.39	1.20E+14	14.78	11.46
Mean Target Load	140.14	300.29	2.56	1.00	1.50	6.08E+13	20.02	200.20
Mean Reduction Needed (%)	N/A	38.18	43.11	23.61	42.16	52.87	23.40	N/A

Sample Site M1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	830.03	26331.84	11.45	2.39	44.84	2.79E+15	114.49	52.47
Min Load (tons/yr)	357.77	85.86	1.91	0.95	0.95	2.81E+13	23.85	6.68
Mean Load (tons/yr)	471.43	1235.50	4.67	1.23	4.15	3.40E+14	38.24	22.72
Mean Target Load	333.92	715.54	6.87	2.39	3.58	1.02E+14	47.70	477.03
Mean Reduction Needed (%)	N/A	40.95	39.44	0.00	47.14	59.49	25.85	N/A

Sample Site M2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1145.88	29416.65	11.97	3.99	57.01	2.81E+15	188.13	91.21
Min Load (tons/yr)	421.87	102.62	1.14	1.14	1.14	2.07E+13	28.50	9.12
Mean Load (tons/yr)	574.94	1504.80	5.78	1.56	5.28	3.72E+14	49.81	29.23
Mean Target Load	399.06	855.14	8.32	2.85	4.28	1.22E+14	57.01	570.09
Mean Reduction Needed (%)	N/A	42.41	37.56	28.57	50.11	63.20	32.76	N/A

Sample Site M3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1200.86	25444.06	16.65	3.57	52.31	4.91E+15	184.29	112.95
Min Load (tons/yr)	416.14	107.01	2.38	1.19	1.19	2.16E+13	29.72	5.94
Mean Load (tons/yr)	592.08	1480.65	6.90	1.53	5.39	4.86E+14	54.30	33.27
Mean Target Load	416.14	891.73	8.58	2.97	4.46	1.27E+14	59.45	594.49
Mean Reduction Needed (%)	N/A	46.08	47.18	16.67	45.43	60.13	38.57	N/A

Sample Site M4 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1188.51	33206.65	14.93	1.79	53.75	1.92E+15	161.26	125.42
Min Load (tons/yr)	388.21	107.50	2.99	1.19	1.19	2.87E+13	29.86	5.97
Mean Load (tons/yr)	573.09	1701.88	6.57	1.42	7.19	3.25E+14	48.52	32.62

Mean Target Load	418.07	895.86	8.35	2.99	4.48	1.27E+14	59.72	597.24
Mean Reduction Needed (%)	N/A	51.18	47.38	0.00	48.57	54.55	27.95	N/A

Sample Site M5 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1143.54	25519.10	16.25	12.64	44.54	3.33E+15	150.47	264.82
Min Load (tons/yr)	397.23	108.34	2.41	1.81	3.01	8.19E+12	30.09	30.09
Mean Load (tons/yr)	575.74	1218.84	7.20	5.04	9.43	3.74E+14	52.80	144.01
Mean Target Load	421.31	902.80	11.38	3.01	4.51	1.28E+14	60.19	601.87
Mean Reduction Needed (%)	N/A	43.42	42.77	48.38	60.15	54.87	29.00	N/A

Sample Site M6 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1149.77	8853.86	23.98	7.38	9.22	1.14E+15	116.82	270.53
Min Load (tons/yr)	393.50	110.67	2.46	1.23	1.23	5.58E+12	30.74	6.15
Mean Load (tons/yr)	602.29	700.93	8.55	3.17	5.59	1.50E+14	49.43	116.03
Mean Target Load	430.40	922.28	4.66	3.07	4.61	1.31E+14	61.49	614.85
Mean Reduction Needed (%)	N/A	48.67	38.95	33.84	48.80	45.75	27.32	N/A

Sample Site W1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	276.87	3908.68	5.92	1.18	10.96	1.21E+15	39.98	25.61
Min Load (tons/yr)	114.00	26.65	0.30	0.30	0.44	9.40E+12	7.40	1.48
Mean Load (tons/yr)	149.22	403.78	2.24	0.42	1.46	3.54E+14	13.92	6.56
Mean Target Load	103.64	222.08	2.06	0.74	1.11	3.16E+13	14.81	148.06
Mean Reduction Needed (%)	N/A	49.22	43.66	27.08	43.06	82.11	26.08	N/A

Sample Site W2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	73.95	2974.07	0.81	0.20	3.98	1.07E+14	11.78	3.78
Min Load (tons/yr)	32.91	7.31	0.12	0.08	0.08	5.90E+11	2.03	0.41
Mean Load (tons/yr)	42.25	137.67	0.31	0.09	0.30	1.48E+13	2.77	1.31
Mean Target Load	28.44	60.94	0.51	0.20	0.30	8.66E+12	4.06	40.63
Mean Reduction Needed (%)	N/A	40.64	33.26	N/A	92.01	53.94	56.44	N/A

Sample Site W3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	29.01	304.04	0.32	0.10	0.26	2.25E+13	2.19	0.85
Min Load (tons/yr)	14.90	3.58	0.06	0.04	0.04	3.61E+10	0.99	0.08
Mean Load (tons/yr)	17.97	42.36	0.12	0.05	0.08	3.69E+12	1.10	0.24
Mean Target Load	13.91	29.81	0.21	0.10	0.15	4.24E+12	1.99	19.87
Mean Reduction Needed (%)	N/A	45.28	35.02	N/A	38.18	36.65	9.09	N/A

Trail Creek Watershed Sampling Data Analysis Results Using Estimated Flow Data

Sample Site E1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	152.30	1175.65	2.39	0.67	3.34	1.09E+14	18.73	12.42
Min Load (tons/yr)	14.28	133.60	1.74	0.27	0.67	1.21E+13	11.62	12.30
Mean Load (tons/yr)	83.29	654.62	2.06	0.47	2.00	6.06E+13	15.18	12.36
Mean Target Load	93.52	4.79	0.92	0.67	1.00	2.85E+13	13.36	133.60
Mean Reduction Needed (%)	N/A	66.00	52.95	37.50	8.00	73.89	28.57	N/A

Sample Site E2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	353.36	1392.02	4.46	1.07	5.71	8.19E+14	28.55	22.13
Min Load (tons/yr)	142.77	32.12	0.54	0.36	0.36	3.24E+12	8.92	3.39
Mean Load (tons/yr)	184.05	199.88	1.65	0.51	1.22	1.36E+14	13.66	10.65
Mean Target Load	124.93	535.39	2.67	0.89	1.34	3.80E+13	17.85	178.46
Mean Reduction Needed (%)	N/A	29.99	48.66	16.67	40.59	67.20	18.09	N/A

Sample Site E3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	394.71	3592.09	4.18	1.67	10.02	9.57E+14	37.59	25.90
Min Load (tons/yr)	162.90	37.59	0.63	0.42	0.42	3.79E+12	10.44	0.84
Mean Load (tons/yr)	213.55	299.04	1.75	0.63	1.45	1.26E+14	15.42	11.95
Mean Target Load	146.19	626.53	3.12	1.04	1.57	4.45E+13	20.88	208.84
Mean Reduction Needed (%)	N/A	47.91	42.37	23.61	42.16	61.63	23.40	N/A

Sample Site M1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	865.97	27472.01	11.94	2.49	46.78	2.91E+15	119.44	54.74
Min Load (tons/yr)	373.26	89.58	1.99	1.00	1.00	2.93E+13	24.88	6.97
Mean Load (tons/yr)	491.84	1288.99	4.87	1.29	4.32	3.55E+14	39.90	23.70
Mean Target Load	348.38	1493.04	7.45	2.49	3.73	1.06E+14	49.77	497.68
Mean Reduction Needed (%)	N/A	49.90	43.60	N/A	47.14	59.49	25.85	N/A

Sample Site M2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1195.49	30690.16	12.49	4.16	59.48	2.94E+15	196.27	95.16
Min Load (tons/yr)	440.13	107.06	1.19	1.19	1.19	2.16E+13	29.74	9.52
Mean Load (tons/yr)	599.83	1569.94	6.03	1.63	5.51	3.88E+14	51.96	30.50
Mean Target Load	416.34	1784.31	8.90	2.97	4.46	1.27E+14	59.48	594.77
Mean Reduction Needed (%)	N/A	36.98	48.43	28.57	50.11	63.20	32.76	N/A

Sample Site M3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1252.91	26546.71	17.37	3.72	54.58	5.12E+15	192.28	117.85
Min Load (tons/yr)	434.18	111.65	2.48	1.24	1.24	2.25E+13	31.01	6.20
Mean Load (tons/yr)	617.74	1544.82	7.19	1.59	5.62	5.07E+14	56.65	34.71
Mean Target Load	434.18	1860.75	9.28	3.10	4.65	1.32E+14	62.03	620.25
Mean Reduction Needed (%)	N/A	38.46	48.84	16.67	45.43	60.13	38.57	N/A

Sample Site M4 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1239.87	34641.61	15.58	1.87	56.07	2.00E+15	168.22	130.84
Min Load (tons/yr)	404.98	112.15	3.12	1.25	1.25	3.00E+13	31.15	6.23
Mean Load (tons/yr)	597.86	1775.42	6.85	1.48	7.50	3.39E+14	50.62	34.03
Mean Target Load	436.14	1869.15	9.32	3.12	4.67	1.33E+14	62.31	623.05
Mean Reduction Needed (%)	N/A	48.52	48.14	N/A	48.57	54.55	27.95	N/A

Sample Site M5 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1390.70	31034.59	19.76	15.37	54.16	4.05E+15	182.99	322.06
Min Load (tons/yr)	483.09	131.75	2.93	2.20	3.66	9.96E+12	36.60	36.60
Mean Load (tons/yr)	700.18	1482.27	8.76	6.12	11.47	4.55E+14	64.22	175.13
Mean Target Load	512.36	2195.84	10.95	3.66	5.49	1.56E+14	73.19	731.95
Mean Reduction Needed (%)	N/A	42.73	44.88	48.38	60.15	54.87	29.00	N/A

Sample Site M6 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2701.31	9801.22	54.98	9.56	31.08	2.15E+15	289.23	413.18
Min Load (tons/yr)	13.50	8.26	0.10	0.04	0.07	-8.50E+13	0.69	0.69
Mean Load (tons/yr)	621.19	790.37	12.17	3.49	7.16	1.78E+14	74.53	138.45
Mean Target Load	443.99	1902.80	8.14	3.17	15.49	1.54E+14	63.43	634.27
Mean Reduction Needed (%)	N/A	26.83	48.27	34.94	48.50	42.31	27.3183	N/A

Sample Site W1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	288.93	4079.03	6.18	1.24	11.43	1.26E+15	41.72	26.73
Min Load (tons/yr)	118.97	27.81	0.31	0.31	0.46	9.81E+12	7.73	1.55
Mean Load (tons/yr)	155.73	421.38	2.33	0.44	1.52	3.70E+14	14.52	6.84
Mean Target Load	108.16	463.53	2.31	0.77	1.16	3.29E+13	15.45	154.51
Mean Reduction Needed (%)	N/A	48.92	43.53	27.08	43.06	82.11	26.08	N/A

Sample Site W2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	77.08	3100.00	0.85	0.21	4.15	1.11E+14	12.28	3.94
Min Load (tons/yr)	34.30	7.62	0.13	0.08	0.08	6.15E+11	2.12	0.42
Mean Load (tons/yr)	44.04	143.50	0.32	0.09	0.31	1.55E+13	2.88	1.36
Mean Target Load	29.64	127.05	0.63	0.21	0.32	9.03E+12	4.23	42.35
Mean Reduction Needed (%)	N/A	68.42	41.67	N/A	92.01	53.94	56.44	N/A

Sample Site W3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	30.26	317.10	0.33	0.10	0.27	2.35E+13	2.28	0.89
Min Load (tons/yr)	15.54	3.73	0.06	0.04	0.04	3.76E+10	1.04	0.08
Mean Load (tons/yr)	18.74	44.18	0.13	0.05	0.09	3.85E+12	1.15	0.25
Mean Target Load	14.51	62.18	0.31	0.10	0.16	4.42E+12	2.07	20.73
Mean Reduction Needed (%)	N/A	41.61	37.51	N/A	38.18	36.65	9.09	N/A

Trail Creek Watershed Sampling Data Analysis Results Using Calculated Peak Flow Data

Sample Site E1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	252.33	5230.78	8.20	3.12	17.96	1.45E+15	81.97	53.87
Min Load (tons/yr)	97.35	70.26	1.17	0.78	0.78	1.42E+13	19.52	7.42
Mean Load (tons/yr)	131.63	479.06	3.79	1.20	2.68	2.52E+14	31.75	23.54
Mean Target Load	89.66	585.54	5.37	1.95	2.93	8.32E+13	39.04	390.36
Mean Reduction Needed (%)	N/A	33.08	49.47	37.50	41.93	68.08	24.68	N/A

Sample Site E2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	743.49	2928.91	9.39	2.25	12.02	1.72E+15	60.08	46.56
Min Load (tons/yr)	300.40	67.59	1.13	0.75	0.75	6.81E+12	18.78	7.13
Mean Load (tons/yr)	387.25	420.56	3.48	1.08	2.57	2.85E+14	28.74	22.42
Mean Target Load	262.85	563.25	5.15	1.88	2.82	8.01E+13	37.55	375.50
Mean Reduction Needed (%)	N/A	34.08	44.50	16.67	40.59	67.20	18.09	N/A

Sample Site E3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	697.24	6345.26	7.38	2.95	17.71	1.69E+15	66.40	45.74
Min Load (tons/yr)	287.75	66.40	1.11	0.74	0.74	6.69E+12	18.45	1.48
Mean Load (tons/yr)	377.23	528.25	3.09	1.12	2.56	2.22E+14	27.24	21.11
Mean Target Load	258.24	553.37	4.72	1.84	2.77	7.86E+13	36.89	368.91
Mean Reduction Needed (%)	N/A	38.18	43.11	23.61	42.16	61.63	23.40	N/A

Sample Site M1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2384.29	75639.56	32.89	6.85	128.81	8.01E+15	328.87	150.73
Min Load (tons/yr)	1027.71	246.65	5.48	2.74	2.74	8.08E+13	68.51	19.18
Mean Load (tons/yr)	1354.20	3549.03	13.42	3.54	11.91	9.72E+14	109.86	65.25
Mean Target Load	959.20	2055.42	19.72	6.85	10.28	2.88E+14	137.03	1370.28
Mean Reduction Needed (%)	N/A	40.95	39.44	N/A	47.14	59.49	25.85	N/A

Sample Site M2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2997.48	76950.29	31.32	10.44	149.13	8.94E+15	492.12	238.61
Min Load (tons/yr)	1103.55	268.43	2.98	2.98	2.98	6.57E+13	74.56	23.86
Mean Load (tons/yr)	1503.98	3936.36	15.11	4.08	13.82	1.18E+15	130.29	76.47
Mean Target Load	1043.90	2236.93	21.77	7.46	11.18	3.86E+14	149.13	1491.28
Mean Reduction Needed (%)	N/A	42.41	37.56	28.57	50.11	63.20	32.76	N/A

Sample Site M3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2541.03	53839.68	35.22	7.55	110.70	1.34E+16	389.96	239.01
Min Load (tons/yr)	880.56	226.43	5.03	2.52	2.52	5.90E+13	62.90	12.58
Mean Load (tons/yr)	1252.85	3133.06	14.59	3.23	11.41	1.33E+15	114.89	70.40
Mean Target Load	880.56	1886.90	18.16	6.29	9.43	3.47E+14	125.79	1257.94
Mean Reduction Needed (%)	N/A	46.08	47.18	16.67	45.43	60.13	38.57	N/A

Sample Site M4 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2466.10	68902.01	30.98	3.72	111.53	5.19E+15	334.60	260.24
Min Load (tons/yr)	805.51	223.06	6.20	2.48	2.48	7.77E+13	61.96	12.39
Mean Load (tons/yr)	1189.14	3531.31	13.63	2.95	14.91	8.79E+14	100.68	67.69
Mean Target Load	867.47	1858.87	17.33	6.20	9.29	3.44E+14	123.92	1239.24
Mean Reduction Needed (%)	N/A	51.18	47.38	N/A	48.57	54.55	27.95	N/A

Sample Site M5 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2708.77	60448.31	38.49	29.94	105.50	1.03E+16	356.42	627.29
Min Load (tons/yr)	940.94	256.62	5.70	4.28	7.13	2.52E+13	71.28	71.28
Mean Load (tons/yr)	1363.79	2887.13	17.06	11.93	22.34	1.15E+15	125.08	341.11
Mean Target Load	997.97	2138.50	27.00	7.13	10.69	3.95E+14	142.57	1425.67
Mean Reduction Needed (%)	N/A	43.42	40.94	48.38	60.15	54.87	29.00	N/A

Sample Site M6 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	2936.61	22613.46	61.24	18.84	23.56	3.66E+15	298.37	690.97
Min Load (tons/yr)	1005.04	282.67	6.28	3.14	3.14	1.78E+13	78.52	15.70
Mean Load (tons/yr)	1538.30	1790.23	21.83	8.11	14.29	4.78E+14	126.24	296.35
Mean Target Load	1099.27	2355.57	11.90	7.85	11.78	4.19E+14	157.04	1570.38
Mean Reduction Needed (%)	N/A	48.67	38.95	33.84	48.80	45.75	27.32	N/A

Sample Site W1 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	1926.65	27199.76	41.21	8.24	76.24	8.41E+15	278.18	178.24
Min Load (tons/yr)	793.33	185.45	2.06	2.06	3.09	6.54E+13	51.51	10.30
Mean Load (tons/yr)	1038.40	2809.85	15.56	2.95	10.17	2.46E+15	96.85	45.64
Mean Target Load	721.21	1545.44	14.33	5.15	7.73	2.20E+14	103.03	1030.29
Mean Reduction Needed (%)	N/A	49.22	43.66	27.08	43.06	82.11	26.08	N/A

Sample Site W2 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	73.95	2974.07	0.81	0.20	3.98	1.07E+14	11.78	3.78
Min Load (tons/yr)	32.91	7.31	0.12	0.08	0.08	5.90E+11	2.03	0.41
Mean Load (tons/yr)	42.25	137.67	0.31	0.09	0.30	1.48E+13	2.77	1.31
Mean Target Load	28.44	60.94	0.51	0.20	0.30	8.66E+12	4.06	40.63
Mean Reduction Needed (%)	N/A	40.64	33.26	N/A	92.01	53.94	56.44	N/A

Sample Site W3 Descriptive Statistics	Dissolved Oxygen	Total Suspended Solids	Ammonia	Ortho Phosphorus	Total Phosphorus	E. coli (cfu/year)	TKN	Nitrate + Nitrite
Max Load (tons/yr)	29.01	304.04	0.32	0.10	0.26	2.25E+13	2.19	0.85
Min Load (tons/yr)	14.90	3.58	0.06	0.04	0.04	3.61E+10	0.99	0.08
Mean Load (tons/yr)	17.97	42.36	0.12	0.05	0.08	3.69E+12	1.10	0.24
Mean Target Load	13.91	29.81	0.21	0.10	0.15	4.24E+12	1.99	19.87
Mean Reduction Needed (%)	N/A	45.28	35.02	N/A	38.18	36.65	9.09	N/A

Appendix S: Load Reduction Calculations

Agricultural Fields and Filter Strips

Please check which BMPs apply:

☑ Agricultural Field Practices

☑ * Filter Strips

Please select a state and a county, and default USLE parameter values will be entered.

Users should use the local USLE parameter values if available!

State: Indiana

County: La Porte

Please fill in the gray areas below:

USLE or RUSLE	Before Treatment	After Treatment	Example **Before Treatment**	Example **After Treatment**
Rainfall-Runoff Erosivity Factor (R)	140.00	140.00	**120**	**120**
Soil Erodibility Factor (K)	0.24	0.24	**0.35**	**0.35**
Length-Slope Factor (LS)	0.35	0.35	**0.44**	**0.44**
Cover Management Factor (C<=1.0)*	0.20	0.20	**0.7**	**0.5**
Support Practice Factor (P<=1.0)*	1.00	1.00	**0.775**	**0.11**
Predicted Avg Annual Soil Loss (ton/acre/year)	2.36	2.36	**10.03**	**1.02**

* User must use the local C and/or P values (in red) to obtain the reduction due to the field practices.

		Example
Enter contributing area (acres)	1	**14**

Application of BMPs will change C and/or P values in the USLE, and may include:

Prescribed Grazing
Residue Management, Mulch Till
Conservation Crop Rotation
Conservation Cover
Cover and Green Manure
Critical Area Planting
Stripcropping, Contour
Stripcropping, Field
Stripcropping, Field

* Filter Strips may further reduce sediment by 65%, phosphorous by 75% and nitrogen by 70% based on Pennsylvania state university (1992).

Please select a gross soil texture:

○ Clay (clay, clay loam, and silt clay)
◉ Silt (silt, silty clay loam, loam, and silt loam)
○ Sand (sand, sandy clay, sandy clay loam, sandy loam, and loamy sand)
○ Peat

Estimated Load Reductions for Agricultural Field Practices

	Treated	**Example**
Sediment Load Reduction (ton/year)	0	**85**
Phosphorus Load Reduction (lb/year)	0	**100**
Nitrogen Load Reduction (lb/yr)	0	**200**

Estimated Additional Load Reductions through Filter Strips

	Filter-Strip Efficiency	**Filter-Strip Treated**	**Example**
Sediment Load Reduction (ton/year)	0.65	1	**92**
Phosphorus Load Reduction (lb/year)	0.75	2	**114**
Nitrogen Load Reduction (lb/yr)	0.70	4	**227**

Total Estimated Load Reductions

	Total	**Example**
Sediment Load Reduction (ton/year)	1	**177**
Phosphorus Load Reduction (lb/year)	2	**214**
Nitrogen Load Reduction (lb/yr)	4	**427**

Pennsylvania State University. 1992. Nonpoint Source Database. In U.S. EPA, Guidance specifying management measures for sources of nonpoint pollution in coastal waters, page 2-15.

Feedlot Pollution Reduction

Please fill in the gray areas below.

Notes:
An animal lot refers to an open lot or combination of open lots intended for confined feeding, breeding, raising or holding animals. It is specifically designed as a confinement area in which manure accumulates or where the concentration of animals is such that vegetation cannot be maintained. The purpose of these calculations is to represent Biological Oxygen Demand (BOD), phosphorus (P), and nitrogen reductions after an animal waste system is installed. This method has two assumptions: 1) the feedlot is adjacent to a receiving hydrological system without any buffering areas; and 2) installing the animal waste system will prevent any further pollutants from the lot from reaching the hydrologic system. Feedlots that cannot show impact to the hydrologic system being protected should not be evaluated with this computation.

The fundamental methodology of this worksheet is based on "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual" (Michigan DEQ, June 1999). However, the Michigan DEQ methodology was modified to calculate annual load through inclusion of climatological data. In addition, biological oxygen demand, phosphorus, and nitrogen constants used in this worksheet were derived from U.S. EPA's STEPL model, developed by Tetra Tech, Inc. in order to enhance consistency between methods.

STEP 1

10 — **Contributing Area (acres): the area contributing polluted water to the discharge point(s).**

STEP 2

Percent Paved: Percent of the contributing area that is paved

- ( ) 0-24%
- (•) 25-49%
- ( ) 50-74%
- ( ) 75-100%

STEP 3

Please select your State. Indiana

Please select your County. Adams

Nearest Weather Station IN VALPARAISO WATERWORK

Note: Precipitation data for Alaska and Hawaii were unavailable for this version of the workbook.

STEP 4

Animal Numbers	Animal Type	Design Weight*
0	Slaughter Steer	1,000
0	Young Beef	500
20	Dairy Cow	1,400
5	Young Dairy Stock	500
0	Swine	200
0	Feeder Pig	50
0	Sheep	100
0	Turkey	10
0	Chicken	4
0	Duck	4
0	Horse	1,000

*Design weight in pounds. Interpolation of values should be based on the maximum weight animals would be expected to reach.

STEP 5

Select a Best Management Practice

- ( ) No BMP
- ( ) Diversion
- ( ) Filter Strip
- ( ) Runoff Mgmt System
- ( ) Terrace
- (•) Waste Mgmt System
- ( ) Waste Storage Facility
- ( ) Solids Separation Basin
- ( ) Solids Separation Basin w/ Infilt Bed

END **Estimated Load and Load Reductions**

Pollutants	Load before BMP	**Load Reduction**	Load after BMP
Biochemical Oxygen Demand load (lbs/yr)	**845**	**NA**	**NA**
Phosphorus load (lbs/yr)	**83**	**75**	**8**
Nitrogen load (lbs/yr)	**851**	**681**	**170**

NA indicates no BMP efficiency data available.

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- ( ) Sands, loamy sands
- ( ) Sandy loam
- ( ) Fine sandy loam
- (•) Loams, sandy clay loams, sandy clay
- ( ) Silt loam
- ( ) Silty clay loam, silty clay
- ( ) Clay loam
- ( ) Clay
- ( ) Organic

Please fill in the gray areas below:

Parameter		Bank #1	Bank #2	**Example**	
Length (ft)		100	100	**500**	
Height (ft)		5	5	**15**	
Lateral Recession Rate (ft/yr)*		0.2	0.2	**0.5**	
Soil Weight (tons/ft3)		0.045	0.045	**0.04**	
Soil P Conc (lb/lb soil)**	USER	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**	USER	0.001	0.001	**0.001**	**

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	**BMP Efficiency* Bank #2**	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	1.0	1.0	4.5	4.5	**150**
Phosphorus Load Reduction (lb/year)			3.8	3.8	**150**
Nitrogen Load Reduction (lb/yr)			7.7	7.7	**300**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Appendix T: List of Funding Opportunities

APPENDIX III

FUNDING SOURCES

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) - PROGRAM GRANTS TO STATES Watersheds and Nonpoint Source Programs Branch, U.S. EPA Region 5 77 W. Jackson Blvd., Chicago, IL, 60604-3590 (312) 353-2308; www.epa.gov/r5water/wshednps.htm			
Nonpoint Source Implementation Grants (319)	The 319 program provides formula grants to the States to implement nonpoint source projects and programs in accordance with Section 319 of the Clean Water Act.	States and Indian Tribes	Grants are awarded to a lead agency (IDEM). States and local organizations receiving 319 grants are required to provide 40 percent of program cost.
Water Quality Cooperative Agreements (104 (b)(3))	Grants are provided to support new approaches to meeting storm water, combined sewer outflows, sludge, and pretreatment requirements as well as enhancing State capabilities. Eligible projects usually include research, investigations, experiments, training, environmental technology demonstrations, surveys, and studies related to the causes, effects, extent, and prevention of pollution.	State water pollution control agencies, interstate agencies, local public agencies, Indian Tribes, nonprofit institutions, organizations, and individuals	Grants are awarded; matching is encouraged .
Water Quality Management Planning (205 (J))	Formula grants are awarded to State water quality management agencies to carry out water quality planning. States are required to allocate at least 40 percent of funds to eligible Regional Public Comprehensive Planing Agencies (RPCPO) and Interstate Organizations (IO).	States	States are required to allocate at least 40 percent of funds to eligible RPCPOs and IOs.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
State Revolving Funds (SRF)	EPA awards grant money to States to establish SRFs. Under the SRF program, Indiana has created revolving loan funds to provide independent and permanent sources of low-cost financing for a range of water quality infrastructure projects. States set loan terms, repayment periods, and other loan features. SRFs are available to fund a wide variety of water quality projects including all types of nonpoint source and estuary management projects, as well as more traditional wastewater treatment projects.	States	Grants are awarded to a lead agency (IDEM). Loans are provided by IDEM to eligible participants.
Capitalization Grants for State Revolving Funds	EPA awards grants to States to capitalize their Clean Water State Resolving Funds (SRF). The States, through the SRF, make loans for high priority water quality activities. Loans are used for water quality management activities.	States, Tribes, Puerto Rico, Territories, and DC	Grants are awarded to a lead agency (IDEM). Loans are provided by IDEM to eligible participants. States are required to provide a 20 percent match
Capitalization Grants for Drinking Water State Revolving Funds	EPA awards grant money to Indiana for Drinking Water State Revolving Funds (DWSRF) creation. Indiana, through its DWSRF, provides loans for drinking water supply-related projects. Although the majority of loan money is intended for upgrades of infrastructure (public or private drinking water supplies), Indiana also has the option to use some of the DWSRF funds for source water protection, capacity development, drinking water programs, and operator certification programs. DWSRF emphasizes preventing contamination and enhancing water systems management.	States, Territories, U.S. possessions, and Indian Tribes.	Grants and loans are awarded to drinking water suppliers. A 20 percent match from the State is required.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Water Pollution Control Program Grants (Section 106)	This program authorizes EPA to provide assistance to States and interstate agencies to establish and implement ongoing water pollution control programs. Prevention and control measures supported include permitting, pollution control activities, surveillance, monitoring, and enforcement; advice and assistance to local agencies; and the provision of training and public information. The Section 106 programs help foster a watershed approach at the State level by looking at water quality problems holistically.	States, interstate agencies, and Indian Tribes	Funds are allotted among the State and Interstate Water Pollution Control agencies on the basis of the extent of water pollution problems in the respective States.
EPA - PROJECT GRANTS Watersheds and Nonpoint Source Programs Branch, U.S. EPA Region 5 77 W. Jackson Blvd., Chicago, IL, 60604-3590 (312) 353-2308; www.epa.gov/r5water/wshednps.htm			
Great Lakes Program	EPA's Great Lakes Program issues awards assistance to projects affecting the Great Lakes Basin or in support of the U.S.-Canada Great Lakes Water Quality Agreement. Such activities include surveillance and monitoring of Great Lakes water quality and land use activities.	State water pollution control agencies, interstate agencies, other public or nonprofit agencies, institutions, organizations, and individuals	Project grants, use of property and equipment, provision of specialized services, and dissemination of technical information are the forms of assistance provided.
Pollution Prevention Grants Program	This program provides project grants to States to implement pollution prevention projects. The grant program is focused on institutionalizing multimedia pollution prevention (air, water, land).	States and Indian Tribes	Individual grants are awarded based on requests. States are required to provide at least 50 percent of total project costs
Wetlands Protection Development Grants Program	This program provides financial assistance to States, Indian Tribes, and local governments to support wetlands development or augmentation and enhancement of existing programs. Projects must clearly demonstrate a direct link to an increase in the group's ability to protect its wetland resources.	States, Indian Tribes, Interstate/Intertribal agencies, local governments	Project grants are used to fund individual projects. States or Tribes must provide a 25 percent match of the total project cost

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
NATURAL RESOURCES CONSERVATION SERVICE (NRCS) 6013 Lakeside Boulevard, Indianapolis, IN 46278 (317) 290-3200, http://www.in.nrcs.usda.gov/			
Environmental Quality Incentives Program (EQIP)	EQIP provides technical, financial, and educational assistance, half of it targeted to livestock-related natural resource concerns and the other half to more general conservation priorities. EQIP is available primarily in priority areas where there are significant natural resource concerns and objectives.	Non-federal landowners engaged in livestock operations or agricultural productions. Eligible land includes cropland, rangeland, pasture, forest land, and other farm and ranch lands	EQIP can provide up to 75 percent of costs of certain conservation practices. Incentive payments can be up to 100 percent for 3 years, paid at a flat rate. The maximum is $10,000 per person per year and $50,000 over the length of the contract.
Forestry Incentives Program (FIP)	FIP supports good forest management practices on privately owned, nonindustrial forest lands nationwide. FIP is designed to benefit the environment while meeting future demands for wood products. Eligible practices are tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities. FIP's forest maintenance and reforestation provides numerous natural resource benefits, including reduced soil erosion and enhanced water quality and wildlife habitat. Land must be suitable for conversion from nonforest to forest land, for reforestation, or for improved forest management and be capable of producing marketable timber crops.	Private landowner of at least 10 acres and no more than 1,000 acres of nonindustrial forest or other suitable land. Individuals, groups, Indian Tribes, and corporations whose stocks are not publicly traded might be eligible provided they are not primarily manufacturing forest products or providing public utility services.	FIP provides no more than 65 percent of the total costs, with a maximum of $10,000 per person per year.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Small Watershed Program	This program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres. Technical and financial assistance is available for installation of works of improvement to protect, develop, and utilize the land and water resources in small watersheds.	Local or State agency, county, municipality, town or township, soil and water conservation district, flood prevention or flood control district, Indian Tribe or Tribal organization, or nonprofit agency with authority to carry out, maintain, and operate watershed improvement works	Assistance can cover 100 percent of flood prevention construction costs; 50 percent of construction costs related to agricultural water management, recreation and fish and wildlife; and none of the costs for other municipal and industrial water management. Technical assistance and counseling may also be provided.
Wetlands Reserve Program (WRP)	The Wetlands Reserve Program (WRP) is a voluntary program to restore and protect wetlands on private property. WRP provides landowners with financial incentives to enhance wetlands in exchange for retiring marginal agricultural land. Landowners may sell a conservation easement or enter into a cost-share restoration agreement. Landowners voluntarily limit future use of the land, yet retain private ownership. Landowners and the NRCS develop a plan for the restoration and maintenance of the wetland.	The easement participant must have owned the land for at least 1 year. An owner can be an individual, partnership, association, corporation, estate, trust, business or other legal entities, a State (when applicable), political subdivision of a State, or any agency thereof owning private land. Land must be restorable and suitable for wildlife benefits.	WRP provides three options to the landowner: *Permanent Easement*: USDA purchases easement (price is lesser of land value or payment cap.) USDA pays 100 percent of restoration costs. *30-year Easement*: Payment will be 75 percent of what would be paid for a permanent easement. USDA pays 75 percent of restoration costs. *Restoration Cost Share Agreement*: Agreement (min. 10 yr.) to restore degraded wetland habitat. USDA pays 75 percent of restoration costs.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Wildlife Habitat Incentives Program (WHIP)	WHIP is a voluntary program for people who want to develop and improve wildlife habitat on private land. It provides both technical assistance and cost sharing to help establish and improve fish and wildlife habitat. A wildlife habitat plan is developed that describes the landowner's goals for improving wildlife habitat, includes a list of practices and schedule for installing them, and details the steps necessary for maintenance.	Individuals must own or have control of the land under consideration, and cannot have the land already enrolled in programs that have a wildlife focus, such as the WRP, or use the land for mitigation.	USDA will pay up to 75 percent of installation costs and will provide technical assistance for successfully establishing habitat development projects.
Resource Conservation and Development Program (RC&D)	RC & D provides a way for local residents to work together and plan how they can actively solve environmental, economic, and social problems facing their communities. Assistance is available for planning and installation of approved projects specified in RC&D area plans, for land conservation, water management, community development, and environmental enhancement.	Must be an RC&D area authorized by the Secretary of Agriculture for assistance	Technical assistance Grants (as funding allows) up to 25 percent of total cost not to exceed $50,000. Financial assistance has not been available in recent years due to budget constraints. Local or State government must provide 10 percent of total cost and are also responsible for operation and maintenance.
Watershed Surveys and Planning	This program provides planning assistance to Federal, State and local agencies for the development of coordinated water and related land resources programs in watershed and river basins. Special priority is given to projects helping to solve problems of upstream rural community flooding, water quality improvement coming from agricultural nonpoint sources, wetland preservation, and drought management for agricultural and rural communities.	State, Federal, Indian tribes, or local agencies	Technical assistance is provided. Each cooperating agency is expected to fund its own participation.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Emergency Watershed Protection (EWP) Program	The EWP Program was set up to respond to emergencies created by natural disasters. All EWP work must reduce threats to life and property. It must be economically and environmentally defensible. EWP work can include a wide variety of measures ranging from reshaping and protecting eroded banks to reseeding damaged areas.	Public and private landowners are eligible for assistance but must be represented by a project sponsor who must be a public agency.	NRCS can fund up to 75 percent of total cost.
INDIANA FARM SERVICE AGENCY 5981 Lakeside Boulevard, Indianapolis, IN 46278 (317) 290-3030; http://www.fsa.usda.gov/EDSO/in/			
Conservation Reserve Program (CRP)	CRP reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers.	Agricultural land owners	Farmers receive an annual rental payment for the term of the multi-year contract up to $50,000 per fiscal year. Cost sharing is provided to establish the vegetative cover practices up to 50 percent. Incentive payments provided for wetland hydrology restoration equal to 25 percent of the cost.
Emergency Conservation Program (ECP)	The ECP provides financial assistance to farmers and ranchers for the restoration of farmlands on which normal farming operations have been impeded by floods or other natural disasters. ECP also provides funds for carrying out emergency water conservation measures during periods of severe drought. ECP assistance is available for removing debris and restoring permanent systems and conservation installations.	Eligible farmers are determined by individual on-site inspections.	FSA pays up to 64 percent of the total cost with a maximum of $200K total-cost sharing paid to an individual per disaster. The NRCS provides technical assistance.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
U.S. FOREST SERVICE – Hoosier National Forest 811 Constitution Avenue, Bedford, IN 47421 (812) 275-5987; http://www.fs.fed.us/			
Cooperative Forestry Assistance	Cooperative Forestry Assistance helps State Foresters or equivalent agencies with forest stewardship programs on private, State, local, and other non-Federal forest and rural lands, plus rural communities and urban areas. This assistance is provided through the following programs: Forest Stewardship Program, Stewardship Incentive Program, Economic Action Programs, Urban and Community Forestry Program, Cooperative Lands Forest Health Protection Program, and Cooperative Lands Fire Protection Program. These programs help to achieve ecosystem health and sustainability by improving wildlife habitat, conserving forest land, reforestation, improving soil and water quality, preventing and suppressing damaging insects and diseases, wildfire protection, expanding economies of rural communities, and improving urban environments.	State Forester or equivalent State agency can receive moneys. State agencies can provide these moneys to owners of non-Federal lands, rural communities, urban/municipal governments, nonprofit organizations, and State, local, and private agencies acting through State Foresters or equivalent.	Formula grants, project grants, and cost share programs are available as well as use of property and facilities.
Stewardship Incentive Program	The Stewardship Incentive Program provides technical and financial assistance to encourage nonindustrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity.	Eligible landowners must have an approved Forest Stewardship Plan and own 1,000 or fewer acres of qualifying land. Authorizations may be obtained for exceptions of up to 5,000 acres.	Technical or financial assistance can be provided.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
U.S. FISH AND WILDLIFE SERVICE 620 S. Walker, Bloomington, IN, 47403 (812) 334-4261; http:\\www.fws.gov			
Coastal Wetlands Planning, Protection, and Restoration Act	This program provides funds to assist States in pursuing coastal wetland conservation projects. Funds can be used for acquisition of interests in coastal lands or waters, and for restoration, enhancement, or management of coastal wetland ecosystems on a competitive basis with all coastal states.	All States bordering the Atlantic, Gulf and Pacific coasts, Great Lakes and other U.S. coastal territories	Project grants. Federal share of costs not to exceed 50 percent; Federal share may be increased to 75 percent if a coastal State has established a fund (1) for the acquisition of coastal wetlands, other natural areas, or open spaces, or (2) derived from a dedicated recurring source of moneys.
Partners for Wildlife Habitat Restoration Program	The Partners for Wildlife Program provides technical and financial assistance to private landowners through voluntary cooperative agreements in order to restore formerly degraded wetlands, native grasslands, riparian areas, and other habitats to conditions as natural as feasible. Under cooperative agreements, private landowners agree to maintain restoration projects as specified in the agreement but otherwise retain full control of the land. To date, the Partners for Wildlife Program has restored over 360,000 acres of wetlands, 128,000 acres of prairie grassland, 930 miles of riparian habitat, and 90 miles of in-stream aquatic habitat.	Private landowners (must enter into a cooperative agreement for a fixed term of at least 10 years)	Project grants (cooperative agreements) are provided. Program's goal is that no more than 60 percent of project cost is paid by Federal moneys (the program seeks remainder of cost share from landowners and nationally-based and local entities).

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Wildlife Conservation and Appreciation Program	The Wildlife Conservation and Appreciation Program provides grants to fund projects that bring together USFWS, State agencies, and private organizations and individuals. Projects include identification of significant problems that can adversely affect fish and wildlife and their habitats; actions to conserve species and their habitats; actions that will provide opportunities for the public to use and enjoy fish and wildlife through nonconsumptive activities; monitoring of species; and identification of significant habitats.	State fish and wildlife agencies	Project grants are provided.
North American Wetlands Conservation Act (NAWCA) Grant Program	The NAWCA grant program promotes long-term conservation of North American wetland ecosystems. Principal conservation actions supported by NAWCA are acquisition, enhancement and restoration of wetlands and wetlands-associated habitat.	Public or private, profit or nonprofit entities or individuals establishing public-private sector partnerships	Project grants (cooperative agreements and contracts) are provided. Cost-share partners must at least match grant funds 1:1 with U.S. non-federal dollars.
U.S. ARMY CORPS OF ENGINEERS Louisville District P.O. Box 59, Louisville, KY 40201 (502) 582-5607		Detroit District P.O. Box 1027, Detroit, MI 48231 (313) 226-6828	
Planning Assistance to States Program	The USACE to assist States, Indian Tribes local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources under this program. The program can encompass many types of studies dealing with water resources issues. Typical studies are only planning level of detail. Types of studies conducted in recent years include water quality studies, flood plain management, environmental conservation, and many others.	States, Indian Tribes local governments, and other non-Federal entities	Federal allotments for each State or Tribe from the nation-wide appropriation are limited to $500,000 annually.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Project Modifications of Improvement of Environment (Section 1135 of WRDA 1986)	This authority can be used to restore habitat and improve water quality that has been impacted by existing Corps projects. The Indiana Department of Natural Resources sponsored this program for modifications at Little Pitcher Lake in Indiana.	States and non-governmental groups	The federal/non-federal cost share is 75/25.
Beneficial Use of Dredged Materials (Section 204 of WRDA 92)	This authority can be used to protect, restore, and create aquatic habitat, including wetlands, in connections with dredging of Federal harbors and channels.	Projects involve dredging; Federal harbors and channels	The federal/non-federal cost share is 75/25.
Aquatic Ecosystems Restoration (Section 206 of WRDA 96)	This authority can be used to construct projects for the restoration and protection of aquatic ecosystems. This authority is not limited to ecosystems impacted by existing Corps projects.	State and non-governmental groups	The federal/non-federal cost share is 65/35.
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT (IDEM) Planning Branch - Watershed Management Section P.O. Box 6075, Room 1255; 100 North Senate Avenue; Indianapolis, IN 46206-6015 (317)232-0019; http://www.ai.org/idem/owm/			
Nonpoint Source Implementation Grants (319)	The 319 program provides grants to implement nonpoint source projects and programs in accordance with Section 319 of the Clean Water Act. See http://www.state.in.us/idem/owm /assessbr/nps/projs319.html for examples of 319 program grants in Indiana.	State and local governments, Indian Tribes, Nonprofit organizations	State and local agencies and organizations requesting funding are required to provide 25 percent of program cost.
State Revolving Funds (SRF)	EPA awards grants to States to capitalize their Clean Water SRFs. The States, through the SRF, make loans for high priority water quality activities. Loans are used for water quality management activities.	Local groups, citizens' groups, nonprofit organizations, and private citizens implementing NPS activities	Loans are provided by the State of Indiana to eligible participants. A 20 percent match from Indiana is required.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Drinking Water State Revolving Funds (DWSRF)	EPA awards grant money to Indiana for DWSRFs creation. Indiana, through its DWSRF, provides loans for drinking water supply-related projects. Although the majority of loan money is intended for upgrades of infrastructure (public or private drinking water supplies), Indiana also has the option to use some of the DWSRF funds for source water protection, capacity development, drinking water programs, and operator certification programs. Thus, the DWSRF allows for an emphasis on preventing contamination and enhancing water systems management.	Public water systems, State, interstate agencies; Indian Tribes; local communities, citizens' groups; nonprofit organizations; and individuals	Grants and loans are provided to drinking water suppliers A 20 percent match from Indiana is required.
INDIANA DEPARTMENT OF NATURAL RESOURCES (IDNR) - Division of Soil Conservation 402 W. Washington St., Room W-265; Indianapolis, IN 46204 (317) 233-3870; http://www.state.in.us/dnr/soilcons/			
T-by-2000/ Urban Conservation Program	T-by-2000 is a state-funded soil conservation/water quality protection initiative aimed at significantly reducing soil erosion and resulting sedimentation throughout Indiana. The main objective of the Urban Conservation Program is control of soil erosion and off-site sedimentation from non-farm lands, especially areas of development.	Governmental units, private individuals and organizations, educational institutions, contractors, developers, and other businesses	Technical assistance is provided primarily through local Soil and Water Conservation Districts (SWCD) and Wastewater Quality Specialists. Educational presentations and training are also provided.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
T-by-2000/ Lake and River Enhancement (LARE) Program	The LARE program is intended to ensure the continued viability of Indiana's public access lakes and streams. The program goals are to control inflows of sediments and associated nutrients into lakes and streams and where appropriate, forestall or reverse degradation from these inflows through remedial action. Qualifying projects include water quality monitoring, lake and watershed studies, feasibility studies, construction projects and watershed land treatment projects.	Local entities, planning and development organizations, or governmental units	Technical assistance is provided through IDNR's Division of Soil Conservation. Financial assistance may fund construction actions up to $100,000 for a specific project or up to $300,000 for all projects on a specific lake or stream. The program also provides up to 80 percent cost-share approved watershed land treatment practices. Other special projects could be fully funded.
T-by-2000/ Agricultural Conservation Program	The Agricultural Conservation Program helps farmers determine, apply and finance appropriate solutions to erosion and water quality related problems.	Any person who rents or owns land used for agriculture	Technical assistance for identification, design, and installation of conservation plans is provided through IDNR's Division of Soil Conservation.
T-by-2000/ Soil Conservation Education Program	The Conservation Education Program helps to increase public awareness and understanding of erosion, its causes, its impacts, and alternatives for control.	Local entities, planning and development organizations, governmental units, and schools	Educational programs are provided.
Hoosier Riverwatch	Hoosier Riverwatch is a state-wide program that focuses on increasing public awareness of water quality issues by training volunteers to care for and monitor the health of Indiana's streams and rivers. See http://www.state.in.us/dnr/soilcons/riverwatch/99grants.htm for information about who received 1997 and 1998 Hoosier Riverwatch grants.	Nonprofit organizations, public agencies, environmental organizations and schools	Grants are available to organizations to establish local volunteer water quality monitoring programs.
IDNR - Division of Forestry 402 W. Washington St. Rm. W296; Indianapolis, IN 46204 (317) 232-4105; http://www.state.in.us/dnr/forestry/			

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Classified Forest program	The main objective of this program is to encourage better private woodland management and protection. Classified forests are set aside for the production of timber and wildlife, the protection of watersheds, and the control of soil erosion. This program has management and protection requirements.	Owners of forest areas with 10 acres or more, supporting a growth of native or planted trees	Free technical advice and assistance is provided, and the assessed value of classified land is set at $1.00 per acre for tax purposes.
Urban Forest Conservation Grants	These grants are intended to help communities develop long term programs to manage their urban forests. Grantees may conduct any project that helps to improve, and protect trees and other associated natural resources in urban areas.	Local municipalities, nonprofit organizations, and state agencies	Grants are awarded ranging from $2,000 to $20,000.
Arbor Day Grant Program	Arbor Day Grants can be used to fund any type of activity which helps promote Arbor Day and the planting and care of urban trees. Activities could include educational workshops, public awareness campaigns, printing and distribution of materials, etc.	State agencies, municipalities, nonprofit organizations, and local organizations	Grants of $500 or $1,000 are awarded.
Hometown Indiana Grants	This program provides state funding for planting trees on public property or right-of-ways in urban areas. Applicants may also propose other types of projects which help develop urban forestry programs.	Municipalities or nonprofit groups	Grants from $2,500 to $20,000 are provided.
Tree Steward Grant Programs	This program is an educational training program which can be conducted in any county in Indiana.	Conservation groups, cities, county government, or county extension offices can conduct the program	The program involves six training sessions which cover a variety of tree care and planting topics.

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
MISCELLANEOUS SOURCES			
Sustainable Agriculture Research and Education (SARE) Program	Managed by USDA and the Cooperative State Research, Education, and Extension Service (CSREES), the SARE Program works to increase knowledge about - and help farmers and ranchers adopt - practices that are economically viable, environmentally sound and socially responsible. To advance such knowledge nationwide, SARE administers a competitive grants program first funded by Congress in 1988. Regional administrative councils recommend projects to be funded after proposals go through technical peer review. The diversity in membership of the regional administrative councils reflects SARE's commitment to serve the broad spectrum of the agricultural community. Nationally, SARE devotes significant resources to ongoing outreach projects. SARE's Professional Development Program offers learning opportunities to a variety of agricultural extension and other field agency personnel. SARE's Sustainable Agriculture Network (SAN) disseminates information relevant to SARE and sustainable agriculture through electronic and print publications.	Land-grant colleges or universities, other universities, State agricultural experiment stations, State cooperative extension services, nonprofit organizations, individuals, Federal agencies, and State agencies	SARE projects are funded through four different grant programs: Research and Education Grants; Professional Development Grants; Agriculture in Concert with the Environment (ACE) Grants; and Producer Grants. See http://www.ces.ncsu.edu/san/htdocs/sare/grants2.htm for further description of the types of projects funded by these grants. North Central Region – CSREES University of Nebraska-Lincoln 13-A Activities Bldg. Lincoln, NE 68583-0840 (402) 472-7081
Surface Transportation Programs	Surface Transportation Program (STP) funds may be used by State and local governments for any roads (including the National Highway System) that are not functionally classified as local or rural minor collectors. Each State sets	Public or private, profit or nonprofit entities or individuals Local government agencies Universities, colleges, technical schools, institutes	Project grants (cooperative agreements) Matching funds might be required U.S. Department of Transportation Federal Highway Administration, ISTEA 400 7th Street, SW, Washington, DC 20590 (202) 366-5004

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Project WET, WILD, Learning Tree	These programs are environmental/conservation education programs emphasizing water resources, wildlife, and forestry. These programs are designed for students in kindergarten through grade 12.	Educators, resource managers, community leaders, and concerned citizens	Training is provided for anyone interested in using the materials for youth education. After attending training, participants will receive a copy of curriculum guides at no charge. Natural Resources Education Harrison State Park 5786 Glenn Road Indianapolis, IN 46216 (317) 562-0788 indianaprojectwet@ameritech.net
Environmental Fund for Indiana (EFI)	EFI is an organization that funds work to prevent human health problems caused by the pollution of water, air and soil, to conserve water and land resources, to preserve our forests and wildlife habitats and to promote sustainable community economies. Organizations throughout Indiana belong to this group.	Various groups can apply for funds. Funding decisions are based on proposed projects.	Variable forms of assistance is provided through the members of EFI. Environmental Fund for Indiana 155 E. Market St. #612 Indianapolis, IN 46204 (800) 791-7064 http://www.envirolink.org/orgs/hecweb/efi
IPALCO Golden Eagle Environmental Grants	This program is designed to provide funds for projects which will preserve, protect, enhance or restore environmental and biological resources throughout Indiana.	Any unit of Indiana local or state government and nonprofit organizations	Variable amounts are provided. Golden Eagle Grants c/o Indiana Park and Recreation Assoc. 101 Hurricane Street Franklin, IN 46131 (317) 736-8994 http://www.ipalco.com/ABOUTIPALCO/News/03-30-99.html

FUNDING SOURCES (Continued)

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
NiSource Environmental Challenge Fund	This program is designed to stimulate local efforts to preserve, protect and enhance the environment in the service territories of NiSource subsidiaries in Indiana. The Fund provides support for natural resource/wildlife enhancement projects. Proposed projects must: a) directly enhance, protect or preserve northern Indiana's environment; and b) produce a tangible result. Examples include wetland projects and habitat improvement.	Any non-profit group is eligible to apply to the Fund for project grants. Examples of eligible groups include grass-roots organizations, neighborhood associations and community groups.	Partial project funding is possible. It is anticipated that project awards will be between $500 and $5,000. In 1998 fifteen projects were awarded a total of $37,502.50. An initial payment of 75 percent of the grant is funded with the remaining 25 percent paid upon proof of project completion. Environmental Affairs NiSource Inc. 801 E. 86th St. Merrillville, IN 46410 (219)647-5246
American Electric Power	AEP partners with community groups and environmental agencies for habitat conservation programs that strive to preserve, restore, and enhance existing habitats. AEP is located in Lawrenceburg and Rockport, IN.	Community groups, environmental agencies	Partnerships for habitat conservation. AEP/Indiana 1 Summit Square Fort Wayne, IN 46802 (219) 425-2118 http://www.aep.com/index.html
Lake Monroe Watershed Best Management Practices Cost Share Program	This program encourages the use of best management practice s during logging operations in the Lake Monroe Watershed.	Any logging operation within Monroe, Lawrence, Jackson, Bartholomew, or Brown counties	Cost share for each site is 75 percent of the actual cost for carrying out the BMPs, not to exceed $600. Improved Harvesting Practices Forester 6220 Forest Rd. Martinsville, IN 46151 (765) 342-4026 ihpmccoy@scican.net

Appendix U: Management Brochures

Wetland Conservation

Indiana identifies nonpoint source (NPS) pollution as the state's leading source of surface water and ground water quality impairment. A wetland, a land area where water saturation is the dominant factor, can help prevent NPS pollution from degrading water quality.

Acting like a coffee filter, wetlands intercept runoff and capture NPS pollutants. Wetland vegetation helps keep stream channels intact by reducing the velocity of runoff thus reducing stream bank erosion during periods of high flow. Wetland vegetation also reduces stream temperature by providing streamside shading.

Data recorded from the 1981 National Wetlands Inventory, shows Indiana's Lake Michigan coastal region contains approximately 7,240 wetlands covering more than 11 percent of the total coastal land area.

However, development or excessive pollutant loads can damage wetlands. Once degraded, a damaged wetland cannot provide the same water quality benefits and often becomes a significant source of NPS pollution. For example, excessive amounts of decaying wetland vegetation can reduce the amount of available dissolved oxygen for fish and other aquatic life. In addition, degraded wetlands also release stored nutrients and other chemicals into surface water and ground water.

Three management strategies can be used to maintain water quality benefits provided by wetlands and riparian areas:

- preservation of existing wetlands
- restoration
- construction of engineered systems

Riparian areas, or stream corridors are defined as vegetated ecosystems along a water body through which water and materials pass. Characteristically, riparian areas have high water tables and are subject to periodic natural flooding.

Wetland Preservation

As the first of three strategies, wetland preservation protects the full range of wetland functions by discouraging development activity in and around wetlands. Simultaneously, this strategy encourages proper management of upstream activities, including agriculture, forestry, and urban development.

Wetland and Riparian Restoration

The second strategy, wetland and riparian restoration, promotes the restoration of degraded wetlands and riparian areas with NPS pollution control potential. Wetlands that have been filled and drained retain their characteristic soil and hydrology, allowing their natural functions to be reclaimed. Restoration is a complex process that requires planning, implementation, monitoring, and management. It involves renewing natural and historical wetlands that have been lost or degraded and reclaiming their functions and values as vital ecosystems.

Wetland and riparian restoration activities which factor in ecological principles include replanting degraded wetlands with native plant species and constructing structural devices to control water flows.

Construction of Engineered Systems

The third strategy recommended promotes the use of engineered vegetated treatment systems (VTS). Designed to remove suspended sediments from NPS pollution before the runoff reaches a natural wetland, VTS have proved especially effective in the restoration of degraded wetlands.

One example of a VTS is the vegetated filter strip. A vegetated filter strip is a swath of land planted with grasses and trees to intercept uniform sheet flows of runoff before reaching a wetland. Vegetated filter strips are most effective at sediment removal, with removal rates usually greater than 70 percent.

Another type of VTS, constructed wetlands is an engineered complex of water, plants, and animals that simulate naturally occurring wetlands. Studies indicate that constructed wetlands can achieve sediment removal rates greater than 90 percent. Like vegetated filter strips, constructed wetlands offer an alternative to other systems that are more structural in design.

Healthy wetlands benefit plants, animals, and humans because they protect many different natural resources, only one of which is clean water. Unfortunately, an estimated 85 percent of wetlands in Indiana were lost between the late 1700's and the mid 1980's, and undisturbed wetlands still face threats today. To help prevent NPS pollution from further degrading Indiana's waters, and to protect many other State natural resources, wetlands protection must remain a focal point for Indiana education campaigns, watershed protection plans, and community conservation efforts.

DNR
Indiana Department of Natural Resources

INDIANA LAKE MICHIGAN COASTAL PROGRAM

Urban Conservation

Did you know that impervious surfaces such as pavement and rooftops of a typical city block generates nine times more runoff than a woodland area of the same size? In contrast, the porous and varied terrain of natural landscapes like forests, wetlands, and grasslands trap precipitation and allow it to slowly filter into the ground.

Increased Runoff: While the installation of storm sewer systems helps cities to quickly divert runoff from roads and other impervious surfaces; runoff gathers speed once it enters these storm sewer systems. Upon leaving these systems and emptying into streams, this large volume of rapidly flowing runoff erodes adjacent streambanks, damages streamside vegetation, and widens stream channels. Ultimately, this results in lower water depths during non-storm periods, higher than normal water levels during wet weather periods, increased sediment loads, and higher water temperatures.

Increased Pollutant Loads: In addition to increased runoff, urbanization also increases the variety and amount of pollutants transported in runoff. Sediment from new construction sites and development projects; oil, grease, and toxic chemicals from vehicular traffic; road salts; nutrients and pesticides from turf management and gardening; and viruses and bacteria from failing septic systems are examples of pollutants generated in urban areas.

When this urban polluted runoff enters storm drains, it can kill native vegetation, harm fish and wildlife populations, foul drinking water supplies, and make recreational areas unsafe.

Point and Nonpoint Distinctions

There are two different types of laws that help to control urban runoff; one focusing on urban point sources and the other focusing on urban nonpoint sources. The National Pollution Discharge Elimination System of the Clean Water Act addresses urban point source pollution from industrial and sewage treatment plants. Urban nonpoint source pollution is covered by Indiana's Stormwater and Sediment Control Program under the Clean Water Act, as well as through state water quality protection programs.

Measures to Manage Urban Runoff

Plans for New Development: New developments should make every effort to maintain the volume of runoff at pre-development levels by using structural controls and pollution prevention strategies. The *Indiana Handbook for Erosion Control in Developing Areas,* available through the Indiana Department of Natural Resources – Division of Soil Conservation, establishes guidelines to minimize land disturbances, retain natural drainage and vegetation, and protect sensitive ecological areas.

Plans for Existing Development: Runoff management plans for existing areas should identify priority pollutant reductions opportunities, protect natural areas that help control runoff, and begin ecological restoration activities to clean up degraded water bodies. Involving groups within the community as well as private citizens helps to prioritize the cleanup strategies, increase volunteer turnout in restoration efforts, and protect ecologically valuable areas.

Plans for Onsite Disposal Systems: The control of nutrient and pathogen loadings to surface waters can begin with the proper design, installation, and operation of onsite disposal systems (OSDSs). These septic systems should be situated away from open waters and sensitive resources such as wetlands and floodplains. Septic systems should be inspected, pumped out, and repaired at regular intervals. Household maintenance of these systems plays a large role in preventing excessive system discharges.

Public Education: Educational projects can help increase understanding and management of nonpoint source pollution in communities. Indiana schools are encouraged to work through their county soil and water conservation districts and the Indiana Lake Michigan Coastal Program to conduct educational projects that teach students how to prevent pollution and keep their community waters clean.

DNR
Indiana Department of Natural Resources

INDIANA LAKE MICHIGAN COASTAL PROGRAM

Protecting Indiana's Coastal Waters

Today, more than 700,000 people live in Indiana's coastal counties (Lake, Porter, and LaPorte). Aside from aesthetics, Indiana's coastal waters provide homes for an amazing array of plants and animals and are recreational retreats for more than two million visitors per year.

Yet, high levels of bacterial pollution closed beaches in these three coastal counties 347 times in 2001. Rapidly increasing population growth and urban development along our state's coast could cause a higher frequency of future coastal water quality problems.

Many times the source of these coastal water quality problems is nonpoint source (NPS) pollution. Within Indiana, sources of NPS pollution include agricultural and urban runoff, faulty septic systems, marinas and recreational boating, physical changes to stream channels, and habitat degradation.

During 1998 to 1999, the Indiana Department of Environmental Management (IDEM) conducted a Unified Watershed Assessment of Indiana's Lake Michigan region. IDEM ranked the present condition of water in lakes, rivers, and streams and investigated resource concerns and stressors on water quality for the region. IDEM found that all the watersheds in the coastal region did not meet designated uses or other natural resource goals. Stressors were identified as residential septic system density, urbanization, and some agricultural activities.

In 1990, Congress enacted Section 6217 of the Coastal Zone Act Reauthorization Amendments to confront the NPS pollution problem in the United States' coastal waters. The central purpose of this program, the Coastal Polluted Runoff Program is to strengthen coordination between federal and state coastal management and water quality programs and to enhance state and local efforts to manage land use activities that degrade coastal waters and habitats. As one of 34 states and territories with approved coastal management programs, Indiana will implement a Coastal Polluted Runoff Program within its Lake Michigan coastal watersheds.

Indiana will develop goals for four major categories of NPS pollution:

1. Agricultural runoff;
2. Urban runoff;
3. Marinas and recreation boating; and
4. Hydrological modifications.

Examples of practices or methods for addressing NPS pollution include:

- Reducing runoff from impervious parking lot surfaces by placing gently sloping grassy swales between rows of parking spaces;
- Installing soil erosion and sedimentation controls to prevent pollutants from leaving the site of land disturbing activities; and
- Planting or preserving buffer strips of vegetation along stream banks to reduce runoff and protect against erosion.

The Indiana Department of Natural Resources through the Lake Michigan Coastal Program (LMCP), will work with IDEM, Purdue Cooperative Extension Service, and other stakeholders to identify strategies and coordinate public participation in development of a Coastal Polluted Runoff Program. Development of the program will include the public and representatives from business, industry, local, state, and federal agencies, environmental organizations, recreational interests, and agriculture.

Several existing state programs work to address NPS pollution through voluntary partnerships. The LMCP will work with these existing programs to develop specific goals for Indiana's coastal waters; this approach, in addition to public involvement will reduce duplication and lead to the development of a successful Coastal Polluted Runoff Program in Indiana.

DNR
Indiana Department of Natural Resources

INDIANA LAKE MICHIGAN COASTAL PROGRAM

Nonpoint Source Pollution

Why are some of Indiana's waterways too dirty for swimming, fishing, or drinking? Why are native plants and animals disappearing from state rivers, lakes, and coastal waters?

Over 100 million tons of soil erodes annually from Indiana's landscape. Much of that soil enters the state's waterways as sediment. Sedimentation and polluted stormwater runoff affect the use of Indiana's waters.

Today, nonpoint source (NPS) pollution remains the state's largest source of water quality problems. It's the main reason that many of Indiana's surveyed rivers, lakes, and coastal waters are not clean enough to meet basic uses such as fishing or swimming.

NPS pollution occurs when rainfall, snowmelt, or irrigation water runs over land or through the ground, picks up pollutants and sediment, and deposits them into rivers, lakes, and coastal waters or introduces them into groundwater. NPS pollution is widespread and can occur any time activities disturb land or water.

Imagine the path a drop of rain takes from the time it hits the ground to when it reaches a river. Any pollutant it picks up on its journey has the potential to become part of the NPS pollution problem.

Agriculture, forestry, grazing, urban runoff, construction, recreational boating, septic systems, physical changes to stream channels, and habitat degradation are all potential sources of NPS pollution. Even careless or uninformed household management can also contribute to NPS pollution problems.

The most common NPS pollutants are sediment and nutrients. These wash into water bodies from agricultural land and animal feeding operations, construction sites, and other areas of disturbance. Other common NPS pollutants include pesticides, pathogens (bacteria and viruses), salts, oil, grease, toxic chemicals, and heavy metals. The United States annually spends millions of dollars to restore and protect the areas damaged by NPS pollutants.

Since most nonpoint source pollution is caused by land-based activities, each of us may be contributing to the pollution without even being aware of it. Some of the ways you can make a difference include:

- Place all trash in receptacles; never throw down a storm drain.
- Keep roadways, street gutters, and walkways swept and clear of soil, grass, and debris.
- Use environmentally safe cleaning products that do not contain phosphorus or other toxic chemicals.
- Recycle all used motor oil by taking it to an authorized service station or local recycling center.
- When washing your vehicle, direct the flow of water into the grass or gravel. Never let it flow into the street gutters or storm drains.
- Reduce the amount of pesticides and fertilizers applied to plants and lawns (read the directions carefully).
- Use biological methods and traps to reduce insects, weeds, and fungus instead of toxic insecticides and herbicides. Never apply pesticides or herbicides near wells.
- Plant grass or other plants in exposed soil areas.
- Inspect your septic system annually; pump the septic tank every three to five years.

DNR
Indiana Department of Natural Resources

INDIANA LAKE MICHIGAN COASTAL PROGRAM

NOAA

Clean Marinas

Thousands of people annually enjoy recreational boating within the state of Indiana and more than 21 marinas dot the coastline and waterfront property of Indiana. Because boats, wave runners, and other watercrafts are operated and maintained directly in the water or near the shore, the growing number of recreational boaters and marina managers must take special care to manage maintenance activities that cause water pollution.

Individual watercrafts and marinas usually release only small amounts of pollutants. Yet, when multiplied by thousands of boaters, they can cause distinct water quality problems in Indiana's lakes, rivers and coastal waters. The following are potential environmental impacts from boating and marinas: high toxicity in the water; increased pollutant concentrations in aquatic organisms and sediments; increased erosion rates; decrease in oxygen (eutrophication); and high levels of pathogens. Additionally, marina construction can lead to the physical destruction of sensitive ecosystems and bottom-dwelling aquatic communities.

Water pollution from boating and marinas is linked to poorly flushed waterways, boat maintenance, discharge of boat sewage, stormwater runoff from marina parking areas, and the physical alteration of shoreline, wetlands, and aquatic habitats during marina construction and operation.

Managing Boat Operation and Maintenance

During boat operation and maintenance activities, a significant amount of solvent, paint, oil, and other pollutants can potentially wash directly into surface water or seep into ground water. Many boat cleaners contain chlorine, ammonia, and phosphates - substances which can potentially harm fish and limit aquatic bottom growth. Additionally, petroleum hydrocarbons released through small oil spills during refueling and/or motor activities can harm bottom-dwelling organisms that form the base of the aquatic food chain.

Managing Boat Sewage and Waste

Water quality is degraded by the discharge of sewage and waste from boats. Fecal contamination from improper disposal of human waste during boating makes water unsightly and unsuitable for recreation; causes severe human health problems; and stimulates algae growth, reducing the available oxygen needed by fish and other aquatic organisms.

Boaters should avoid the discharge of all sewage into recreation waters. While on the boat, fecal matter and other solid waste should be contained in a U.S. Coast Guard-approved marine sanitation device (MSD). Upon return to the marina or dock, portable toilets should be emptied into approved shore side waste handling facilities and MSDs should be discharged into approved pumpout stations.

Boaters can reduce pollution by:

Selecting nontoxic cleaning products that will not harm humans or aquatic life;

Using drop clothes;

Cleaning and maintaining boats away from the water;

Vacuuming up loose paint chips and paint dust;

Fueling boat engines carefully, avoiding petroleum spillage;

Recycling used motor oil;

Discarding worn motor parts into proper receptacles;

Draining water out of all waterlines and tanks during winter freezes; and

Keeping boat motors well tuned to prevent fuel and lubricant leaks and to improve fuel efficiency.

Managing Location and Design of Marinas

The location and design of marinas are two of the most significant factors impacting marina water quality. Poorly planned marinas disrupt natural water circulation and cause soil erosion and habitat destruction. To reduce activities that contribute to NPS pollution, marinas should be located and designed so that natural flushing regularly renews marina waters. Additionally, incorporation of some simple design elements can greatly reduce NPS pollution, including:

1. Where possible, minimize paved surfaces next to the bulkhead to allow rain to soak into the ground instead of running into the water; install lawn and garden buffers along the bulkhead to act as natural filters and add beauty to the facility; each year fix up a section of the facility with new landscaping to reduce runoff.
2. Use the earth as much as possible as a natural filtration system with crushed stone paving, sand filters, wet ponds, grassy swales (low areas), traps to catch solids from runoff.
3. Install simple oil traps with absorption pillow and debris filters between the work areas and the bulkhead to protect the water quality.

Proper planning and an educated boating public will help reduce marina pollution, promote long-term economic benefits and environmental health, and help recreational boating to remain a fun-filled outdoor experience. Clean marinas, clean boats, and clean boating habits benefit the entire boating community as well as aquatic life.

DNR
Indiana Department of Natural Resources

INDIANA LAKE MICHIGAN COASTAL PROGRAM

NOAA

Agricultural Conservation

Indiana has more than 15,000,000 acres of agricultural land that produce an abundant supply of low-cost, nutritious food and other products. Based on 1990 land use data, approximately 35 percent of Lake Michigan's coastal region is identified as agricultural land. Noted worldwide for its high productivity, quality, and efficiency in delivering goods to the consumer, Indiana's agriculture has increased its conservation farming practices by more than 80 percent since 1990.

Throughout the United States, land managers observed, that when improperly managed, agricultural land can greatly affect water quality. Improperly managed agricultural activities that cause nonpoint source (NPS) pollution include confined animal facilities, grazing, irrigation, plowing, planting, pesticide spraying, fertilizing, and harvesting. The major agricultural NPS pollutants that result from these activities are sediment, nutrients, pesticides, and pathogens.

Managing Sediment: Sedimentation occurs when soil particles from an area, such as a plowed farm field, are carried through wind or water runoff to a water body, such as a stream or lake. Excessive sedimentation clouds the water, reducing sunlight penetration to aquatic plants; covers fish spawning areas and food supplies; and clogs the gills of fish. Too often, other pollutants like phosphorus, pathogens, and heavy metals are attached to the soil particles washing into the State's lakes, streams and rivers.

Agricultural landusers can reduce erosion and sedimentation by 20 to 90 percent through the application of conservation tillage measures, buffer strips, and nutrient management to control the volume and flow rate of runoff water, keeping the soil in place, and reducing soil transport.

Managing Nutrients: To enhance production of agricultural crops, nutrients such as phosphorus, nitrogen, and potassium are applied. When applied in excess of the crop's needs, unused nutrients are washed into streams, rivers, and lakes, causing excessive plant growth; creating foul tasting and smelling drinking water; and killing fish.

Agricultural landusers can reduce the overload of nutrients in runoff through the implementation of nutrient management plans. In turn, these plans help the agricultural landuser maintain high yields while sustaining low fertilizer expenditures.

Managing Confined Animal Facilities: Although by confining animals to areas or lots, farmers can efficiently feed and maintain livestock; these confined animal facilities become major sources of animal waste. Runoff from poorly managed facilities can contaminate streams, rivers, and lakes, as well as ground water sources. With the installation of appropriate waste management systems, livestock managers can limit discharge by storing and managing facility wastewater and runoff.

Managing Irrigation: Irrigation water is applied to supplement natural precipitation or to protect crops from freezing or wilting. Inefficient irrigation can cause water quality problems. Agricultural landusers can reduce NPS pollution from irrigation by improving water use efficiency through the measurement of actual crop needs.

Managing Pesticides: Pesticides, herbicides, and fungicides are used to kill pests and control weed and fungus growth. To reduce NPS contamination from these chemicals, agricultural land users can apply Integrated Pest Management (IPM) techniques based on the specific soils, climate, pest history, and crop for a particular field. IPM helps limit pesticide use and manages necessary applications to minimize pesticide movement from the field.

Managing Livestock Grazing: Overgrazing exposes soils, increases erosion, encourages invasion by undesirable plants, destroys fish habitat, and reduces the filtration of sediment necessary for building streambanks and floodplains. To reduce the impacts of grazing on water quality, livestock managers can adjust grazing intensity, keep livestock out of sensitive areas, provide alternative water and shade sources, and revegetate rangeland and pastureland.

DNR
Indiana Department of Natural Resources

INDIANA LAKE MICHIGAN COASTAL PROGRAM

Hydromodification/Wetland Management Measure Implementation Objectives for 6217 Watershed

HYDROMODIFICATION

Eugene Matzat, Purdue CES, Section Moderator

Objectives	Measures of Success	Resources Needed	Agencies	Time
Protect and restore instream and riparian habitats (channels)	Increase in high quality instream and riparian habitats and biodiversity.	Funds, technical assistance, education, and monitoring	IDEM, IDNR, US Army Corps of Engineers, US Fish & Wildlife	1-5 years
Reduce erosion and sediment and chemical pollutant loading	Reduced rates of erosion and sediment and chemical pollutants	Funds, technical assistance, education, and monitoring	IDEM, IDNR, US Army Corps of Engineers, Drainage Boards, USDA-NRCS	5-10 years
Minimize the negative physical and chemical impacts of channelization (surface waters)	Fishable, swimmable, drinkable surface waters.	Funds, technical assistance, education, and monitoring	IDEM, IDNR, US Army Corps of Engineers, Drainage Boards	10-15 years

WETLANDS and RIPARIAN AREAS

Kenneth Eck, Purdue CES, Section Moderator

Objectives	Measures of Success	Resources Needed	Agencies	Time
Protect wetlands and riparian areas in Coastal Zone.	No net loss of wetlands and riparian areas	Funds, technical staff, education	IDNR, IDEM, US Army Corps of Engineers, US Fish & Wildlife, USDA-NRCS	1-5 years
Restore and enhance wetlands and riparian areas in Coastal Zone	Increase in wetlands and riparian areas	Funds, technical staff, education	IDNR, IDEM, US Army Corps of Engineers, US Fish & Wildlife, USDA-NRCS	1-5 years
Explore applications for use of vegetated treatment systems	Increased use and decreased cost of vegetated treatment systems	Education, policy changes for select systems, funds for demonstrations	IDEM, IDNR, Ind. State Board of Health, USDA-NRCS, USDA-RD	1-15 years