Mahoning River Watershed Action Plan

Photo by T. Nuskievicz

DRAFT – PENDING ENDORSEMENT

Prepared by:
Youngstown State University
Scott C. Martin, Ph.D, P.E.
Project Coordinator

August, 2004

Preface

This report describes a Watershed Action Plan developed for the Mahoning River basin. The watershed planning process was supported by a Section 319 (Clean Water Act) grant issued to the Trumbull Soil and Water Conservation District (SWCD) and was directed by the Mahoning River Consortium. Youngstown State University (YSU) was retained to coordinate development of the Plan using the approach described in *A Guide to Developing Local Watershed Action Plans in Ohio* ("the *Guide*"; Ohio EPA, 1997), and to prepare this report. Dr. Scott C. Martin, Professor of Civil and Environmental Engineering at YSU, served as the Project Coordinator. The Mahoning River Watershed Planning Task Force, composed of Mahoning River Consortium members and stakeholders, was established to supervise the planning process, and to play an active role in converting the results of the Watershed Inventory and public input into an action plan. The Plan identifies specific goals and objectives related to water quality, and actions to be implemented to achieve those goals and objectives.

The initial goal of the project was to develop a Plan for the entire Mahoning River watershed. However, during the course of the project, the Ohio Environmental Protection Agency (OEPA) developed a formal process for review and approval of watershed action plans, including rigorous guidelines for the content of such plans (Appendix 8 to the *Guide*). After discussions with Ohio EPA personnel, a decision was made to focus the planning efforts on two subwatersheds – the Mosquito Creek watershed and the watershed draining directly to the Lower Mahoning River.

This Watershed Action Plan consists of three main parts. The first three sections provide the necessary background information for stakeholders, including basic principles of water quality, an introduction to the Mahoning River watershed, and a description of the watershed planning process. The next three sections describe the physical, chemical, and biological conditions of the watershed (a "Watershed Inventory"), and identify the causes and sources of impairments to water resources. In this section, a general description of entire Mahoning River basin is presented first, followed by more detailed information on the Mosquito Creek and Lower Mahoning River watersheds. The last three sections describe in detail the specific actions planned to protect and improve water resources in the watershed.

The Watershed Inventory represents a "snapshot" of recent conditions in the Mahoning River basin. Much of the water quality information presented here was collected in the time period from 1994 to 2003. The condition of water resources and/or causes of impairment in some parts of the watershed have not been adequately documented. In addition, some environmental conditions in a watershed (e.g., land use, fish populations, water chemistry) may change significantly within a short period of time. The Watershed Action Plan reflects the current understanding of water quality conditions, and implementation is expected to yield substantial improvements in water resources in the watershed. However, additional and ongoing monitoring will be necessary as the Plan is implemented. Both the Watershed Inventory and the Watershed Action Plan should be updated periodically, as the need and opportunity arise, in order to ensure the most efficient use of resources available for watershed improvements.

Acknowledgements

Development of this Plan was made possible by the contributions and commitment of many stakeholders throughout the Mahoning River watershed. Troy Smith of Trumbull Soil and Water Conservation District TSWCD) initiated the planning process by obtaining a Section 319 grant from Ohio EPA. Over 200 concerned citizens, public officials, Mahoning River Consortium members, and other stakeholders completed questionnaires and attended public forum meetings to provide input on environmental problems in the watershed and potential solutions. Holly Burnett of Youngstown State University's Center for Urban and Regional Studies (YSU-CURS) developed an attractive and informative brochure to educate stakeholders on the watershed planning process, and prepared a review of stakeholder attitudes on water quality issues. John Bralich of YSU-CURS developed all GIS maps for this report. Rosida Porter, Mark Bergman, and Julio Perez of Ohio EPA provided valuable guidance on the requirements for state approval of watershed plans. Bob Davic, Bryan Schmucker, and Mary Ann Silagy of Ohio EPA provided data on point source discharges and in-stream water quality for the Mahoning River and its tributaries. Several YSU graduate students contributed to this project. Faraz Ahmad and Ankur Patel analyzed NPDES and STORET data, respectively, on the watershed. Mohammad Faizan developed a web site for the watershed planning project. Baba Yahaya conducted a water quality monitoring study of Mosquito Creek watershed and developed pollutant loading estimates.

The members of the Mahoning River Watershed Planning Task Force, listed in Table P-1, provided information on recent and proposed local initiatives to protect water resources, previous studies and plans, and sources of water resource data. The Task Force also assisted with the organization of public forums, solicited stakeholder input, evaluated the available information and formulated a set of goals, objectives, and action plans for the watershed. Several other individuals at local public agencies provided key information for the planning effort. Ted Smith of the Trumbull County Health Department supplied the results of macroinvertebrate surveys. Thomas Holloway, former Trumbull County Sanitary Engineer, provided maps of unsewered areas of concern.

Table P-1. Members of the Mahoning River Watershed Planning Task Force.

Name	Affiliation
Jeff Benedict	U.S. Army Corps of Engineers
Holly Burnett	Mahoning River Education Project
Nancy Brundage	Audubon Society; League of Women Voters
William DeCicco	CASTLO Community Improvement Corp.
Deborah Duda	U.S. Army Corps of Engineers
Stephanie Dyer	Eastgate Regional Council of Governments
Carl Johnston	Youngstown State University, Biological Sciences
Joshua Kollat	Youngstown State University, Student
Scott Martin	Youngstown State University, Civil/Env. Engineering
Kim Mascarella	Eastgate Regional Council of Governments
Rachel McCartney	Eastgate Regional Council of Governments
Patricia Natali	Ohio EPA
Trish Nuskievicz	Trumbull County Planning
Rose Reilly	U.S. Army Corps of Engineers
Carmen Rozzi	U.S. Army Corps of Engineers
Tom Shepker	WCI Steel
Pat Shepker	Treasurer, Mahoning River Consortium

Table of Contents

Section	Page
Preface	ii
Acknowledgements	iii
Table of Contents	iv
List of Tables	vi
List of Figures	vii
Chapter 1 – Background	1
Watershed Planning	1
Water Resources and Water Quality	3
The Importance of Water	3
Water Resources and Watersheds	4
Evaluating the Quality of Water Resources	5
Physical Integrity	5
Chemical Integrity	6
Biological Integrity	7
Sources of Water Pollution	7
Human Impacts on Streams	8
Approaches to Protecting Water Resources	11
Chapter 2 – Introduction to the Mahoning River Watershed	13
Watersheds and Tributaries	13
Incorporated Areas and Phase II Storm Water Communities	17
Demographics	17
Planning Organizations and Previous Efforts	19
The Mosquito Creek Watershed	20
The Lower Mahoning River Corridor Watershed	22
Chapter 3 – Development of the Watershed Action Plan	23
The Watershed Group	23
Watershed Partners	23
Mission of the MRC:	23
Structure and Operational Procedures	23
Outline of the Plan's Content	23
Plan Endorsement by Watershed Partners	25
Public Education	25
Chapter 4 – Watershed Inventory	27
Description of the Mahoning River Watershed	27
Topography, Geology, and Soils	27
Biological Features	27
Water Resources	32
Climate and Precipitation	32
Surface Water	33
Wetlands	33
Streams	36
Aquatic Use Designations	41
Lakes and Reservoirs	41

Section	**Page**
Chapter 4 – Watershed Inventory (continued)	
Land Use and Land Cover	43
Urban Land	50
Forest Land	50
Agricultural Land	50
Crop Production, Tillage, Rotations	51
Livestock, Grazing	51
Chemical Use, Irrigation	51
Open Water	52
Non-Forested Wetlands	52
Barren Land	52
Protected Lands	52
Trends in Land Use	53
Cultural Resources	53
Previous and Complementary Water Quality Efforts	57
Mahoning River Environmental Dredging/Restoration	57
Areawide 208 Planning	57
Phase II Storm Water Plans	58
Elimination of Combined Sewer Overflows	58
Riparian Easements and Purchases	59
Agricultural BMPs	59
Home Sewage Disposal Regulations	60
WCI Steel, Inc. River Dredging Project	60
Physical Characteristics of Streams and Floodplains	60
Early Settlement Conditions	60
Channel Entrenchment and Floodplain Condition/Connectivity	60
Forested Riparian Buffers	61
Permanent Protection of Stream Corridors	61
Natural Stream Channels	61
Channel Modifications and Channelization	62
Dams	62
Livestock Access to Streams	62
Eroding Banks	62
Riparian Levees	63
Status and Trends	63
Water Resource Quality	63
Use Attainment	64
Other Water Quality Data	65
Causes and Sources of Impairment	72
Point Sources	72
Nonpoint Sources	82
Water Quality Trends	85
Chapter 5 – Problem Statements, Restoration Goals and Action Plans	86
Mosquito Creek Watershed Action Plan	87
Lower Mahoning River Corridor Watershed Action Plan	92

Section	Page
Chapter 6 – Implementation, Evaluation, and Revision of the Watershed Action Plan	98
Implementation	98
Evaluation	98
Plan Update/Revision	99
References	100
Appendix A	101

List of Tables

Table	Title	Page
P-1	Members of the Mahoning River Watershed Planning Task Force.	iv
2-1	Areas of Selected Tributary Watersheds in the Mahoning River Basin.	13
2-2	11-Digit Hydrologic Unit Codes (HUCs) for the Mahoning River Watershed.	17
2-3	Incorporated Areas in the Mahoning River Watershed and Phase II Storm Water Status.	18
2-4	Counties and Unincorporated Townships (County in Parentheses) in the Mahoning River Watershed Subject to the Phase II Storm Water Program.	18
2-5	Demographic Statistics for Mahoning, Trumbull and Portage Counties.	19
2-6	14-Digit Hydrologic Units in the Mosquito Creek Watershed.	20
2-7	14-Digit Hydrologic Units in the Lower Mahoning River Corridor.	22
3-1	Stakeholder Groups Participating in Development of the Mahoning River Watershed Action Plan.	23
4-1	Areas Covered by Major Soil Associations in the Mahoning River Watershed.	29
4-2	Areas of Hydric and Non-Hydric Soils in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	29
4-3	Monthly Mean Temperature and Precipitation for 1971-2000, National Weather Service Station, Youngstown-Warren Regional Airport, Vienna, OH.	32
4-4	Wetland Areas in the Mahoning River Watershed, Based on the Ohio Wetland Inventory (OWI).	33
4-5	Lengths and Watershed Areas of Selected Tributaries in the Mahoning River Watershed.	37
4-6	Flow Measurements at USGS Gaging Stations in the Mahoning River Watershed.	37
4-7	Aquatic Use Designations for Selected Streams in the Mahoning River Watershed.	42
4-8	Reservoirs in the Mahoning River Watershed.	43
4-9	Land Use (Area in Acres) in the Mahoning River, Mosquito Creek, and Lower Mahoning River Corridor Watersheds.	46
4-10	Land Cover (Area in Acres) in the Mahoning River, Mosquito Creek, and Lower Mahoning River Corridor Watersheds.	46
4-11	Agriculture Statistics for Trumbull County, 1990 and 2000.	51
4-12	Summary of Riparian Protection Projects in the Mahoning River Watershed.	59
4-13	Summary of Macroinvertebrate Index Values Obtained by the Trumbull County Stream Quality Monitoring Program, 2001-03.	65
4-14	Summary of Water Quality Data Collected by Ohio EPA for the Mahoning River at Leavittsburg and Lowellville, 1990-2001 (STORET database).	67
4-15	Summary of In-Stream NPDES Water Quality Monitoring Data Reported to Ohio EPA by Mosquito Creek Wastewater Treatment Plant in 2000 and 2001.	67
4-16	95% Confidence Limits of Trophic State Index (TSI) Values for Six Lakes Managed by Aqua Ohio, Inc. (from Farran, 1990).	68
4-17	Summary of 2004 Water Quality Monitoring Results for the Mosquito Creek Watershed Performed by Youngstown State University. Mean Concentrations with Number of Measurements in Parentheses (from Yahaya, 2004).	70
4-18	Bacteria Measurements by Ohio EPA in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	71

List of Tables (Continued)

Table	Title	Page
4-19	Causes and Sources of Aquatic Life Use (Warmwater Habitat) Impairment in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	73
4-20	Sources and Causes of Water Quality Impairment in the Mosquito Creek Reservoir, and General Recommendations for Corrective Action.	74
4-21	Summary of Sources and Causes of Water Quality Impairment in the Lower Mahoning River Corridor Watershed, and General Recommendations for Corrective Action.	76
4-22	Best Estimates of Pollutant Loadings (in kg/yr) from Point Source Discharges in the Mahoning River Watershed for the Years 2000 and 2001, with Percentages of Total Point Source Loading Contributed by Each Discharger.	77
4-23	Estimates of Point and Nonpoint Source Loadings to the Mahoning River, from Ahmad (2004).	83
4-24	Estimates of Nonpoint Source Pollutant Export Rates from Various Parts of the Mosquito Creek Watershed, from Yahaya (2004).	84
4-25	Estimates of Pollutant Loadings to Mosquito Creek Reservoir, from Yahaya (2004).	85

List of Figures

Figure	Title	Page
1-1	The Watershed Planning Process Recommended by Ohio EPA (1997).	2
1-2	Example of a Watershed	4
1-3	Point Sources and Nonpoint Sources of Pollution in a Watershed.	8
2-1	The Mahoning River Watershed	14
2-2	Watershed Boundaries of Tributaries in the Mahoning River Basin.	15
2-3	USGS 11-Digit Hydrologic Units in the Mahoning River Watershed.	16
2-4	The Mosquito Creek and Lower Mahoning River Corridor Watersheds.	21
4-1	Topography of the Mahoning River Watershed.	28
4-2	Soil Associations in the Mahoning River Watershed.	30
4-3	Hydric and Non-Hydric Soils in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	31
4-4	Ohio Wetland Inventory Map of the Mahoning River Watershed.	34
4-5	Ohio Wetland Inventory Map for Mosquito Creek and Lower Mahoning River Corridor Watersheds.	35
4-6	National Flood Insurance Program Map for the Mahoning River in Warren, OH.	38
4-7	National Flood Insurance Program Map forLower Mosquito Creek and the Mahoning River in Niles, OH.	39
4-8	Flooding in Perkins Park Ampitheatre, Warren, OH, July 23, 2003 (photo by T. Nuskievicz).	40
4-9	Flooding in Mall Parking Lot, Niles, OH, July 23, 2003 (photo by T. Nuskievicz).	40
4-10	Land Use in the Mahoning River Watershed.	44
4-11	Land Use in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	45
4-12	Land Cover in the Mahoning River Watershed.	47
4-13	Land Cover in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	48
4-14	Aerial Photo of a Portion of the Mosquito Creek Watershed (Source: TerraServer).	49
4-15	Aerial Photo of a Portion of the Lower Mahoning River Corridor Watershed (Source: TerraServer).	49
4-16	Publicly Owned Land in the Lower Mosquito Creek Corridor.	54
4-17	Location of Properties on the National Register of Historic Places in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.	56
4-18	Mean Dissolved Oxygen Concentration for 2000 and 2001 Vs. River Mile in the Mahoning River, from NPDES Monitoring Data Upstream and Downstream Of WWTP Discharges (from Ahmad, 2004).	67
4-19	Map of Sampling Locations for Water Quality Survey of Mosquito Creek Watershed by Yahaya (2004).	69
4-20	ArcView GIS Map Showing Average Point Source Loadings of Total Suspended Solids in the Mahoning River Watershed for 2000 and 2001, in kg/yr.	78
4-21	ArcView GIS Map Showing Average Point Source Loadings of Ammonia Nitrogen in the Mahoning River Watershed for 2000 and 2001, in kg/yr.	79

List of Figures (Continued)

Figure	Title	Page
4-22	ArcView GIS Map Showing Average Point Source Loadings of Nitrate + Nitrite Nitrogen in the Mahoning River Watershed for 2000 and 2001, in kg/yr.	80
4-23	ArcView GIS Map Showing Average Point Source Loadings of 5-Day Carbonaceous BOD in the Mahoning River Watershed for 2000 and 2001, in kg/yr.	81

Chapter 1
Background

Watershed Planning

The protection of water resources requires a cooperative effort on the part of many "stakeholders". A stakeholder can be defined as anyone who has an interest or role in environmental protection, or in the policies and programs designed to protect and enhance environmental quality within a watershed. Stakeholders include local, state, and federal environmental agencies, political officials, special interest groups, and private citizens. Watershed planning efforts are often coordinated by a watershed group, or association, formed by individuals with a strong commitment to enhancing the quality of life in their community through environmental protection. A useful step taken by many watershed groups is the preparation of a formal Watershed Action Plan. A Watershed Action Plan is a document that identifies and prioritizes water quality problems within a watershed, and outlines specific steps to address these problems. The Plan becomes a blueprint to guide the activities of the watershed group and other stakeholders.

The Ohio EPA has published a concise, helpful guidance document on watershed planning, entitled *A Guide to Developing Watershed Action Plans in Ohio* (OEPA, 1997). The *Guide* identifies six essential steps in the planning process:

1. Build Public Support
2. Create an Inventory of the Watershed
3. Define the Problems
4. Set Goals and Develop Solutions
5. Create an Action Plan
6. Implement and Evaluate

The watershed planning process is shown graphically in Figure 1-1. Some key elements of effective watershed planning include the following:

1. *Broad stakeholder support*: Participation of stakeholders with diverse backgrounds and perspectives is essential to the development of a comprehensive plan with strong public support.
2. *Focus on water quality*: In order to optimize the effectiveness of available resources, the watershed group should concentrate on the use of best management practices (BMPs) that produce tangible improvements in water quality.
3. *Measurable goals*: The Watershed Action Plan should identify specific tasks, responsible parties, and timetables. Quantitative indicators of success should be identified and used to track progress toward each goal.
4. *Monitoring and feedback*: The Watershed Action Plan should be considered a "living document". As monitoring and experience lead to a better understanding of water quality problems, the problems may be redefined, and goals, solutions, and action plans may be modified.

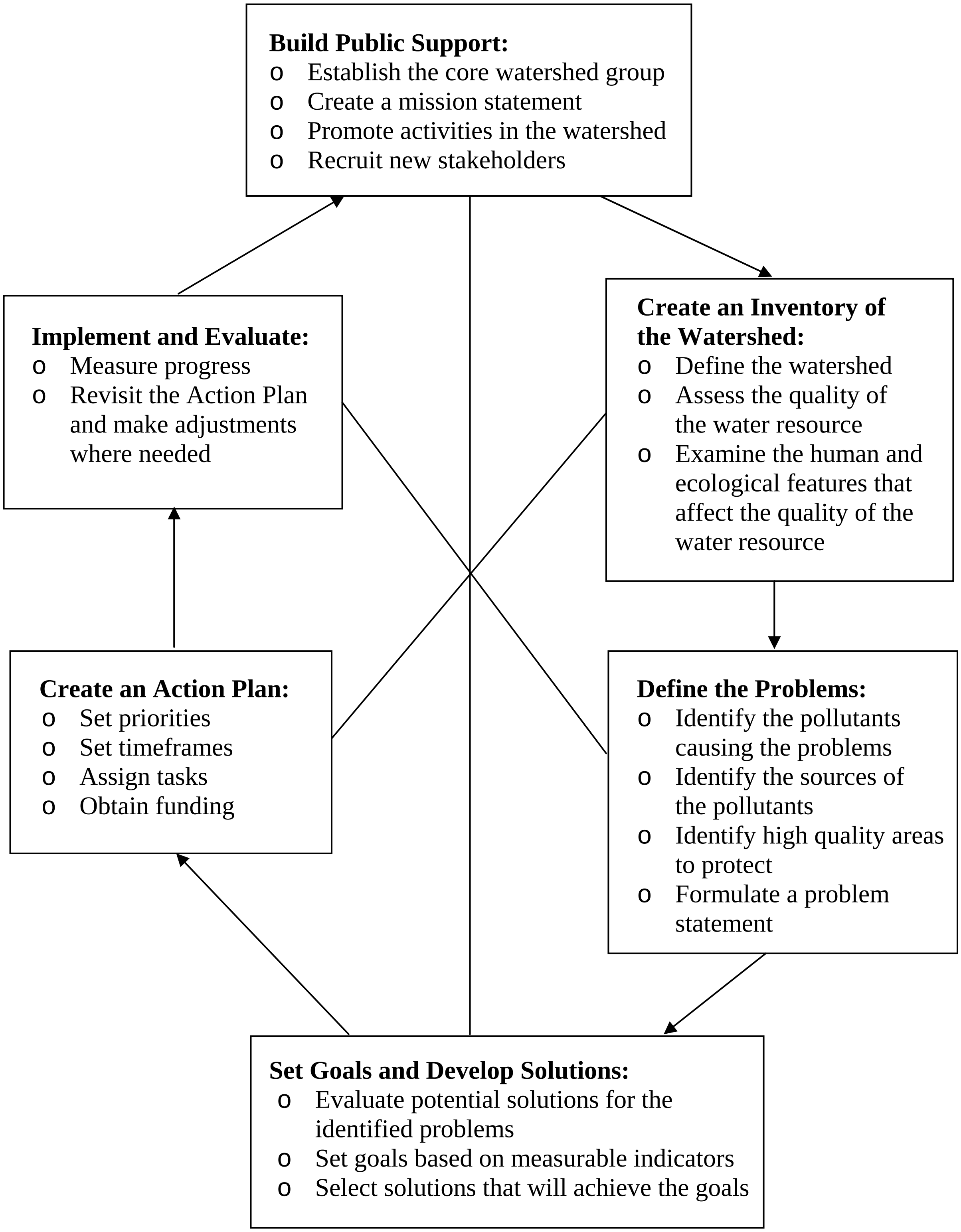

Figure 1-1. The Watershed Planning Process Recommended by Ohio EPA (1997).

As the name implies, watershed planning focuses primarily on watersheds as the planning region (or "unit"), rather than political subdivisions. This "watershed approach" is based on the direct connection between land use and human activities in a watershed and the condition of its water resources. However, in this report, we recognize that many stakeholders are more familiar with political boundaries and other geographical features (especially roads) than with watershed boundaries. In addition, land use policies and regulations, as well as the jurisdiction of public agencies, are generally established using political boundaries. Therefore, reference is made to both political boundaries and watershed boundaries in the following sections.

Water Resources and Water Quality

The Importance of Water

Water is essential to sustain human life. The human body is about 70% water, and an individual can typically survive one week or less without water. Throughout history, human settlements, communities, cities, and civilizations have developed around plentiful supplies of water. For example, the ancient Egyptians used the Nile River as a source of water. The Romans built aqueducts to supply water to their expanding empire.

In modern times, tremendous demands have been placed on our water resources. The water needs of exploding populations have resulted in serious water shortages in many parts of the world, including some regions of the United States. In developed and developing countries, new technologies used in homes, businesses, and industries have greatly increased the amount of water each person uses. In the U.S., 400 trillion gallons of water is used each day to meet our society's needs. This amounts to about 1,500 gallons per person each day (Solley *et al.*, 1995).

Although the withdrawal of water supplies to meet requirements for drinking, cleaning, agriculture, industrial production, etc., is essential to support modern communities, it is by no means the only important use of our water resources. The lakes, streams, estuaries, and oceans of the world also serve as receiving waters for wastewater discharges, routes of transportation, sources of food, sites for recreation, and habitat for an incredible diversity of plants and animals. The condition of a region's water resources is closely linked to its quality of life. Clean lakes and streams can be a source of community or regional pride and contribute to economic growth.

On the other hand, excessive or unregulated human activity near waterways can quickly degrade the water quality and interfere with desired uses of the water. In the United States, many environmental regulations have been introduced since the 1970's to protect water resources. This has resulted in significant improvements in the water quality of many waterways. However, many others remain in poor condition, or continue to worsen as human activity in the surrounding area increases. At the present time, federal and state regulations alone are not sufficient to ensure clean water and healthy waterways. Therefore, it is important that citizens of each community work with local officials to develop strategies for protecting and improving the quality of their water resources.

Water Resources and Watersheds

The water resources that communities use to meet their needs are divided into two major categories – *surface water* and *groundwater*. Surface waters are those water bodies that are visible at the earth's surface, and include lakes, streams, and wetlands. Groundwater is the water that occupies the spaces between grains of soil and the cracks in rocks below the earth's surface. A large underground reservoir of groundwater is called an *aquifer*. These two waters are not entirely separate. Surface water can seep into the ground and become groundwater. Groundwater can flow to the earth's surface through springs or be pumped to the surface from wells; it can also become surface water by flowing through the soil into stream channels, lakes or wetlands.

The quality of water resources is directly related to the activities that take place on the land surrounding it. The land area from which a surface water drains into a common outlet is called a *watershed*. The concept of a watershed is shown in Figure 1-2. Other names for a watershed include "drainage basin" or "hydrologic unit" (OEPA, 1997). Watersheds may range in size from a few acres or less (e.g., for a small private pond) to over a million square miles (e.g., for the Mississippi River). Rivers may receive inflows of water from several smaller streams called tributaries. The watersheds of these tributaries are sometimes called *subwatersheds*.

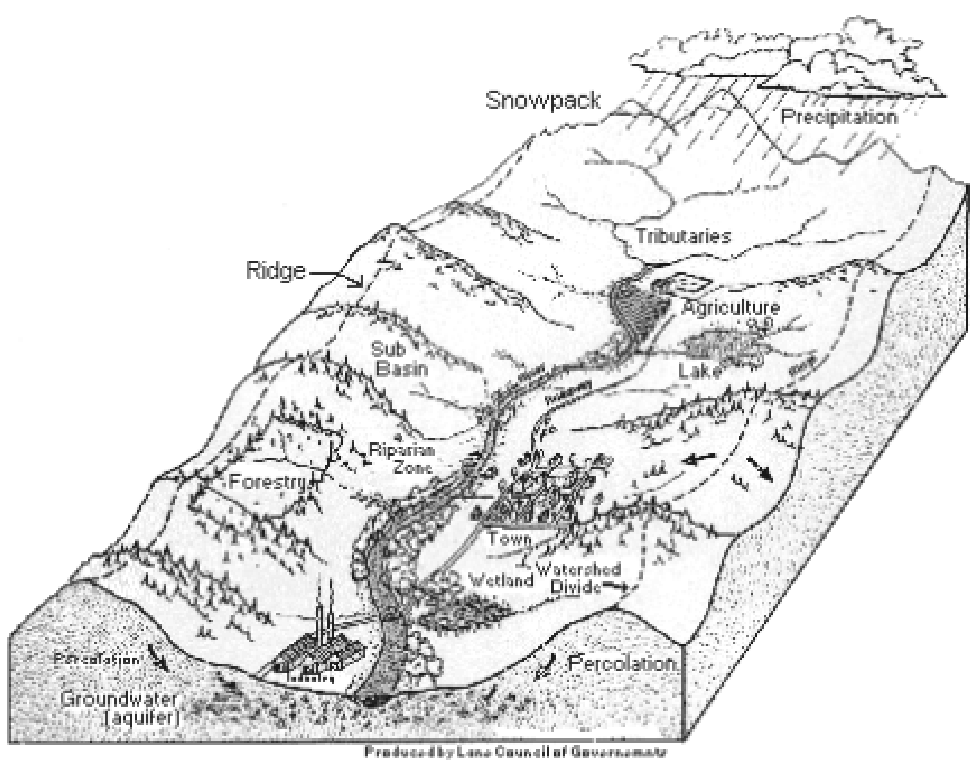

Figure 1-2. Example of a Watershed. (www.4j.lane.edu/partners/eweb/ttr/curriculum/ watershd.html)

Evaluating the Quality of Water Resources

There are many factors that determine the quality of any particular water resource, and its suitability for various beneficial uses. These factors include: physical features, such as size, shape, and position within the landscape (known as *morphometry* or *geomorphology*); concentrations of various chemical substances in water and sediments; and the types and numbers of plants, animals, and microorganisms present in the water body and its surroundings. Many physical, chemical, and biological measurements are used to evaluate the condition of water resources. These measurements can be compared against various standards and guidelines developed by government agencies and scientists. Factors related to the physical, chemical, and biological integrity of water resources are discussed in more detail in the following sections.

Physical Integrity

The ability of a stream to carry out its natural functions depends to a large extent on the physical characteristics of the stream channel and adjacent land. Stream corridors can be considered to consist of three parts – the stream channel, the floodplain, and the transitional upland fringe. The term *riparian* corridor or zone is also frequently used to refer to the land extending laterally from the edge of a stream to the adjacent uplands. Stream corridors serve as a medium to transport and store water and other materials (e.g., organic matter, sediment, pollutants, etc.), energy, and organisms. Healthy stream corridors serve the following valuable ecological functions in the landscape (FISRWG, 1998):

1. *Habitat*: Stream corridors provide an area where plants and animals can live, grow, feed, and reproduce during all or part of their life cycle.
2. *Barrier or Filter:* Stream corridors prevent the movement, or allow selective penetration, of energy, materials, and organisms. Vegetation in the corridor can filter out sediment, nutrients, and other pollutants in runoff from the watershed, and can reduce the quantity and energy of flowing water reaching the stream.
3. *Conduit:* Stream corridors serve a pathways for the movement (both laterally and longitudinally) of materials, energy and organisms.
4. *Source or Sink:* Stream corridors act as sources by providing materials, energy, or organisms to the surrounding landscape (for example, deposition during floods); they act as sinks by temporarily storing surface water, groundwater, nutrients, energy, sediments, etc.

In general, stream corridors that are wide and continuous serve these functions better than those that are narrow or contain gaps. The structure and functions of stream corridors are constantly changing, even in the absence of human disturbance. For example, sediment, organic matter and nutrients are deposited on the floodplain during flood periods. Also, the path of the stream (e.g., meander pattern) may change due to natural erosion and deposition processes in the stream channel. Thus, stream corridors exist in a condition of dynamic equilibrium with their surroundings. It is important to recognize and accommodate the dynamic nature of streams in watershed planning.

One method used to evaluate many of the physical characteristics of a stream is the Qualitative Habitat Evaluation Index (QHEI). Overall, the QHEI is designed to provide a quantitative summary of aquatic habitat quality in streams. The index is determined by the assignment and summing of scores based on visual observations of stream corridor conditions in the following categories:

1. Substrate – origin and composition of streambed material;
2. Instream Cover – types and extent of structures offering protection to aquatic organisms;
3. Channel Morphometry – sinuosity, human impacts, and stability of the stream channel;
4. Riparian Zone and Bank Erosion – condition of riparian zone, flood plain and stream banks.
5. Pool/Glide and Riffle/Run Quality – depth, proportions, and current velocity of pools and riffles;
6. Gradient of stream channel.

It is apparent that the QHEI incorporates parameters related to the barrier/filter, conduit, and source/sink functions of a stream, as well as habitat. Thus, it is a good overall tool for evaluating the physical health of a stream corridor. A QHEI scoring sheet used by Ohio EPA is presented in Appendix A. The maximum possible QHEI score is 100.

Fluvial geomorphologists – scientists who study the physical form of stream corridors – have developed detailed classification systems for stream type, and sophisticated methods for characterizing the conduit function of streams (e.g., Rosgen, 1996). These methods are useful in planning stream restoration projects, but are beyond the scope of this discussion.

Chemical Integrity

The chemical characteristics of water and bottom sediments in a stream or lake can have a significant impact on the water body's suitability for any particular use. For example, the USEPA has set limits on over 70 chemicals in public drinking water supplies. All of these chemicals can cause adverse effects on human health. Likewise, most aquatic organisms need an environment that is largely free of chemical contamination to live, grow, and reproduce. In addition, each species has an optimum range of conditions such as temperature, pH and dissolved oxygen. The species may not be able to survive if conditions deviate significantly from these ranges. It should be noted, however, that some species are more tolerant of pollution than others.

Many chemical contaminants, including toxic organic chemicals and heavy metals, can attach to sediments and deposit on the bottom of lakes and streams. Organisms that live in the bottom sediments (called *benthic macroinvertebrates*) are directly exposed to these chemicals and provide a route for them to enter the aquatic food chain. Synthetic organic chemicals and heavy metals are persistent (not easily decomposed) in the environment and may accumulate to harmful levels in the bodies of aquatic organisms, particularly those at higher trophic levels (such as fish).

Measurement of the chemical quality of water and aquatic sediments typically requires the collection of representative samples from the water body and analysis in a laboratory. The results are then compared to criteria (goals) or standard values for a desired aquatic use. Ohio's Water Quality Standards are listed in Section 3745-1 of the Ohio Administrative Code (OAC). Each major water body in the state is assigned one or more use designation(s) in the categories of aquatic life habitat, water supply, and/or recreation. Chemical and biological criteria are listed in the OAC for each use designation. These standards include concentration limits for over 130 chemical parameters.

Biological Integrity

Another measure of the quality of a stream or lake is the number and diversity of living organisms that inhabit the water body. Aquatic organisms range from microscopic viruses and bacteria to large mammals (e.g., beaver) and fish (e.g., catfish, muskellunge). Like humans, aquatic organisms need an adequate supply of food, shelter from predators and the forces of nature, and an environment free of pollution, to live and grow. In many cases, organisms depend on one another for some of these needs. For example, in a lake, small animals called zooplankton consume algae as their primary source of food. Then, small fish eat the zooplankton, and large fish may eat the small fish. Or, in a stream, bacteria in the bottom sediments decompose plant matter (such as fallen leaves), providing a source of carbon to support the growth of a variety of small animals (*macroinvertebrates*) that inhabit the bottom sediments. Certain species of fish, such as carp and catfish (known as “bottom feeders”), eat these small animals as their main source of food.

The environment (or surroundings) in which an organism lives is called its *habitat*. A habitat and all of the organisms that live in it make up an *ecosystem*. Those found in water are called *aquatic ecosystems*, while those found on the land are called *terrestrial ecosystems*. Watersheds with relatively little human impact tend to contain high quality aquatic habitat. Streams in these watersheds have many of the features (such as clean water, meanders, pools, riffles, and shade from adjacent trees) that are typically required to support a high diversity of aquatic life. In watersheds with heavy human impacts, many of these desirable features are absent.

Ohio’s Water Quality Standards include biological criteria (goals) that are based on the fish and macroinvertebrate populations in a water body. Criteria for the various aquatic life use designations are listed for three indices:

1. The Index of Biological Integrity (IBI) – a measure of fish species diversity and populations; scores range from 0 to 60;
2. The Modified Index of Well-Being (MIwb) – based on fish mass and species populations; scores range from 0 to 10; and
3. The Invertebrate Community Index (ICI) – based on the species diversity and numbers of macroinvertebrates living in the stream or river bottom sediments; scores range from 0 to 60.

The Ohio EPA evaluates the attainment or non-attainment of aquatic life use designations based primarily on the biological criteria.

<u>Sources of Water Pollution</u>

Before European settlers came to North America, the land was very sparsely populated, and forests dominated the landscape. Human impacts on water resources were minimal, and water quality was, in general, much better than it is today. The roots of trees, shrubs, and grasses stabilized the soil and prevented erosion. As a result, lakes and streams were clearer and cleaner, and supported a greater diversity of aquatic life. As the density of human settlement increased, land was cleared for agriculture, villages, and transportation routes. Soil was exposed to the forces of nature, and became susceptible to erosion by wind and rain. The eroded soil often entered streams and lakes, making the water more turbid, and ultimately deposited in these water bodies, hindering transportation and the survival of some species of aquatic plants and animals. The solid waste and human waste from increasing populations also began entering waterways, further polluting the water with organic matter and bacteria, and resulting in problems such as declining fish populations, odors, and the transmission of diseases. In modern times, such trends as the development of large cities, industrial production, rapid expansion in chemical manufacturing and use, and intensive mining of natural resources, have introduced a wide array of pollutants into the environment and placed further stress on water resources.

As water flows from the higher elevations of a watershed (or the *headwaters*) to the outlet, it may accumulate pollutants from a variety of sources. These sources are commonly divided into two categories – *point sources* and *nonpoint sources*. Point sources of pollution enter a waterway at a specific, well-defined location, typically the end of a pipe. Examples include discharges from municipal or industrial wastewater treatment plants. Nonpoint sources of pollution generally originate from a broad area and enter a waterway at many different locations. Examples include runoff from farmland, woodlots, surface mines, construction sites, residential areas, and roadways resulting from a rainfall or melting snow. These two types of pollutant sources are shown graphically in Figure 1-3. More detailed descriptions of the impacts on streams due to various human activities are presented below.

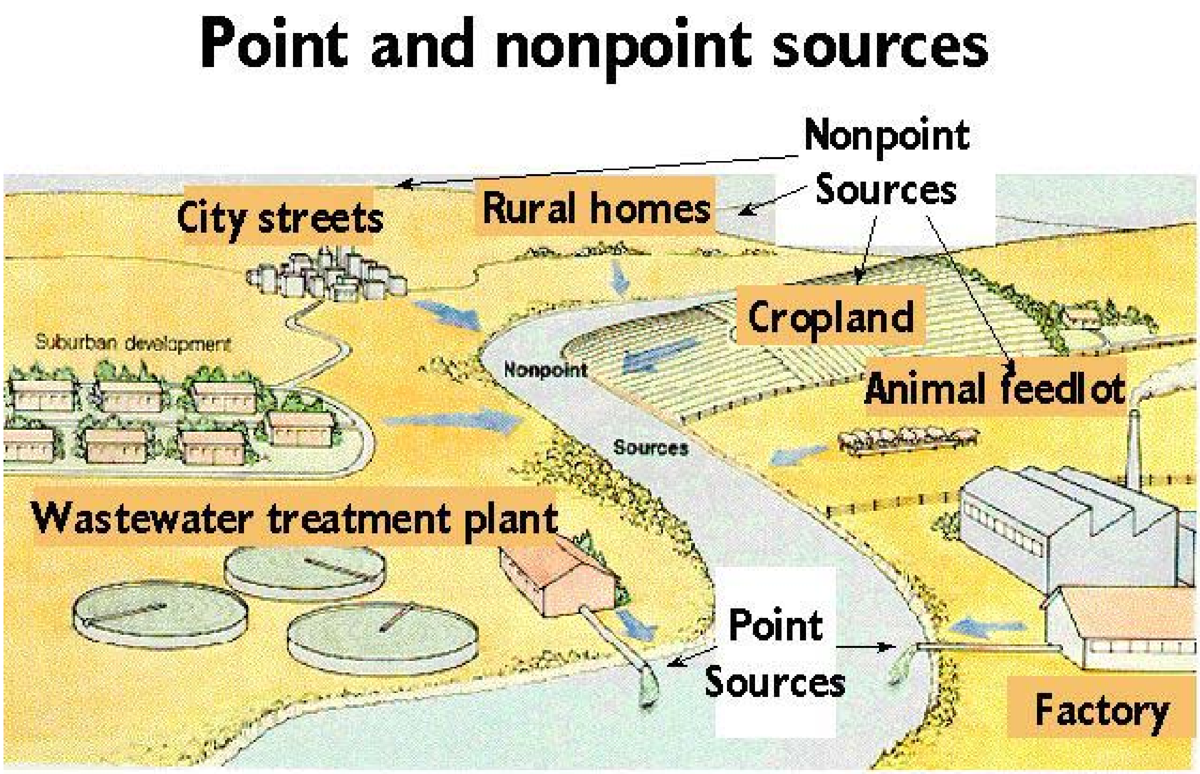

Figure 1-3. Point Sources and Nonpoint Sources of Pollution in a Watershed. (pas.byu.edu/AgHrt282/ Nonpoint/sld003.htm)

Human Impacts on Streams:

While natural disturbances such as floods, tornadoes, fire, and landslides may have significant impacts on stream corridors, the focus of most stream restoration projects is on reversing the negative impacts of human disturbances on stream corridor functions. Impairments can occur directly through modifications to the structure of the stream corridor itself, or indirectly through land use activities in the watershed. Several human activities that commonly impair stream corridors are summarized below (FISRWG, 1998):

1. *Dams:*
   Dams can dramatically change the flow regime of a stream, typically slowing the flow above the dam and moderating flood flows below the dam. This often leads to silt depositition within the stream channel above the dam. Below the dam, patterns of sediment scouring and deposition below the dam will also be modified. Thus, the aquatic habitat may become unsuitable for many stream organisms, both above and below the dam. Impoundment can also lead to higher water temperatures, and lower dissolved oxygen levels above the dam. In addition, fish migration and the transport of sediment and nutrients may be blocked by the dam, riparian vegetation can be inundated and the groundwater table altered.

2. *Channelization:*
   Channelization refers to the process of re-routing a stream to a manmade channel that is frequently straight, of uniform cross-section and slope, and lined with non-native material (e.g., rip-rap or concrete). The goal is usually to increase local hydraulic capacity and/or prevent local stream bank erosion. Channelization destroys the normal pool and riffle structure of a stream, required by aquatic organisms for safe migration, feeding, and reproduction. Flood flows are transported with little storage or attenuation, often exacerbating flooding or stream bank erosion problems downstream.

3. *Exotic Species:*
   When non-native species of plants (e.g., kudzu, purple loosestrife) or animals (e.g., zebra mussels) are introduced into a stream corridor, they often have no natural predators and grow to dominate the population of a stream or the riparian corridor. Thus, species diversity is reduced, resulting in the loss of desirable native plants and animals as well as a decrease in the stability of the ecosystem (i.e., its ability to adapt to future disturbances).

4. *Agriculture:*
   Many activities associated with agriculture can have adverse impacts on streams. The clearing and tilling of land for crop production reduces the infiltration capacity of soil, increasing surface runoff, and greatly increases the potential for soil erosion. An increase in sediment load can disturb a stream from dynamic equilibrium and lead to changes in channel morphometry and the size distribution of bottom sediments. These changes can impair the habitat function of the stream channel. Nutrients (nitrogen, phosphorus, and potassium) and pesticides applied during the growing season can leach into the groundwater or be carried in surface runoff to adjacent streams, either in dissolved form or adsorbed to sediments. These pollutants can significantly alter the growth patterns of aquatic plants and animals, and exert secondary effects on water quality parameters such as dissolved oxygen and pH.

Channelization of streams and clearing of riparian vegetation are common in order to maximize the area available for crop or livestock production. The clearing of riparian vegetation reduces the barrier and filtering functions of the stream corridor, allowing more water and pollutants to reach the stream. The habitat and conduit functions of stream corridors are also impaired when riparian vegetation becomes narrow and fragmented. Livestock grazing is common in stream corridors due to the abundance of vegetation and water. The loss of ground cover from grazing can increase the runoff of water and pollutants. Trampling can compact and/or destabilize the soil, increasing erosion, and also damage streamside vegetation, reducing shading and increasing stream temperatures. Also, animal fecal material can increase the loading of nutrients, bacteria and pathogens, and oxygen-demanding substances (ammonia, organic wastes) to the stream. Increases in pollutant loadings can impair the quality of in-stream habitat, making the stream suitable only for pollution-tolerant species.

5. *Forestry:*
   Tree removal in a watershed or stream corridor typically results in increased surface runoff and a decrease in available habitat for a variety of terrestrial (and potentially aquatic) species. A short-term increase in nutrient loading to adjacent streams may occur due to the decay of limbs left behind. The construction and use of access roads by heavy equipment result in direct physical impact on habitat as well as soil disturbance, leading to erosion and sedimentation in stream channels.

6. *Mining:*
   Like agriculture and forestry, surface mining often involves the removal of vegetative cover from the land and disturbance of the soil. These changes have serious negative impacts on wildlife habitat and increased runoff, accelerated erosion, and degraded water quality in streams. In some cases, the stream corridor may be modified, excavated, or filled during mining activity. Streams can also be contaminated by “acid mine drainage” (AMD), formed by contact of water with sulfide minerals such as pyrite. Large amounts of iron and sulfuric acid can accumulate in runoff water, along with smaller quantities of toxic heavy metals such as lead, copper, and zinc. Iron is oxidized ($Fe^{+2} \rightarrow Fe^{+3}$) upon exposure to oxygen and precipitated as a bright orange solid, coating the streambed and destroying benthic habitat. Sulfuric acid in mine drainage can significantly depress the pH of streams, placing tremendous stress on aquatic organisms; many aquatic organisms cannot survive at pH less than 5.0.

7. *Recreation:*
   Activities such as hiking, camping, fishing, boating, all-terrain vehicles, etc., can cause impacts on the functions of stream corridors. Vegetation may be cleared for trails, roads, or access areas, reducing habitat and promoting soil erosion. Soil may be compacted by foot or vehicle traffic. Turbulence from motorized boats can resuspend sediments from the streambed and cause bank erosion. In-stream structures can alter patterns of bank erosion and deposition. Pollutants such as human waste and petroleum products may also enter the stream as a result of recreation activities.

8. *Urbanization:*
   Along with agriculture and mining, urbanization is responsible for the most serious and widespread impacts on stream corridors. Impervious surfaces such as streets, sidewalks, parking lots, and roofs of buildings decrease groundwater recharge and increase surface runoff. The peak flows in streams often increase dramatically, disturbing the dynamic equilibrium and causing increased flooding and stream bank erosion downstream. Channelization and the removal of riparian vegetation are also common to accommodate development. Vegetation is also removed, and the earth disturbed, on active construction sites, greatly increasing the potential for soil erosion. Besides suspended sediment, urban runoff may contain elevated amounts of nutrients, heavy metals, oil and grease, salt, litter, and other pollutants. With impaired barrier and filtering functions, the aquatic habitat in urban streams may be physically and chemically degraded. In addition, the removal of riparian vegetation and woody debris may make the stream corridor a poor source of organic matter to support aquatic and terrestrial life. Treated municipal wastewater is discharged to streams and rivers, adding oxygen demanding substances (organic matter and ammonia), nutrients, bacteria, etc. Untreated wastewater can also enter urban streams from old or malfunctioning sewers and septic systems, and from combined sewer overflows (CSOs).

<u>Approaches to Protecting Water Resources</u>:

Modern science and technology has led to tremendous advances in understanding of the sources and effects of pollution, as well as methods of measuring and controlling the release of pollutants. The rate at which pollutants enter a water body is called the *load* or *loading rate*. Point source loading can be reduced through changes in water use practices and by applying various physical, chemical, and biological treatment processes. Nonpoint source pollution loading can be controlled through the implementation of a variety of *best management practices*, or BMPs. These consist of land use techniques and related activities (such as education and maintenance of facilities) designed to minimize the export of pollutants from the land.

In the early 1970's, federal and state governments in the U.S. began aggressive efforts to control pollution. The federal Environmental Protection Agency (USEPA), and several state environmental agencies (such as Ohio EPA), were created to enforce a number of new environmental laws and regulations. The Federal Water Pollution Control Act (or "Clean Water Act") and other laws controlling water pollution have focused primarily on point sources, since these are easier to capture, treat, and monitor than nonpoint sources. The discharge of pollutants from municipal and industrial wastewater treatment plants is now strictly regulated through the National Pollution Discharge Elimination System (NPDES) permit program. However, despite major advancements in wastewater treatment, point sources still have an adverse impact on water quality in many cases.

Efforts to control nonpoint sources of pollution have been much less aggressive. The implementation of BMPs is generally voluntary, and the few regulations that apply to nonpoint sources (e.g., permits for runoff and erosion control at construction sites) are often not strictly enforced. As a result, many environmental professionals now consider nonpoint sources to be the nation's most important water quality problem.

The Total Maximum Daily Load (TMDL) program, established under Section 303(d) of the Clean Water Act, is designed to identify the amounts of pollutant loading reductions required to meet water quality standards in each watershed. A TMDL analysis yields a written, quantitative assessment of water quality problems in a watershed, and addresses both point source and nonpoint source pollutant loadings. The Ohio EPA has established a schedule that will lead to a TMDL evaluation for all watersheds in the state by the year 2014. Most of the Mahoning River watershed is currently scheduled for TMDL analysis in 2010. In order to provide data on the condition of streams and rivers required to support a TMDL analysis, the Ohio EPA periodically conducts detailed field monitoring of each major watershed. The last field survey of the Mahoning River watershed was conducted in 1994; the next survey is scheduled for 2008.

Chapter 2
Introduction to the Mahoning River Watershed

Watersheds and Tributaries

The Mahoning River watershed, shown in Figure 2-1, covers an area of about 1,140 square miles (730,000 acres) in northeastern Ohio and western Pennsylvania. The watershed includes portions of seven counties (Mahoning, Trumbull, Portage, Columbiana, Stark, Geauga, and Ashtabula) in Ohio and one county (Lawrence) in Pennsylvania. The *headwaters* (origin) of the Mahoning River are located in the northwestern corner of Columbiana County. The river flows north between Sebring and Alliance, passes through Berlin Reservoir and Lake Milton, and joins the West Branch just north of Newton Falls. Near Warren, the Mahoning River changes direction, curving to the east and then the southeast. After passing through Warren, the river flows southeast through several cities that line its banks – Niles, McDonald, Girard, Youngstown, Campbell, Struthers, and Lowellville. The Mahoning River flows into Pennsylvania and joins the Shenango River near New Castle to form the Beaver River. The Beaver River is a tributary to the Ohio River, and the Ohio River is a tributary to the Mississippi River. So, water flowing through the Mahoning River and its tributaries eventually reaches the Gulf of Mexico.

Several major tributary streams contribute to the flow of water in the Mahoning River, including the West Branch, Eagle Creek, Mosquito Creek, Meander Creek, Mill Creek, and Yellow Creek. Each tributary stream collects water from its own drainage area or subwatershed. The tributary watersheds of the Mahoning River drainage basin are outlined in Figure 2-2. The watershed areas drained by the some of the larger tributaries are summarized in Table 2-1. For purposes of identification, the United States Geological Survey (USGS) assigns an 8-digit Hydrologic Unit Code (HUC) to most large watersheds. The HUC for the Mahoning River watershed is 05030103. The watershed is further divided into subwatersheds that are assigned 11-digit HUCs. These subwatershed areas are drained by one or more tributary streams. The 11-digit hydrologic units are described in Table 2-2 and shown on a map in Figure 2-3. These are further subdivided into 14-digit watersheds by USGS.

Table 2-1. Areas of Selected Tributary Watersheds in the Mahoning River Basin.

Watershed Name	Watershed Area (Acres)	Watershed Area (Square Miles)	% of Mahoning River Watershed
West Branch	71,494	111.7	9.76
Eagle Creek	69,872	109.2	9.54
Mosquito Creek	90,008	140.6	12.29
Meander Creek	54,534	85.2	7.44
Mill Creek	49,646	77.6	6.78
Yellow Creek	26,798	41.9	3.66
Mahoning River Watershed	732,541	1144.6	100.00

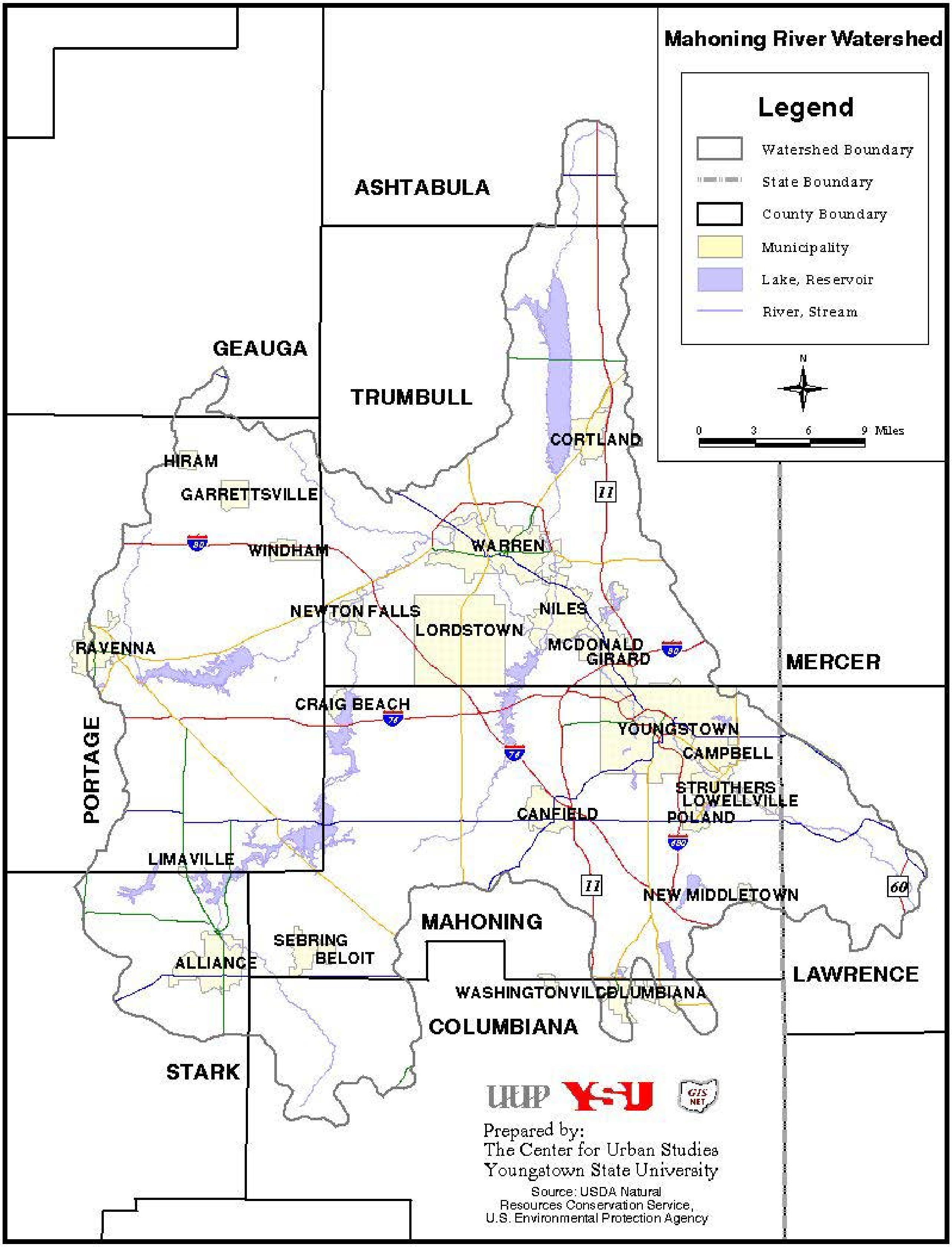

Figure 2-1. The Mahoning River Watershed.

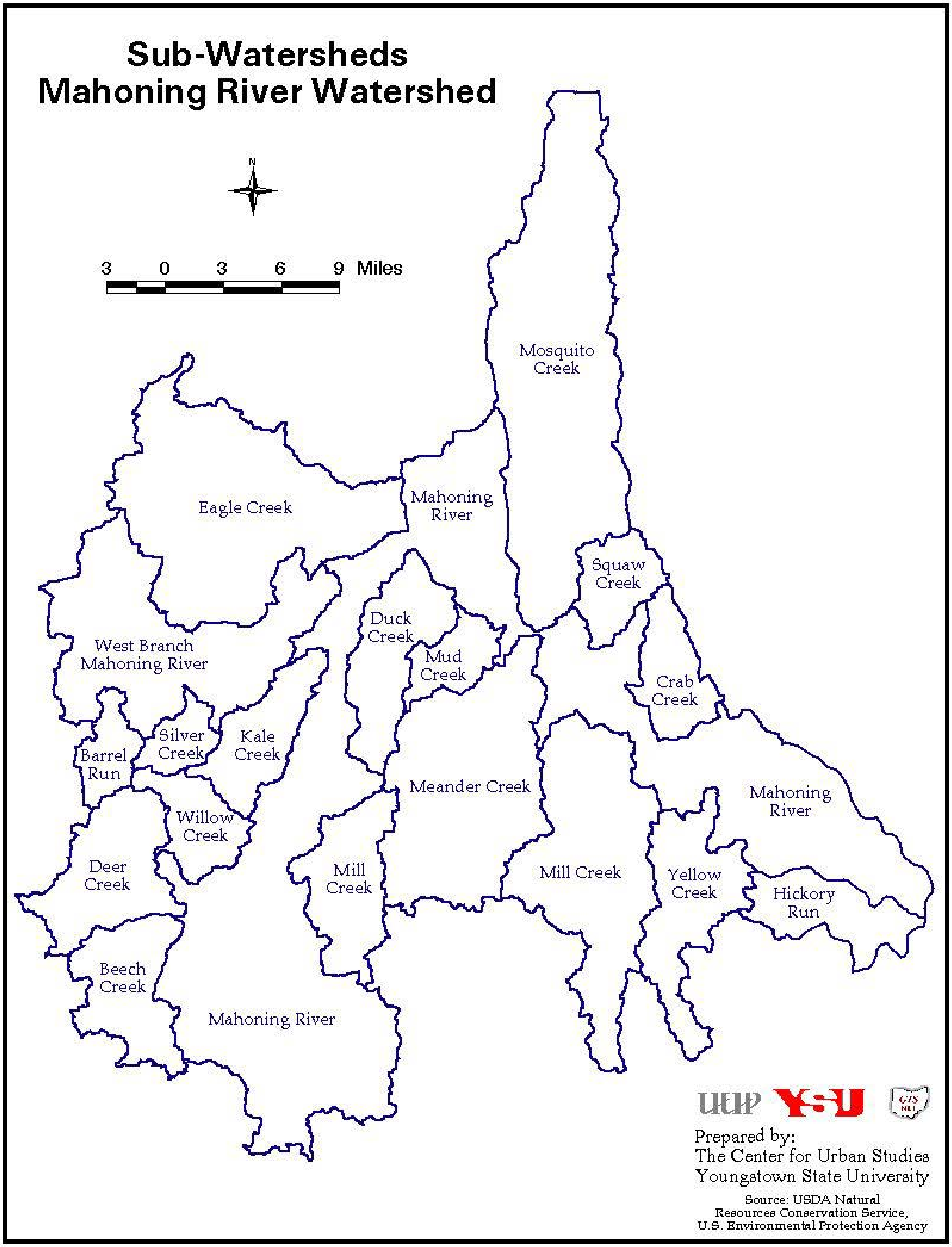

Figure 2-2. Watershed Boundaries of Tributaries in the Mahoning River Basin.

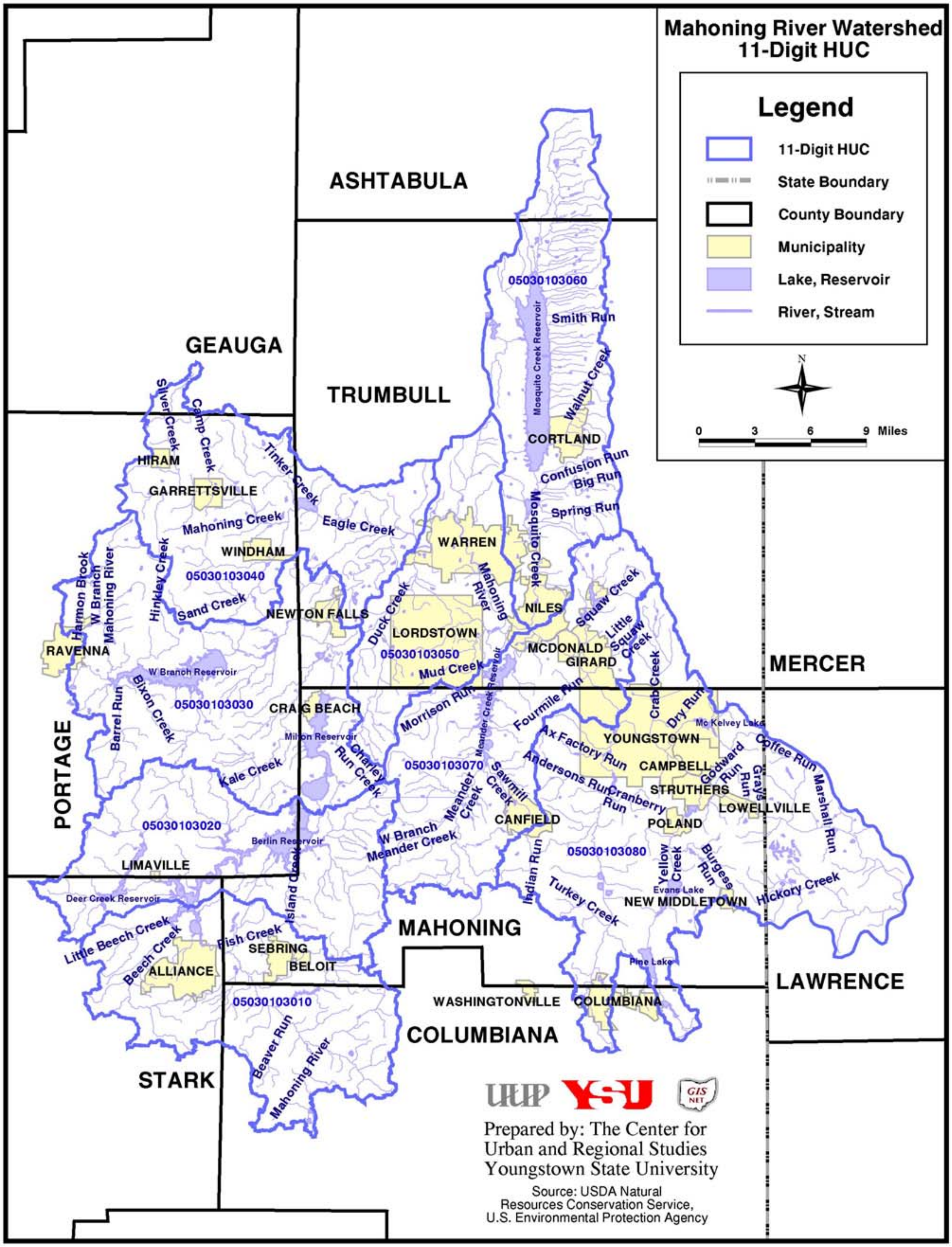

Figure 2-3. USGS 11-Digit Hydrologic Units in the Mahoning River Watershed.

Table 2-2. 11-Digit Hydrologic Unit Codes (HUCs) for the Mahoning River Watershed.

USGS 11-Digit HUC	Hydrologic Unit Description
05030103 010	Mahoning River (headwaters to downstream of Beech Creek)
05030103 020	Mahoning River (downstream of Beech Creek to downstream of Berlin Dam)
05030103 030	Mahoning River (downstream of Berlin Dam to downstream of West Branch)
05030103 040	Mahoning River (downstream of West Branch to upstream of Duck Creek)
05030103 050	Mahoning River (upstream of Duck Creek to upstream of Mosquito Creek); excluding Mahoning R. mainstem
05030103 060	Mosquito Creek
05030103 070	Mahoning River (downstream of Mosquito Creek to upstream of Mill Creek); excluding Mahoning R.
05030103 080	Mahoning River (upstream of Mill Creek to mouth); excluding Mahoning R. mainstem

Incorporated Areas and Phase II Storm Water Communities

The population living within the Mahoning River watershed is about 540,000. The majority of these residents live in incorporated areas (shown in yellow in Figures 2-1 and 2-3) or nearby suburban townships. A list of incorporated areas in the watershed is presented in Table 2-3 along with population estimates from the 2000 census. The larger incorporated areas operate municipal separate storm sewer systems (MS4s) and are required to develop and implement Storm Water Management Plans under the USEPA's Phase II Storm Water Program (indicated in Table 2-3). In addition, several counties and townships in the Mahoning River watershed operate MS4s, and are subject to the Phase II requirements. These are listed in Table 2-4.

Demographics

The Mahoning River watershed is rich in natural resources, including fertile farmland, natural gas, coal, limestone, iron ore, and salt. These resources first attracted settlers to the region in the early 1800's, and led to the development of a huge steel-making industry along the lower Mahoning River, between Warren and Youngstown, in the 20th century. Mill workers and their families, including immigrants from many countries, settled in the cities along the river, increasing the population of Youngstown to 168,330 by 1950 and Warren to 61,423 by 1967. Most of the steel mills closed in the late 1970's and early 1980's. For the past 30-40 years, there has been a rapid migration of population out of Youngstown, Warren, and other cities toward the surrounding townships (most notably Austintown, Boardman, Canfield, and Poland Townships in Mahoning County, and Howland and Liberty Townships in Trumbull County). Commercial districts have also largely moved from the cities to the suburbs.

Selected demographic statistics for Mahoning, Trumbull, and Portage Counties are summarized and compared with values for the State of Ohio in Table 2-5. Since the majority of Mahoning and Trumbull County residents live within the Mahoning River watershed, statistics from these two

Table 2-3. Incorporated Areas in the Mahoning River Watershed and Phase II Storm Water Status.

Community	County	Phase II	Population 2000 Census
Columbiana Village	Columbiana		5,635 [a]
Beloit Village	Mahoning		1,024
Campbell City	Mahoning	Yes	9,460
Canfield City	Mahoning	Yes	7,374
Craig Beach Village	Mahoning		1,254
Lowellville Village	Mahoning		1,281
New Middletown Village	Mahoning	Yes	1,932
Poland Village	Mahoning	Yes	2,866
Sebring Village	Mahoning		4,912
Struthers City	Mahoning	Yes	11,756
Youngstown City	Mahoning	Yes	82,026
Garretsville Village	Portage		2,262
Hiram Village	Portage		1,242
Ravenna City	Portage	Yes	11,771 [a]
Alliance City	Stark		23,353
Limaville Village	Stark		193
Cortland City	Trumbull		6,830
Girard City	Trumbull	Yes	10,902
Lordstown Village	Trumbull	Yes	3,633
McDonald Village	Trumbull	Yes	3,481
Mineral Ridge Village	Trumbull		3,900
Newton Falls Village	Trumbull	Yes	5,002
Niles City	Trumbull	Yes	20,932
Warren City	Trumbull	Yes	46,832

a – the watershed boundary passes through the city or village; thus, a portion of this population lives outside the Mahoning River watershed.

Table 2-4. Counties and Unincorporated Townships (County in Parentheses) in the Mahoning River Watershed Subject to the Phase II Storm Water Program.

Geauga County	Marlboro Twp. (Stark)	Howland Twp. (Trumbull)
Mahoning County	Beaver Twp. (Mahoning)	Johnston Twp. (Trumbull)
Portage County	Canfield Twp. (Mahoning)	Liberty Twp. (Trumbull)
Stark County	Coitsville Twp. (Mahoning)	Mecca Twp. (Trumbull)
Trumbull County	Poland Twp. (Mahoning)	Newton Twp. (Trumbull)
Charlestown Twp. (Portage)	Springfield Twp. (Mahoning)	Vienna Twp. (Trumbull)
Paris Twp. (Portage)	Bazetta Twp. (Trumbull)	Warren Twp. (Trumbull)
Ravenna Twp. (Portage)	Braceville Twp. (Trumbull)	Weathersfield Twp. (Trumbull)
Rootstown Twp. (Portage)	Champion Twp. (Trumbull)	
Shalersville Twp. (Portage)	Fowler Twp. (Trumbull)	

Table 2-5. Demographic Statistics for Mahoning, Trumbull and Portage Counties.

Parameter	Mahoning County	Trumbull County	Portage County	State of Ohio
Population, 2000	257,555	225,116	152,061	11,353,140
Population, percent change, 1990 to 2000	-2.7%	-1.2%	6.6%	4.7%
Persons under 18 years old, percent, 2000	23.7%	24.4%	23.7%	25.4%
Persons 65 years old and over, percent, 2000	17.8%	15.7%	11.0%	13.3%
White persons, percent, 2000	81.0%	90.2%	94.4%	85.0%
High school graduates, percent of persons age 25+, 2000	82.4%	82.5%	85.9%	83.0%
Bachelor's degree of higher, percent of persons age 25+, 2000	17.5%	14.5%	21.0%	21.1%
Home ownership rate, 2000	72.8%	74.3%	71.3%	69.1%
Median value of owner-occupied housing units, 2000	$79,700	$85,500	$123,000	$103,700
Median household money income, 1999	$35,248	$38,298	$44,347	$40,956
Persons below poverty level, percent, 1999	12.5%	10.3%	9.3%	10.6%

Source: U.S. Census Bureau

counties give the most accurate picture of demographic conditions. Watershed residents are older, on average, than other areas of the state. Their education level and household income are lower than the statewide averages. Employment growth is stagnant, resulting in a net population decrease between 1990 and 2000. However, the cost of housing is low compared to other areas in Ohio.

Planning Organizations and Previous Efforts

Two watershed groups promote environmental protection in the Mahoning River watershed. The Mahoning River Consortium (MRC) addresses issues in the entire Mahoning River watershed; the Alliance for Watershed Action and Riparian Easements (AWARE) focuses on the Mill Creek, Yellow Creek, and Meander Creek watersheds. AWARE developed a preliminary Watershed Action Plan for Mill Creek and Yellow Creek watersheds in 1998 under a pilot grant from OEPA. This plan is currently being rewritten to meet current OEPA standards. However, at this time, no approved watershed action plans exist for the Mahoning River basin.

Regional environmental and transportation planning in Mahoning and Trumbull Counties is the responsibility of the Eastgate Regional Council of Governments. In 1977, Eastgate (then EDATA) developed the original Areawide Water Quality Management Plan (AWQMP) for Mahoning and Trumbull Counties, pursuant to Section 208 of the Clean Water Act. The primary focus of the plan was design and construction of wastewater treatment facilities. The organization is currently working on an update to the “208 Plan”. The plan will delineate service areas for wastewater facilities, nonpoint source controls, and the protection of critical resources within the two counties.

Regional environmental planning for Portage and Stark Counties is the responsibility of NEFCO (Northeast Four Corners Organization). However, their 208 Plan covers only watersheds within the Lake Erie basin, and does not include the Mahoning River watershed.

Each county in the watershed maintains a Soil and Water Conservation District (SWCD) office and a Planning office.

The Mosquito Creek Watershed

This plan focuses in detail on Mosquito Creek watershed, shown in Figure 2-4 (including 14-digit HUCs). The watershed area is 140.6 square miles (or 90,000 acres) – the largest tributary watershed in the Mahoning River basin. About 82% of the watershed lies in Trumbull County and 18% (the headwaters of Mosquito Creek) in Ashtabula County. The areas of the 14-digit subwatersheds are listed in Table 2-6. The southern half of the watershed is urban/suburban, and includes portions of the Cities of Niles and Warren, and all of Cortland. The northern half of the watershed is mostly rural. Mosquito Creek Reservoir is the dominant feature of the watershed. The (approx.) 8000 acre reservoir was constructed by the U.S. Army Corps of Engineers in 1943 to provide flood control, low-flow augmentation, and water quality control. The reservoir also serves as the water supply for the City of Warren and some surrounding areas.

Table 2-6. 14-Digit Hydrologic Units in the Mosquito Creek Watershed.

14-Digit HUC	Description	Watershed Area (acres)	% of Mosquito Cr. Watershed
05030103 060 010	Mosquito Creek headwaters	16,700	18.9
05030103 060 020	Walnut Creek	6,200	7.0
05030103 060 030	Mosquito Creek Reservoir	39,500	44.6
05030103 060 040	Lower Mosquito Creek	26,100	29.5

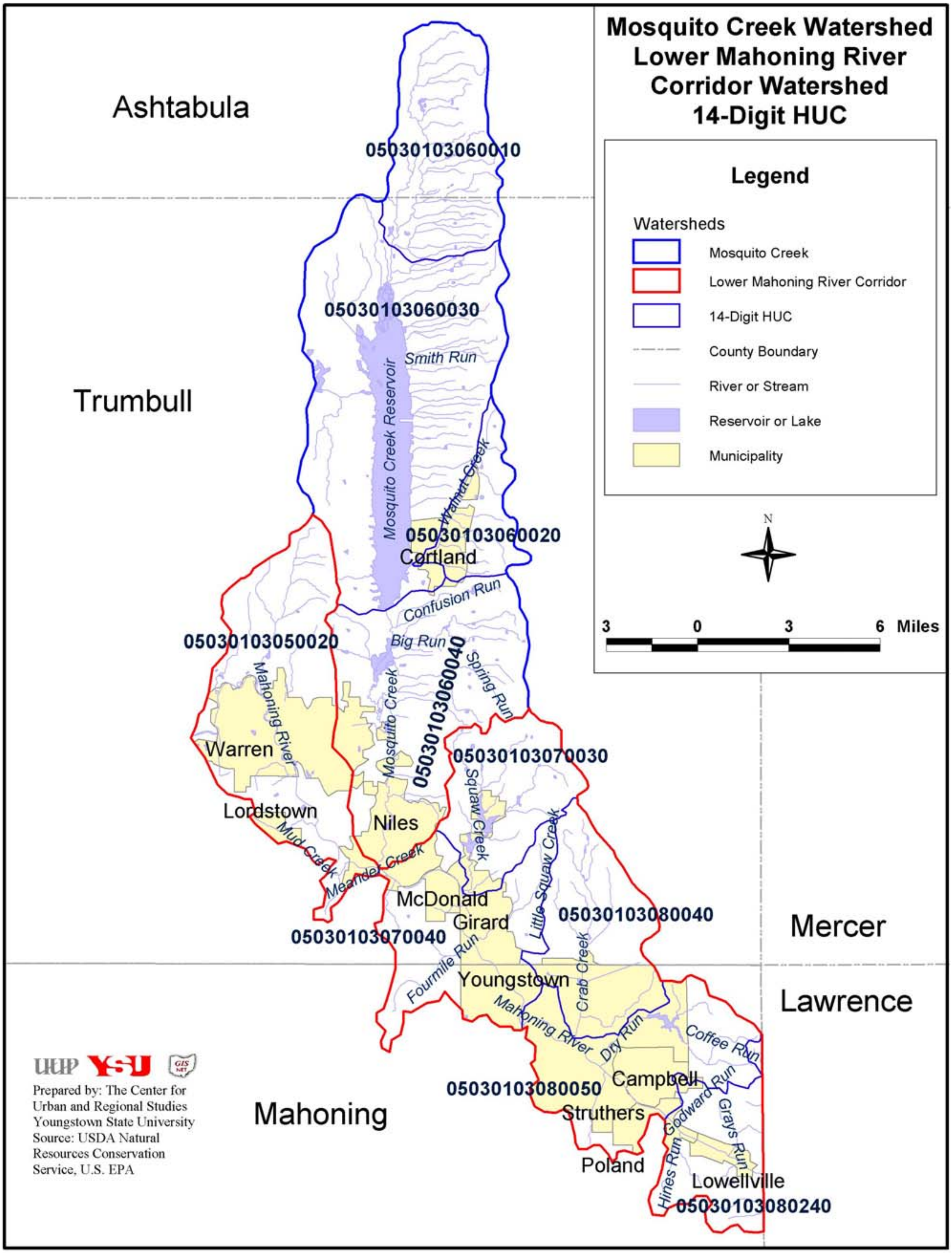

Figure 2-4. The Mosquito Creek and Lower Mahoning River Corridor Watersheds.

The Lower Mahoning River Corridor Watershed

This plan also focuses in detail on the Lower Mahoning River Corridor watershed. Six 14-digit HUCs, listed in Table 2-7, were included in the planning effort. This area totals about 147 square miles (or 94,300 acres). Combined with the Mosquito Creek watershed, these HUCs (also shown in Figure 2-4) form a contiguous section of the Mahoning River watershed occasionally referred to as the "focus area" or "study area" in this Plan.

The Lower Mahoning River Corridor was the site of intensive steel making activity throughout much of the 20th century, and includes most of the cities that developed around the steel mills. Roughly half of this corridor lies in Trumbull County, and half in Mahoning County. Incorporated areas in the corridor include the Cities of Warren, Niles, Girard, Youngstown, Campbell and Struthers, and Villages of Lordstown and McDonald.

Table 2-7. 14-Digit Hydrologic Units in the Lower Mahoning River Corridor.

14-Digit HUC	Description	Watershed Area (acres)	% of Lower Mahoning R. Corridor Watershed
05030103 050 020	Mahoning R. from Duck Cr. to Mosquito Cr.	25,800	27.4
05030103 070 030	Squaw Creek	11,800	12.5
05030103 070 040	Mahoning R. from Mosquito Cr. to Mill Cr.	17,000	18.0
05030103 080 040	Crab Creek	13,500	14.3
05030103 080 050	Mahoning R. from Mill Cr. to Yellow Cr.	16,200	17.2
05030103 080 240	Mahoning R. below Yellow Cr. (Ohio portion only)	10,000	10.6

Chapter 3
Development of the Watershed Action Plan

The Watershed Group

The watershed group coordinating the development and implementation of this Watershed Action Plan is the Mahoning River Consortium (MRC). The MRC was formed in 1996 for the purpose of restoring, maintaining, and enhancing the environmental quality of the Mahoning River and its tributaries.

Watershed Partners:

A highly diverse group of stakeholders participates in the MRC and an even broader group was engaged in the watershed planning process. Members of the organizations and groups listed in Table 3-1 participated in development of the Watershed Action Plan.

Mission of the MRC:

The mission of the MRC is to restore and maintain higher environmental quality of the Mahoning River, its corridor and its watershed in order to enhance the social, recreational and economic development of the Mahoning River valley communities. The MRC will advocate research, multiple use planning, education, recreation, social and economic activities that positively impact the quality of life along the river.

Structure and Operational Procedures:

Membership in the MRC is open to any individual or group. The structure and operational procedures are described in the organization's Bylaws, adopted in 2001. Annual dues range from $5.00 per year for students to $25.00 per year for groups. Voting members include "any person or organization that pays annual membership dues and is 18 years or older." General membership meetings are held on the third Friday of each month. The affairs of the MRC are directed and managed by an elected Board of Directors consisting of nine members serving staggered three year terms. Board meetings are held monthly following the general membership meetings. The coordination of general membership meetings is largely the responsibility of four officers – President, Vice-President, Secretary, and Treasurer – elected by the Board of Directors. The Bylaws also established the following Committees open to any MRC members: Steering; Membership; Finance; Recreation; Environment; Education; Research; Activities; Economic Development; and Agriculture.

Outline of the Plan's Content

Background on characteristics of the Mahoning River watershed is provided in the Watershed Inventory (Chapter 4). Causes and sources of watershed impairments are also documented in Chapter 4. Problem statements, watershed restoration goals, and action plans designed to achieve these goals are presented in Chapter 5. For each proposed action, the lead parties, resources

Table 3-1. Stakeholder Groups Participating in Development of the Mahoning River Watershed Action Plan.

Watershed Residents: Mahoning River Consortium AWARE Headwaters Trust Audubon Society of Mahoning Valley Ducks Unlimited Sierra Club	Cortland Conservation Club Trumbull Canoe Trails Boy Scouts of America Greenpeace Nature Conservancy National Wildlife Federation
Businesses: ACTION Economic Development Task Force CASTLO Community Improvement Corp.	WCI Steel
Landowners: Trumbull County Farm Bureau	Mosquito Creek Wetland Preservation Group
Community Organizations: Warren Rotary Lake Milton Improvement Association	Austintown Kiwanis United Methodist Church Peace Council
Local Government: Mahoning County Association of Township Trustees Mahoning County District Board of Health Mahoning County Trustees Trumbull County Planning Commission Trumbull County Soil & Water Conservation District	City of Youngstown Planning Dept. Trumbull County Board of Health
State Government: Ohio EPA	
Educational Institutions or Educators: Girard City Schools Mahoning River Education Project Youngstown State University	Youngstown Environmental Studies Society (YSU)
Non-Governmental Organizations: League of Women Voters Easter Seals	
Regulated Community: American Water Works Association Water Environment Foundation	Trumbull County Sanitary Engineer

required, time frame, and performance indicators are also identified. An overview of the approach to the Plan implementation, monitoring and evaluation process is described in Chapter 6. Support information is presented in the Appendix.

Plan Endorsement by Watershed Partners

Many of the organizations listed in Table 3-1 have made significant contributions to development of the Watershed Action Plan. The Plan will be distributed to several watershed partners, including local, state, and federal government agencies and political officials for their review and formal endorsement. Key organizations include the following:

- Ohio EPA
- U.S. Army Corps of Engineers
- Trumbull Soil and Water Conservation District
- Trumbull County Planning Commission
- Trumbull County Board of Health
- Trumbull County Commissioners
- Trumbull County Sanitary Engineer
- Mahoning Soil and Water Conservation District
- Mahoning County Board of Health
- Eastgate Regional Council of Governments
- Mahoning County Commissioners
- City of Youngstown Planning Department
- Youngstown City Council
- Warren City Council
- CASTLO Community Improvement Corp.
- Trumbull County Township Trustees Association
- Mahoning County Township Trustees Association

Public Education

Several strategies were used to educate stakeholders on environmental issues and obtain input on water quality problems and priorities during the watershed planning process. The Public Participation Plan for the project included the following activities:

1. A four-page color brochure describing the watershed and the watershed planning process was prepared and 2000 copies were distributed. Copies were placed at all public libraries in Trumbull and Mahoning Counties.
2. A two-page Stakeholder Survey form was developed and distributed to solicit input on interests and concerns in the watershed. About 160 completed forms were received.
3. A Watershed Action Plan brochure and Stakeholder survey was mailed to over 350 individuals and groups on the MRC’s stakeholder list.
4. A web site was developed to provide basic information on the planning process and an online version of the Stakeholder Survey form
5. Five Stakeholder Forum meetings were held at locations throughout the watershed (Sebring, Newton Falls, Girard, Cortland, and Canfield). These were advertised in many local media outlets. Total attendance was approximately 60.

6. Presentations on the watershed planning effort were given to several community groups and local political officials.
7. Key "resource persons" (mostly from local government agencies involved with environmental issues) were interviewed to obtain information for the watershed inventory.

Public education and involvement will remain important components as the Plan is formally endorsed, implemented, and evaluated.

Chapter 4
Watershed Inventory

Description of the Mahoning River Watershed

Topography, Geology, and Soils:

The headwaters of the Mahoning River are located at Watercress Marsh (elevation 1200 ft.) in Butler Township, Columbiana County, about five miles southwest of Salem, Ohio. Elevations in the watershed range from a high point of 1380 ft. on a ridge northeast of the headwaters to a low point of 780 ft. at the confluence with the Mahoning and Shenango Rivers near New Castle, Pennsylvania. A topographic map of the Mahoning River watershed is shown in Figure 4-1.

Elevations in the Mosquito Creek watershed range from a high point of about 1200 ft. on the ridge that forms the eastern boundary of the watershed to a low point of about 850 ft. at the confluence of Mosquito Creek and the Mahoning River. The normal pool elevation of Mosquito Creek Reservoir is 901 ft. The eastern half of the watershed slopes from east to west at a gradual and uniform grade of about 1.5%. The western half of the watershed is very flat, sloping eastward toward Mosquito Creek Reservoir at an average slope of less than 0.5%. Mosquito Creek flows south from the headwaters in southern Ashtabula County to the Mahoning River in Niles, a distance of 35.9 miles at an average slope of 7.0 ft/mile.

Topography in the Lower Mahoning River Corridor changes significantly between Leavittsburg and the Pennsylvania state line. In the upper portion, between Leavittsburg and Niles, the river corridor is broad and gently sloping. In the lower portion, between Girard and the state line, the river corridor is narrow and the land slopes steeply away from the river. The river gradient averages about 2.2 ft/mile.

The bedrock geology of the Mahoning River watershed consists of layered sedimentary rocks that represent former sands, silts, and muds, deposited 280 million to 400 million years ago. Rocks exposed in the watershed are primarily from Mississippian and Pennsylvanian Age systems. Rocks of the Mississippian system, including thick shales, sandstone, and interbedded shales and sandstones, are exposed over most of Trumbull County. Rocks of the Pennsylvanian system, composed of a sequence of sandstones, shales, siltstones, coal, clay, and limestone, are exposed throughout Mahoning County.

The Mahoning River watershed is covered by deposits of unconsolidated clay, sand, and gravel, left by at least two continental ice sheets. The entire watershed was at one time covered by glaciers, with the last major advance being about 20,000 years ago. The glaciers scoured and eroded the soils and bedrock as they advanced and accumulated an unsorted mixture of clay, sand, and gravel. This material was deposited in front of the ice sheet or left behind when the glaciers melted.

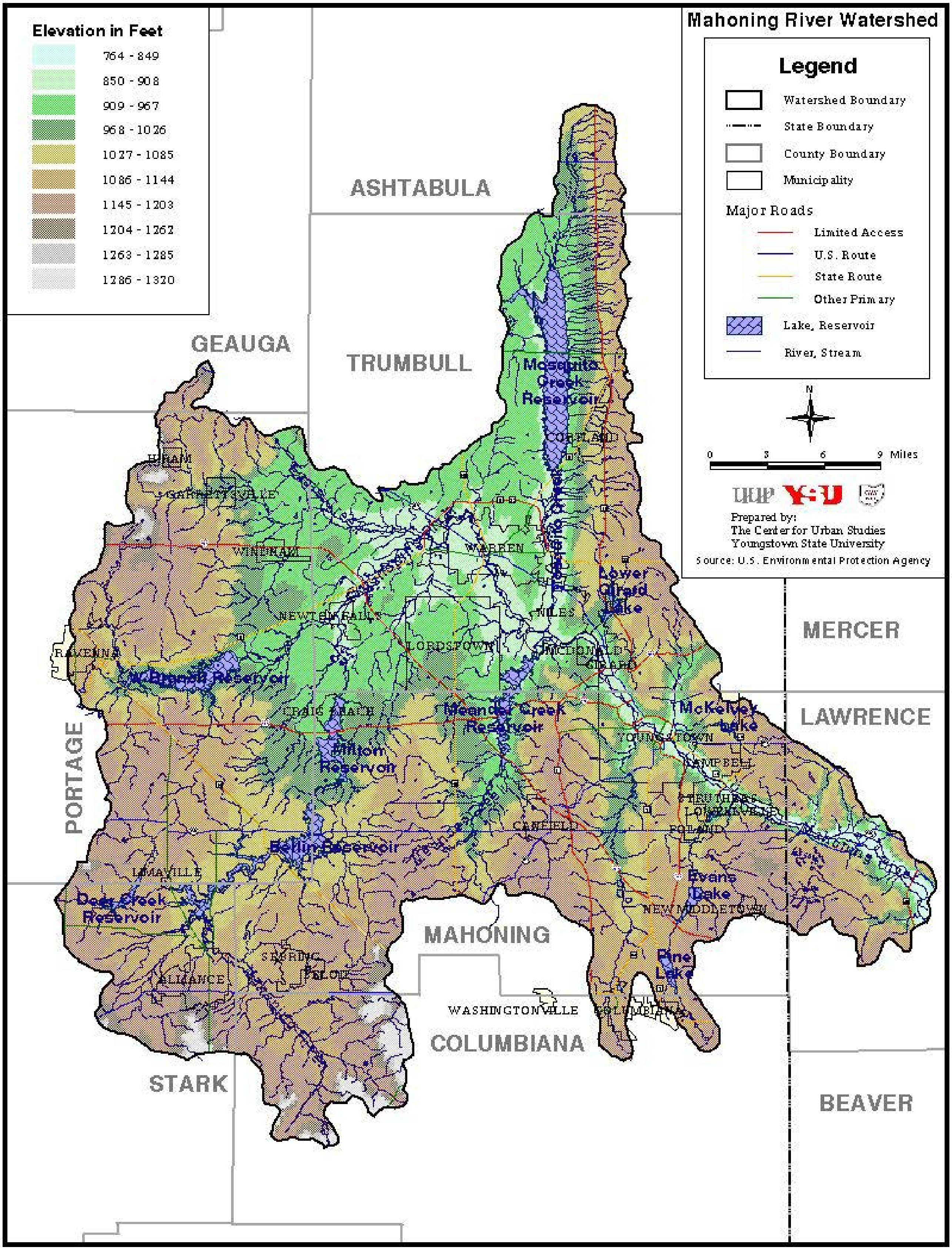

Figure 4-1. Topography of the Mahoning River Watershed.

A map of the major soil associations of the Mahoning River watershed is shown in Figure 4-2. The land areas covered by each soil series in the watershed and the focus areas are listed in Table 4-1. Of particular interest is the presence of hydric soils or non-hydric soils with hydric inclusions. A *hydric soil* is defined as one that is saturated or flooded long enough during the growing season to develop anaerobic conditions (i.e., the absence of oxygen) that favor the growth of hydrophytic vegetation (USDA Soil Conservation Service, 1975). Due to their position in the landscape and/or their very low permeability, these soils pose significant limitations for development. Non-hydric soils with hydric inclusions show evidence of periodic saturation and anaerobic conditions, but not enough to be classified as hydric. A map showing the hydric soils in the focus area is presented in Figure 4-3. The areas covered by these soil types are summarized in Table 4-2.

Table 4-1. Areas Covered by Major Soil Associations in the Mahoning River Watershed.

		Mahoning River Watershed		**Mosquito Creek Watershed**		**Lower Mahoning River Corridor Watershed**	
Map Unit ID	**Soil Series Name**	**Area (Acres)**	**% of Watershed**	**Area (Acres)**	**% of Watershed**	**Area (Acres)**	**% of Watershed**
OH046	Hanover	28	0.00				
OH059	Haskins	55,960	8.72	2,510	2.81	14,120	15.11
OH069	Ravenna	130,610	20.34			14,970	16.01
OH072	Fitchville	78,000	12.15	5,720	6.42	17,260	18.46
OH074	Darien	9,185	1.43	9,185	10.31		
OH081	Sheffield	11,320	1.76	11,320	12.71		
OH082	Remsen	90.690	0.01			1,560	1.67
OH084	Wadsworth	130,370	20.30	20,140	22.61	18,645	19.94
OH126	Sebring	187,160	29.15	40,210	45.14	26,145	27.96
OH131	Wooster	3,890	0.61			790	0.85
PA006	Cambridge	7,300	1.14				
PA009	Loudonville	19,500	3.04				
PA010	Canfield	8,690	1.35				

Table 4-2. Areas of Hydric and Non-Hydric Soils in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

	Mosquito Creek Watershed		**Lower Mahoning River Corridor Watershed**	
Soil Type	**Area (Acres)**	**% of Watershed**	**Area (Acres)**	**% of Watershed**
Hydric	35,390	39.73	19,990	21.38
Non-hydric with hydric inclusions	21,090	23.67	14,970	16.01
Non-hydric	24,590	27.61	57,210	61.19
Open water	8,010	8.99	1,330	1.42

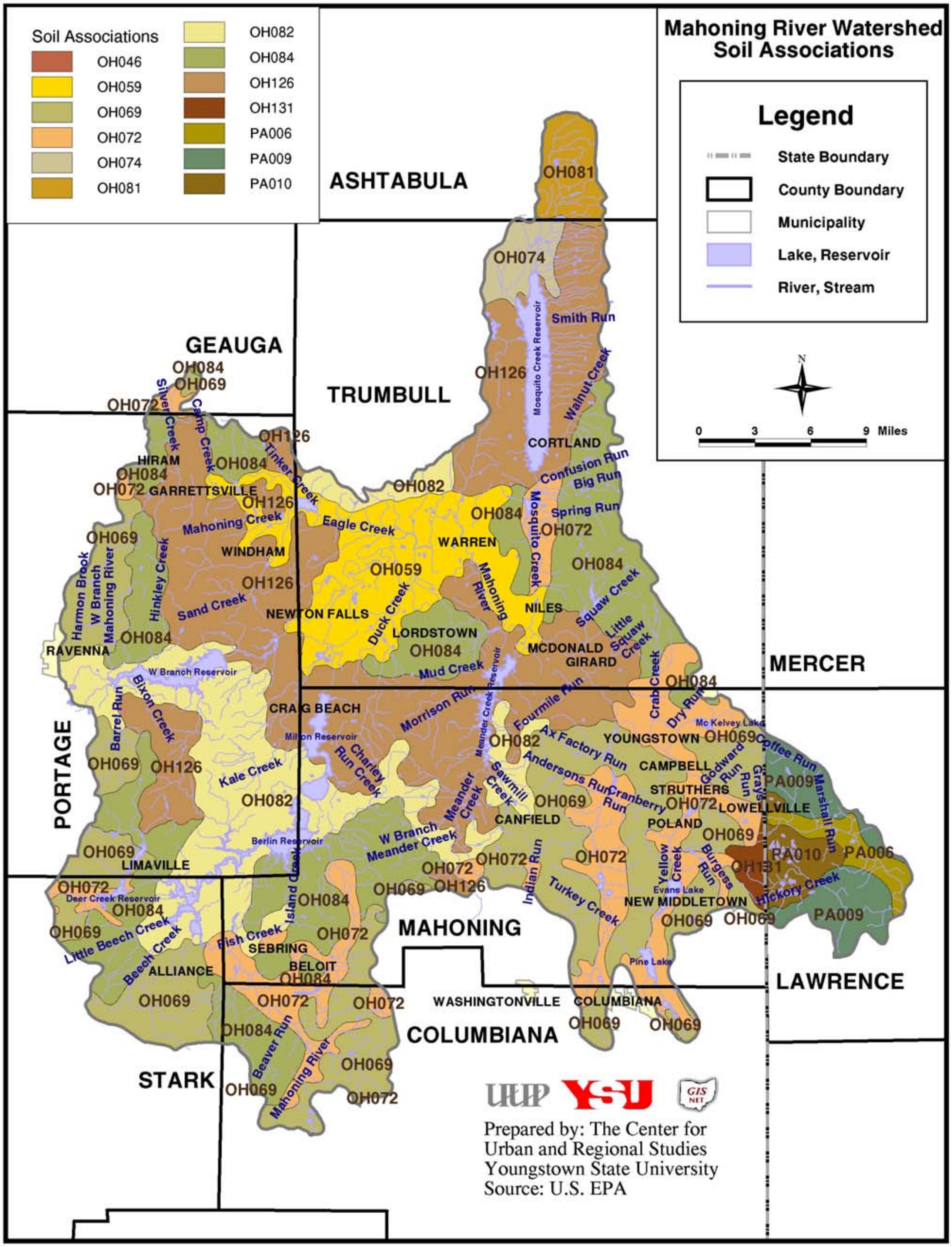

Figure 4-2. Soil Associations in the Mahoning River Watershed.

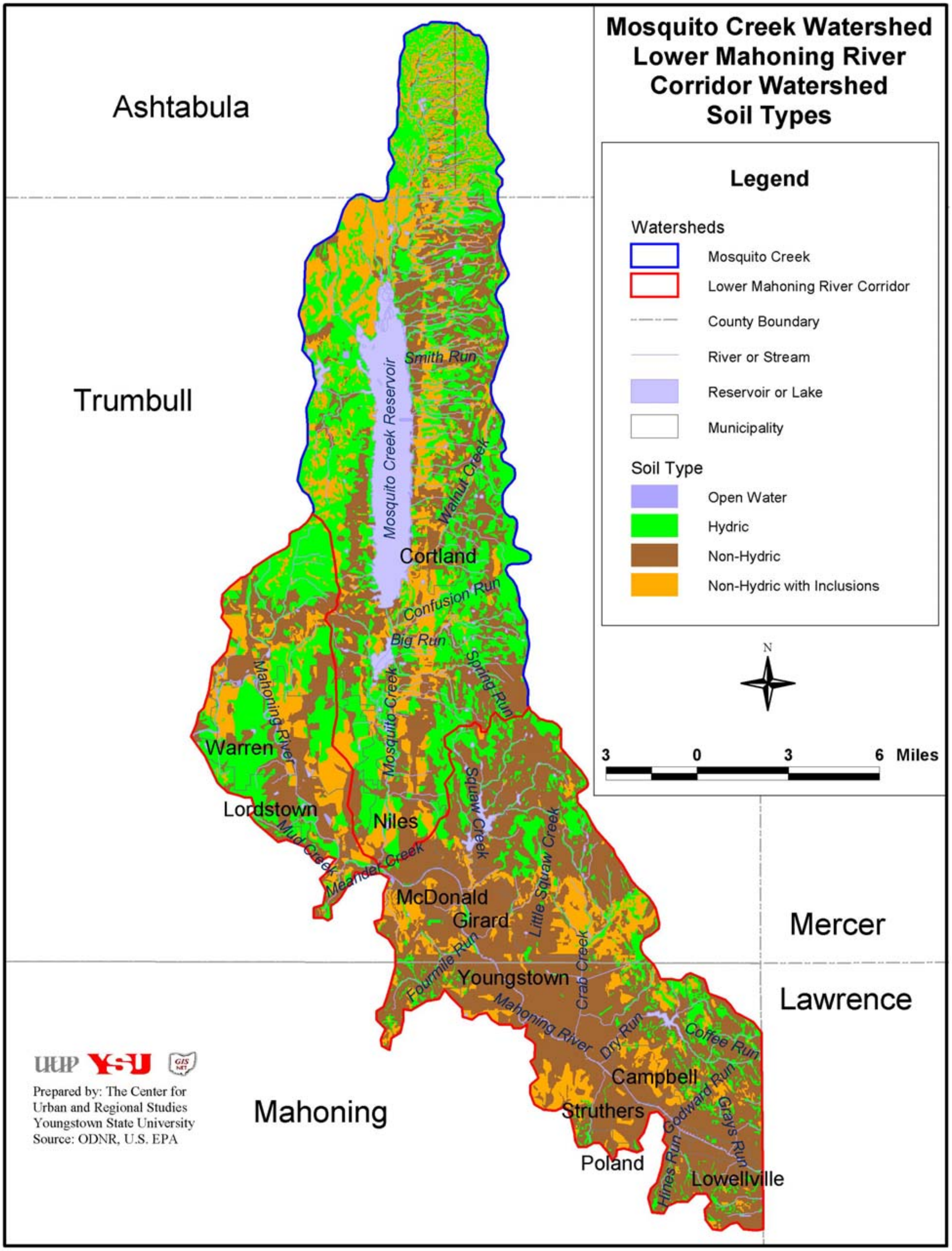

Figure 4-3. Hydric and Non-Hydric Soils in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

<u>Biological Features</u>:

The Ohio Department of Natural Resources maintains the Natural Heritage Data Base, which contains information on natural areas and rare species in Ohio. A search of the data base conducted by ODNR indicates that the following endangered and rare species have been observed in the Mosquito Creek and Lower Mahoning River Corridor watersheds:

- *Endangered Animals:*
  - Bald Eagle (*Haliaeetus leucocephalus*)
  - Eastern Massasauga (*Sistrurus catenatus*)
  - Northern Harrier (*Circus cyaneus*)
- *Rare Plants:*
  - Grove Sandwort (*Arenaria lateriflora*)
  - Gray Birch (*Betula populifolia*)

<u>Water Resources</u>:

Climate and Precipitation: Temperature and/or precipitation are monitored at several National Weather Service stations in the Mahoning River Watershed. Stations are located in Canfield, Hiram, Mineral Ridge, Ravenna, Warren, and at Mosquito Creek Reservoir and the Youngstown-Warren Regional Airport. Records from these stations for the period of 1970-2000 showed a mean annual temperature of about 48 ^{o}F and total annual precipitation averaging 38-40 inches. The mean monthly values vary only slightly from station to station. Data from the period 1971-2000 at the Youngstown-Warren Regional Airport station, presented in Table 4-3, are representative of conditions in the watershed. The northwestern portion of the watershed receives slightly more precipitation, as indicated by the 1971-2000 mean annual precipitation of 40.23 inches at Ravenna and 41.93 inches at Hiram.

Table 4-3. Monthly Mean Temperature and Precipitation for 1971-2000, National Weather Service Station, Youngstown-Warren Regional Airport, Vienna, OH.

Month	Temperature (^{o}F)	Precipitation (in)
January	24.9	2.34
February	27.7	2.03
March	36.7	3.05
April	47.4	3.33
May	57.6	3.45
June	65.9	3.91
July	69.9	4.10
August	68.4	3.43
September	61.5	3.89
October	50.8	2.46
November	40.7	3.07
December	30.4	2.96
	Mean = 48.5	Total = 38.02

Surface Water:

Wetlands – General wetland maps, generated from remote sensing data, are available from the Ohio Wetland Inventory (OWI) and the National Wetland Inventory (NWI). OWI maps for the entire Mahoning River watershed, Mosquito Creek watershed, and the Lower Mahoning River Corridor are shown in Figures 4-4 and 4-5. The areas of various wetland types identified in the OWI database are listed in Table 4-4. NWI maps for the Mahoning River watershed are available in hard copy only. Significant differences may exist between the two databases. However, it must be emphasized that the OWI and NWI databases show only the location of potential wetlands. The actual presence, type, and boundaries of a wetland can only be determined through field delineation by an experienced professional.

One of the largest and most important wetlands in the Mahoning River watershed lies north and west of Mosquito Creek Reservoir. These wetlands lie within the Mosquito Creek Wildlife Area, an 8,525 acre waterfowl management area managed by the Ohio Division of Wildlife. This refuge provides habitat for tens of thousands of nesting and migratory birds, including Ohio endangered species such as the bald eagle and osprey.

Table 4-4. Wetland Areas in the Mahoning River Watershed, Based on the Ohio Wetland Inventory (OWI).

Wetland Type	**Wetland Areas (Acres)**		
	Mahoning River Watershed	**Mosquito Creek Watershed**	**Lower Mahoning River Corridor Watershed**
Farmed wetland (wet meadow in agricultural areas)	292	26	5
Shallow Marsh (emergent vegetation in water <3 ft)	9,258	1,071	2,144
Shrub/scrub wetland (emergent woody vegetation in water <6 in)	11,750	2,437	2,373
Wet meadow (grassy vegetation in water <6 in)	4,183	431	368
Woods on hydric soils	35,059	7,471	2,904
Open water	22,771	7,343	647

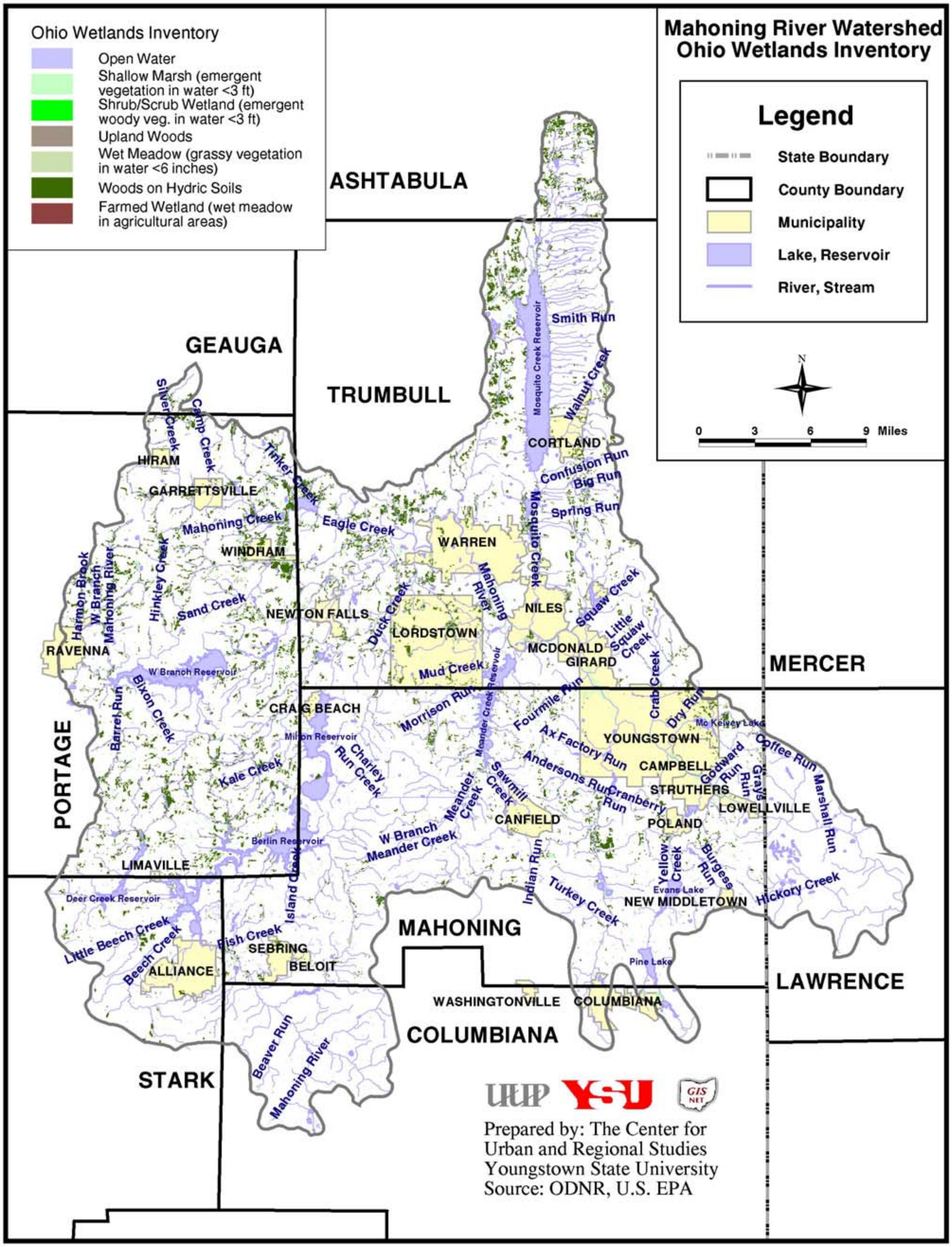

Figure 4-4. Ohio Wetland Inventory Map of the Mahoning River Watershed.

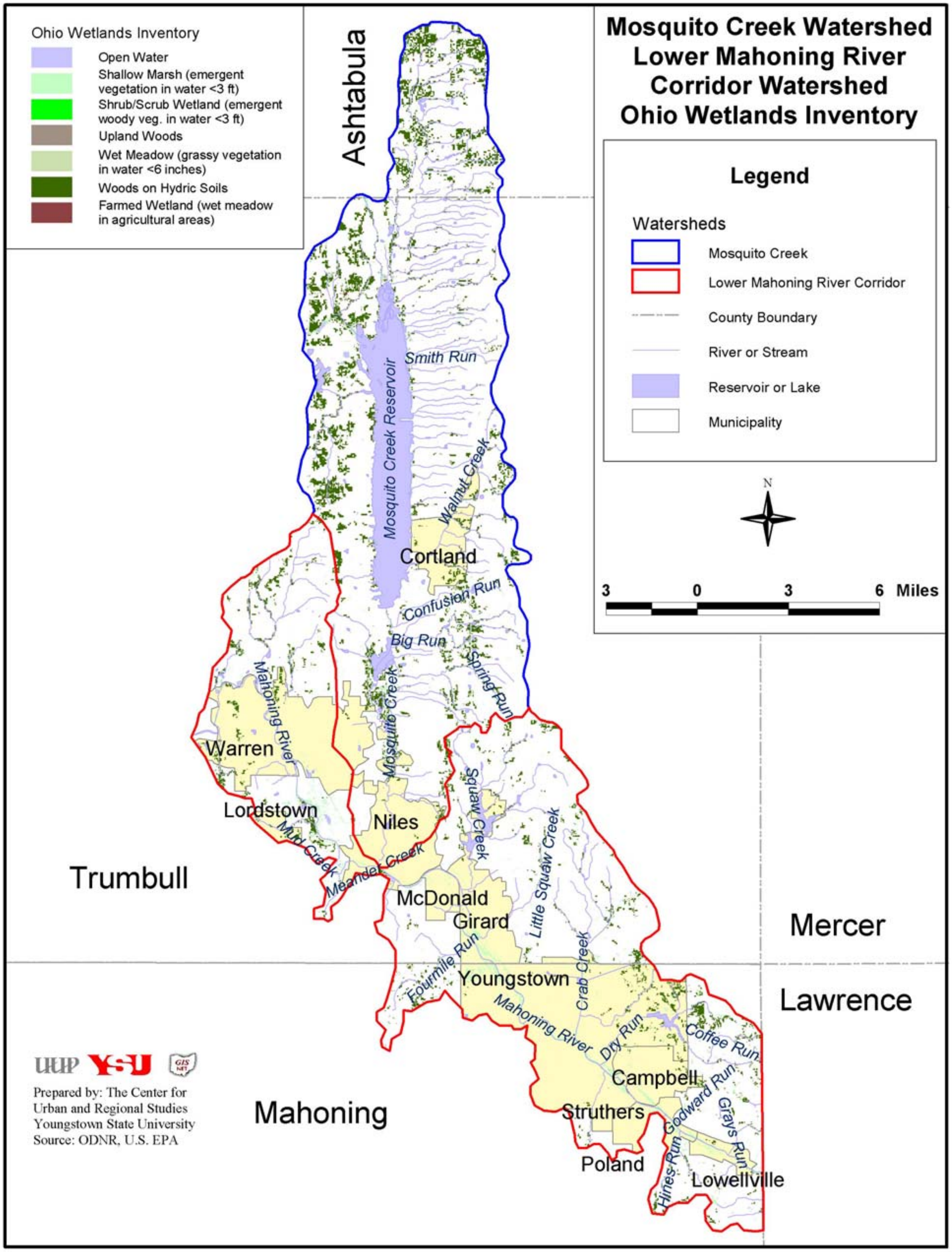

Figure 4-5. Ohio Wetland Inventory Map for Mosquito Creek and Lower Mahoning River Corridor Watersheds.

Streams – The lengths and watershed areas of major tributaries in the Mahoning River watershed are presented in Table 4-5. Smaller tributaries located within the focus areas for this plan (i.e., Mosquito Creek and Lower Mahoning River Corridor watersheds) are included as well.

Data on flow rates in many larger rivers and streams are available from gaging stations maintained by the United States Geological Survey (USGS). The data from selected gaging stations in the Mahoning River watershed are summarized in Table 4-6.

The locations of 100-year and 500-year flood plains for many streams are estimated by the Federal Emergency Management Agency (FEMA) and delineated on National Flood Insurance Program maps. Two examples are shown in Figures 4-6 (the Lower Mahoning River Corridor in the City of Warren), and 4-7 (the lower Mosquito Creek corridor in the City of Niles). The width of the 100-year flood plain ranges from only 10-20 feet where steep banks rise above the river, to more than 750 feet where the river has access to a broad natural flood plain.

Historically, a few severe and damaging floods have occurred in the Lower Mahoning River Corridor. For example, in March of 1913, river stage at the USGS gage in Leavittsburg reached 24 feet, or 14 feet higher than the normal flood stage. This flood caused widespread damage throughout the river corridor. Flooding has been greatly reduced by the construction of several large dams on the upper reaches of the Mahoning River (e.g., Berlin Lake and Lake Milton dams) and its tributaries (e.g., Meander Creek, Mosquito Creek, and West Branch). Nevertheless, flooding damage may still occur during heavy rainfall, such as the 100-year storm (approx.) experienced in July of 2003. Flooding can occur both within the flood plains adjacent to rivers and streams (see Figure 4-8), or in developed areas outside the flood plains where the capacity of storm sewers and retention facilities are inadequate to carry runoff from a large storm (see Figure 4-9).

Sinuosity and entrenchment indices have not been determined for any streams in the Mosquito Creek or Lower Mahoning River Corridor watersheds.

Table 4-5. Lengths and Watershed Areas of Selected Tributaries in the Mahoning River Watershed.

Tributary Name	Length (mi)	Gradient (ft/mi)	Watershed Area (acres)	Watershed Area (sq. mi.)
Mahoning River Watershed	108.3	4.0	725,000	1132.8
Beech Creek	10.2	17.7	20,860	32.6
West Branch	29.2	11.0	69,500	108.6
Eagle Creek	21.5	15.4	69,810	109.1
Meander Creek	20.4	9.6	55,360	86.5
Mill Creek	20.9	17.8	51,070	79.8
Yellow Creek	11.1	24.8	20,640	32.1
Kale Creek	13.6		16,320	25.5
Duck Creek	13.9		21,170	33.1
Mosquito Creek	33.7	7.0	89,090	139.2
Walnut Creek	6.6		6,190	9.7
Confusion Run	4.5			
Big Run	5.3			
Spring Run	5.3			
Lower Mahoning River Corridor	46.4 (total) 34.9 (Ohio)		93,500	146.1
Squaw Creek	7.4		11,760	18.4
Crab Creek	7.8	41.4	12,860	20.1

Table 4-6. Flow Measurements at USGS Gaging Stations in the Mahoning River Watershed.

USGS Gage Number	Location	Period[1]	Mean Annual Discharge (cfs)	10-Year Low Flow (cfs)
03086500	Mahoning R. at Alliance, OH	1942-1992		
03087000	Beech Creek near Bolton, OH	1944-1950		
03088000	Deer Creek at Limaville, OH	1942-1950		
03091500	Mahoning R. at Pricetown, OH	1930-2001		
03090500	Mahoning R. below Berlin Dam	1931-1990		
03092000	Kale Creek Near Pricetown, OH	1942-1992		
03092090	West Branch Mahoning R. near Ravenna, OH	1966-1992		
03092500	West Branch Mahoning R. near Newton Falls, OH	1927-1980		
03093000	Eagle Creek at Phalanx Station, OH	1927-2001		
03093500	Duck Creek at Leavittsburg, OH	1942-1947		
03094000	Mahoning R. at Leavittsburg, OH	1941-2001		
03095500	Mosquito Creek below Mosquito Creek Dam, near Cortland, OH	1927-1990		
03096000	Mosquito Creek at Niles, OH	1930-1950		
03097500	Meander Creek at Mineral Ridge, OH	1930-1950		
03097550	Mahoning R. at Ohio Edison Plant, Niles, OH	1988-2001		
03098000	Mahoning R. at Youngstown, OH	1922-1981		
03098500	Mill Creek at Youngstown, OH	1944-1970		
03098600	Mahoning R. below West Ave., Youngstown, OH	1988-2001		
03098700	Crab Creek at Youngstown, OH	1999-2000[2]		
03099500	Mahoning R. at Lowellville, OH	1944-1990		

1 – Period for which annual mean streamflow data are available on USGS web site.
2 – Incomplete data for both years; mean of 18 monthly streamflow values given.

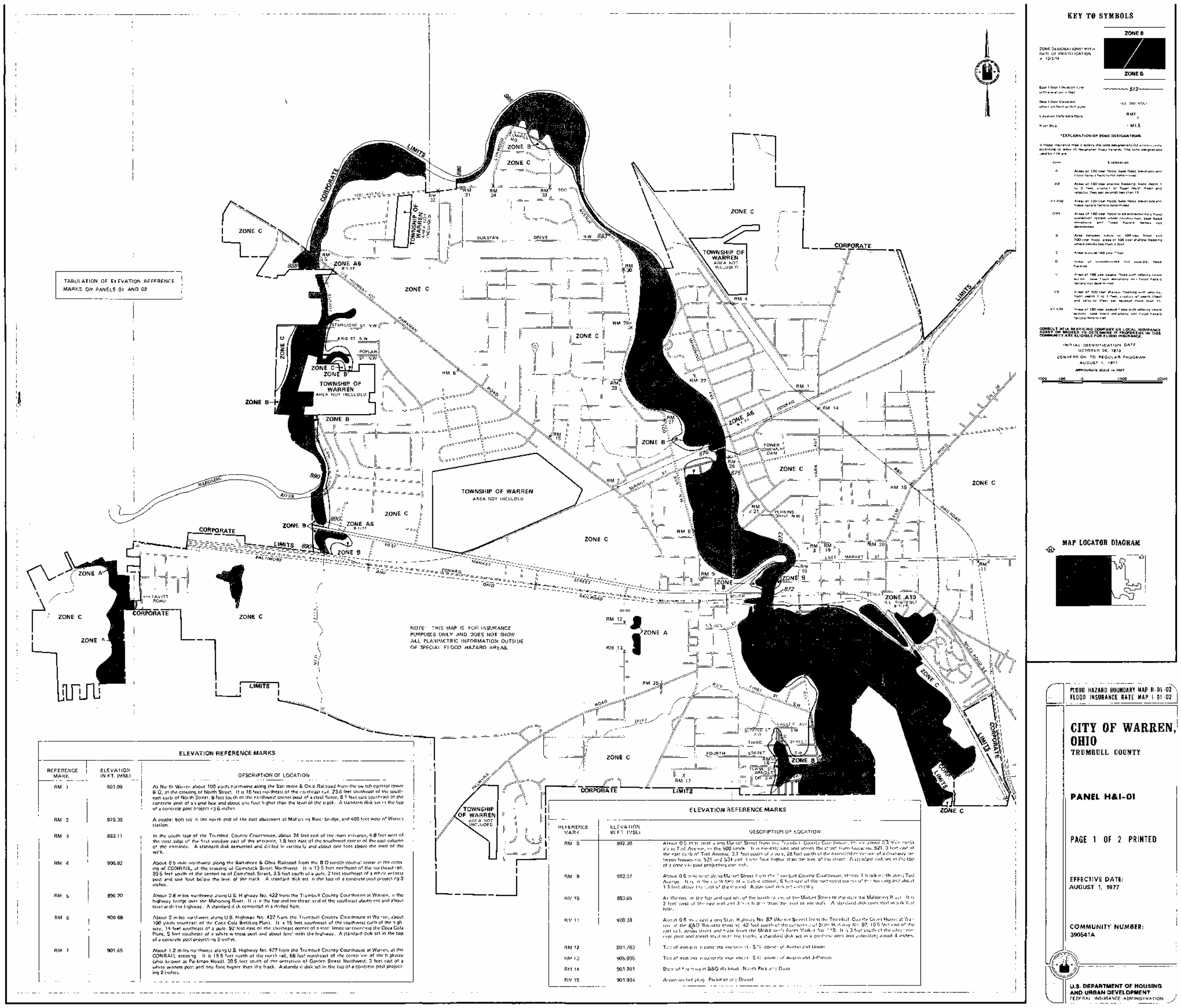

Figure 4-6. National Flood Insurance Program Map for the Mahoning River in Warren, OH.

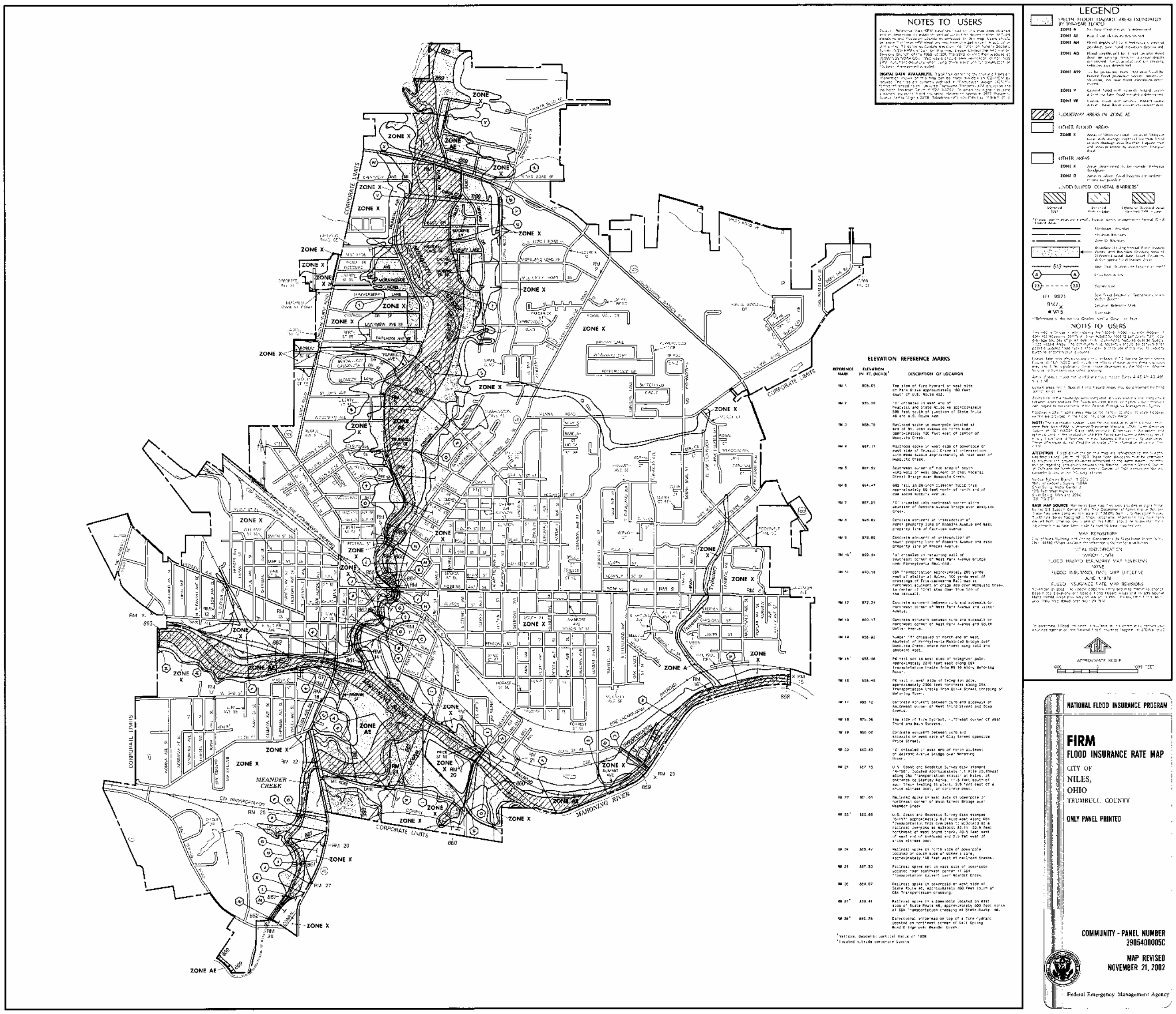

Figure 4-6. National Flood Insurance Program Map for Lower Mosquito Creek and the Mahoning River in Niles, OH.

Figure 4-8. Flooding in Perkins Park Ampitheatre, Warren, OH, July 23, 2003 (photo by T. Nuskievicz).

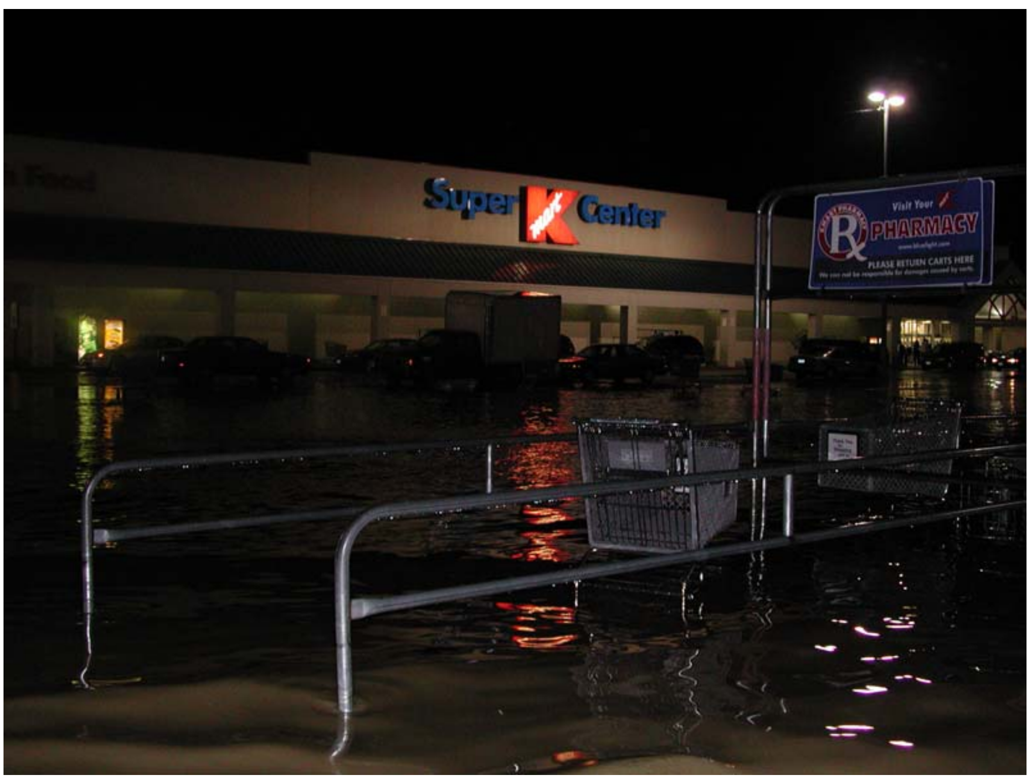

Figure 4-9. Flooding in Mall Parking Lot, Niles, OH, July 23, 2003 (photo by T. Nuskievicz).

Aquatic Use Designations: The aquatic life habitat, water supply, and recreation use designations are given in rule 3745-1-25 of the Ohio Revised Code for 67 streams and stream segments in the Mahoning River watershed. A partial listing of use designations is presented Table 4-7. All designated streams in the Mosquito Creek and Lower Mahoning River Corridor watersheds are included in this table. Virtually all designated streams in the watershed are classified as warmwater habitat (WWH), agricultural water supply (AWS), industrial water supply (IWS), and primary contact recreation (PCR) waters. Only Silver Creek, a tributary to Eagle Creek, is assigned a higher aquatic use designation – coldwater habitat (CWH). Most streams in the Eagle Creek watershed are also designated as state resource waters (SRW). In addition to the AWS and IWS designations, all of the following are designated as public water supplies (PWS):

- Publicly owned lakes and reservoirs;
- Privately owned lakes and reservoirs used as sources of public drinking water supplies;
- All surface waters within 500 yards of a public water supply surface water intake; and
- All surface waters used as emergency water supplies.

<u>Lakes and Reservoirs</u> – Many reservoirs are formed by dams along the Mahoning River and its tributaries. The watershed contains no natural lakes. A listing of the larger reservoirs in the watershed is presented in Table 4-8. A few smaller reservoirs that lie within the Lower Mahoning River Corridor watershed, as defined by this study, are also included. The size, use, watershed area, and hydraulic detention time of the reservoirs (if known) are also tabulated. The *hydraulic detention time* is the average length of time water spends in a reservoir. It can be calculated by dividing the volume of the reservoir by the flow rate of water through the reservoir.

Table 4-7. Aquatic Use Designations for Selected Streams in the Mahoning River Watershed.

Stream	Aquatic Life Habitat	Water Supply	Recreation
Mahoning River	WWH	PWS[1], AWS, IWS	PCR
Yellow Creek	WWH	PWS[1], AWS, IWS	PCR
Pine Hollow Creek	WWH	AWS, IWS	PCR
Dry Run	WWH	AWS, IWS	PCR
Crab Creek	WWH	AWS, IWS	PCR
Kimmel Brook	WWH	AWS, IWS	PCR
Mill Creek	WWH	AWS, IWS	PCR
Fourmile Run	WWH	AWS, IWS	PCR
Little Squaw Creek	WWH	AWS, IWS	PCR
Squaw Creek	WWH	AWS, IWS	PCR
Meander Creek	WWH	PWS[1], AWS, IWS	PCR
Mosquito Creek	WWH	PWS[1], AWS, IWS	PCR
Spring Run	WWH	AWS, IWS	PCR
Big Run	WWH	AWS, IWS	PCR
Confusion Run	WWH	AWS, IWS	PCR
Walnut Creek	WWH	AWS, IWS	PCR
Mud Creek	WWH	AWS, IWS	PCR
Smith Run	WWH	AWS, IWS	PCR
Duck Creek	WWH	AWS, IWS	PCR
Eagle Creek	WWH	AWS, IWS	PCR
West Branch	WWH	PWS[1], AWS, IWS	PCR
Kale Creek	WWH	AWS, IWS	PCR
Deer Creek	WWH	AWS, IWS	PCR
Beech Creek	WWH	AWS, IWS	PCR

1 – Portions of the stream and/or impoundments along the stream are designated as public water supplies.

WWH = Warmwater habitat; PWS = Public water supply; AWS = Agricultural water supply; IWS = Industrial water supply; PCR = Primary contact recreation.

Table 4-8. Reservoirs in the Mahoning River Watershed.

Reservoir	Capacity, Full (million cu. ft.)	Surface Area Full (acres)	Watershed Area (acres)	Uses[1]	Detention Time (days)
Walborn Reservoir				D,R	
Berlin Lake	3,973		61,280	F,D, R, L	
Lake Milton	1,297		67,460	F,D, R, L	
West Branch (Kirwan) Reservoir	3,428		20,015	F,R,L	
Mosquito Creek Reservoir	4,535	7,850	24,220	F,D, R, L	
Meander Creek Reservoir	1,546		20,760	D	
Girard Lake	170.2	250	7,808	R	
Liberty Lake	68.5	104	2,471	R	
Lake Newport				R	
Lake Glacier				R	
McKelvey Lake	135.6	123	5,461	R	
Pine Lake	61.4	472	3,039	R	
Evans Lake	469.6	652	6,672	D,R	
Lake Hamilton	96.8	98	8,327	D,R	

1 – F = flood control; D = drinking water supply; R = recreation; L = low flow augmentation.

<u>Land Use and Land Cover</u>:

Geographic information system (GIS) data for land use and land cover are available for the Mahoning River watershed. These data were gathered by satellite using remote sensing techniques. Land use is shown for the entire Mahoning River watershed in Figure 4-10, and for the focus area of this study in Figure 4-11. The land area devoted to each use is listed in Table 4-9. Land cover for the entire watershed is shown in Figure 4-12, and for the Mosquito Creek and Lower Mahoning River Corridor watersheds in Figure 4-13. Land cover is also summarized in Table 4-10.

It should be noted that there are significant discrepancies between the land use and land cover GIS databases, and that neither has been verified by field surveys. The land use database tends to overestimate the land devoted to agriculture. A significant fraction of the land classified as agricultural is not actively used for farming. Although this land may be owned by farmers, it is actually shrub or forested land. The land cover database tends to overestimate forested land and underestimate urban/suburban land. Suburban areas with large trees on residential lots are often classified as wooded.

In the remainder of this section, the land use and land cover in the Mosquito Creek and Lower Mahoning River Corridor watersheds are discussed in more detail. A representative aerial photo of the Mosquito Creek watershed is shown in Figure 4-14, and for the Lower Mahoning River Corridor in Figure 4-15.

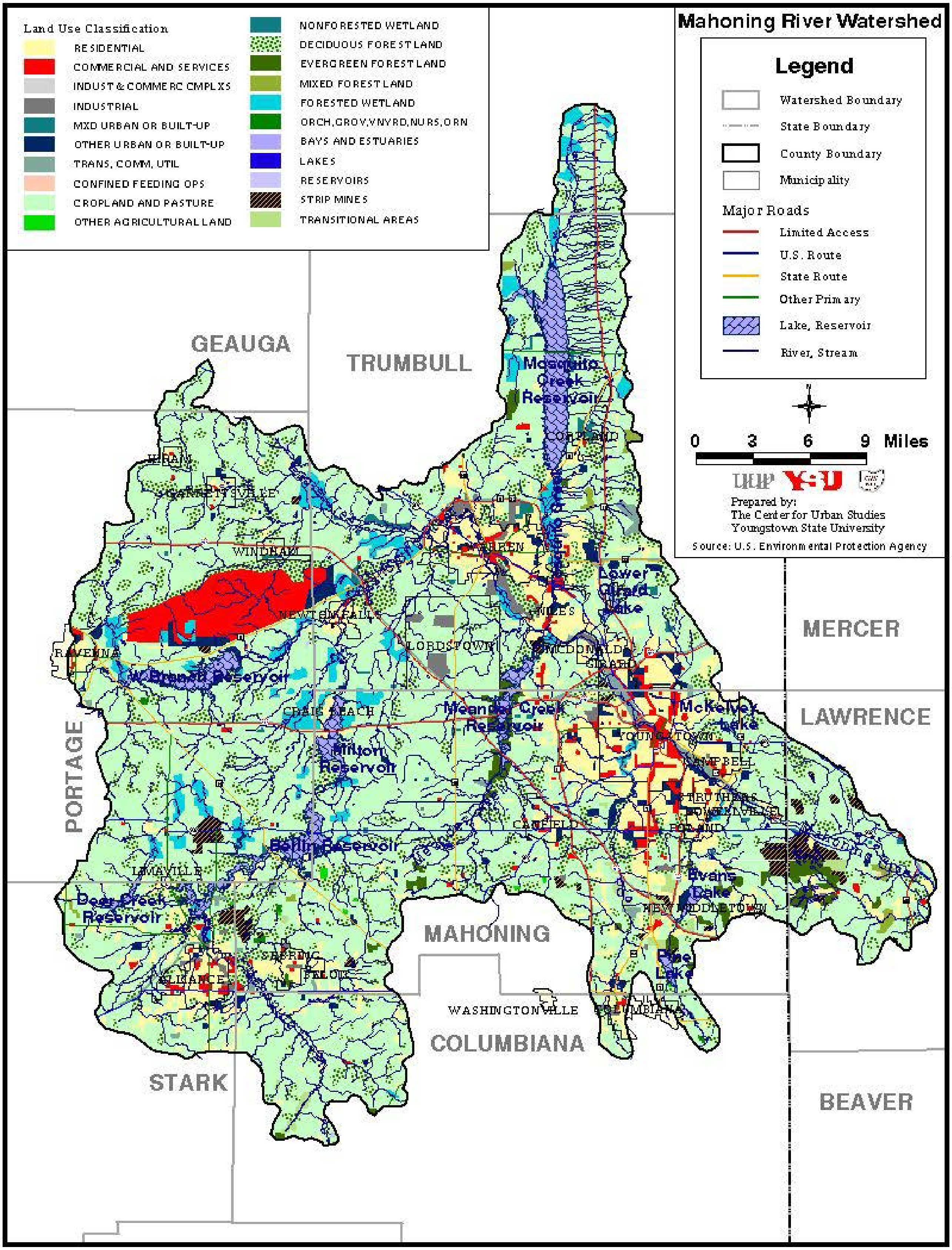

Figure 4-10. Land Use in the Mahoning River Watershed.

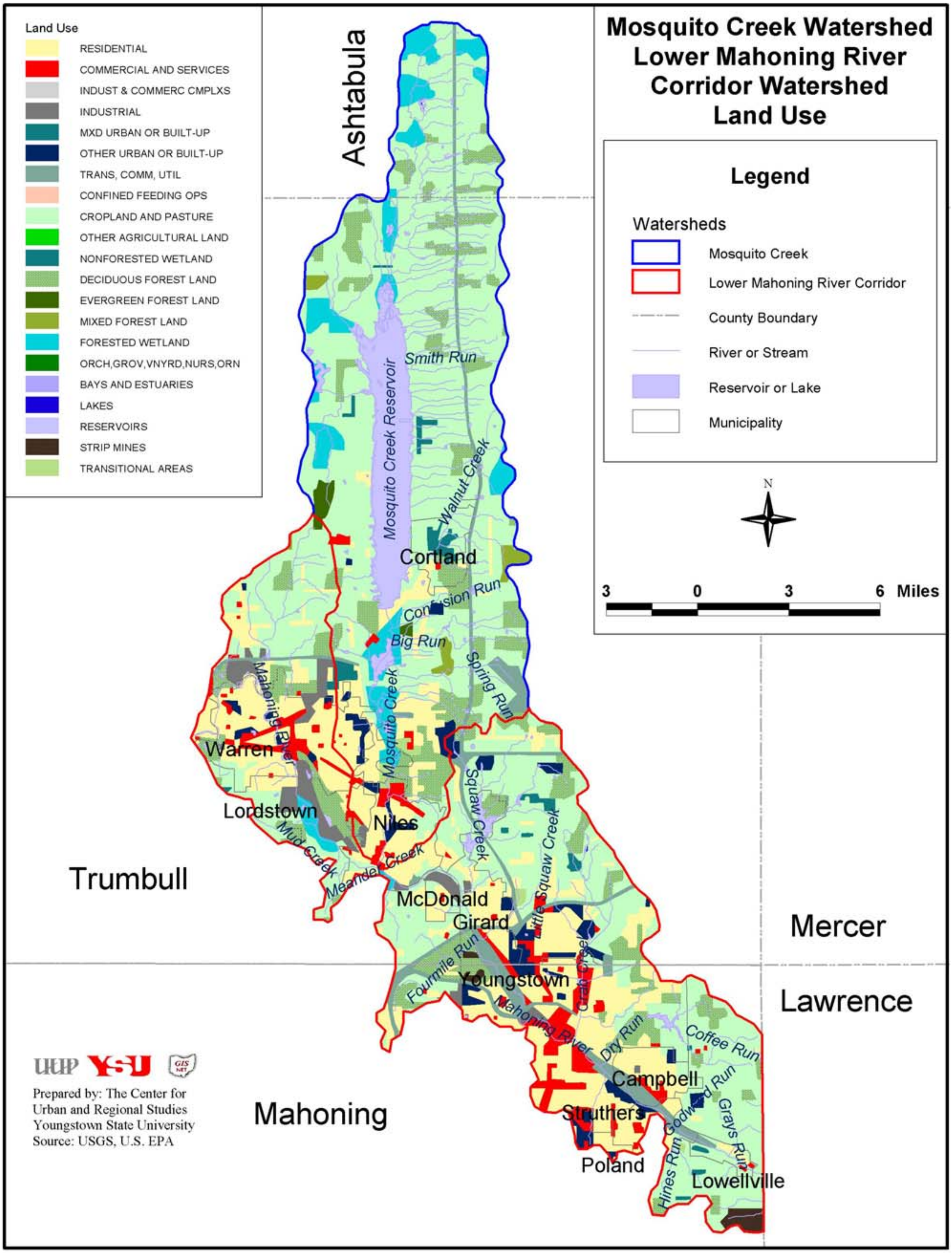

Figure 4-11. Land Use in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

Table 4-9. Land Use (Area in Acres) in the Mahoning River, Mosquito Creek, and Lower Mahoning River Corridor Watersheds.

Type	LMRC	% of W'shed	Mosquito Creek	% of W'shed	Mahoning River	% of W'shed
Residential	26,442	39.43	7,417	9.08	78,772	11.28
Commercial and Services	5,395	8.05	995	1.22	27,237	3.90
Industrial	3,059	4.56	102	0.12	6,002	0.86
Transp., Comm., Utilities	5,109	7.62	2,598	3.18	14,588	2.09
Mixed Urban or Built-Up	654	0.98	1,081	1.32	3,039	0.44
Other Urban or Built-Up	3,318	4.95	1,085	1.33	10,748	1.54
Cropland and Pasture	37,877	56.49	49,422	60.52	410,086	58.73
Other Agricultural Land	0	0.00	0	0.00	840	0.12
Deciduous Forest Land	9,558	14.25	9,628	11.79	81,970	11.74
Evergreen Forest Land	69	0.10	539	0.66	8,288	1.19
Mixed Forest Land	30	0.04	909	1.11	2,003	0.29
Forested Wetland	640	0.95	7,373	9.03	23,694	3.39
Nonforested Wetland	0	0.00	0	0.00	1312	0.19
Lakes	16	0.02	21	0.03	140	0.02
Reservoirs	421	0.63	7,545	9.24	18,227	2.61
Strip Mines	753	1.12	0	0.00	7,838	1.12
Transitional Areas	155	0.23	365	0.45	3,420	0.49
TOTAL	67,054	100.00	81,665	100.00	698,204	100.00

LMRC = Lower Mahoning River Corridor

Table 4-10. Land Cover (Area in Acres) in the Mahoning River, Mosquito Creek, and Lower Mahoning River Corridor Watersheds.

Type	LMRC	% of W'shed	Mosquito Creek	% of W'shed	Mahoning River	% of W'shed
Agriculture/Open Urban Areas	19,302	20.64	33,616	37.74	269,153	38.55
Barren Land	112	0.12	26	0.03	657	0.09
Non Forested Wetlands	4,553	4.87	4,127	4.63	26,238	3.76
Open Water	467	0.50	7,032	7.89	16,993	2.43
Shrub/Scrub Land	3,925	4.20	4,087	4.59	21,043	3.01
Urban Land	15,130	16.18	2,828	3.17	36,214	5.19
Wooded Land	50,008	53.49	37,365	41.94	327,907	46.96
TOTAL	93,496	100.00	89,082	100.00	698,204	100.00

LMRC = Lower Mahoning River Corridor

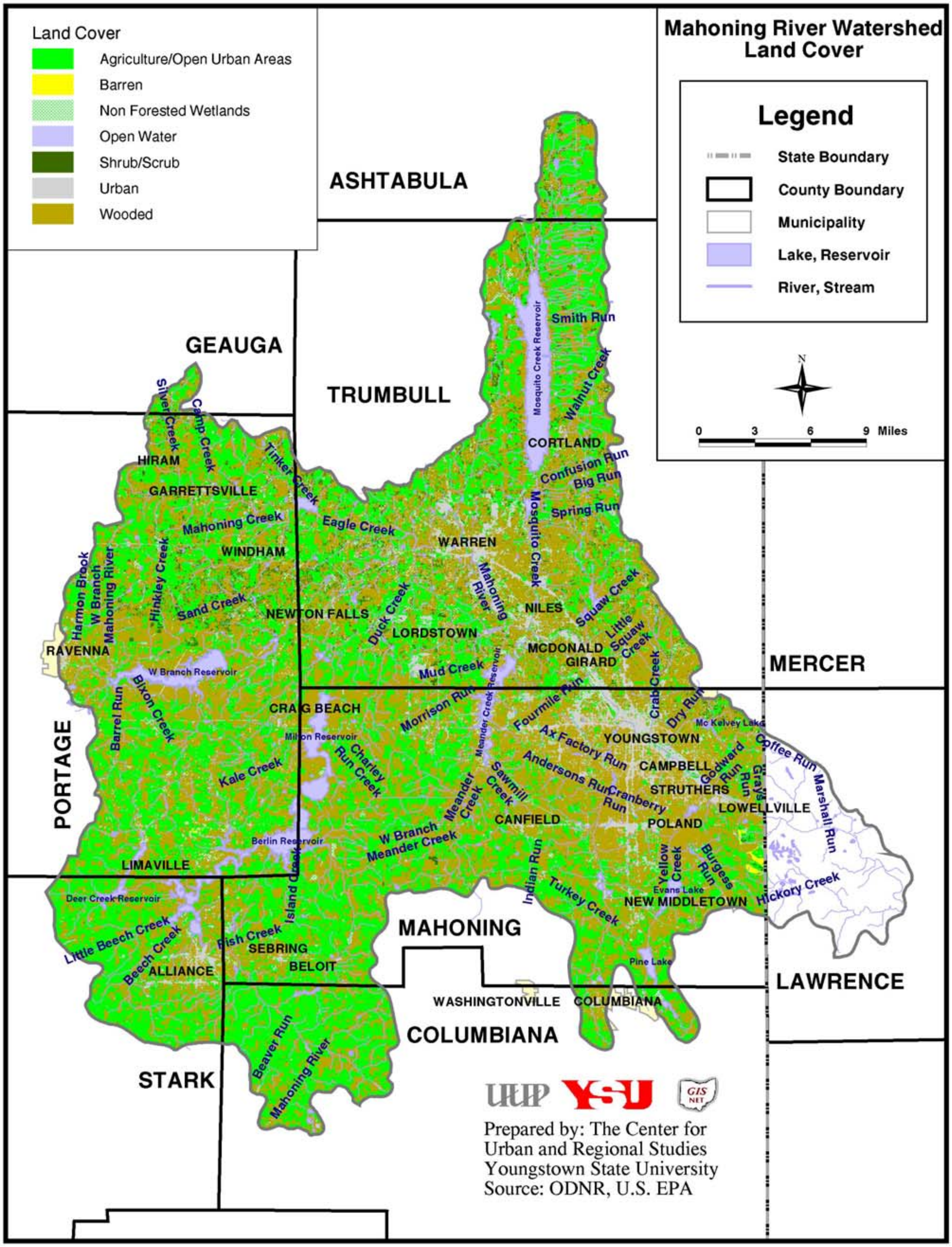

Figure 4-12. Land Cover in the Mahoning River Watershed.

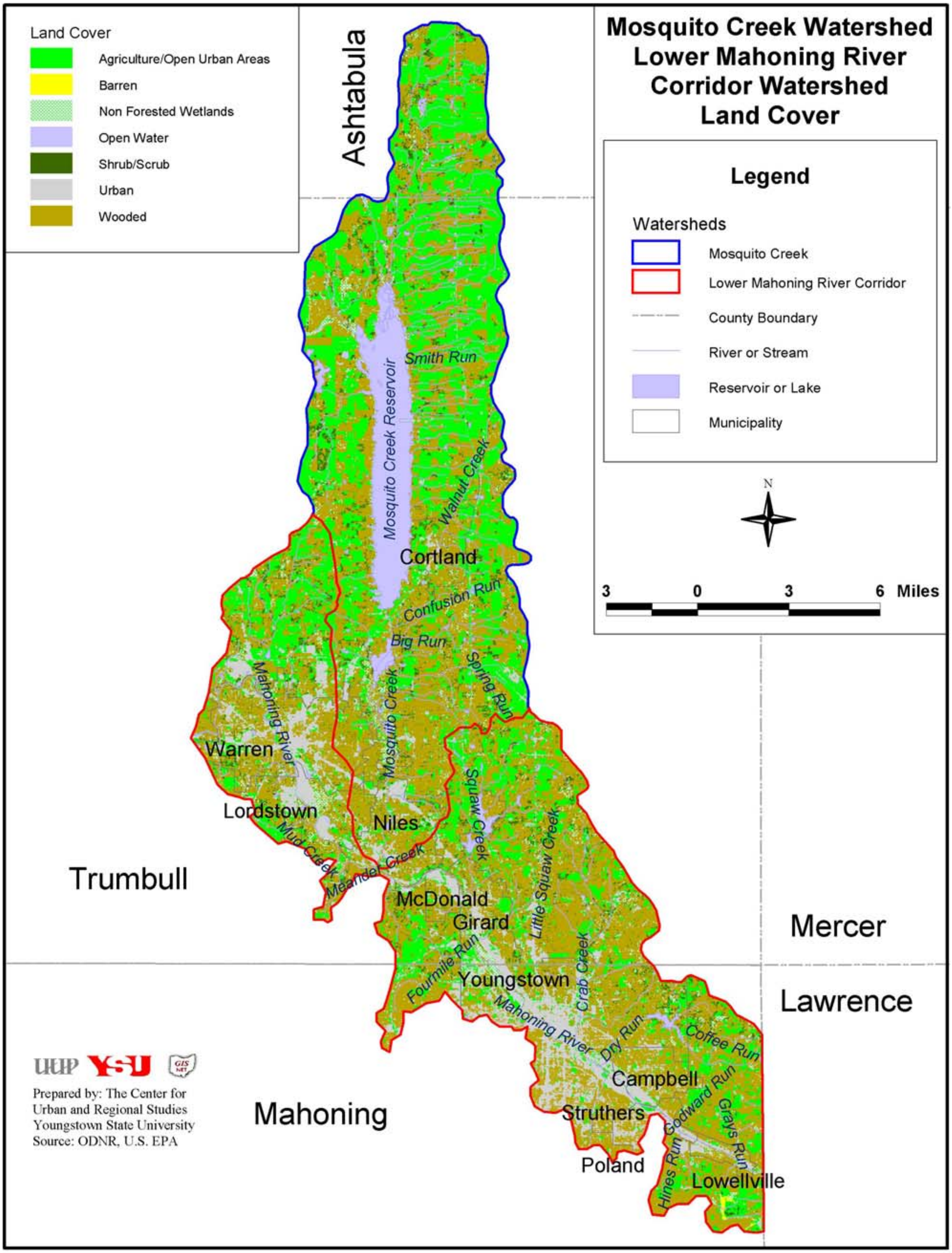

Figure 4-13. Land Cover in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

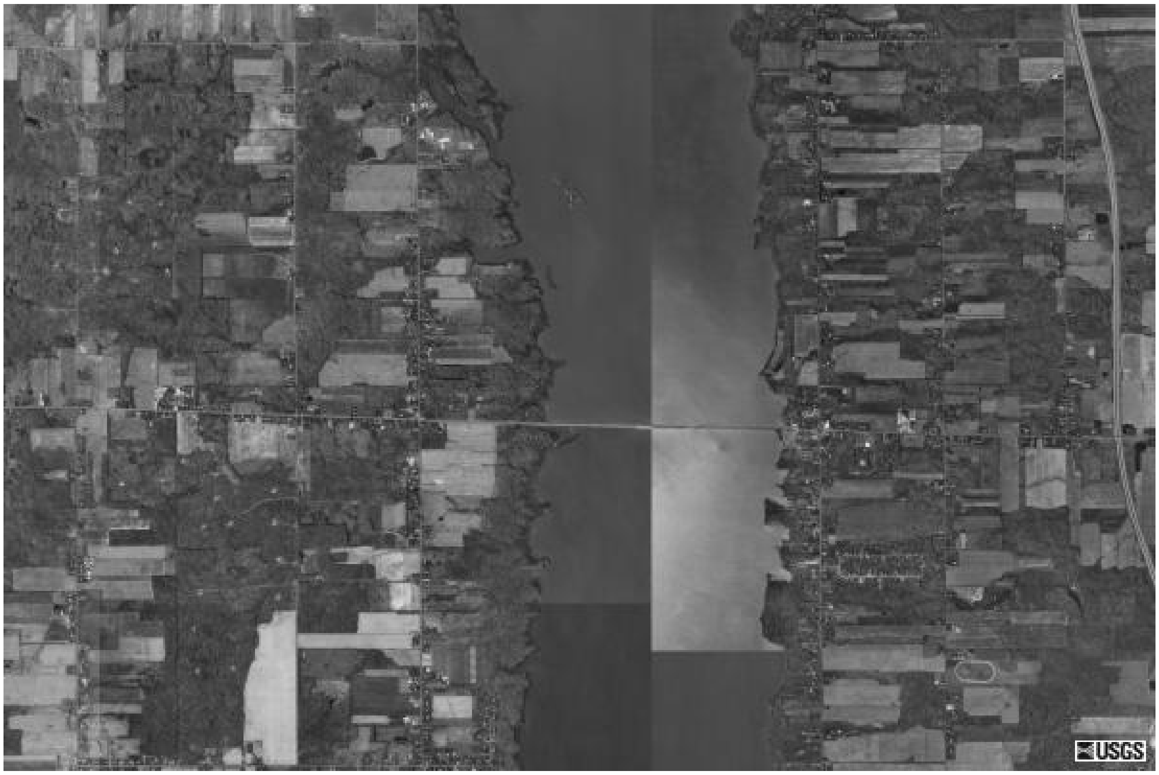

Figure 4-14. 1994 Aerial Photo of a Portion of the Mosquito Creek Watershed (Source: TerraServer).

Figure 4-15. 1994 Aerial Photo of a Portion of the Lower Mahoning River Corridor Watershed (Source: TerraServer).

Urban Land: Urban land makes up only 5-10% of the Mosquito Creek watershed. Most of this lies at the southern tip of the watershed in the Cities of Warren and Niles, and Howland Township. The City of Cortland, which lies just east of the southern end of Mosquito Creek Reservoir, is another significant urban area. Large areas of impervious surfaces are found in shopping malls and plazas near State Route (SR) 422 in Niles, as well as in the Cities of Warren and Niles. These two Cities are served by sanitary sewers, as are the suburb of Howland and the City of Cortland. The remainder of the watershed is unsewered, and is served by home sewage treatment systems.

Urban and residential land use occupies roughly 30-40% of the Lower Mahoning River Corridor watershed. Most of this lies within a short distance (2 miles) of the Mahoning River in the Cities of Warren, Niles, Girard, Youngstown, Campbell, and Struthers. Although the largest contiguous areas of impervious surfaces are now found in suburban shopping districts outside the corridor, these urban areas nevertheless contain thousands of acres of roofs, roads, and parking lots. Virtually all of the land in this watershed is served by sanitary sewers.

Forest Land: Forest lands are found along the Mosquito Creek corridor above the Reservoir and in the Mosquito Creek Wildlife Area. In addition, many areas with hydric soils that are too wet to farm are covered with forest. Past experience with the ODNR land cover database indicates that it overestimates forest land and underestimates shrub land and urban land (Christou, 2003). Nevertheless, a substantial portion (perhaps 40%) of the Mosquito Creek watershed is undeveloped land covered by vegetation ranging from grass and small shrubs to large trees.

Tremendous discrepancy exists between the land use and land cover databases for forest land in the Lower Mahoning River Corridor. The land cover data indicate that 53.5% of the watershed is forested – unquestionably a high estimate. The land use data estimate is about 11%, which is no doubt low; 20-30% is probably a realistic estimate. Much of the forest land in the LMRC watershed lies in the riparian areas adjacent to the Mahoning River and its tributaries.

Agricultural Land: The Mosquito Creek watershed is used extensively for agriculture. Roughly 30-35% of the land in the watershed is actively farmed. Shrub and pasture land that is owned by farmers but not in productive use may account for another 10-15% of the watershed. Only about 10-15% of land in the Lower Mahoning River Corridor watershed is devoted to agriculture. Most of this is in the Squaw Creek watershed north of Girard, and near Lowellville. Nearly all of the agricultural land in these two watersheds lies in Trumbull County. The northern tip of the Mosquito Creek watershed, in Ashtabula County, is also used extensively for farming. Overall, the 2000 Ohio Department of Agriculture Annual Summary for Trumbull County should give a reasonable picture of farming practices in the project area. Selected statistics are presented in Table 4-11; data from 1990 are also included to identify recent trends. It is estimated that agricultural production in the study area equals roughly 50% of that for Trumbull County.

The total land devoted to farms in the area has declined dramatically since the Mosquito Creek Reservoir was built in 1943. The Ohio Department of Agriculture (1998) estimates that there was a 60% decrease in farmland in Trumbull County between 1945 and 1992. Most of this can be attributed to the long-term decline in livestock inventory throughout Ohio.

Table 4-11. Agriculture Statistics for Trumbull County, 1990 and 2000.

Quantity	1990	2000
Total Number of Farms	1020	1000
Total Land in Farms (Acres)	127,000	124,000
Average Farm Size (Acres)	125	124
Corn for Grain (Acres)	22,900	16,600
Soybeans (Acres)	9,200	23,300
Wheat (Acres)	3,700	5,000
Oats (Acres)	4,600	2,400
Hay (Acres)	22,600	19,200
Cattle and Calves (Number)	18,500	13,100
Milk Cows (Number)	7,650	3,600
Hogs and Pigs (Number)	3,000	1,400
Fertilizer Deliveries (Tons)	6,226	3,874

Source: Ohio Department of Agriculture

Crop Production, Tillage, Rotations – In recent years, roughly equal areas of farmland have been devoted to corn, soybeans, and hay production in Trumbull County. The acreage of soybeans has more than doubled since 1990 due to the popularity of soy-based products, while the land devoted to corn and hay has decreased. About 50% of farmers in the Mosquito Creek watershed use a conservation tillage practice known as ridge tillage, where the crop is planted in a narrow ridge and the area between rows is not tilled in most years. The rest of the farmers use “minimal tillage”, where they use a chisel plow in the spring, then disk the soil and plant seeds. Larger farms typically use a three-year crop rotation of corn, soybeans, and a small grain (e.g., wheat, oats)

Livestock, Grazing – The livestock inventory in Trumbull County declined by 38% between 1990 and 2000. This, again, is a continuation of a long-term trend throughout the State of Ohio. About 50% of the farmers in the Mosquito Creek watershed use confined feedlots. Feeding may be indoors or outdoors, or both. These farmers, which include most of the larger herds, purchase feed or grow their own. Ground corn and silage are the most common feeds. The other half of farmers use pasture rotation, allowing animals to graze in pastures and rotating from one to another. Mostly dairy cattle are maintained in the Mosquito Creek watershed. There is one small herd of sheep (10-20 animals), and no significant herds of pigs.

Chemical Use, Irrigation – Fertilizer use for Trumbull County varies from year to year, with no consistent trend evident. Data available from the Ohio Department of Agriculture show total fertilizer deliveries for the County of 7,650 tons for 1990, 1,740 tons for 1994, 6,940 tons for 1996, and 3,874 tons for 2000. In the Mosquito Creek watershed, about 90% of farmers use chemical fertilizer; 10% (mostly the dairy farmers) use both chemical fertilizer and manure. Probably 75% do soil tests to determine application rates.

There are ten manure storage facilities in the Mosquito Creek watershed. They serve herds of from 30 to 150 head of dairy cattle. Most accept both milking parlor wash water and manure, moved by gravity flow and loader, respectively, to a pond near the barn. Ponds are mixed at least once per year, and either pumped to the fields or transported in a tank and spread. Ponds are designed with a one year capacity. The manure is plowed into the soil as soon as possible (when dry enough). A few farms have "dry storage" facilities, receiving manure only with no milking parlor wash water.

In Trumbull County, soils are very fine-grained and normally hold water near the surface for much of the growing season. Thus, there is little need for irrigation. In 1997, only 533 acres (less than 1%) of cropland in the County were irrigated.

Open Water: The Mosquito Creek Reservoir has a surface area of 7,850 acres at the summer pool elevation of 901.4 ft. (USACE, 1994). The Reservoir is a dominant feature of the Mosquito Creek watershed, and plays a critical role in the quality of life and economy of the area. The City of Warren treats 14 million gallons per day (MGD) of water from the reservoir and supplies drinking water to a population of about 80,000 residents, as well as several large industrial users (e.g., WCI Steel, General Motors, Thomas Steel, Delphi Automotive).

Besides the Mahoning River itself, Girard and Liberty Lakes, both on Squaw Creek, and McKelvey Lake, on Dry Run, account for the majority of the open water in the Lower Mahoning River Corridor watershed.

Non-Forested Wetlands: Estimates of the areas of non-forested wetlands from the land cover database (Table 4-10) agree reasonably well with the OWI database (Table 4-4). In the Mosquito Creek watershed, non-forested wetlands are found primarily in three locations – in the Mosquito Creek Wildlife Area; around the perimeter of Mosquito Creek Reservoir; and in the flood plain of lower Mosquito Creek within four miles below the dam. In the Lower Mahoning River Corridor watershed, large areas of non-forested wetlands are shown in Figure 4-13 within the WCI Steel complex in Warren and near the mouth of Fourmile Run. The value of the former area is questionable, since it lies on developed industrial land, in the vicinity of WCI's slag dump.

Barren Land: Barren land includes sandy areas (e.g., beaches), land with exposed rock, strip mines and other surface excavations. The amount of barren land in the Mosquito Creek watershed is insignificant. In the Lower Mahoning River Corridor watershed, a large area of barren land lies in Poland Township near the Ohio-Pennsylvania state line. A limestone quarry owned by ESSROC, Inc. and the Carbon-Limestone solid waste landfill, owned by Browning-Ferris Industries (BFI) of Ohio, Inc., are located in this area.

Protected Lands: Protected lands include public forests and parks, as well as private land in easements and land trusts. In the Mosquito Creek watershed, the two largest protected areas are the Mosquito Creek Wildlife Area and Mosquito Lake State Park. The Mosquito Creek Wildlife Area is an 8,525-acre management area that provides nesting and resting areas for waterfowl, as well as public hunting and bird-watching opportunities. The area is managed by the Ohio Department of Natural Resources (ODNR), Division of Wildlife, and consists of a combination of state and federal lands. Roughly one-half, or slightly less (about 4,000 acres), of the Wildlife Area lies within the Mosquito Creek watershed. The western half lies in the Grand River watershed. A more detailed description of the Mosquito Creek Wildlife Area can be found on the ODNR web site at www.dnr.state.oh.us/wildlife/pdf/pub149.pdf.

Mosquito Lake State Park occupies 3,961 acres of land in Bazetta Township on the western shore of Mosquito Creek Reservoir. The Park provides access to a wide variety of water recreation (e.g., swimming, boating, fishing), winter recreation (e.g., snowmobiling, ice skating, cross country skiing, ice fishing), hiking, camping, picnicking, etc. Facilities are operated by the ODNR and include a 600 ft. beach, 234 camping sites, and five boat launch ramps.

Several hundred acres of land within the riparian corridor and floodplain of lower Mosquito Creek are under public ownership. Trumbull County, Howland Township, and the Mahoning River Consortium have recently added over 350 acres to the protected land in this corridor using grants from the Clean Ohio Fund. The public land and recent acquisitions in this area are presented in Figure 4-16.

Protected lands in the Lower Mahoning River Corridor consist mostly of small urban parks, such as Perkins and Packard Parks in Warren, and Wick and Crandall Parks in Youngstown.

Trends in Land Use: Over the past few decades, residential and commercial development has moved outward from the urban Mahoning River corridor to previously rural areas of Mahoning and Trumbull Counties. This movement accelerated after the decline of the steel industry, and was much more pronounced in Youngstown than in Warren. The population of Youngstown declined dramatically from 168,330 in 1950 to 82,026 in 2000. However, the populations of Mahoning and Trumbull Counties as a whole have only declined slightly from their peaks in 1960. This reflects the movement of residential and commercial development into suburban communities such as Boardman, Poland, and Canfield to the south of Youngstown, Austintown to the west of Youngstown and south of Warren, and Liberty and Howland north of Youngstown and east of Warren.

In the Lower Mahoning River Corridor watershed, the major change in land use over the past 30 years has been the increase in unused or underused urban land. Thousands of acres of “brownfields” (abandoned industrial land) lie along the Mahoning River between Warren and the state line. Many residential neighborhoods in the City of Youngstown contain several vacant lots where homes have been abandoned and razed. With these changes, there has no doubt been a modest decrease in impervious surfaces in this watershed.

In the Mosquito Creek watershed, some former industrial sites along the Mahoning River have been abandoned. In addition, over the past 40 years, much of the commercial activity has moved from the City of Warren to the area near SR 422 in the City of Niles. This, combined with increased residential development in Howland, Liberty, and Cortland, has resulted in a modest decrease in agricultural land, and to a lesser extent, forest land in these areas.

<u>Cultural Resources</u>:

The National Historic Preservation Act (NHPA) requires that agencies undertaking a project, activity, or program carried out with Federal financial assistance, or subject to Federal regulations, evaluate the potential impact on "historic properties”, defined as districts, sites, buildings, structures, and objects eligible for inclusion in the National Register of Historic Places, maintained by the National Park Service. A map of properties within the project area listed on the National

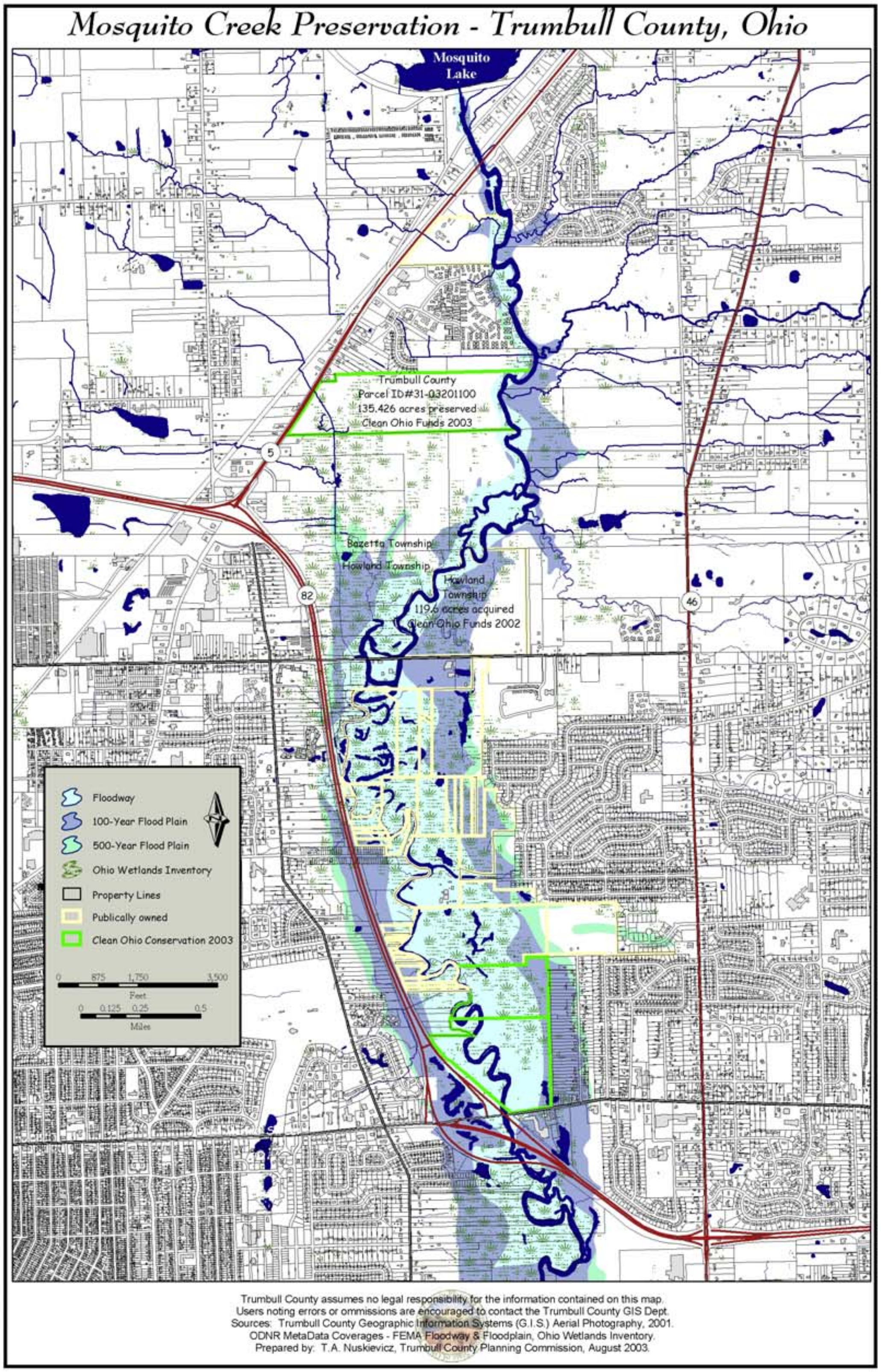

Figure 4-16. Publicly Owned Land in the Lower Mosquito Creek Corridor.

Register is shown in Figure 4-17. In addition, many cemeteries are located in these watersheds. Impacts to these properties should be avoided, or at least minimized, in the planning of any development or environmental conservation projects.

The U.S. Army Corps of Engineers, Pittsburgh District, has conducted cultural resources evaluations in conjunction with studies on Mosquito Creek Reservoir and the Mahoning River.

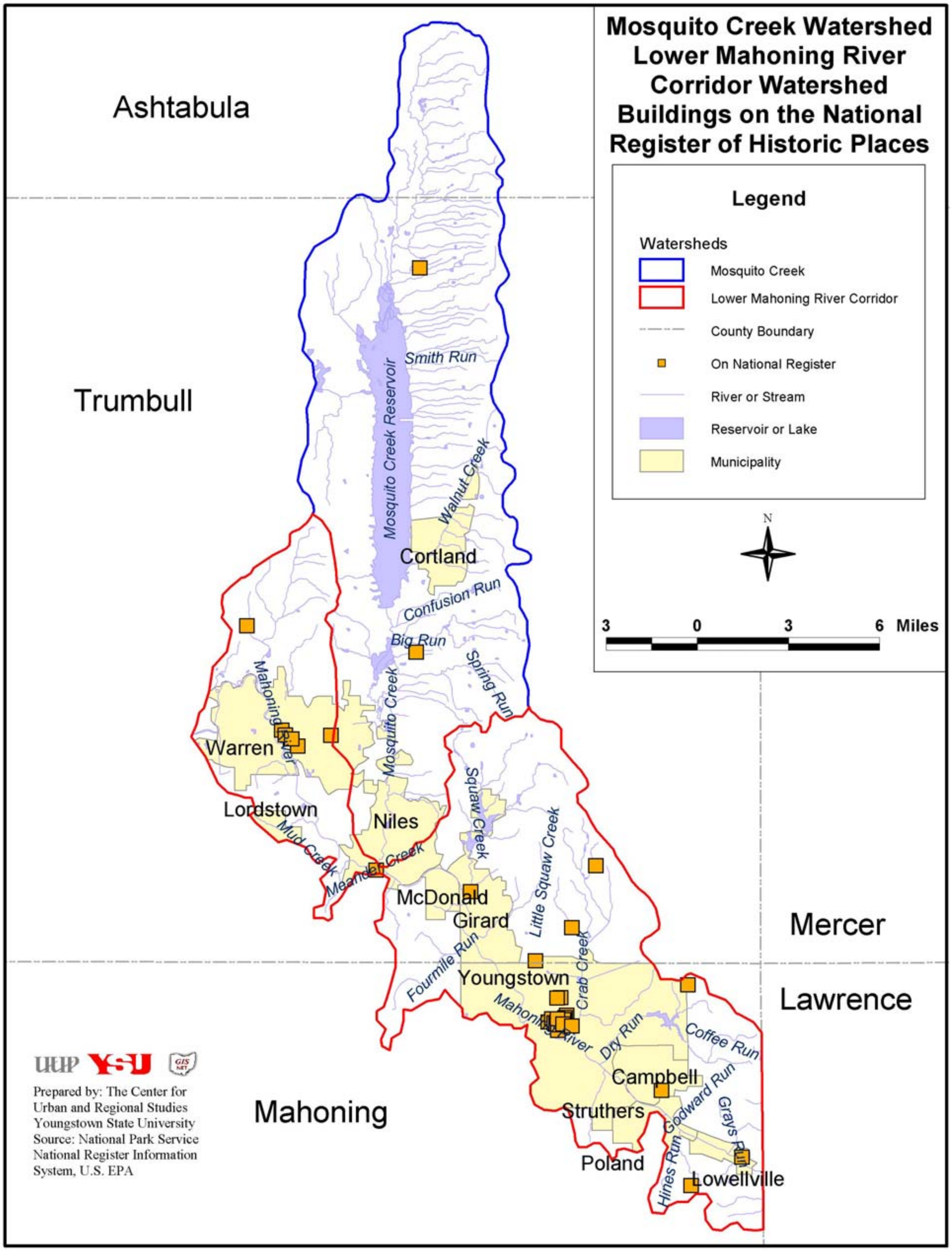

Figure 4-17. Location of Properties on the National Register of Historic Places in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

Previous and Complementary Water Quality Efforts:

Several previous and ongoing projects/efforts in the study area have the potential to contribute to improvements in water quality. These are described in the following sections.

Mahoning River Environmental Dredging/Restoration: In May of 1999, the U.S. Army Corps of Engineers, Pittsburgh District, completed the Mahoning River Environmental Dredging Reconnaissance Study (USACE, 1999). This study was conducted with 100% Federal funding (about $1.5 million), pursuant to Section 312 of the Water Resources Development Act of 1990. Problems related to contaminated sediments in 31 miles of the Lower Mahoning River (between Leavittsburg and the state line) were investigated, along with opportunities for ecosystem restoration. The study concluded that:

1. The project area contains approximately 462,000 cubic yards of contaminated river bottom sediments and 286,000 cubic yards of contaminated sediments along the river banks;
2. Contaminated sediments must be removed in order to achieve the desired improvements in biological communities in the river;
3. Removal of some or all of the nine low head dams in the project area would enhance the biological and aquatic recovery;
4. Removal of the sediments by dredging and subsequent restoration of the river is technically feasible and is in the Federal interest; and
5. The cost of the restoration, including the removal and disposal of contaminated bottom and bank sediments, and removal of dams, would exceed $100 million.

In May, 2002, the Corps of Engineers began the next phase of study – the Feasibility Study – for this project. This phase involves a detailed evaluation of remediation (cleanup) alternatives, as well as the costs and potential economic benefits. The study will result in a recommended plan for restoration of the Lower Mahoning River ecosystem, and an outline of the future design and construction work required. Completion of the Feasibility Study is expected in June, 2005. The $3 million study is funded through a cost-sharing agreement (50% each) between the Corps and the Eastgate Regional Council of Governments, the local project sponsor. The non-Federal share of the project cost was provided through the State of Ohio's Water Resources Restoration Sponsor Program (WRRSP). Several members of the Mahoning River Consortium have served on the Steering Committees for these studies, and Corps of Engineers representatives have served on the Watershed Planning Task Force.

Areawide 208 Planning: The Eastgate Regional Council of Governments is currently updating the Areawide Water Quality Management Plan (AWQMP) for Mahoning and Trumbull Counties, required by Section 208 of the Clean Water Act. The "208 Plan" will delineate service areas for wastewater facilities, nonpoint source controls, and the protection of critical resources within the two counties. The developed portions of the two-county area are divided into 201 Facility Planning Areas (FPAs). All of the Lower Mahoning River Corridor watershed, and the southern half of the Mosquito Creek watershed, lie with these FPAs.

Phase II Storm Water Plans: In December, 1999, USEPA expanded the Clean Water Program by promulgating storm water discharge regulations for urbanized areas. Ohio EPA has been authorized to implement USEPA's regulations requiring small communities (see Tables 2-3 and 2-4) operating municipal separate storm sewer systems (MS4s) to develop a Storm Water Management Program (SWMP) incorporating the following six minimum control measures (Ohio EPA, 2004):

1. **Public Education and Outreach Program** on the impacts of storm water on surface water and possible steps to reduce storm water pollution. The program must be targeted at both the general community and commercial, industrial and institutional dischargers.

2. **Public Involvement and Participation** in developing and implementing the Storm Water Management Plan.

3. **Elimination of Illicit Discharges** to the MS4.

4. **Construction Site Storm Water Runoff Ordinance** that requires the use of appropriate BMPs, pre-construction review of Storm Water Pollution Prevention Plans (SWP3s), site inspections during construction for compliance with the SWP3, and penalties for non-compliance.

5. **Post-Construction Storm Water Management Ordinance** that requires the implementation of structural and non-structural BMPs within new development and redevelopment areas, including assurances of the long-term operation of these BMPs.

6. **Pollution Prevention and Good Housekeeping** for municipal operations such as efforts to reduce storm water pollution from the maintenance of open space, parks and vehicle fleets.

The Best Management Practices (BMPs) chosen must significantly reduce pollutants in urban storm water compared to existing levels in a cost-effective manner. Mahoning and Trumbull Counties are both developed SWMPs for most of the Phase II communities within their boundaries, and submitted them to Ohio EPA by the March 10, 2003 deadline. All MS4s affected by Phase II are required to fully develop and implement their SWMPs by December 8, 2007.

Elimination of Combined Sewer Overflows: The City of Youngstown's 650 mile wastewater collection system has 106 overflow structures discharging to the Mahoning River and its tributaries. The combined sewer system is designed to carry the maximum dry weather flow of sanitary and industrial wastewater, as well as a portion of the runoff from rainfall or snowmelt events. However, when the storm water flow rate is high, the capacity of the sewer is exceeded, and the remainder of the flow is bypassed to the receiving water; this is called a combined sewer overflow (CSOs). In the 1990's, the USEPA developed and began implementation of a CSO Control Policy, which required communities to develop a Long Term Control Plan for CSOs (ms consultants, 2000). In March, 2002, the U.S. Department of Justice, USEPA and the State of Ohio reached an agreement with the City of Youngstown on a long-term plan to reduce the City's CSO discharges. Under the settlement, the City will spend an estimated $12 million on short-term (6 years) improvements and $100 million on long-term (20 years) improvements to eliminate over 800 million gallons per year of wet weather sewage discharges.

Riparian Easements and Purchases: Local watershed groups, including the Mahoning River Consortium, have used state and federal funding programs for several riparian protection projects (easements and land purchases) within the Mahoning River watershed. A summary of the location, date, size, cost, and funding source for several of these projects is presented in Table 4-12.

Table 4-12. Summary of Riparian Protection Projects in the Mahoning River Watershed.

Location/Type	Size (acres)	Year	Cost	Funding Source
Mill Creek (Beaver Twp.) Easement	150	2000		ODNR Nature Works Stream Banking Program
Yellow Creek (Boardman Twp.) Easement	140	2000		ODNR Nature Works Stream Banking Program; Landowner donation
Indian Run (Canfield Twp.) Easement	60	2001		ODNR Nature Works Stream Banking Program
Sawmill Creek (Canfield Twp.) Purchase	150	2001	$1.8 million	Ohio EPA Water Resources Restoration Sponsor Program
Cranberry Run (Boardman Twp.) - Purchase	25	2003	$125,000	Clean Ohio Fund
Mosquito Creek (Howland Twp.) - Purchase	119	2002		Clean Ohio Fund
Mosquito Creek (Howland Twp.) - Purchase	100.5	2003		Clean Ohio Fund
Mosquito Creek (Howland Twp.) - Purchase	135	2003		Clean Ohio Fund

Agricultural BMPs: Riparian filter strips and manure storage facilities have been installed at several locations in the Mosquito Creek watershed. Filter strips are vegetated areas 30-60 feet wide on each side of a stream that intercept runoff and pollutants from adjacent farmland. Manure storage facilities typically provide one year of storage capacity for manure, and possibly also milking parlor wastewater. Storage ponds are mixed at least once per year and the contents delivered to fields by pumps/piping or spreader tanks in the spring. Manure is plowed into the soil as soon as feasible.

In addition, an estimated 20-25 farmers in the Mosquito Creek watershed have participated in USDA's Integrated Pest and Nutrient Management Program. Under this program, farmers receive funding from USDA for three years to conduct soil analyses and maintain records of chemical applications.

Home Sewage Disposal Regulations: Mahoning and Trumbull County Boards of Health regulate the installation and use of home sewage treatment systems (or "septic systems") in the focus area of this project. Due to problems with failing septic systems, regulations have changed substantially in recent years. Both counties have permitted off-lot discharge of wastewater in the past, usually following treatment in a septic tank and aeration tank, but have now eliminated this practice for new systems. Mahoning County Board of Health requires that lots with new septic systems be large enough for both a primary tile field (for leaching of wastewater into the ground) and a replacement tile field. Both counties now require inspection of septic systems prior to the sale of a home. Systems that do not meet current standards must be upgraded before the home can be sold. In Mahoning County, these inspections have shown that 35-40% of home septic systems do not function properly; in Trumbull County, 90% provide inadequate treatment. Required upgrades may include construction of a new tile field (if possible) for on-lot wastewater disposal, or the addition of sand filter, chlorination, and dechlorination processes where off-lot discharge is unavoidable.

WCI Steel, Inc. River Dredging Project: In 2002, WCI Steel, Inc. dredged about 15,000 cubic yards of contaminated sediments from a 1.2 mile reach of the Mahoning River in Warren, under a Special Environmental Project (SEP) agreement with the Ohio EPA. The sediment was removed by hydraulic dredge, and the dredge slurry was dewatered in 14 ft. diameter X 200 ft. long woven fabric "geotubes". The 9.6 million gallons of filtrate water was treated at the City of Warren wastewater treatment plant and 5,140 dry cubic yard (about 4,400 tons) of dry sediment was placed in a conventional solid waste landfill (BFI Carbon Limestone Landfill, in Poland, OH).

Physical Characteristics of Streams and Floodplains:

As part of this study, a limited survey was conducted of the physical condition of streams and floodplains in the project area. Qualitative observations of several characteristics were recorded, including: type of bottom substrate; bank erosion; channel modifications; sinuosity; entrenchment; riparian width and land cover; access to floodplain; floodplain condition; human impacts; and land use on adjacent uplands.

Early Settlement Conditions: The project area lies within the Western Glaciated Allegheny Plateau Ecoregion of Ohio, and was most likely dominated by an elm-ash swamp forest type prior to European settlement (Ohio State University, 2004). Large tracts of land were cleared and drained for agriculture by the middle of the 19th century, particularly in the Mosquito Creek watershed. Rapid industrial and urban development along the Mahoning River began around 1880-1900. Early records indicate that the Mahoning River once supported a healthy fish population and recreation.

Channel Entrenchment and Floodplain Condition/Connectivity: Most streams in the upper portion of the Mosquito Creek watershed have access to a floodplain. A few have been channelized, but entrenchment is generally low. The land surface has not been modified (i.e., no levees or filling of riparian areas); thus, floodplain connectivity remains intact in this area.

In the southern portion of Mosquito Creek watershed, some streams have limited access to the floodplain. Sections of Spring Run, Big Run, and Walnut Creek experience moderate to high entrenchment and have limited access to the floodplain. The total number of miles of entrenched streams has not been determined.

Tributaries to the Lower Mahoning River have limited floodplain access in a few locations. For example, the channel of Little Squaw Creek has been modified in the City of Girard and is highly entrenched and cut off from its natural floodplain. Similar conditions exist on Squaw Creek (near SR 193) and Crab Creek (e.g., in City of Youngstown).

The Lower Mahoning River has access to its floodplain along much of its length, although peak flows are moderated considerably by the network of impoundments within the watershed. In the vicinity of many steel mills, fill was placed to create high banks along the river and prevent flooding. In these locations, the river no longer has access to its floodplain.

Forested Riparian Buffers: No detailed survey has been performed to determine the number of miles of forested riparian buffers in the project area. In the upper Mosquito Creek watershed, roughly half of the streams locations inspected in the field survey had forested riparian buffers 50 ft. or more in width. Wooded riparian corridors are also common along tributary streams in the lower Mosquito Creek watershed and the Lower Mahoning River Corridor, but widths are generally less than 100 ft., and often less than 50 ft. Extensive forested wetlands as much as 4,000 ft. wide are found along Mosquito Creek, both above and below Mosquito Creek Reservoir. Much of the riparian corridor along the Lower Mahoning River is forested as well, since development along the river is limited by the presence of railroad tracks. The width of riparian forest varies considerably, but is generally less than 200 ft.

Permanent Protection of Stream Corridors: Only a few stream miles are permanently protected in the project area. The Mosquito Creek Wildlife Area includes a short reach of Mosquito Creek just north of Mosquito Creek Reservoir, and a portion of the northwest shoreline of the reservoir. The federal government (through the U.S. Army Corps of Engineers) owns Mosquito Creek reservoir and land around the shoreline. While a forest buffer is maintained around most of the reservoir, the width varies and other land uses (e.g., agriculture, recreation) are permitted as well. Several thousand feet of Mosquito Creek are protected through public ownership (Village of Howland and Trumbull Co.) between the dam and North River Rd.

Land along the Lower Mahoning River is still mostly under private ownership (e.g., railroad and steel companies). However, cities and community development organizations have acquired a significant amount of land formerly occupied by steel companies. Little, if any, of this land is permanently protected for environmental conservation at this time. Packard and Perkins Parks in the City of Warren provide some degree of permanent protection for about two miles of the eastern bank of the Mahoning River. The park land is mostly covered with mowed grass and scattered trees, and is used for a variety of recreation, including hiking, picnicking, softball, and concerts.

Natural Stream Channels: For the most part, natural stream channels exist in the focus area only where flooding and/or topography prohibits other land uses. Examples include the large wetland areas along Mosquito Creek both above and below Mosquito Creek Reservoir.

Channel Modifications and Channelization: Several streams in the focus area have been modified or channelized. Many small tributaries to the upper portion of Mosquito Creek have been channelized to facilitate agriculture. Walnut Creek is channelized for one mile or more along SR 5 north of Cortland. Other tributaries to Mosquito Creek are channelized for short distances (less than 500 ft.), including Spring Run, Confusion Run, and the south branch of Big Run.

In the Lower Mahoning River Corridor watershed, Crab Creek is confined to a straight trapezoidal concrete channel from the SR 7/62 bridge to the Mahoning River, a distance of about two miles. Crab Creek is also partially confined (on the east side) by railroad tracks for a distance of 1.5-2.0 miles in Liberty Township and the City of Youngstown. Little Squaw Creek is channelized for about ¾ mile near SR 422 in the City of Girard, and also in Liberty Memorial Park. Even the channel of the Lower Mahoning River has been straightened and deepened in a few locations by placement of fill along its banks.

The total miles of modified stream channels in the project area is not known. However, based on the preliminary field survey, the total most likely exceeds ten miles.

Dams: There are several dams located on streams in the focus area. The largest impoundment is Mosquito Creek Reservoir (7800 acres). A few small farm or residential ponds are formed by dams on tributaries to Mosquito Creek. As mentioned previously, there are nine low head dams along the Lower Mahoning River. These have a significant negative impact on aquatic habitat. Other impoundments on tributaries to the Lower Mahoning River form Girard Lake on Squaw Creek and McKelvey Lake on Dry Run.

Livestock Access to Streams: Animals have unrestricted access to streams as several locations in the focus area, mostly in the Mosquito Creek watershed. The largest herds observed during the field survey have access to upper Mosquito Creek near Windsor Rd. (Colebrook Twp., Ashtabula Co.) and SR 46 (80 and 30 head, respectively). About 20 cows have direct access to an unnamed tributary in Mecca Twp., Trumbull Co. A few other locations, mostly in the northern portion of the watershed, provide unrestricted stream access for small numbers (less than ten) of animals.

Eroding Banks: Stream bank erosion is evident throughout the project area, and no doubt makes a significant contribution to suspended solids loading in both the Mosquito Creek and Lower Mahoning River Corridor watersheds. Tributaries to the headwaters of Mosquito Creek are generally small and stream flow has limited erosive power; thus, only slight bank erosion is seen is this area. More severe bank erosion is seen on the main branch of Mosquito Creek, for example near SR 46 in Greene Township. The larger tributaries (Walnut Creek, Spring Run, Big Run, and Confusion Run) in the southern portion of Mosquito Creek watershed experience slight to moderate bank erosion at most of the locations visited during the field survey. Severe bank erosion was noted on Spring Run at SR 46 and on Walnut Run at Bradley-Brownlee Rd.

In the Lower Mahoning River Corridor watershed, moderate bank erosion occurs at some locations on Squaw Creek (e.g., at Smith Stewart Rd.), Little Squaw Creek (e.g., near SR 193), and Crab Creek (e.g., near Warner Rd., SR 304, and Logan Gate). Severe bank erosion occurs on Little Squaw Creek at Liberty Memorial Park in Girard. In addition, since Liberty Lake was drained, the accumulated bottom sediment is now exposed to the force of flowing water for the first time, and is eroding rapidly, resulting in extremely high turbidity in Squaw Creek below the former lake. This problem requires immediate attention. No survey of bank erosion has been performed on the main stem of the Mahoning River. However, bank erosion is believed to be low in most locations due to the moderating effect of the reservoir network on peak flow rates, and the presence of a forested riparian buffer.

Riparian Levees: Fill has been placed along the banks of streams in the project area in order to prevent flooding of the adjacent property. The primary example of this is along the Mahoning River at the site of steel mills. A riparian levee was also constructed along a short segment of Spring Run west of SR 46 to protect a residential development.

Status and Trends: Over the past 50 years, residential and commercial development has shifted from the urban centers of Warren and Youngstown to suburban areas. This has resulted in a substantial decline in population, business, and industry in the Lower Mahoning River Corridor. Many commercial buildings in these cities (particularly Youngstown) have been unoccupied or underutilized for decades; residential neighborhoods contain numerous vacant lots and abandoned houses; and large tracts of "brownfield" property formerly occupied by steel mills remain vacant as well. While cities, community development organizations and environmental groups have tried to promoted the reuse of these urban areas and discourage suburban sprawl, these efforts have not been very successful to date. It is anticipated that redevelopment of the urban corridor of the Mahoning River will occur at a slow pace in the future.

The southern portion of Mosquito Creek watershed (particularly Howland and Bazetta Townships) has experienced the suburban sprawl mentioned above. The area near Eastwood Mall on SR 422 in Niles, and northward along SR 46 has seen rapid expansion of retail stores in the past 10-15 years. New housing developments have been built at several locations in Howland and Bazetta Townships. Unfortunately, much of the development surrounds the Mosquito Creek corridor and associated wetlands. Moderate development pressure is expected to continue in this area despite the fact that the population of Trumbull County as a whole is declining. Several transportation improvement projects are either ongoing or proposed to reduce traffic congestion in the area. The improvement of roads and extension of sewers in Howland and Bazetta Townships has the potential to promote even further residential and commercial development in environmentally sensitive areas surrounding Mosquito Creek.

<u>Water Resource Quality</u>:

Data from several sources were compiled and reviewed to evaluate the quality of water resources in the study area. These sources include federal (e.g., U.S. Army Corps of Engineers, USGS), state (e.g., Ohio EPA), and local (e.g., Trumbull County Board of Health) organizations. Data on the Lower Mahoning River are abundant, and the focus of this planning effort was on compiling and interpreting the data. Data on the Mosquito Creek watershed are sparse; therefore, a limited monitoring program was conducted as part of this study, with a focus on estimating nonpoint nutrient and sediment loading rates from the watershed.

Use Attainment: As explained in Chapter 1, the Ohio EPA evaluates the attainment of the designated aquatic use for a water body using three biological indices – the Index of Biotic Integrity (IBI), the Modified Index of Well-Being (MIwb), and the Invertebrate Community Index (ICI). The warmwater habitat (WWH) criteria (i.e., minimum scores for attainment) are:

IBI – Headwaters:	40
IBI – Wading:	38
IBI – Boat:	40
MIwb – Wading:	7.9
MIwb – Boat:	8.7
ICI:	34

"Full" attainment means that all measured biological indices meet the criteria; "Partial" attainment means that at least one criterion is met, but at least one is not; and "Non" attainment means that none of the measured indices meet the criteria.

Ohio EPA conducted a "Biological and Water Quality Study of the Mahoning River Basin" in 1994, in which attainment status was determined at 42 sampling sites on the Mahoning River mainstem and 25 sites on Mahoning River tributaries (Ohio EPA, 1996). On the Mahoning River mainstem, all sites between WCI Steel in Warren and the confluence with the Beaver River in New Castle, PA (RM 35.4 to RM 0.2) were in non-attainment, and biological communities were reported to be in poor to very poor condition. Between the Leavittsburg dam and Perkins Park in Warren (RM 45.5 to RM 38.2), the results were mixed. Two sites showed non-attainment, three were in partial attainment, and two in full attainment (although with incomplete data). While conditions are significantly better in this reach of the river, particularly for macroinvertebrates (ICI), no more than one index clearly exceeded the WWH criteria at any given site. Based on the 1994 study, Ohio EPA concluded that 0.3 river miles of the lower Mahoning River mainstem were in full attainment, 5.8 miles in partial attainment, and 41.3 miles in non-attainment (29.8 miles in OH and 11.5 miles in PA). Several small tributaries streams in the Lower Mahoning River Corridor watershed are also designated as WWH; their status is summarized in the next section (Table 4-14).

During the 1994 study, Ohio EPA sampled only one site in the Mosquito Creek watershed. This site was in Mosquito Creek, 0.6-1.0 mile above the confluence with the Mahoning River, and was found to be in non-attainment.

Additional data on the macroinvertebrate populations in streams of the study area are available from the Trumbull County Stream Quality Monitoring Program (or "Stream Watch"), conducted by the Trumbull County Board of Health since 2001. Macroinvertebrates were sampled three times per year (spring, summer, and fall) at four sites in the Mosquito Creek watershed (two locations on Mosquito Creek in Niles; Walnut Run in Bazetta Twp.; and Spring Run in Howland) and five sites in the Lower Mahoning River watershed (two locations on Squaw Creek in Girard; two locations on Little Squaw Creek – in Liberty and Girard; and one location on Crab Creek in Liberty). Sampling and index calculations were performed using a method developed by the Ohio Stream Quality Monitoring Project (http://www.dnr.state.oh.us/dnap/monitor/default.htm). Organisms were collected by kick-seine and the number of taxa present from three lists – pollution sensitive, pollution intermediate, and pollution tolerant – were determined. Index values were calculated from the equation:

$$Index\ Value = (PS\ X\ 3) + (PI\ X\ 2) + (PT\ X\ 1)$$

where: PS = number of taxa present from pollution sensitive list;
PI = number of taxa present from pollution intermediate list;
PT = number of taxa present from pollution tolerant list.

To ensure consistency, three replicate measurements were made for each location and date. Further details are available at http://www.health.co.trumbull.oh.us/Streamwatch/Streamwatch.htm.

Summary statistics on the Index Values obtained for these sites are presented in Table 4-13. Index values of 23 and above are considered excellent. Although a few individual values reached 23 or higher, none of the mean values fell in this range. Scores of 17-22 are considered good stream quality. Average values for Mosquito Creek B, Squaw Creek B, and Little Squaw Creek B fell at the low end of this range, while Crab Creek in Liberty Twp. fell at the upper end of the range. Mosquito Creek A, Walnut Run, Spring Run, and Little Squaw Creek A showed fair (substandard) stream quality, reflected by mean scores of 11-16. Squaw Creek A showed poor quality (score of 10 or less).

The correlation between the macroinvertebrate index values and attainment status for WWH criteria is uncertain. It is possible that Crab Creek in Liberty Twp. is in full, or at least partial, attainment. However, all of the other streams appear to have moderately to severely impaired benthic communities.

Table 4-13. Summary of Macroinvertebrate Index Values Obtained by the Trumbull County Stream Quality Monitoring Program, 2001-03.

Site	Number	Range	Mean	Standard Deviation	Stream Rating[1]
Mosquito Creek A (Niles)	12	9-19	12.42	3.23	Fair
Mosquito Creek B (Niles)	9	9-22	17.22	4.68	Good
Walnut Run (Bazetta Twp.)	13	11-23	16.15	3.65	Fair
Spring Run (Howland)	12	9-20	15.58	3.12	Fair
Squaw Creek A (Girard)	12	3-15	9.67	3.94	Poor
Squaw Creek B (Girard)	12	13-23	17.25	3.14	Good
Little Squaw Cr. A (Liberty Twp.)	8	12-18	15.12	2.17	Fair
Little Squaw Cr. B (Girard)	6	7-21	16.67	5.39	Good
Crab Creek (Liberty Twp.)	7	18-26	21.43	3.10	Good

1 – Based on mean index value.

Other Water Quality Data:

- *Ohio EPA Monthly Monitoring:*

The Ohio EPA collects grab samples monthly from the Mahoning River at Leavittsburg and Lowellville, and analyzes them for a number of chemical water quality parameters. These data are stored in the STORET database. As part of this study, the STORET data collected for Leavittsburg and Lowellville between 1990 and 2001 (12 years) were obtained and analyzed. A summary is presented in Table 4-14.

Table 4-14. Summary of Water Quality Data Collected by Ohio EPA for the Mahoning River at Leavittsburg and Lowellville, 1990-2001 (STORET database).

		Leavittsburg Station ID - 602280			**Lowellville Station ID - 602300**		
Parameter	**Units**	**Mean**	**Standard Deviation**	**No. of Samples**	**Mean**	**Standard Deviation**	**No. of Samples**
BOD 5-DAY	mg/L	2.10	0.55	46	2.87	1.17	72
RESIDUE, TOTAL NFLT	mg/L	18.51	17.88	148	21.64	22.72	149
RESIDUE DISS-180 C	mg/L	264.12	55.79	146	330.46	68.34	147
PH LAB SU		7.56	0.32	110	7.58	0.26	110
NO2&NO3-N TOTAL	mg/L	0.67	0.45	147	1.83	0.66	146
NH3+NH4-N TOTAL	mg/L	0.10	0.08	147	0.25	0.16	146
TOT KJEL N	mg/L	0.53	0.19	144	0.87	0.32	146
PHOS-TOT P	mg/L	0.11	0.10	145	0.23	0.09	145
CADMIUM CD,TOT	µg/L	0.20	0.00	151	0.21	0.05	152
CHROMIUM CR,TOT	µg/L	30.03	0.34	141	30.17	1.23	141
COPPER CU,TOT	µg/L	9.64	2.14	153	10.12	2.33	152
MERCURY HG,TOTAL	µg/L	0.20	0.00	4	0.20	0.00	4
NICKEL NI,TOTAL	µg/L	40.00	0.00	120	40.13	1.04	124
LEAD PB,TOT	µg/L	2.62	3.02	153	6.19	4.64	152
ZINC ZN,TOT	µg/L	16.81	12.99	153	51.88	220.09	152
CYANIDE CN-TOT	mg/L				1.31	2.22	46
PHENOLS TOTAL	µg/L				13.58	4.79	43

- *NPDES Monitoring:*

Permitted wastewater dischargers must monitor water quality in the receiving stream both upstream and downstream of their discharge, and report these data to Ohio EPA. As part of this study, the monitoring results reported by all major dischargers in the Mahoning River watershed were obtained from Ohio EPA for 2000 and 2001. Ahmad (2004) analyzed the data and prepared summary tables and graphs. Data from the Mosquito Creek Waste Water Treatment Plant (WWTP) are summarized in Table 4-15. Another example is shown in Figure 4-17 for dissolved oxygen (DO) in the Mahoning River. This graph indicates that oxygen levels are satisfactory in the Mahoning River. However, the data shown are mean concentrations. During the summer, DO levels occasionally fail to meet the WWH criteria in the lower Mahoning River. In addition, during the 1994 Ohio EPA survey, WWH "exceedences" (i.e., violations of the criteria) were noted for fecal coliform bacteria, water temperature, aldrin (an insecticide banned by USEPA since 1987), and total lead (Ohio EPA, 1996).

- *Aqua Ohio, Inc. Reservoirs:*

Routine water quality monitoring was conducted by Youngstown State University from 1985 to 1990 on six reservoirs (Pine, Evans, Hamilton, Girard, Liberty, and McKelvey) under the management of Ohio Water Service (now Aqua Ohio, Inc.). Using these data, Farran (1990) calculated 95% confidence limits for Trophic State Index (TSI) values based on three measures of water quality – chlorophyll a and total phosphorus concentrations, and Secchi disk transparency. The results are presented in Table 4-16. In general, lakes with TSI < 30 are oligotrophic (low productivity); those with 30 ≤ TSI ≤ 50 are mesotrophic (moderate productivity); and those with

Table 4-15. Summary of In-Stream NPDES Water Quality Monitoring Data Reported to Ohio EPA by Mosquito Creek Wastewater Treatment Plant in 2000 and 2001.

Parameter	Units	Upstream of Discharge			Downstream of Discharge		
		Mean	Std. Dev.	N[1]	Mean[2]	St. Dev.[2]	N[1]
Temperature	C	12.5	7.9	22	12.8	7.5	23
pH	S.U.	7.36	0.11	22	7.4	0.13	23
Ammonia N	mg/L	0.20	0.11	22	0.28	0.13	23
Fecal coliforms	#/100 mL	337	204	12	367	249	12
Total hardness	mg/L CaCO3				124	16.9	23
Total zinc	µg/L				19.7	10.8	23
Total chromium	µg/L				0.18-1.2	0.50-0.87	22
Total nickel	µg/L				4.0	9.9	22
Total lead	µg/L				3.7-4.3	8.1-8.3	22
Total copper	µg/L				4.2	2.3	22
Total cadmium	µg/L				0.036-0.21	0.10-0.13	22

1 - N = Number of measurements
2 – Ranges reflect uncertainty due to undetectable concentrations.

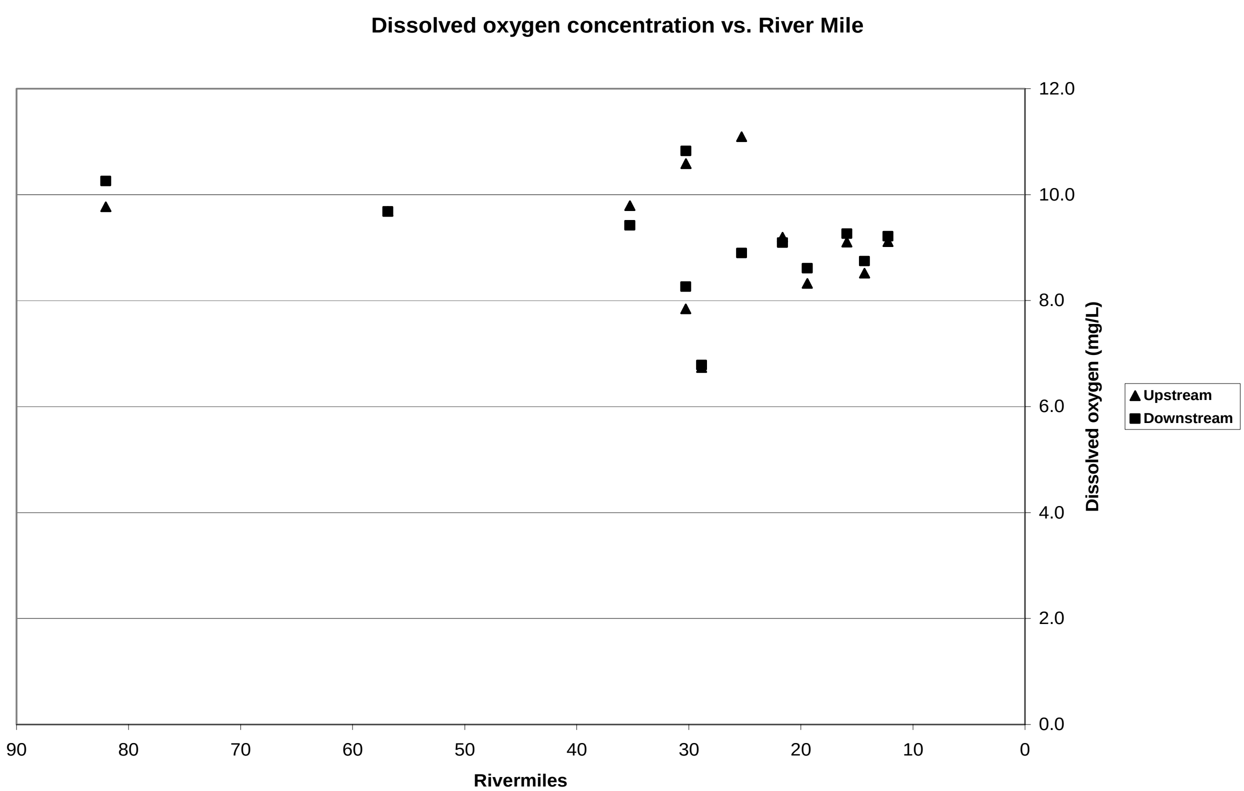

Figure 4-18. Mean Dissolved Oxygen Concentration for 2000 and 2001 Vs. River Mile in the Mahoning River, from NPDES Monitoring Data Upstream and Downstream Of WWTP Discharges (from Ahmad, 2004).

Table 4-16. 95% Confidence Limits of Trophic State Index (TSI) Values for Six Lakes Managed by Aqua America, Inc. (from Farran, 1990).

Lake	TSI (Chlorophyll a)	TSI (Total P)	TSI (Secchi depth)
McKelvey	49.4 ± 10.2	42.0 ± 13.2	45.8 ± 6.6
Evans	52.9 ±15.2	50.2 ± 8.7	50.6 ± 9.2
Hamilton	57.9 ± 13.2	54.3 ± 8.3	53.5 ± 10.0
Liberty	59.3 ± 15.2	56.5 ± 6.0	53.1 ± 10.7
Girard	61.8 ±18.7	61.6 ± 7.9	56.0 ± 10.8
Pine	61.2 ± 12.8	59.6 ± 12.7	63.2 ± 9.1

TSI > 50 are eutrophic (high productivity) (Wetzel, 2001). All of the reservoirs, except perhaps McKelvey, would be classified as eutrophic based on these indices. Lake McKelvey falls in the mesotrophic range.

- *YSU Study of Mosquito Creek and Tributaries:*

As part of this watershed action plan development, a program of water sampling and analysis was conducted by Youngstown State University (YSU) in the Mosquito Creek watershed during the winter and spring (January to May) of 2004 (Yahaya, 2004). The goal was to develop preliminary estimates of nonpoint source nutrient (nitrogen and phosphorus) and sediment loading rates. Samples were collected from twelve locations, shown in Figure 4-19 and described in Table 4-17. In general, flow (or discharge) was measured in the field using a Global velocity meter, and samples were collected for laboratory analyses of turbidity, pH, suspended solids, nitrate nitrogen, ammonia nitrogen, soluble reactive phosphorus, and total phosphorus. The water quality data obtained are summarized in Table 4-17. Loading rates are discussed in the section on Nonpoint Sources.

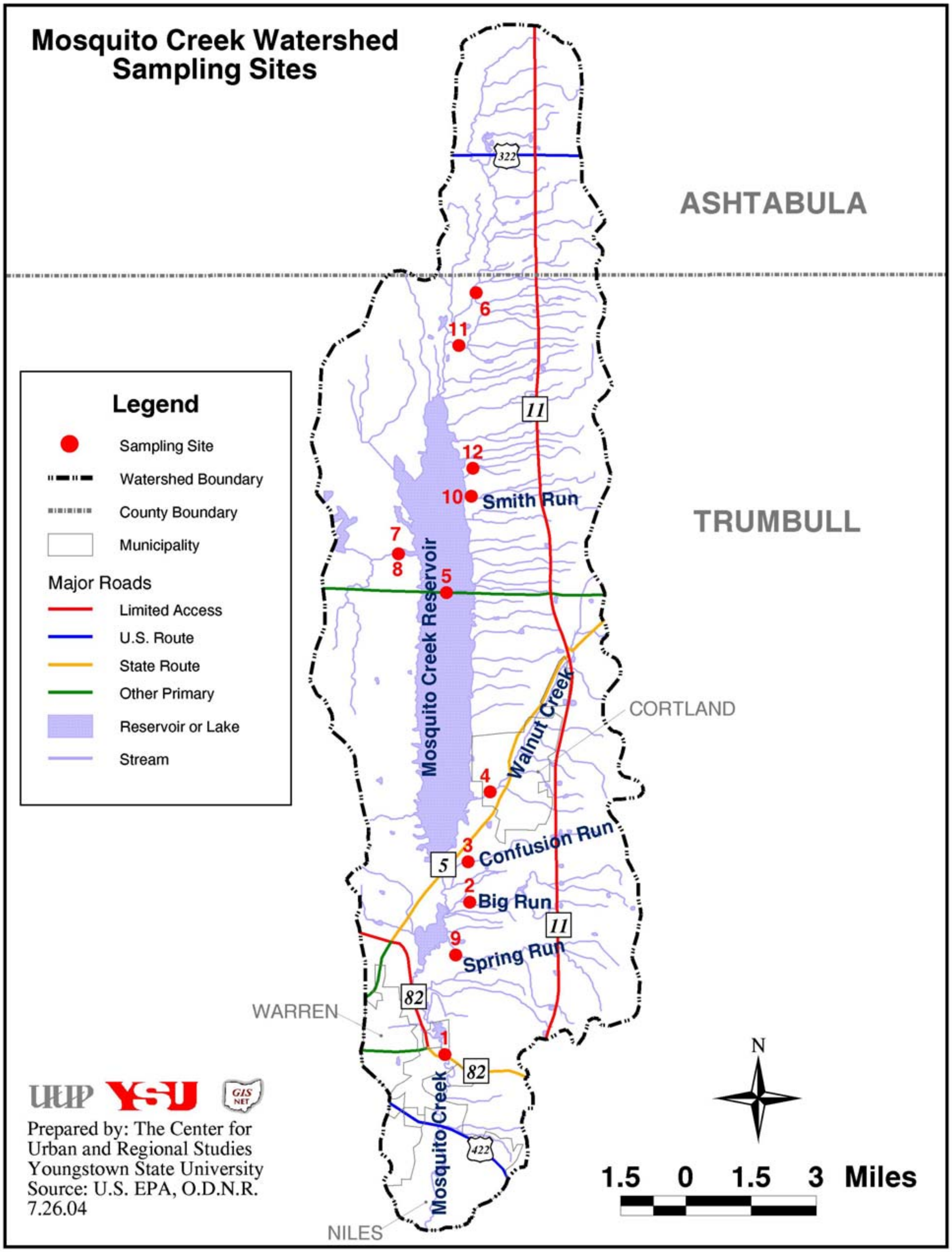

Figure 4-19. Map of Sampling Locations for Water Quality Survey of Mosquito Creek Watershed by Yahaya (2004).

Table 4-17. Summary of 2004 Water Quality Monitoring Results for the Mosquito Creek Watershed Performed by Youngstown State University. Mean Concentrations with Number of Measurements in Parentheses (from Yahaya, 2004).

Site No.	Stream	Location	Flow cfs	Turbidity NTU	pH	SS mg/L	NO_3-N µg/L	NH_3-N µg/L	SRP µg/L	TP µg/L
1	Lower Mosquito Cr.	Warren-Sharon Rd.		11.8 (4)	7.27 (4)	9.7 (8)	372 (8)	157 (8)	33.4 (8)	84.1 (8)
2	Big Run	McCleary-Jacoby Rd.	17.4 (5)	9.0 (4)	7.70 (4)	8.0 (8)	229 (8)	120 (8)	17.1 (8)	49.2 (7)
3	Confusion Run	McCleary-Jacoby Rd.	7.2 (6)	13.3 (4)	7.90 (4)	6.7 (8)	461 (8)	114 (8)	17.5 (7)	49.3 (8)
4	Walnut Creek	State Route 46	27.8 (6)	20.7 (4)	7.96 (4)	10.3 (8)	542 (8)	104 (8)	16.9 (8)	55.3 (8)
5	Mosquito Cr. Reservoir	State Route 88 Causeway		11.8 (4)	7.73 (4)	12.9 (6)	306 (6)	17.5 (6)	2.1 (5)	55.2 (6)
6	Upper Mosquito Cr.	York Street, Greene Twp.	65.6 (6)	55.5 (4)	7.73 (4)	26.6 (8)	607 (8)	65.1 (8)	28.2 (8)	106 (7)
7	Unnamed Tributary	Hoagland-Blackstub Rd.	16.0 (6)	31.8 (4)	7.48 (4)	16.3 (8)	342 (8)	244 (8)	58.1 (8)	132 (7)
8	Ditch Entering Unnamed Tributary	Hoagland-Blackstub Rd.		412 (1)	7.19 (1)	358 (1)	187 (1)	321 (1)	72.1 (1)	579 (1)
9	Spring Run	Near SR 46 and North River Rd.	11.5 (2)	8.4 (2)	8.01 (2)	6.0 (2)	97.7 (2)	19.5 (2)	5.2 (2)	34.4 (2)
10	Smith Run, North Branch	SR 46 North of Mahan-Denman Rd.	1.9 (3)	11.4 (3)	8.09 (3)	54.1 (3)	948 (3)	35.2 (3)	63.9 (3)	130.7 (3)
11	Unnamed Tributary	SR 46 South of Wakefield Creek Rd.	4.8 (2)	9.3 (2)	7.61 (2)	5.2 (2)	764 (2)	23.6 (2)	19.0 (2)	58.8 (2)
12	Mud Creek, South Branch	SR 46 South of Davis-Peck Rd.	1.3 (1)	4.4 (1)	8.56 (1)	3.2 (1)	837 (1)	24.4 (1)	6.5 (1)	22.8 (1)

SS = Suspended Solids
NO_3-N = Nitrate Nitrogen
NH_3-N = Ammonia Nitrogen
SRP = Soluble Reactive Phosphorus
TP = Total Phosphorus

- *Ohio EPA Bacteria Monitoring*

The Ohio EPA has conducted occasional sampling throughout Trumbull County for fecal coliform and *E. coli* measurements. The results for samples taken within the focus area of this study are presented in Table 4-18. Ohio law deems a public nuisance to exist if waters exceed 5000 fecal coliforms per 100 mL or 576 *E. coli* per 100 mL. Clearly, many roadside ditches and streams in the county are contaminated by surface discharges from inadequate home sewage treatment systems.

Table 4-18. Bacteria Measurements by Ohio EPA in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

Location	Township	Date	Fecal Coliforms (org/100 mL)	*E. coli* (org/100 mL)
Ditch at Rt. 305 recycle bin (Elm Rd. area)	Bazetta	06/26/00	130,000	>6,700
Ditch at Rt. 305 recycle bin (Elm Rd. area)	Bazetta	07/06/00	250,000	>48,000
Ditch at corner of Lakeshore Dr. and Everett-Cortland-Hull Rd. (0952 hr)	Bazetta	05/13/99	68,000	
Ditch at corner of Lakeshore Dr. and Everett-Cortland-Hull Rd. (1313 hr)	Bazetta	05/13/99	330,000	
Stream at end of Lakeshore Dr. (1032 hr)	Bazetta	05/13/99	900,000	
Stream at end of Lakeshore Dr. (1322 hr)	Bazetta	05/13/99	1,200,000	
Open ditch at 1147 Johnson Plank Rd.	Bazetta	06/26/00	130,000	>20,000
Open ditch at 1147 Johnson Plank Rd.	Bazetta	07/06/00	480,000	>48,000
Roadside ditch along Housel-Craft Rd.	Mecca	07/11/00	670,000	490,000
Roadside ditch along Housel-Craft Rd.	Mecca	07/17/00	480,000	550,000
Tributary at end of Lakeview Dr.	Mecca	07/11/00	19,000	18,000
Tributary at end of Lakeview Dr.	Mecca	07/17/00	19,000	21,000
Ditch at 5458 Lakeview Dr.	Mecca	07/11/00	310,000	>24,000
Ditch at 5458 Lakeview Dr.	Mecca	07/17/00	310,000	140,000
Tributary at McKinley Hts, dwst McDonalds	Weathersfield	07/06/00	70,000	>9,000
Tributary at McKinley Hts, dwst McDonalds	Weathersfield	07/17/00	42,000	12,000
Tributary at McKinley Hts, dwst culvert	Weathersfield	06/26/00	26,000	14,000
Tributary at McKinley Hts, dwst culvert	Weathersfield	07/06/00	9,700	>9,600
McKinley Hts Phases 2-3, Forest Dr.	Weathersfield	07/10/02	520,000	240,000
McKinley Hts Phases 2-3, Forest Dr.	Weathersfield	08/05/02	190,000	200,000
McKinley Hts Phases 2-3, Bianco Ave. W	Weathersfield	07/10/02	1,300	1,100
McKinley Hts Phases 2-3, Bianco Ave. W	Weathersfield	08/05/02	140,000	140,000
McKinley Hts Phases 2-3, Bianco Ave. E	Weathersfield	07/10/02	200,000	73,000
McKinley Hts Phases 2-3, Bianco Ave. E	Weathersfield	08/05/02	63,000	17,000
Thomas Lane, roadside ditch (0920 hr)	Liberty	06/12/00	7,100	
Thomas Lane, roadside ditch (1123 hr)	Liberty	06/12/00	49,000	
Secrist Lane (0936 hr)	Liberty	06/12/00	360,000	
Secrist Lane (1138 hr)	Liberty	06/12/00	460,000	
Underwood Dr. (0958 hr)	Liberty	06/12/00	580,000	
Underwood Dr. (1158 hr)	Liberty	06/12/00	90,000	

Causes and Sources of Impairment: The Ohio EPA's Nonpoint Source Assessment Group has identified known causes and sources of water quality impairment based on the Mahoning River Biological and Water Quality Study (Ohio EPA, 1996). The information published on the agency's web site for the designated streams in the focus area is summarized in Table 4-19. Based on the available water quality data and a field survey, sources and causes of impairment were identified in greater detail for the Mosquito Creek watershed; the results are summarized in Table 4-20. A limited field survey (Squaw Creek, Little Squaw Creek, and Crab Creek watershed only) was conducted in the Lower Mahoning River Corridor watershed. However, the summary of causes and sources of impairment for the Lower Mahoning River (Table 4-21) was based primarily on the extensive background data available.

Point Sources: Using NPDES monitoring results reported to Ohio EPA in 2000 and 2001, Ahmad (2004) calculated point source loading rates of total suspended solids (SS), ammonia nitrogen (NH_3-N), nitrate+nitrite nitrogen (NO_3-N), and 5-day carbonaceous BOD (CBOD5), from all significant point source discharges in the Mahoning River watershed. The results are presented in Table 4-22, and shown graphically in Figures 4-20 through 4-23, respectively. Loading rates of total phosphorus (TP) were also calculated, and are given in Table 4-22, for the plants required to monitor this parameter.

Table 4-19. Causes and Sources of Aquatic Life Use (Warmwater Habitat) Impairment in the Mosquito Creek and Lower Mahoning River Corridor Watersheds.

Stream/River Segment	Length (miles)	Assessment Status	Known Sources of Impairment	Known Causes of Impairment
Mosquito Creek (Headwaters to Mosquito Creek Reservoir Dam)	21	NPS impaired	Flow regulation/ modification	Flow alteration
Mud Creek	4	No info.		
Smith Run	2	No info.		
Walnut Creek	5	No info.		
Confusion Run	4	No info.		
Big Run	5	No info.		
Spring Run	5	No info.		
Mosquito Creek (Mosquito Creek Reservoir Dam to Mahoning R.)	12	PS & NPS impaired	Industrial and municipal point sources; in-place pollutants	Suspended solids
Mahoning R. (Duck Cr. to Meander Cr.)	15	PS & NPS impaired	Industrial and municipal point sources; urban runoff/storm sewers (NPS); spills; contaminated sediments; hazardous waste	Nutrients; metals; priority organics; pathogens; oil & grease; chlorine
Squaw Creek	7	Attaining use		
Fourmile Run	4	No info.		
Little Squaw Creek	5	No info.		
Mahoning R. (Meander Cr. to Mill Cr.)	9	PS & NPS impaired	Industrial and municipal point sources; spills; combined sewer overflows; in-place pollutants	Nutrients; priority organics; thermal modifications
Kimmel Brook	2	No info.		
Crab Creek	8	Attaining use		
Dry Run	7	NPS impaired	Unknown	
Mahoning R. (Mill Cr. to Yellow Cr.)	6	PS & NPS impaired	Municipal point sources; combined sewer overflows; urban runoff/storm sewers (NPS); spills; flow regulation/modification; contaminated sediments; in-place pollutants; dam construction;	Organic enrichment/D.O.; habitat alterations; nutrients; metals; priority organics; pathogens; oil & grease
Godward Run	1	No info.		
Hines Run	3	Attaining use		
Grays Run	2	No info.		
Mahoning R. (Yellow Cr. to PA)	4	PS & NPS impaired	Municipal point sources; ; flow regulation/modification; contaminated sediments; in-place pollutants; urban runoff; landfills	Metals; priority organics; chlorine

Table 4-20. Sources and Causes of Water Quality Impairment in the Mosquito Creek Reservoir, and General Recommendations for Corrective Action.

Stream	Segment/ Tributary	Location	Problem/Cause	Source(s)	General Recommendations
Mosquito Creek	Above Reservoir	Near Windsor Rd., Ashtabula Co.	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/livestock	Exclusionary fencing; establish riparian vegetation.
Mosquito Creek	UMC-1,2	Beckwith Rd., Ashtabula Co.	Siltation	Agriculture/crops; channelization; stream bank erosion; removal of riparian vegetation	Establish riparian vegetation (filter strips); Promote conservation tillage and chemical/ manure management.
Mosquito Creek	UMC-4	Troutman Rd., Ashtabula Co.	Siltation	Agriculture/crops; channelization; stream bank erosion; removal of riparian vegetation	Establish riparian vegetation (filter strips); Promote conservation tillage and chemical/ manure management.
Mosquito Creek	UMC-6	Troutman Rd., Ashtabula Co.	Siltation	Agriculture/crops; removal of riparian vegetation	Establish riparian vegetation (filter strips); Promote conservation tillage and chemical/ manure management.
Mosquito Creek	Above Reservoir	Near SR 46, Trumbull Co.	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/livestock	Exclusionary fencing; establish riparian vegetation.
Mosquito Creek	Mud Cr. Tribs. MC-1 to 5	Dennison – Ashtabula Rd. between SR 46 & SR 88	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/crops & livestock; channelization; stream bank erosion; removal of riparian vegetation	Exclusionary fencing; establish riparian vegetation (filter strips); promote conservation tillage and chemical/ manure management.
Mosquito Creek	Smith Run SR-2	Love-Warner Rd. to SR-46	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/livestock; removal of riparian vegetation	Exclusionary fencing
Mosquito Creek	WM-1	Hoagland-Blackstub Rd. and Morrell Ray Rd., north of SR 88.	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/livestock & crops; home septic systems; stream bank erosion; channelization	Exclusionary fencing; eliminate or treat off-lot sewage discharges; establish riparian vegetation (filter strips).
Mosquito Creek	WM-1	Housel-Craft Rd. and Morrell Ray Rd.	Siltation	Agriculture/crops; channelization; removal of riparian vegetation	Establish riparian vegetation (filter strips); Promote conservation tillage and chemical/ manure management.
Mosquito Creek	WM-2	Hoagland-Blackstub Rd.	Siltation	Removal of riparian vegetation	Establish riparian vegetation.
Mosquito Creek		Lakeview Dr.	Nutrient & Organic Enrichment; Bacteria	Home septic systems	Eliminate or treat off-lot sewage discharges.
Mosquito Creek		Lakeshore Dr.	Nutrient & Organic Enrichment; Bacteria	Home septic systems	Eliminate or treat off-lot sewage discharges.
Mosquito Creek		Area near Hoagland-Blackstub Rd. and SR 5	Siltation; Nutrient & Organic Enrichment; Bacteria	Home septic systems; removal of riparian vegetation; agriculture/crops;	Eliminate or treat off-lot sewage discharges; establish riparian vegetation (filter strips).
Walnut Creek		Johnston Twp.	Siltation	Agriculture/crops; channelization; stream bank erosion; removal of riparian vegetation.	Establish/expand riparian vegetation (filter strips); investigate natural channel design.
Walnut Creek		City of Cortland	Siltation; flow alterations	Urban runoff/storm sewers; channelization; stream bank erosion	Evaluate adequacy of storm water detention facilities.

Table 4-20. Continued

Stream	Segment/ Tributary	Location	Problem/Cause	Source(s)	General Recommendations
Confusion Run		McCleary-Jacoby Rd. and SR 305	Nutrient & Organic Enrichment; Bacteria	Home septic systems	Eliminate or treat off-lot sewage discharges.
Confusion Run		Near mouth	Siltation	Urban runoff/storm sewers; stream bank erosion	Evaluate adequacy of storm water detention facilities.
Big Run	BR-1	Ridge Rd.	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/livestock; removal of riparian vegetation; stream bank erosion.	Exclusionary fencing; establish riparian vegetation (filter strips)
Big Run	BR-2	Henn Hyde Rd.	Siltation; Nutrient & Organic Enrichment; Bacteria	Agriculture/livestock; home septic systems; channelization; stream bank erosion.	Exclusionary fencing; expand riparian vegetation; eliminate or treat off-lot sewage discharges.
Big Run		Cadwallader-Sonk Rd. and SR 46	Siltation	Removal of riparian vegetation.	Establish riparian vegetation.
Big Run		McCleary-Jacoby Rd.	Nutrient & Organic Enrichment; Bacteria	Home septic systems	Eliminate or treat off-lot sewage discharges.
Spring Run		Howland-Wilson Rd. to SR 46	Siltation	Stream bank erosion	Investigate floodplain modifications and storm water detention at headwaters near Yo.-Warren Regional Airport
Spring Run		Near North River Rd., west of SR 46	Siltation; flow alterations	Urban runoff/storm sewers; channelization; stream bank erosion; removal of riparian vegetation.	Establish riparian vegetation.
Mosquito Creek	From dam to mouth		Siltation; flow alterations	Urban runoff; stream bank erosion.	Preserve floodplains and adjacent wetlands; upgrade storm water detention facilities.

Table 4-21. Summary of Sources and Causes of Water Quality Impairment in the Lower Mahoning River Corridor Watershed, and General Recommendations for Corrective Action.

Stream	Segment/ Tributary	Location	Problem/Cause	Source(s)	General Recommendations
Mahoning River	Lower	Entire reach	Flow/habitat alteration	Dam construction	Remove all low head dams.
Mahoning River	Lower	Entire reach	Priority organics; metals; oil and grease	Contaminated bottom sediments and river banks	Remove contaminated sediments; prevent recontamination from river banks.
Mahoning River	Lower	Entire reach	Bacteria; organic enrichment	Combined sewer overflows	Reduce or eliminate combined sewer overflows.
Mahoning River	Lower	Entire reach	Siltation	Agriculture; urban runoff/storm sewers; stream bank erosion	Promote agricultural BMPs (filter strips; conservation tillage, chemical/manure management) throughout the watershed; establish riparian vegetation; protect and restore flood plains and wetlands; evaluate and improve storm water detention facilities.
Mahoning River	Lower	Entire reach	Trash	Urban runoff/storm sewers	Evaluate and improve storm water detention facilities; evaluate storm water treatment options.

Table 4-22. Best Estimates of Pollutant Loadings (in kg/yr) from Point Source Discharges in the Mahoning River Watershed for the Years 2000 and 2001, with Percentages of Total Point Source Loading Contributed by Each Discharger.

Facility	Mean Flow (MGD)	TP	TSS	%	Ammonia	%	Nitrite + Nitrate Nitrogen	%	CBOD (5 day)	%
Alliance WWTP	6.20	2,621	40,402	3	4,140	2	107,752	10	56,267	8
Boardman WWTP	4.66	9,240	11,522	1	725	0.31	91,533	9	21,995	3
Campbell WWTP	1.20		22,321	1	13,349	6	6,190	1	6,166	1
Columbiana WWTP	1.10	2,541	20,032	1	1,299	1	9,705	1	9,900	1
Craig Beach WWTP	1.05		1,414	0	154	0.07	3,980	0.4	1,353	0.2
Garrettsville WWTP	0.25		3,570	0	145	0.06	6,412	1	1,930	0.3
Girard WWTP	17.95		72,597	5	7,316	3	47,781	5	53,241	8
Lowellville WWTP	0.23		3,587	0.2	1,151	0.49	4,732	0	1,754	0.3
Meander Crk WWTP	3.05	4,650	27,965	2	8,450	4	37,100	4	12,097	2
Mosquito Crk WWTP	3.28		27,861	2	2,509	1	56,992	5	10,777	2
Newton Falls WWTP	0.82		7,783	1	10,865	5	4,815	0.5	11,002	2
Niles WWTP	4.94		60,140	4	11,010	5	73,358	7	66,060	10
Ohio Edison Niles	118.8		61,264	4	16,457	7				
RMI Titanium	0.43		5,132	0	311	0.13			1,985	0.3
Sebring WWTP	0.72		7,283	0	589	0.25	12,249	1	3,709	1
Struthers WWTP	4.35		160,104	10	61,069	26	35,824	3	141,246	21
Thomas Steel	1.04		24,813	2						
Warren WWTP	13.22		102,129	7	25,054	11	172,780	16	75,264	11
WCI-S804	46.8				23,241	10				
WCI-S8	6.64		141,401	9						
WCI-S603	0.86		35,453	2						
WCI-S602	1.49		45,384	3						
WCI-S13	25.93		326,760	21	16,406	7				
Windham WWTP	0.29		728	0	38	0.02	5,663	1	1,068	0.2
Youngstown WWTP	32.05		342,756	22	29,255	13	378,631	36	208,338	30
Total			**1,552,398**		**233,534**		**1,055,498**		**684,151**	

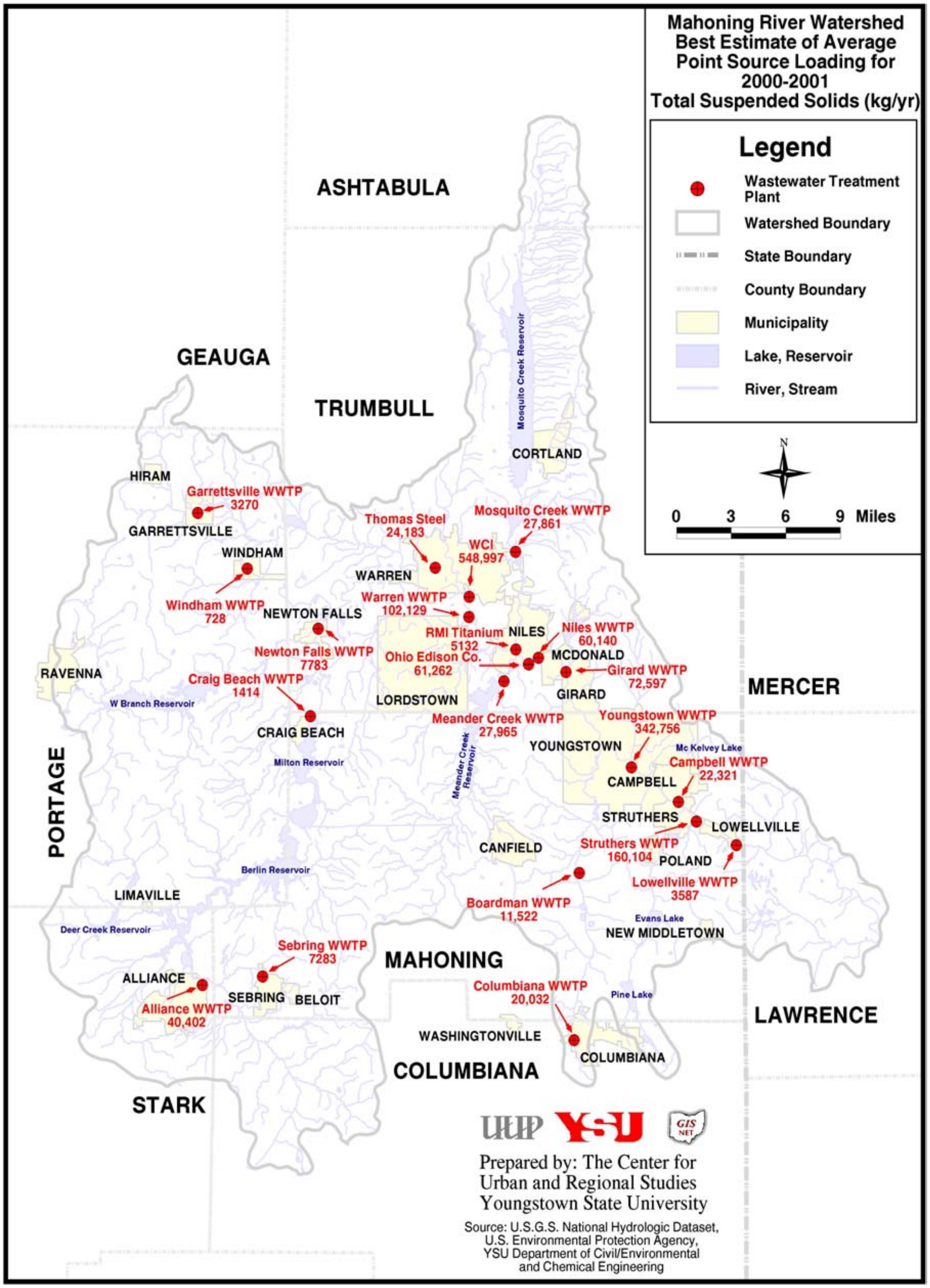

Figure 4-20. ArcView GIS Map Showing Average Point Source Loadings of Total Suspended Solids in the Mahoning River Watershed for 2000 and 2001, in kg/yr.

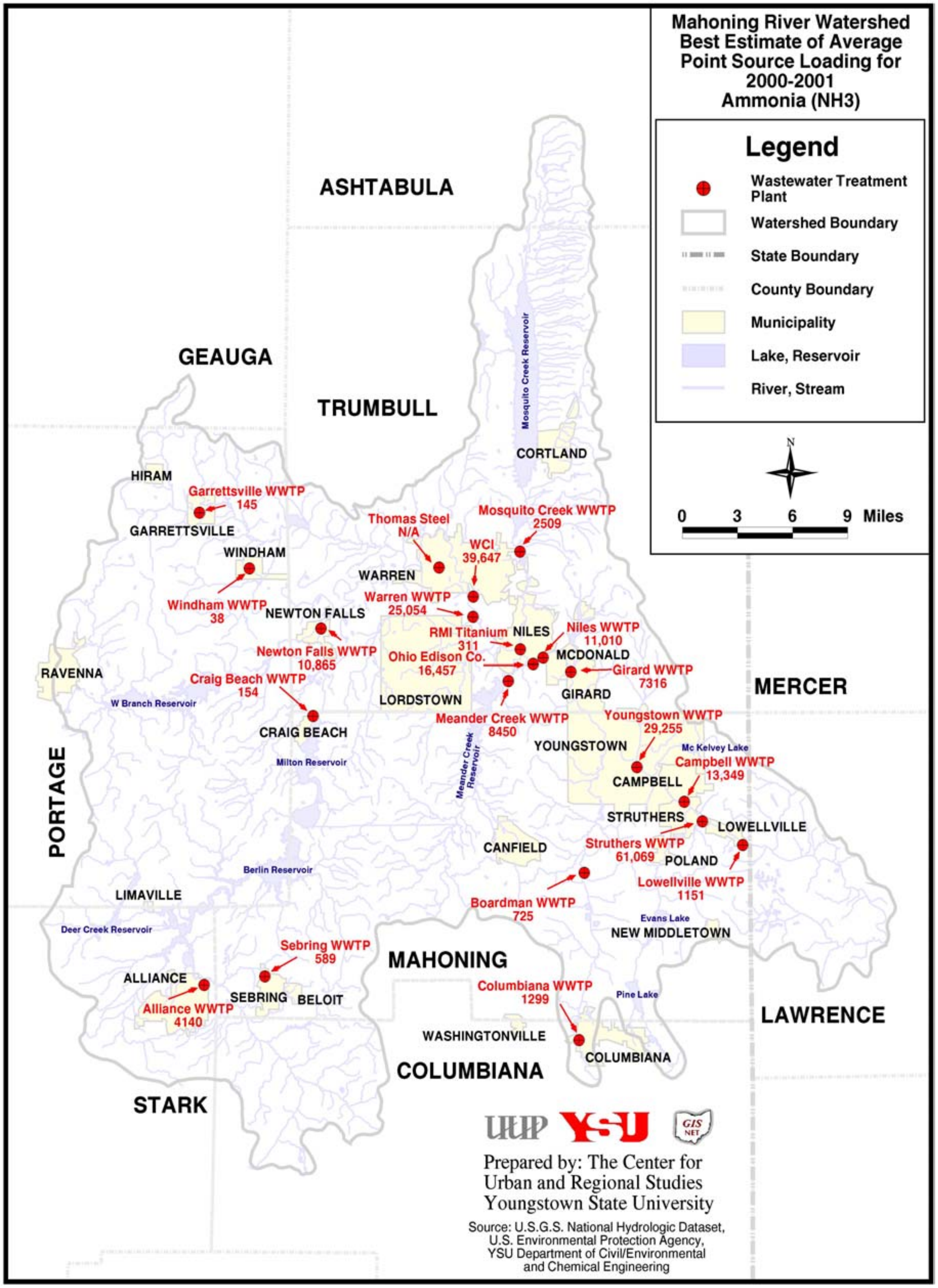

Figure 4-21. ArcView GIS Map Showing Average Point Source Loadings of Ammonia Nitrogen in the Mahoning River Watershed for 2000 and 2001, in kg/yr.

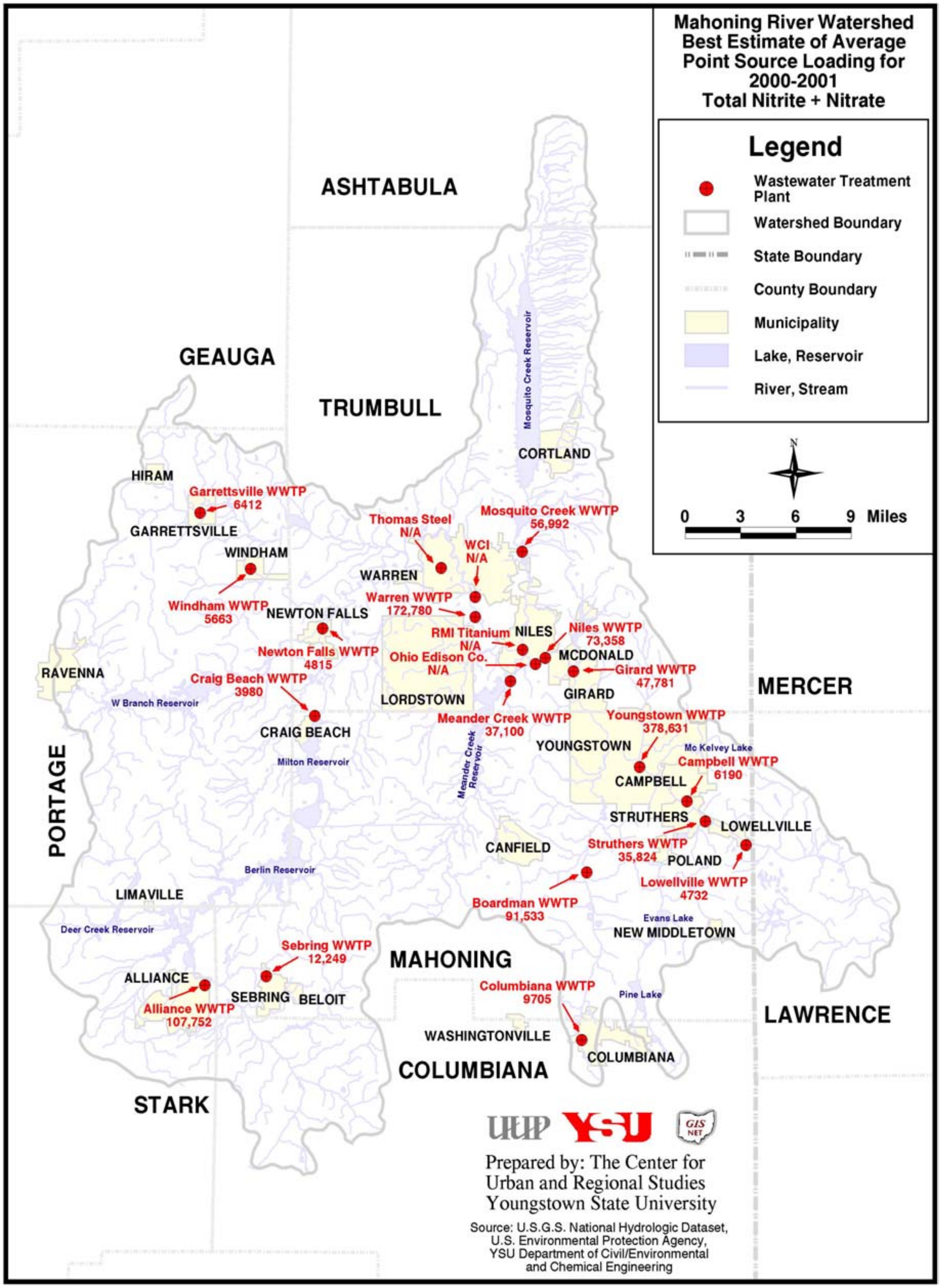

Figure 4-22. ArcView GIS Map Showing Average Point Source Loadings of Nitrate + Nitrite Nitrogen in the Mahoning River Watershed for 2000 and 2001, in kg/yr.

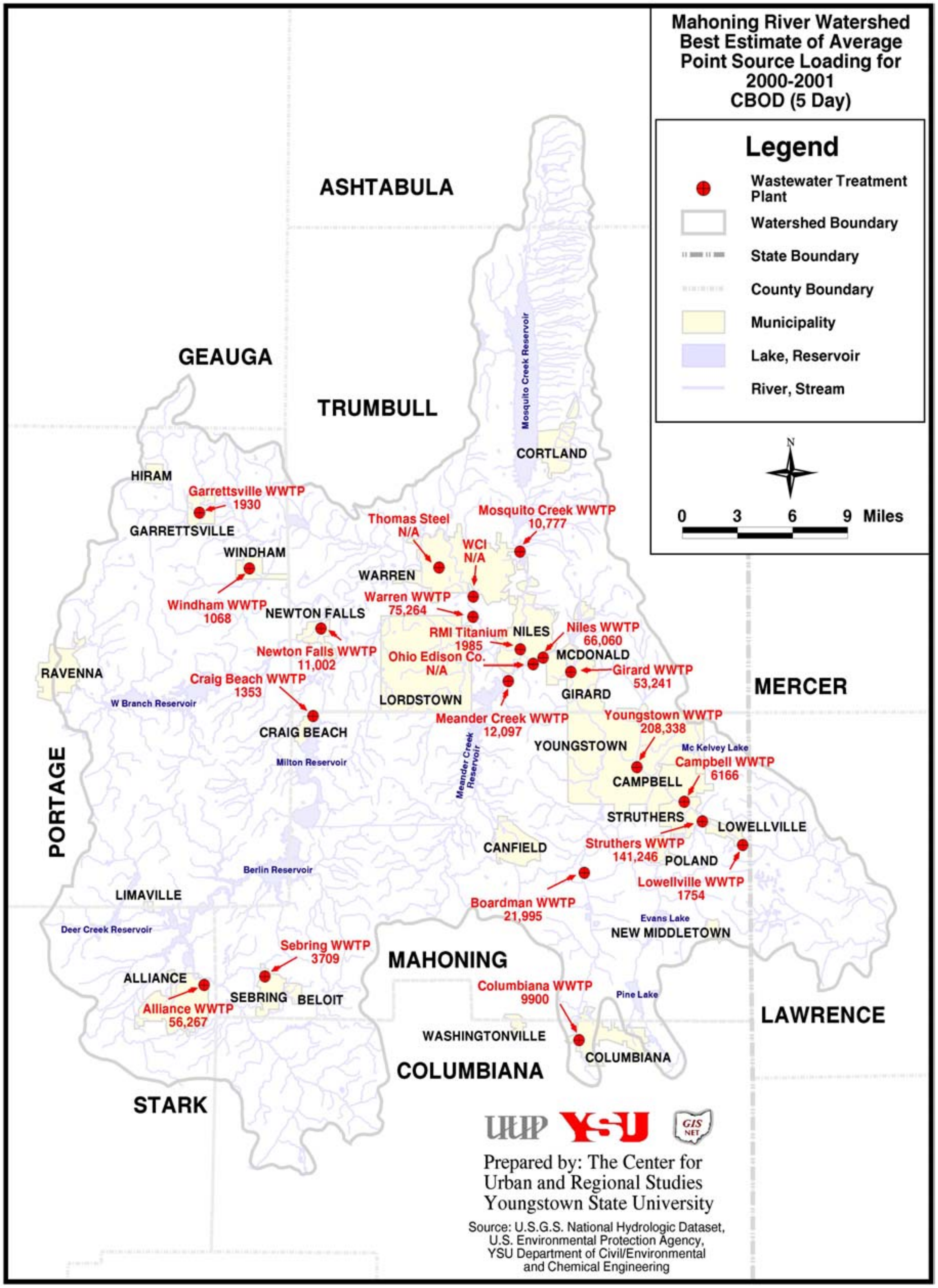

Figure 4-23. ArcView GIS Map Showing Average Point Source Loadings of 5-Day Carbonaceous BOD in the Mahoning River Watershed for 2000 and 2001, in kg/yr.

Nonpoint Sources: Ahmad (2004) estimated the mass flux (in kg/d) of 5-day CBOD, total suspended solids (TSS), ammonia nitrogen (AN) and nitrate + nitrite nitrogen (NN) in the Mahoning River at both Leavittsburg and Lowellville from Equation 4-1.

$$M = Q \times C \qquad (4\text{-}1)$$

Where:

M = mass flux rate of a pollutant, kg/d
Q = flow rate in river at point of interest, m^3/d
C = concentration of pollutant in river at point of interest, kg/m^3

Flow rates were taken from USGS gaging station data for Leavittsburg and Lowellville. Concentrations were measured weekly by Ohio EPA and obtained from the STORET database. Data from the period 1990-2001 were used in the calculations. In addition, Ahmad (2004) estimated the relative contributions of point sources and nonpoint sources for each pollutant. Point source loading estimates were obtained from NPDES monitoring data, and nonpoint source loadings were estimated as the difference between total mass flux and total upstream point source discharges. Pollutants from point sources were assumed to behave as conservative substances (i.e., no loss or gain due to reactions in the river between the point of discharge and the monitoring location). The results are summarized in Table 4-23. While the majority of nitrogen originates from point sources, most of the suspended solids and organic matter (5-day CBOD) come from nonpoint sources.

In the Mosquito Creek watershed, there is one major point source discharge – the Mosquito Creek Wastewater Treatment Plant. The plant discharges estimated loadings of 27,861 kg/yr of suspended solids, 2,509 kg/yr of ammonia nitrogen, 56,992 kg/yr of nitrate + nitrite nitrogen, and 10,777 kg/yr of 5-day CBOD (Table 4-22, from Ahmad, 2004) at River Mile 7.1 of Mosquito Creek. There is also one package plant treating wastewater from homes in the vicinity of Sterling Drive on the southwestern shore of Mosquito Creek Reservoir.

As part of this watershed planning effort, Yahaya (2004) compared pollutant export rates from various parts of the Mosquito Creek watershed based on the monitoring study described previously (see Figure 4-19 and Table 4-17). Loading rates (in lb/d or kg/d) for each stream were calculated for each sampling date from the product of flow rate and measured pollutant concentration. These were averaged, multiplied by 365 d/yr, and divided by the contributing drainage area (in acres or hectares) to obtain pollutant export rates (in lb/acre/d or kg/ha/d). The results are presented in Table 4-24. In general, the northern and western portions of the watershed showed higher export rates than the southern and eastern sections.

Yahaya (2004) also estimated pollutant loadings to Mosquito Creek Reservoir using two approaches – one based on limited stream monitoring in the watershed, and the other based on USEPA's STEPL (Spreadsheet Tool for Estimating Pollutant Load) model. STEPL uses input data on land use, annual rainfall, numbers of agricultural animals, home sewage treatment systems, Universal Soil Loss Equation parameters, runoff curve numbers, pollutant concentrations in runoff water and soil, etc., to calculate mean annual pollutant loads in lb/yr. In most cases, local data can be used if available, or location-specific default values from the STEPL database can be accepted. Pollutant loading reductions resulting from the application of various BMPs can also be estimated. A summary of the loading estimates is presented in Table 4-25.

Table 4-23. Estimates of Point and Nonpoint Source Loadings to the Mahoning River, from Ahmad (2004).

a) At Leavittsburg, OH:

Parameter	Mass Flux in River (kg/d)	Total Upstream Point Sources		Nonpoint Source Loading	
		kg/d	% of Total	kg/d	% of Total
CBOD5	2,071	206	9.9	1,864	90.1
TSS	47,081	168	0.4	46,914	99.6
NH_3-N	159	44	27.7	115	72.3
NO_3-N	1,210	386	31.9	824	68.1

b) At Lowellville, OH:

Parameter	Mass Flux in River (kg/d)	Total Upstream Point Sources		Nonpoint Source Loading	
		kg/d	% of Total	kg/d	% of Total
CBOD5	8,070	1,668	20.7	6,402	79.3
TSS	71,425	4,086	5.7	67,339	94.3
NH_3-N	688	596	86.6	92	13.4
NO_3-N	4,845	2,506	51.7	2,339	48.3

Table 4-24. Estimates of Nonpoint Source Pollutant Export Rates from Various Parts of the Mosquito Creek Watershed, from Yahaya (2004).

a) In kg/ha/yr:

Site #	Location	Drainage Area	SRP	TP	NO_3^- - N	NH_3 - N	SS
		Hectares	kg/ha/yr	kg/ha/yr	kg/ha/yr	kg/ha/yr	kg/ha/yr
2	Big Run	1,234.0	0.10	0.87	1.33	0.19	133.10
3	Confusion Run	763.3	0.16	0.57	2.84	0.29	90.86
4	Walnut Creek	2,695.2	0.20	0.77	3.82	0.36	180.12
6	Upper Mosquito Cr.	4,374.6	0.70	2.71	8.53	1.47	1,097.18
7	Unnamed tributary	1,384.1	0.44	1.52	2.11	0.75	390.29
9	Spring Run	1,350.5	0.05	0.34	0.66	0.20	64.86
10	Smith Run	226.5	0.61	1.19	6.93	0.21	209.50
12	Mud Creek	272.1	0.03	0.09	3.65	0.11	13.42

b) In lb/acre/yr:

Site #	Location	Drainage Area	SRP	TP	NO_3^- - N	NH_3 - N	SS
		Acres	lb/acre/yr	lb/acre/yr	lb/acre/yr	lb/acre/yr	lb/acre/yr
2	Big Run	3,047.0	0.09	0.78	1.19	0.17	107.81
3	Confusion Run	1,884.6	0.15	0.51	2.54	0.26	73.60
4	Walnut Creek	6,654.7	0.18	0.69	3.41	0.32	145.90
6	Upper Mosquito Cr.	10,801.6	0.62	2.42	7.62	1.31	888.71
7	Unnamed tributary	3,417.5	0.39	1.36	1.89	0.67	316.14
9	Spring Run	3,334.7	0.04	0.30	0.59	0.18	52.54
10	Smith Run	559.2	0.55	1.06	6.19	0.19	169.70
12	Mud Creek	671.7	0.02	0.08	3.26	0.10	10.87

Table 4-25. Estimates of Pollutant Loadings to Mosquito Creek Reservoir, from Yahaya (2004).

a) Based on Monitoring Study:

	Loading Rate	
Parameter	**kg/yr**	**lb/yr**
Total P	41,916	92,407
NO_3^- - N	131,870	290,722
NH_3 - N	22,020	48,545
TSS	15,200,435	30,400,734

b) From USEPA's STEPL Model:

	Loading Rate	
Parameter	**kg/yr**	**lb/yr**
Total P	25,075	55,291
Total N	96,096	211,891
Sediment	8,198,912	18,078,600
5-day CBOD	253,219	558,348

Water Quality Trends: In the late 1970's and early 1980's, most of the large steel making industries along the Mahoning River closed, dramatically reducing the loadings of such industrial pollutants as heat, oil and grease, PAH, PCBs, and heavy metals to the Lower Mahoning River. Most of the municipal wastewater treatment plants discharging to the Mahoning River upgraded to secondary level treatment in the late 1980's, resulting in further water quality improvements. Ohio EPA noted substantial improvements between the intensive surveys conducted by Ohio EPA in 1980 and 1994, including lower concentrations of ammonia nitrogen, phenols, cyanide, zinc, chromium, and nickel. However, no significant improvement was found in pollutant concentrations in Lower Mahoning River bottom sediments (Ohio EPA, 1996).

Between 1980 and 1994, dissolved oxygen levels increased and ammonia nitrogen decreased in Mosquito Creek above the confluence with the Mahoning River due to the 1983 upgrade of the Mosquito Creek wastewater treatment plant. However, total suspended solids concentrations increased significantly during the same time frame. Rapid development of the Lower Mosquito Creek corridor is one potential contributing factor. Further work is needed to identify the cause of this apparent increase (Ohio EPA, 1996).

Chapter 5
Problem Statements, Restoration Goals and Action Plans

Based on the results of the watershed inventory and input from stakeholders, two sets of problem statements were developed – one for the Mosquito Creek watershed, and one for the Lower Mahoning River Corridor watershed. Next, watershed restoration and protection goals were established that will contribute to the solution of each problem. And finally, several actions were identified that will lead to the accomplishment of the goals. Along with each action, the lead parties responsible, required resources, time frame, and indicators of success were identified as well. The proposed action plans are presented on the following pages.

Mosquito Creek Watershed Action Plan

Problem #MC-1: The rate of sediment accumulation in Mosquito Creek Reservoir is very high. The suspended solids loading from the reservoir watershed is estimated at 12,000 tons/yr. Export rates are highest in the upper Mosquito Creek watershed (HUC # 05030103 060 010). Sediment deposition in the reservoir reduces storage capacity, and deposition in streams impairs aquatic habitat. Agricultural runoff, channelization, and stream bank erosion are the major sources of the problem.

Goals:
MC-1A. Maintain the use of Mosquito Creek Reservoir for flood control, water supply, and recreation.
MC-1B. Meet warmwater habitat criteria in Mosquito Creek and all major tributaries.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
E&O	Mosquito Creek watershed	Promote NRCS programs to farmers	NRCS TSWCD	Staff time	Ongoing	Info packets distributed
Proj	Upper Mosquito Cr. tribs near Beckwith and Troutman Rds., Colebrook Twp. Ashtabula Co.	Establish riparian buffers or filter strips on 10,000 ft. of streams.	NRCS	Time for grant-writing; Landowner participation	2005 to 2008	Ft. of streams protected
Proj	Upper Mosquito Cr. tribs near Beckwith and Troutman Rds., Colebrook Twp, Ashtabula Co.	Increase use of conserva-tion tillage by 300 acres	NRCS	Staff time; Landowner participation	2005 to 2008	% of crop land using conserva-tion tillage
Proj	Mud Cr. tribs near SR46 and Dennison-Ashtabula Rd., Greene Twp., Trumbull Co.	Establish riparian buffers or filter strips on 2,000 ft. of streams.	TSWCD NRCS	Time for grant-writing; Landowner participation	2005 to 2008	Ft. of streams protected
Proj	Mud Cr. tribs near SR46 and Dennison-Ashtabula Rd., Greene Twp., Trumbull Co.	Increase use of conserva-tion tillage by 100 acres	TSWCD NRCS	Staff time; Landowner participation	2005 to 2008	% of crop land using conserva-tion tillage.
Proj	Unnamed trib. West of Mosquito Cr. Reservoir; near Morrell Ray and Housel-Craft Rds.	Establish riparian buffers or filter strips on 2,000 ft. of streams.	TSWCD NRCS	Landowner participation	2005 to 2008	Ft. of streams protected
Proj	Unnamed trib. west of Mosquito Cr. Reservoir, near Morrell Ray and Housel-Craft Rds.	Increase use of conserva-tion tillage by 100 acres	TSWCD NRCS	Staff time; Landowner participation	2005 to 2008	% of crop land using conserva-tion tillage
Proj	Walnut Creek near SR5, Johnston Twp., Trumbull Co.	Natural channel design; establish riparian buffer	MRC TSWCD	Time for grant-writing	By Dec., 2008	Ft. of stream restored
Res	Walnut Creek, City of Cortland	Evaluate adequacy of storm water retention facilities	TCSE TSWCD	Staff time	2005 to 2006	Summary report
Pol	Trumbull County	Adopt and implement revised Erosion and Sediment Control Rules	TSWCD	Staff time	By Dec., 2004	Rules adopted
Pol	Trumbull County	Adopt and implement storm water management program	TSWCD TCPC	Staff time	By Dec., 2004	Rules adopted
Res	Mosquito Creek watershed	Monitor sediment loading and accumulation rates; evaluate cost effectiveness of BMPs.	YSU USACE	$20,000/yr	Start 2005	Annual reports
Res	Upper Mosquito Cr.; Mud Creek; Smith Run	Monitor fish, macroinverte-brates, and QHEI	OEPA TSWCD		Every 5 years	IBI, MIwb, ICI, QHEI

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy

Organizations:
- MRC – Mahoning River Consortium
- NRCS – Natural Resources Conservation Service
- TCBH – Trumbull County Board of Health
- TCSE – Trumbull County Sanitary Engineer
- TCPC – Trumbull County Planning Commission
- TSWCD – Trumbull Soil & Water Conservation District
- USACE – U.S. Army Corps of Engineers
- YSU – Youngstown State University

Problem #MC-2: Bacteria levels in streams and ditches throughout the Mosquito Creek watershed pose a threat to human health. Discharges from malfunctioning home sewage treatment systems (HSTS) and livestock waste are the main sources of this problem.

Goals:
MC-2A. Eliminate surface discharges of pollutants from home sewage treatment systems.
MC-2B. Eliminate direct access of livestock to streams in the watershed.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Proj	Mosquito Cr. near Windsor Rd., Colebrook Twp., Ashtabula Co.	Livestock exclusion for approx. 80 head of cattle; establish riparian buffer	NRCS	Staff time: grant writing	By Dec., 2006	Meeting w/ land-owner; no. cattle excluded
Proj	Mosquito Cr. at SR46, Greene Twp., Trumbull Co.	Livestock exclusion for approx. 30 head of cattle; establish riparian buffer	TSWCD NRCS	Staff time: grant writing	By Dec., 2006	Meeting w/ land-owner; no. cattle excluded
Proj	Unnamed trib at Morrell Ray Rd., Mecca Twp., Trumbull Co.	Establish riparian buffer between pasture and stream	TSWCD NRCS	Staff time	By Dec., 2006	Meeting w/ land-owner; ft. of buffer
Proj	South branch, Smith Run at Love-Warner Rd., Mecca Twp.	Livestock exclusion; establish riparian buffer	TSWCD NRCS	Staff time: grant writing	By Dec., 2007	Meeting w/ land-owner; animals excluded
Proj	Lakeshore and Westlake Drs., Bazetta Twp.	Eliminate discharge from approx. 60 home septic systems; construct sanitary sewers; upgrade package plant	TCBH TCSE	$1 million	To be deter-mined locally	Number of failing HSTS eliminated.
Proj	Lakeview Dr., Mecca Twp.	Upgrade approx. 35 home septic systems	TCBH TCSE	$13,000/home; Homeowner participation	To be deter-mined locally	Number of failing HSTS eliminated.
Proj	Unnamed trib at Hoagland-Blackstub Rd., Mecca Twp.	Eliminate discharge from failing HSTS; construct sanitary sewers	TCBH MRC	To be determined	To be deter-mined locally	Number of failing HSTS eliminated.
Proj	Big Run at McCleary-Jacoby Rd., Bazetta Twp.	Eliminate discharge from failing HSTS; construct sanitary sewers	TCBH MRC	To be determined	To be deter-mined locally	Number of failing HSTS eliminated.
Res/Pol	Trumbull Co.	Evaluate role of water conservation and alterna-tive HSTS in Co. residen-tial wastewater regulations.	TCBH Eastgate MRC	Time: staff; volunteers	By Dec., 2005	Committee formed
E&O	Mosquito Creek watershed	Conduct educational program(s) for farmers on agricultural BMPs	TSWCD NRCS	Staff time	Ongoing	Info packets distributed
E&O	Mosquito Creek watershed	Conduct educational program(s) for homeowners on HSTS design, construc-tion, and maintenance	TCBH	Staff time	Ongoing	Info packets distributed
Res/Pol	Mosquito Creek watershed	Evaluate the potential use of local ordinances on livestock exclusion	MRC	Volunteer time	By Dec., 2006	Committee formed
Res	Mosquito Creek watershed	Monitor fecal coliform levels in ditches and creeks	TSWCD	$5,000/yr; staff time	Annually	FC levels

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
Eastgate – Eastgate Regional Council of Governments
MRC – Mahoning River Consortium
NRCS – Natural Resources Conservation Service
TCBH – Trumbull County Board of Health
TCBH – Trumbull County Board of Health
TCSE – Trumbull County Sanitary Engineer
TSWCD – Trumbull Soil & Water Conservation District

Problem #MC-3: Mosquito Creek Reservoir experiences high nutrient loading rates from the watershed. Total phosphorus loading to the reservoir is estimated at 32,000 kg/yr and total nitrogen loading at 96,000 kg/yr. Measured spring total phosphorus levels are about 55 µg/L, which contributes to eutrophic conditions (high algal productivity) in the reservoir. The major sources of nutrients are agriculture (fertilizer and livestock waste) and malfunctioning septic systems.

Goal:
MC-3A. Reduce the total phosphorus loading to Mosquito Creek Reservoir by 25%.

Action Plan:

Most of the actions proposed for Problems #MC-1 (sediment loading) and MC-2 (bacterial contamination) will also contribute to a reduction in the nonpoint source loading of phosphorus from the watershed. Only additional actions proposed to address this problem are listed below:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Proj	Upper Mosquito Cr. watershed	Expand use of chemical analysis for selecting fertilizer application rates to 90% of cropland.	NRCS TSWCD	Staff time	2005 to 2008	Acres fertilized based on chem. analysis
Res	Mosquito Creek watershed	Monitor total P loading rates and levels in reservoir	YSU	$20,000/yr	Start 2005	Annual reports
Res	Mosquito Creek watershed	Conduct TMDL analysis	OEPA	Agency funding	2013	Report prepared
Res	Mosquito Creek watershed	Refine models for predicting nonpoint source loadings of total P and sediment and effect of BMPs	YSU OEPA	Staff time	Ongoing	Report(s) prepared

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
OEPA – Ohio Environmental Protection Agency
NRCS – Natural Resources Conservation Service
TSWCD – Trumbull Soil & Water Conservation District
YSU – Youngstown State University

Problem #MC-4: High quality terrestrial habitat along lower Mosquito Creek is threatened by development. Aquatic habitat in this reach is also impaired, and does not meet WWH criteria. Urban development around and in the floodplain, as well as storm water runoff from these developed areas, are the primary sources of the problem.

Goals:
MC-4A. Prevent all future development within the 500-year flood plain of lower Mosquito Creek.
MC-4B. Protect and restore unique and valuable ecological features along lower Mosquito Creek.
MC-4C. Improve QHEI to 65 or greater throughout lower Mosquito Creek (from dam to mouth).

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Proj	Lower Mosquito Cr. corridor	Acquire property or easements on land in the 500 year flood plain, wetlands and critical wildlife habitat	TCPC MRC	Est. $2500 per acre; time for grant writing	Ongoing; By 2008	Acres protected
Pol E&O	Trumbull County	Adopt and implement storm water management program, including: ▪ Formation of storm water management district ▪ Strong public education ▪ Use of non-structural BMPs ▪ Riparian, wetland, and 100-year flood plain setbacks ▪ Conservation subdivisions ▪ Strict enforcement	TSWCD TCPC TCE TSWMD	Staff time; Other to be determined	By Dec., 2008	Rules adopted, implemented
E&O	Mosquito Creek watershed	Develop and disseminate educa-tional material and programs on flooding, soils, and open space for developers, homeowners, realtors, bankers, etc.	MRC TSWCD	Staff/volunteer time; Costs to be determined	Ongoing	Stakeholders contacted
E&O	Lower Mosquito Cr. corridor	Review all development and transportation proposals; attend public meetings; provide input on environmental impacts	MRC	Staff/volunteer time	Ongoing	Projects evaluated; comments submitted
Res	Mosquito Creek watershed	Revise 100-year and 500-year flood plain maps	FEMA	Agency funding	By 2010	FEMA maps revised
Res	Lower Mosquito Creek, Howland Twp. and City of Niles	Evaluate adequacy of existing storm water retention facilities; identify BMPs for storm water reduction, retention, and treatment.	TCE TSWCD	Staff time	2005 to 2006	Summary report
Proj	Big Run,. and SR46, Bazetta Twp.	Establish riparian buffer	TSWCD MRC	Staff time	By Dec., 2005	Ft. of stream protected
Proj	Big Run, Ridge Rd., Fowler Twp.	Livestock exclusion for 5-10 horses; establish riparian buffer	TSWCD NRCS	Staff time for grant-writing	By Dec., 2007	Meeting w/ land-owner; animals excluded
Proj	Big Run (south branch) Cadwallader-Sonk and Henn Hyde Rds.	Livestock exclusion for 5-10 horses; establish riparian buffer	TSWCD NRCS	Staff time for grant-writing	By Dec., 2007	Meeting w/ land-owner; animals excluded
Proj	Big Run (south branch) Cadwallader-Sonk and Henn Hyde Rds.	Natural or two-stage channel design	MRC TSWCD	Time for grant-writing	By Dec., 2008	Ft. of stream restored
Proj	Big Run (south branch) Henn Hyde Rd.	Eliminate discharge from failing HSTS	TCBH MRC		To be deter-mined locally	Number of failing HSTS eliminated.
Proj	Spring Run, west of SR46	Establish riparian buffer	TSWCD MRC	Staff time	By Dec., 2005	Ft. of stream protected
Res	Lower Mosquito Cr.; Spring Run; Big Run; Confusion Run	Monitor fish, macroinvertebrates, and QHEI	OEPA TSWCD		Every 5 years	IBI, MIwb, ICI, QHEI

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:

- Eastgate – Eastgate Regional Council of Governments
- MRC – Mahoning River Consortium
- OEPA – Ohio Environmental Protection Agency
- TCE – Trumbull County Engineer
- TSWMD – Storm Water Management District
- TCBH – Trumbull County Board of Health
- NRCS – Natural Resources Conservation Service
- TCBH – Trumbull County Board of Health
- TSWCD – Trumbull Soil & Water Conservation District

Lower Mahoning River Corridor Watershed Action Plan

Problem #LM-1: Bottom and bank sediments along the entire lower Mahoning River are highly contaminated with priority organics (e.g., PAH, PCBs), heavy metals, and oil/grease. Nearly the entire reach is in non-attainment of warmwater habitat criteria, and fish have a high incidence (average about 15%) of DELT anomalies (deformities, fin erosions, lesions, and tumors). Ohio Department of Health advisories against fish consumption and wading have been in effect for many years.

Goals:
LM-1A. Remove contaminated sediments from river bottom; remove, treat, or isolate contaminated bank sediments.
LM-1B. Eliminate the Ohio Department of Health's fish consumption and swimming/wading advisories.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Res	Lower Mahoning R.; Leavittsburg to PA line	Complete Feasibility Study of sediment dredging and river restoration (in progress).	USACE Eastgate	$3 million	April, 2003 to May, 2005	Feasibility Phase report published.
Res	Lower Mahoning R.; Leavittsburg to PA line	Identify local sponsor and funding source(s) for design and construction phases	USACE MRC	Time: grant writing	Dec., 2005	Letters of commitment
E&O	Mahoning R. watershed	Conduct educational programs targeted to specific stakeholders (e.g., K-12, political leaders, businesses, farmers, gen. public) to promote: ▪ river knowledge, appreciation ▪ support for restoration	MRC YSU	$25,000/yr Time: grant writing; volunteers	Ongoing	Number of stakeholders participating
Proj	Lower Mahoning R.; Leavittsburg to PA line	Complete pre-construction engineering and design (PED) for river remediation (in phases moving downstream)	USACE; Local sponsor	$10 million	2006 to 2015	PED reports completed.
Proj	Lower Mahoning R.; Leavittsburg to PA line	Remove contaminated sediments; restore riparian zone	USACE; Local sponsor	$100 million	2008 to 2017	River miles restored.
Res	Lower Mahoning R.; Leavittsburg to PA line	Conduct surveys of fish species distribution, DELT anomalies, and fish tissue analysis for priority organics.	OEPA	Agency funding	Every 5 years	Incidence of DELT; tissue pollutant levels.
Res	Lower Mahoning R.; Leavittsburg to PA line	Measure residual levels of priority organics and heavy metals in bottom sediments	OEPA	Agency funding	Every 5 years	Pollutant concs.
Pol	Lower Mahoning R.; Leavittsburg to PA line	Reevaluate fish consumption and swimming/wading advisories	ODH OEPA	Staff time	Every 5 years	Removal of advisories

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
- Eastgate – Eastgate Regional Council of Governments
- ODH – Ohio Department of Health
- USACE – U.S. Army Corps of Engineers
- MRC – Mahoning River Consortium
- OEPA – Ohio Environmental Protection Agency
- YSU – Youngstown State University

Problem #LM-2: The lower Mahoning River is impounded at nine locations by low head dams, mostly built by steel manufacturers to provide a source of cooling water. These dams impede fish migration and recreation, have negative impacts on river quality (e.g., higher temperature and lower dissolved oxygen) and degrade aquatic habitat (deposition of contaminated sediment; decreased habitat diversity). The dams are an important factor contributing to the non-attainment of warmwater habitat criteria.

Goals:
LM-2A. Increase QHEI scores to 65 or greater throughout the lower Mahoning River.
LM-2B. Achieve attainment of warmwater habitat criteria throughout the lower Mahoning River.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Proj	Lower Mahoning R.; Leavittsburg to PA line	Evaluate uses and functions of low head dams; estimate cost of removal	USACE TCPC	Feasibility Study funding; staff time	Ongoing; By May, 2005	Feasibility Phase report completed
Proj Res	Lower Mahoning R.; Leavittsburg to PA line	Evaluate USACE authority and identify alternative sources of funding (including ODOT)	USACE Eastgate MRC TCPC	Feasibility Study funding; volunteer time	Ongoing; By May, 2005	Authority and funding source identified
E&O	Cities bordering Lower Mahoning R.	Hold public meetings on benefits and costs of dam removal; solicit public and political support	USACE Eastgate MRC	Feasibility Study funding; volunteer time	Ongoing; By Dec., 2005	Meetings held
Res Proj	Warren Dam and Girard Dam	Identify and install alternate water supplies for industries relying on these dams	MRC Industries ODOD	Staff/volunteer time; Funding	By 2015	Water supplies replaced
Proj	Lower Mahoning R.; Leavittsburg to PA line	Remove all dams; larger dams should be removed after the remediation of contaminated sediments upstream	USACE? MRC TCPC Others to be determined	$4.2 million (preliminary USACE est.)	2004 to 2017	Dams removed
Res	Lower Mahoning R.; Leavittsburg to PA line	Conduct surveys of habitat, fish, and macroinvertebrates; evaluate QHEI, IBI, MIwb, and ICI.	OEPA	Agency funding	Every 5 years	QHEI, IBI, MIwb, and ICI scores

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
- Eastgate – Eastgate Regional Council of Governments
- ODOT – Ohio Department of Transportation
- OEPA – Ohio Environmental Protection Agency
- USACE – U.S. Army Corps of Engineers
- ODOD – Ohio Department of Development
- MRC – Mahoning River Consortium
- TCPC – Trumbull County Planning Commission

Problem #LM-3: Several of the cities along the lower Mahoning River have combined sewers that discharge to the river and its tributaries. Rainfalls of sufficient intensity cause overflows carrying untreated sewage into the river. In addition, discharges from malfunctioning home sewage treatment systems (HSTS) in unsewered areas enter the Mahoning River. Bacterial contamination from combined sewer overflows (CSOs) and malfunctioning HSTS poses a threat to human health for both local and downstream communities.

Goal:
LM-3A. Eliminate discharges from combined sewer overflows and home sewage treatment systems to the lower Mahoning River and its tributaries.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Res	Lower Mahoning R. corridor	Conduct studies to quantify CSO discharges	Cities	Funding for consultants	Ongoing; By Dec., 2006	Reports prepared
Res	Lower Mahoning R. corridor	Complete TMDL study for bacteria	OEPA Cities Counties	Funding for consultants	Ongoing; By Dec., 2004	Report completed
E&O	Lower Mahoning R. corridor	Provide educational material to landowners, developers, and public officials on BMPs to reduce storm water. Solicit commitment for implementation	MRC Cities SWCDs	Staff/volunteer time;	By Dec., 2006	Stakeholders contacted
Res Proj	Lower Mahoning R. corridor	Identify and implement projects to replace 100 acres of impervious surface with gravel, permeable pavers, etc.	MRC Cities SWCDs TCE; MCE	Time for grant writing; cost to be determined	By 2008	Acres of impervious surface eliminated
Pol E&O	Lower Mahoning River corridor	Adopt and implement storm water management programs, including: ▪ Strong public education and outreach ▪ Max. use of non-structural BMPs ▪ Riparian and wetland setbacks ▪ Conservation subdivisions ▪ Strict enforcement	City Engineers MSWCD TSWCD	Staff time	By Dec., 2004	Rules adopted
Res	Lower Mahoning River Corridor cities	Evaluate adequacy of storm water retention facilities	City, County Engineers	Staff time	By 2006	Summary reports
Proj	Lower Mahoning River Corridor cities	Upgrade storm water retention facilities where necessary	City, County Engineers	To be determined	To be determined	Peak flows reduced
Proj	Lower Mahoning River corridor	Improve storm and sanitary sewers to reduce CSO discharge: ▪ Separate storm and sanitary ▪ Increase capacities	City Engineers	Funding; staff time for grant-writing (e.g., HUD-CDBG)	Ongoing	Gallons of discharge prevented
Proj	Mahoning River	Install sanitary sewers in all unsewered areas discharging to the Mahoning River	Ohio EPA TCBH MCBH TCE, MCE	To be determined	To be determined	Gallons of discharge prevented

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:

CDBG – Community Development Block Grant
MCBH – Mahoning County Board of Health
MRC – Mahoning River Consortium
TCE – Trumbull County Engineer
TSWCD - Trumbull Soil & Water Conservation District
HUD – U.S. Dept. of Housing and Urban Development
MCE – Mahoning County Engineer
TCBH – Trumbull County Board of Health
MSWCD – Mahoning Soil & Water Conservation District

Problem #LM-4: Suspended solids (SS) concentrations in the Mahoning River and its tributaries are high, especially during and after rainfall events. The annual SS load is estimated at 16,600 tons/yr, with 94% originating from nonpoint sources. Agriculture, construction activity, urban runoff, and stream bank erosion throughout the Mahoning River watershed contribute significantly to this problem. Suspended sediment impairs the use of the river for recreation and water supply. Sediment deposition impairs aquatic habitat.

Goal:
LM-4A. Reduce suspended solids load in the lower Mahoning River by 25%.

Action Plan:
Several action items under Problem #LM-3 focus on reducing storm water runoff and peak flows. These will also contribute to a reduction in sediment export from the immediate lower Mahoning River corridor, as well as a reduction in the contribution of stream bank erosion to the sediment load. The following additional actions are proposed:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Res	Mahoning River watershed	Quantify sources of SS; evaluate cost effectiveness of BMPs.	MRC YSU	Volunteer time	By Aug., 2005	Summary report prepared
Res	Lower Mahoning R. corridor	Complete TMDL study for SS and nutrients	OEPA	Funding for consultants	To be determined	Reports completed
E&O	Mahoning River watershed	Promote NRCS programs and agricultural BMPs to farmers	NRCS; County SWCDs	Staff time	Ongoing	Info packets distributed
Proj	Mahoning River watershed	Increase use of conservation tillage to 90% of crop land	NRCS; County SWCDs	Staff time	By 2015	Acres converted to conservation tillage
Proj	Mahoning River watershed	Establish 50 miles of riparian buffers and filter strips	NRCS; County SWCDs	Staff time	By 2015	Miles of streams protected
Proj	Mahoning River watershed	Encourage reforestation and wetland development in watershed.	MRC SWCDs USACE	Staff time	Ongoing	Acres of land converted
Proj	Lower Girard Lake	Stabilize erosion from lake bed	MRC Girard	To be determined	By Dec., 2004	Measures implemented
Proj E&O	Lower Girard Lake	Convert lake bed to wetlands; design and implement related educational projects	MRC Girard	To be determined	By Dec., 2006	Acres of wetland created
E&O	Mahoning River watershed	Conduct educational programs for various stakeholder groups (e.g., political leaders, developers, public) on stream ecology and protection	MRC YSU	Volunteer time; grant writing	Ongoing	Number of stakeholders participating
Res	Lower Mahoning River Corridor	Conduct survey of river bank erosion and riparian buffers	MRC YSU	Volunteer time	By Aug., 2005	Summary report prepared
Proj	Lower Mahoning River Corridor	Establish riparian buffers where absent; expand existing buffers	MRC	Volunteer time	To be determined	Ft. of river protected
Res	Lower Mahoning River Corridor	Evaluate flood plain connectivity and natural channel features	MRC YSU	Volunteer time	By Dec., 2006	Summary report prepared
Proj	Lower Mahoning River Corridor	Implement projects to improve flood plain connectivity, sinuosity, etc.	To be determined	To be determined	To be determined	Ft. of river improved
Res	Lower Mahoning R.; Leavittsburg to PA line	Conduct surveys of water quality, fish, macroinvertebrates and QHEI	OEPA	Agency funding	Every 5 years	SS, QHEI, IBI, MIwb, and ICI scores

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
- MSWCD – Mahoning Soil and Water Conservation District
- NRCS – Natural Resources Conservation Service
- TSWCD – Trumbull Soil and Water Conservation District
- YSU – Youngstown State University
- MRC – Mahoning River Consortium
- OEPA – Ohio Environmental Protection Agency
- USACE – U.S. Army Corps of Engineers

Problem #LM-5: The accumulation of trash in and along the lower Mahoning River impairs the aesthetic quality of the river, and may have negative impacts on aquatic and terrestrial species of wildlife. Urban storm water runoff and illegal dumping are the primary sources of this problem.

Goal:
LM-5A. Substantially reduce the accumulation of trash in and along the lower Mahoning River.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
E&O	Lower Mahoning River corridor	Conduct public information programs – e.g., storm drain labeling; litter prevention	MRC MCRD YSU	Time: grant writing; volunteers	Ongoing	Stakeholders participating
E&O Proj	Lower Mahoning River corridor	Conduct stream cleanup events in selected locations, w/ emphasis on those used for recreation	MRC	Volunteer time; misc. supplies	Annually	Events held; Numbers of participants; Quantities of trash
Res	Lower Mahoning River Corridor cities	Evaluate adequacy of storm water treatment facilities	MRC; City Engineers	Staff time	By 2006	Summary reports
Proj	Lower Mahoning River Corridor cities	Construct storm water treatment facilities as necessary	MRC; City Engineers	To be determined	To be determined	Vol. of water treated; Quantities of trash

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
- MRC – Mahoning River Consortium
- MCRD – Mahoning County Recycling Division
- YSU – Youngstown State University

Problem #LM-6: The Mahoning River's ecological, recreational, aesthetic, commercial, and bequest values will be enhanced by restoration projects. The river is a valuable but underutilized asset for the region.

Goals:
LM-6A. Increase access and recreation opportunities on the lower Mahoning River.
LM-6B. Redirect development from forested and undeveloped areas of the watershed to vacant urban land in the Lower Mahoning River Corridor.
LM-6C. Fully realize the bequest value of the Mahoning River.

Action Plan:

Action Type	Location	Proposed Action	Lead Parties	Resources Required	Time Frame	Performance Indicators
Proj E&O	Mahoning R.	Solicit public input on recreational use and access to Mahoning R.	USACE Eastgate MRC	Feasibility Study funding; volunteer time	Ongoing; By Dec., 2006	Meetings held
Res	Lower Mahoning River	Estimate potential economic benefits of recreation	USACE OSU	Feasibility Study funding	Ongoing; By Dec., 2006	Reports published
Proj	Lower Mahoning River	Establish access facilities for recreational use	USACE MRC	To be determined	2009 to 2020	Facilities constructed
Res Proj	Lower Mahoning River	Identify and implement projects to enhance the aesthetic quality, wildlife habitat, and sustainability of the river corridor	MRC	To be determined	2005 to 2020	Acres of riparian buffer; wildlife counts; etc.
E&O	Mahoning River	Organize and hold public events to encourage recreational use of the river	MRC	$3000/yr; volunteer time	Ongoing	Number of participants
Proj	Lower Mahoning River watershed	Develop plans for redevelopment of vacant urban land; incorporate protection and appreciation of Mahoning R.	CASTLO Cities	To be determined	Ongoing	Plans completed
Proj	Lower Mahoning River watershed	Promote environmentally responsible development on vacant urban land; discourage suburban sprawl.	CASTLO Cities MRC	Staff/volunteer time	Ongoing	Info packets distributed to stakeholders
E&O	Lower Mahoning River watershed	Introduce programs in K-12 schools to promote understanding and stewardship of Mahoning River and watershed	MRC YSU Schools	Staff/volunteer time; $50,000/yr	Ongoing	Schools and students participating
Res	Lower Mahoning River	Conduct surveys to assess public use of facilities, economic impact of recreation, attitudes toward the river, etc.	MRC YSU	Time for grant writing	2010 to 2020	Report published

Types of Actions: Proj – Project; E&O – Education and Outreach; Res – Research; Pol – Policy
Organizations:
CASTLO – Campbell/Struthers/Lowellville Community Improvement Corp.
Eastgate – Eastgate Regional Council of Governments
ODOD – Ohio Department of Development
USACE – U.S. Army Corps of Engineers
MRC – Mahoning River Consortium
OSU – Ohio State University
YSU – Youngstown State University

Chapter 6
Implementation, Evaluation and Revision of Watershed Action Plan

Implementation

Preliminary time frames are listed for most proposed actions/objectives in the action plans presented in Chapter 5. These are subject to revision as priorities are evaluated at the local level. Several education strategies are included in the action plans. In addition, written endorsement of the Plan will be sought from numerous local political entities, and this process will provide an important opportunity for further education of this key stakeholder group.

If ample funding were available, the following four goals would receive the highest priority:

1. Remove contaminated bottom and bank sediments from the Lower Mahoning River (Goal LM-1A);
2. Prevent further development in the 500 year flood plain and other ecologically valuable areas in the lower Mosquito Creek corridor (Goals MC-4A and MC-4B).
3. Eliminate surface discharges of pollutants from home sewage treatment systems in the Mosquito Creek watershed (Goal MC-2A); and
4. Reduce sediment loading to Mosquito Creek Reservoir in order to protect current uses (Goal MC-1A).

Progress toward these goals would yield the greatest contributions toward the goals of aquatic use attainment. However, the availability of funding may dictate the order of implementation of action items in the Plan. In evaluating BMPs for pollutant loading reductions, USEPA's STEPL model and other predictive tools will be applied to prioritize prospective projects based on cost-effectiveness. This will require site specific information that is not available at this point in the planning process.

One of the most precious resources in implementing the Plan will be staff time. Thus, a key priority of the Mahoning River Consortium, not listed in the Watershed Action Plan, is to secure funding for, and hire, a qualified and energetic Mahoning River Watershed Coordinator.

Evaluation

Performance indicators listed in Chapter 5 for all proposed actions/objectives. Tracking progress toward attainment of aquatic use standards will require periodic monitoring of water, sediment, biota, and habitat quality. While Ohio EPA's monitoring program is extremely valuable, it lacks the necessary frequency and geographic coverage. Thus, maximum use will be made of volunteer monitoring, and alternative funding sources will be sought for supplemental monitoring programs.

An aggressive publicity campaign will keep stakeholders informed of progress in implementation of the Plan, and toward attainment of water quality standards. Mechanisms will include press releases to local media, MRC newsletters, watershed festivals, talks to community groups, progress reports to political officials, etc.

Plan Update/Revision

Copies of the full Watershed Action Plan will be distributed to key stakeholder groups for review and written endorsement. It is not expected that changes in the problem statements or goals will be necessary for many years. However, projected time frames and priorities are almost certain to change and should be considered flexible. In addition, action items may be added if necessary, or be removed if accomplished. The Board of Directors of the Mahoning River Consortium will be ultimately responsible for implementation and revision of the Plan. Time frames and priorities will be evaluated continuously throughout the implementation of the Plan. The MRC Board will organize an *ad hoc* committee whenever necessary to review the Plan, coordinate its revision, and inform stakeholders of any significant changes. A complete review and revision of the Plan will take place, at a minimum, every five years.

References

Ahmad, M.F., 2004. Estimation of Point Source and Nonpoint Source Loadings in the Mahoning River Watershed. Master's Thesis, Youngstown State University, Youngstown, OH, 85 p.

Christou, C., 2002. Impact of Historic Trends in Nutrient Loading on the Trophic Status of Meander Creek Reservoir. Master's Thesis, Youngstown State University, Youngstown, OH, 52 p.

Farran, G.M., 1990. Inorganic Chemical Profiles of the Sediment Cores from Six Northeastern Ohio Reservoirs, Master's Thesis, Youngstown State University, Youngstown, OH.

FISRWG, 1998. Stream Corridor Restoration: Principles, Processes, and Procedures. Federal Interagency Stream Restoration Working Group. Published by National Technical Information Service, Springfield, VA.

Ohio EPA, 1996. Biological and Water Quality Study of the Mahoning River Basin, OEPA Technical Report MAS/1995-12-14, Ohio Environmental Protection Agency, Division of Surface Water, Columbus, OH.

Ohio EPA, 1997. A Guide to Developing Local Watershed Action Plans in Ohio, 79 p.

Rosgen, D., 1996. Applied River Morphology, Second Edition, Wildland Hydrology, Pagosa Springs, CO.

Solley, W.B., Pierce, R.R., and Perlman, H.A., 1998. Estimated use of water in the United States in 1995: U.S. Geological Survey Circular 1200, 71 p.

USACE, 1994. Mosquito Creek Lake Master Plan, U.S. Army Corps of Engineers, Pittsburgh District, 143 p.

USACE, 1999. Mahoning River Environmental Dredging Reconnaissance Study, U.S. Army Corps of Engineers, Pittsburgh District.

Wetzel, R.G., 2001. Limnology, Third Edition. Academic Press.

Yahaya, B.M., 2004. Nonpoint Source Pollution in the Mosquito Creek Watershed. Master's Thesis, Youngstown State University, Youngstown, OH, 61 p.

Appendix A

- QHEI Score Sheets

Ohio EPA Qualitative Habitat Evaluation Index Field Sheet QHEI Score: ____

River Code: ____ **RM:** ____ **Stream:** ____
Date: ____ **Location:** ____
Scorers Full Name: ____ **Affiliation:** ____

1] SUBSTRATE (Check ONLY Two SubstrateTYPE BOXES; Estimate % present

TYPE POOL RIFFLE / 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

NUMBER OF SUBSTRATE TYPES: (High Quality Only, Score 5 or >)
- ☐-4 or More [2]
- ☐-3 or Less [0]

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 ☐ Max 20

COMMENTS ____

2] INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions) (Structure) **TYPE:** Score All That Occur

- ___UNDERCUT BANKS [1]
- ___OVERHANGING VEGETATION [1]
- ___SHALLOWS (IN SLOW WATER) [1]
- ___ROOTMATS [1]
- ___POOLS> 70 cm [2]
- ___ROOTWADS [1]
- ___BOULDERS [1]
- ___OXBOWS, BACKWATERS [1]
- ___AQUATIC MACROPHYTES [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 ☐ 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	

Channel ☐ Max 20

COMMENTS: ____

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 ☐ 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]

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 ☐ Max 12

COMMENTS: ____

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 ☐ Max 8

COMMENTS: ____ ☐- NO RIFFLE [Metric=0]

6] GRADIENT (ft/mi): ____ DRAINAGE AREA (sq.mi.) : ____

%POOL: ☐ %GLIDE: ☐
%RIFFLE: ☐ %RUN: ☐

Gradient ☐ 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) ☐

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?