APPLICATION OF TECHNIQUES TO IDENTIFY WETLAND MITIGATION AND STREAM RESTORATION OPPORTUNITIES

by

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Submitted in Partial Fulfillment of the Requirements

for the Degree of

Master of Science in Engineering

in the

Civil and Environmental Engineering

Program

YOUNGSTOWN STATE UNIVERSITY
AUGUST 2003

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ABSTRACT

The major goals of this project were to identify wetland mitigation opportunities within the Meander Creek, Mill Creek and Yellow Creek watersheds and stream restoration opportunities in Meander Creek watershed. The project involved application of a ranking system for wetland mitigation potential to forty-three land parcels, and development of a geographic information system (GIS) based procedure to evaluate and map two metrics of the Qualitative Habitat Evaluation Index (QHEI) - Riparian Width and Flood Plain Quality. Field inspections were conducted at sites with high potential for wetland mitigation and stream restoration in order to evaluate the strengths and limitations of the procedures. The methods use well established, publicly available GIS databases, including soil type, land cover, waterways, and topography overlaid in digital format so that the watershed study area can be analyzed spatially.

The wetland mitigation study generated numerically ranked lists of potential wetland mitigation sites in each watershed. The stream restoration study produced color-coded maps of stream corridor conditions in the Meander Creek Watershed. Field inspections confirmed the accuracy of the GIS-based rankings in most cases. The study results can serve as a starting point for approaching landowners to discuss the acquisition of land parcels for wetland mitigation. Further analysis of stream segments is recommended, using a technique that incorporates additional measures of stream health.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Scott C. Martin, for his guidance, advice, time and support, without which this project would not have been possible. During my two year association with him, two of his qualities that I observed were willingness to help everybody who was in need and a limitless patience to listen to what others had to say. I also wish to thank the Center of Urban and Regional Studies (CURS) at Youngstown State University for allowing me to use their GIS capabilities. I had a great time at CURS with Mr. John Bralich, who taught me the art and power of using GIS map overlays. He is an expert in GIS applications and was always there when I needed him the most. I wish to thank Dr. Douglas Price and Dr. Lauren Schroeder for accepting to serve on my defense committee. I would like to extend my appreciation to the Mahoning County Soil and Water Conservation District for providing funding for this project. I wish to thank the best department secretary at YSU, Linda Adavasio, for her constant motivation and help to see that I completed my thesis on time. I would like to let my family and friends know how much I appreciate them for their support and inspiration. I would like to send a prayer of thanks and dedicate this project to my dad who passed away last year.

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Chapter 1

INTRODUCTION

1.1 Background Information

1.1.1 Location of Watersheds

A basic goal of the Clean Water Act is the protection of biological integrity of the streams and the rivers of the United States. The Mahoning River, near the city of Youngstown in Northeastern Ohio has several tributaries, including, Mill Creek, Yellow Creek and Meander Creek, which are critical to the economy and the quality of life in the region. (Martin, 2001) These three watersheds cover about 60% of Mahoning County as shown in Figure 1.1. A brief description of each watershed follows.

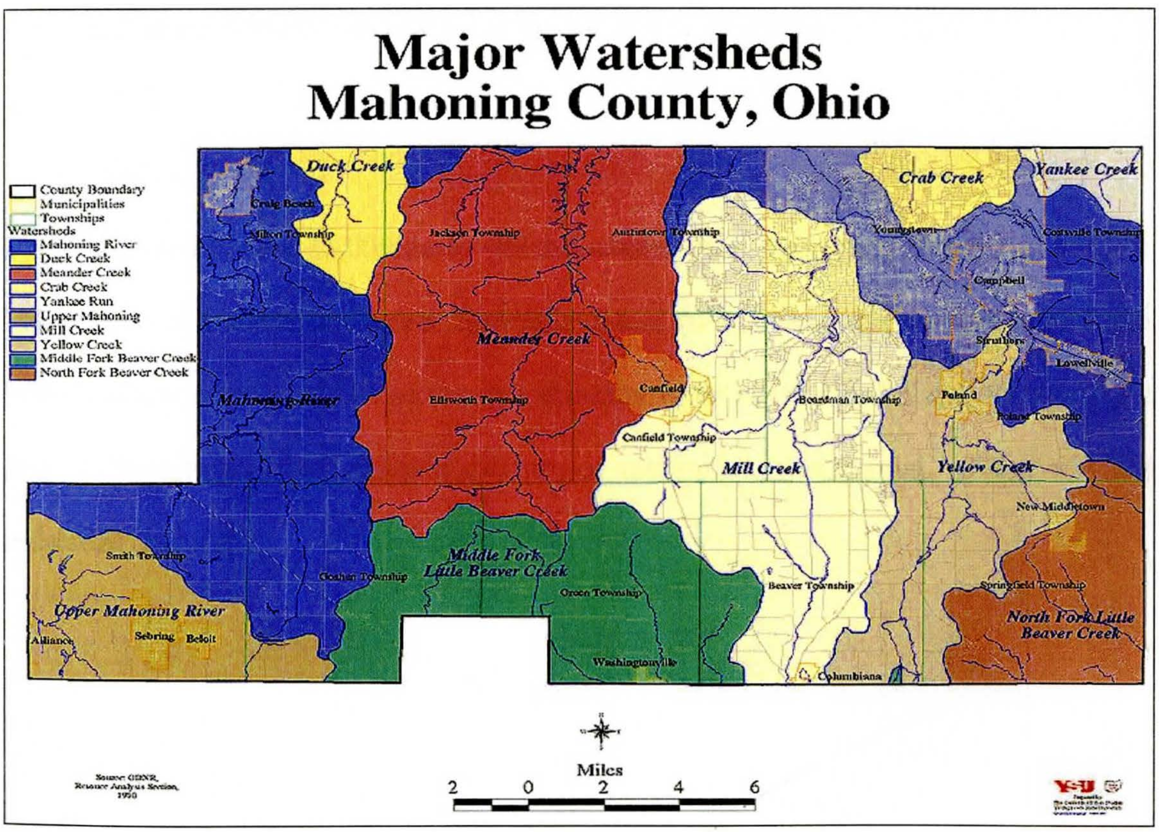


Figure 1.1 Major Watersheds in Mahoning County, Ohio (YSU-CURS)

1.1.2 Meander Creek

This watershed covers 50,000 acres which includes Meander Creek Reservoir and parts of Jackson, Milton, Austintown, Canfield, Goshen and Green Townships. Land use is mostly agricultural, with some residential and commercial. This is the drinking water supply for the Cities of Youngstown and Niles, as well as surrounding areas (e.g. Austintown, Canfield, Boardman).

1.1.3 Mill Creek

This watershed covers 47,000 acres which includes Mill Creek Park and the Canfield Fairgrounds, and parts of the City of Youngstown, as well as Canfield, Beaver, Boardman, and Austintown Townships. Land uses include recreational and residential areas, and heavy commercial activity along SR 224 in Boardman.

1.1.4 Yellow Creek

This watershed covers 23,000 acres which includes Pine, Hamilton, Burgess and Evans Lakes, parts of Boardman, Beaver, Springfield, and Poland Townships and also the Cities of Poland and Struthers. This serves as a drinking water supply for Poland, Struthers and part of Boardman. Land use is a mixture of residential, commercial, agriculture, and industrial (mining).

1.2 Problem Description

There has been a substantial population shift from the City of Youngstown to the southern and western suburbs and rural areas. This movement has resulted in water quality problems within each watershed. Three manmade lakes (Newport, Cohasset, and Glacier) along Mill Creek in Mill Creek Park are all highly eutrophic as a result of high nutrient loading from both point and nonpoint sources in the watershed. (Martin, 2001) In Meander Creek Reservoir, the area's primary source of drinking water, severe taste and odor problems have occurred due to the growth of algal blooms believed to be the result of an increase in nutrient loading from nonpoint sources (e.g., residential development). Also, heavy sediment loading from farms and construction sites has caused the deposition of over 400,000 cubic yards of sediment in Lake Newport. (Martin, 2001) Nonpoint source nutrient loading has led to high productivity in reservoirs along Yellow Creek. Heavy runoff from many shopping plazas has caused increased streambank erosion and deposition of trash in flood plain wetland areas. Mill Creek MetroParks administrators have observed the severe stress on wildlife populations resulting from the loss of habitat as a consequence of the new development. One such observation is a deer population increase to nearly six times the estimated sustainable limit despite continuing efforts to control the population. (Martin, 2002)

A noticeable trend concurrent with development, and that has contributed to water quality impairment, is the destruction of riparian areas and wetlands in the watersheds. In order to protect these riparian areas, a local watershed group, AWARE (Alliance for Watershed Action and Riparian Easements) has focused much of their attention in the Mill Creek and Yellow Creek watersheds. Despite this effort, the loss of riparian areas and wetlands continues with development. When developers disturb more than 0.1 acre of wetlands on a construction site, a Section 404 permit is required from the U.S. Army Corps of Engineers. Under Section 404 of the Clean Water Act, wetlands may legally be destroyed, but their loss must be compensated for by the restoration, creation, or enhancement of other wetlands. In theory, this strategy should result in "no net loss" of wetlands. This process of restoration, creation or enhancement is termed "mitigation." While preference is given to mitigation on-site or within the same watershed, there has been little adherence to this standard within the three watersheds. As an effort to alleviate the problems due to destruction of riparian areas and wetlands in the watersheds, AWARE along with Mahoning Soil and Water Conservation District (MSWCD) initiated a project to develop Wetland Mitigation and Stream Restoration Plans for the three watersheds. The goals of this project are as follows:

1) Develop a geographic information system (GIS) database for wetlands and related factors in Mill Creek, Yellow Creek, and Meander Creek watersheds;
2) Develop a convenient GIS-based procedure to identify locations with greatest potential for wetland mitigation;
3) Apply the procedure to identify and rank several prospective mitigation sites in the three watersheds and evaluate its performance; and
4) Develop a GIS-based procedure that acts as a screening tool to identify the most degraded stream reaches in each watershed.

Youngstown State University (YSU) accepted responsibility for the management and execution of the proposed project after having received input from the AWARE Wetland

Mitigation Committee. The Ohio Department of Natural Resources (ODNR), through the MSWCD, provided a grant to fund the project.

1.3 Statement of Study Goals:

The project study involved substantial contributions by former YSU graduate students Scott Airato and Robert A. Willamson. Building upon their contributions, the goals established for this study were as follows:

1) Apply a ranking system for wetland mitigation potential to land parcels within the three watersheds;
2) Develop a GIS-based procedure for obtaining two metrics of the Qualitative Habitat Evaluation Index (QHEI)- Riparian Width and Flood Plain quality;
3) Evaluate and map the two QHEI metrics for all streams in the Meander Creek Watershed; and
4) Conduct field inspection of sites with high potential of wetland mitigation and stream restoration.

Chapter 2

LITERATURE REVIEW

2.1 What are Wetlands?

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season. Wetlands are the link between land and water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils and vegetation, making these areas very important features of a watershed. A general or a potential jurisdictional wetland is defined as an area having one or more of the three indicators (vegetation, soil type, and hydrology) of jurisdictional wetlands. (Lyon, 2001) Figure 2.1 shows a picture of a wetland.

Figure 2.1 Wetland (ce:http://lwcd.org/WetlandPics.htm)

Jurisdictional wetlands are defined as those areas that are inundated by surface or ground water for a frequency and duration sufficient to normally support vegetation adapted to hydric soils or reducing soil conditions. (Environmental Laboratory, 1987) Jurisdictional wetlands are defined by field procedures using the *U.S. Army Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) and subject to USACE oversight. General wetlands differ from jurisdictional wetlands because they can be inventoried using a variety of techniques in addition to field visits. This distinction allows for assessment and inventory of wetlands over large areas using aerial photographs, GIS, satellite remote sensing data, and field evaluation.(Lyon, 2001) A general wetland may or may not be a jurisdictional wetland, but has a value based on its potential to be enhanced, restored, or protected from future development.

2.2 Types of Wetlands

The U.S. Department of the Interior's Fish and Wildlife Service has classified five major categories of wetlands also known as the National Wetlands Inventory (NWI) Classification - *Marine, Estuarine, Palustrine, Lacustrine*, and *Riverine.* (Cowardin et al., 1979) The watersheds considered in this study contain only *Palustrine, Lacustrine,* and *Riverine* wetlands. A brief description of these three types follows. (Cowardin et al., 1979)

Palustrine: "Palustrine" comes from the Latin word "palus", or marsh. Wetlands within this category include inland marshes and swamps as well as bogs, fens, tundra and floodplains. It also includes the small, shallow, permanent or intermittent bodies of water called ponds. Palustrine systems include any inland wetland which lacks flowing water and contains ocean derived salts in concentrations of less than .05%.

Lacustrine: The term "lacustrine" is related to the word "lake" - thus a lacustrine wetland is, by definition, lake-associated. This category may include freshwater marshes, aquatic beds, as well as lakeshores. The Lacustrine system is bounded by upland or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and by contour approximating the normal spillway or pool elevation for systems formed by damming a river channel.

Riverine: The term "riverine" is related to the word "river" and refers to any habitat fed by water flowing through a channel. Riverine wetland habitat includes river banks, streams, freshwater marshes, and freshwater aquatic beds. The riverine system terminates downstream where the channel enters a lake, and upstream where the channel leaves a lake.

A number of common terms have been used over the years to describe the types of wetlands. Some of these names are tabulated in Table 2.1.

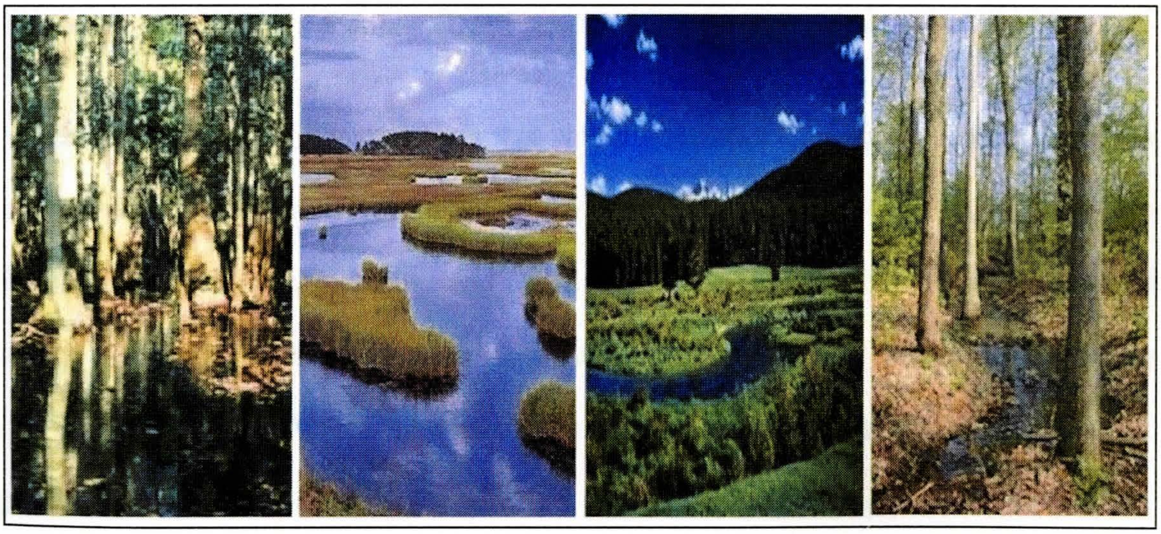
Table 2.1 Types of Wetland Areas (http://www.eco-pros.com/types_of_wetlands.htm)

Various Names for Types of Wetland Areas				
Bog	Fen	Cypress swamp	Gulf	Estuary
Peatland	Pond	Prairie pothole	Salt marsh	Vernal pool
Mangrove	Riparian area	Brackish marsh	Tundra	Spong
Baylands	Pocosin	Wet meadow	Lagoon	Stream
Taiga	River	Hardwood swamp	Lake	Saltflat
Seep	Slough	Freshwater marsh	Floodplain	Creek
Channel	Wet pasture	Intertidal mudflats	Spring	Reservoir

Some of these popular wetland terms are described by Mitsch and Gosselink (Mitsch and Gosselink, 1986) as follows:

- Swamp: Wetland dominated by trees or shrubs (reed and grass-dominated wetlands are also called swamps).
- Marsh: A frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions.
- Wet Meadow: It can be defined as grassland with waterlogged soil near the surface but without standing water for most of the year.
- Slough: A swamp or shallow lake system in the Northern and Midwestern United States.

Figure 2.2 shows pictures of these common types of wetlands.



Swamp **Marsh** **Wet Meadow** **Slough**

Figure 2.2 Types of Wetlands (http://www.epa.gov/owow/wetlands/types)

2.3 Functions and Values of Wetlands

Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs. Wetlands provide many beneficial functions as follows. (USEPA, 2002):

- Habitat for Fish, Wildlife, and Plants
- Improving Water Quality and Hydrology
- Flood Protection
- Shoreline Erosion Prevention
- Recreation, Education, and Research

Wetlands remove or slow the movement of sediment, which destroys insect, fish, mollusc and plant habitat in streams. Fish and wildlife use wetlands to varying degrees depending upon the species involved. Some live only in wetlands for their entire lives; others require wetland habitat for at least part of their life cycle; still others use wetlands much less frequently, generally for feeding. (USEPA, 2002)

Wetlands absorb and filter pollutants that would contaminate ground water, rivers, lakes and estuaries. They are the "kidneys of the environment." (Eco-Pros, 2002) They help improve water quality, including that of drinking water, by intercepting surface runoff and removing or retaining inorganic nutrients, processing organic wastes, and reducing suspended sediments before they reach open water. For example, as the runoff water passes through wetlands, they retain or process excess nitrogen and phosphorus, decompose organic pollutants, and trap suspended sediments that would otherwise clog waterways and affect fish and amphibian egg development. In addition to improving water quality through filtering, some wetlands maintain stream flow during dry periods; others replenish groundwater.

Due to their low topographic position relative to uplands (e.g., isolated depressions, floodplains), wetlands store and slowly release surface water, rain, snowmelt, groundwater and flood waters. (USEPA, 2002) Trees and other wetland vegetation also impede the movement of flood waters and distribute them more slowly over floodplains. This combined water storage and slowing action lowers flood heights and reduces erosion downstream and on adjacent lands. It also helps reduce floods and prevents water logging of agricultural lands.

Wetlands protect shorelines and stream banks against erosion because of their position on the landscape, i.e. at the margins of lakes, rivers, bays, and the ocean. Wetland plants hold the soil in place with their roots, absorb the energy of waves, and break up the flow of stream or river currents. (USEPA, 2002)

Wetlands provide for fishing, hunting and outdoor recreation. Nature-based tourism involves birds, many of which are wetland-dependent. These places are used for hiking, boating, and other recreational activities. They are frequently studied in conjunction with environmental programs. They serve as exciting grounds for wildlife photography.

2.4 Wetland Mitigation

As society has come to appreciate the various values of wetlands, it has also generally decided that, in those cases where the destruction of certain wetlands is inevitable (for instance, to allow the construction of a highway), it is desirable to accomplish some sort of replacement for the wetlands that have been lost. This replacement is generally referred to as "mitigation”. This can be achieved by wetland creation, restoration, enhancement, and in some cases, prevention to avoid wetland losses. A brief description of each mitigation type is as follows:

- Creation: Introduction of a wetland at a site where wetlands did not exist historically.
- Restoration: This method refers to activities such as filling in or damming of drainage ditches that result in the reintroduction of wetlands at a site where they existed historically, but did not exist prior to the mitigation activity.
- Enhancement: This term refers to activities that enhance the value of wetland areas that have been degraded. Gwin, et al.,(1999) define enhancement as "the modification of specific structural features of an existing wetland to increase one or more functions based on management objectives, typically done by modifying site elevations or the proportion of open water. Although this term implies gain or improvement, a positive change in one wetland function may negatively affect other wetland functions". One example of enhancement could be increasing the area of deep water by excavating parts of an emergent wetland may provide more duck habitat (the desired wetland value), but may decrease foraging and cover habitat for young fish.
- Preservation: This mitigation type involves actions that lead to the preservation of an existing wetland, for instance, the acquisition of an area of jurisdictional wetlands resulting in ownership being turned over to a conservation agency like

the Fish & Wildlife Service, or an organization like the Nature Conservancy. (US EPA, 2002)

It is interesting to note that the first two mitigation types actually result in the conversion of non-wetland areas to a wetland. (U.S. EPA, 2002) Of these, the regulatory agencies prefer restoration, because it is generally felt that wetlands returned to a site where they occurred naturally are likely to provide more ecological functions than wetlands established on a site where they did not occur naturally.

2.5 Source Data for Watershed Geographic Information System (GIS) Databases

The advent of Geographic Information Systems (GIS) has provided a powerful inventory, analysis and educational tool for the investigation of mitigation opportunities within watersheds. (Schloss and Mitchell, 1996) The fundamental layers of source data used to create the watershed GIS for this study were obtained from the Ohio Department of Natural Resources (ODNR) and the United States Geological Survey (USGS). From ODNR, 1994 Land Cover, 1971 Soil Maps, and the 1987 Ohio Wetlands Inventory (OWI) were used. Table 2.2 shows a breakdown of the source data used in the GIS. The land coverage was produced by digital image processing utilizing a multi-spectral scanner that collects electromagnetic radiation reflected from the earth's surface in the visible, near infrared and mid-infrared wavelength bands. This is called Landsat Thematic Mapper Data, the resolution of which is a 30 meter by 30 meter cell. The data were classified into general land cover categories as shown in Table 2.3. (ODNR, 2000)

Table 2.2 Source of GIS Data

Data Set	Data Source	Most Recent Year Available
Roads Hypsography (10-ft contour intervals) Township Boundary Municipal Boundary Hydrology	USGS	Taken from most recent 7.5-minute quadrangle sheet prior to 1995
Watershed Boundary Land Cover Soil Type (OCAP Codes) Underground Abandoned Mines Ohio Wetlands Inventory (OWI)	ODNR	1980 1994 1971 1995 1987
National Wetlands Inventory	US Fish and Wildlife Service	April 1977
Aerial Photograph Coverage Cadastral Layer (Parcel Tax Maps) Hypsography (2-ft contour intervals)	Mahoning County Enterprise GIS Files	April 1998

The soils maps were created as a part of an Ohio Capability Analysis Program (OCAP) Land Capability Project in cooperation with the Eastgate Regional Council of Governments and the Mahoning County Planning Commission. From USGS, the Hypsography (10-foot contours) was obtained from the most recent (prior to 1995) 7.5 minute quadrangle in digital line graph (DLG) format at a scale of 1:24,000.

Table 2.3 1994 Land Cover Classification (www.dnr.state.oh.us/gims(ODNR, 2000))

CODE	DESCRIPTION
1	URBAN (open impervious surfaces: roads, buildings, parking lots and similar hard surface areas which are not obstructed from aerial view by tree cover.) See 7. BARREN
2	AGRICULTURE/OPEN URBAN AREAS (cropland and pasture; parks, golf courses, lawns and similar grassy areas not obstructed from view by tree cover)
3	SHRUB/SCRUB (young, sparse, woody vegetation; typically areas of scattered young tree saplings)
4	WOODED (deciduous and coniferous)
5	OPEN WATER
6	NON FORESTED WETLANDS (includes wetlands identified from 1994 Thematic Mapper data as well as from the Ohio Wetlands Inventory)
7	BARREN (strip mines, quarries, sand and gravel pits, beaches) Many of the URBAN features identified in this inventory are constructed from materials obtained from the BARREN features. Because of this, there will on occasion be URBAN areas identified as BARREN as well as BARREN areas identified as URBAN.

2.6 Modeling Wetland Mitigation Potential using GIS

Schloss and Mitchell (1996) explored the use of GIS overlays to model non-regulatory approaches to watershed protection and discovered that overlay mapping was a cost-effective aid in decision-making. Many successful attempts to integrate a GIS database into watershed planning have been documented since then. Some of these include: "Development of a Water Supply Protection Model in GIS", by the Southwest Florida Water Management District, (Griner, 1993) in order to identify lands suitable for water management, water supply, and the conservation and protection of water resources; and "Modeling Wetland Restoration Potential at the Watershed Scale", (White, et al.; 1999) in order to identify existing wetlands within the Cuyahoga River Watershed in northeastern Ohio.

The integration of analytical techniques designed to assess multi-criteria concerns in a GIS can be used as an important tool to evaluate the suitability of sites falling within the feasible areas identified in a standard GIS overlay procedure. (Carver, 1991) The advantages of the GIS multi-criteria evaluation (MCE) can be summarized as follows: (Carver, 1991)

- GIS is an ideal means of performing deterministic analyses on any geographical data.
- GIS provides a suitable framework for the application of spatial analysis methods, like MCE techniques, which do not have their own data management facilities.
- GIS and MCE based systems have the potential to provide a more rational objective and a non-biased approach in decision making.

2.7 Stream Restoration

Stream restoration means the reestablishment of degraded and destroyed parts of the stream at sites where they once existed. The National Research Council (NRC), in its 1992 report, *Restoration of Aquatic Ecosystems*, defined stream restoration as the "return of an ecosystem to a close approximation of its condition prior to disturbance of the stream." That report also states, "The term restoration means the reestablishment of pre-disturbance aquatic functions and related physical, chemical and biological characteristics (Cairns, 1988; Magnuson et al.,1980; Lewis, 1989). Stream restoration is a holistic process not achieved through the isolated manipulation of individual elements.

2.8 Disturbances Affecting Stream Corridors

Disturbances that bring changes to stream corridors and associated ecosystems are natural events or human induced activities that may occur separately or simultaneously. (Federal Interagency Stream Restoration Working Group, (FISRWG) 2001) Fig 2.3 shows how these disturbances place stress on the stream corridor either individually or together and impair its ability to perform key ecological functions. A brief description of each type of disturbance is as follows:

2.8.1 Natural Disturbances

Among the many natural events that disturb the stream corridor are floods, hurricanes, tornadoes, fire, lightning, volcanic eruptions, earthquakes, insects and disease, landslides, temperature extremes and drought. Different ecosystems respond to these disturbances differently, depending on their relative stability, resistance and resilience.

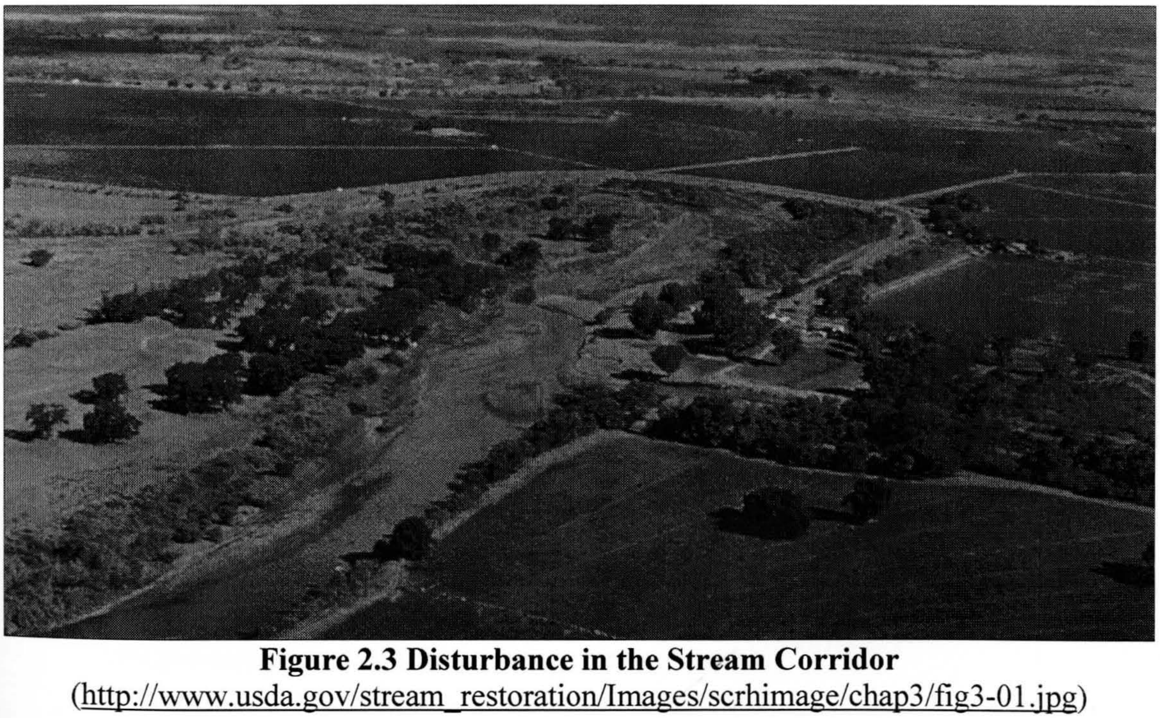


Figure 2.3 Disturbance in the Stream Corridor
(http://www.usda.gov/stream_restoration/Images/scrhimage/chap3/fig3-01.jpg)

2.8.2 Human Induced Disturbances

Construction of dams, stream channelization and diversion, vegetative clearing, in-stream modifications, soil exposure and compaction, irrigation and drainage, deposition of sediments and contaminants, removal of trees, domestic livestock grazing, mining, recreation, and urbanization are among the many human induced disturbances that damage the stream corridors. Human induced disturbances brought about by land use activities have the greatest potential for introducing enduring changes to the ecological structure and functions of the stream corridor.

2.9 Overview of Restoration Principles

Stream corridor restoration design is still in an experimental stage. Every design is unique because the design criteria, standards, and specifications for a project may vary substantially with a slight variation in its physical, climatic and geographic location. A typical restoration design consists of restoring the following attributes of the stream: (FISRWG, 2001)

- Valley form, connectivity, and dimension: This part of the design focuses on restoring the structural characteristics of the stream corridor.
- Soil properties: It is important to carefully analyze the soils and their related potentials and limitations to support diverse native plant and animal communities, as well as for restoration involving channel reconstruction. Deep plowing, though expensive, can be used to restore soil properties lost due to compaction.
- Plant communities: Restoring vegetative communities is a highly visible and integral component of a functioning stream corridor.

- Habitat measures: Greentree reservoirs, nest structures and food patches are types of habitat measures that provide short term habitat until overall restoration results reach the level of maturity.
- Stream channel restoration: This part includes the design of the channel dimensions, meander design, use of channel models for design verification, detailed design, and stability assessment.
- Stream bank restoration: This section focuses on design guidelines and related techniques for streambank stabilization. These techniques include anchored cutting systems, geotextile systems, and integrated systems. These measures can help reduce surface runoff and sediment transport to the stream.
- Instream habitat recovery: This consists of selection of stream segment, evaluation of fish populations and their habitat, diagnose physical habitat problems and design a habitat improvement plan.
- Land use scenarios: Agriculture, forestry, grazing, mining, recreation, and urbanization are some of the main land uses that can lead to stream corridor disturbances. Design of buffer strips in order to achieve sediment and nutrient management is one example of land use restoration.

Stream corridor restoration design has the following advantages: (FISRWG, 2001)

- A healthy, sustainable pattern of land uses across the landscape.
- Improved natural resource quality and quantity.
- A variety of native plants and animals.
- A sense of stewardship for private landowners and the public.
- Restoration and protection of the associated ecosystems.

2.10 Qualitative Habitat Evaluation Index (QHEI)

The Qualitative Habitat Evaluation Index (QHEI) was designed as a technique to evaluate and quantify the condition of aquatic habitat in streams. The QHEI empirically measures the quality of a river habitat and its ability to support aquatic life. The QHEI is not an all-encompassing parameter. It includes substrate composition, channel morphology, in-stream cover, riparian zones, and riffle/pool quality by assigning scores based on quality and quantity. It was designed to assess the physical characteristics that effect fish communities (OEPA, 1989). The greater the QHEI score, the better the condition. OEPA has established an overall score of 60 or greater as the attainment level for WWH criteria. (Williamson, 1999)

2.11 Metrics of QHEI

There are seven metrics that determine the QHEI. The maximum possible score is 100. The higher scores represent streams that exhibit diverse aquatic life and other biological indices. Table 2.4 contains a summary of the different metrics and their respective scores. Tables 2.5 and 2.6 serve as guidelines for interpreting the quality of habitat from the QHEI score. Williamson (1999) developed GIS maps of two QHEI metrics - Riparian Width and Flood Plain Quality – in streams of the Yellow Creek watershed in order to identify potentially degraded stream segments. Details of these metrics are described below.

Table 2.4 Metrics of QHEI (OEPA, 1989)

Substrate	Type	0-20	Max 20 pts
	Quality	-5-3	
Instream Cover	Type	0-9	Max 20 pts
	Amount	1-11	
Channel Quality	Sinuosity	1-4	Max 20 pts
	Development	1-7	
	Channelization	1-6	
	Stability	1-3	
Riparian/ Erosion	Width	0-4	Max 10 pts
	Flood plain quality	0-3	
	Bank erosion	1-3	
Pool Riffle	Max depth	0-6	Max 20 pts
	Current available	-2-4	
	Pool morphology	0-2	
	Riffle/Run depth	0-4	
	Riffle substrate stab	0-2	
	Riffle embeddedness	-1-2	
Drainage area			Not included
Gradient			Max 10 pts
Total Score			Max 100 pts

Table 2.5 Habitat Categories for Ranges of QHEI (OEPA, 1989)

QHEI	Habitat Quality
0-40	Very Poor
41-50	Poor
51-60	Fair
61-70	Good
71-80	Very Good
81-90	Excellent
91-100	Extraordinary

Table 2.6 Interpretation of QHEI (CSU, 1999)

QHEI Score	Meaning
> 60	Stream segment suitable for warmwater habitat without impairment
45-60	Stream segment may meet warmwater habitat, but may show a level of impairment
32-45	Stream segment meets modified warmwater habitat criteria
< 32	Stream segment may be suitable for modified warmwater habitat

2.11.1 Riparian Width

The watershed ecosystem consists of several smaller systems. The riparian corridor is a system that acts as a buffer, or a transition zone between the terrestrial and aquatic ecosystems. Physical, geographical, climatic and biotic processes define the riparian corridor. (Binford and Buchenau, 1993) Riparian Width can be defined as the width of the streamside vegetation on both banks. The wider the Riparian Width, the greater the score. Wide Riparian Widths provide greater protection from nonpoint source pollution and better aquatic habitat. The right and the left banks are scored individually (looking downstream), and the average of the two is used to score the section delineated. (OEPA, 1989) Table 2.7 shows the score based on width for the Riparian Width metric.

Table 2.7 Riparian Width Scoring (OEPA, 1989)

Classification	Width	Score
Wide	> 50 m	4
Moderate	10-50 m	3
Narrow	5-10 m	2
Very Narrow	< 5 m	1
None	0 m	0

2.11.2 Flood Plain Qualit y

The Flood Plain Quality focuses on the area immediately outside the riparian corridor or 100 meters from the stream, whichever is greater. (OEPA, 1989) It accounts for the vegetation and land use. The land use is classified into four categories, namely, conservation tillage, urban or industrial, open pasture/row crops, and mining/construction. Both banks of the stream are scored individually before computing the average Flood Plain Quality score. The scoring system for Flood Plain Quality is shown in Table 2.8

Table 2.8 Flood Plain Quality Scoring (OEPA, 1989)

Vegetation	Score
Forest/Swamp	3
Shrub/Old field	2
Residential, park, new field	1
Fenced pasture	1
Conservation Tillage	1
Urban or Industrial	0
Open pasture/Row Crops	0
Mining/Construction	0

Chapter 3

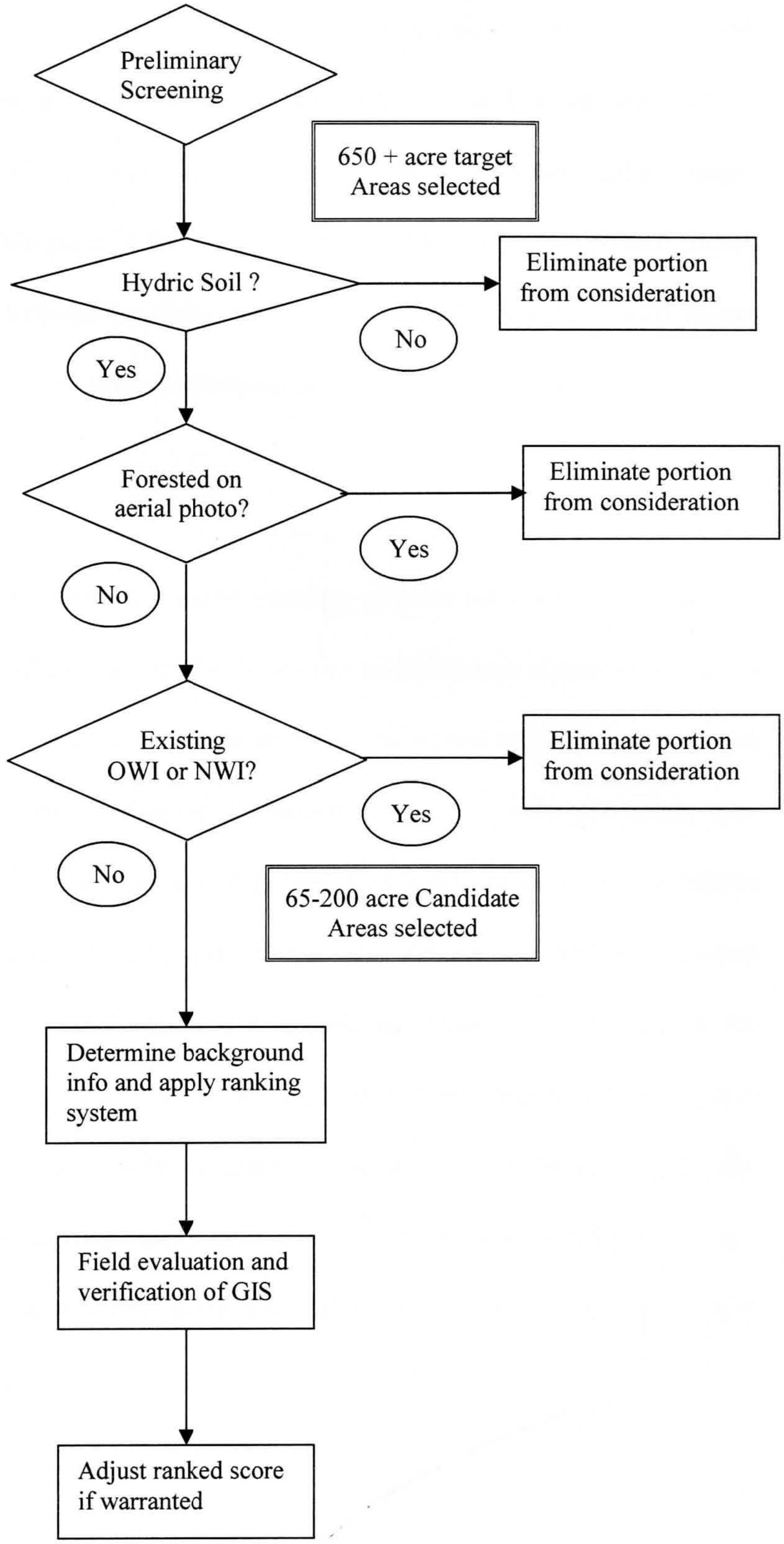
METHODS AND PROCEDURES

3.1 General Description of Project Approach for Wetland Mitigation

The procedure used to identify wetland mitigation opportunities within the Meander Creek, Mill Creek and Yellow Creek watersheds was developed using the GIS capabilities at the Center for Urban and Regional Studies on the campus of Youngstown State University, and verified through field observations. ArcView (Version 3.2) and Arc/INFO (Version 8.1) geographic information systems were used to model the factors needed to identify mitigation potential.

3.1.1 Overview of Previous Work by Airato (2002)

The overall procedure developed by Airato (2002) to identify and rank potential wetland mitigation sites is depicted by the algorithm in Figure 3.1. The procedure is designed to facilitate rapid searches of large tracts of land (e.g. watersheds) for potential mitigation opportunities. Preliminary screening was first performed using a GIS to identify areas dominated by hydric soils, flat topography, and suitable land cover (excluding urban, wooded, and open water areas). (Airato, 2002) These areas were called 'Target Areas" in his study. In this step, forested land as well as NWI and OWI wetlands were eliminated from consideration. A secondary screening was then applied to identify substantially smaller (65-200 acres) parcels of land for detailed analysis. The resulting areas were called "Candidate Areas". A weighted ranking system was developed to evaluate the ability of the Candidate Area to support the development of a wetland, based on



Individual candidate parcels may still have small areas that are non-hydric and/or forested.

A "Yes" could indicate a jurisdictional wetland yet to be delineated or a farm that is a prior converted wetland.

Figure 3.1
GIS Based Methodology
for Evaluation of Wetland Mitigation Potential developed by Airato (2002)

hydrology, soils, and capability of supporting hydrophytic vegetation. Site descriptions and background information were also catalogued for each Candidate Area. Airato (2002) evaluated five "Candidate Areas" for wetland mitigation potential using the ranking system. The accuracy of the GIS was tested through field observations and digital images of Candidate Areas were catalogued in the GIS databases. An adjustment to the ranked score was then applied if warranted by field observations. Finally, the weighted scores were tabulated so that comparisons and conclusions could be made. (Airato, 2002)

3.1.2 Current Work

Building upon Airato's contribution, the same ranking scheme was applied to several additional areas, called "Candidate Parcels" in this study, to produce a comprehensive list of potential mitigation sites in the three watersheds. The selection of these parcels was not restricted to the "Target Areas" selected by Airato. This comprehensive study also helped identify landowners for each parcel. Forty-three Candidate Parcels from the three watersheds were selected for the ranking procedure. Site description and background information were gathered from the GIS and the ranking system was applied to the candidate parcels to quantify the potential for wetland mitigation. Several of the parcels were selected for field inspection in order to confirm the validity of the scores and the ranking system. The results of this study will serve as a crucial component of the Wetland Mitigation Plan to be developed by the Alliance for Watershed Action and Riparian Easements (AWARE).

3.2 Description of Mitigation Ranking System

The mitigation ranking system used in this study consists of a general inventory and a ranked assessment. The general inventory includes a site description and background information, and provides relevant information about individual parcels within the Candidate Parcel. The ranked assessment was designed to evaluate the ability of the Candidate Parcels to support the development of a wetland by quantifying three factors related to the success of a mitigated wetland (Airato, 2002).

1. Adequate Hydrology (55% weighting)
2. Hydric Soils (35% weighting)
3. Environment capable of supporting hydrophytic vegetation (10% weighting)

The general inventory portion of the ranking system shown in Table 3.1 was designed to be completed using the data contained in the GIS. A detailed description of procedures used to develop the GIS is provided by Airato (2002).

The ranking system shown in Table 3.2 generates a score for a Candidate Parcel based on a linear weighted summation. The ranking system includes five criteria related to the three factors that support the development of a wetland. The GIS coverage and tools used to evaluate each criterion are listed in Table 3.3. Weighting percentages are assigned to each criterion as indicated in the **W** column of Table 3.2. For each of these criteria, the potential conditions are listed in the **R** column and given a score between 0 and 10. The scoring for a parcel is calculated using the equation, $\mathbf{S} = \sum \mathbf{W}^* \mathbf{R}$.

Table 3.1 General Inventory of Candidate Parcel

Candidate Area Site Description & Background Information

1. Candidate Area ID ____________________
2. Parcel ID

   ____

3. Coordinate or Location Description

   ____

   Watershed ________________ Sub-watershed ____________________

4. Size _______________
5. Are NWI wetlands on-site? Yes No

   If yes, Type of Wetland
   __________Open Water (OW)
   __________Scrub/Shrub (SS)
   __________Forested (FO)
   __________Isolated (EM)

   List all NWI designation(s)
   (i.e. PSS6 – Palustrine, Scrub/shrub, Deciduous)

   ____

   ____

   ____

6. Have OWI wetlands been delineated on-site? Yes No

Table 3.2 Wetland Mitigation Ranking System

Candidate Area Site Ranking System

Can the environment under review support the development of a wetland?

1) Hydrology 55%
2) Soils 35%
3) Environment capable of supporting hydrophytic vegetation 10%

W	R			W x R	Questions Addressed
35%	**Major Source of Hydrology**				1
	10	Perennial			
	7	Intermittent			
	4	Ephemeral (storm event)			
	1	Groundwater discharge			
25%	**Soil Types Present in Candidate Area**				2
	__________	% Hydric	x 10 =		
	__________	% Hydric inclusions	x 6 =		
	__________	% Non-hydric	x 1 =		
				=========	
			Total:		
20%	**Proximity to Delineated OWI Wetlands or Streams**				1,2,3
	10	Contiguous		(% allocation)	5%,10%,5%
	5	< 1 mile			
	1	> 1 mile			
15%	**Average Slope**				1
	10	0 – 0.5%			
	7	0.5 – 1%			
	2	> 1%			
5%	**Mitigation Buffer from Disturbed Areas**				3
	10	> 30 m			
	8	21 – 30 m			
	5	11 – 20 m			
	2	< 10 m			

Composite Score = $\sum$ W x R = __________

Field Evaluation:

Concurs with GIS evaluation? Yes No*

* List conditions more favorable for mitigation:

____

____

* List conditions less favorable for mitigation:

____

____

Table 3.3 Evaluation Matrix for Ranking Scheme Criterion Parameters

Parameter	Arc View GIS Function and Layers Used
Major Source of Hydrology	Arc View GIS/USGS Hydrology Coverage
Soil Types present in candidate parcel area	Arc View GIS "Calculate Acreage"/ODNR Detailed Soils Coverage
Proximity to delineated OWI wetlands or streams	Arc View GIS/ODNR Ohio Wetlands Inventory Coverage
Average Slope	Arc View GIS Spatial Analyst/USGS/Mahoning County Enterprise GIS Hypsography Coverage
Mitigation Buffer from Disturbed Areas	Arc View GIS "Measuring Tool"/Aerial Photographs

3.3 Selection of Candidate Parcels for Wetland Mitigation

By applying Airato's (2002) GIS overlay methodology, land parcels that showed one or more of the criterion parameters of the ranking system (Table 3.2 and 3.3) were selected and assigned an identification number. The identification number also denotes the watershed in which the parcel lies; e.g. Candidate Parcel No. "mn33" denotes parcel number 33 in Meander Creek watershed. Similarly, Yellow Creek and Mill Creek parcels were denoted by "yl" and "ml", respectively. Aerial photographs (from 1998) stored in the GIS were used to select parcels with appropriate land cover. The numbers of parcels selected in Meander Creek, Mill Creek and Yellow Creek watersheds were thirty-three, six and four, respectively.

3.4 Application of Ranking System

The General Inventory section (Table 3.1), which covers site description and background information, was completed for each Candidate Parcel. The presence of NWI wetlands and their types were determined using "hard copy" maps available from U.S. Fish & Wildlife Service. Next, scores were determined for each criterion in the ranking system

(Table 3.2) and total scores calculated for each Candidate Parcel. Finally, a ranked list of wetland mitigation opportunities within each watershed was tabulated.

3.5 Field Inspection for Wetland Mitigation

In order to check the validity of the ranking system and to overcome the limitations of outdated information in GIS databases, field inspection is an essential part of this technique. Ten candidate parcels with a range of mitigation scores were selected from the list of forty-three for field inspection. Field observations were catalogued using digital photos and used to determine concurrence with the information obtained from the GIS-based methodology. Information obtained from field inspection that differed from the GIS data was entered in the space provided on the ranking sheets. For parcels where the field inspection differed from the information produced by the GIS-based methodology, GIS aerials were rechecked in order to draw appropriate conclusions and identify weaknesses in the method.

3.6 General Description of Project Approach for Stream Restoration

The procedure used to identify stream restoration opportunities within the Meander Creek watershed was also developed using the GIS capabilities at the Center for Urban and Regional Studies (CURS) at Youngstown State University, and verified through field observations. ArcView (Version 3.2) and Arc/INFO (Version 8.1) were again used to model factors related to restoration potential.

3.7 GIS Methodology for Stream Restoration

To rapidly identify potential degraded stream segments for a large watershed, accurate and publicly available data sets must be used. The GIS was created by overlaying layers of such data in digital form. Mahoning County Enterprise GIS files were obtained on compact discs and imported into the GIS. Table 3.4 lists the GIS source data used as input in this portion of the study.

Table 3.4 Source of GIS Data used in Stream Restoration Study

Data Set	Data Source	Most Recent Year Available
Aerial Photograph Coverage	Mahoning County Enterprise GIS Files	April 1998
Cadastral Layer (Parcel Tax Maps)		
Hydrology		

The data were acquired and manipulated in the GIS software by Center for Urban and Regional Studies technicians to produce continuous coverage for the Meander Creek watershed. All streams in the watershed were then divided into smaller segments of approximately 800-1000 ft and each segment was designated by an alphabetical/numeric method. Starting from the northern (downstream) portion of the watershed, the stream reaches along Meander Creek were given a designation MCx, where x=1, 2, 3, etc. A similar approach was used for major tributaries and lake shorelines (abbreviations listed in Table 3.5). For tributaries flowing into these main streams/lakes, additional alphabetical and/or numerical designations were added. For example, tributaries flowing into MC1 were designated by MC1x, where x = a, b, c, etc. Each stream reach was subdivided into 800-1000 ft segments to obtain a total of 1001 stream segments for analysis. The number of stream segments in each section of the watershed is shown in Table 3.5.

Table 3.5 Details of Stream divisions

Stream division names	Abbreviation	Number of sub-divisions
Meander Creek	MC	399
Meander Reservoir	MR	344
Morrison Run	MO	102
Sawmill Creek	SC	63
West Branch	WB	85
Diehl Lake	DL	8
Total number of stream segments in the entire watershed		1001

Figure 3.2 shows the designations of all stream reaches in the Meander Creek watershed.

3.8 Riparian Width and Flood Plain Quality Evaluation

The right and left stream banks (looking downstream) were scored individually for the Riparian Width and Flood Plain Quality metrics of QHEI using the ArcView GIS and the average of the two banks was calculated for each stream segment. Riparian Width and Flood Plain Quality scores were based on scoring criteria shown in Tables 2.7 and 2.8. The scores were entered in the attribute table of the ArcView file for each stream segment. The two scores were then added to obtain a composite score of the riparian metrics (excluding stream bank erosion). The maximum possible scores were 4.0 for Riparian Width, 3.0 for the Flood Plain Quality, and 7.0 for the composite score.

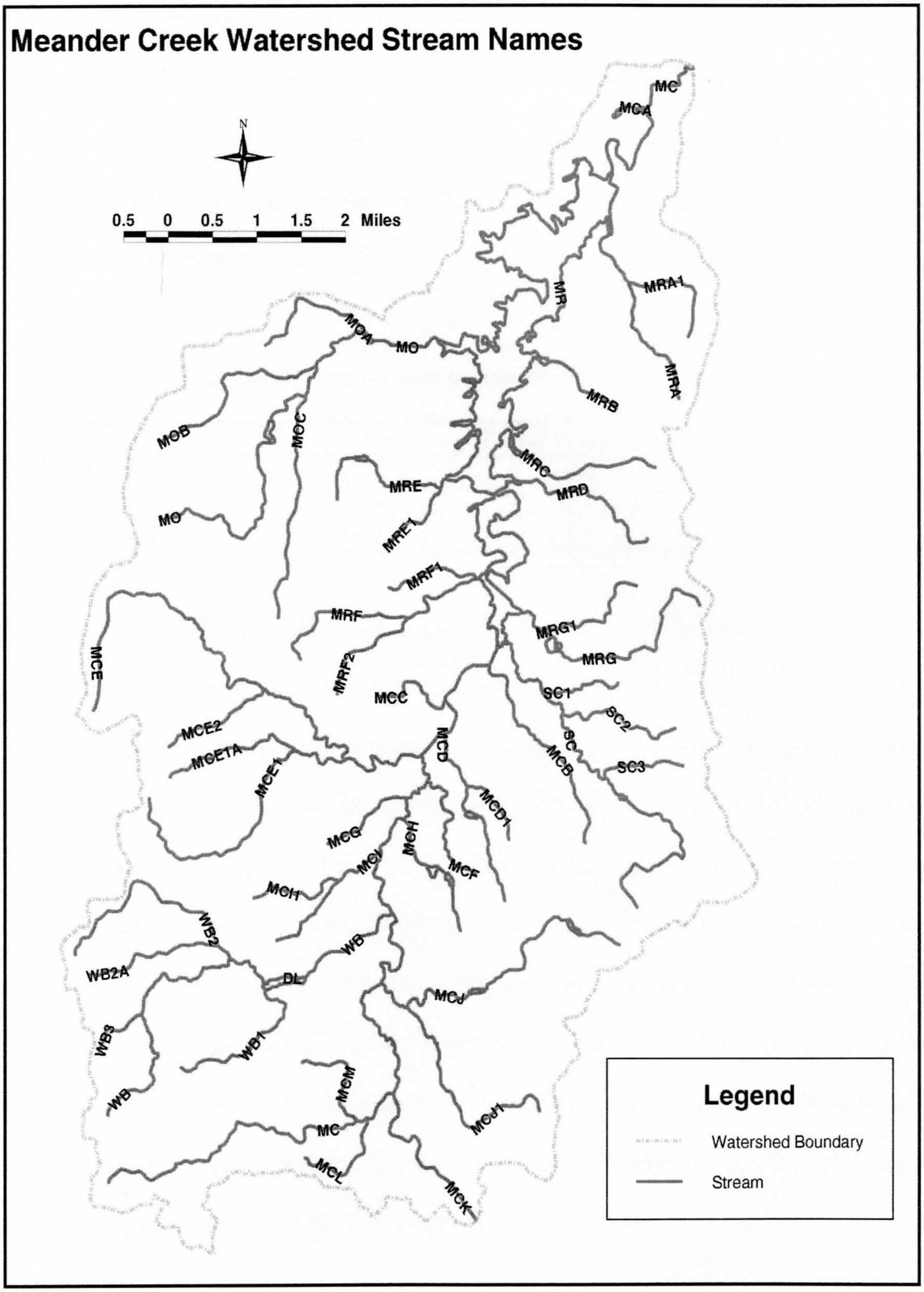


Figure 3.2 Stream Reach Designations for Meander Creek Watershed (YSU-CURS)

3.9 Distribution of Riparian Width and Flood Plain Quality Scores

Using the ArcView GIS software, stream segment information from the attribute table Riparian Width score, Flood Plain Quality score and composite score was graphically represented. Scores for each metric were divided into three categories - poor, moderate and excellent as shown in Table 3.6

Table 3.6 QHEI Metric Score Distribution for Different Stream Conditions

Ranking	Riparian Width	Flood Plain Quality	Composite
Poor	0-1.0	0-1.0	0-2.0
Moderate	1.01-2.99	1.01-1.99	2.01-4.99
Excellent	3.0-4.0	2.0-3.0	5.0-7.0

A score of 1.0 or less was classified as poor for the two individual QHEI metrics. This limit was based on the assumption that any stream with average riparian width less than 5 meters is considered potentially degraded. In addition, a flood plain that does not have forest, swamp or shrub vegetation on both sides of the stream or has shrub vegetation on one side, and highly impacted land (e.g., urban, industrial, row crops, mining) on the other, is potentially degraded and suitable for restoration. A range of 0 to 2.0 was chosen as representing poor condition for the composite score. A color code was chosen to effectively identify the condition of each stream segment. Red, yellow and green colors were chosen to represent poor, moderate and excellent stream conditions respectively. The color-coded maps of stream condition were useful in identifying areas of concern and selecting a group of sites for field inspection.

3.10 Field Inspection of Stream Segments

Field inspection is essential to confirm the validity of the GIS analysis for locating degraded streams. Eight areas with low QHEI metric scores were selected for field inspection. Digital photos were taken and observations were recorded. For locations where the field inspection outcome differed from the information produced by the GIS methodology, GIS aerials were reevaluated to identify potential weaknesses in the technique.

Chapter 4

RESULTS AND DISCUSSION

4.1 Site Description, Background Information and Ranked Scores for Candidate Areas Showing Potential for Wetland Mitigation

Forty-three Candidate Parcels within the Meander Creek, Mill Creek and Yellow Creek watersheds were selected for the wetland mitigation ranking procedure. Site description and background information were gathered from the GIS and the ranking system was applied to each parcel.

The distribution of the Candidate Parcels within the Meander Creek, Mill Creek and Yellow Creek watersheds are shown in Figures 4.1, 4.2 and 4.3, respectively. Attributes of the selected parcels obtained from the Mahoning County Enterprise GIS databases are tabulated in Tables 4.1-4.3. These tables provide valuable information about the selected parcels, such as parcel number on tax maps, candidate parcel number, tax district, parcel size in acres, township location, parcel location/address, owner name and mailing address, land value, land use and soil properties. Information obtained from these tables was useful in completing the site description and ranking sheets.

Using National Wetland Inventory (NWI) maps and the portion of the NWI legend shown in Figure 4.4, wetland ecosystems in the selected Candidate Parcels were characterized. Most wetlands were characterized as *Palustrine* and support forest, shrubs or emergent vegetation. Final site description / background information sheets and the

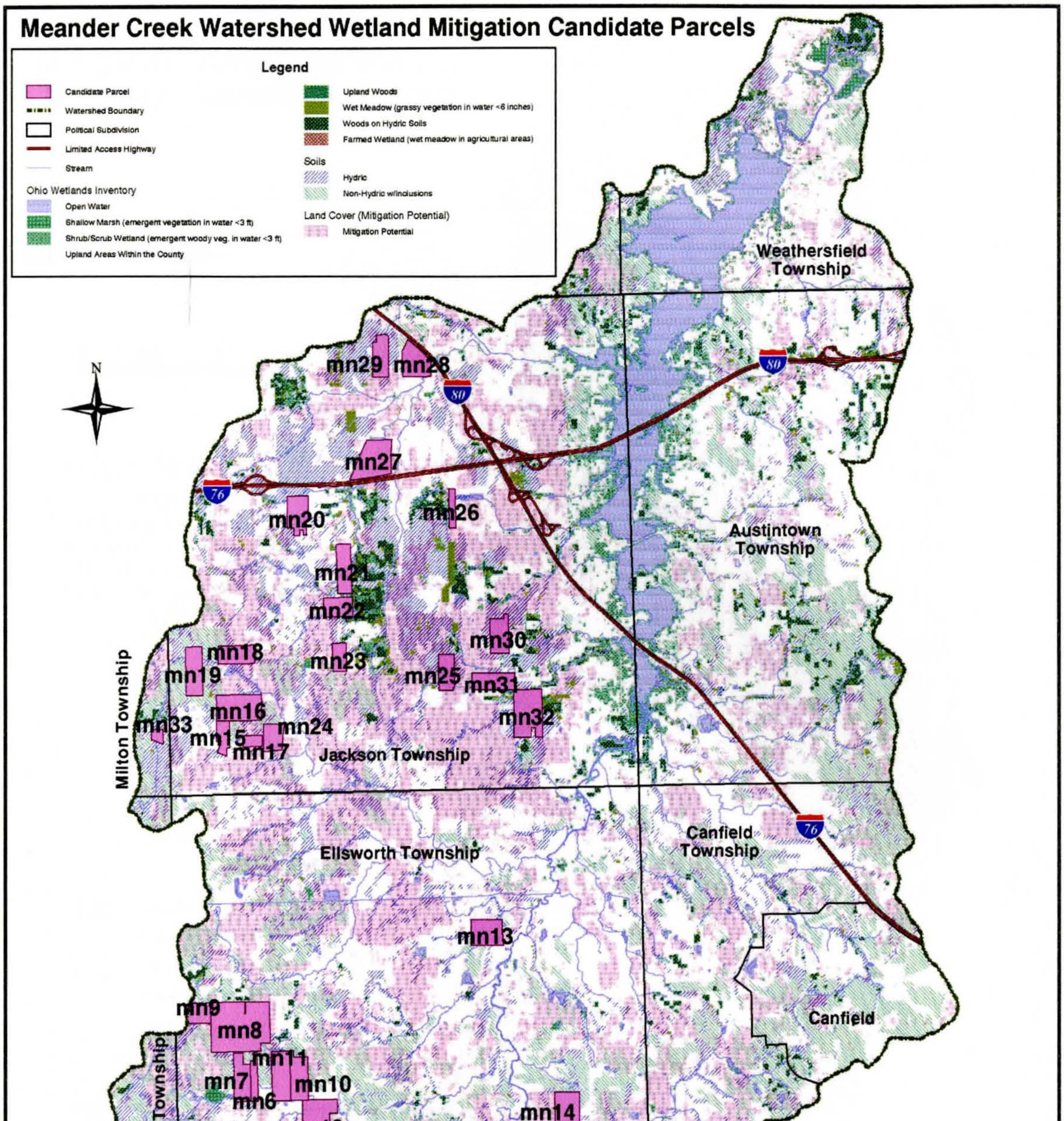


Figure 4.1 Wetland Mitigation Candidate Parcels in the Meander Creek Watershed

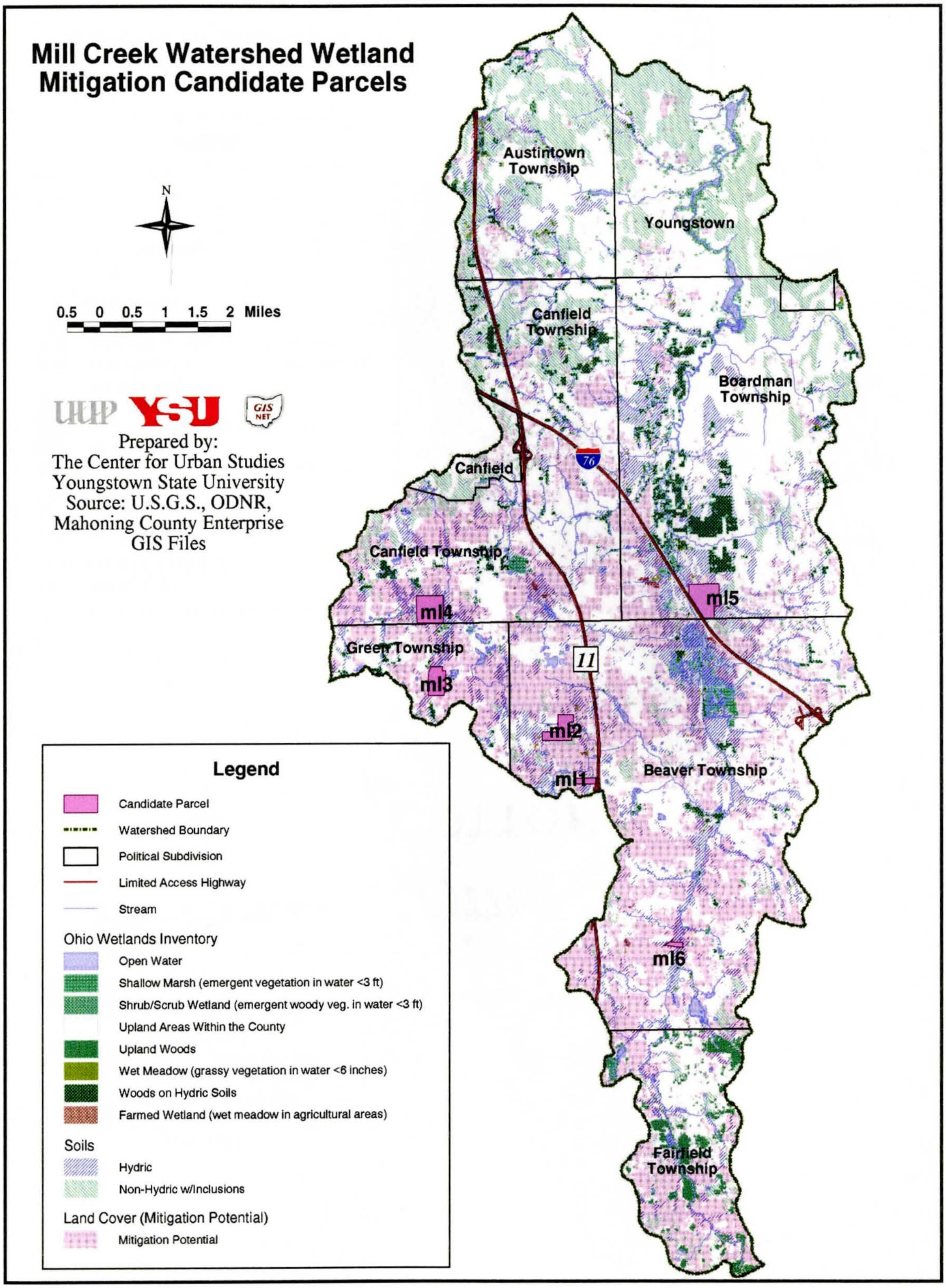


Figure 4.2 Wetland Mitigation Candidate Parcels in the Mill Creek Watershed

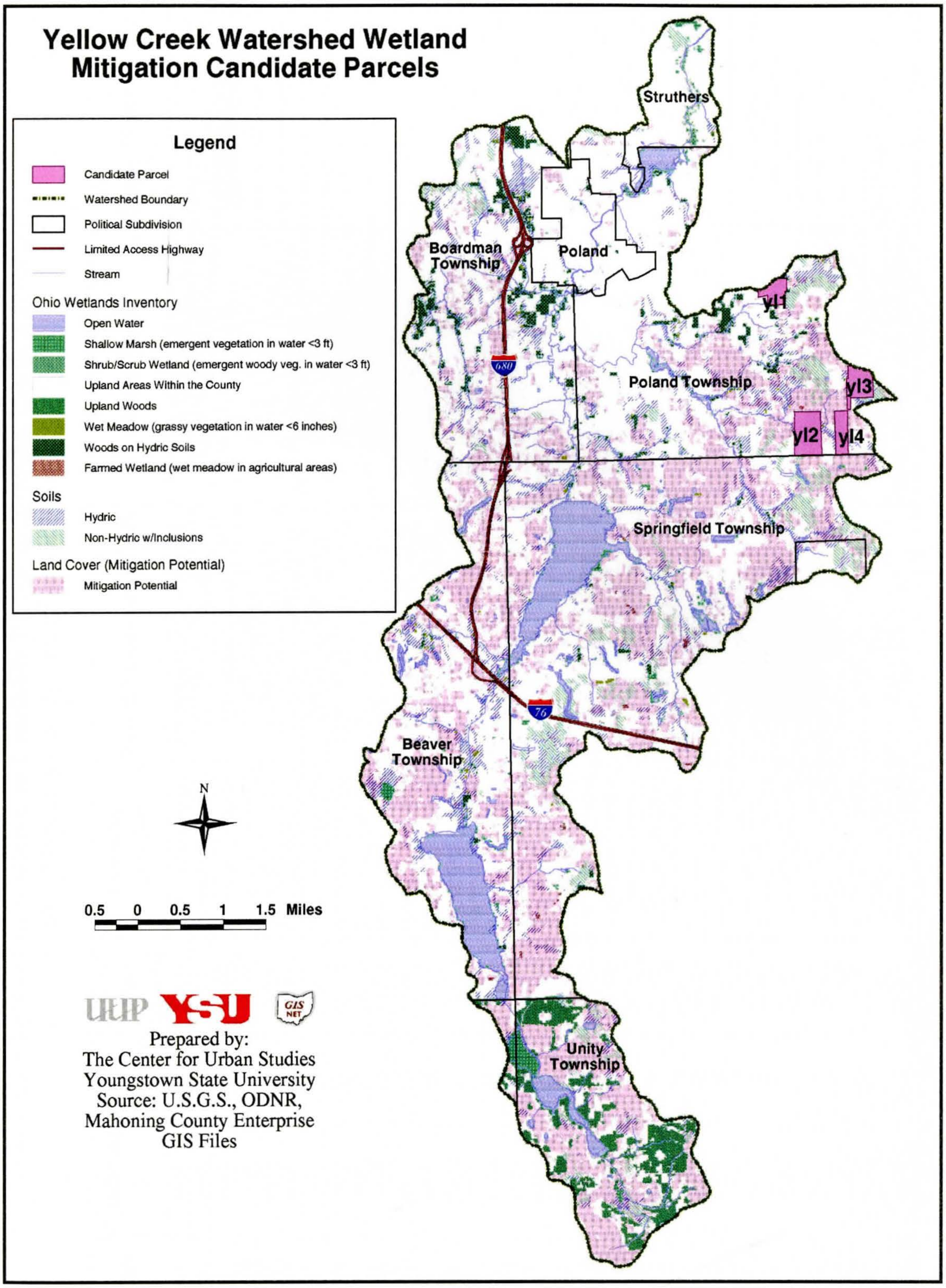


Figure 4.3 Wetland Mitigation Candidate Parcels in the Yellow Creek Watershed

Table 4.1 Bankground Information on Candidate Parcels in Meander Creek Watershed

Source: Mahoning County Enterprise GIS Files

Parcel Number	Candidate #	Tax District	Parcel Size (Acres)	Township Location	Parcel Location/Address	Owner Name	Owner Name (cont.)
22-046-0-003.00-0	**mn1**	22	52.973	Berlin Township	WESTERN RESERVE RD W	BATES ORAL L	
23-002-0-017.00-0	**mn2**	23	56.821	Ellsworth Township	8251 DUCK CREEK RD	MYERS DAVID ETAL	
23-003-0-002.00-0	**mn3**	23	39.498	Ellsworth Township	12905 BERLIN STATION	PITCAIRN JAMES R	PITCAIRN DIANE K
23-003-0-008.06-0	**mn4**	23	10.767	Ellsworth Township	LEFFINGWELL RD	B & S PARTNERS	
23-003-0-010.01-0	**mn5**	23	5.907	Ellsworth Township	7797 DUCK CREEK RD	JONES JACK H & MARY J	
23-005-0-003.00-0	**mn6**	23	20.920	Ellsworth Township	AKRON CANFIELD RD	SEKELY JAMES R & TRACY	
23-005-0-010.00-0	**mn7**	23	50.617	Ellsworth Township	AKRON CANFIELD RD	SEKELY JAMES R	
23-006-0-005.00-0	**mn8**	23	195.539	Ellsworth Township	12798 AKRON CANFIELD	BROWN HAROLD	
23-006-0-008.00-0	**mn9**	23	32.186	Ellsworth Township	6055 DUCK CREEK RD	KALBFELL EDWIN T & C	
23-016-0-011.00-0	**mn10**	23	54.778	Ellsworth Township	12295 AKRON CANFIELD	HOWE ANTHONY N	
23-016-0-012.00-0	**mn11**	23	63.622	Ellsworth Township	12403 AKRON CANFIELD	CARRADINE JOAN E	
23-017-0-007.00-0	**mn12**	23	98.414	Ellsworth Township	12014 BERLIN STATION	MOFF DUANE D & KMBERLY	
23-031-0-004.00-0	**mn13**	23	56.454	Ellsworth Township	GAULT	MAHONING-TRUMBULL	BEAGLE CLUB INC
23-042-0-001.00-0	**mn14**	23	55.266	Ellsworth Township	9471 BERLIN STATION	BAIRD FAMILY LIMITED	PARTNERSHIP
50-002-0-001.01-0	**mn15**	50	26.402	Jackson Township	BAILEY RD	DE MARCO DOMINIC	
50-002-0-002.00-0	**mn16**	50	82.083	Jackson Township	2934 BAILEY	HOLONKO TANYA M	
50-002-0-013.00-0	**mn17**	50	15.146	Jackson Township	BAILEY RD	PRACHICK CHARLES & LINDA	
50-003-0-008.00-0	**mn18**	50	44.913	Jackson Township	BAILEY	GENETTA LEO A & ELIZ	
50-003-0-010.00-0	**mn19**	50	55.831	Jackson Township	DUCK CREEK RD	HOLONKO TANYA M	
50-015-0-003.00-0	**mn20**	50	50.044	Jackson Township	MAHONING AV	OHLIM LTD PARTNERSHIP	
50-016-0-011.00-0	**mn21**	50	50.027	Jackson Township	11635 MAHONING	MC GEE ANDERSON S	
50-017-0-009.00-0	**mn22**	50	37.763	Jackson Township	ROSEMONT RD	DRAKE DAVID V	
50-018-0-011.00-0	**mn23**	50	27.349	Jackson Township	2541 ROSEMONT	KING DANIEL E & S D	
50-019-0-020.00-0	**mn24**	50	36.672	Jackson Township	BAILEY	MARKEL RICHARD C &	MARKEL MICHAEL W
50-023-0-007.00-0	**mn25**	50	39.534	Jackson Township	BLOTT RD	RUGGLES GARY A & PAULA A	
50-027-0-094.00-P	**mn26**	50	18.244	Jackson Township	MAHONING	OHIO EDISON CO	
50-028-0-013.00-0	**mn27**	50	84.776	Jackson Township	SALEM WARREN	HIVELY LEE R JR	
50-030-0-005.00-0	**mn28**	50	56.221	Jackson Township	SALEM WARREN	ANDERSON GODFREY TR	
50-030-0-010.00-0	**mn29**	50	44.741	Jackson Township	11200 GLADSTONE	PAULSEY B R & L M	
50-039-0-002.01-0	**mn30**	50	45.652	Jackson Township	NEW	MEANDER GOLF COURSE INC	
50-040-0-005.00-0	**mn31**	50	50.209	Jackson Township	2818 GAULT	RUGGLES GARY A & PAULA A	
50-041-0-033.00-0	**mn32**	50	93.325	Jackson Township	KIRK	GRAHAM DAVID W &	GRAHAM THEODORE L
51-146-0-004.03-0	**mn33**	51	9.745	Milton Township	PALMYRA RD	BIEDA JOSEPH M & ARLENE M	

Table 4.1 (Continued)

Candidate #	Owner's Mailing Address	City and Zip Code	Land Value	Land Use Class	Land Use Class Definition	% Hydric	% Non-Hydric	% Hydric W/Inc.	% Open Water
mn1	13857 WESTERN RESERVE RD	SALEM OH 44460	$88,300.00	100	Vacant Land	39%	18%	43%	0%
mn2			$217,700.00	101	Cash Grain/General Farm	47%	17%	36%	0%
mn3	7805 N MIDDLETOWN RD	SALEM OHIO 44460	$65,700.00	101	Cash Grain/General Farm	54%	10%	36%	0%
mn4	6611 GLENDALE	YOUNGSTOWN OH 44512	$33,800.00	100	Vacant Land	23%	71%	6%	0%
mn5	2276 SHETLAND	POLAND OH 44514	$24,800.00	511	1-Family Dwelling 0-9.99 AC	23%	7%	70%	0%
mn6	12881 AKRON CANF RD	NORTH JACKSON OHIO 44451	$41,100.00	101	Cash Grain/General Farm	18%	82%	0%	0%
mn7	235 JENNINGS AVE	SALEM OHIO 44460	$13,100.00	100	Vacant Land	39%	59%	2%	0%
mn8	BOX 127	ELLSWORTH OH 44416	$367,900.00	110	Vacant Land	31%	24%	44%	1%
mn9	460 WOODLAND AVE	SALEM OHIO 44460	$71,200.00	101	Cash Grain/General Farm	65%	34%	1%	0%
mn10	12295 AKRON CANFIELD RD	NORTH JACKSON OH 44451	$81,100.00	101	Cash Grain/General Farm	6%	80%	14%	0%
mn11	12403 AKRON CANFIELD RD	NORTH JACKSON OH 44451	$112,800.00	101	Cash Grain/General Farm	6%	86%	8%	0%
mn12	12014 BERLIN STATION RD	BERILN CENTER OH 44401	$153,800.00	102	Livestock 0/T 03 &04	13%	79%	8%	0%
mn13			$79,100.00	199	Greenhouse	13%	62%	25%	0%
mn14	7060 CRORY RD	CANFIELD OHIO44406	$249,900.00	102	Livestock 0/T 03 &04	22%	22%	56%	0%
mn15	86 ROBINHOOD DR	YOUNGSTOWN OHIO 44511	$43,400.00	100	Vacant Land	18%	28%	54%	0%
mn16	2934 S BAILEY RD	NORTH JACKSON OH 44451	$107,300.00	101	Cash Grain/General Farm	35%	50%	15%	0%
mn17	4388 TIPPECANOE	YOUNGSTOWN OHIO 445LL	$22,500.00	101	Cash Grain/General Farm	43%	57%	0%	0%
mn18	2770 S BAILEY RD	NORTH JACKSON OH 44451	$57,500.00	101	Cash Grain/General Farm	53%	39%	8%	0%
mn19	2934 S BAILEY RD	NORTH JACKSON OH 44451	$66,700.00	101	Cash Grain/General Farm	32%	68%	0%	0%
mn20	8110 MARKET ST	YOUNGSTOWN OH 44512	$298,600.00	300	Vacant Industrial Land	49%	51%	0%	0%
mn21	11625 MAHONING AVE	NORTH JACKSON OH 44451	$71,500.00	100	Vacant Land	64%	36%	0%	0%
mn22	2074 ROSEMONT	NORTH JACKSON OH 44451	$56,100.00	100	Vacant Land	66%	34%	0%	0%
mn23	2541 ROSEMONT RD	NORTH JACKSON OH 44451	$48,800.00	101	Cash Grain/General Farm	44%	44%	12%	0%
mn24	10275 SANDY LANE	NORTH JACKSON OH 44451	$131,400.00	101	Cash Grain/General Farm	48%	47%	5%	0%
mn25	2818 GAULT RD	NORTH JACKSON OH 44451	$54,600.00	100	Vacant Land	61%	39%	0%	0%
mn26	76 S MAIN ST	AKRON OH 44308	$27,600.00	474	Unknown Land Use	29%	71%	0%	0%
mn27	P O BOX 736	CANFIELD OH 44406	$180,100.00	101	Cash Grain/General Farm	34%	55%	0%	11%
mn28	4440 LOGAN WAY	YOUNGSTOWN OH 44505	$85,800.00	100	Vacant Land	33%	65%	2%	0%
mn29			$61,400.00	101	Cash Grain/General Farm	73%	27%	0%	0%
mn30	7489 SALINAS TRAIL	YOUNGSTOWN OH 44512	$76,000.00	463	Golf Course	90%	10%	0%	0%
mn31	2818 GAULT RD	NORTH JACKSON OH 44451	$94,800.00	101	Cash Grain/General Farm	49%	51%	0%	0%
mn32	10449 KIRK RD	NORTH JACKSON OH 44451	$86,400.00	101	Cash Grain/General Farm	70%	30%	0%	0%
mn33	5927 GIBSON RD	CANFIELD OH 44406	$39,000.00	101	Cash Grain/General Farm	93%	0%	7%	0%

Table 4.2 Background Information on Candidate Parcels in Mill Creek Watershed

Source: Mahoning County Enterprise GIS Files

Parcel Number	Candidate #	Tax District	Parcel Size (Acres)	Township Location	Parcel Location/Address	Owner Name	Owner Name (cont.)
05-167-0-001.00-0	**ml1**	5	17.616	Beaver Township	11500 DETWILER	GRACE JAMES R	
05-179-0-004.00-0	**ml2**	5	72.457	Beaver Township	DETWILER RD	DEPIZZO SANDRA M TRUSTEE	
09-051-0-025.00-0	**ml3**	9	66.919	Green Township	10000 WASHINGTONVILL	SCHLEGEL JANET L &	PAULIN KENNETH
26-031-0-001.00-0	**ml4**	26	104.796	Canfield Township	WESTERN RESERVE RD W	MARTZ SHERMAN G JR TR	@(3)
29-108-0-001.00-0	**ml5**	29	114.155	Boardman Township	WESTERN RESERVE RD	BIEBER ORVILLE C TR	@(3)
43-124-0-003.01-0	**ml6**	43	10.006	Beaver Township	13761 NEW BUFFALO RD	MERLO MARK & CINDY	

Candidate #	Owner's Mailing Address	City and Zip Code	Land Value	Land Use Class	Land Use Class Definition	% Hydric	% Non-Hydric	% Hydric w/Inc.	% Open Water
ml1	11500 DETWILER RD	COLUMBIANA OH 44408	$49,800.00	101	Cash Grain/General Farm	44%	56%	0%	0%
ml2	3079 W SOUTH RANGE RD	COLUMBIANA OHIO 44408	$113,600.00	100	Vacant Land	45%	53%	2%	0%
ml3	0000 WASHINGTONVILLE RI	CANFIELD OH 44406	$115,800.00	101	Cash Grain/General Farm	47%	53%	0%	0%
ml4	6295 WESTERN RESERVE RD	CANFIELD OH 44406	$171,800.00	100	Vacant Land	66%	30%	4%	0%
ml5	2301 WESTERN RESERVE RD	CANFIELD OH 44406	$230,000.00	100	Vacant Land	79%	20%	0%	1%
ml6	4459 LAUREL OAK DR	ALLISON PARK PA 15101	$41,200.00	512	-Family Dwelling 10-19.99 A	96%	4%	0%	0%

Table 4.3 Candidate Parcels in Yellow Creek Watershed

Source: Mahoning County Enterprise GIS Files

Parcel Number	Candidate #	Tax District	Parcel Size (Acres)	Township Location	Parcel Location/Address	Owner Name	Owner Name (cont.)
35-036-0-006.00-0	**yl1**	35	44.291	Poland Township	STRUTHERS RD	RAYBUCK J I & LUTZ R E TR	
35-067-0-001.00-0	**yl2**	35	97.243	Poland Township	ARREL RD	THOMPSON ELIZABETH A	
35-111-0-001.00-0	**yl3**	35	67.646	Poland Township	5291 MILLER RD	BOWMASTER ERWIN J	
35-118-0-003.00-0	**yl4**	35	46.451	Poland Township	4921 ARREL RD	MOLNAR ANN	@(14)

Candidate #	Owner's Mailing Address	City and Zip Code	Land Value	Land Use Class	Land Use Class Definition	% Hydric	% Non-Hydric	% Hydric w/Inc.	% Open Water
yl1	7100 STRUTHERS RD	POLAND OH 44514	$65,300.00	100	Vacant Land	46%	43%	4%	7%
yl2	24 COLLEGE ST	POLAND OH 44514	$151,500.00	100	Vacant Land	29%	70%	1%	0%
yl3	5291 MILLER RD	LOWELLVILLE OH 44436	$122,600.00	101	Cash Grain/General Farm	45%	36%	19%	0%
yl4	4921 ARREL RD	LOWELLVILLE OH 44436	$87,600.00	101	Cash Grain/General Farm	22%	78%	0%	0%

ECOLOGICAL SYSTEM	P - Palustrine								
No Subsystem									
CLASS	RB - Rock Bottom	UB - Unconsolidated Bottom	AB - Aquatic Bed	FL - Flat	ML - Moss/Lichen	EM - Emergent	SS - Scrub/Shrub	FO - Forested	OW - Open Water/ Unknown Bottom
Subclass	1 Bedrock	1 Cobble/Gravel	1 Submergent Algal	1 Cobble/Gravel	1 Moss	1 Persistent	1 Broad-leaved Deciduous	1 Broad-leaved Deciduous	
	2 Boulder	2 Sand	2 Submergent Vascular	2 Sand	2 Lichen	2 Nonpersistent	2 Needle-leaved Deciduous	2 Needle-leaved Deciduous	
		3 Mud	3 Submergent Moss	3 Mud		3 Narrow-leaved Nonpersistent	3 Broad-leaved Evergreen	3 Broad-leaved Evergreen	
		4 Organic	4 Floating-leaved	4 Organic		4 Broad-leaved Nonpersistent	4 Needle-leaved Evergreen	4 Needle-leaved Evergreen	
			5 Floating	5 Vegetated Pioneer		5 Narrow-leaved Persistent	5 Dead	5 Dead	
			6 Unknown submergent	6 Vegetated Non-pioneer		6 Broad-leaved Persistent	6 Deciduous	6 Deciduous	
			7 Unknown surface				7 Evergreen	7 Evergreen	

MODIFYING TERMS

In order to more adequately describe wetland and aquatic habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME Non-Tidal		WATER CHEMISTRY pH Modifiers for all Fresh Water	SPECIAL MODIFIERS	
A Temporary	H Permanent	a Acid	b Beaver	h Diked/Impounded
B Saturated	J Intermittently Flooded	t Circumneutral	d Partially Drained/Ditched	r Artificial
C Seasonal	K Artificial	I Alkaline	f Farmed	s Spoil
D Seasonal Well-drained	Z Intermittently Exposed/Permanent			x Excavated
E Seasonal Saturated	W Intermittently Flooded/Temporary			
F Semipermanent	Y Saturated/Semipermanent/Seasonals			
G Intermittently Exposed	U Unknown			

Figure 4.4 A Portion of the National Wetland Inventory Legend

corresponding ranking sheets for two Candidate Parcels - mn22 and mn14 - are shown in Tables 4.4-4.7. Field inspection notes were also entered on the ranking score sheet when observations differed from GIS-based information.

4.2 Final Rankings of Candidate Parcels

The ranked scores of all candidate parcels within the Meander Creek, Mill Creek and Yellow Creek watersheds are listed in Tables 4.8, 4.9 and 4.10, respectively. The ranking implies the order in which the owners of the individual parcels should be approached to further evaluate potential wetland mitigation sites. These rankings using the GIS-based model will serve as an important crucial component of the Wetland Mitigation Plan to be developed by the Alliance for Watershed Action and Riparian Easements (AWARE).

The ranking sheets show that within Meander Creek watershed, Candidate Parcel mn22 in Jackson Township has the highest composite score of 9.24, while the lowest score is Candidate Parcel mn13 in Ellsworth Township, with a composite score of 6.16. Similarly, among Mill Creek Candidate Parcels, ml4 has the highest composite scope of 8.09, while ml2 is the lowest at 5.54. In the Yellow Creek watershed, scores ranged from 7.05 (yl2) to 7.95 (yl4). The distribution of composite scores is sufficient to differentiate between sites with limited potential for wetland mitigation and those with excellent potential. While good mitigation sites can be found in all three watersheds, they are far more common, and of higher quality, in the Meander Creek watershed than in Mill and Yellow Creek watersheds.

Table 4.4 Site Description/Background Information Candidate for Parcel mn22

Candidate Area Site Description & Background Information

1. Candidate Area ID _mn 22_ .
2. Parcel ID _50-017-0-009.00-0_ .
3. Coordinate or Location Description

   ROSEMENT RD, JACKSON TOWNSHIP .

   Watershed _MEANDER CREEK_ Sub-watershed ________ .
4. Size _37.763 acres_ .
5. Are NWI wetlands on-site? [Yes] No

   If yes, Type of Wetland

   _____ Open Water (OW)
   __X__ Scrub/Shrub (SS)
   __X__ Forested (FO)
   __X__ Isolated (EM)

   List all NWI designation(s)
   (i.e. PSS6 – Palustrine, Scrub/shrub, Deciduous)

   P-F01 /SS / EM – Y: - PALUSTRINE, FORESTED .

   BROAD LEAVED DECIDUOUS, SCRUB/ SHRUB, .

   EMERGENT, SATURATED /SEMIPERMANENT / SEASONAL .
6. Have OWI wetlands been delineated on-site? [Yes] No

Table 4.5 Ranked Score for Candidate Parcel mn22

Candidate Area Site Ranking System

Can the environment under review support the development of a wetland?

1)	Hydrology	55%
2)	Soils	35%
3)	Environment capable of supporting hydrophytic vegetation	10%

W	R				W x R	Questions Addressed
35%	**Major Source of Hydrology**				**[3.50]**	1
	[10]	Perennial				
	7	Intermittent				
	4	Ephemeral (storm event)				
	1	Groundwater discharge				
25%	**Soil Types Present in Candidate Area**				**[1.74]**	2
	66	% Hydric	x 10 =	6.60		
	0	%Hydric inclusions	x 6 =	-		
	34	% Non-hydric	x 1 =	0.34		
				=========		
			Total:	6.94		
20%	**Proximity to Delineated OWI Wetlands or Streams**				**[2.00]**	1,2,3
	[10]	Contiguous			(% allocation)	5%,10%,5%
	5	< 1 mile				
	1	> 1 mile				
15%	**Average Slope**				**[1.50]**	1
	[10]	0 – 0.5%				
	7	0.5 – 1%				
	2	> 1%				
5%	**Mitigation Buffer from Disturbed Areas**				**[0.50]**	3
	[10]	> 30 m				
	8	21 – 30 m				
	5	11 – 20 m				
	2	< 10 m				

Composite Score = $\sum$ W x R = 9.24

Field Evaluation:

Concurs with GIS evaluation? [Yes] No*

* List conditions more favorable for mitigation:

* List conditions less favorable for mitigation:

Higher average ground slope observed. So, might need earthwork to distribute water to entire property

Table 4.6 Site Description/Background Information Candidate for Parcel mn14

Candidate Area Site Description & Background Information

1. Candidate Area ID _mn14_.

2. Parcel ID _23-042-0-001.00-0_.

3. Coordinate or Location Description

   9471 BERLIN STATION, TAX DISTRICT 22.

   Watershed _MEANDER CREEK_ Sub-watershed ________.

4. Size _55.266 acres_.

5. Are NWI wetlands on-site? **[Yes]** No

   If yes, Type of Wetland

   ______Open Water (OW)
   ______Scrub/Shrub (SS)
   ___X___Forested (FO)
   ___X___Isolated (EM)

   List all NWI designation(s)
   (i.e. PSS6 – Palustrine, Scrub/shrub, Deciduous)

   P-F01 / EM – Y: - PALUSTRINE, FORESTED.

   BROAD LEAVED DECIDUOUS, EMERGENT,.

   SATURATED /SEMIPERMANENT / SEASONAL.

6. Have OWI wetlands been delineated on-site? Yes **[No]**

Table 4.7 Ranked Score for Candidate Parcel mn14

Candidate Area Site Ranking Scheme

Can the environment under review support the development of a wetland?

4)	Hydrology	55%
5)	Soils	35%
6)	Environment capable of supporting hydrophytic vegetation	10%

W	R				W x R	Questions Addressed
35%	**Major Source of Hydrology**				**[2.45]**	1
	10	Perennial				
	[7]	Intermittent				
	6	Ephemeral (storm event)				
	3	Groundwater discharge				
25%	**Soil Types Present in Candidate Area**				**[1.45]**	2
	22	% Hydric	x 10 =	2.20		
	56	% Hydric inclusions	x 6 =	3.36		
	22	% Non-hydric	x 1 =	0.22		
				========		
			Total:	5.78		
20%	**Proximity to Delineated OWI Wetlands or Streams**				**[1.00]**	1,2,3
	10	Contiguous				(% allocation) 5%,10%,5%
	[5]	< 1 mile				
	1	> 1 mile				
15%	**Average Slope**				**[1.05]**	1
	10	0 – 0.5%				
	[7]	0.5 – 1%				
	4	> 1%				
5%	**Mitigation Buffer from Disturbed Areas**				**[0.50]**	3
	[10]	> 30 m				
	9	21 – 30 m				
	7	11 – 20 m				
	2	< 10 m				

Composite Score = $\sum$ W x R = 6.45

Field Evaluation:

Concurs with GIS evaluation? [Yes] No*

* List conditions more favorable for mitigation:

____

____

* List conditions less favorable for mitigation:

____

____

Table 4.8 Final Rankings of Candidate Parcels in Meander Creek Watershed

Parcel Number	Candidate #	Parcel Size (Acres)	Township	Parcel Location/Address	Composite Score	Rank
50-017-0-009.00-0	**mn22**	37.763	Jackson	ROSEMONT RD	9.24	1
51-146-0-004.03-0	**mn33**	9.745	Milton	PALMYRA RD	8.93	2
50-041-0-033.00-0	**mn32**	93.325	Jackson	KIRK	8.88	3
50-016-0-011.00-0	**mn21**	50.027	Jackson	11635 MAHONING	8.74	4
23-006-0-005.00-0	**mn8**	195.539	Ellsworth	12798 AKRON CANFIELD	8.55	5
50-003-0-010.00-0	**mn19**	55.831	Jackson	DUCK CREEK RD	8.47	6
23-003-0-008.06-0	**mn4**	10.767	Ellsworth	LEFFINGWELL RD	8.34	7
50-039-0-002.01-0	**mn30**	45.652	Jackson	NEW	8.25	8
50-030-0-005.00-0	**mn28**	56.221	Jackson	SALEM WARREN	8.07	9
23-002-0-017.00-0	**mn2**	56.821	Ellsworth	8251 DUCK CREEK RD	8.06	10
50-028-0-013.00-0	**mn27**	84.776	Jackson	SALEM WARREN	8.04	11
50-030-0-010.00-0	**mn29**	44.741	Jackson	11200 GLADSTONE	7.89	12
50-003-0-008.00-0	**mn18**	44.913	Jackson	BAILEY	7.84	13
50-018-0-011.00-0	**mn23**	27.349	Jackson	2541 ROSEMONT	7.69	14
50-040-0-005.00-0	**mn31**	50.209	Jackson	2818 GAULT	7.65	15
50-019-0-020.00-0	**mn24**	36.672	Jackson	BAILEY	7.44	16
50-002-0-001.01-0	**mn15**	26.402	Jackson	BAILEY RD	7.38	17
50-027-0-094.00-P	**mn26**	18.244	Jackson	MAHONING	7.2	18
23-017-0-007.00-0	**mn12**	98.414	Ellsworth	12014 BERLIN STATION	7.14	19
23-006-0-008.00-0	**mn9**	32.186	Ellsworth	6055 DUCK CREEK RD	7.03	20
22-046-0-003.00-0	**mn1**	52.973	Berlin	WESTERN RESERVE RD W	6.97	21
23-003-0-010.01-0	**mn5**	5.907	Ellsworth	7797 DUCK CREEK RD	6.94	22
23-003-0-002.00-0	**mn3**	39.498	Ellsworth	12905 BERLIN STATION	6.92	23
50-023-0-007.00-0	**mn25**	39.534	Jackson	BLOTT RD	6.87	24
23-005-0-003.00-0	**mn6**	20.920	Ellsworth	AKRON CANFIELD RD	6.66	25
23-016-0-011.00-0	**mn10**	54.778	Ellsworth	12295 AKRON CANFIELD	6.61	26
23-016-0-012.00-0	**mn11**	63.622	Ellsworth	12403 AKRON CANFIELD	6.54	27
50-002-0-002.00-0	**mn16**	82.083	Jackson	2934 BAILEY	6.53	28
50-002-0-013.00-0	**mn17**	15.146	Jackson	BAILEY RD	6.52	29
23-042-0-001.00-0	**mn14**	55.266	Ellsworth	9471 BERLIN STATION	6.45	30
23-005-0-010.00-0	**mn7**	50.617	Ellsworth	AKRON CANFIELD RD	6.4	31
50-015-0-003.00-0	**mn20**	50.044	Jackson	MAHONING AV	6.35	32
23-031-0-004.00-0	**mn13**	56.454	Ellsworth	GAULT	6.16	33

Table 4.9 Final Rankings of Candidate Parcels in Mill Creek Watershed

Parcel Number	Candidate #	Parcel Size (Acres)	Township	Parcel Location/Address	Composite Score	Rank
26-031-0-001.00-0	**ml4**	104.796	Canfield	WESTERN RESERVE RD W	8.09	1
29-108-0-001.00-0	**ml5**	114.155	Boardman	WESTERN RESERVE RD	8.08	2
43-124-0-003.01-0	**ml6**	10.006	Beaver	13761 NEW BUFFALO RD	7.71	3
09-051-0-025.00-0	**ml3**	66.919	Green	10000 WASHINGTONVILL	7.61	4
05-167-0-001.00-0	**ml1**	17.616	Beaver	11500 DETWILER	7.54	5
05-179-0-004.00-0	**ml2**	72.457	Beaver	DETWILER RD	5.54	6

Table 4.10 Final Rankings of Candidate Parcels in Yellow Creek Watershed

Parcel Number	Candidate #	Parcel Size (Acres)	Township	Parcel Location/Address	Composite Score	Rank
35-118-0-003.00-0	**yl4**	46.451	Poland	4921 ARREL RD	7.95	1
35-036-0-006.00-0	**yl1**	44.291	Poland	STRUTHERS RD	7.62	2
35-111-0-001.00-0	**yl3**	67.646	Poland	5291 MILLER RD	7.22	3
35-067-0-001.00-0	**yl2**	97.243	Poland	ARREL RD	7.05	4

4.3 Field Observations of Candidate Parcels

Ten Candidate Parcels with a range of mitigation scores were selected from the list of forty-three for field inspection. For each parcel, a photographic log of observations was created to determine concurrence with the information obtained from the GIS-based screening and ranking methodology. Digital photos and visual observations were mostly taken from roads adjacent to the parcels. In some cases, it was not possible to observe conditions on a portion of the site. A brief account of the field observations follows.

Candidate Parcel mn22

- Higher average ground slope than expected. Slight rise in elevation away from stream that might require some earthwork to distribute water to entire property.

Candidate Parcel mn33

- Property appears to be mostly wooded; should have been eliminated in screening process.
- Residential development at a few places; also an impediment to wetland mitigation.

Candidate Parcel mn32

- Stream channel appears to be modified.
- Standing water in floodplain of stream.
- Partly wooded. Some trees have been cut.
- Cattails on west side of property; growth extends towards rear of parcel.

- Appears to be pasture land in the rear north end of the property.

Candidate Parcel mn8

- Actively farmed.
- Eastern boundary of property is around 20 feet in elevation above the creek.

Candidate Parcel mn12

- Active farmland.
- Source of hydrology is questionable. (intermittent)

Candidate Parcel mn1

- Mostly pasture land.
- Small hills at southeast and southwest corners; difficult to get water to these areas.
- Center and northeast portions of property look good for mitigation.

Candidate Parcel mn13

- Very hilly; not suitable for mitigation.
- Small wetland near southeast corner.

Candidate Parcel mn14

- Actively farmed.
- No significant source of hydrology.

- There is a drainage channel in the southeast corner of the site, but flow appears to be intermittent.

Candidate Parcel ml4

- Actively farmed; large corn field.
- New upscale development on the west side of the property. Potentially high property value on west side of parcel.
- Mill Creek MetroParks bikeway on the east side of property.
- Perennial stream on east side of the bikeway; may be difficult to channel flow into center of parcel.
- The site is pretty flat, except that it is high on the west side. So, there is a good chance for mitigation on the east side.

Candidate Parcel ml5

- The property is very flat, with a drainage ditch down the center of the property.
- Residential and commercial development nearby; property value may be high.

Figures 4.5 and 4.6 show two examples of digital photographs taken during the field inspection of wetland mitigation Candidate Parcels. For both of these parcels, field inspection confirmed the accuracy of the ranking. Photographs in Figures A.1-A.3 of the Appendix were taken at locations on candidate parcels mn22, mn33 and mn12 respectively, where a few discrepancies with the GIS-based ranking scores were observed.

Figure 4.5. Candidate Parcel mn32, Looking North from Southeast Corner

Figure 4.6. Candidate Parcel mn1, Looking North from Southeast Corner

4.4 Assessment of Wetland Mitigation Ranking Methodology

4.4.1 Discussion

The GIS-based application of the ranking system agreed with the field observations for most Candidate Parcels. Table 4.11 summarizes the similarities and differences revealed during field inspection.

Table 4.11 Comparison between GIS-Based Ranking System and Field Observations

Candidate Parcel #	GIS based Score	Does it match the field observation?	Comments
mn22	9.24	Partially	Higher average ground slope
mn33	8.93	No	Mostly wooded, with residential development
mn32	8.88	Yes	-
mn8	8.55	Yes	-
mn12	7.14	No	Source of hydrology questionable
mn 1	6.97	Yes	-
mn 13	6.16	Yes	-
mn 14	6.45	Yes	-
ml 4	8.09	Yes	-
ml 5	8.08	Yes	-

Among the ten parcels selected for field observation, GIS-based scores for seven parcels totally agreed with field observations. Field observation for parcel mn22 concurred with the GIS evaluation for all but one attribute. The observed average slope was higher than the one interpreted using GIS. So, it might be advisable to reduce the score. Field observation for mn33 and mn12 did not match the GIS-based scoring system. Property on mn33 was heavily wooded with residential development in a few places, while mn12 showed signs of perennial hydrology only on the forested portion of the site.

GIS aerials for these two parcels were closely observed after the field visits and the following conclusions were drawn.

- A portion of the area surrounding parcel mn33 was densely wooded. So, by comparison, vegetation on the property appeared to be scrub/shrub with some patches of sparse vegetation (see Figure 4.7). The fact that the aerials were taken in the month of April, when leaves have not fully emerged on deciduous trees, probably contributed to this perception. Field inspection was carried out in mid-July, when leaves were fully formed.
- It is hard to interpret the perennial nature of the stream on parcel mn12 from the GIS aerials. (see Figure 4.8) Field observation suggests that the streams on the southern portion of the property are intermittent in nature. Since this would be the most viable location for a mitigation wetland, the GIS-based composite score should be revised to reflect the intermittent nature of the source of hydrology. The hydrology score for mn12 was based on the perennial stream running through the forested area at the northern end of the parcel. However, this area would not be a viable candidate for mitigation.

Given the uncertainty in classifying the site hydrology, it is probably not justified to report wetland mitigation ranking scores to two decimal places. To do so, implies a level of precision that cannot be achieved by these methods. Alternative approaches could include rounding the scores to the nearest integer, and/or developing qualitative rankings such as excellent, good, fair, etc.

Figure 4.7 GIS Aerial Photo of Candidate Parcel mn33 (YSU-CURS, 2003)

Figure 4.8 GIS Aerial photo of Candidate Parcel mn12 (YSU-CURS, 2003)

It can be concluded that a strong correlation exists between the GIS-based ranking and the actual field observations in most cases. The ranking proved effective in evaluating the criteria most important to successful wetland mitigation. The strengths and limitations of the screening and ranking method are summarized below.

4.4.2 Strengths

1. The GIS-based method to identify potential wetland mitigation opportunities can be applied to different numbers and/or sizes of candidate parcels. The same procedure can also be applied to any other watershed or region for which GIS data are available. In short, this method is very versatile.
2. The method serves as a starting point for approaching landowners to discuss the acquisition of land parcels for wetland mitigation. It can greatly reduce the time and expense of locating suitable land.
3. This method shows a high degree of accuracy in identifying sites with the most suitable soils, topography, hydrology and land cover for wetland mitigation. Sites with the highest ranking scores should have the greatest probability of success in establishing wetlands, and the lowest construction costs.

4.4.3 Limitations

1. The method does not account for any landowner preferences and hence falls short of predicting whether the chosen mitigation sites can actually be acquired at a reasonable price.

2. Sometimes, the GIS hydrology layer and aerial photographs do not give a clear picture of the nature of the source of hydrology (i.e. perennial or intermittent).
3. It is sometimes difficult to distinguish between shrub land cover and forest on aerial photos.
4. Constant updating of GIS databases is not feasible. Hence GIS-based results may be influenced by outdated information, and can vary from field observations.
5. Reporting ranking scores to two decimal places is not justified.
6. A detailed site investigation and preliminary wetland design will be needed before the feasibility of any site for wetland mitigation can be ultimately determined.
7. The ranking does not consider the value of wetland functions in the landscape or watershed.

4.5 Riparian Width Scores

A map of Riparian Width scores for the Meander Creek watershed is shown in Figure 4.9. The headwaters of any watershed are most susceptible to human impact. This trend is evident for Meander Creek. Figure 4.9 shows that most of the poor riparian corridors in the Meander Creek watershed are located around the headwaters. Riparian forests have been steadily decreasing due to rapid development in Austintown and Canfield townships. There has been a substantial loss in the riparian width in some areas of Jackson and Ellsworth townships also.

With heavy traffic in densely populated areas, large amounts of pollutants such as road salt, oil, grease, and trash carried by runoff from paved roads can enter the stream.

Agriculture at a few places in Jackson Township has led to narrow riparian buffers, leading to possible high loading of nutrient and suspended solids.

4.6 Flood Plain Quality Scores

The Flood Plain Quality score results are shown in Figure 4.10. There are several areas in the Meander Creek watershed that have a poor Flood Plain Quality. This can be attributed to a combination of factors such as residential and urban development and channelization of stream segments for agriculture. It is not surprising to find many poor scores in headwater areas, since land use in the watershed is about 14% urban, and 45% agriculture/pasture. (Christou, 2002)

4.7 Sum of Flood Plain and Riparian Width Scores

The sum of the floodplain and riparian width scores of the QHEI riparian metric in the Meander Creek watershed is shown is Figure 4.11. Areas of low composite scores can be mainly attributed to human induced disturbances such as stream channelization and diversion, clearing of riparian vegetation and development of the flood plain. Human induced disturbances brought about by land use activities have the greatest potential for introducing enduring changes to the ecological structure and functions of the stream corridor.

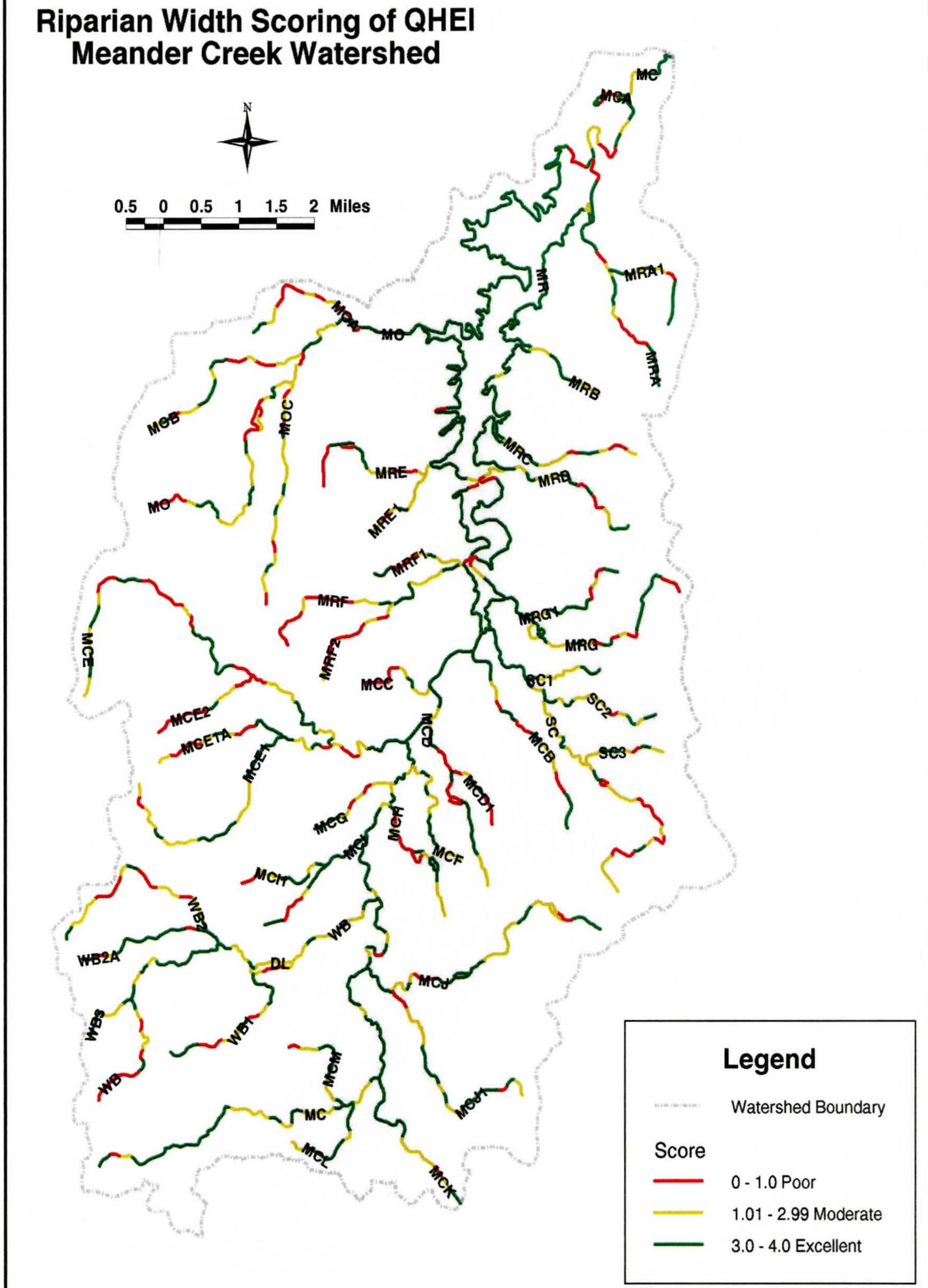


Figure 4.9 Riparian Width Score of QHEI in Meander Creek Watershed
Source: (YSU-CURS)

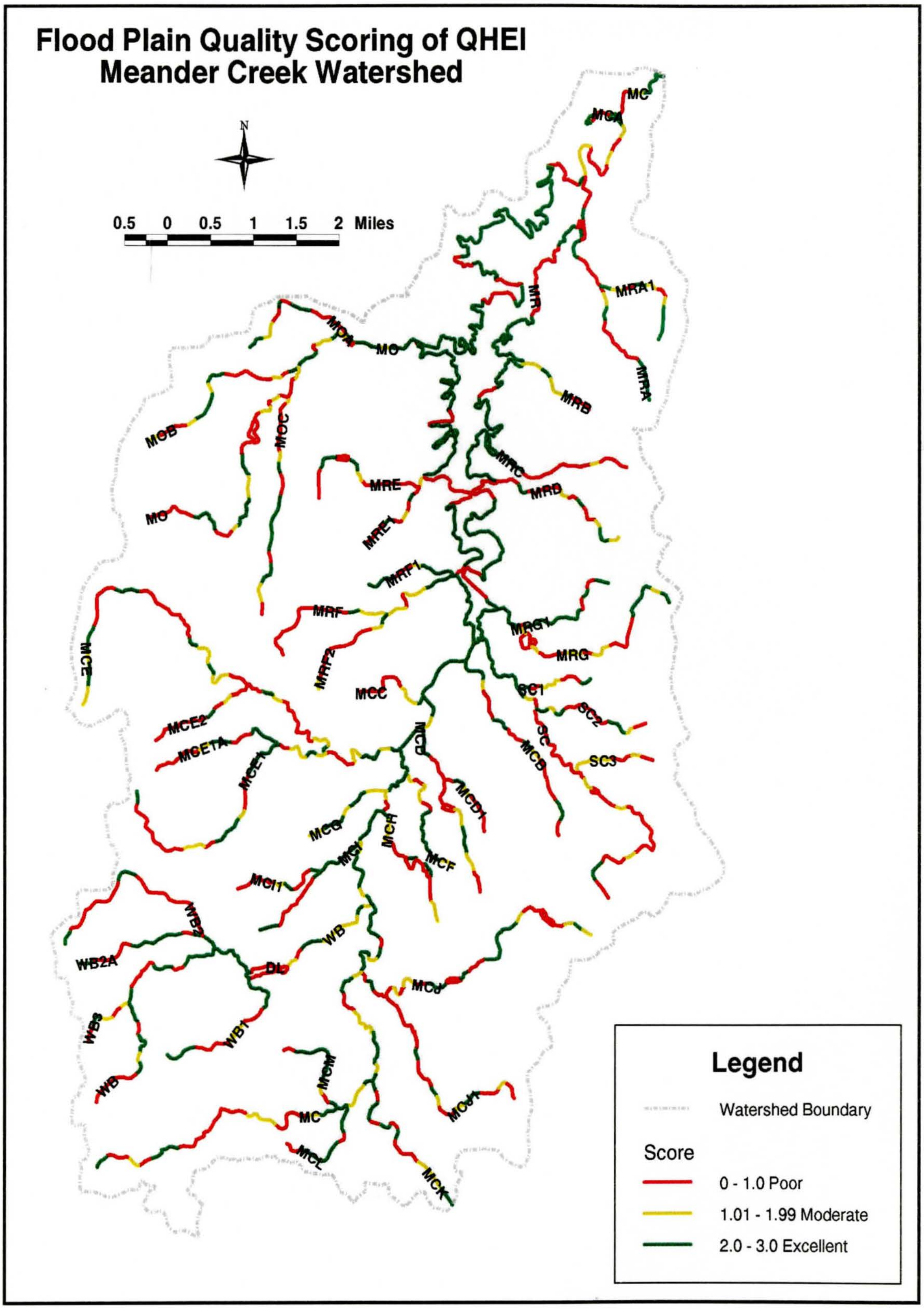


Figure 4.10 Flood Plain Quality Score of QHEI in Meander Creek Watershed
Source: (YSU-CURS)

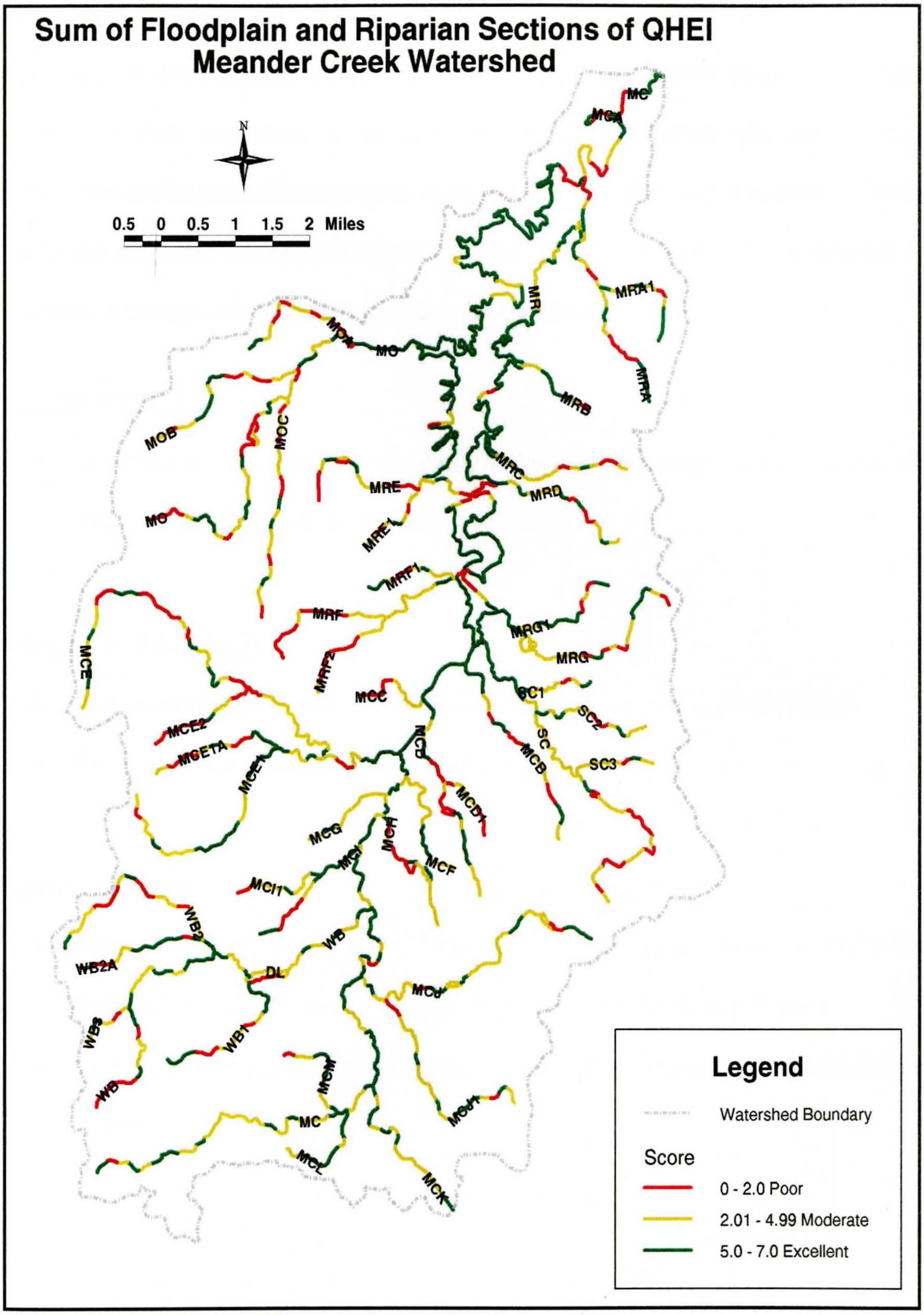


Figure 4.11 Composite Score of QHEI in Meander Creek Watershed
Source: (YSU-CURS)

4.8 Field Observations

Eight areas within Meander Creek watershed having low riparian metric scores were selected for field inspection. A photographic log of observations was developed to confirm the information obtained from the GIS-based methodology. Figure 4.12 shows the stream segments selected for field inspection. Field inspection sites are denoted by blue dots. A brief account of the field observations follows.

Segment: MRA 4

- Modification of streambed observed. Ridge Lake Housing Condominiums (55 units) are being built in the vicinity.

Segments: MRA 9,10,11

- Section of stream channel north of I-80 appears to be man-made (modified).
- Thick grass and small shrubs in stream corridor and flood plain.

Segment: MRE 14

- Area surrounding creek consists of open areas with grass, some shrubs, a few parking lots, industry, police station, school, and also Mahoning Avenue.
- Could not find exact location of stream channel at headwaters near Mahoning Avenue.

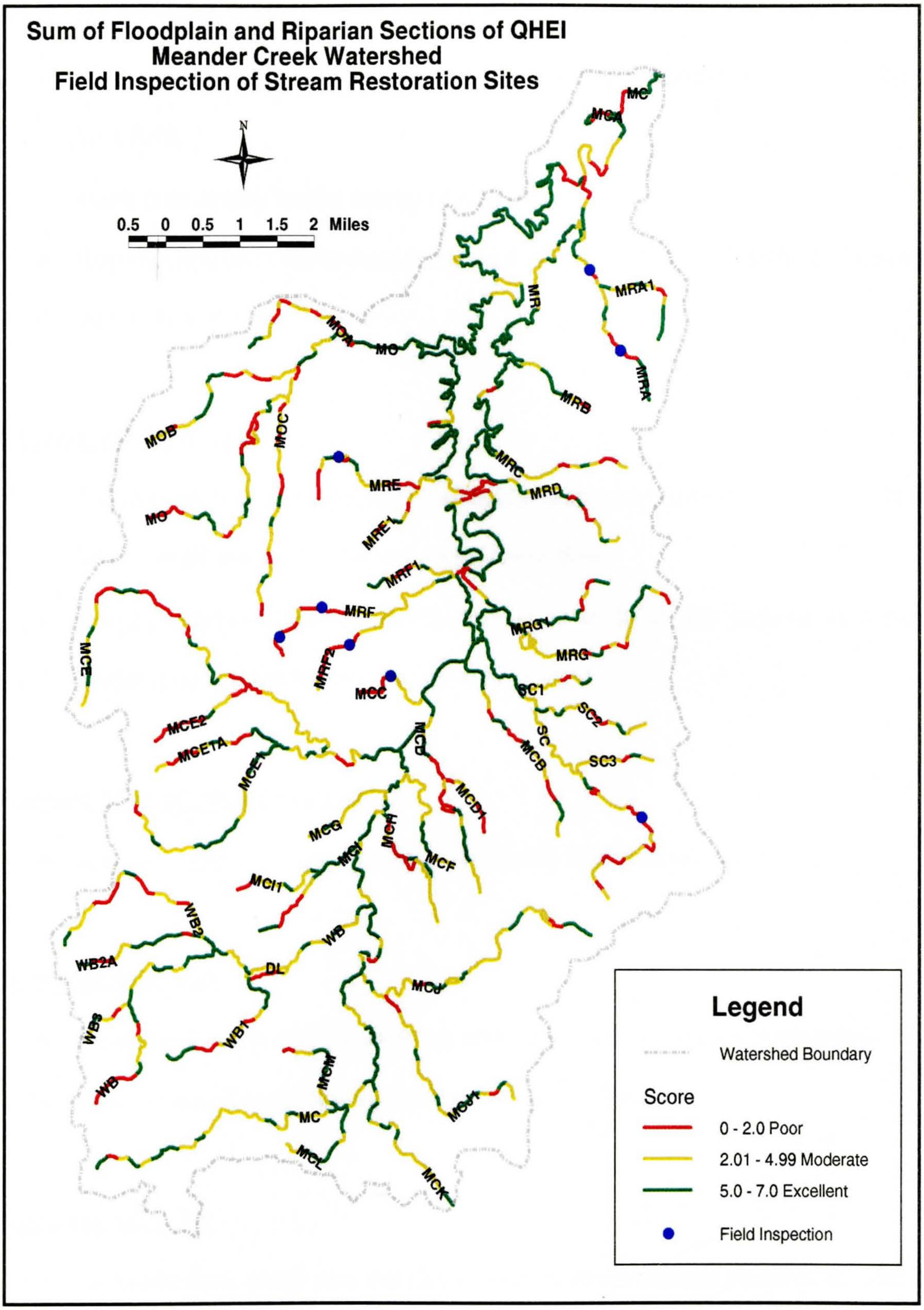


Figure 4.12 Field Inspection of Stream Restoration Sites in Meander Creek Watershed Source: (YSU-CURS)

Segment: MRF (Blott Road)

- Riparian corridor is very narrow on north side of Blott Road. It's bounded by a farm field.
- There is an animal feedlot nearby (downstream).
- Heavily vegetated riparian corridor at least 30 feet wide on each bank on the south side of Blott Road.

Segment: MRF (Route 45)

- A combination of a pasture and a residential lawn near headwaters on west side of SR45. Small stream channel with intermittent flow.
- Heavily vegetated riparian corridor around 15 to 20 meters wide on each side, bordered by residential areas on east side of SR45.

Segment: MRF (Blott and Gault Road)

- A creek running through a pasture, with a very little riparian vegetation.

Segments: MRF 2g,h

- Residential area west of Gault Road, no riparian width; stream is impounded.
- East of Gault Road; Corn cropland on both sides of stream.

Segments: MCC 7,8

- At headwaters, creek runs parallel to Gibson Road through pastureland, and in roadside ditch along Gibson Road.

- Further downstream at Gibson Road crossing, riparian corridor is heavily vegetated.

Segments: SC 17-36 (City of Canfield)

- Little riparian vegetation; mostly residential area.
- Stream bank erosion is common. Streambed appears to be covered with silt in some locations.
- Heavily riprapped channel observed at a few locations. Stream has been relocated and channelized in some locations.

Figures 4.13 and 4.14 show two examples of digital photographs taken during the field inspection of stream segments for restoration opportunities. Additional photographs are shown in Figures A.4-A.6 in the Appendix.

Figure 4.13. Stream Segments MRA 4 looking North at the Stream Corridor near the South end of the segment (MRA 4) in Meander Creek Watershed

Figure 4.14. Stream Segment MRF Looking East from Intersection of Blott Road and Gault Road in Meander Creek Watershed

4.9 Assessment of Methodology to Determine Stream Restoration Opportunities

4.9.1 Discussion

The GIS-based evaluation using aerial photographs to identify stream restoration opportunities within Meander Creek watershed agreed with the field observations for all selected parcels. The comparison is shown in Table 4.15.

Table 4.12 Comparison between GIS Based Ranking System and Field Observations

Stream Reach	GIS based Evaluation	Does it match the field observation?	Comments
MRA 4	Poor	Yes	-
MRA 9,10,11	Poor	Yes	-
MRE 14	Poor	Yes	Couldn't find exact location
MRF (Blott & Gault Road)	Poor	Yes	-
MRF (Route 45)	Poor	Yes	-
MRF 2g,h	Poor	Yes	-
MCC 7,8	Poor	Yes	-
SC 17-36 (Canfield)	Poor	Yes	-

As seen from Table 4.12, GIS-based evaluation for all eight parcels agreed with the field observations. Figure 4.12 shows a GIS aerial picture of degraded stream reach MRA 4 in Meander Creek watershed. Field inspection for MRA 4 revealed that the streambed had been modified and residential condominiums are being built in its vicinity. (See Figure 4.13) However, there were some discrepancies observed in small portions of stream reaches. For example, segment MRA 9 showed thick grass and small shrubs in its corridor and flood plain. The quality of the riparian area is much better than it appeared on aerial photos.

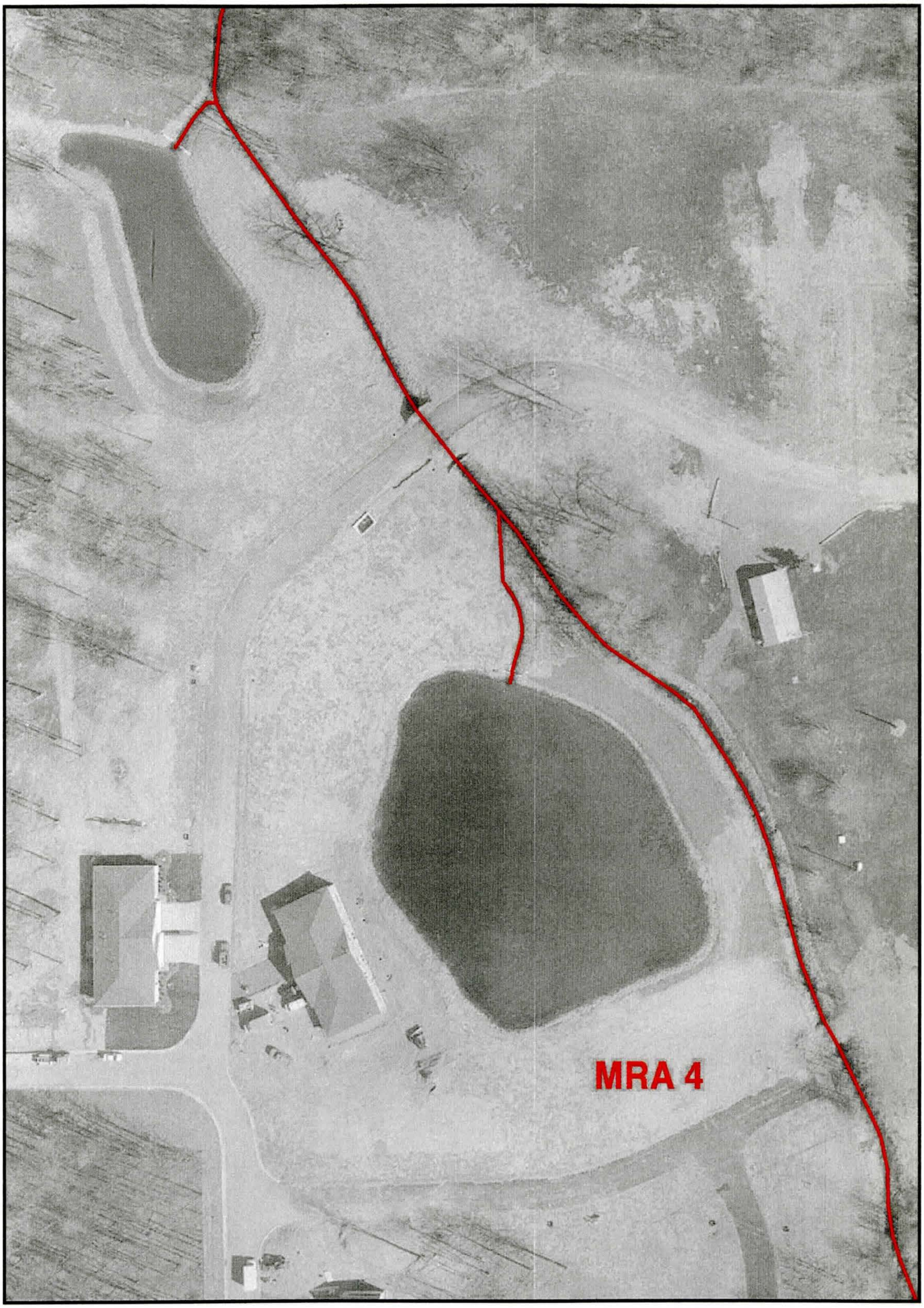


Figure 4.15 GIS Aerial picture for Stream Reach MRA 4 (YSU-CURS, 2003)

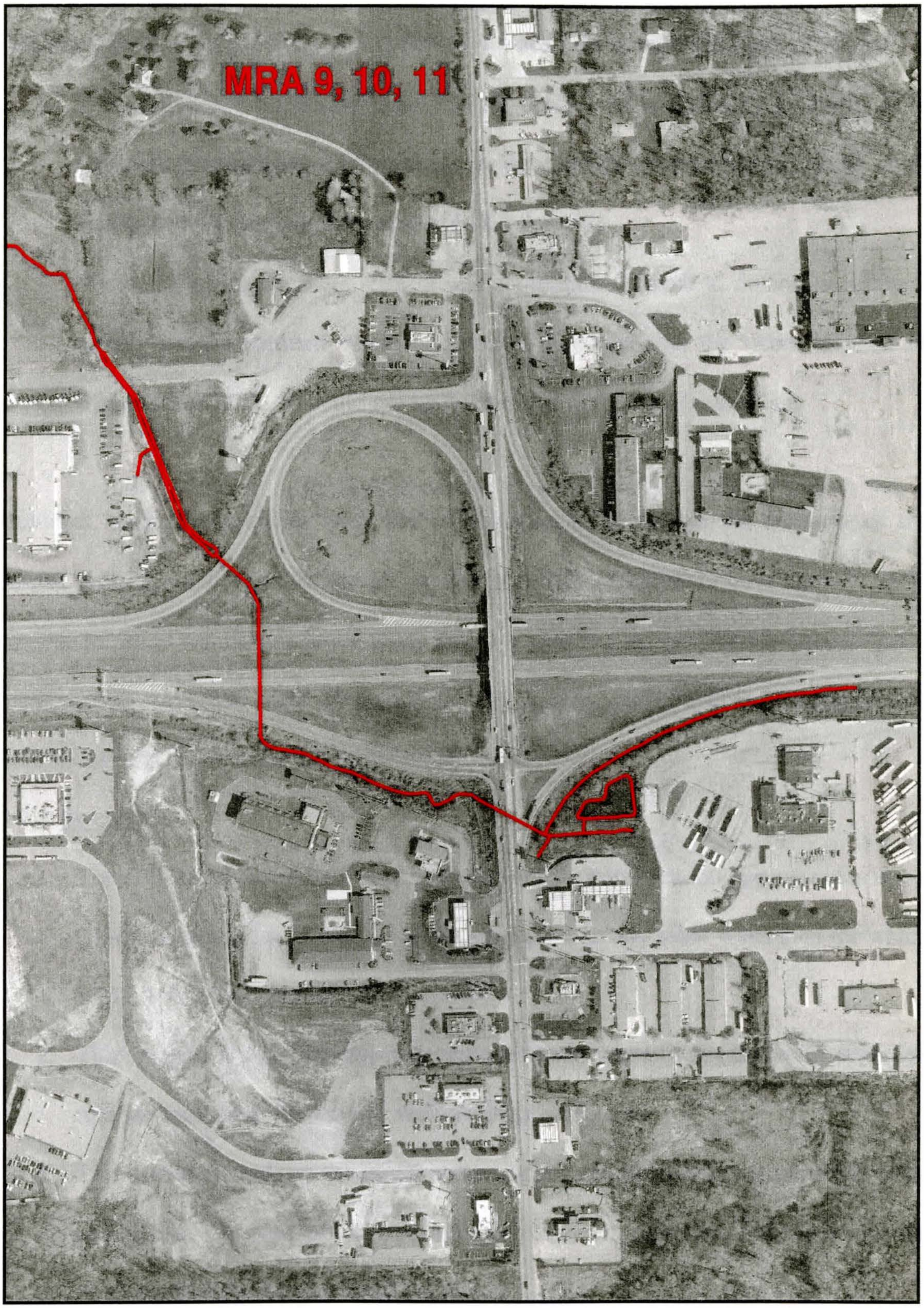


Figure 4.16 GIS Aerial picture for Stream Reach MRA 9,10,11 (YSU-CURS, 2003)

Possible reasons for the differences between field and GIS observations are as follows:

- Low resolution of the aerial photographs could lead to difficulty in determining the type and thickness of vegetation in the riparian zone and flood plain. (See Figure 4.16 for aerial photograph of MRA 9,10,11)
- While evaluating the field sites, it was sometimes difficult to determine where a certain stream segment began and ended. For example, the exact location of stream reach MRE 14 could not be determined during field inspection.

However, such discrepancies were not serious enough to change the outcome of the stream ranking, as most of the stream reaches matched very closely with the GIS aerial evaluation. So, it can be concluded that a strong correlation exists between the GIS-based method and the actual field observations. In summary, the following strengths and limitations of this screening method were identified:

4.9.2 <u>Strengths</u>

1. The GIS-based method to identify potential stream restoration opportunities using QHEI metrics is very versatile. It can be applied to any other watershed for which a GIS with aerial photographs is available.
2. This method is very reliable and can accurately identify streams with degraded riparian areas and flood plains within a large watershed.
3. This method speeds up the initial screening process of identifying and delineating potential stream restoration opportunities in a given study area and minimizes the time required for detailed field inspection.

4. Stream segments can be color coded in the GIS, which makes it easy for even a layman to identify the condition of each stream segment.

4.9.3 Limitations

1. Sometimes, the reliability of aerial photographs is questionable due to low resolution, which could lead to difficulty in interpreting the condition of vegetation in the riparian zone and flood plain.
2. This method evaluates only two metrics of QHEI, which amount to just seven percent of the total QHEI score designed by EPA. Thus, the method is only a screening technique, designed to generate a preliminary list of stream segments for potential restoration. More detailed field evaluations and analytic methods must be applied before the final selection of segments for restoration.
3. Constant updating of databases is not feasible and practical. Hence GIS-based results may be outdated and vary from field observations.
4. The ability of the restoration designer will eventually play a big part in successfully restoring a stream corridor.

Chapter 5

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

5.1 Summary and Conclusions

The GIS-based screening and ranking methods were developed to identify wetland mitigation and stream restoration opportunities. The procedures use well established, publicly available data sets, including soil type, land cover, waterways, and topography, in addition to aerial photographs. A comparison between the studies on wetland mitigation and stream restoration opportunities is shown in Table 5.1

Table 5.1 Comparison between Wetland Mitigation and Stream Restoration Studies

Description	Wetland Mitigation	Stream Restoration
Watershed in Study Area	Meander Creek, Mill Creek and Yellow Creek Watersheds	Meander Creek Watershed
GIS Data Sources	USGS, ODNR, US Fish and Wildlife Service, Mahoning County Enterprise GIS Files	Mahoning County Enterprise GIS Files
Attributes Evaluated	Hydrology, Soil types, Environment supporting Vegetation	Riparian Width and Flood Plain Quality Metrics of QHEI
Number of sites considered	43 Candidate Parcels	1001 Stream Reaches
Sites selected for field inspection	10 Candidate Parcels	8 Stream Sections
Number of Sites where Field Observations matched GIS Evaluation	8 Candidate Parcels	8 Stream Reaches
Accuracy of GIS-based technique	80%	100%

The GIS-based ranking system for Wetland Mitigation was applied to forty-three Candidate Parcels within the three watersheds and gave scores ranging from 5.54 to 9.24 (out of 10). The distribution of scores is sufficient to differentiate between sites with limited potential for wetland mitigation and those with excellent potential. Scores for two QHEI metrics (Riparian Width and Flood Plain Quality) were determined from aerial photos for 1000 stream segments in the Meander Creek watershed. The condition of stream segments was represented on color coded GIS maps. Several stream segments with potential for restoration were identified.

Both techniques were evaluated by field investigations. A strong correlation exists between the GIS-based evaluations and actual field observations in most cases. Sometimes, the reliability of aerial photographs is questionable due to its low resolution. In other cases, GIS information may be outdated (e.g., change in land use) or difficult to interpret (e.g., perennial versus intermittent streams). A detailed site investigation and preliminary wetland mitigation/stream restoration design must be performed before its ultimate feasibility can be determined.

5.2 Recommendations

5.2.1 Wetland Mitigation

- Ranking scores should be rounded to the nearest integer, and the following qualitative rating applied:

  9-10: Excellent; 8: Good; 7: Fair; 6: Marginal; ≤ 5: Poor.

- The present study can serve as a starting point for approaching landowners to discuss the acquisition of land parcels for wetland mitigation.
- A wetland designer should be consulted in order to develop an optimum design for wetland mitigation projects.
- The costs and benefits (values) of establishing wetlands on the various Candidate Parcels should be considered in developing the most cost effective wetland mitigation plan
- Cost analysis for wetland mitigation of sites will help classify them on the basis of cost effectiveness.

5.2.2 Stream Restoration

- A more detailed evaluation method should be applied to determine the condition and restoration potential for stream segments identified in this study. The method could involve other metrics of QHEI, attributes of the stream like stream meandering, streambank erosion, and consideration of aquatic functions.
- A stream restoration designer should be consulted in order to develop an optimum design for stream segments with the highest potential for restoration.
- Permits issued for future construction work should be checked to ensure that minimal damage is caused to existing or restored streams.
- A collective effort is necessary to restore the degraded streams. Coordination among local and state agencies and landowners is required for effective decision making.

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APPENDIX

Figure A.1 Candidate Parcel mn22, Looking East from Southwest Corner

Figure A.2 Candidate Parcel mn33, Looking North at culvert from South boundary

Figure A.3 Candidate Parcel mn12, Looking North from South Parcel Boundary

Figure A.4 Stream Segment MRA 9,10,11, Looking South towards Interstate 80.

Figure A.5 Stream Segment MRF 2g,h Looking East on Gault Road

Figure A.6 Stream Segments SC 17-36 Looking North from Blueberry Road