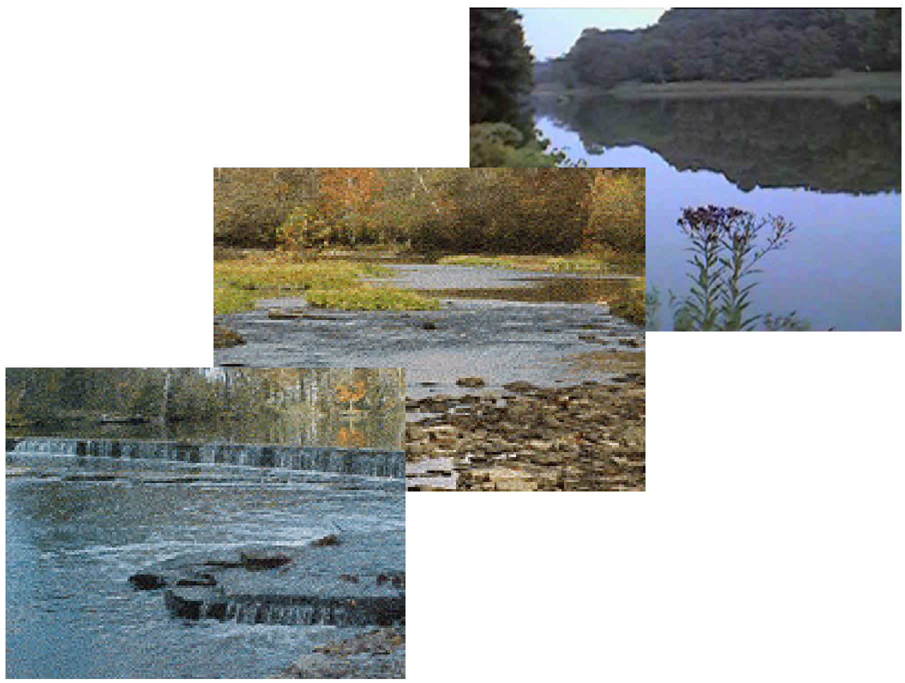
Upper Olentangy Watershed Management and Action Plan

Submitted by:
The Olentangy Watershed Alliance



Funding provided by:
Ohio EPA
319 Nonpoint Source Pollution
Grant Program
Grant #: 01(h)E-13

December, 2006

Contact Information:

The sponsoring organizations for the Upper Olentangy River Watershed Project are the Olentangy Watershed Alliance and City of Delaware.

City of Delaware
Public Utilities
3080 U.S. 23 North
Delaware, OH 43015
(740) 363-9374

www.olentangyriver.org

Technical questions for the Watershed Management and Action Plans should be addressed to:

Dr. Larry Brown, Professor
Water Management Specialist
Department of Food, Agricultural, and Biological Engineering
The Ohio State University
590 Woody Hayes Dr
Columbus, OH 43210
(614) 292-3826
Brown.59@osu.edu

Acknowledgements

Development of the Upper Olentangy River Watershed Management and Action Plan was accomplished through the dedication of multiple watershed stakeholders. As with all collaborative projects, many people and organizations have been involved in the Upper Olentangy project, and thus difficult to recognize everyone. However, the following people and organizations are acknowledged for their vision, efforts and commitments to compile this plan.

Bob Barger, resident of the watershed

Joe Bonnell, Ohio State University Extension

Larry C. Brown, Professor, The Ohio State University

City of Delaware, Ohio

Crawford Soil and Water Conservation District

Delaware Soil and Water Conservation District

Friends of the Lower Olentangy River

Ronica Harger, Administrative Assistant, City of Delaware

The late Dan Kush, Ohio Department of Natural Resources

Don Lee, farmer and Superintendent of Water, Village of Cardington

Marion Soil and Water Conservation District

Thomas Marshall, Utility Director, City of Delaware

Gale E. Martin-Hansgen, Watershed Coordinator, 2003-2004

Vince Mazeika, Ohio EPA

Richard Miller, Drinking Water Superintendent, City of Delaware

Morrow Soil and Water Conservation District

Ohio Environmental Protection Agency

Ohio Farm Bureau

Olentangy River Watershed Project Area Assistance Team

Brad Stanton, Deputy Utility Director, City of Delaware

Lindsey Ulrey, Watershed Coordinator, 2004-2005

Village of Cardington, Ohio

Jon Witter, PostDoc Researcher (former Graduate Student, The Ohio State University

Table of Contents

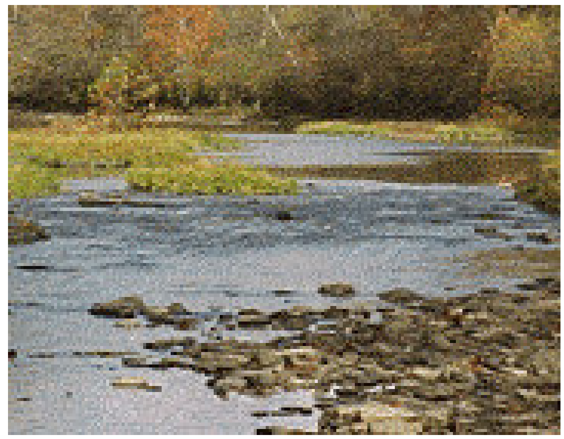
List of Figures

List of Tables

List of Appendices

1. Introduction

The Upper Olentangy River Watershed (UORW) project area is an important water resource for central Ohioans. This watershed has abundant water resources and rich with diverse aquatic communities of fish, freshwater mussels and associated benthic invertebrate fauna. The watershed is home to six state-listed endangered, threatened or special concern aquatic species while providing water resources for agricultural production, some industry, recreation and drinking water for an estimated 250,000 residents within and surrounding the watershed (Ohio EPA, 2006). Unfortunately, pollution from point sources (*e.g. from pipes*), runoff from agricultural and urban areas, poorly maintained septic systems, and unstable riparian corridors are degrading many of the water resources today.



Among the most visible and widely publicized threats in the Olentangy River Watershed is the development of agricultural farm land to residential and industrial uses. This is especially evident in Delaware County in the southern most reaches of the project watershed. The Olentangy River watershed drains Ohio's first and sixth most rapidly growing counties, Delaware and Morrow, respectively (Ohio EPA, 2006).

Restoring and protecting this watershed's diverse range of economic, social and ecological resources requires a holistic, integrated and collaborative approach that actively engages stakeholders in the planning, implementation and evaluation processes. This document serves to guide this process.

1.1. Purpose and Goals

The purpose of this Plan is to provide watershed stakeholders an adaptive strategic framework for action that protects water resources currently meeting attainment standards, and restores water resources currently not meeting attainment goals. This plan represents the culmination of extensive field surveys, technical analyses, public participation and outreach, and documentation of the knowledge from an array of watershed stakeholders.

Increasing public awareness and concern for water resources pollution resulted in the enactment for the Federal Water Pollution Control Act Amendment of 1972. Subsequently amended in 1977, this has become widely known as the Clean Water Act.

The national goals of this Act are for water resources to become "fishable, swimmable and drinkable". This Act outlines the structure for regulating pollutant discharges into the United States water resources, and gives the U.S. Environmental Protection Agency (EPA) the authority to develop and implement pollution control programs such as setting wastewater standards for industry. The Act makes it unlawful for any person to discharge any pollutant from a point source, into navigable waters, unless a permit is obtained from appropriate authority (FLOW, 2005).

Congress amended the Clean Water Act (CWA) in 1987 to establish the section 319 Nonpoint Source Management Program because it recognized the need for greater federal leadership to help focus State and local nonpoint source efforts. Under section 319, State, Territories, and Indian Tribes receive grant money which support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects (US EPA, 2006).

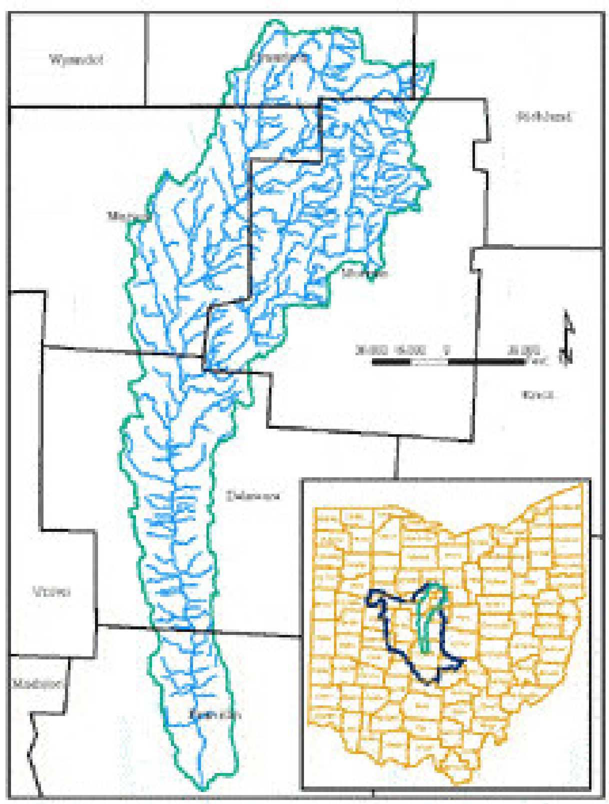
Nonpoint source pollution remains the leading source and cause of impairment to Ohio's waterways, and including the Olentangy River and its tributaries of the Upper Olentangy River Wateshed (UORW).

Thus, the goal of this Upper Olentangy River Watershed Management and Action Plan is to provide a framework of strategies for stakeholders to adopt that will lead to all water bodies attaining water quality goals and standards established by the Ohio EPA.

1.2. Project Background

The Olentangy River is a source of drinking water for the Cities of Delaware and Galion, and Del-Co Water (Ohio EPA, 2005). These water purveyors' have experienced water quality concerns related to nonpoint source pollution runoff from agricultural production common in the Upper Olentagy River Watershed. Technology-based solutions such as contaminant removal at the water treatment facility can be expensive and difficult to manage. Historically, these utilities have augmented ground water with contaminated surface waters to dilute the concentrations, or have transferred and stored higher quality waters in constructed up-ground reservoirs for consumption during seasonal pollutant runoff events. Because of growth and development, especially in Delaware City and surrounding Delaware County, these drinking water purveyors have either begun construction or plan to increase production capacity. In 1999, these water systems recognized the need for a balanced water resources approach and began to engage with watershed stakeholders such as the Olentangy Watershed Alliance (OWA) to help address nonpoint source pollution runoff.

Concurrently in 1999, interested local citizens, Ohio EPA (Vince Mazeika), ODNR (the late Dan Kush), OSU Extension (Joe Bonnell) formed the Olentangy Watershed Alliance (OWA). Regular meetings were held in the City of Delaware and educational programs begun. In 2000, OWA had coordinate with the Friends of the Lower Olentangy (FLOW), and with funding through a grant from the Ohio Department of Natural Resources, Division of Soil and Water Conservation (ODNR-DSWC), hired Erin Miller as the Watershed Coordinator for both watershed groups.



By 2003, OWA began to focus on water resource concerns in the upper reaches of the watershed (i.e. above Delaware Reservoir), which is consistent with the organization's goal of improving and protecting the quality of water for the Del-Co water and the Cities of Delaware and Galion.

OWA Board members were elected from the upper shed, and Don Lee, a Morrow county farmer and conservation leader, was elected as the Board's Chair. As Erin Miller began to focus more of her time on developing the Lower Olentangy Watershed Action Plan (FLOW, 2005), OWA hired Gale Martin-Hansgen, a Morrow County resident with farm background and Natural Resources major at OSU, as coordinator. Ms. Martin-Hansgen worked in the Morrow County SWDC office in Mt. Gilead, giving her crucial direct access to the farming community.

Also in 2003, the City of Delaware had applied and received an Ohio EPA 319(h) watershed planning grant. The City contracted with The Ohio State University, Department of Food, Agricultural, and Biological Engineering to compile the Watershed Management and Action Plan. Dr. Larry C. Brown and Jon Witter, Graduate Research Associate and Ph.D. student were lead management plan developers, in close cooperation with OWA and the City of Delaware. The Upper Olantangy River (UOR) team included Ronica Harger, Brad Stanton, Richard Miller, Thomas Marshall, all from the Department of Public Utilities, City of Delaware (DDPU); Gregg Sablak Delaware SWCD (now with Ohio EPA); Bob Bargar and Gale Martin Hansgen, OWA; several representatives from the City of Galion and Delco Water Plant; Don Lee, Village of Cardington and farmer; and Ohio EPA advisor Vince Mazeika. OWA and the City of Delaware representatives assisted with local community focus group meetings. Don Lee recruited watershed farmers to participate in stakeholder meetings. He also brought Jon Witter into contact with key farmers and farm locations for monitoring streams.

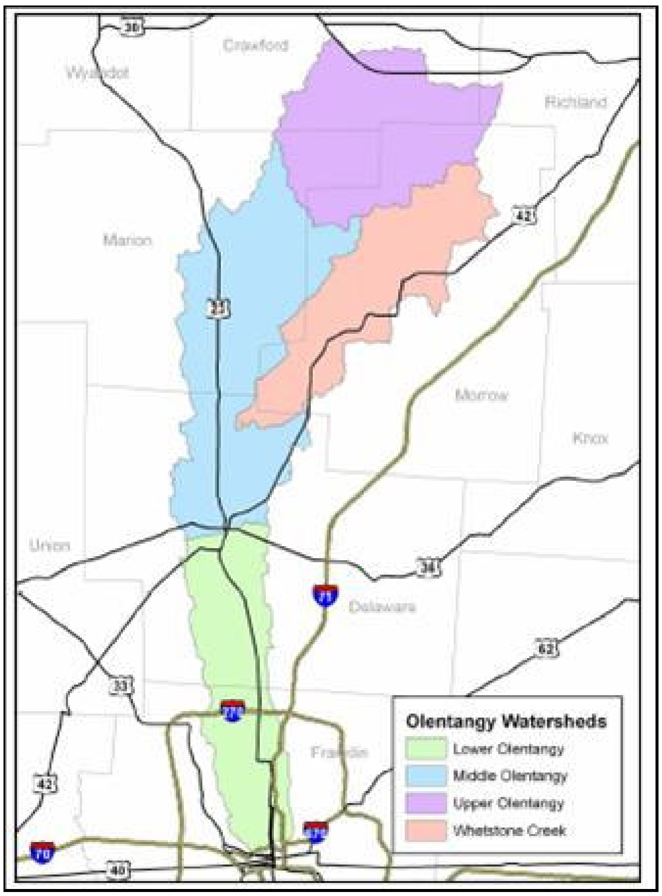
In 2004, OWA received another ODNR grant for outreach among the agricultural community as the watershed plan was being developed. Lindsay Grimm, Morrow County resident with farm background and graduate of Animal Science and Natural Resources programs at OSU, was hired as coordinator. Lindsay was housed with the Morrow County Soil and Water Conservation District (SWCD) office and worked with the supervision of Don Lee Board Chair, the OWA Board and advice from Dan Barker, Supervisor of the SWCD office and NRCS personnel. Farmers reviewed and commented on earlier watershed plan draft, and a brief report on farmer recommendations was submitted to Larry C. Brown for inclusion in the revised watershed plan.

1.3. Watershed Description

With an 8-digit Hydrologic Unit Code (HUC) number 05060001, the Upper Olentangy River Watershed (UORW) project area encompasses approximately 430 square miles in portions of Crawford, Delaware, Marion, Morrow and Richland counties of Central Ohio. Figure 1 depicts the watershed project area which is comprised of three smaller 11-digit hydrologic unit codes (HUC-11) watersheds, and represented by nearly 80% of the entire Olentangy Watershed. The hydrologic "address" for the Upper Olentangy, Middle Olentangy and Whetstone Creek watersheds corresponds to hydrologic unit code numbers 05060001-090, 05060001-100, and 05060001-110, respectively. A detailed HUC-14 smaller watershed code, name and description are listed in Table 3.2, page 17 of Appendix I.

The Olentangy River headwaters originate in northern Morrow County, about three miles southeast of the City of Galion. Flowing from the city, the river meanders northwesterly until it abuts against the St. John's End Moraine, where it is deflected southwesterly, flowing parallel the moraine. The river continues to flow south-southwest through a nearly level landscape of eastern Marion County and into northern Delaware County before discharging into Delaware Lake.

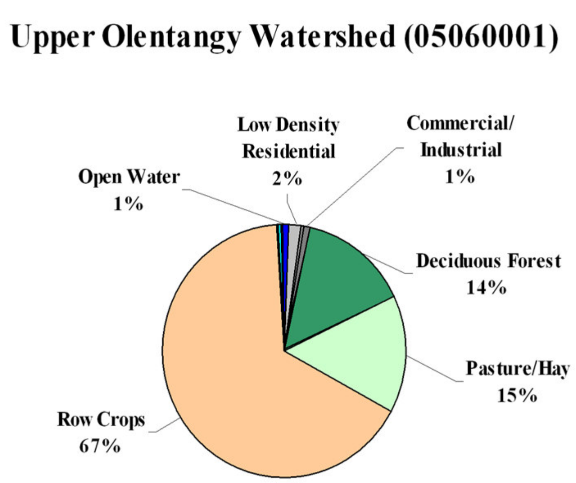
Figure 1: Map of Olentangy River watershed and the three sub-watersheds comprising the Upper Olentangy River Watershed project area; Upper and Middle Olentangy, and Whetstone Creek watersheds (Ohio EPA, 2005).



Whetstone Creek also originates in northern Morrow County and within two miles of the Olentangy River headwaters, but flows directly southward away from the Olentangy through a landscape of gently rolling hills, and through the Villages of Mt. Gilead and Cardington. Exiting the Cardington, Whetstone Creek travels southwesterly through a mostly level landscape before flowing into the northeastern region of Delaware Lake.

Downstream of the Delaware Lake dam, the U.S. Army Corp of Engineers regulate the dam discharge rate and subsequent flow in the Olentangy River. From Delaware Lake, the river flows through the City of Delaware, into southern Delaware County and into the City of Columbus, where the Olentangy merges with Scioto River, Alum Creek, and Big Walnut Creek to form the upper Scioto Basin at Columbus. The Scioto River then flows southward and discharges into the Ohio River at Portsmouth, OH.

Figure 2: Percent land use of the Upper Olentangy River Watershed project area.



Land Use Category	Percent
Open Water	0.8
Residential – Low Density	1.8
Residential – High Density	0.3
Commercial / Industrial/ Transportation	0.7
Quarries/ Strip Mines	0.0
Deciduous Forest	14.4
Evergreen Forest	0.2
Mixed Forest	0.03
Agricultural - Pasture/ Hay	14.9
Agricultural - Row Crop	66.1
Urban/ Recreational Grasses	0.3
Woody Wetlands	0.3
Emergent Herbaceous Wetlands	0.2

Land use is predominantly agricultural (82%) with mostly cropland and some pastures for livestock. Forested land is scattered throughout the landscape and is found mostly along stream corridors. The conversion of agricultural lands to residential, commercial and industrial development is occurring at rates among the fastest in the nation in the southern region near the City of Delaware. More than 80% of the cropland is used for corn and soybean production with lesser amounts of wheat, small grain, and hay. Tillage types vary in the watershed depending on weather, soil type, available equipment, and crop planted. Producers tend to use conventional (chisel) tillage for corn, and no-till or reduced tillage (greater than 30% residue) for soybean production (OSU, 2006a and OSU, 2006b). A comprehensive survey of agricultural land use and management practices for the entire Upper Olentangy River Watershed project are discussed in Chapter 4, page 23 of Appendix I (OSU, 2006a), and HUC-14 sub-watershed analysis is presented in Appendix II (2006b).

The Cities of Delaware, Galion and Marion are the largest incorporated communities within the watershed. The City of Galion in Crawford County is the furthest north community located in the Olentangy headwaters. Less than ten square miles of the watershed are located within Richland County with no incorporated communities. Similar to the larger communities, smaller communities such as the Villages of Ashley, Cardington, Caledonia, Edison, Mt. Gilead and Waldo are also situated within the watershed that rely on the water resources of the Olentangy watershed.

1.4. Special Districts

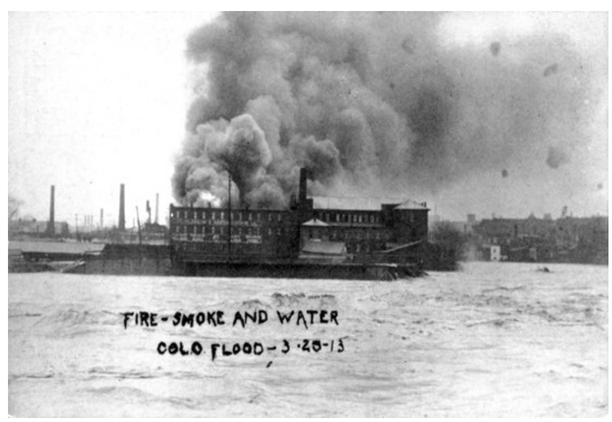
The Delaware, Morrow and Marion County's have county-level planning agencies that provide direction and technical assistance for residential, commercial and industrial development within each county. Often these planning agencies coordinate with Soil and Water Conservation Districts (SWCDs) regarding technical land use capabilities and limitations based on soils, slopes, and other hydrological factors.

1.5. Special Designations

Although the Upper Olentangy River Watershed project area does not have national or state wild and scenic river designations, the Lower Olentangy River watershed corridor does have both designations between the City of Delaware and the Delaware and Franklin County boundary (FLOW, 2003).

1.5.1. Delaware Lake and Delaware State Park

Delaware Lake is one among a system of dams throughout the Scioto and Ohio River Basins designed for flood control. Major floods of 1913 and then again in 1937 raised public awareness and concern for the need to protect lives and prevent property damage from flooding of communities along the Olentangy River. Almost 100 people died in Columbus when the Scioto River reached record levels and poured 9 to 17 feet deep through neighborhoods (Image from the Ohio Historical Society, 2006). At a cost of $4,307,000, the dam was authorized by the Flood Control Act of 1938 for the purposes of flood reduction, water supply, recreation, and wildlife habitat. The U.S. Army Corps of Engineers (US ACOE) constructed the dam and currently maintains and operates the dam, Huntington District.



The Delaware State Park is located on the southwest side of the reservoir and provides camping, picnicking, and boat launching facilities (USACOE, 2006).

Figure 3: Aerial photo of Delaware Lake dam (US ACOE, 2004).

1.5.2. Delaware Wildlife Area

The Delaware Wildlife Area is located adjacent to the Delaware Reservoir and provides a variety of grassland and woodland habitats for wildlife management. The wildlife area covers 4,670 acres north of the City of Delaware and south of the City of Marion. The wildlife management plan for the area provides for a diversity of habitats for upland wildlife. Management techniques include sharecropping, planting of permanent nesting cover, manipulating timber stands, and periodic burning to control succession. Wetland wildlife habitat has been improved by the construction of 54 ponds and the flooding of 159 acres of seasonal wetlands. The Olentangy Wildlife Research Station, which serves as the headquarters for statewide upland wildlife research, is located here. Many field research projects have been carried out on this area since 1951.

Populations of black bass, bluegill, crappie, white bass, saugeye, and catfish occur in the reservoir. A great variety of both nesting and migrant birds utilize the area. Of particular interest are the spring migration of waterfowl and songbirds and the fall migration of hawks. Red-tailed hawks, American kestrels, and Northern harriers (marsh hawks) are common summer sights over the open fields and woodlots. Large numbers of turkey vultures are also present during summer. Among the rare and unusual birds which have been observed are the bald eagle, Northern goshawk, osprey, king rail, snowy owl, long-eared owl, great egret, cattle egret, and sandhill crane. In 1994, wild turkeys were relocated from eastern Ohio to the Delaware Wildlife Area. Bird observation is a popular activity at Delaware. Cottontail rabbit, ring-necked pheasant, mourning dove, squirrels, woodchuck, raccoon, muskrat, mink, and opossum are the principal upland game and fur species. Resident populations of Canada geese, wood ducks, and mallards occur on the area. During the spring and fall migrations, these and other waterfowl species can be found in large numbers on the reservoir, ponds, and seasonally flooded marsh (US ACOE, 2006).

1.5.3. Mount Gilead State Park

Mt. Gilead State Park is located in Morrow County near the center of the state. The first lake at Mt. Gilead was built in 1919 on the upper level of Sam's Creek. On July 10, 1930, a larger lake was completed below the first one on this same tributary of Whetstone Creek. The recreational area was originally under the supervision of the Bureau of Engineering. In 1949, it was turned over to the newly formed ODNR Division of Parks and Recreation to be maintained as a state park (ODNR, 2006).

Figure 4: Photo of Mt Gilead State Park Lake (ODNR, 2006).

1.6. Phase 2 Storm Water Communities

1.6.1. The City of Galion

In 2000, Galion City Council, after recommendations from a Storm Water Advisory Committee, created a storm water utility. Revenue collection started in January 2001. This Utility fund will provide funding for maintenance and for improvements (City of Galion, 2006).

1.6.2. City of Delaware

The City of Delaware is currently in the process of creating a Storm Water utility that will manage requirements of the Storm Water Phase 2 program. The City has submitted a draft Storm Water Management Plan to Ohio EPA and anticipates beginning implementation of management measures in 2007 based on final plan approval (City of Delaware, 2006).

1.7. Demographics

Both population and housing are increasing in the Upper Olentangy River Watershed. Between 1990 and 2000, 5,659 people have moved into the watershed living in 3,518 new homes. However, this is trend is not consistent throughout the entire basin. During this same period, the most dramatic growth occurred in the Middle Olentangy Watershed, but below Delaware Lake Dam near the City of Delaware. For the period from April 2000 to July 2004, Delaware County was the eleventh fastest growing county in the United States (Ohio EPA, 2006). Concurrently, northern areas of the watershed in Crawford and Morrow counties had experienced a slow rate of declining population. Although the number of households in the Upper Olentangy Watershed has slightly increased 3%, the population has decreased by 457 residents. This data is indicative of a population shift from the rural community and from small- to medium-sized villages and cities. Table 1 depicts population and housing statistics summarized by HUC-14 watershed. A complementary demographic analysis for each township, village, and city are presented in Chapter 9 beginning on page 58 of Appendix I (OSU, 2006a).

Table 1: Population and housing demographics of the Upper Olentangy Watershed project area (Ohio EPA, 2006).

HUC-14			Population		Households		Percent Change	
			1990	2000	1990	2000	Population	Housing
05060001	**090**	**Upper Olentangy Watershed**						
		010	15,501	14,977	6,479	6,593	-3%	2%
		020	901	877	338	360	-3%	7%
		030	831	879	289	344	6%	19%
		040	2,160	2,203	795	856	2%	8%
		Sub-Total:	**19,393**	**18,936**	**7,901**	**8,153**	**-2%**	**3%**
	100	Whetstone Creek Watershed						
		010	6,964	7,902	2,787	3,236	13%	16%
		020	1,895	2,050	735	834	8%	13%
		030	1,417	1,475	532	594	4%	12%
		Sub-Total:	**10,276**	**11,427**	**4,054**	**4,664**	**11%**	**15%**
	110	Middle Olentangy Watershed (Above Delaware Lake Dam)						
		010	1,488	1,525	593	617	2%	4%
		020	1,175	1,263	445	486	7%	9%
		030	818	868	319	340	6%	7%
		040	4,297	4,634	1,680	2,023	8%	20%
		050	1,090	1160	413	478	6%	16%
		060	6,092	6,340	2,559	2,823	4%	10%
		070	666	693	246	274	4%	12%
		080	1,305	1,451	518	638	11%	23%
		Sub-Total:	16,931	17,934	6,773	7,679	6%	13%
		Middle Olentangy Watershed (Below Delaware Lake Dam)						
		090	8,302	9,391	3,393	3,954	13%	17%
		100	645	743	249	311	15%	25%
		110	6,166	8,941	1,997	3,124	45%	56%
		Sub-Total	**15,113**	**19,075**	**5,639**	**7,389**	**26%**	**31%**
		Total:	**61,713**	**67,372**	**24,367**	**27,885**	**9%**	**14%**

Source: Ohio EPA, 2006

Increasing population shifts and corresponding rapid development in the lower reaches of the project watershed near the City of Delaware raises concern for its affects on water resources. Development typically impacts streams in two ways: first, an intense period of land disturbance during construction of roads, sewers, and buildings, then the resulting altered landscape that handles water differently than the pre-construction landscape. Near-term impacts include stream channelization and pollution from construction site runoff as housing and infrastructure expand to accommodate the growth. Long-term impacts include an increase in the watershed's total impervious surface, which results in faster runoff and higher-volume storm flows. This change in the hydrologic regime of a stream system can increase stream-bank erosion and destabilize channels, resulting in greater siltation downstream and increasingly ephemeral tributary stream flow (Ohio EPA, 2006).

1.8. Cultural History

The earliest-known residents of the Upper Olentangy River watershed were the Mound Builders. Several examples of the mounds the Native Americans built can be found in Canaan Township of western Morrow County. After the Mound Builders, the Iroquois, Delaware, Shawnee, Wyandot and Ottawa Indian tribes inhabited the area.

For example, the Delaware people were often referred to by other Native Americans as Na-Be-Naugh-a or "people from the east." This is because these people moved westward from their ancestral home in the Delaware Valley to escape pressure exerted upon them by the fierce Iroquois nation and European settlers. The tribe assumed the name of Delaware, derived from the designation of their eastern valley. The word originates from the name of Lord Delaware, once the governor of Virginia (ODNR, 2006). Although there are no records of large camps or villages, the area was a favorite hunting ground for the Native Americans as late as 1819 (Morrow County, 2005).

In the early 1800s, a route near present U.S. 23 was well worn by European settlers destined for Lake Erie. The Greenville Treaty Line of 1795, a historic treaty that established the final Ohio boundary separating Native American territory from that of American settlers', crosses through the center of the watersheds it crosses the southern portion of Marion County and the enter of Morrow County.

A brick tavern was constructed in 1810 that served as a resting place for the travelers. The structure was built on a small hill overlooking Mount Gilead Lake east of the City of Mount Gilead. The Delaware, Wyandot and Shawnee Native American tribes joined forces in an attempt to block the western expansion of the settlers. In response to the coming war with the British and Indians, a Captain Taylor directed the building of a palisade around the tavern. The new Fort Morrow served to protect the establishment as well as to function as a sanctuary for local settlers in case of Indian attack. Although several scares brought families to its protective cover, no actual attacks were recorded (ODNR, 2006).

The first permanent settlers came into the area following the War of 1812. The first gristmill and sawmill were built on Whetstone Creek in 1821. During the next several years, settlers came to the area from Knox, Perry and Muskingum counties and from Connecticut, Maryland, New Jersey, Pennsylvania and Virginia. The settlers cultivated the soils along streams and in the higher areas of moraines. They started farms by clearing three to five-acre plots of woodland and then planting corn, flax, wheat or pasture species. Later, as more woods were cleared, the settlers brought in livestock, drained wet spots and planted orchards. Most of the early crops were consumed locally, because the poor road conditions limited the transportation of goods. In 1848, the county's transportation problem was partially solved when a railroad was built through the villages of Cardington and Edison (Morrow County, 2005).

The river's name has an interesting history. Olentangy was a name given to this river in 1833 by a legislative act that was attempting to restore Native American names to certain rivers in the state. The word Olentangy literally means 'River Of Red Face Paint'. This name actually belonged to Big Darby Creek further to the west, where Wyandotte of the Columbus area got their red face paint. The Olentangy River should have been named the Whetstone River. Both Native Americans and early settlers used the black Ohio and Olentangy shale found along the river for whetstones to sharpen their tools (OWA, 2006)

Several routes of the Underground Railroad ran through the county, notably along County Road 24. The town of Mt. Gilead, the Morrow County seat, served as a major stop on the Underground Railroad prior to the Civil War (Morrow County, 2005). Two of the earliest educational institutions in Ohio were in Morrow County. Iberia College, today known as Ohio Central College, opened in Iberia in 1849, continued as an educational institution until 1875 and dissolved in 1885. The first president of Iberia College, the Rev. , an abolitionist and local Presbyterian minister who refused a Presidential Pardon granted by . The reverend had been convicted for violating the . He died in 1868 and was buried in Iberia Cemetery. His actions were but a part of the operations of the , along which Iberia was a significant host to several "stations" (Wikipedia.com, 2006).

In more recent history, an oil boom occurred in Morrow County. In 1961, a well was drilled on the Orrie Myers' property that produced 200 barrels a day. As a result of that wells success, 30-40 wells are drilled in Morrow County annually (Morrow County, 2005).

Among the watershed's most notable citizens include two United States Presidents and are Rutherford B. Hayes from the City of Delaware, and Warren G. Harding (Morrow County, 2005).

1.9. Background/ Previous watershed protection measures.

A complete listed of previous watershed conservation protection and restoration programs is described in Chapter 5 beginning on page 28 of Appendix I (OSU, 2006a). In general however, and as noted in the Watershed Resources Inventory report, in terms of water quality initiatives, the Upper Olentangy has received little attention when compared to surrounding watersheds. Other than local conservation office staff initiatives, state and federal programs, more watershed protection measures have been focused on the Great Lakes watersheds and federal and state cost-share assistance funds have been directed to those watersheds. One attempt to prioritize problems in the Upper Olentangy was held by local agencies and residents in Crawford County during the late 1990's. However, a comprehensive implementation of those priorities was not funded.

Of particular interest however, in 2004 the USDA Farm Services Agency (FSA) in collaboration with the State of Ohio and local partners, had applied and successfully secured Ohio's third Conservation Reserve Enhancement Program (CREP) for the entire Scioto River watershed. More than $200 million are available to implement 70,000 acres of riparian buffers, filter strips, wetlands, and even water table management practices. Agricultural landowners in the Upper Olentangy River watershed are eligible for this program. At an average rate of 11.4 acres/ contract, 83 signed contracts representing 944 acres of conservation practices have been enrolled in the Scioto CREP program in the UORW. The Upper Scioto watershed has more than 9,000 acres enrolled in CREP practices from 293 contracts and represents an average 31 acres/ contract. By way of comparison, at an average rate of 38 acres/ contract, almost 19,000 acres from 500 contracts have been enrolled in the CREP program in the Lower Scioto watershed of Madison, Ross and Pickaway counties.

2. Watershed Plan Development

The Olentangy Watershed Alliance (OWA) is a non-profit 501 (c)(3) registered, grassroots, citizen's organization dedicated to protecting the Olentangy.

According to the OWA Bylaws, as adopted on May 16, 2002, and presented in Appendix III:

> ***"OWA is a group of citizens, public officials and special interest groups organized for non-profit purposes work in partnership with farming, urban, and other local communities to understand, appreciate and responsibly use the Olentangy River, its tributaries and watershed. The OWA vision is to enhance and preserve the water quality, natural integrity, scenic beauty and recreational value of the Olentangy River watershed in partnership with local communities. OWA is not formed for political lobbying or campaigning purposes."***

In conjunction with the City of Delaware and The Ohio State University, OWA has been the lead organization that facilitated development of this watershed inventory and action plan. OWA represent the local citizens interested in the protection and improvement of water resources in the Olentangy River. OWA helped identify, host and engage an array of watershed partners that contributed to the planning process. This Upper Olentangy Watershed Management and Action Plan was developed with input of citizens and stakeholders of the watershed.

OWA's vision is to enhance and preserve the water quality, natural integrity, scenic beauty, and recreational value of the Olentangy River watershed in partnership with diverse community interests (OWA, 2006)

2.1. Mission Statement

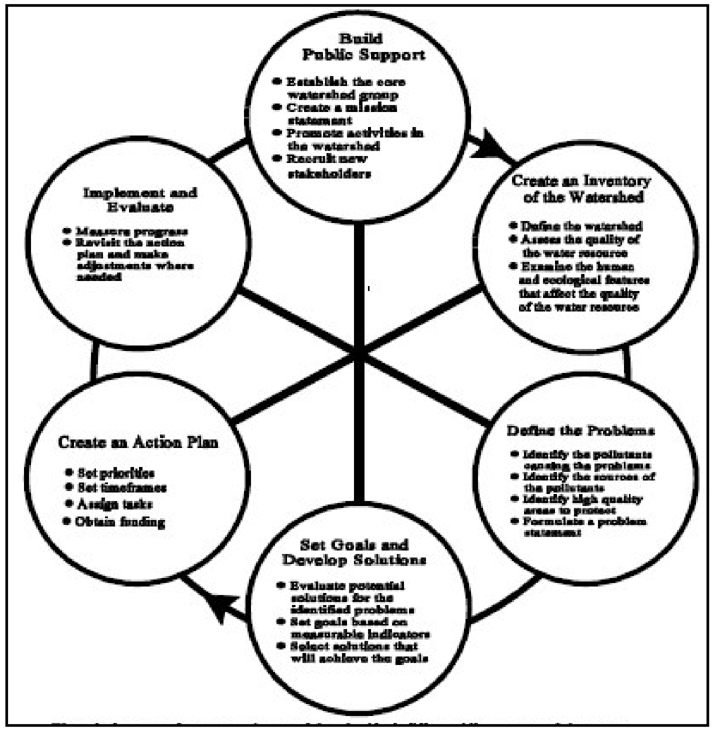
The mission statement of the Olentangy Watershed Alliance (OWA) is,

> ***"…to work in partnership with farming, urban and other local communities to understand, appreciate and responsibly use the Olentangy River, its tributaries and watershed".***

2.2. Watershed Planning Process

The Olentangy Watershed Alliance relied on Ohio EPA's planning process known as the "Watershed Approach" model as a guide to develop this plan. Ohio EPA defines the watershed approach is defined as (Ohio EPA, 1997):

> *A comprehensive effort to address multiple causes of water quality and habitat degradation in a watershed. It is a **process** that emphasizes prioritizing problem areas and developing comprehensives, integrated solutions by involving stakeholders from both inside and outside of government.*



The watershed planning process has six core steps that include:

- Build public support
- Create an Inventory of the Watershed
- Define the Problems
- Set Goals and Develop Solutions
- Create an Action Plan
- Implement and Evaluate

Ohio EPA states that many groups typically begin with ***Building Public Support*** that help raise awareness, understanding and support among the watershed community for the planning process. Encouraging the public to participate in the watershed process typically yields greater opportunity for successful implementation of restoration and protection measures because the public have a better appreciation of the value of water resources that serve their community. Moreover, once water issues are identified, citizens of the watershed can help develop solutions that can be adopted locally; oftentimes at little to no costs.

2.3. Partners

To help engage a diverse range of public participation in the Upper Olentangy River watershed, OWA reached out to involve watershed citizens, local governments, conservation organizations, conservation agencies, regulated dischargers, university researchers, and drinking water purveyors. Members of the advisory council represented a diverse group of local governmental officials and advocacy groups. All stakeholders in the community agreed to serve on the committee and were active during the planning process. Advisory council members included:

Bob Barger, resident of the watershed

Ronica Harger, Administrative Assistant, City of Delaware

Don Lee, farmer and Superintendent of Water, Village of Cardington

Thomas Marshall, Utility Director, City of Delaware

Gale E. Martin-Hansgen, Watershed Coordinator, 2003-2004

Richard Miller, Drinking Water Superintendent, City of Delaware

Brad Stanton, Deputy Utility Director, City of Delaware

Lindsey Ulrey, Watershed Coordinator, 2004-2005

Jon Witter , Graduate Student, The Ohio State University

Larry C. Brown, Professor, The Ohio State University

2.4. Partnership Structure

Organizational procedures and structure is provided in the organization's Bylaws. A copy of this document is provided in Appendix III.

2.5. Operation Procedures/ Bylaws

The Olentangy Watershed Alliance Bylaws with organizational and operational producers were developed with assistance by the late Dan Kush of ODNR. A copy of this document is provided in Appendix III.

2.6. Group Decision Making Process

The OWA's Board decision making process has been via Board discussions and votes at public meetings. In making decisions, the Board has always drawn upon advice and expertise from others, including our watershed coordinators, farm and non-farm stakeholders in the valley, and skilled and knowledgeable personnel from the Morrow County and Delaware County Soil and Water Conservation Districts and USDA Natural Resources Conservation Service, Ohio EPA, Ohio Department of Natural Resources, the City of Delaware, Del-Co Water, OSU Extension and the U.S. Army Corps of Engineers.

2.7. Outline of Plan's content

The outline of the Upper Olentangy River Watershed Management Plan is consistent with the 2003 Ohio EPA Appendix 8 update, "Outline of a Watershed Plan from "A Guide to Developing Local Watershed Action Plans in Ohio". This plan is composed of eight chapters summarizing elements of the guidance recommendations. Complementing these documents in Appendices I and II are the Comprehensive

Watershed Inventory and Action Plan that provide detailed hydrologic unit code (HUC-14) scale watershed analyses.

Chapter 1, Introduction: this chapter provides an overview of the project watershed area that includes communities, special areas in the watershed, demographics, and background information on previous watershed protection efforts.

Chapter 2, Watershed Plan Development: the Olentangy Watershed Alliance (OWA) is described in this chapter, how they are organized and the process they used to develop this watershed management and action plan.

Chapter 3, Watershed Inventory Summary: A comprehensive inventory of the Upper Olentangy Watershed is briefly summarized in this chapter and refers the reader to the *Upper Olentangy River Watershed: Watershed Resources Inventory and Management* Plan (OSU, 2005a), provided in Appendix I.

Chapter 4, Watershed Impairments: A summary of causes and sources of impairments affecting the watershed are provided in this chapter. A detailed sub-watershed list of impairments is also provided in Appendix II.

Chapter 5, Watershed Restoration and Protection Goals: A summary of restoration and protection goals for the watershed are provided in this chapter. A detailed list of restoration and protection goals for each 14-digit HUC sub-watershed is provided in Appendix II.

Chapter 6, Implementation: A summary of implementation objectives, schedule, and performance indicators are provided in this chapter. A complementary detailed list of implementation objectives, schedule and performance indicators for each 14-digit HUC watershed are provided in Appendix II. Also, an education, information and marketing strategy are discussed in Chapter 6. Lastly, sources of funding to implement various best management practices (BMPs) are summarized.

Chapter 7, Evaluation: Metrics to evaluate the performance of practices and programs implemented in the watershed are provided. A water quality monitoring program is briefly discussed in this chapter.

Chapter 8, Plan Update/ Revision Process: A discussion of how the watershed plan will be reviewed and updated routinely or as needed is briefly presented in this chapter.

Appendix I, Upper Olentangy River Watershed: Section A -Watershed Resources Inventory: This report is a comprehensive detailed watershed inventory analysis. This report was used by watershed stakeholders to help identify and prioritize water resource concerns and solutions (OSU, 2006a).

Appendix II: Upper Olentangy River Watershed: Section B - Watershed

Management and Action Plan: This report is a comprehensive HUC-14 sub-watershed action plan based on detailed analysis of causes and source of impairment; restoration and protection goals; objective, costs estimates; and performance metrics (OSU, 2006b).

Appendix III: Olentangy Watershed Alliance Bylaws: Approved bylaws of the Olentangy Watershed Alliance (OWA, 2002).

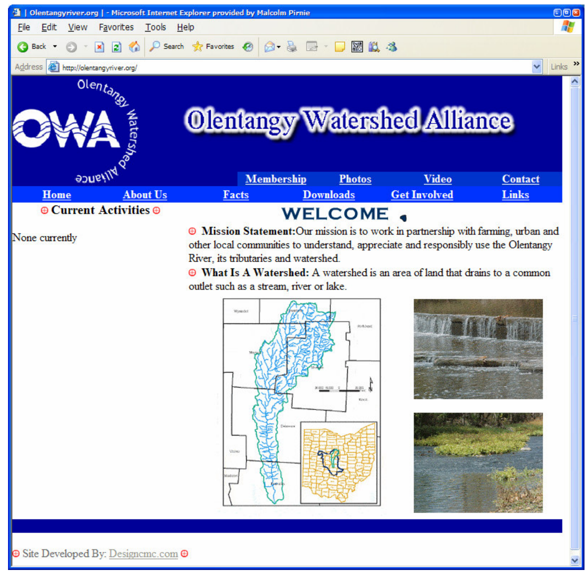
2.8. Endorsement

Officials representing a variety of local units of government have played a critical role in the development of this Upper Olentangy Watershed report. The City of Delaware has provided sponsorship, financial and in-kind resources to support development of this report. Other communities, county agencies and villages such as the Village of Cardington, City of Galion, Delaware SWCD, Marion SWCD, Morrow SWCD have supported and continue to sponsor staff and provide resources to advance the progress of the vision and goals of this report.

Following state endorsement of this plan, the Watershed Coordinator will present key findings and recommendations of this report to cities, villages, townships and county officials for continued local support and endorsement of the action items recommended in this report.

2.9. Education and Outreach

The Olentangy Watershed Alliance (OWA) has created and facilitated an array of public education and outreach programs. The intent of these programs is to raise the watershed's citizens and stakeholder's understanding, knowledge, and appreciation of land use management and water resources in Upper Olentangy River watershed. Examples of education and outreach elements during the planning process have included:



- Project web site;
- Newsletters;
- Building and maintaining membership;
- Conducting monthly public meetings; and,
- Hosting public workshops.

For example, the Upper Olentangy Watershed Action Planning Team held several series of public watershed stakeholders meetings. These meeting series focused on identifying problems that affect water quality in the watershed, as well as identify areas or practices that are improving or maintaining the quality of water. Five public meetings were conducted April 16, 23, 24, 26, and May 7, 2003 in Cardington, Mt. Gilead, Galion, Marion, and Delaware, respectively; and three follow-up public meetings were conducted August 5, 6 and 7, 2003 in Caledonia, Cardington, and Waldo, respectively. Findings from the first series of meetings were presented during the second meeting series which allowed the audience to expand on the list of problems or solutions to water quality issues (OSU, 2006a).

Results of these public meetings by the Action Planning Team are presented in subsequent chapters in the watershed problem identification and prioritization, and development and prioritization of project goals and objectives (OSU, 2006b).

3. Watershed Inventory

A comprehensive inventory of the physical, biological, water resources and land use features of the Upper Olentangy River Watershed project area Watershed Resources Inventory (OSU, 2006a) is presented in Appendix I of this report. A detailed mapping, land use, and water quality assessment has been compiled for the eighteen 14-digit hydrologic unit code (HUC) scale watersheds (OSU, 2006b). The data were used to help identify water quality impairments, and establish restoration and protection goals.

3.1. Overview

The Olentangy watershed is characterized with a distinct variety of cultural landscapes from the headwaters to the river's confluence with the Scioto River in Columbus. Small streams, ditches and tributaries in Crawford, Marion and Morrow counties drain the predominantly agricultural landscapes scattered with small towns and villages. As the Olentangy River flows south through Delaware County, the landscape becomes intensely developed along the U.S. 23 corridor. This corridor of contrasting development yet intense natural beauty (the steep forested ravines that ladder the river's east flank) extends southward to the Franklin county line (OSU, 2006a, OEPA, 2005).

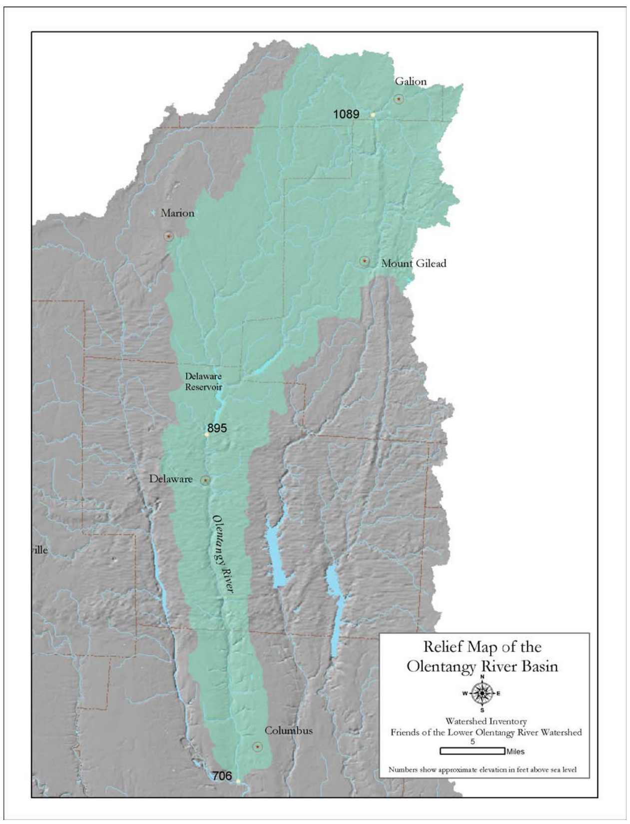


Figure 5: Relief map of the Olentangy River Basin (FLOW, 2005).

4. Watershed Impairments

Average annual rainfall in the Upper Olentangy River Watershed exceeds thirty-six inches that replenishes groundwater and surface waters. Not including small tributaries and intermittent streams, more than 540 miles of meandering streams and rivers convey water through and from the landscape. Wetlands help filter and store surface waters and cover almost 2% of the watershed area. Larger open surface water retention areas represent an estimated 1,848 acres and provide Central Ohio flood control, recreation and public drinking water supplies (OSU, 2006a). Unfortunately, many of these water resources have been impaired (Ohio EPA, 2005).

4.1. Causes and Sources of Impairment

Causes of impairments include siltation, nutrient enrichment, bacteria/ pathogens, habitat alteration, flow alteration, and elevated temperature. Sources of impairment in the watershed have been linked to agricultural row crop and livestock production, point source discharges, channelization, hydro-modification, home sewage treatment systems (HSTS), development and urban runoff (Ohio EPA, 2006; Ohio EPA, 2005; OSU, 2006a, 2006b).

Because of the relatively large area of the Upper Olentangy River Watershed project area, a comprehensive cause and source of impairment assessment has been completed for each of the smaller HUC-14 watersheds. Causes of and corresponding sources of impairments for each of the eighteen HUC-14 watersheds are summarized in Table 1. A brief discussion is presented in the following paragraphs. A detailed characterization with public comments for each sub-watershed is presented in Chapter 7, page 39 of the Watershed Resources Inventory Report in Appendix I (OSU, 2006a). Causes and sources of impairment associations, photos and maps of each sub-watershed are fully discussed in the Watershed Management and Action Plan provided in Appendix II (OSU, 2006b).

Table 2: Summary of causes and sources of impairment for each of the 14-digit hydrologic unit code (HUC) sub-watersheds in the Upper Olentangy River Watershed (Ohio EPA, 2006; and OSU, 2006b).

14-Digit HUC			Watershed Name	Sedimentation	Nutrient Enrichment	Bacteria/ Pathogens	Habitat Alterations	Flow Alterations	Temperature
05060001	090	Upper Olentangy Watershed							
		010	Rocky Fork	*a,c,u,h*	*a,p,s,u*	*p,s*	*l,c*	*h*	
		020	Olentangy @ Flat Run	*a,c*	*a,s*	*s*	*b,c*		
		030	Mud Run	*a,c*	*a,*	*s*	*c*		
		040	Flat Run	*a,c*	*a,s*	*s*	*c*		
	100	Whetstone Creek Watershed							
		010	Whetstone Creek	*a,c,u*	*a,p,s*	*p,s*	*c*		*c*
		020	Shaw Creek	*a,c*	*a,*	*s*	*c*		*c*
		030	Whetstone below Shaw	*a,h*	*a,*	*s*	*c*	*h*	*c*
	110	Middle Olentangy Watesrhed (Above Delaware Lake Dam)							
		010	Otter Creek	*a,c*	*a,p*	*p,s*	*l*		
		020	Olentangy River @ Otter Creek	*ac*	*a,p*	*p,s*	*c*		
		030	Riffle Creek	*a,c*	*a*	*s*	*c*		
		040	Grave Creek	*a,c*	*a,p*	*c,s*	*c*		
		050	Norton Run	*a,c,h*	*a*	*s*		*h*	
		060	Qua Qua Creek	*a,c*	*a,s*	*s*	*c*		
		070	Brondige Run	*a*	*a,s*	*s,d*	*c,d*		
		080	Indian Run	*a,c*	*a,*	*s*	*c*		
		Middle Olentangy (Below Delaware Lake Dam)							
		090	Olentangy River	*a,u*	*a,s*	*s*		*c,h,u*	
		100	Horseshoe Run	*a,d*	*a,*	*s*			
		110	Delaware Run	*a,u*	*a,s*	*s*	*c*	*c*	

Table 3: Codes and description of sources of impairment used in Table 2.

Code	Description of Source of Impairment
a	Agricultural row crop production
l	Livestock with unrestricted access to streams
p	Ohio EPA NPDES permitted point source discharge
c	Channelization
h	Hydromodification
s	Home sewage treatment systems (HSTS)
d	Development
u	Urban runoff

The most widespread sources of impairments throughout the watershed project area originate from agricultural row crop production, stream channelization, and home sewage treatment systems (HSTS). For example, poorly maintained HSTS, or septic systems, are significant sources of ***fecal coliform bacteria*** impairment in all eighteen HUC-14 watersheds; even among the more urban and developing sub-watersheds near the City of Delaware. The number of septic systems per HUC-14 watershed is listed in Table 5 (Ohio EPA, 2006).

Channelization is a source of ***sedimentation*** impairment in all but one sub-watershed, and source of riparian ***habitat alteration*** in fourteen of the 18 smaller HUC-14 basins (See Table 2). Hydromodification is a source of impairment in four sub-watersheds and are linked to urban land use activities such as construction of an up-ground reservoir for the City of Galion, Delaware Lake, and low-head dams along the Olentangy River within the City of Delaware (See Table 2).

Agricultural row crop production is prevalent throughout the Upper Olentangy River Watershed project area, and consequently is the most common and widespread source of ***sedimentation and nutrient enrichment*** (See Table 2). The cumulative effect of agricultural nonpoint source runoff, including channelization, is evident in Delaware Lake. At an annual sedimentation rate of 0.4%, the Reservoir has lost 14.8% of it original capacity with more than 3.2 million cubic yards or 3.7 million tons of sediment (Ohio EPA, 2005). Moreover, the three drinking water purveyors that withdraw water from the Olentangy River rely on higher quality water stored in up-ground reservoirs, or augment with groundwater for dilution to comply with federal drinking water standards. This low cost "dilution" treatment strategy is directly attributed to the seasonal occurrences of elevated levels of nitrate and atrazine in agricultural runoff (OSU, 2006a). An analysis of the nitrate and atrazine concentration data in Delaware Lake is presented in Chapter 8, page 48 of the Watershed Resources Inventory in Appendix I (OSU, 2006a).

4.2. Point Source Pollution Loading

In accordance with the Clean Water Act, the US Environmental Protection Agency (EPA) requires communities and industry to collect and treat wastewater and stormwater prior to discharging effluent into the nation's streams and rivers. Ohio EPA uses the federal National Pollutant Discharge Elimination System (NPDES) permit program to regulate the quantity of pollutants entering the waterways from point sources of pollution. There are fifty-seven (57) facilities that have an Ohio EPA NPDES permit to discharge treated effluent into receiving streams within the Upper Olentangy River watershed. Ohio EPA has grouped these systems into seven (7) major, thirty-five (35) minor, and fifteen (15) miscellaneous and industrial wastewater treatment facilities. Although non-compliant discharges can occur, this regulatory approach has been widely recognized as successful. According to Ohio EPA draft Total Maximum Daily Load (TMDL) for the Olentangy River Watershed, NPDES permitted facilities are contributing less than 10% of the total phosphorus (TP), 1% of total suspended solids (TSS), and 1% of fecal coliform (FC) to the total annual watershed pollutant load (Ohio EPA, 2006). Thus the remaining pollutant loads, and majority, originate from the non-regulated nonpoint sources.

4.3. Nonpoint Sources of Pollution Loading

Nonpoint source pollution is pervasive throughout the Upper Olentangy River watershed and remains the leading cause of water resources impairment. Nonpoint source loads for three pollutants by HUC-14 watersheds are summarized in Table 4. According to the draft TMDL for the Olentangy Watershed, Ohio EPA defines nonpoint pollutants that originate from "surface runoff, groundwater, and sub-surface" sources from unregulated areas other than discharge permitted wastewater treatment facilities and Municipal Separate Storm Sewer Systems (MS4) (Ohio EPA, 2006). One important note to point out, Ohio EPA does not include septic systems or livestock pollutant loads in the nonpoint annual load equation.

The TMDL report data clearly indicate that more than 96% of the watershed project area is a source of unregulated nonpoint source pollution that significantly contributes to the total annual pollutant load. Nearly all, 99.9%, of the annual sediment load, 85.6% of the total phosphorus load, and 45.7% of fecal coliform bacteria emanate from unregulated nonpoint sources. Ohio EPA estimates septic systems contribute nominal total phosphorus and total suspended solid annual loads, 2.8% and 0.03% respectively. However, these systems contribute 48.8% of the watershed's total annual fecal colifom load (See Table 5).

Interestingly, livestock access to streams contribute less than 5% of the total fecal coliform, and zero percent of total phosphorus and total suspended solid annual loads (Ohio EPA, 2006). A detailed HUC-14 watershed land use map, description, and analysis of both HSTS and livestock access to streams is documented in Appendix II (OSU, 2006b).

Table 4: Unregulated nonpoint source pollution is the leading cause of impairment to the Upper Olentangy River Watershed (OEPA, 2006). Data in parentheses indicate the percent of total load for each HUC-11 sub-watershed. This data was used for the watershed stakeholders to prioritize implementation projects.

				Area	Total Phosphorus		Total Suspended Solids		Fecal Coliform	
HUC-14			Watershed Name	Acres	(lb/acre/ year)	(1,000 lb/yr)	(ton/ acre/ year)	(1,000 ton/ year)	(count/acre/ 100ml)	(count/ 100ml)
0506001	Upper Olentangy Watershed									
	090	010	Rocky Fork	29,482	0.81	23.8	0.58	17.1	2.71E+10	7.99E+14
	090	020	Olentangy @ Flat Run	13,475	0.36	4.8	0.06	0.8	1.38E+11	1.86E+15
	090	030	Mud Run	13,085	1.37	17.9	0.41	5.4	1.08E+11	1.41E+15
	090	040	Flat Run	27,051	0.95	25.7	0.50	13.5	5.49E+09	1.49E+14
	090		***Sub-Watershed Total:***	**83,093**	**0.87**	**72.3 (78.7)**	**0.44**	**36.8 (99.8)**	**5.1E+10**	**4.22E+15 (45.7)**
	Whetstone Creek Watershed									
	100	010	Whetstone Creek	39,213	0.50	19.6	0.34	13.3	4.16E+10	1.63E+15
	100	020	Shaw Creek	19,156	0.89	17.0	0.43	8.2	2.43E+11	4.65E+15
	100	030	Whetstone below Shaw	13,661	0.83	11.3	0.36	4.9	2.36E+09	3.22E+13
	100		***Sub-Watershed Total:***	**72,030**	**0.67**	**48.0 (81.0)**	**0.55**	**26.5 *(99.9)***	**2.39E+11**	**6.32E+15 *(57.4)***
	110	Middle Olentangy Watershed (Above Delaware Dam)								
	110	010	Otter Creek	14,817	0.91	13.4	0.29	4.3	1.55E+10	2.30E+14
	110	020	Olentangy River @ Otter Creek	15,098	1.09	16.4	0.34	5.1	1.01E+10	1.52E+14
	110	030	Riffle Creek	11,096	1.12	1.4	0.33	3.7	3.35E+10	3.72E+14
	110	040	Grave Creek	6,606	1.37	9.0	0.40	2.6	2.42E+09	1.60E+13
	110	050	Norton Run	10,598	1.62	17.2	0.38	4.0	2.09E+11	2.21E+15
	110	060	Qua Qua Creek	9,869	1.63	16.0	0.39	3.8	2.21E+11	2.18E+15
	110	070	Brondige Run	7,926	0.91	7.2	0.27	2.1	1.79E+10	1.42E+14
	110	080	Indian Run	8,697	0.52	4.5	0.18	1.6	2.03E+09	1.77E+13
	110		***Sub-Watershed Total:***	**84,707**	**1.14**	**96.4 *(92.3)***	**0.32**	**27.3 (99.8)**	**6.29E+10**	**5.33E+15 (44.4)**
	110	Middle Olentangy Watershed (Below Delaware Dam)								
	110	090	Olentangy River	13,533	1.29	17.4	0.58	7.8	2.12E+09	2.87E+13
	110	100	Horseshoe Run	7,087	1.51	10.7	0.47	3.3	2.21E+09	1.57E+13
	110	110	Delaware Run	4,908	0.49	2.4	0.29	1.4	2.06E+09	1.01E+13
	110		***Sub-Watershed Total:***	**25,528**	**1.20**	**30.6 (56.0)**	**0.49**	**12.6 (45.0)**	**2.13E+09**	**5.45E+13 (2.2)**
			Watershed Project Area Total:	**265,358 (96.2)**	**0.93**	**247.3 (85.6)**	**0.39**	**103.2 (99.9)**	**6.0E+10**	**1.59E+16 (45.7)**

Table 5: Contribution of annual pollutant loads from Home Sewer Treatment Systems (HSTS) for the eighteen Hydrologic Unit Code (HUC-14) watersheds in the Upper Olentangy River Watershed (OEPA, 2006). Data in parentheses indicate the percent of total existing load for each HUC-11 sub-watershed.

14-Digit Hydrologic Unit Codes (HUC)			Watershed Name	Number of HSTS	Total Phosphorus (lb/year)	Total Suspended Solids (ton/year)	Fecal Coliforms (count/100ml)
05060001	090	Upper Olentangy Watershed					
		010	Rocky Fork	865	450	1.69	9.39E+14
		020	Olentangy @ Flat Run	212	94	0.35	1.96E+14
		030	Mud Run	160	71	0.27	1.49E+14
		040	Flat Run	900	1,633	6.12	3.41E+15
			Sub-Watershed Total:	**2,137**	**2,248 (2.4)**	**8.43 (0.02)**	**4.69E+15 (51.0)**
	100	Whetstone Creek Watershed					
		010	Whetstone Creek	2,000	1,336	5.01	2.79E+15
		020	Shaw Creek	310	348	1.31	7.27E+14
		030	Whetstone below Shaw	430	384	1.44	8.02E+14
			Sub-Watershed Total:	**2,740**	**2,068 (3.5)**	**7.76 (0.03)**	**4.32E+15 (39.3)**
	110	Middle Olentangy Watershed (Above Delaware Lake Dam)					
		010	Otter Creek	200	223	0.84	4.65E+14
		020	Olentangy River @ Otter Creek	300	271	1.02	5.65E+14
		030	Riffle Creek	185	249	0.93	5.19E+14
		040	Grave Creek	155	201	0.75	4.19E+14
		050	Norton Run	180	159	0.60	3.32E+14
		060	Qua Qua Creek	457	686	2.57	1.43E+15
		070	Brondige Run	500	560	2.10	1.17E+15
		080	Indian Run	100	129	0.48	2.68E+14
			Sub-Watershed Total:	**2,077**	**2,477 (2.3)**	**9.29 (0.03)**	**5.17E+15 (43.1)**
		Middle Olentangy Watershed (Below Delaware Lake Dam)					
		090	Olentangy River	427	566	2.12	1.18E+15
		100	Horseshoe Run	251	340	1.28	7.10E+14
		110	Delaware Run	212	281	1.05	5.86E+14
			Sub-Watershed Total:	**890**	**1,187 (3.7)**	**4.45 (0.04)**	**2.48E+15 (98)**
			Watershed Project Area Total:	**7,844**	**7,980 (2.8)**	**29.9 (0.03)**	**1.7E+16 (48.8)**

4.4. Habitat Alteration

While habitat alteration does not contribute directly to pollutant loading it does affect both the assimilative capacity of streams and the attainment of aquatic life uses. All of the HUC-14 basins within the watershed have been noted to have some degree of channelization or other anthropogenic activity that affects instream habitat. Many of those channelized reaches have been modified to provide drainage to support agricultural row crop production. Agricultural and urban drainage improvements performed historically often serve to disconnect the riparian zone from the stream. That disconnect, compounds the effects of hydro-modification on attainment of aquatic life criteria. In some areas the riparian zones have been converted to other uses. The extent of channelization and habitat impairment for all eighteen HUC-14 watersheds are discussed in Appendix I (OSU, 2006a), pages 45 – 47, and assessment results reported throughout Appendix II (OSU, 2006b).

4.5. Public Participation

The Upper Olentangy Watershed Action Planning Team hosted a series of public meetings where participants identified perceived water quality problems, and identified areas or practices they believe are maintaining high quality or improving the quality of water. Five public meetings were conducted April 16, 23, 24, 26, and May 7, 2003 in Cardington, Mt. Gilead, Galion, Marion, and Delaware. Three follow-up public meetings were facilitated by the team on August 5, 6 and 7, 2003 in Caledonia, Cardington, and Waldo, respectively. Findings from the first series of meetings were presented during the second meeting series which allowed the audience to expand on the list of problems or solutions to water quality issues. Overall, each group agreed that results from previous meetings were quite thorough and only a few additions were made.

On December 15, 2003, and January 14, 28, and 29, 2004, the Action Planning Team hosted a series of half-day Best Management Practices (BMP) Workshops in Crawford, Marion, Morrow, and Delaware counties. Nearly 60 stakeholders with a wide variety of backgrounds and interests participated in facilitated discussions to prioritize water quality problems, as well as discuss which BMP's would be acceptable. Soil erosion, unrestricted livestock access to streams, septic systems, nutrients and log jams were identified as the primary problems related to water quality. With key issues identified during the first two series of meetings in 2003, a list of water quality problems was developed for the BMP workshops, and participants were asked to prioritize their top two concerns. The following table summarizes the cumulative results of that exercise. Identified and locally recommended BMPs were used to form the list of Objectives in each sub-watershed reported in Appendix II (OSU, 2006b).

Table 6: Watershed stakeholder water quality problem identification and prioritization (OSU, 2006a).

Problem	Top Priority	Second Priority
Soil Erosion/Sediment	19	8
Log Jams	16	12
Atrazine	6	3
Livestock Runoff	5	2
Septic Systems	4	4
Stream Bank Erosion	3	11
Nitrate	3	8
Urban/Rural Stormwater	2	2
Litter/Dumping	2	1
Flooding	0	4

4.6. Problem Statements

A comprehensive list of problem statements have been compiled for each of the eighteen HUC-14 watersheds and are presented in Appendix II, *Watershed Management Plan and Action Plans* (OSU, 2006b).

5. Watershed Restoration and Protection Goals

This chapter summarizes restoration and protection goals that were compiled by the Olentangy Watershed Alliance, The Ohio State University, and Ohio EPA. A comprehensive list of management measures has been compiled for each sub-watershed to address specific causes and sources of water resources impairments. Costs estimates for management measures that address sources of nonpoint source pollution have also been developed for each of the sub-watersheds in the Upper Olentangy River Watershed.

5.1. Goals

Watershed restoration and protection goals were identified for the Upper Olentangy Watershed project area (OSU, 2006a). Goals for each HUC-14 watershed are presented in the Watershed Action Plan attached in Appendix II (OSU, 2006b). The following Table 1 summarizes the restoration and protection goals for each sub-watershed. It is evident from this table that reducing agricultural cropland runoff, improving riparian habitat by stabilizing stream corridors, and repairing failing septic systems are the goals throughout the entire project area. It is also evident of where urban runoff controls are necessary in the City of Delaware area south of Delaware Dam.

Table 7: This table summarizes types of watershed protection and restoration goals for the Upper Olentangy River Watershed for each HUC-14 watershed. Details characterizing goals for each HUC-14 sub-watershed are listed in Appendix II.

14-Digit Hydrologic Unit Code (HUC)			Watershed Name	1) Manure Management	2) Livestock Stream Access Restrictions	3) Prescribed Grazing Systems	4) Reduce Cropland Sediment Runoff	5) Improve Riparian Habitat	6) Repair Failing Septic Systems	7) Cropland Subsurface Drainage Management	8) Restore Channelized Drainage Ditches	9) Reduce Urban Runoff	10) Reduce Urban Peak Discharge
0506001	090	Upper Olentangy River Watershed											
		010	Rocky Fork	X		X	X	X					
		020	Olentangy at Flat Run	X			X	X	X	X	X		
		030	Mud Run	X			X	X	X	X	X		
		040	Flat Run				X	X	X	X	X		
	100	Whetstone Creek Watershed											
		010	Whetstone Creek	X			X	X	X				
		020	Shaw Creek	X			X	X	X				
		030	Whetstone below Shaw Creek				X	X	X		X		
	110	Middle Olentangy River Watershed (Above Delaware Lake)											
		010	Otter Creek				X	X	X	X	X		
		020	Olentangy River at Otter Creek				X	X	X	X	X		
		030	Riffle Creek				X	X	X	X	X		
		040	Grave Creek				X	X		X	X		
		050	Norton Run				X	X	X	X	X		
		060	Qua Qua Creek				X	X		X	X		
		070	Brondige Run				X	X	X	X	X		
		080	Indian Run				X	X	X	X	X		
		Middle Olentangy River Watershed (Below Delaware Lake)											
		090	Olentangy River				X	X	X		X	X	X
		100	Horseshoe Run				X	X	X		X		
		110	Delaware Run				X	X	X		X	X	X

5.2. Objectives

A list of potential implementation objectives to achieve water quality goals has been compiled for all eighteen HUC-14 scale watersheds. The objectives for each sub-watershed describe the type of objective, number of units to install or adopt, estimated costs, potential funding sources, timeline, and performance indicators. Examples of objectives listed in Appendix II include (OSU, 2006b):

- Reduce phosphorus and sediment loading by 6.1 and 13.3 tons/year, respectively, through the adoption of 2,000 acres of residue management; 2,000 acres cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 15 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, 8 watering facilities, and adoption of 370 acres of Prescribed Grazing Plans with priority to lands adjacent to streams.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 124 acres of filter strips; 50 acres riparian buffers; and, constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (9.39E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for 25 of the 865 systems with improved on-site treatment systems or collection sewers.

A list of prioritized objectives is presented in Chapter 6, Implementation of this report.

While working with the watershed community, the importance of local agencies (in particular Soil and Water Conservation Districts, the Natural Resources Conservation Districts, Ohio State University Extension Services, Health Departments, etc.) was apparent. As a part of the local community, these agencies interact with the watershed stakeholders routinely and are the first point of contact for most conservation or health related issues. Successful implementation of this watershed plan will require a continuation of these strong and close relationships that has been developing during the past eight years. Also, residents repeatedly stated that they prefer participation in conservation programs remain voluntary. The Olentangy Watershed Alliance (OWA) has developed this implementation plan that leverages local relationships, and the voluntary stakeholder supported approach toward achieving water quality goals (OSU, 2006a).

6.1. Prioritize Objectives

Objectives to address water quality impairments have been identified and prioritized for the eighteen HUC-14 watersheds. A timeline defining tasks, solutions, resources, method, timeframe, performance indicators for each solution have been developed for these sub-watersheds and are presented in detail in Appendix II (OSU, 2006b). OWA, and partnering agencies, will lead the implementation phase of this program. These prioritized objectives will provide the initial framework for action beginning in 2007 when a full-time watershed coordinator will manage the implementation process.

Priority Implementation Objectives

The following objectives have been reviewed, prioritized and endorsed by members of the Olentangy Watershed Alliance on December 6, 2006.

Shaw Creek Watershed (HUC 05060001 100 020)

1) Reduce phosphorus and sediment loading by 2.1 (25%) and 3,212 (39%) tons/year, respectively, through the implementation of 50 acres of filter strips; 20 acres of riparian buffers; 20,000 linear feet of new grassed waterways; and, the development of 15 nutrient/ manure management plans for cropland and livestock operations.

2) Reduce nitrogen loading by 30% through the installation of 10 acres of filter strips on non-subsurface drained cropland; 10 acres of filter strips on subsurface

drained cropland coupled with drainage water management; 50 acres of cropland (without no filters/buffers) coupled with drainage water management; 100 acres of late spring N-test; and, development of 10 nutrient/manure management plans for cropland and livestock operations.

3) Reduce atrazine (and other pesticides) loading by 50% through the development of 10 pesticide management plans.

4) Reduce pathogen loading 100% (7.27E+14 count/ml) from home sewage treatment systems (HSTS) by replacing or repairing 78 poorly maintained systems.

Olentangy River Watershed (HUC 05060001 110 090): below Delaware Lake dam to below Horseshoe Run

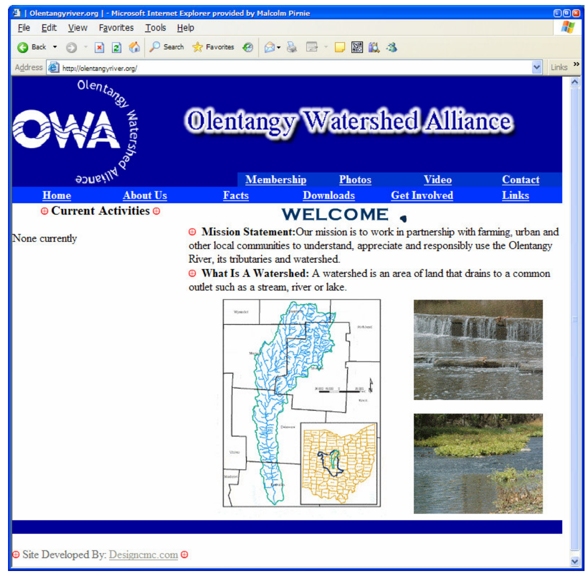
5) Reduce phosphorus and sediment loading by 4.4 tons (51%) and 6,122 tons (78%)/year, respectively, through the installation of 7.9 new acres of filter strips; 15.0 acres of riparian buffers; 300 new acres of no-till or other conservation tillage practice; and, 25 nutrient management plans for agricultural cropland producers.

6) Reduce pathogen loading by 100% (1.18E+15 count/ml) from home sewage treatment systems (HSTS) by replacing and/or repairing 63 on-site treatment systems.

7) Improve riparian habitat and QHEI scores along Olentangy River by the removal of the Central Avenue Dam located within the Olentangy River.

6.2. Education/ Information/ Marketing Strategy

As previously discussed in Chapter 2, the Olentangy Watershed Alliance has used an array of public education and outreach approaches to raise the level of awareness, understanding and knowledge about land management and water resources in Upper Olentangy River watershed. OWA and partners will continue to expand there public education and outreach programs. Examples of education and outreach elements OWA has successfully used the following outreach mechanisms:



- Project web site
- Newsletters
- Building and maintaining membership
- Conducting monthly public meetings
- Hosting public workshops

Through a dedicated Watershed Coordinator, OWA plans to continue to raise and maintain public awareness using these outreach mechanisms. The Watershed Coordinator will employ include a targeted education and marketing strategy based on priority goals and objectives. For example, to address the pervasive nonpoint source pollution from agricultural runoff will include nutrient management workshops. Following a successful education and outreach model developed in the nearby Upper Big Walnut Creek Watershed, OWA and partners will seek the assistance of the Ohio State University Extension nutrient and herbicide management specialists who can help producers develop site specific plans that minimize the risk of pollutant runoff.

In addition to cropland management strategies, the Upper Olentangy River Watershed is in a unique position to significantly raise public awareness about stream and riparian corridor management. In 2005, US EPA Region 5 awarded the Ohio Department of Natural Resources, Division of Soil and Water Conservation a 319(*h*) grant of $411,000 for a 3-year demonstration project of practices that align modern drainage practices with CREP management practices to address nutrient, sediment, habitat alteration and hydromodification impairments in the Upper Olentangy River Watershed. This project will provide an opportunity for public education and outreach to enhance awareness and understanding for the need for stream stabilization. OWA will coordinate directly with these project managers and researchers to ensure that the research information will be disseminated among watershed stakeholders.

6.3. Funding Strategy

Multiple sources of funding have supported landowners and local officials in site-specific for protecting and restoring water quality throughout the watershed. OWA recognize that although these funding sources exists, a hands-on Watershed Coordinator is critical to maintain direct communications with local county conservation planning committees who identify and prioritize environmental resources concerns, and thus prioritize program funds to these resource concerns. OWA will ensure that the water resource concerns documented and referenced in this report will be provided to each conservation committee such that they will have the opportunity to target federal programs and funding to prioritized watersheds.

6.3.1. Agricultural Nonpoint Source Runoff

Because of the pervasive nature of agricultural sources of nonpoint source pollution in the watershed, engaging the agricultural community to address these issues is critical to the success of meeting water quality goals. The US Department of Agriculture (USDA) can provide significant technical, educational and financial resources to producers throughout the watershed. In collaboration with the local Soil and Water Conservation Districts (SWCD), USDA can deliver an array of conservation programs and practices customized for the Upper Olentangy River Watershed. The traditional USDA "farm bill" conservation programs have provided incentives for farmers to install conservation best management practices such as buffer strips through the Conservation Reserve Program (CRP), and livestock waste facilities or exclusion fencing through the Environmental Quality Incentives Program (EQIP).

As previously discussed in Chapter 2, in 2004, the USDA Farm Services Agency (FSA) in collaboration with the State of Ohio and local partners, had applied and successfully secured $200 million for Ohio's third Conservation Reserve Enhancement Program (CREP) for the entire Scioto River watershed. The Scioto CREP is a farmer/landowner-implemented agricultural environmental stewardship program that will compensate landowners to change their land use along streams from detrimental agricultural activities to conservation-oriented uses. The goal of the CREP is to create 70,000 acres of filter strips, riparian buffers, wildlife habitat, wetlands, and tree plantings to reduce sediment and nutrient runoff into the Scioto River and its tributaries, including the Olentangy watershed. As a result it hopes to improve biodiversity in the entire watershed. Participants in CREP will enroll for 15 years and receive 15 annual payments from USDA-FSA. Additional bonus incentives are available for planting warm season grasses and restoring wetlands. In addition, cost-share funding is available for controlled drainage water management, livestock fencing, and livestock watering systems which are recommended practices in this plan (Ohio EPA, 2006).

During the public meeting process facilitated by the planning team, funding programs currently available were identified to help implementation of conservation practices. It should be noted that these funds are limited and many applications for conservation practice assistance are denied. The programs that are currently available in the counties are as follows (OSU, 2006a):

Environmental Quality Incentive Program (EQIP) - USDA cost share program. This program can be used for any USDA cost shareable practice including but not limited to: animal waste storage facility, grid sampling & nutrient management, compost facility, and cover crops.

ODNR Pollution Abatement – State of Ohio cost share program for practices to solve existing pollution problems for animal waste or sediment.

Conservation Reserve Program (CRP) – This is the USDA land retirement or set aside program. It pays an annual rental payment for taking cropland out of production and establishing grasses or tree cover as well as creating wetlands.

Conservation Reserve Program (Continuous CRP) – The USDA program aimed at establishing grass filter strips, riparian tree buffers, windbreaks, and/or creating wetlands. This program pays an annual rental payment and offers cost share. This is not a competitive program and eligible lands are automatically accepted.

Conservation Reserve Enhancement Program (CREP) – USDA and State of Ohio buffer program similar to USDA CRP buffer program, but offers additional payments to the landowner in return for longer term contracts. This program is available in Crawford, Delaware, and Morrow counties for specified watersheds not including the Upper Olentangy watershed.

Wildlife Habitat Incentive Program (WHIP) – USDA program that offers landowners cost share assistance for grassland plantings, riparian tree plantings and wetland restoration to benefit wildlife.

Wetland Reserve Program (WRP) – USDA program to encourage restoration and enhancement of wetlands. The landowner receives a payment for placing a 30+ years to permanent conservation easement on the land.

Pheasant's Forever – Offers rental assistance on native grass no-till drill for planting native warm season grasses. Also, offers food plot and native grasses seed.

Division of Environmental and Financial Assistance (DEFA) – Program offers buy down on interest rate of a loan for many conservation equipment/practices. This assistance is currently available for producers in the Great Lakes watersheds in Crawford and Marion counties.

Ducks Unlimited – May offer additional cost share on wetland creation and enhancements.

6.3.2. Home Sewage Treatment Systems (HSTS)

During the various meeting series conducted by the project team it was evident that many water quality problems might be linked to on-site treatment of waste by septic systems. At the workshops, representatives from health departments shared the various BMP's that are currently available. Crawford County is currently in the process of acquiring funds to develop a waste treatment facility for the Sugar Grove area, an area with a long history of poor on-site waste treatment. They are, also, in the process of acquiring funds for septic system improvements and inspection.

Several years ago, Morrow County Health Department started a revolving loan fund where low interest loan payments would then return to the County Health Department for use in future on-site waste treatment upgrades. They currently sponsor large garbage and tire disposal days as an incentive for residents to dispose of those items properly.

Delaware County Health Department has been quite active in terms of BMP programs. They are currently in the process of locating and documenting treatment systems. Data and information is entered into a database and linked to a GIS database. All package treatment systems are catalogued and as new inspections are completed and systems are constructed they gather that information as well. Currently 30% of the aeration systems in Delaware County are inspected annually. They are currently developing a proposal aimed at inventorying all systems in the county and looking into a low interest revolving loan fund similar to the one available in Morrow County (OSU, 2006a).

7. Evaluation

Plan evaluation is a critical step in the Watershed Planning Approach process. This phase will help the watershed partners assess the program's performance and progress towards water quality goals, and, if necessary, adapt corrective changes (Ohio EPA, 1997). The Olentangy Watershed Alliance (OWA) will collaborate with various watershed partners who lead the implantation of restoration and protection projects and programs, and manage water quality monitoring programs. Teaming with these technical partners, OWA will synthesize information provided by partners and summarize into brief reports that tract key performance indicators of implementation and water quality. These report briefs will be used to enable OWA to assess the overall progress of goals and objectives outlined in this Watershed Action. Also, these reports will be shared with watershed partners and used for public outreach and education. Such information is critical to the long-term success of watershed programs such that those who implement watershed projects will believe they are a part of the solution and have been involved in the progress towards achieving the water quality goals.

7.1. Tracking Criteria

Tracking criteria to determine if the program's progress is being achieved will include data and information from participating watershed partners. For example, program participation and enrollment, types and units of practices and actions implemented, accepted empirical pollutant loading equations to estimate before and after implementation, and water quality monitoring data are key criteria that will be compiled for reportable program performance metrics. OWA will also use technology such as geographic information systems (GIS) for recording, managing, mapping and reporting tracking criteria provided by watershed partners .

7.2. Partnering to tracking and monitoring progress

OWA will be responsible to track progress of this Watershed Plan. To effectively and efficiently track and monitor the programs progress, they will collaborate with project partners. Partners such as City of Delaware, Del-Co Water, The Ohio State University Extension (OSUE), Ohio EPA, Soil and Water Conservation Districts (SWCDs), County Health Departments, USDA Natural Resources Conservation Service (NRCS) and Farm Services Agency (FSA) offices in each watershed county, as well as other partnering organizations where projects are implemented will be sharing data and information that enable OWA to track the program's performance. Each of these partnering agencies possesses the appropriate technical knowledge of program tracking and reporting methodologies.

For example, for the near-term, the SWCDs, NRCS and FSA can assist in the tracking the implementation of best management practices (BMPs) by type, number, geographic location and pollutant load reduction estimates. The SWCDs and OSU Extension can assist with tracking education and outreach performance. County Health departments can track the progress of home sewage treatment system (HSTS) retrofitted or replaced. A summary of relative effectiveness of USDA-NRCS approved conservation practices are summarized in Appendix II (OSU, 2006b).

For the intermediate period, Ohio EPA's comprehensive Five-Year Basin Approach water quality monitoring program can be used to assess if targeted HUC-14 watersheds have achieved water quality attainment criteria based on the implementation objects facilitated by OWA. For the long term progress assessment, OWA will coordinate with the City of Delaware and Del-Co Water through their routine water quality monitoring programs to determine if nitrate and atrazine concentrations have been reduced at the drinking water intake facilities during seasonal runoff periods. This monitoring will enable OWA to track the watershed-wide aggregate performance

This incremental and collaborate monitoring approach will enable OWA and watershed partners to quickly identify and highlight successful approaches, learn and share unsuccessful approaches, and adapt the program towards achieving water quality goals.

8. Plan Update/ Revision

The Olentangy Watershed Alliance (OWA) has adopted an adaptive Watershed Approach framework that is flexible to changes in the watershed, stakeholder interests' changes and as other issues arises. OWA recognize that this plan is a "living and dynamic" document that can be modified as necessary. OWA plans to conduct an annual review of the plan to assess the overall direction of the program. As the Board determines that the program is achieving its identified goals and as other stakeholders begin to raise other issues of concern, the Board will direct the Watershed Coordinator to amend the Watershed Action Plan as warranted. The Coordinator will notify the ODNR Division of Soil and Water Conservation and Ohio EPA Division of Surface and amend the Plan in accordance with Policy statement.

8.1. Distribution List

With assistance of the City of Delaware, the Olentangy Watershed Alliance will be the primary clearinghouse of documents and information contained and referenced herein. Because OWA is a collaborative effort among various agencies, local communities, and citizens, OWA will ensure a copy of the state endorsed Watershed Management Plan and supporting documents are made available in local libraries for public viewing. OWA will be responsible to track progress of this Watershed Plan. OWA will provide a set of copies to the following organizations:

- Local community libraries
- Village and City offices
- County Soil and Water Conservation District offices
- County Health Department office
- www.olentangyriver .org

9. References

City of Delaware. 2006. *Draft Storm Water Management Plan*. Public Utilities, Delaware, Ohio.

City of Galion. 2006. Storm Water Utility. http://www.ci.galion.oh.us/Water/storm%20water%20utility.htm

D'Ambrosio J., Ward A., and Witter J. 2006. *Olentangy River Watershed Total Maximum Daily load Study*. Department of Food, Agricultural and Biological Engineering, Ohio State University, Columbus, Ohio.

FLOW. 2003. *A Snapshot: The State of the Lower Olentangy River Watershed in 2001: Lower Olentangy River Watershed Inventory.* Friends of the Lower Olentangy Watershed. Columbus, Ohio.

FLOW. 2005. *The Lower Olentangy Watershed Action Plan in 2003: Strategies for Protecting and Improving Water Quality and Recreational Use of the Olentangy River and Tributary Streams in Delaware and Franklin Counties.* Friends of the Lower Olentangy Watershed. Columbus, Ohio.

Morrow County. 2005. *Morrow Co Plan, Ohio Comprehensive Land Use Plan*. Comprehensive Land Use Plan Steering Committee. Mt. Gilead, Ohio.

Ohio EPA. 2005. *Biological and Water Quality Study of the Olentangy River, Whetstone Creek and Select Tributaries 2003-2004*. Division of Surface Water, Columbus, OH. EAS/2005-12-6

Ohio EPA. 2006. *Total Maximum Daily Loads for the Olentangy River Watershed*. Division of Surface, Columbus, OH. Draft for Public Review.

Ohio EPA. 1997. *A Guide to Developing Local Watershed Action Plans in Ohio*. Division of Surface Water, Columbus, OH.

Ohio Department of Natural Resources. 2006. *Mt. Gilead State Park.* http://www.ohiodnr.com/parks/parks/mtgilead.htm.

Ohio Historical Society. 2006. *March 23-27, 1913: Statewide Flood.* http://www.ohiohistory.org/etcetera/exhibits/swio/pages/content/1913_flood.htm

Olentangy Watershed Alliance. 2006. *Olentangy River Facts*. http://www.olentangyriver.org/

OWA. 2002. *Olentangy Watershed Alliance Bylaws*. Olentangy Watershed Alliance Delaware, OH.

OSU. 2006a. *Upper Olentangy River Watershed: Watershed Resources Inventory and Management Plan*. Department of Food, Agricultural and Biological Engineering, Ohio State University, Columbus, Ohio.

OSU, 2006b. *Upper Olentangy River Watershed: Watershed Management Plan and Action Plan*. Department of Food, Agricultural and Biological Engineering, Ohio State University, Columbus, Ohio.

US Army Corps of Engineers. 2006. Delaware Lake. http://www.lrh.usace.army.mil/projects/lakes/deo/

US Environmental Protection Agency. 2006. Clean Water Act Section 319. http://www.epa.gov/OWOW/NPS/cwact.html

USDA, NRCS. 1990. Sediment survey of Delaware Reservoir. US Department of Agriculture, Natural Resources Conservation Service. Delaware, Ohio.

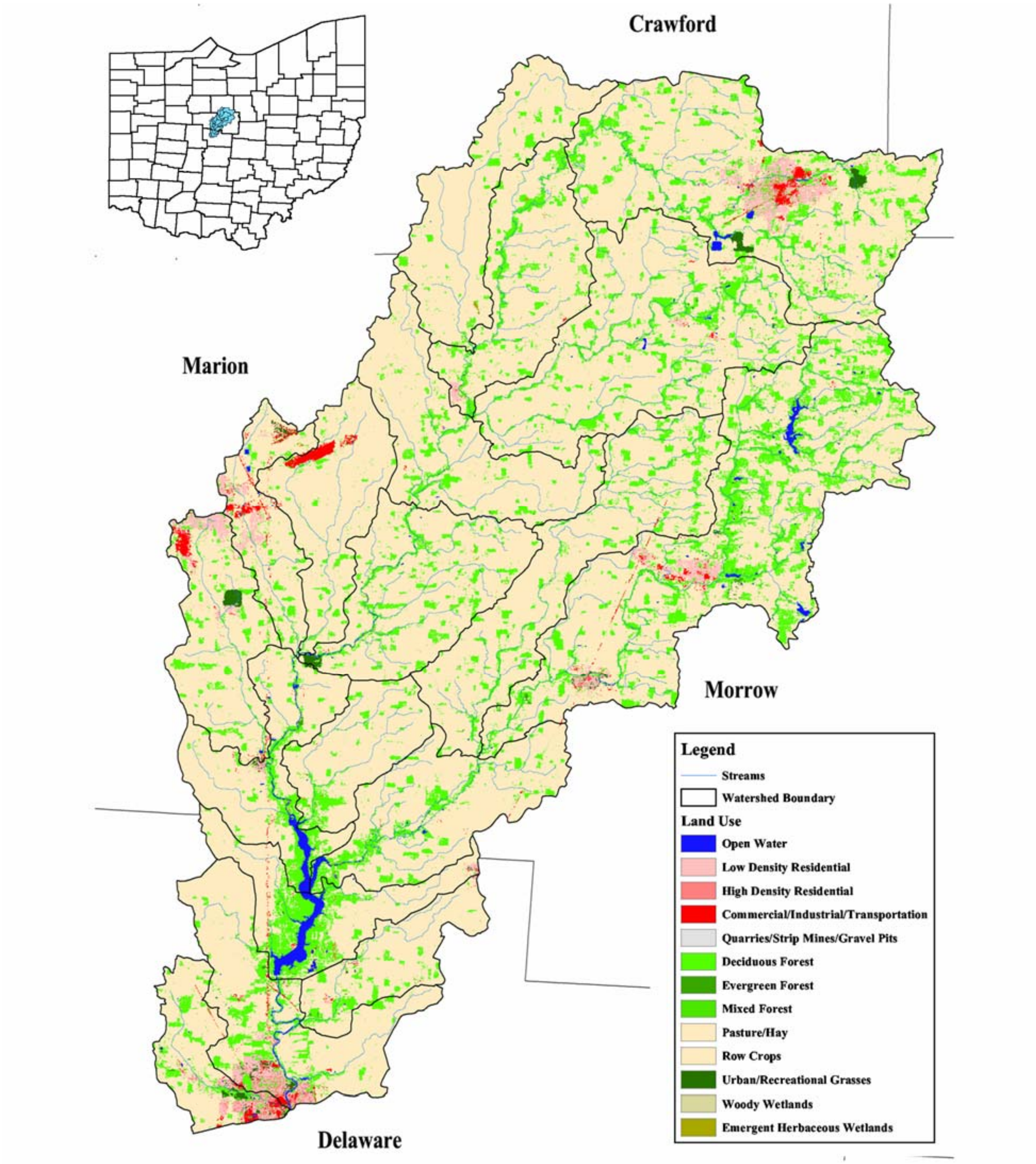
United States Geological Survey. 1992. National Land Cover Dataset. http://seamless.usgs.gov/webiste/seamless/products/nlcd92.asp

Wikipedia. 2006. Iberia, Ohio. http://en.wikipedia.org/wiki/Iberia%2C_Ohio

Witter, J. 2005. *Water Quality, Geomorphology, and Aquatic Life Assessments for the Olntangy River TMDL Evaluation*, Dissertation. Department of Food, Agricultural and Biological Engineering, Ohio State University, Columbus, Ohio.

Upper Olentangy River Watershed: Watershed Resources Inventory and Management Plan

Section A - Watershed Resources Inventory



Submitted to Olentangy Watershed Alliance, City of Delaware, Ohio Environmental Protection Agency, and Ohio Department of Natural Resources

December 2006

Jon Witter, Larry C. Brown, and Katherine M. Skalak, Editors, The Ohio State University

In cooperation with the Upper Olentangy River Project Team

Section A: Watershed Resources Inventory

Table of Contents

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 1 - Watershed Geology

Topography, Geology, Soils and Glacial History

Bedrock in central Ohio (Figure 1.1) consists of discrete layers of sedimentary rock (limestone, shale, sandstone) that can be distinguished on the basis of their characteristic physical features which are termed formations. Bedrock across central Ohio is influenced by the effects of the Cincinnati-Findlay Arch system, a structural high whose axis trends roughly north-south across western Ohio, west of the central Ohio region. This causes the bedrock layers in central Ohio to slope at an angle of 26 degrees to the east-southeast, away form the axis of the arch. These eastward-dipping formations have been beveled and truncated by subsequent glaciations which cause these bedrock layers to be arranged at the surface in broad, roughly north-south trending bands with the oldest formation to the west and the youngest formations to the east. These formations vary as to their physical and chemical characteristics, especially with regard to their hardness, resistance to erosion, and ability to store groundwater.

The parallel north-south trends of the Scioto River, the Olentangy River, Alum Creek, and Big Walnut Creek appear to be related to the surface configurations of the bedrock formations, with the trend of the stream channel paralleling the strike of the bedrock formations. The stream channels appear to be incised where weaker, less-resistant rock layers intersect the ground surface at a low angle.

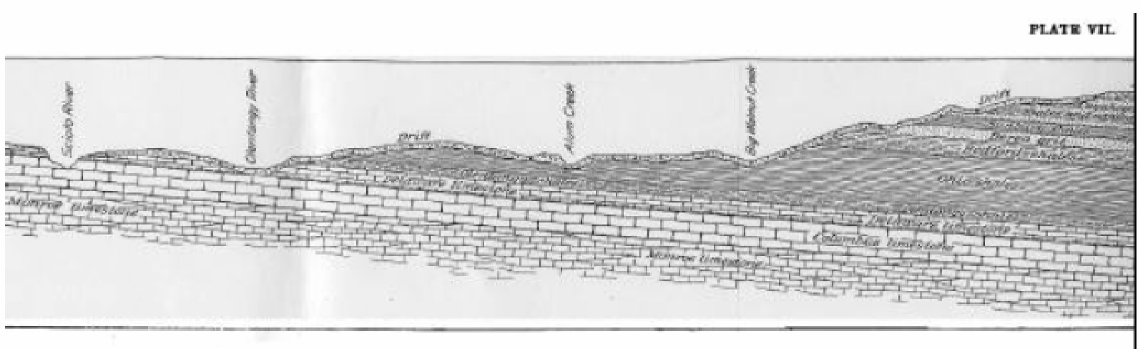


Figure 1.1: Bedrock geology of Central Ohio (Source - Geologic Survey of Ohio).

A series of continental glaciers caused large masses of ice up to 1,000 feet thick to repeatedly rumble across central Ohio, starting nearly two million years ago and melting and retreating from this portion of the state roughly 14,000 years ago. These glacial events in central Ohio functioned both as bulldozers, beveling, scraping, and eroding rocks and soils from the surface; and as dump trucks, depositing large quantities of clay, sand, gravel, and cobbles, filling in low areas and linear hills of glacial materials known as end moraines.

Glacial ice in central Ohio was part of a broad, southward-trending body of ice called the Scioto Lobe that extended from the Lake Erie Basin to Northern Pike County. The advance of this broad salient of ice followed pre-existing valleys that now comprise the Scioto River Basin. As the ice sheets advanced across the region, the crushing weight of the ice eroded and planed off the pre-glacial bedrock surface, resulting in a flat, level peneplane surface at an elevation of roughly 1,000 feet above mean sea level across most of central Ohio (Westgate, 1926). The irregular stopping, retreat, and melting of the Wisconsinan ice front between 18,000 and 14,000 years ago led to depositions of variable thickness of poorly-sorted, clay-rich glacial soil termed glacial till, deposited either as smooth-surfaced level ground moraine deposits or in a number of linear, elevated, broadly arching end moraines across the central Ohio area (Goldthwait et al., 1965). The latter include: The Powell End Moraine trending roughly west to east across southern Delaware County intersecting the river near High Banks Metro Park; the Broadway End Moraine which trends west to east just north of the city of Delaware and which forms the natural setting for the citing of the Delaware Dam, damming the Olentangy River to form Delaware Lake in northern Delaware County; and the St. John's End Moraine which trends from the southwest to the northeast across central Marion County and into central Crawford County. These end moraines rise 50 to 60 feet above the surrounding till plains and are typically one to two miles wide.

The extent of the major soil series across the watershed are illustrated in Figure 1.2. These soils consist primarily of clay-rich, high-lime glacial drift soils formed from the fine-grained glacial tills characteristic of the region. The Upper Olentangy River Sub-basin is part of the Clayey High-Lime Till Plains ecoregion characterized by clay-rich, low permeability soils. Soils tend to be poorly drained due to the level topography across much of the watershed and the high percentage of clay in these soils. However, these soils have moderate to high natural fertility due to the moderate to high lime content of the soils. These fertile soils are the basis for the current agricultural land use that constitutes the bulk of the economies in many central Ohio counties. Properties of the major soil series in the watershed are listed in Table 1.1 at the end of this chapter.

Soils databases and GIS data layers provide a wealth of information that can be utilized to identify locations in the watershed that are potentially suitable for various types of BMP's. The following maps were derived from data contained in SSURGO databases for Crawford, Richland, Marion, Morrow, and Delaware Counties. Figure 1.3 highlights areas that have been classified as Highly Erodible Lands (HEL). According to the 2002 Farm Bill for land to be considered highly erodible, potential erosion must be equal to or greater than eight times the rate at which the soil can sustain productivity. These areas have potential to be large sources of sediment and conservation practices that limit erosion such as cover crops, buffer strips, or grass swales are often targeted in these areas.

General soils and landuse information for the Upper Olentangy River Watershed are illustrated in the following series of figures. Figure 1.4 highlights areas in the watershed with hydric soils. Hydric soils are those soils that are sufficiently wet to develop anaerobic conditions during the growing season and support, under normal conditions, a prevalence of hydrophytic vegetation. These areas are often suitable for wetland restoration or construction. Figures 1.5 and 1.6 illustrate areas with poor drainage characteristics and potential areas where drainage water management practices might be practical. Figure 1.5 identifies the SSURGO drainage class (well drained, moderately well drained, poorly drained, somewhat poorly, or very poorly drained) of soils in the watershed. Figure 1.6 identifies a subset of the drainage classes which include poorly drained, somewhat poorly, or very poorly drained soils that are on soils with an average slope that is less than or equal to 1%. These areas are best suited to drainage water management practices described further in a later section

Figure 1.7 highlights various categories of farmland which include prime farmland, prime farmland if drained, prime farmland if drained and protected from flooding, and areas that are not prime farmland. For an area to be considered prime farmland it must have been cultivated at some time during the previous four years and meet certain chemical and physical criteria outlined by the USDA-NRCS. Specific criteria can be found at http://www.nd.nrcs.usda.gov/technical/primefrmlndcriteria.html. Landuse planning that might include zoning or farmland preservation incentives could benefit from this type of information.

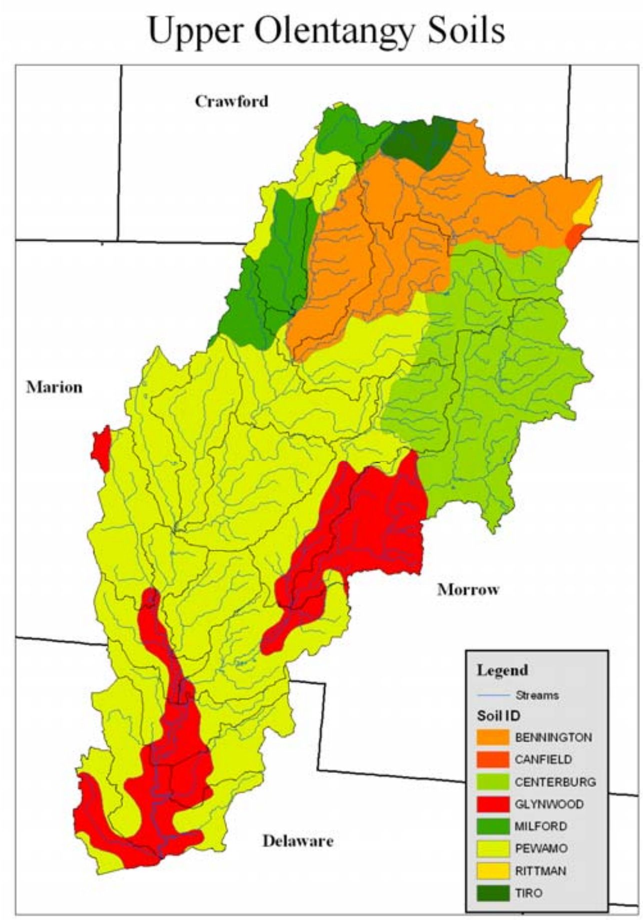


Figure 1.2: Major soil series in the Upper Olentangy Watershed.

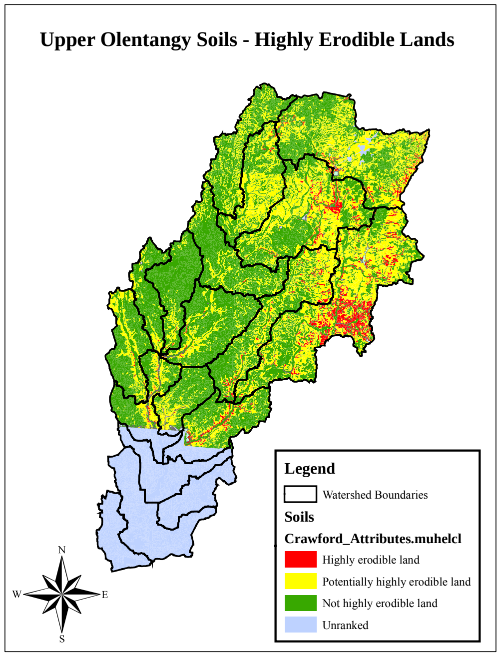


Figure 1.3: Areas of highly erodible soils in the Upper Olentangy Watershed.

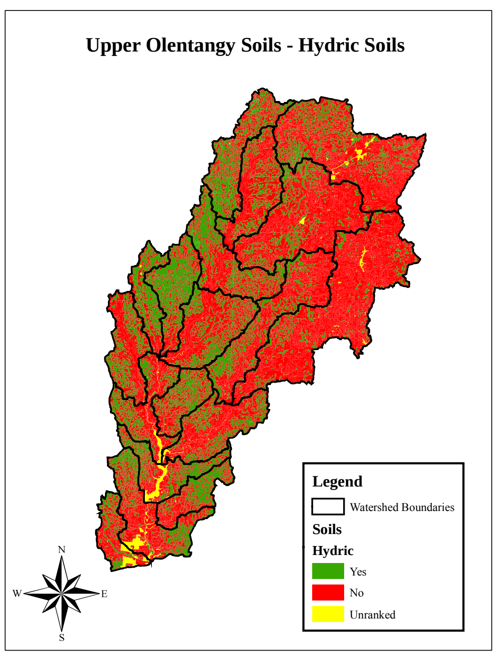


Figure 1.4: Areas of hydric soils in the Upper Olentangy Watershed.

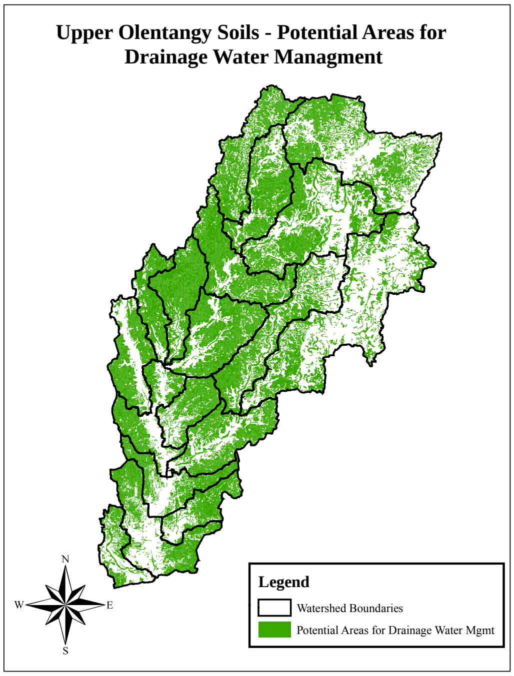


Figure 1.5: Areas with soils which have potential for drainage water management in the Upper Olentangy Watershed.

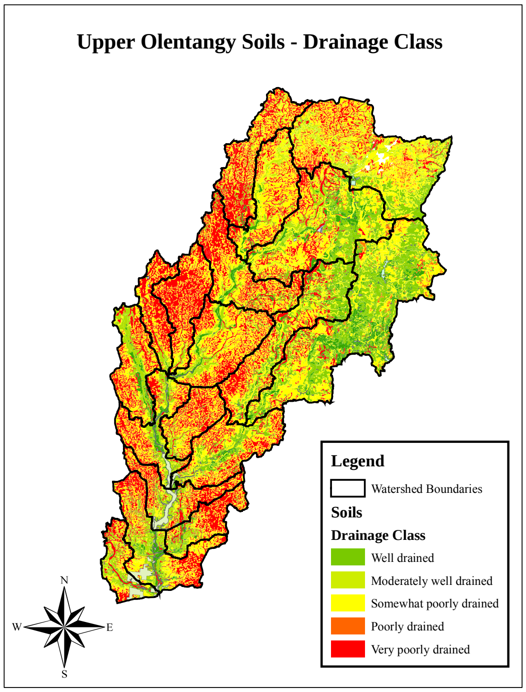


Figure 1.6: Drainage classes of soils in the Upper Olentangy Watershed.

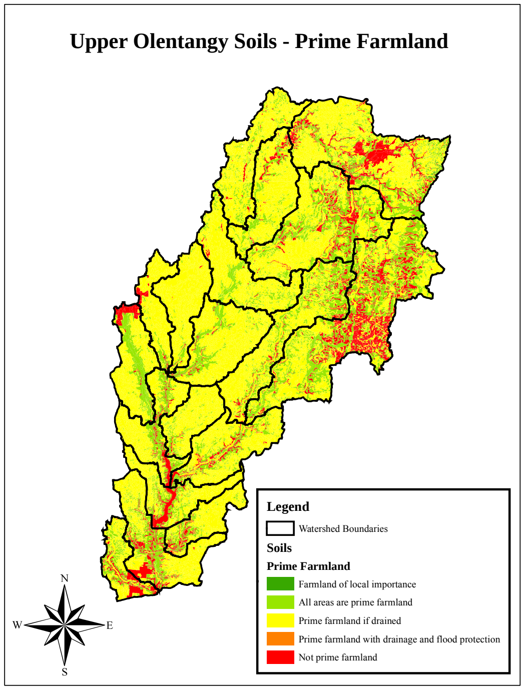


Figure 1.7: Prime farmland in the Upper Olentangy Watershed.

The melting of the glacial ice produced large volumes of melt water whose often catastrophic release carved new stream channel and/or exploited old bedrock valleys, taking the path of least resistance across the new glacial landscape, re-routing post-glacial stream flow in central Ohio to the south to the Ohio River. These melt water flows also reworked the sediments deposited by the glaciers and flushed these downstream of the retreating ice front. Stream currents moved variably-sorted accumulations of sand, gravel, and cobbles downstream where they were spread across the floodplains and often back-filled stream valleys forming locally thick deposits of glacial outwash. Outwash deposits in central Ohio are typically important sources of ground water supplies

The Upper Olentangy River has a youthful stream configuration, flowing across a young glacial landscape of level till plains over peneplaned bedrock. The river channel is shallowly entrenched, at most 20-30 feet below the level of the till plain. Glacial cover is 50-60 feet thick in northern Marion County, thinning to 30-40 feet of glacial till at the Marion-Delaware County line (Crowell, 1979; ODNR well logs). The entire area is currently agricultural with most of the region in row crops, either corn or soybeans.

The Olentangy River has its start at the confluence of several small streams just east of Galion (elevation of 1,189 feet above sea level) in westernmost Richland County. The drainage divide that separates the Olentangy Watershed and the adjacent Mohican River Watershed comprises a distance of only about 1,000 feet. The fledgling Olentangy River initially flows a short distance to the northwest of Galion until it meets the SW-NE trending St. John's End Moraine where it is deflected to the southwest, paralleling the trend of the moraine. The river continues to flow to the south-southwest across level to gently rolling portions of eastern Marion

County and into northern Delaware County. The river across much of this latter region is highly sinuous with a relatively low stream gradient of 4.7 feet per mile (Westgate, 1926).

The river is dammed at the point where it intersects the W-E trending Broadway End Moraine, several miles north of Delaware. The dammed portion of the river forms Delaware Lake, a sinuous, rather narrow body of water that extends five miles to the north of the dam to the Marion-Delaware County line. Whetstone Creek, a major southwest flowing tributary of the Olentangy River (watershed area = 114 square miles), joins the river near the upper end of the lake. The river was dammed and the lake formed primarily for flood-control in 1948. Flow out of the lake is controlled by the U.S. Army Corps of Engineers. At summer pool, the level of the lake is at 915 feet above sea level with a storage capacity of 13,024 acre-feet of water. Flow out of the lake at the dam is highly variable depending on rainfall events, with minimum outflows averaging from 5 cubic feet per second from November through July to 27.5 cubic feet per second from July through October (USACOE, 2000).

Table 1.1: Properties of the dominant soils in the Upper Olentangy Watershed.

Soil Name	Minimum Slope (%)	Maximum Slope (%)	Water Table Depth (ft)	Depth to Bedrock (ft)	Hydrologic Soil Group	Drainage Class
PEWAMO	0	2	0.0-0.0	60	C/D	Poorly
GLYNWOOD	2	6	2.0-3.5	60	C	Moderately Well
GLYNWOOD	2	6	2.0-3.5	60	C	Moderately Well
GLYNWOOD	2	6	2.0-3.5	60	C	Moderately Well
CENTERBURG	2	6	1.5-3.0	60	C	Moderately Well
CENTERBURG	2	6	1.5-3.0	60	C	Moderately Well
CENTERBURG	2	6	1.5-3.0	60	C	Moderately Well
GLYNWOOD	2	6	2.0-3.5	60	C	Moderately Well
CENTERBURG	2	6	1.5-3.0	60	C	Moderately Well
GLYNWOOD	2	6	2.0-3.5	60	C	Moderately Well
PEWAMO	0	2	0.0-0.0	60	C/D	Poorly
CENTERBURG	2	6	1.5-3.0	60	C	Moderately Well
CANFIELD	3	8	1.5-3.0	60	C	Moderately Well
MILFORD	0	2	0.0-0.0	60	B/D	Poorly
RITTMAN	2	6	1.5-3.0	60	C	Moderately Well
BENNINGTON	0	2	1.0-2.5	60	C	Somewhat Poorly
BENNINGTON	0	2	1.0-2.5	60	C	Somewhat Poorly
BENNINGTON	2	6	1.0-2.5	60	C	Somewhat Poorly
BENNINGTON	0	2	1.0-2.5	60	C	Somewhat Poorly
PEWAMO	0	2	0.0-0.0	60	C/D	Poorly
BENNINGTON	0	2	1.0-2.5	60	C	Somewhat Poorly
TIRO	0	2	1.0-2.5	60	C	Somewhat Poorly
PEWAMO	0	2	0.0-0.0	60	C/D	Poorly
MILFORD	0	2	0.0-0.0	60	B/D	Poorly
PEWAMO	0	2	0.0-0.0	60	C/D	Poorly

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 2 – Biological Features

Rare, Threatened and Endangered Species

The biological resources of the Upper Olentangy are many. Several of the species are listed as rare, threatened, or endangered and have a state or federal status which affords some degree of protection. The Ohio Department of Natural Resources' Division of Wildlife has jurisdiction over the wildlife and invertebrate communities and has classified certain species into the following categories:

Endangered (E) – A native species or subspecies threatened with extirpation form the state. The danger may result from one or more causes, such as habitat loss, pollution, predation, interspecific competition, or disease.

Threatened (T) – A species or subspecies whose survival in Ohio is not in immediate jeopardy, but to which a threat exists. Continued or increased stress will result in its becoming endangered.

Species of Concern (S) – A species or subspecies which might become threatened in Ohio under continued or increased stress. Also, a species or subspecies for which there is some concern but for which information is insufficient to permit an adequate status evaluation. This category may contain species designated as a furbearer or game species but whose statewide population is dependent on the quality and/or quantity of habitat and is not adversely impacted by regulated harvest.

Special Interest (I) – A species that occurs periodically and is capable of breeding in Ohio. It is at the edge of a larger, contiguous range with viable population(s) within the core of its range. These species have no federal endangered or threatened status, are at low breeding densities in the state and have not been recently released to enhance Ohio's wildlife diversity. With the exception of efforts to conserve occupied areas, minimal management efforts will be directed for these species because it is unlikely to result in significant increases in their populations within the state.

Extirpated (X) – A species or subspecies that occurred in Ohio at the time of European settlement and that has since disappeared from the state.

Extinct (O) – A species or subspecies that occurred in Ohio at the time of European settlement and that has since disappeared from its entire range.

Table 2.1 Lists the plant and animal species with protection status at the state or federal level. Figure 2.1 shows a graphical depiction of their location and range.

Table 2.1: Summary of rare, threatened, or endangered species of the Upper Olentangy Watershed.

Species	Common Name	Type	State Status	Federal Status
Turkey vulture roost	Turkey vulture roost	Animal Assemblage		
Great blue heron colony	Great blue heron colony	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Mollusk bed	Mollusk bed	Animal Assemblage		
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Pleurobema cordatum	Ohio Pigtoe	Invertebrate Animal	E	
Lampsilis fasciola	Wavy-rayed Lampmussel	Invertebrate Animal	SC	
Pleurobema sintoxia	Round Pigtoe	Invertebrate Animal	SC	
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Villosa fabalis	Rayed Bean	Invertebrate Animal	E	
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Lampsilis fasciola	Wavy-rayed Lampmussel	Invertebrate Animal	SC	
Pleurobema sintoxia	Round Pigtoe	Invertebrate Animal	SC	
Villosa fabalis	Rayed Bean	Invertebrate Animal	E	
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Villosa fabalis	Rayed Bean	Invertebrate Animal	E	
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Pleurobema sintoxia	Round Pigtoe	Invertebrate Animal	SC	
Villosa fabalis	Rayed Bean	Invertebrate Animal	E	
Epioblasma triquetra	Snuffbox	Invertebrate Animal	E	
Lampsilis fasciola	Wavy-rayed Lampmussel	Invertebrate Animal	SC	
Villosa fabalis	Rayed Bean	Invertebrate Animal	E	
Alternate-leaf dogwood	Cornus Alternifolia	Other (Botanical)		
Bur oak	Quercus Macrocarpa	Other (Botanical)		
Big bluestem prairie	Big bluestem prairie	Terrestrial Community		
Arenaria lateriflora	Grove Sandwort	Vascular Plant	P	
Spiranthes lucida	Shining Ladies'-tresses	Vascular Plant	P	
Prenanthes racemosa	Prairie Rattlesnake-root	Vascular Plant	P	
Eleocharis compressa	Flat-stemmed Spike-rush	Vascular Plant	T	
Baptisia lactea	Prairie False Indigo	Vascular Plant	P	
Eleocharis compressa	Flat-stemmed Spike-rush	Vascular Plant	T	
Arenaria lateriflora	Grove Sandwort	Vascular Plant	P	
Cuscuta pentagona	Five-angled Dodder	Vascular Plant	E	
Carex mesochorea	Midland Sedge	Vascular Plant	T	
Tyto alba	Barn Owl	Vertebrate Animal	T	
Lutra canadensis	River Otter	Vertebrate Animal	N	
Haliaeetus leucocephalus	Bald Eagle	Vertebrate Animal	E	FT
Taxidea taxus	Badger	Vertebrate Animal	SC	

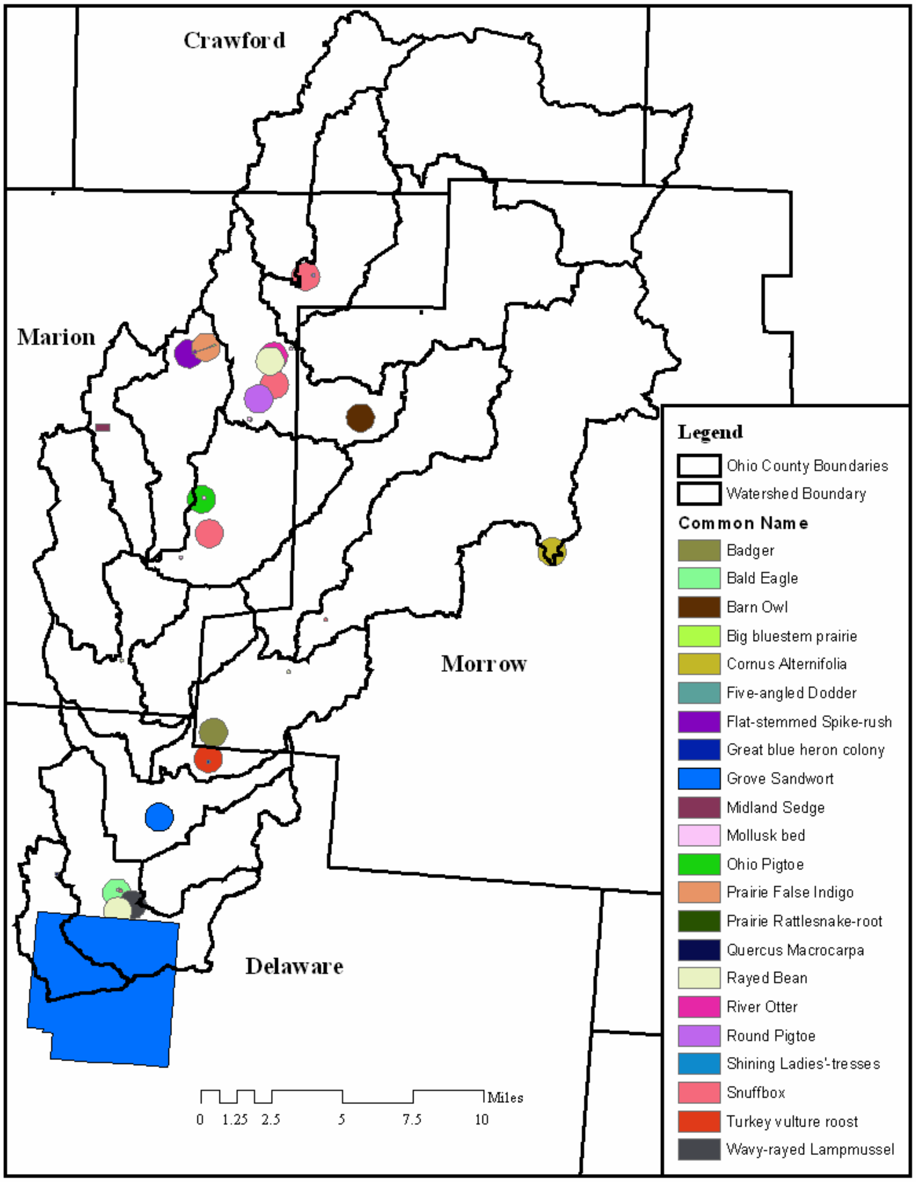


Figure 2.1: Locations of rare, threatened, or endangered species in the Upper Olentangy Watershed (Source: Ohio Department of Natural Resources, Natural Heritage Database).

Fish Species in the Upper Olentangy Watershed

The Ohio EPA has performed biological sampling throughout the Upper Olentangy watershed. Data were obtained from the Ohio EPA Biological Assessment Section and a list of fish species obtained during 1994 biological sampling was compiled. Seventy-seven species were sampled and a complete list is detailed in Table 2.2.

Table 2.2: Fish species sampled during Ohio EPA 1994 study of the Upper Olentangy Watershed.

SPECIES	SPECIES	SPECIES
BANDED DARTER	GOLDFISH	REDFIN SH X ROSEFIN SHINER
BLACK BULLHEAD	GRASS PICKEREL	REDFIN SHINER
BLACK CRAPPIE	GREEN SF X BLUEGILL	REDSIDE DACE
BLACK REDHORSE	GREEN SF X HYBRID	RIVER CARPSUCKER
BLACKNOSE DACE	GREEN SF X LONGEAR	RIVER CHUB
BLACKSIDE DARTER	GREEN SF X PUMPKINSEED	ROCK BASS
BLACKSTRIPE TOPMINNOW	GREEN SUNFISH	ROSEFIN SHINER
BLUEGILL SUNFISH	GREEN SUNFISH	SAND SHINER
BLUEGILL X ORANGESPOT	GREENSIDE DARTER	SAUGER X WALLEYE
BLUNTNOSE MINNOW	HIGHFIN CARPSUCKER	SHORTHEAD REDHORSE
BRINDLED MADTOM	HYBRID X SUNFISH	SILVER REDHORSE
BROOK SILVERSIDE	JOHNNY DARTER	SILVER SHINER
BROOK STICKLEBACK	LARGEMOUTH BASS	SILVERJAW MINNOW
BROWN BULLHEAD	LEAST BROOK LAMPREY	SMALLMOUTH BASS
CENTRAL MUDMINNOW	LOGPERCH	SOUTH. REDBELLY DACE
CENTRAL STONEROLLER	LONGEAR SF X BLUEGILL	SPOTFIN SHINER
CHANNEL CATFISH	LONGEAR SUNFISH	STONECAT MADTOM
COMMON CARP	LONGEAR X ORANGESPOT	STRIPED BASS
CREEK CHUB	MOTTLED SCULPIN	STRIPED SHINER
CREEK CHUBSUCKER	NORTHERN HOG SUCKER	TROUT-PERCH
FANTAIL DARTER	ORANGESPOT X PUMPKSEED	WARMOUTH SUNFISH
FATHEAD MINNOW	ORANGESPOTTED SUNFISH	WHITE BASS
FLATHEAD CATFISH	ORANGETHROAT DARTER	WHITE CRAPPIE
GIZZARD SHAD	PUMPKINSEED SUNFISH	WHITE SUCKER
GOLDEN REDHORSE	QUILLBACK CARPSUCKER	YELLOW BULLHEAD
GOLDEN SHINER	RAINBOW DARTER	

Non-native and Invasive Species

Over 25% of Ohio's plant species are non-native. Based on the reproduction strategies and impacts to native flora and fauna The Nature Conservancy has designated various species as targeted (Table2.3), well-established (Table 2.4), and watch list species (Table 2.5).

Table 2.3: Targeted invasive species of Ohio (The Nature Conservancy, 2004).

Garlic mustard (Alliaria petiolata)	Reed canary grass (Phalaris arundinacea)
Morrow honeysuckle (Lonicera morrowii)	Reed grass (Phragmites australis)
Japanese honeysuckle (Lonicera japonica)	Glossy buckthorn (Rhamnus frangula)
Tatarian honeysuckle (Lonicera tatarica)	Multiflora rose (Rosa multiflora)
Purple loosestrife (Lythrum salicaria)	

Table 2.4: Well-established invasive plant species of Ohio (The Nature Conservancy, 2004).

Quack grass (Agropyron repens)	Canada thistle (Cirsium arvense)
Tree-of-heaven (Ailanthus altissima)	Poison hemlock (Conium maculatum)
Japanese barberry (Berberis thunbergii)	Field bindweed (Convolvulus arvensis)
Smooth brome (Bromus inermis)	Crown-vetch (Coronilla varia)
Flowering-rush (Butomus umbellatus)	Queen Anne's lace (Daucus carota)

Asian bittersweet (Celastrus orbiculatus)	Cut-leaved teasel (Dipsacus laciniatus)
Winged euonymus (Euonymus alatus)	Common teasel (Dipsacus sylvestris)
Wintercreeper (Euonymus fortunei)	Yellow flag (Iris pseudacorus)
Meadow fescue (Festuca pratensis)	Common privet (Ligustrum vulgare)
Day-lily (Hemerocallis fulva)	Moneywort (Lysimachia nummularia)
Dame's rocket (Hesperis matronalis)	White sweet-clover (Melilotus alba)
Curly pondweed (Potamogeton crispus)	Yellow sweet-clover (Melilotus officinalis)
Bouncing Bet (Saponaria officinalis)	Lesser naiad (Najas minor)
Johnson grass (Sorghum halepense)	Water-cress (Nasturtium officinale)
European cranberry-bush (Viburnum opulus)	Narrow-leaved cattail (Typha angustifolia)

Table 2.5: Watch list invasive plant species of Ohio (The Nature Conservancy, 2004).

Porcelain-berry (Ampelopsis brevipedunculata)	Nodding thistle (Carduus nutans)
Spotted knapweed (Centaurea maculosa)	Leafy spurge (Euphorbia esula)
Border privet (Ligustrum obtusifolium)	Nepalgrass (Microstegium vimineum)
Showy pink honeysuckle (Lonicera X bella)	Kudzu (Pueraria lobata)
Star-of-Bethlehem (Ornithogalum umbellatum)	Dog rose (Rosa canina)
Black swallow-wort (Vincetoxicum nigrum)	Chinese silvergrass (Miscanthus sinensis)
Giant knotweed (Polygonum sachalinense)	Mile-a-Minute (Polygonum perfoliatum)

Invasive species such as Tartarian honeysuckle (Figure 2.2), Purple Loosestrife (Figure 2.3), and Reed Grass (Figure 2.4) and others are often able to out compete native flora with aggressive root systems and early growth seasons depriving native species of sunlight and essential nutrients. These species are often able to thrive as natural checks and balances such as predators and disease are absent in the new environment.

Figure 2.2: Tatarian Honeysuckle (ODNR DNAP).

Figure 2.3: Purple loosestrife (ODNR-DNAP).

Figure 2.4: Reed grass (ODNR-DNAP).

It is beyond the scope of this document to provide an exhaustive description of all invasive species, but a complete description of species and there ranges are available on http://nature.org/wherewework/northamerica/states/ohio/science/art7843.html and http://www.dnr.state.oh.us/dnap/invasive/. These fact sheets provide a description and information on the control of common, targeted invasive species that may occur in the Upper Olentangy Watershed. These resources were developed by the Ohio Department of Natural Resources, with support from an Ohio EPA Environmental Education Grant.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 3 – Water Resources

Climate and Precipitation

Reviews of historical climate records for central Ohio indicate that within the Olentangy River watershed, annual temperature averages from 50-51 degrees Fahrenheit (Miller, 2002) and average annual precipitation of 36-37 inches (Figure 3.1). Average monthly precipitation varies from less than 2.0 inches in the winter months to greater than 4.0 inches during the spring.

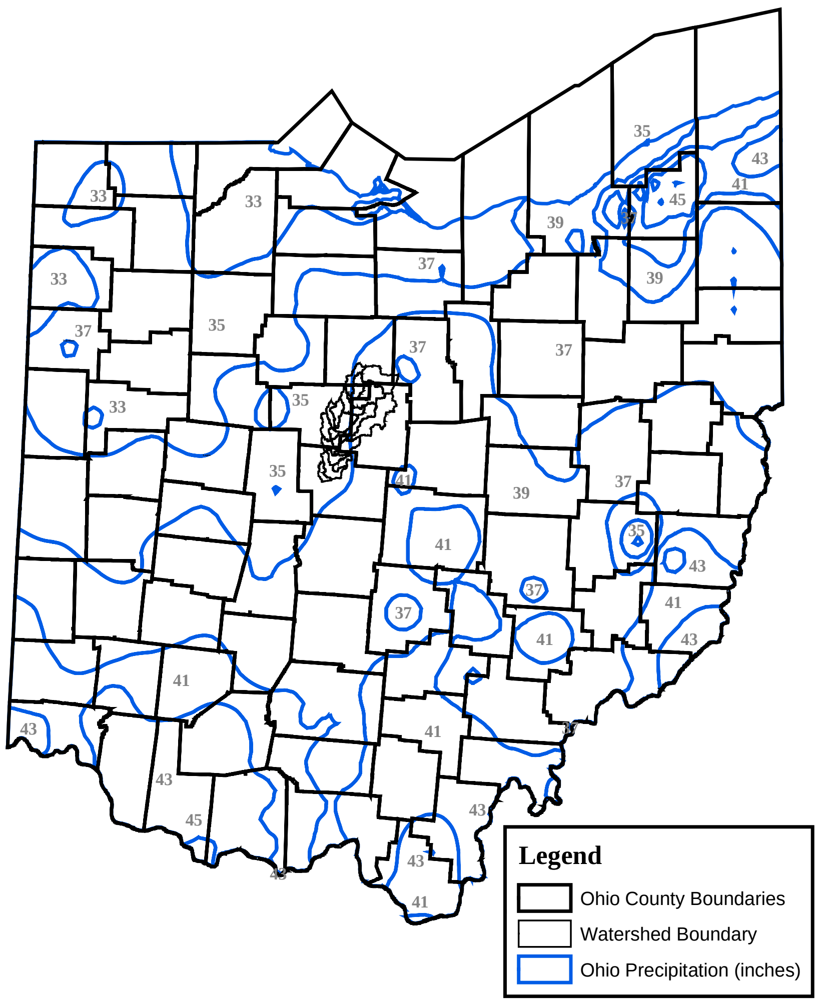


Figure 3.1: Average annual precipitation in Ohio, with the Upper Olentangy Watershed noted.

Streams and Wetlands

Within the Upper Olentangy Watershed there are approximately 540 miles of streams and tributaries including agricultural ditches. Often times, available sources of information have inadequate detail to inventory all streams and tributaries. A survey of streams and tributaries was conducted using aerial photography in a GIS environment. Lengths of streams and tributaries by subwatershed are available in Table 3.1. Maps and descriptions of streams and tributaries by subwatershed can be found in the action plan for each subwatershed.

Many wetlands of the Upper Olentangy were drained for agricultural purposes. Although, the watershed still contains approximately 6770 acres of woody and emergent herbaceous wetlands. [*For more information regarding wetlands please consult Chapter 4 of the Water Resources Inventory.)*] The Upper Olentangy Watershed, also, has approximately 1850 acres of open water Figure 3.2 a result of the reservoirs used for public water supply for the City of Galion and the City of Delaware.

Table 3.1: Stream and tributary length by subwatershed in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Length (miles)
Rocky Fork	05060001 090 010	61.3
Olentangy River @ Flat Run	05060001 090 020	29.9
Mud Run	05060001 090 030	16.4
Flat Run	05060001 090 040	68.2
Whetstone Creek	05060001 100 010	104.6
Shaw Creek	05060001 100 020	46.2
Whetstone Creek below Shaw Creek	05060001 100 030	29.4
Otter Creek	05060001 110 010	26.7
Olentangy River @ Otter Creek	05060001 110 020	33.1
Riffle Creek	05060001 110 030	18.1
Grave Creek	05060001 110 040	10.8
Norton Run	05060001 110 050	18.4
Qua Qua Creek	05060001 110 060	14.5
Brondige Run	05060001 110 070	14.4
Olentangy River below Whetstone Creek	05060001 110 080	14.4
Indian Run	05060001 110 090	17.3
Horseshoe Run	05060001 110 100	11.0
Delaware Run	05060001 110 110	6.5

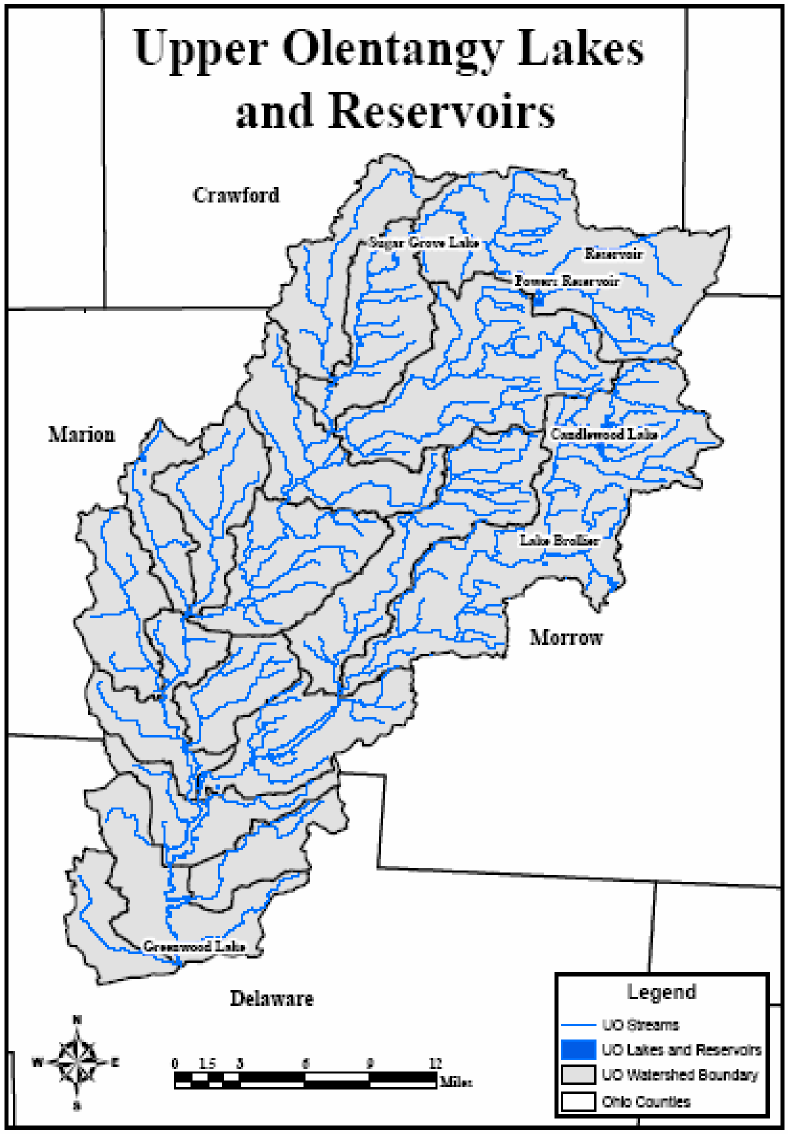


Figure 3.2: Lakes and rservoirs in the Upper Olentangy Watershed.

Watershed Sizes

Within the Upper Olentangy Watershed (8-digit HUC 05060001) there are 18 smaller (14-digit HUC codes) watersheds. The size of these subwatersheds varies from less than 6,500 acres (Delaware Run) to greater than 40,000 (Whetstone Creek) as seen in Table 3.2.

Table 3.2: Subwatersheds (14-digit HUC) in the Upper Olentangy Watershed.

Watershed Boundary Description	14 Digit HUC	Watershed Size (Acres)
Olentangy River headwaters to near New Winchester	05060001090010	31580.1
Olentangy River near New Winchester to above Flat Run	05060001090020	13594.2
Mud Run	05060001090030	13139.3
Flat Run	05060001090040	27211.9
Whetstone Creek headwaters to above Shaw Creek	05060001100010	40206.9
Shaw Creek	05060001100020	19182.8
Whetstone Creek below Shaw Creek to Olentangy River	05060001100030	13890.7
Olentangy River below Flat Run	05060001110010	14906.6
Olentangy River below Claridon to above Grave Creek	05060001110020	15276.3
Riffle Creek	05060001110030	11138.4
Grave Creek	05060001110040	7303.7
Olentangy River below Grave Creek to above Whetstone Creek	05060001110050	11105.4
Qu Qua Creek	05060001110060	10923.3
Brondige Run	05060001110070	7997.0
Olentangy River below Whetstone Creek to Delaware Reservoir Dam	05060001110080	9562.7
Olentangy River from Delaware Reservoir Dam to below Horseshoe R	05060001110090	15147.5
Horseshoe Run	05060001110100	7250.4
Delaware Run	05060001110110	6485.1

Baseflows

The landscape of the Upper Olentangy has been altered significantly in the past several hundred years to support agricultural production. Extensive amounts of land have been tile drained to reduce risks associated with growing crops. Agricultural subsurface drainage (tile drainage) likely has altered the timing of ground water contribution to baseflow as fields are generally drained to field capacity within 1-3 days of a rain event.

Baseflow can be estimated at locations were long term discharge information is available. Three USGS gage stations (Figure 3.3) provide discharge information that can be plotted and used to estimate base flow conditions in the watershed. The gages at New Winchester and Claridon provide useful information, but the gage at Delaware is largely controlled by releases from the dam.

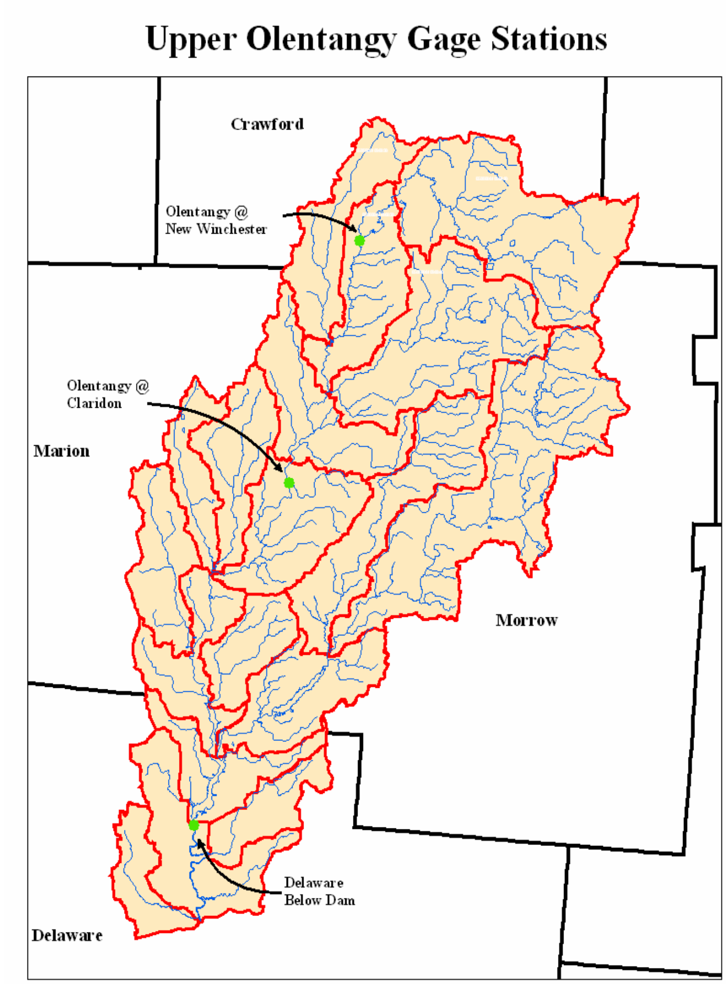


Figure 3.3: USGS gage stations in the Upper Olentangy Watershed.

The discharge of the Olentangy River near New Winchester is illustrated in Figure 3.4 for a period in 1946-1949. Stream flows vary from season to season and year to year. To obtain base flow estimates from these types of illustrations, the graph scale can be changed to more closely examine the lower end of the hydrograph, as is shown in Figure 3.5. Similar periods of stream flow from two other locations on the Olentangy River are illustrated in Figures 3.5 through 3.9. The Olentangy River gage near New Winchester (drainage area of 49.4 m^2) appears to have a baseflow of approximately 3-5 cfs. The Olentangy River gage near Claridon (drainage area of 157.0 m^2) has a base flow of approximately 4-10 cfs. The Olentangy River gage south of Delaware Dam (drainage area of 393 m^2) has a wide range of flows from approximately 1-40 cfs that seem to define a baseflow range. Flows can be highly variable as control over flow is regulated by the dam as the reservoir storage must provide a water source for the City of Delaware.

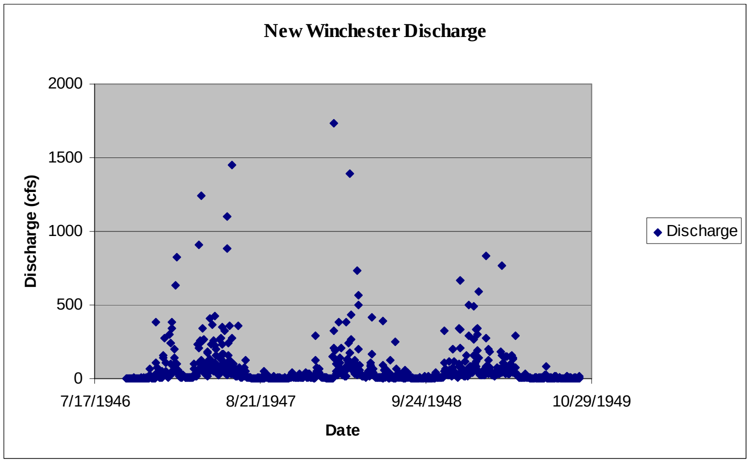


Figure 3.4: Discharge of the Olentangy River near New Winchester.

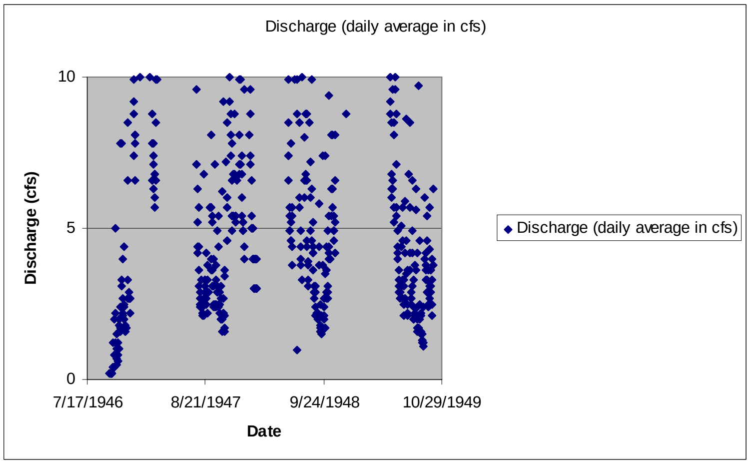


Figure 3.5: Discharge of the Olentangy River near New Winchester.

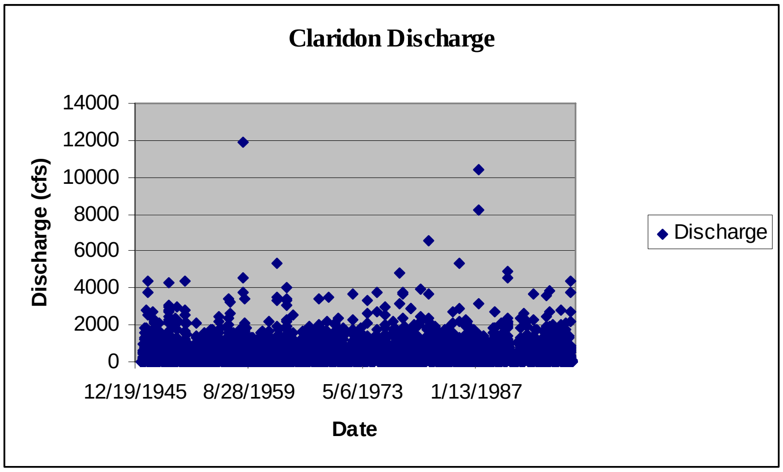


Figure 3.6: Discharge of the Olentangy River at Claridon, OH.

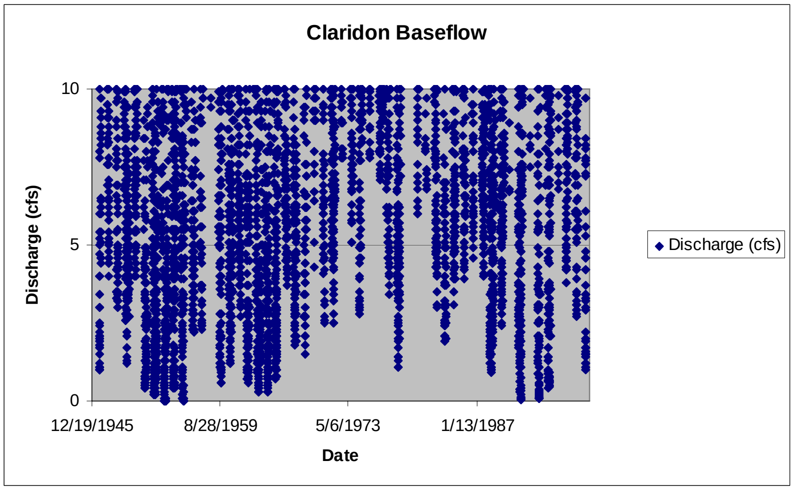


Figure 3.7: Discharge of the Olentangy River at Claridon, OH.

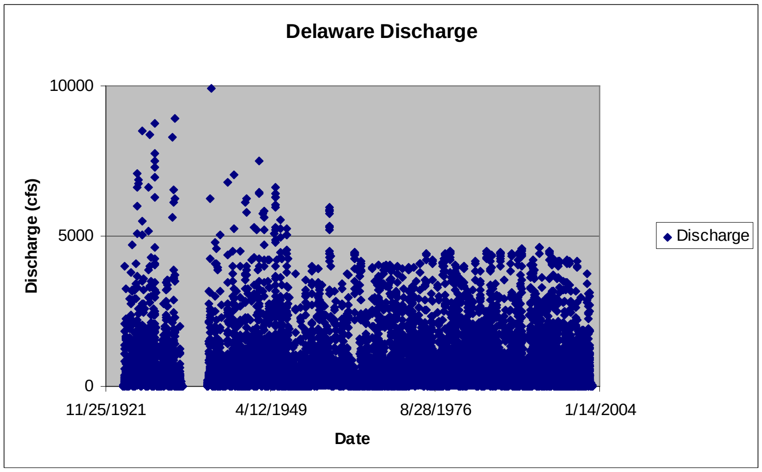


Figure 3.8: Discharge of the Olentangy River south of Delaware Dam.

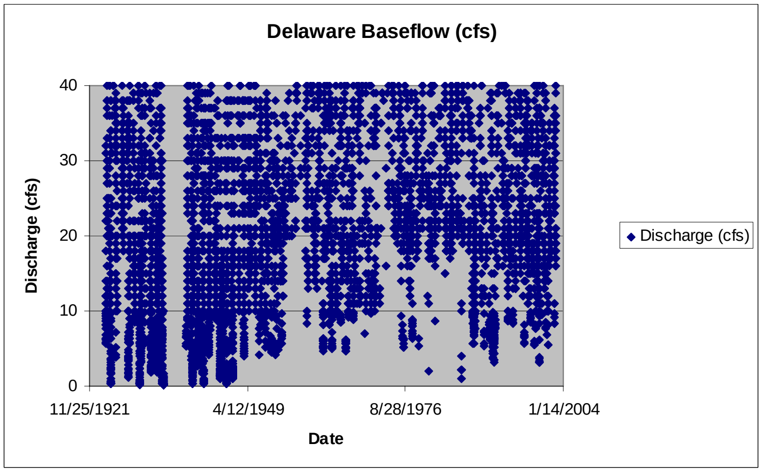


Figure 3.9: Discharge of the Olentangy River south of Delaware Dam.

Sinuosity

Stream or channel sinuosity can be a good indicator of floodplain connectivity. Many studies have shown the importance of an attached floodplain to the resilience of a stream which increases the ability of the system to assimilate pollutants, particularly sediment and sediment attached pollutants. Sinuous streams in this portion of Ohio typically have a riffle-pool morphology that is well suited to support diverse biological communities.

To assess the sinuosity of Upper Olentangy streams we used 1:24,000 USGS topographic maps and aerial photos. Recent aerial photos were used whenever possible and channels where digitized and measured in a GIS environment. When streams were not visible USGS topographic maps were used and measurements were made by hand. Results of the assessment show that many streams in the Upper Olentangy watershed have been modified or straightened at some time. Many of the headwater ditches are regularly maintained, but substantial lengths of agricultural headwater streams are in a state of recovery, building bench or floodplain features at elevations lower than the top of the ditch bank. Results are shown in Chapter 6, Table 6.2.

Aquifers

The quantity and quality of ground water is influenced directly by the properties of the geologic formation that holds water. The aquifers of the Upper Olentangy Watershed are predominately clayey till over shale, as illustrated by the cross-section in Figure 3.10 for Crawford County. Shale does not readily store large volumes of groundwater and as a result well yields are typically low although yields approximately 400 gallons per minute have been reported. Wells in the Upper Olentangy often have above average hydrogen sulfide content as well. Aquifers representative for Morrow County are illustrated in Figure 3.11. Similar illustrations are presented in Appendix A (Figures A3.1 through A3.3).

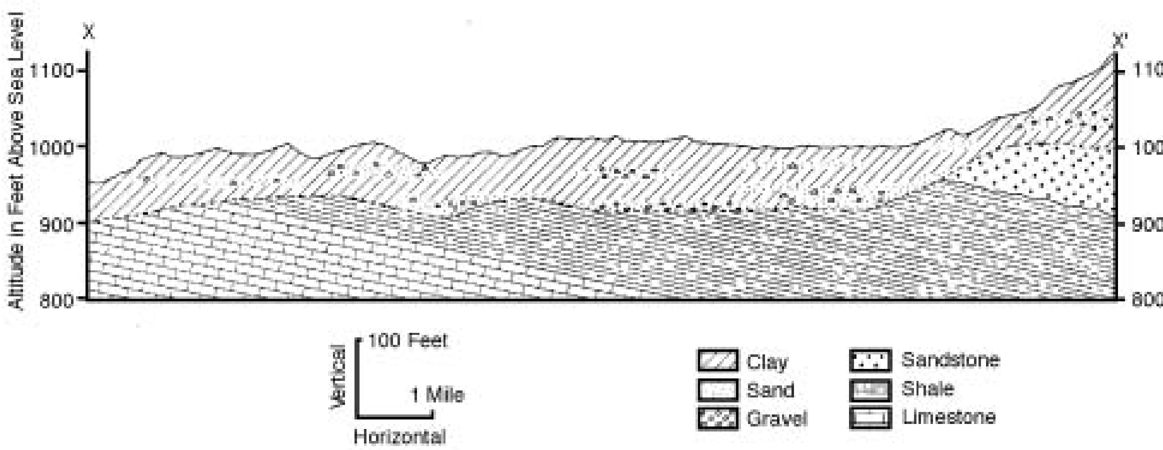


Figure 3.10: Bedrock geology for Crawford County (Prochaska et al., 1993).

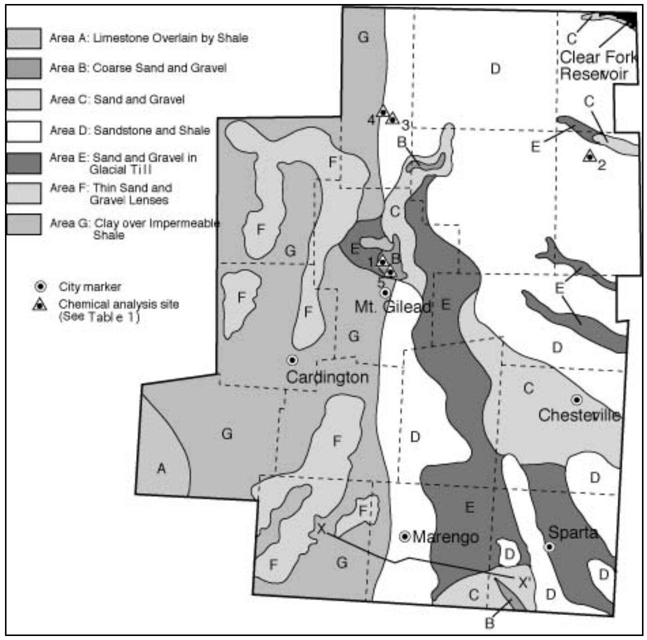


Figure 3.11: Aquifer types for Morrow County (Ruhl et al., 1992).

Source Water Assessment Plan (SWAP)

The Ohio EPA, Division of Surface Water prepared a SWAP for the City of Delaware in 2003. This document provides information for protection of water supplies and represents potential contaminant sources. Primary areas of concern were spills and discharges related to transportation accidents and sedimentation from development sites. There are many transportation corridors in close proximity to the Olentangy River and Delaware Water Treatment Plant. An accident and/or illicit discharge could compromise the immediate safety of the water supply. Delaware is, also, one of the fastest growing counties in the Midwest. Trends indicate that approximately 5,000 homes per year are being built with a portion of those in the Olentangy Watershed. Construction activities involve disturbance of land and potential for sediment pollution is great.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 4 – Land Use

Land Cover Description by Watershed

Land cover and land use in the Upper Olentangy is predominantly agricultural with many stands of deciduous forest. The southern portion of the watershed is undergoing somewhat rapid development and agricultural land use is being replaced by low, medium, and high density residential use as well as industrial development.

To determine the proportions of land use in the Upper Olentangy watershed we used a Geographic Information Systems (GIS) database derived from satellite imagery (see also Figures 1.2 through 1.7 in Chapter 1). Essentially, a satellite will take a "snapshot" of the land. Each land use (i.e., agriculture, forest, wetland, residential, etc.) reflects various colors and intensities of light. A computer program processes the image and groups the land uses based on spectral characteristics. The satellite imagery used for this land use classification records reflectance values over a 30 X 30 meter area. For this assessment we used the National Land Use Classification (NLCD) dataset. The data were manipulated in the GIS environment and land use percentages were extracted for each 14-digit Hydrologic Unit Code (HUC). Results by 14-digit subwatershed are available in Appendix B, Table B4.1. Figure 4.1 below illustrates the land use across the watershed. Figures B4.1 through B4.3 in Appendix B shows the percentages of land use by subwatershed.

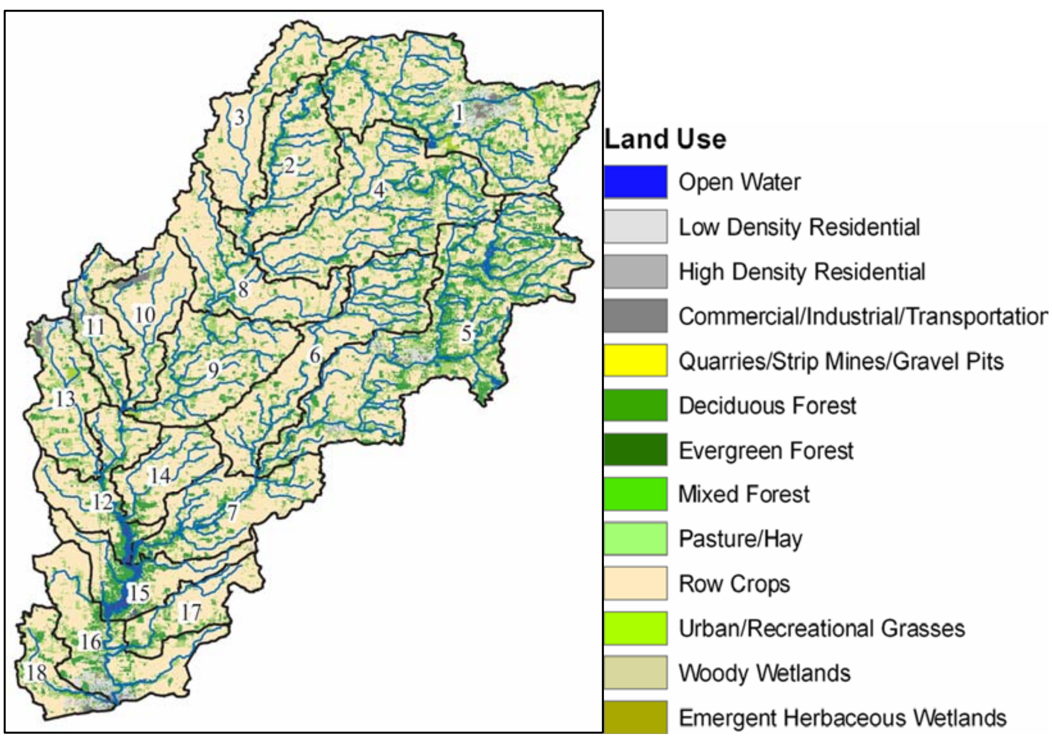


Figure 4.1: General land use across the Upper Olentangy Watershed.

Agriculture

Crop Type

Corn and soybeans are the primary agricultural products grown in the Upper Olentangy watershed. On the average over 80% of the cropland is used for their production with lesser amounts of wheat, small grains, and hay. Local experts predict that corn and soybeans will continue to dominate agricultural production as farms continue to grow in size. Research has shown that fertilization of corn with manure, liquid manure, granular fertilizer and/or anhydrous ammonia can be a significant source of N. For a breakdown of estimated proportions of crop types consult Appendix B, Table B4.2.

Tillage

Tillage types vary in the watershed depending on weather, soil type, available equipment, and crop to be planted. Producers in the Upper Olentangy tend to prefer no-till or reduced tillage for soybean production. At one time no-till corn was the norm, but producers felt a reduction in yield made it necessary to return to conventional tillage. Another consideration in planting is the amount of time available to perform cultural activities. As mentioned earlier, farm size continues to grow. This leaves fewer opportunities to remain flexible with planting schedules. Farmers believe that conventional tillage allows the ground to dry faster and reduce risk related to timing of planting. For estimates of tillage types by subwatershed consult Appendix B, Table B4.3

Rotations

Crop rotations are variable throughout the watershed. To some degree this can be linked to the size of the operation. Small to medium size farms typically incorporate wheat and small amounts of hay into their regular rotation. In Crawford County local agents noted that several farmers have moved to a Corn-Soybean-Soybean-Wheat rotation to help reduce nitrogen costs as they continue to rise. Larger farmers will typically have a Corn-Soybean rotation and occasionally a Corn-Soybean-Wheat rotation. Of particular interest is the small farmer that has attempted to diversify. Finding it difficult to compete for land and economically survive on small acreages several farmers have moved towards high value crops. It is not uncommon to see a few vegetables, berries or ornamentals on small fields.

Livestock Inventory

At one time the livestock feeding operations were prominent in the Upper Olentangy watershed. Morrow County alone produced over 20,000 head of cattle per year. During the 1990's when cattle prices declined and the slaughterhouse closed livestock operations declined significantly. Since that time the livestock production has diversified to include sheep and chickens. With the increase in small and medium size lots many private residents also own horses. The largest increase in livestock production has occurred in Crawford County with several swine operations started in the last decade. Table B4.4 in Appendix B estimates number of livestock by subwatershed.

Grazing

Grazing activities for livestock operations are minimal in the Upper Olentangy watershed. Much of the pasture land in Delaware County is dedicated to landowners with horses. Since the land use information was based on the 1994 National Land Use Classification (NLCD) and animal feeding operations have declined in the watershed it was determined that an update based on information from local agencies was necessary. Also, the 1994 NLCD combines pasture and hay as one land use type. Table B4.5 in Appendix B shows estimates based on information from local agencies regarding the number of acres used for grazing activities.

Chemical Use Patterns

As technology evolves so does pesticide and herbicide use in the watershed. Atrazine, which is a major concern for drinking water purveyors is being used less frequently than in the past. At the various public meetings held throughout the watershed, many farmers commented that they rarely use atrazine. Several farmers that did use Atrazine did so in small quantities. Many thought that atrazine problems in the water supply were caused by high application rates used in past decades. At that time it was not well known that atrazine was a large threat to water supplies.

Today in the watershed most soybeans are Round Up ready and pest control in corn is still accomplished with use of the trizine family of chemicals. Simazine and Metribuzine are two chemicals that are being used more widely as a substitute for Atrazine. Although it should be noted in many cases small amounts of Atrazine are used to “spike” or increase the effectiveness of chemical mixtures.

Home Sewage Treatment Systems

The Ohio EPA listed septic systems and organic enrichment as causes of impairment in several subwatersheds of the Olentangy River. Throughout the watershed there is widespread concern regarding the number and condition of septic systems.

Assembling an accurate inventory of homes is a difficult and time consuming process. Only Delaware County has started a program to thoroughly locate and document new and existing systems. Local health departments are currently working on projects to develop sewage treatment facilities for several communities including Sugar Grove (Crawford County) and Iberia (Morrow County). In our attempt to inventory the number and status of on-site treatment systems we felt the best information would be provided by members of local health departments. A series of maps with watershed boundaries, roads, streams, and an aerial photograph background were distributed to local health departments. Instructions detailing the information we hoped to gather were included. Each health department was contacted in advance to discuss the project so goals could be efficiently met. In general, each health department was contacted after they received the packet and any problems regarding the inventory were resolved. Each department, also, was asked to estimate the accuracy of their inventory. Each department felt that the results they provided were quite accurate considering the enormity of the task. The results of this task are presented in Table B4.6 in Appendix B.

Wetlands

Wetlands in the Upper Olentangy have been classified as Woody Wetlands on hydric soils, shallow marsh, shrub/scrub wetland, wet meadow and farmed wetlands. Woody wetlands are the dominant type in the watershed with a high percentage in the protected areas around Delaware Reservoir. Figure 4.2 shows the spatial distribution of wetland areas in the watershed and Table 4.1 details area in acres.

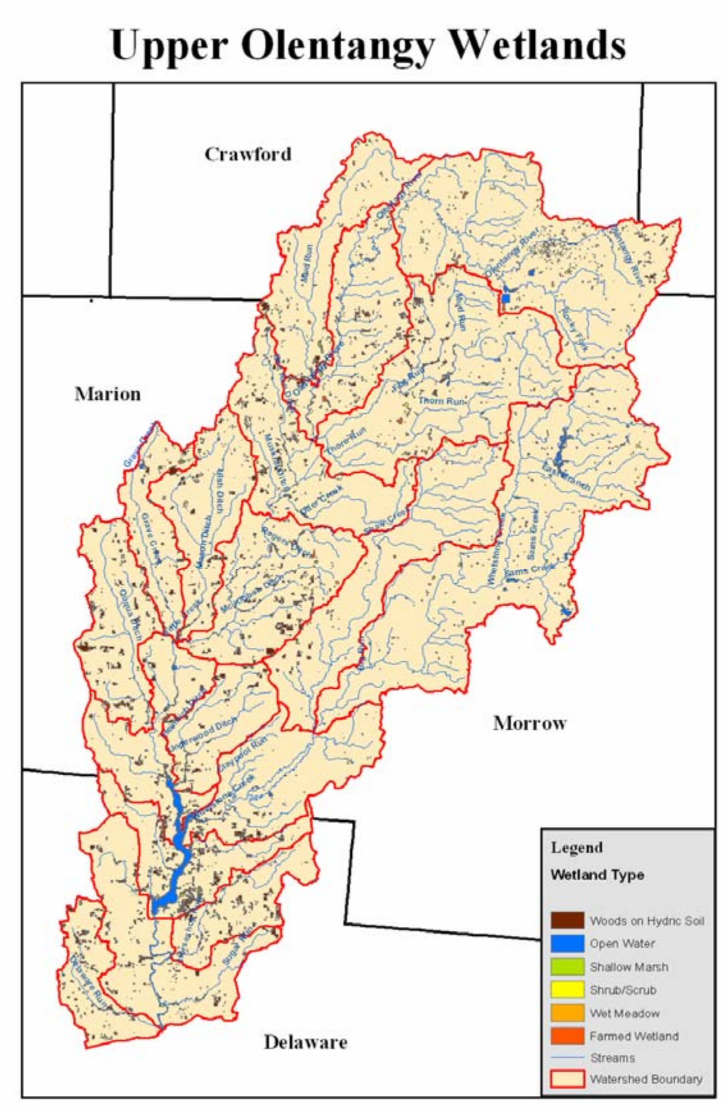


Figure 4.2: Distribution of wetlands by type in Upper Olentangy Watershed.

Table 4.1: Wetlands acreages in the watershed

Wetland Type	Area (acres)
Woods on Hydric Soils	4463.1
Open Water	1848.0
Shallow Marsh	787.8
Shrub/Scrub Wetland	526.4
Wet Meadow	228.3
Farmed Wetland	764.3
Total Wetlands & Open Water	8617.8

Protected Lands

Although land use in the Upper Olentangy is largely agriculture, there are several parks and wildlife areas (Figure 4.3). The City of Galion in Crawford County owns and maintains Cobey Park, East Park, South Park, Heise Park, and Powers Reservoir Park around the City of Galion water supply. In Morrow County, the Mount Gilead State Park provides good hiking and environmental education opportunities. Most of the park land in the Upper Olentangy basin is concentrated around the Delaware Reservoir. Substantial tracts of land are protected by the Army Corps of Engineers, the Delaware Wildlife Area (Division of Wildlife) and Delaware State Park. No areas were reported to be protected by private foundations or land trusts at this time.

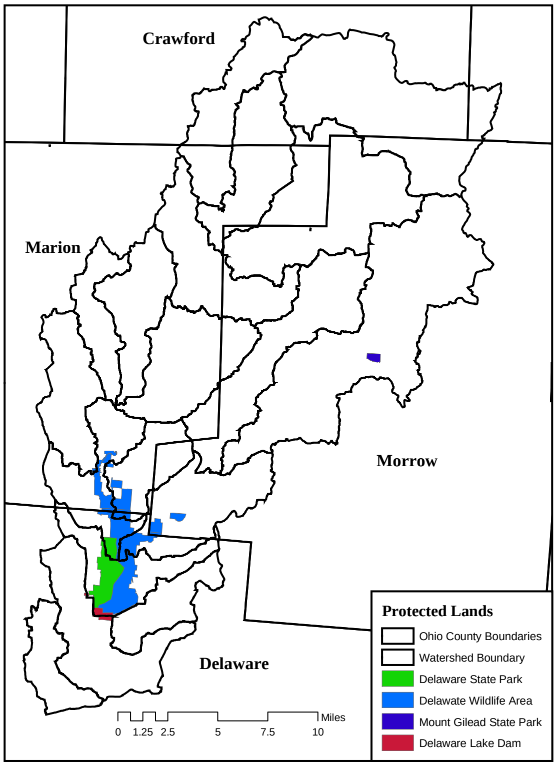


Figure 4.3: Protected land in the Upper Olentangy Watershed.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 5 – Previous and Complementary Efforts

In terms of water quality initiatives, the Upper Olentangy has received little attention when compared to surrounding watersheds. Much attention has been focused on the Great Lakes watersheds and cost share assistance funds have been directed to those watersheds. One attempt to prioritize problems in the Upper Olentangy was held by local agencies and residents in Crawford County during the late 1990's.

Agricultural BMP's

Most cost share assistance directed to agricultural BMP's is allotted to counties through the USDA's Conservation Reserve Program (CRP) and Environmental Quality Incentive Program (EQIP) on a countywide basis. Throughout the meeting series conducted by the planning team, we were able to identify the programs that are currently in place to assist in BMP implementation. It should be noted that these funds are limited and many applications for conservation practice assistance are denied. The programs that are currently available in the counties are as follows:

Environmental Quality Incentive Program (EQIP) - USDA cost share program. This program can be used for any USDA cost shareable practice including, but not limited to: animal waste storage facility, grid sampling and nutrient management, compost facility, cover crops, and drainage water management.

ODNR Pollution Abatement – State of Ohio cost share program for practices to solve existing pollution problems for animal waste or sediment.

Conservation Reserve Program (CRP) – This is the USDA land retirement or set aside program. It pays an annual rental payment for taking cropland out of production and establishing grasses or tree cover as well as creating wetlands.

Conservation Reserve Program (Continuous CRP) – The USDA program aimed at establishing grass filter strips, riparian tree buffers, windbreaks, and/or creating wetlands. This program pays an annual rental payment and offers cost share. This is not a competitive program and eligible lands are automatically accepted.

Conservation Reserve Enhancement Program (CREP) – USDA and State of Ohio buffer program similar to USDA CRP buffer program, but offers additional payments to the landowner in return for longer term contracts. This program is available in Crawford, Delaware, and Morrow counties for specified watersheds not including the Upper Olentangy watershed.

Wildlife Habitat Incentive Program (WHIP) – USDA program that offers landowners cost share assistance for grassland plantings, riparian tree plantings and wetland restoration to benefit wildlife.

Wetland Reserve Program (WRP) – USDA program to encourage restoration and enhancement of wetlands. The landowner receives a payment for placing a 30+ years to permanent conservation easement on the land.

Pheasant's Forever – Offers rental assistance on native grasses and no-till drill for planting native warm season grasses. Also, offers food plot and native grasses seed.

Division of Environmental and Financial Assistance (DEFA) – Program offers buy down on interest rate of a loan for many conservation equipment/practices. This assistance is currently available for producers in the Great Lakes watersheds in Crawford and Marion counties.

Ducks Unlimited – May offer additional cost share on wetland creation and enhancements.

Health Departments

Throughout the various meeting series conducted by the project team it was evident that many water quality problems might be linked to on-site treatment of waste by septic systems. At the workshops, representatives from health departments shared the various BMP's that are currently available. Crawford County is currently in the process of acquiring funds to develop a waste treatment facility for the Sugar Grove area, an area with a long history of poor on-site waste treatment. They are, also, in the process of acquiring funds for septic system improvements and inspection throughout the county.

Several years ago, Morrow County Health Department started a revolving loan fund where low interest loan payments would then return to the County Health Department for use in future on-site waste treatment upgrades. They currently sponsor large garbage and tire disposal days as an incentive for residents to dispose of those items properly.

Delaware County Health Department has been quite active in terms of BMP programs. They are currently in the process of locating and documenting treatment systems. Data and information is entered into a database and linked to a GIS database. All package treatment systems are catalogued and as new inspections are completed and systems are constructed they gather that information as well. Currently 30% of the aeration systems in Delaware County are inspected annually. They are currently developing a proposal aimed at inventorying all systems in the county and looking into a low interest revolving loan fund similar to the program available in Morrow County.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 6 – Physical Attributes

Channel and Floodplain Condition

Many of the headwater streams in the Upper Olentangy watershed have been modified and channelized to support agricultural activities. Many of the agricultural ditches in the watershed are actively maintained, but a significant portion of these ditches have recovered to some degree. We have not observed a case where a channelized stream has recovered to a point where it becomes reattached to the original floodplain, but in many cases fluvial processes have created a lower bench or floodplain. At this time the relationship between channel and landscape characteristics, land use, and management practices that allow a lower attached floodplain to develop is unknown.

Many of the larger rivers in the Upper Olentangy watershed have significant amount of riparian floodplain. The Olentangy River, Whetstone Creek, and Shaw Creek as well as the tributaries to Whetstone and Shaw Creek appear to be well buffer and have allowed meandering and adjustment to occur and maintain floodplain connectivity. Although, it should be mentioned that many streams seem slightly incised with lower width to depth ratios than many other streams in Ohio watersheds. As part of our efforts we have hiked many streams and it is evident that overbank flows occurred frequently. We often observed vegetation pointing in the downstream direction, recent deposition of sand and other fine sediments, and accumulations of woody debris on floodplain areas. It should be noted that several larger events have occurred prior to our investigations, but it is unlikely that any storm was so large that might skew our observations.

Forested Riparian Corridor Assessment

A riparian corridor or buffer zone is an important component of a well functioning stream system. An adequate buffer zone allows streams to migrate, meander, and adjust to perturbations in the hydrologic regime. Streams with adequate room to adjust are constantly eroding and depositing sediment to create and maintain point bars, cut banks, riffles and pools. These features are important to provide a diversity of habitat that many native species utilize throughout their life history. These floodplain areas could also serve as an efficient sink to sediment and sediment transported pollutants. Trees and grasses also provide shading and stabilization of the thermal regime and reduce extreme lows in dissolved oxygen concentrations that stress biological communities.

Research by Mecklenburg and Ward (ODNR and OSU) has shown that the amount of space need to allow meandering to occur is likely a function of stream size and contributing drainage area. Since these relationships are unknown at this time we chose to measure riparian corridor width into three categories. These categories (0-3, 3-10, and 10+ m) were chosen because many buffer strip programs use these general ranges. The assessment was focused on buffer zones adjacent to agricultural lands to determine the amount of buffer currently on these lands. From this information we can then estimate on a subwatershed basis the number of acres needed to provide some arbitrary width of buffer to all croplands. This assessment was conducted using aerial photos in a GIS environment. The width of buffer was measured on each bank and assigned a code corresponding to buffer width on each bank. Results were exported to an Excel Spreadsheet and the data were summarized. Results of the assessment are shown in Table 6.1.

Table 6.1 Riparian corridor width by subwatershed in the Upper Olentangy Watershed.

Watershed Name	0 to 3	3 to 10	10+	Total	Percentage
Brondige Run	26018	6662	10084	42764	2.48
Horseshoe Run	20207	1086	11435	32728	1.89
Delaware Run	2465	6942	11579	20986	1.21
Flat Run	83552	15237	119051	217840	12.61
Grave Creek	29088	7906	11682	48676	2.82
Indian Run	18294	1154	48998	68446	3.96
Mud Run	37176	12194	3424	52794	3.06
Norton Run	20832	3200	34812	58844	3.41
Olentangy River at Flat Run	42963	8354	44829	96146	5.57
Olentangy River below Del. Dam	9248	0	21180	30428	1.76
Olentangy River at Otter Creek	24075	10577	50487	85139	4.93
Otter Creek	44053	11529	28074	83656	4.84
Qu Qua	22505	9237	14680	46422	2.69
Riffle Creek	38042	18733	7511	64286	3.72
Rocky Fork	60529	16080	112169	188778	10.93
Shaw Creek	66839	13937	58674	139450	8.07
Whetstone below Shaw	34440	8420	39480	82340	4.77
Whetstone Creek	120041	29074	218759	367874	21.29
Total	**700367**	**180322**	**846908**	**1727597**	
Percentage %	**40.54**	**10.44**	**49.02**		

Extent of Natural Channel and Channelization

Natural streams in the Upper Olentangy are typically type C or E streams based on the Rosgen classification. The stream types typically have sinuosity greater than 1.2. Therefore, sinuosity provides insight into the number and amount of natural and modified streams. For this assessment we calculated sinuosity (length of channel/length of valley) for all stream segments in each 14-digit subwatershed. Data were collected in a GIS using aerial photos. Data were summarized in a spreadsheet program and values are reported on a 14-digit subwatershed basis. Detailed results are available in Table 6.2. Streams with a sinuousity of approximately 1.0 were typically agricultural ditches and have been labeled as agricultural ditches. Streams with a sinuosity of approximately 1.1 to 1.2 typically exhibited some sort of constraint yet still maintained some sinuosity. These streams have been labeled as semi-natural. Streams with high sinuosity and adequate riparian corridor have been labeled as natural streams.

Figure 6.2. Extent of natural channel and channelization, channel length, and sinuosity by subwatershed in the Upper Olentangy Watershed.

Stream	Type	Length (m)	Sinuosity
5060001090010	Semi-natural	26293	1.2
	Ag ditch	72319	1.0
5060001090020	Natural	8038	1.4
	Semi-natural	16935	1.2
	Ag ditch	23170	1.0
5060001090030	Ag ditch	26447	1.0
5060001090040	Semi-natural	10799	1.2
	Ag ditch	98876	1.0
5060001100010	Semi-natural	28807	1.1
	Natural	2599	1.2
	Ag ditch	136864	1.0
5060001100020	Natural	23457	1.2
	Semi-natural	7316	1.1
	Ag ditch	43502	1.0
5060001100030	Semi-natural	13725	1.1
	Ag ditch	33510	1.0
5060001110010	Semi-natural	7742	1.1
	Ag ditch	35161	1.0
5060001110020	Semi-natural	12179	1.1
	Ag ditch	41157	1.0
5060001110030	Ag ditch	29181	1.0
5060001110040	Semi-natural	3044	1.1
	Ag ditch	14389	1.0
5060001110050	Ag ditch	29684	1.0
5060001110060	Ag ditch	23409	1.0
5060001110070	Semi-natural	2654	1.1
	Ag ditch	20463	1.0
5060001110080	Ag ditch	23130	1.0
5060001110090	Semi-natural	11039	1.1
	Natural	4175	1.4
	Ag ditch	12636	1.0
5060001110100	Natural	1916	1.1
	Ag ditch	15704	1.0
5060001110110	Semi-natural	2834	1.2
	Ag ditch	7693	1.0

Location and Length of Actively Maintained Channel

While channel modification is prevalent throughout the entire watershed regular channel maintenance varies typically by county. Several ditches in Crawford County are under maintenance and undergo cleaning on a 5-year schedule. Marion County has maintained or has scheduled to maintain Riffle Creek, Grave Creek, Qu Qua Creek, and Bee Run. These tributaries to the Olentangy are the majority of streams in Marion County. In Morrow County, many headwater streams had been channelized 40 to 100 years ago, but in general most streams have not been maintained and appear to be recovering. We conducted a survey of local agencies to identify areas that are actively under maintenance. Results of that survey are seen in Table 6.3. It should be noted that these estimates do not include maintenance, which has been observed on a limited basis, conducted by private individuals. It is estimated that maintenance by individual land owners represents a small fraction of the overall total.

Table 6.3 Location and length of actively maintained channel by subwatershed in the Upper Olentangy River Watershed.

Subwatershed	14-digit HUC	Ditch	Length (miles)
Rocky Fork	05060001090010	6 unnamed ditches	12.0
Olentangy River @ Flat Run	05060001090020		
Mud Run	05060001090030		
Flat Run	05060001090040		
Whetstone Creek	05060001100010	None	None
Shaw Creek	05060001100020	None	None
Whetstone Creek below Shaw Creek	05060001100030	None	None
Otter Creek	05060001110010		
Olentangy River @ Otter Creek	05060001110020		
Riffle Creek	05060001110030	Riffle Creek	~6
Grave Creek	05060001110040	Grave Creek	To be maintained 2005
Norton Run	05060001110050		
Qua Qua Creek	05060001110060	Qua Qua Creek	~7
Brondige Run	05060001110070		
Olentangy River below Whetstone Creek	05060001110080	Indian Run Sherwood Carter	4.3 0.48 3.05
Indian Run	05060001110090	Sugar Run	3.73
Horseshoe Run	05060001110100	Horseshoe Run Knuckles	1.66 2.22
Delaware Run	05060001110110	Delaware Run	1.31

Dams

Sixteen dams have been identified in the Upper Olentangy watershed. The largest, Delaware Dam, is operated by the Army Corps of Engineers was built in 1948 for flood control. Delaware Lake is the largest impoundment with a surface areas of approximately 1300 acres. The City of Galion has three dams used to create Power's Reservoir, Amick's Reservoir and Amman Reservoir for public water supply. In total these reservoirs account for approximately 101 acres of surface water. The remaining 12 dams in the Upper Olentangy are for recreational purposes. All recreational lakes have a surface area less than 40 acres with the exception of Candlewood Lake in Morrow County with a surface area of approximately 200 acres. Location of dams can be seen in Figure 6.1. Information including hazard potential, purpose, surface area, drainage area, year built, height, owner, and max discharge is included in Appendix C, Table C6.1

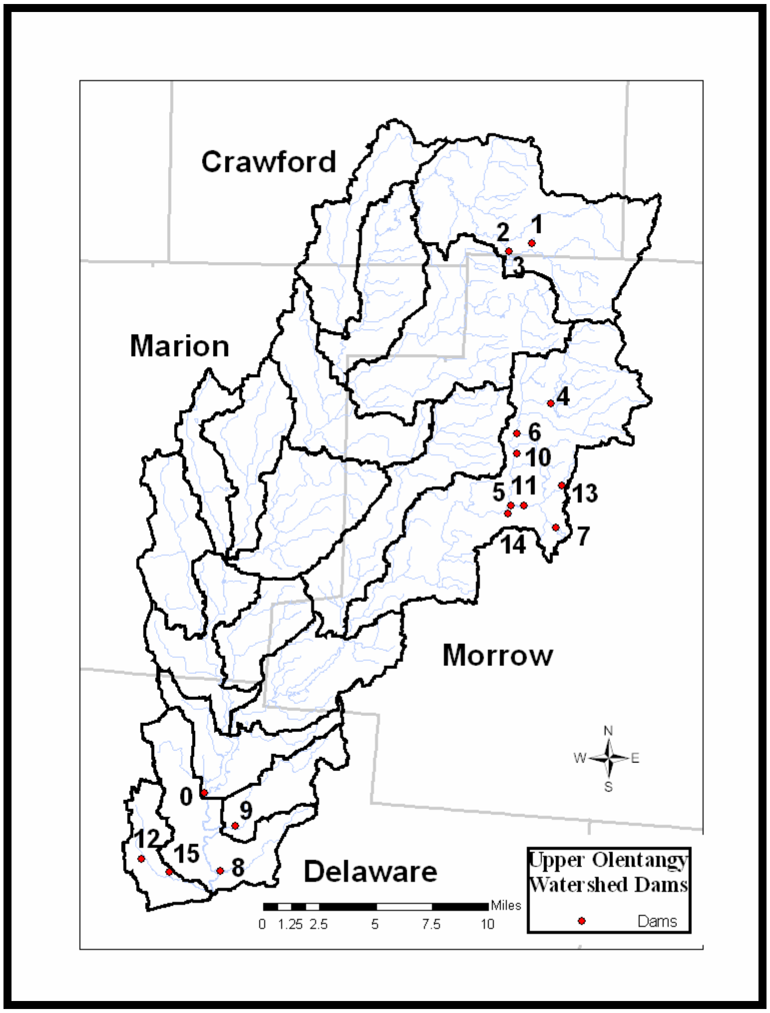


Figure 6.1. Location of dams in the Upper Olentangy River Watershed.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 7 – Water Resource Quality

Designated Use and Attainment Status

Several locations along the main stem of the Upper Olentangy River and its tributaries were sampled by the Ohio Environmental Protection Agency (OEPA) during the 1994 sampling seasons. Twenty-four sites (Table 7.1; Figure 7.1) were sampled and results are published in the Upper Olentangy and Whetstone Creek Technical Support Documents (TSD's) available on the OEPA web site. Summary results and analysis of chemical, physical and biological sampling are seen in Table 7.1. Sampling at 80 locations throughout the watershed was completed in the 2003 and results will be available in 2004. Additional sampling on the Olentangy main stem has been scheduled for the summer of 2004 to supplement 2003 sampling which was conducted during higher than normal flow conditions.

Table 7.1: Summary of Ohio EPA sampling in 1994 in the Upper Olentangy Watershed.

River	Sampling (River Mile)	Attainment	Comment
Upper Olentangy	91.1/90.7	Full	Ust. SR 97
Upper Olentangy	89.3/89.2	Full	Edward St.
Upper Olentangy	87.3/87.2	Partial	Dst. Jefferson St.
Upper Olentangy	86.4/86.1	Full	Ust. Galion WWTP
Upper Olentangy	85.95/86.0	Partial	Galion WWTP mixing zone
Upper Olentangy	85.9	Full	Dst. Galion WWTP
Upper Olentangy	85.2/85.2	Full	Ust. Monet-N. Winchester Rd.
Upper Olentangy	84.2/84.1	Full	Ust. Taylor Rd.
Upper Olentangy	79.8/79.6	Non	Shearer Rd.
Upper Olentangy	63.4/63.4	Full	Lyons Rd.
Upper Olentangy	60.0/59.8	Partial	SR 309
Upper Olentangy	54.6/54.8	Full	Dst. SR 95
Mud Run	0.7/1.5	Partial	Emahiser/Marseille Galion Rd.
Flat Run	0.5/0.3	Full	Dst. Twp. Rd. 60
Grave Creek	0.9/0.5	Partial	Ust. SR 98/Whetstone R. Rd.
Whetstone Creek	25.4/25.5	Full/Full	Upst. Mt. Gilead
Whetstone Creek	22.2/21.8	Full/Full	Upst. Mt. Gilead WWTP
Whetstone Creek	20.9/20.9	Full/Partial	Dst. Mt. Gilead WWTP
Whetstone Creek	19.2/19.2	Full/Partial	Dst. Mt. Gilead & Edison
Whetstone Creek	16.1/16.1	Full/Full	Upst. Cardington
Whetstone Creek	12.9/13.0	Full/Full	Dst. Cardington WWTP
Whetstone Creek	10.1/10.1	Full/Partial	Dst. Cardington
Whetstone Creek	9.1/9.2	Full/Partial	Dst. NPS project
Shaw Creek	0.4/0.4	Full/Partial	At Waldo-Fulton-Chesterfield Rd.

Based on the 1994 sampling of biological communities with respect to ecoregion biocriteria, 49% (17.9 miles) of the Upper Olentangy River was considered to be in FULL attainment of the Warmwater Habitat (WWH) aquatic life use designation (OEPA, 1996). An additional 41.4% (15.1 miles) demonstrated PARTIAL attainment of the WWH criteria (OEPA, 1996). The remaining 9.6% (3.5 miles) were in NON attainment of the WWH criteria (OEPA, 1996).

The Upper Olentangy, Flat Run, and Grave Creek have been designated as Warmwater Habitat (WWH). Mud Run was previously designated as a WWH, but this designation was deemed inappropriate by EPA evaluators and reassigned a Modified Warmwater Habitat (MWH) designation. This reassignment was justified considering the agricultural setting and ongoing modifications to maintain drainage. The Whetstone Creek and Shaw Creek tributaries have been designated as Exceptional Warmwater Habitat (EWH) based on sampling results and the planned infrastructure improvements to municipal wastewater facilities.

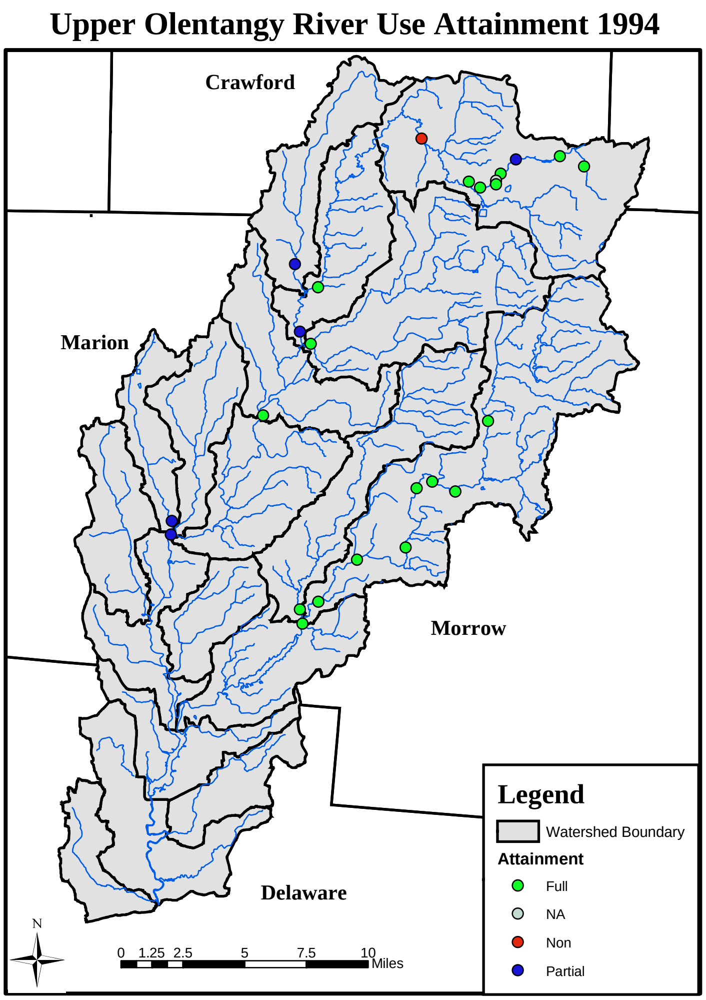


Figure 7.1: Ohio EPA sampling sites in the Upper Olentangy Watershed and results for the 1994 sampling season.

The Ohio EPA has developed these bio-assessment methods to determine if streams are meeting a particular use designation. Streams in a geographic region have been studied and it has been determined that particular assemblages of fish and macroinvertebrates should be capable of surviving in that region. If the biology that is being sampled deviates from the expected, it is likely that some impairment exists in that stream. The biology serves as an indicator that there is likely a problem and the stream system is not functioning as it should. The Ohio EPA has developed the following use designations (Note: the following descriptions have been adapted in short from the Ohio Administrative Code 3745-1-07; for complete description of biological use designations www.epa.state.oh.us/dsw/rules/01-07.pdf):

Warmwater Habitat - these are waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the twenty-fifth percentile of the identified reference sites within each of the following ecoregions: the interior plateau ecoregion, the Erie/Ontario lake plains ecoregion, the western Allegheny plateau ecoregion and the Eastern Corn Belt plains ecoregion. For the Huron/Erie lake plains ecoregion, the comparable species composition, diversity and functional organization are based upon the ninetieth percentile of all sites within the ecoregion.

Limited warmwater - these are waters that were temporarily designated in the 1978 water quality standards as not meeting specific warmwater habitat criteria. Criteria for the support of this use designation are the same as the criteria for the support of the use designation warmwater habitat. However, individual criteria are varied on a case-by-case basis and supersede the criteria for warmwater habitat where applicable. Any exceptions from warmwater habitat criteria apply only to specific criteria during specified time periods and/or flow conditions.

Exceptional warmwater - these are waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the seventy-fifth percentile of the identified reference sites on a statewide basis.

Modified warmwater - these are waters that have been the subject of a use attainability analysis and have been found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Such modifications are of a long-lasting duration (i.e., twenty years or longer) and may include the following examples: extensive stream channel modification activities permitted under sections 401 and 404 of the act or Chapter 6131 of the Revised Code, extensive sedimentation resulting from abandoned mine land runoff, and extensive permanent impoundment of free-flowing water bodies.

Use designations for streams in the Upper Olentangy River Watershed as assigned by the Ohio EPA are illustrated in Figure 7.2. Attainment status for each stream reach evaluated were presented earlier in Table 7.1.

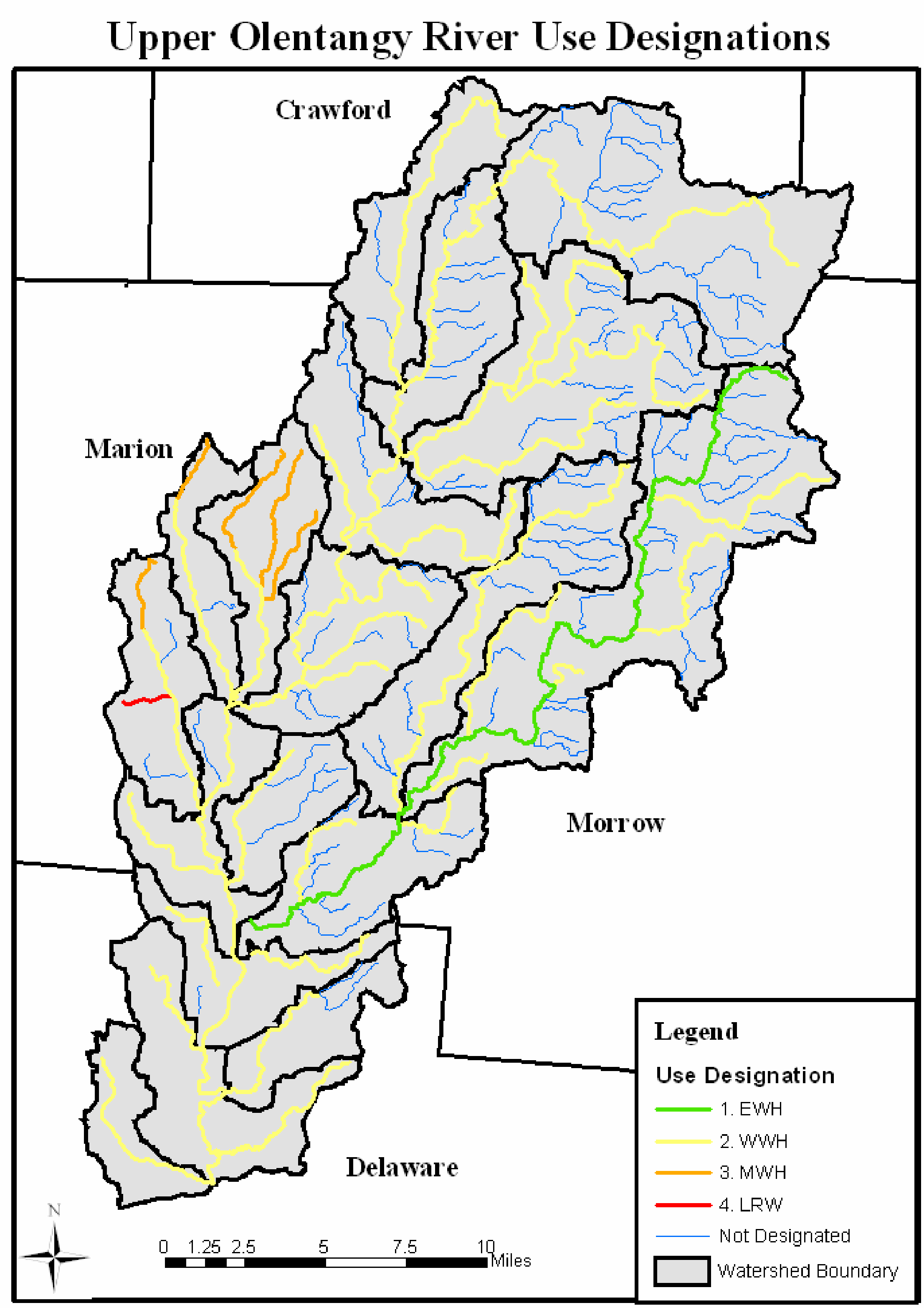


Figure 7.2: Ohio EPA use designation for Upper Olentangy streams.

Sources of Impairment

As part of the sampling process the Ohio EPA will make a determination as to the causes or sources of impairment in a watershed. Causes of impairment as listed by the Ohio EPA are summarized in Figure 7.3.

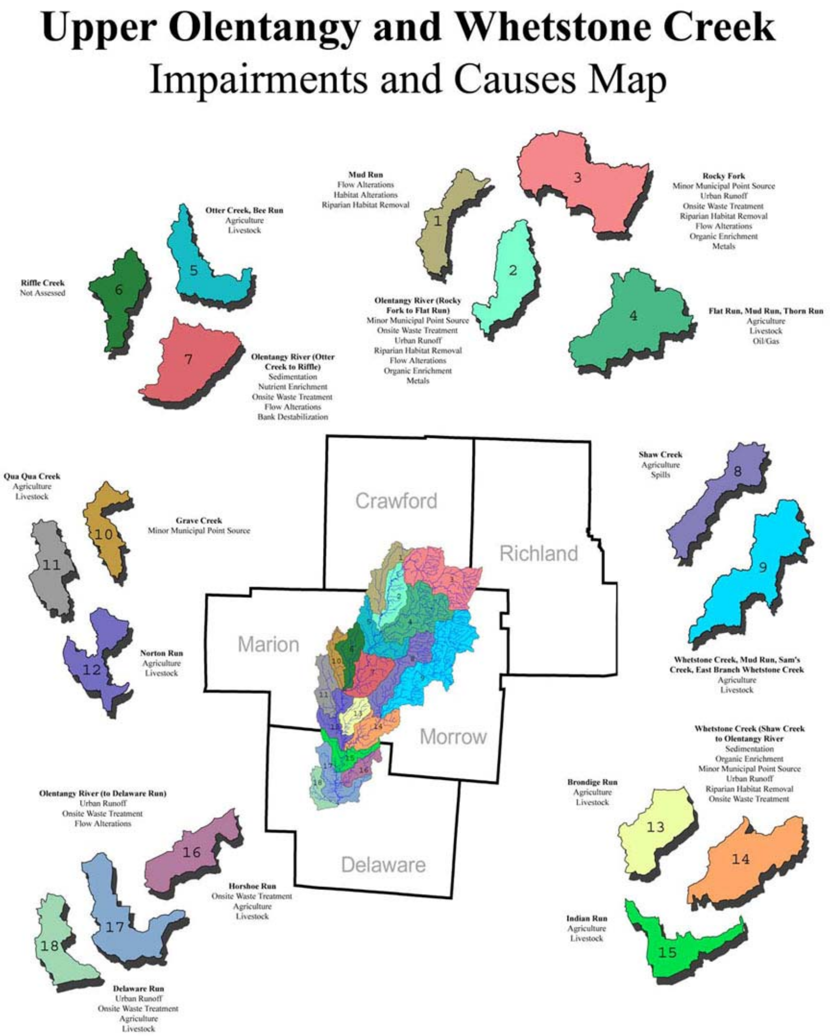


Figure 7.3. Causes of impairment as listed by the Ohio EPA for the subwatersheds in the Upper Olentangy Watershed.

It is a difficult task to accurately assess various sources of impairment at one particular moment in time. The following list will address the sources of impairment as listed by the EPA and incorporate information provided by members of the watershed community during the various meeting series held by the Upper Olentangy Watershed Action Planning Team.

Rocky Fork (05060001090010) – The Rocky Fork watershed is the uppermost headwaters of the Olentangy River. It provides the water supply for the City of Galion in Crawford County. The Ohio EPA has listed the following as possible sources of impairment: minor municipal point source, urban runoff, organic enrichment from onsite waste treatment, riparian habitat removal, flow alterations, and metals. Stakeholders identified streambank erosion and urban runoff as likely sources of impairment. Many feel that runoff from impervious surfaces has caused the streambanks to begin to erode and provide a significant source of sediment.

Olentangy River from Rocky Fork to Flat Run (05060001090020) – The Olentangy River is still realizing the impact of increased flow from runoff from the Rocky Fork watershed at this point. Many people commented that streambank erosion has caused trees to fall into the river and logjams are common. As the logjams grow in size the river has cut a new channel in several areas. Stakeholders believe that the eroding channels are a significant source of sediment. Land application of manure was, also, a major concern for watershed residents. In addition, the Ohio EPA has listed minor municipal point source, urban runoff, and organic enrichment from onsite waste treatment, riparian habitat removal, flow alterations, and metals as sources of impairment.

Mud Run (05060001090030) – Mud Run is a highly agricultural watershed. The entire watershed transports water primarily through agricultural ditches. The Ohio EPA has listed flow alterations, habitat alterations, and riparian habitat removal as the primary sources of impairment. All of these problems are typical for waters flowing in agricultural ditches. Land application of manure was identified as a problem that has caused problems in the past and remains a major source of concern.

Flat Run (05060001090040) – Flat Run is primarily agricultural, but recently more development is starting to occur. The northern portion of the watershed is near Galion and residential construction has increased along the outskirts of Galion. This had many stakeholders concerned about the impact of increased runoff and septic systems being installed. The Ohio EPA has identified agriculture, livestock, and oil/gas wells as sources of impairment.

Whetstone Creek (05060001100010) – The Whetstone Creek is predominantly agricultural watershed, but has a higher proportion of woods and pasture due the topography of the land. The Ohio EPA identified agriculture and livestock as the likely sources of impairment in their 1994 biological sampling. Since that time the watershed has undergone significant change. According to the local agencies and farmers, there has been a major shift to conservation tillage and the number of livestock in the watershed has decreased ~90% since that time. Stakeholders expressed concern over the remaining livestock operations, but meetings in Morrow County tended to focus on septic systems. Soils in Morrow County are poor for onsite waste treatment and despite the efforts of the local health departments and agencies it is difficult to get a handle on this problem. It was reported that a significant number of systems throughout the watershed and Morrow County are failing and prosecution of violators is difficult.

Shaw Creek (05060001100020) – The Shaw Creek is highly agricultural and about 75% of its tributaries are agricultural ditches. Stakeholders once again expressed concern regarding development and maintenance of septic systems in the watershed. The Ohio EPA has listed agriculture and spills as sources of impairment.

Whetstone Creek below Shaw Creek (05060001100030) – This subwatershed is the confluence of the Whetstone and Shaw Creeks with the Delaware Reservoir. The Ohio EPA has listed sedimentation, minor municipal point source, urban runoff, organic enrichment from onsite waste treatment, and riparian habitat removal as sources of impairment. Stakeholders did express concern over development of residential homes and home sewage treatment systems.

Otter Creek (05060001110010) – Otter Creek is a highly channelized watershed and exhibits many of the problems related to agriculture. The Ohio EPA listed agriculture and livestock as primary sources of impairment and stakeholders agreed with that assessment. Stakeholders did express concern over Bee Run, a tributary to the Olentangy. A petition has been submitted to the Marion County Engineer's Office and is currently being slated for maintenance. Several landowners are interested in an alternative, but the clean out appears to be moving forward and will likely devastate the biological communities in the tributary.

Olentangy River at Otter Creek (05060001110020) – The Olentangy River in this subwatershed appears to be more natural and sinuous, but the tributaries are primarily agricultural ditches. The Ohio EPA has listed sedimentation, nutrient enrichment, septic systems, flow alteration, and streambank destabilization as sources of impairment.

Riffle Creek (05060001110030) – The Riffle Creek was not assessed in the 1994 sampling season and therefore no sources of impairment were listed by the Ohio EPA. The watershed is completely channelized and stakeholders identified agricultural problems from sedimentation and nutrient enrichment as likely causes of impairment. Riffle Creek has been maintained in 2004 with probable effects on water quality and biological communities.

Grave Creek (05060001110040) – Grave Creek is on the eastern boundary of the City of Marion. The Ohio EPA has listed minor municipal point source pollution as the primary source of impairment. Stakeholders expressed concern related to problems from urban runoff and septic systems as well. Stakeholders also expressed concern that Grave Creek would be maintained in 2004 or 2005.

Norton Run (05060001110050) – Norton Run is a predominantly agricultural and wooded watershed between the cities of Marion and Delaware. The primary sources of impairment are agriculture and livestock. Local stakeholders have expressed immense concern regarding onsite waster treatment, or lack there of, around the Waldo area. According to stakeholders, many of the residents of the town and surrounding areas directly discharge into nearby ditches. The ditches were described as open cesspools and many residents were concerned about water and air quality caused by improper waster treatment.

Qua Qua Creek (05060001110060) – The Qua Qua Creek is entirely channelized except for a small portion before the confluence with the Olentangy protected by the Delaware Wildlife Area. The Ohio EPA has listed agriculture and livestock as the sources of impairment, but failed to mention issues regarding flow and habitat alteration. Stakeholders mentioned that various sections of the creek always seem to be under maintenance and affects to biology are noticeable.

Brondige Run (05060001110070) – Brondige Run is another highly agricultural watershed and drains directly into the Delaware Reservoir. Causes of impairment are listed as agricultural and livestock related and no other problems were identified by stakeholders.

Indian Run (05060001110080) – Indian Run is the watershed that contains most of the Delaware Reservoir. Much of the land directly around the reservoir is protected by a state park and wildlife areas. The Ohio EPA has listed agriculture and livestock as primary sources of impairment. Stakeholders felt that the increase in development would likely be the primary concern in the future. The explosion of growth in Delaware County threatens most watersheds along transportation corridors throughout the county.

Olentangy River south of Delaware Dam (05060001110090), Horseshoe Run (05060001110100), and Delaware Run (05060001110110) – These watersheds will not be directly addressed by this plan. These watersheds are under heavy development pressure and have had difficulty attaining their use designations due to impacts of urbanization.

Point Source Pollution

The Ohio EPA issues permits to point source discharges as part of the National Pollution Discharge Elimination System (NPDES). A list of entities with permits is summarized in Appendix D, Table D7.1.

Spills and Illicit Discharges

The Ohio Environmental Council has compiled a list of fish kills throughout the state documenting investigations conducted by the Ohio Department of Natural Resources' Division of Wildlife, Office of Law Enforcement. This information is current through the third quarter of 2002. Information regarding incidents since that time has been provided by Melinda Harris from the Ohio EPA, Division of Surface Water. For a complete list of fish kill investigations please contact the Ohio Department of Natural Resources and request the document "Dead in the Water". A summary list of fish kills in the Upper Olentangy watershed is available in Table D7.2 of Appendix D.

Non-point Sources of Pollution

Home Sewage Treatment Systems

The Ohio EPA listed septic systems and organic enrichment as causes of impairment in several subwatersheds of the Olentangy River. Throughout the watershed there is widespread concern regarding the number and condition of septic systems.

Assembling an accurate inventory of homes is a difficult and time consuming process. Only Delaware County has began a program to thoroughly locate and document new and existing systems. Local health departments are currently working on projects to develop sewage treatment facilities for several communities including Sugar Grove (Crawford County) and Iberia (Morrow County). In our attempt to inventory the number and status of on-site treatment systems we felt the best information would be provided by members of local health departments. A series of maps with watershed boundaries, roads, streams, and an aerial photograph background were distributed to local health departments. Instructions detailing the information we hoped to gather were included. Each health department was contacted in advance to discuss the project so goals could be efficiently met. In general, each health department was contacted after they received the packet and any problems regarding the inventory were resolved. Each department, also, was asked to estimate the accuracy of their inventory. Each department felt that the results they provided were quite accurate considering the enormity of the task. The results of this assessment were presented earlier in Appendix B, Table B4.6.

New Home Construction

Although the Upper Olentangy Watershed is primarily agricultural the southern portion is undergoing significant development. The urban areas near the City of Delaware are rapidly expanding. This is not a problem solely for Delaware County though. Areas around Galion, Mt. Gilead and Cardington have seen significant growth as people are willing to commute to work and land becomes more expensive near cities. Local health departments administer permitting related to new home construction and information was collected as described in the previous section. Table D7.3 (Appendix D) summarizes the new home construction estimates by subwatershed.

Animal Feeding Operations

At one time the livestock feeding operations were prominent in the Upper Olentangy watershed. Morrow County alone produced over 20,000 head of cattle per year. During the 1990's when cattle prices declined and the slaughterhouse closed livestock operations declined significantly. Since that time the livestock production has diversified to include sheep and chickens. With the increase in medium size lots many private residents also own horses. The largest increase in livestock production has occurred in Crawford County with several swine operations started in the last decade. Table D7.4 (Appendix D) breaks down number of livestock by subwatershed.

Bridge Crossings and Culverts

Throughout the Olentangy watershed the river and its' tributaries are crossed many times by bridges and culverts. This is important as these features affect the hydrology and poor design often induces sedimentation upstream from the crossing and scour downstream from the crossing. It is reasonable to assume that the number of bridges and culverts has some affect on water and biological quality, but any statement can only be made in a relative sense. To quantify the impact of these crossings a detailed assessment well beyond the scope of this project would be required. It is difficult to account for every bridge or culvert, but we attempted to identify the majority of these structures with the use of GIS. The Whetstone Creek watershed and Rocky Fork watershed had the greatest number of crossings, but are proportionally larger than other 14-digit watersheds in the Upper Olentangy. The distribution of bridge crossings and culverts is illustrated in Figure 7.4. For the number of crossings per subwatershed, see Appendix D, Table 7.5.

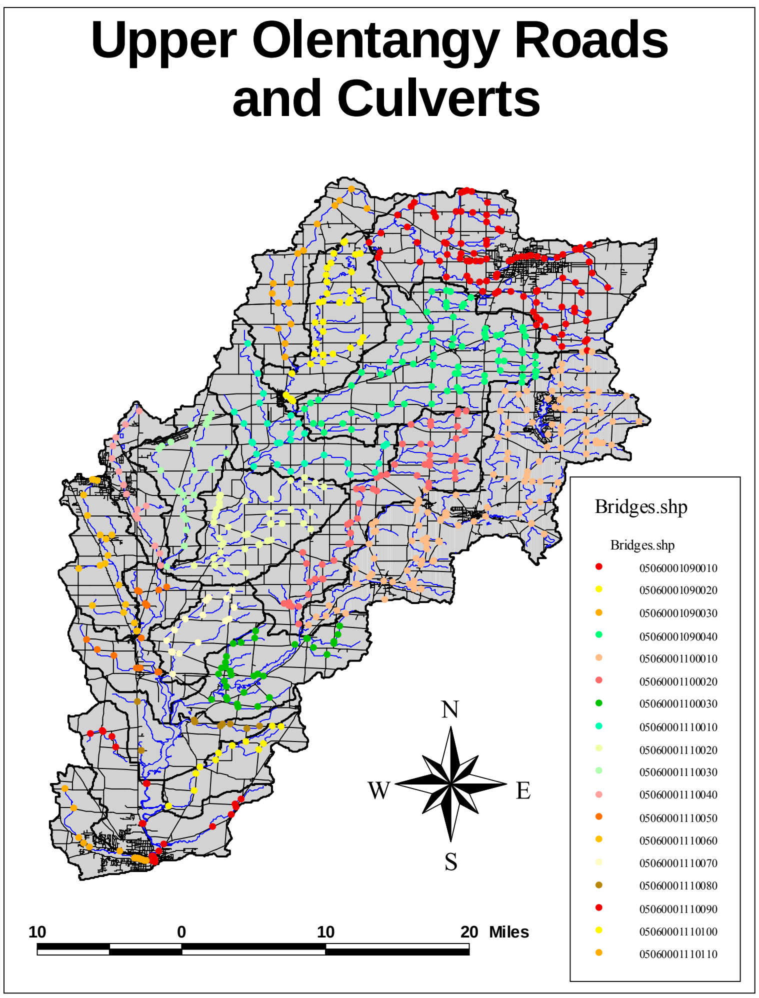


Figure 7.4: Bridge crossings and culverts in the Upper Olentangy Watershed.

Acres of Highly Erodible Land and Potential Soil Loss

Excessive erosion is defined as erosion greater than the tolerable rate. Highly Erodible Land is defined as land where the erodibility index is greater than or equal to 8. The Universal Soil Loss Equation (USLE) is used to calculate soil erosion. The Average Annual Wind Erosion Equation (AAWEQ) is used to calculate wind erosion. Excess erosion leads to water quality concerns from sediments, nutrients, and pesticides as well as air quality in wind erosion. Excess erosion is also an indicator of forgone opportunities for improving soil, water, and air quality, sequestering carbon dioxide, and helping in goals to reduce greenhouse gases in the atmosphere. Table 7.2 lists the reported acreages of Highly Erodible Land. Checking these reported values versus the NRCS 1997 report on soil erosion leads us to believe that reported values may be slightly underestimated.

Table 8.7: Acres of Highly Erodible Lands in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Acres	Loss/acre/year
Rocky Fork	05060001090010	1000	8
Olentangy River @ Flat Run	05060001090020	700	15
Mud Run	05060001090030	700	15
Flat Run	05060001090040	1350	15
Whetstone Creek	05060001100010	3500	8
Shaw Creek	05060001100020	NA	NA
Whetstone Creek below Shaw Creek	05060001100030	<200	8
Otter Creek	05060001110010	1500	15
Olentangy River @ Otter Creek	05060001110020	500	10
Riffle Creek	05060001110030	100	10
Grave Creek	05060001110040	50	10
Norton Run	05060001110050	100	10
Qua Qua Creek	05060001110060	100	10
Brondige Run	05060001110070	800	10
Olentangy River below Whetstone Creek	05060001110080	<200	4-5
Indian Run	05060001110090	<300	4-5
Horseshoe Run	05060001110100	<200	4-5
Delaware Run	05060001110110	<100	4-5

Channelization

Most of the Upper Olentangy is agricultural land. Even areas that are developed to date were likely farm land at one point in time. Agricultural drainage and channelization is extensive throughout the watershed especially in the headwater reaches. Some of the larger streams have not been channelized as well as areas that have remained wooded. A survey detailing the extent of channelization was conducted in a GIS environment using aerial photographs. Some of the photographs are relatively old, but provide quite good estimates for the most part. Streams were categorized into three categories: channelized, semi-natural, and natural. Channelized streams are categorized as straightened and or deepened at some time and have not fully recovered. Semi-natural streams were typically more sinuous but exhibited some degree of constraint with regards to lateral meandering. Natural streams were designated as those with adequate floodplain on which to meander usually with some type of buffer or riparian corridor. Table 7.3 depicts the length of stream in each subwatershed that has undergone channelization.

Status and Trends

The local community provided valuable information in our attempt to identify areas where water quality is improving or degrading. There has been improvement in many areas such as the Whetstone Creek where residents have said that water quality has improved over the last twenty years. Their efforts to adopt conservation tillage and a decline in livestock numbers have helped the Whetstone Creek achieve Exception Warmwater Habitat status, but there are still threats to the water quality of the Whetstone. Animal waste is less of a concern while human waste and onsite treatment poses a more immediate problem. The watershed is a dynamic place and the following list points out special areas of concern based on information from stakeholders:

Bee Run in the Otter Creek Watershed – Bee Run has recently been petitioned for maintenance. The uppermost portion of the run has significant sediment problems and has buried the subsurface drainage outlets. Some corrective action must be taken in this area if it is to function properly as an agricultural ditch. This problem exists in a short section at the headwaters of Bee Run. An initial survey of the stream leads us to believe that the lower portion of the stream had more than sufficient capacity to function properly (Note: This is a preliminary assessment and no final conclusions could be developed without thorough field assessment and data collection). The substrate in the downstream area was primarily small gravel and should provide good substrate and habitat for biology. The petition can allow the County Engineer's Office to clean the entire run. This would likely cause the stream to not meet attainment goals and many stakeholders are interested in alternatives to traditional ditch maintenance practices.

Qua Qua Creek, Riffle Creek, and Grave Creek – The tributaries to the Olentangy River in Marion County have underwent extensive channelization over the years. Stakeholders mentioned that the maintenance process seemed endless and there is a noticeable difference in biological communities after maintenance is performed.

Rocky Fork and the Olentangy River to Flat Run – During the course of watershed meetings we repeatedly heard about logjams in the Rocky Fork and Olentangy headwaters. Many stakeholders provide accounts were the river has cut a new channel around the logjam. They propose that significant amounts of sediment are coming from the stream channel itself. They did realize that there would typically be a supply of woody debris, but the current situation goes well beyond what might be considered "normal". Most stakeholders identified an increase in flow that they believed came from urban runoff from the City of Galion.

Table 7.3: Length of channelization in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Channelized miles
Rocky Fork	05060001090010	44.9
Olentangy River @ Flat Run	05060001090020	14.4
Mud Run	05060001090030	16.4
Flat Run	05060001090040	61.4
Whetstone Creek	05060001100010	79.9
Shaw Creek	05060001100020	27.0
Whetstone Creek below Shaw Creek	05060001100030	20.8
Otter Creek	05060001110010	21.9
Olentangy River @ Otter Creek	05060001110020	25.6
Riffle Creek	05060001110030	18.1
Grave Creek	05060001110040	8.9
Norton Run	05060001110050	18.4
Qua Qua Creek	05060001110060	14.6
Brondige Run	05060001110070	12.7
Olentangy River below Whetstone Creek	05060001110080	14.4
Indian Run	05060001110090	7.9
Horseshoe Run	05060001110100	9.8
Delaware Run	05060001110110	4.8

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 8 – Water Quality Sampling Results

Water Quality Monitoring

As part of the water quality project, the City of Delaware and City of Galion (project partner) has established seven water quality monitoring stations in the Upper Olentangy Watershed and one additional site at the DelCo raw water intake (Figure 8.1 and Table 8.1).

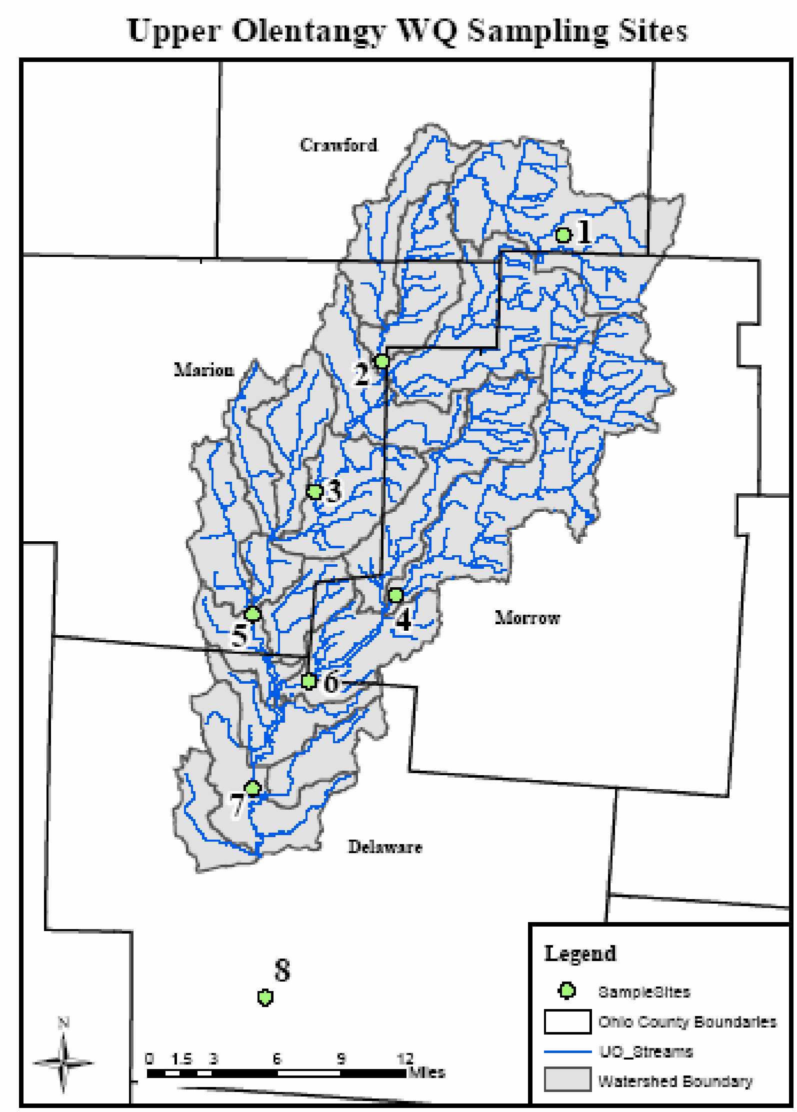


Figure 8.1: Water quality sampling sites in theUpper Olentangy Watershed.

Table 8.1: Description of water quality sampling sites in the Upper Olentangy Watershed.

Site	Location
1	City of Galion Raw Water Intake
2	Olentangy River @ SR 309
3	Olentangy River @ SR 529
4	Whetstone Creek @ Coleman Road
5	Olentangy River @ CR 140
6	Whetstone Creek @ SR 229
7	Delaware WTP Intake
8	Delco Raw Water Intake

Each site has been sampled on a bimonthly basis since April 2003 and tested for nitrate, phosphorus, ammonia, turbidity, total organic compounds, total suspended solids, pH, alkalinity, hardness, and several agricultural chemicals. Additional information is available from previous years from regular sampling at treatment plant intakes and results from studies conducted by Syngenta and the Ohio EPA. Figures 8.2 through 8.7 illustrate the seasonal distribution of nitrate-nitrogen, ammonium-nitrogen, phosphorus, total suspended solids, dissolved oxygen, and atrazine at the eight sampling sites during 2003. Box graphs of these data with mean and maximum concentrations are provided in Appendix E.

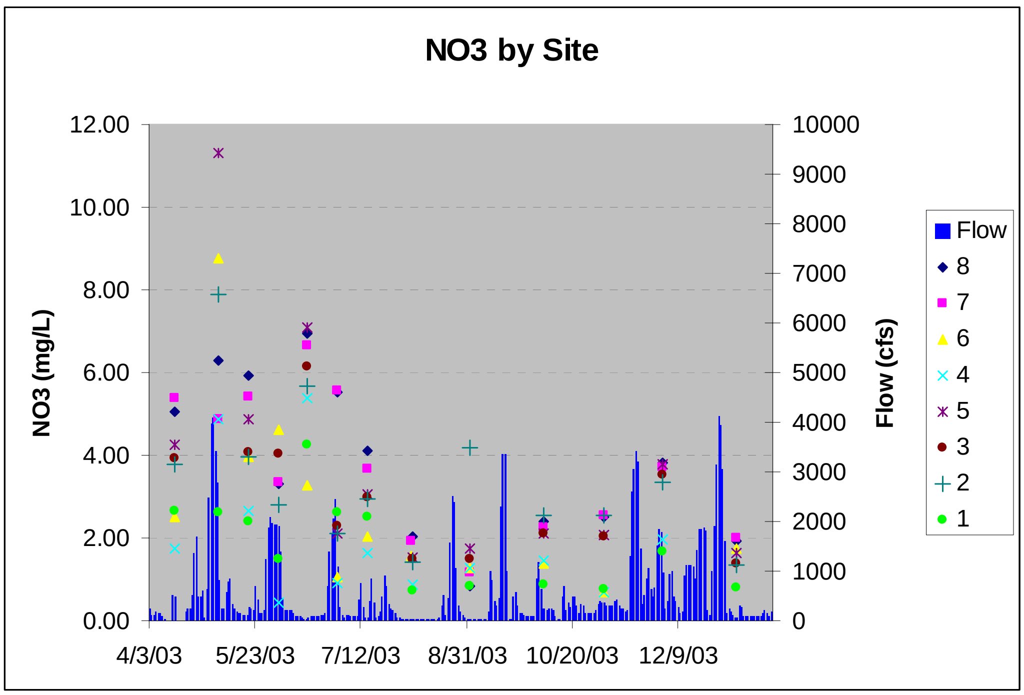


Figure 8.2: Nitrate-nitrogen concentrations and stream flow at sampling sites in the Upper Olentangy Watershed, April-December, 2003.

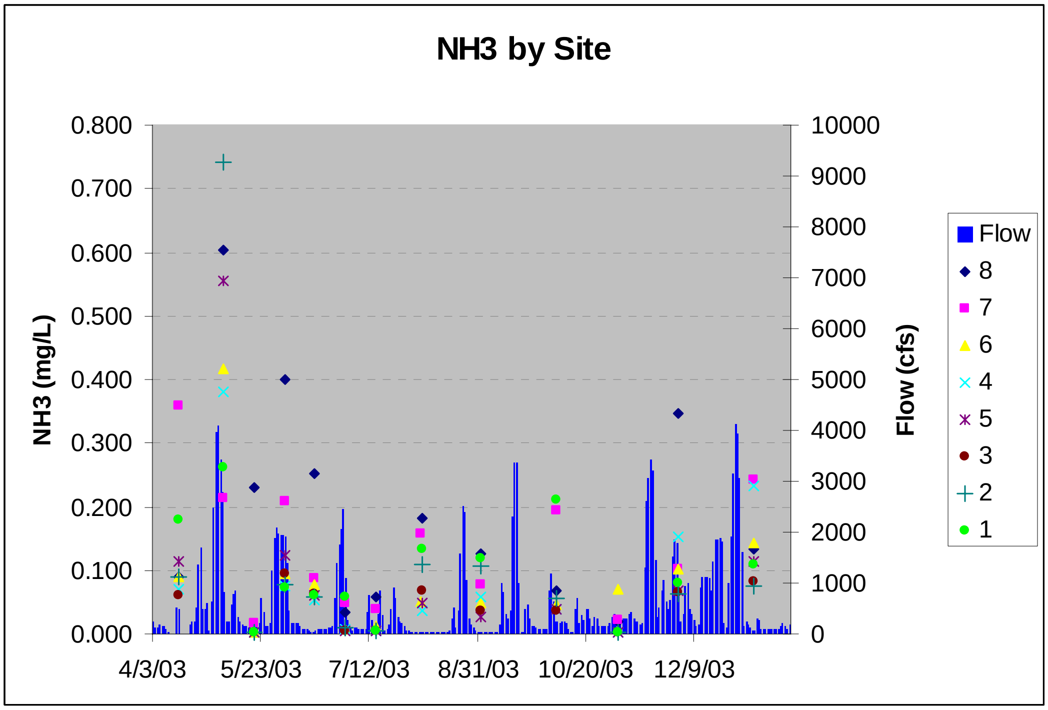


Figure 8.3: Ammonium-nitrogen concentrations and stream flow at sampling sites in the Upper Olentangy Watershed, April-December, 2003.

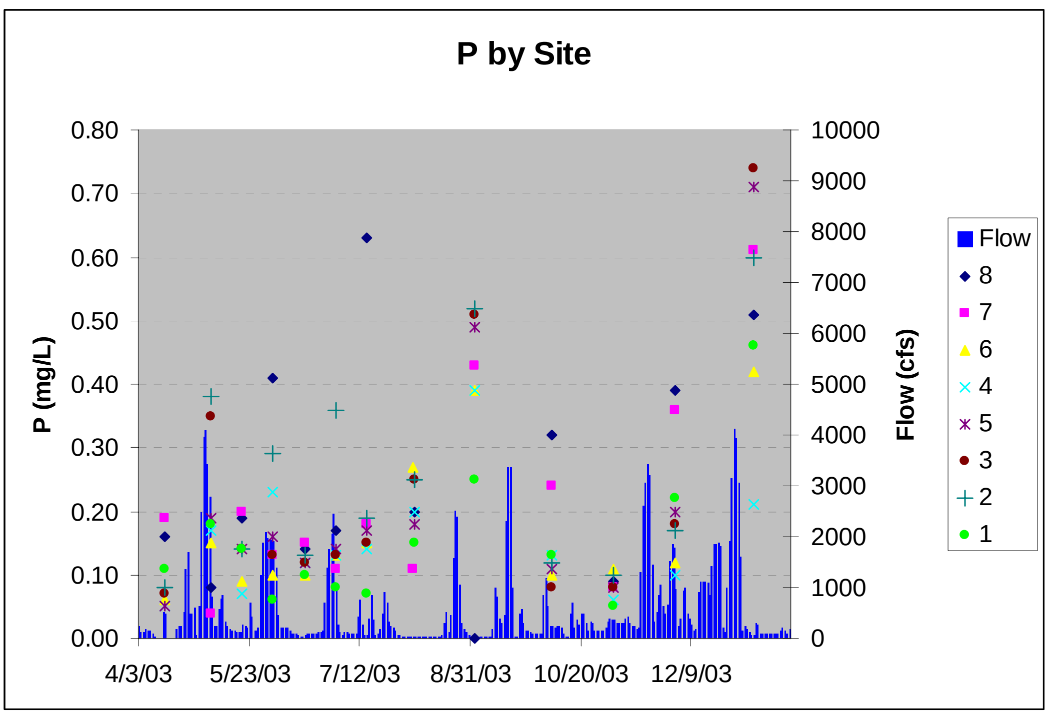


Figure 8.4: Phosphorus concentrations and stream flow at sampling sites in the Upper Olentangy Watershed, April-December, 2003.

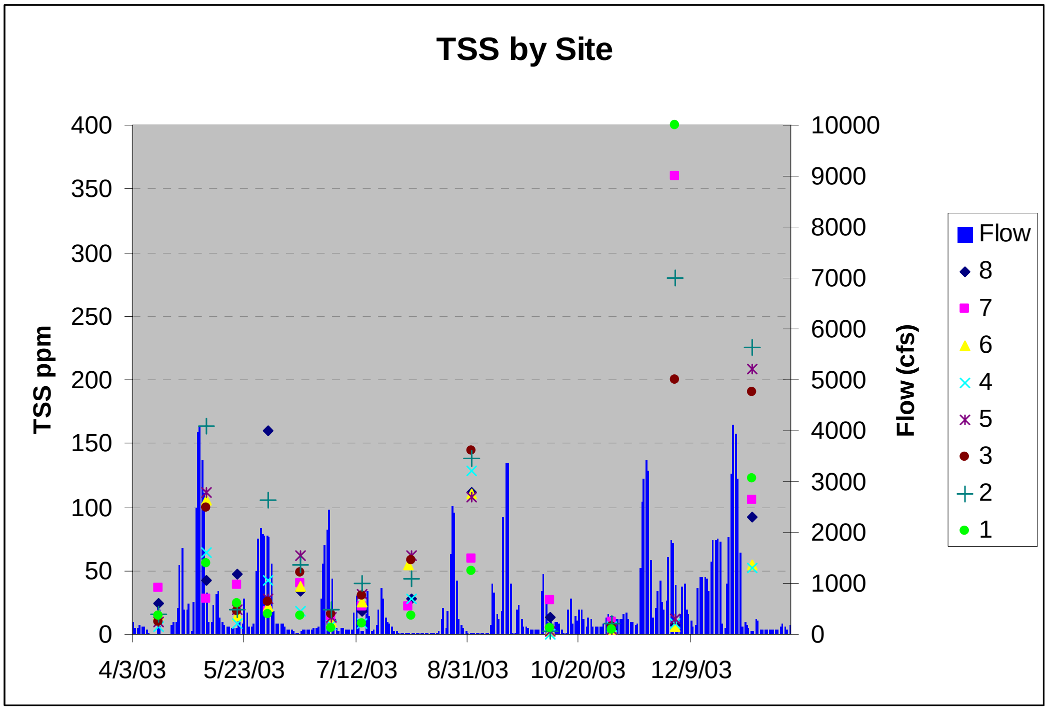


Figure 8.5: Total suspended solids concentrations and stream flow at sampling sites in the Upper Olentangy Watershed, April-December, 2003.

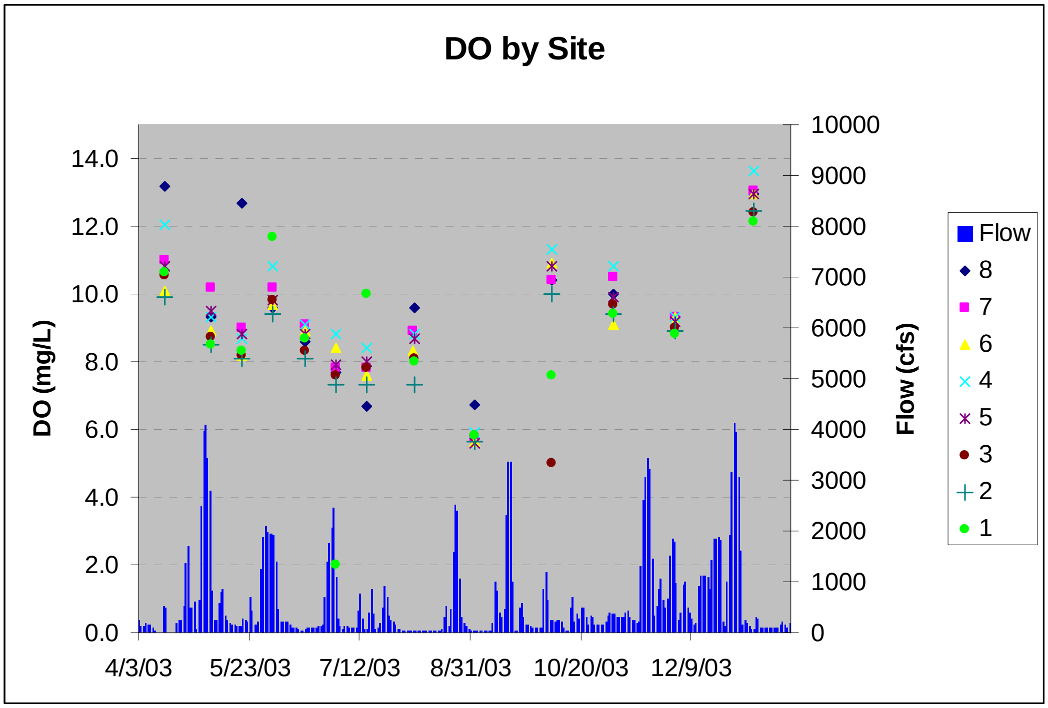


Figure 8.6: Dissolved oxygen concentrations and stream flow at sampling sites in the Upper Olentangy Watershed, April-December, 2003.

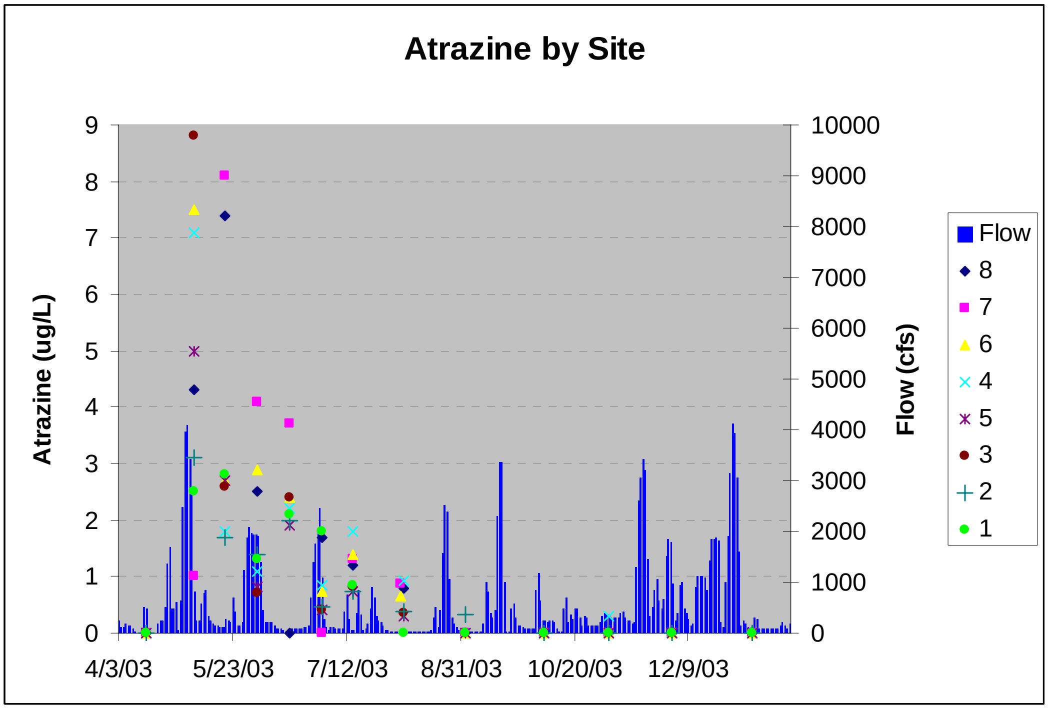


Figure 8.7: Atrazine concentrations and stream flow at sampling sites in the Upper Olentangy Watershed, April-December, 2003.

Figure 8.8 illustrates the concentrations of atrazine at the raw water supply intake for the Delaware Water Treatment plant for June of 1996 through 2003. The month of June is typically when atrazine shows up in the water samples. The pink line across the graph indicates the USEPA Drinking Water Standard for atrazine.

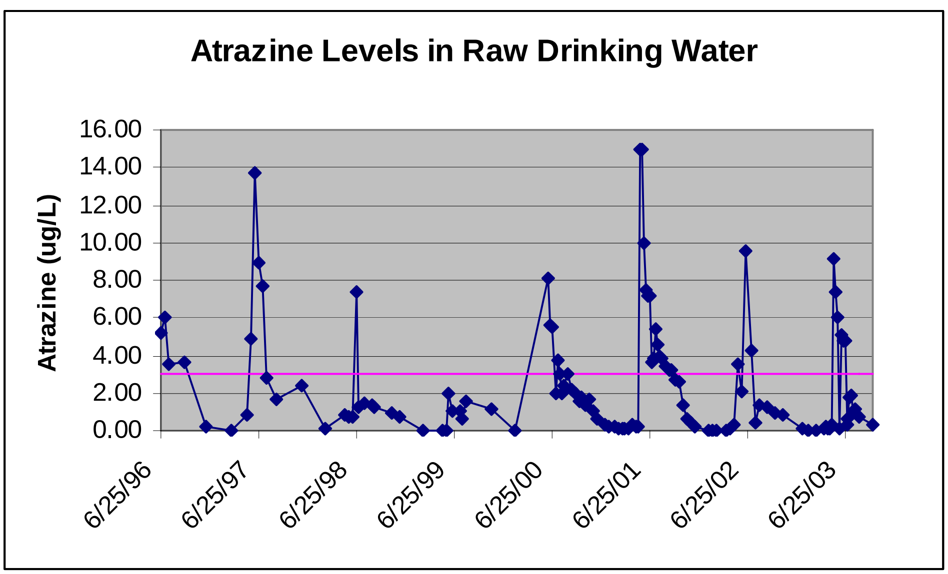


Figure 8.8. Concentrations of atrazine at the raw water supply intake for the Delaware Water Treatment plant for June of 1996 through 2003.

When nitrate-nitrogen concentrations exceed the USEPA Drinking Water Standard of 10 parts per million (mg/l), then public water supplies often dilute the raw water with well water to decrease the nitrate-nitrogen concentration to below 10 ppm. Figure 8.9 illustrates the nitrate-nitrogen concentrations in water that has been diluted with well water at the Delaware Water Treatment Plant. The pink line across the graph indicates the USEPA Drinking Water Standard for nitrate-nitrogen. The month of January is a typical month when nitrate-nitrogen concentrations shows up in the water samples.

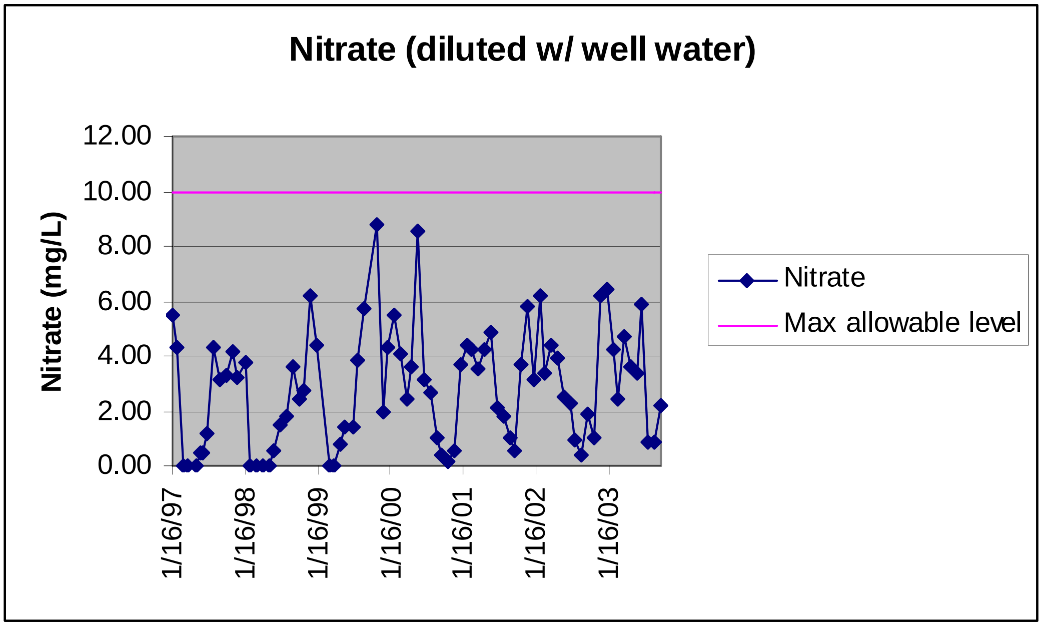


Figure 8.8. Concentrations of nitrate-nitrogen after dilution with well water at the Delaware Water Treatment plant for January 1997 through January 2003.

The graphs presented above provide a general feel for the overall water quality condition of the watershed. Little guidance is given to acceptable levels of ammonia in relation to biological or water quality standards. All samples analyzed for dissolved oxygen met the minimum 5.0 mg/l Water Quality Standard (OEPA, 1999). Atrazine levels did exceed the Water Quality Standard of 3µg/l at several sites during spring high flow conditions.

Although some guidance to Water Quality Standards for nitrate and phosphorus is available, it has been shown that much lower concentrations have an effect on biological criteria set for the state. According to the Ohio EPA (Association Between Nutrients, Habitat; Aquatic Biota in Ohio Rivers and Streams, Ohio EPA Technical Bulletin MAS/1999-1-1), lower concentrations of nitrate and phosphorus can be linked to biological impairment and subsequently failure to meet biological criteria and designated use. Suggested concentrations of nitrate and phosphorus to meet biological standards are divided by stream use designation and watershed size. Use designations include Exceptional Warmwater Habitat (EWH), Warmwater Habitat (WWH), and Modified Warmwater Habitat (MWH). Stream sizes are divided as headwater streams (<20 square miles), wadable streams (20 square miles to <200 square miles), and small rivers (>200 square miles). Table 8.2 shows statewide criteria for nitrate (mg/l) and phosphorus (mg/l) based on use designation and watershed size:

Table 8.2: Suggested statewide criteria for nitrate (mg/l) and phosphorus (mg/l) by stream use designation and watershed size.

Stream Type	EWH - Nitrate and Phosphorus Statewide Criteria (mg/l)	WWH - Nitrate and Phosphorus Statewide Criteria (mg/l)	MWH - Nitrate and Phosphorus Statewide Criteria (mg/l)
Headwater	0.5/0.05	1.0/0.08	1.0/0.34
Wadable	0.5/0.05	1.0/.08	1.6/0.28
Small River	1.0/0.10	1.5/0.17	2.2/0.25

The standards outlined in Table 8.2 represent the 75th percentile level of concentration for nitrate and phosphorus included in that study and a relationship between impairments and concentrations above that level was found. Therefore, it is suggested that water quality samples not exceed that level. The sites selected for the project water quality sampling plan are broad and make it difficult to make specific conclusions. Therefore, results of the Ohio EPA 2003 Water Quality sampling plan for the Olentangy River TMDL will be used to make conclusions for areas that may need reductions in nitrate and phosphorus. Ohio EPA sampling locations and stream type (headwater, wadable) are provided in Table 8.3. Water quality sampling results from the Ohio EPA study are provided below in Table 8.4.

Table 8.3. Ohio EPA sampling locations and stream type (headwater, wadable).

Location	Stream Type	Location	Stream Type
Big Rn @ Card.-Western Rd	Headwater	Shaw Ck @ Beatty Rd	Wadable
Cardington WWTP-001	Wadable	Shaw Ck @ S Canaan Rd	Wadable
Cardington WWTP-Mix Zone	Wadable	Shaw Ck @ SR 529	Wadable
E Br Whet Ck @ MG W. Point Rd	Headwater	Shaw Ck @ Thatcher Rd	Wadable
Indian Run @ Horseshoe Rd.	Headwater	Thorn Rn @ W. Pt. Bellville Rd	Headwater
Mitchell Rn @ Del.-Card. Rd	Headwater	U.T. to Whet. Ck @ RM 33.71	Headwater
Mt Gilead WWTP Mix Zone	Wadable	Whet Ck @ Bennett Rd	Wadable
Mt Gilead WWTP-001	Wadable	Whet Ck @ Loren Rd	Wadable
Olen Rv @ Claridon	Wadable	Whet Ck @ Marion-Williamsport Rd	Wadable
Olen Rv @ Crawford Marion Line Rd	Wadable	Whet Ck @ McKibben Rd	Wadable
Olen Rv ust Galion WWTP	Headwater	Whet Ck @ SR 229	Wadable
Olen. Rv. @ Claridon	Wadable	Whet Ck @ SR 61	Wadable
Olentangy Rv @ SR 96	Wadable	Whet Ck @ SR 95	Wadable
Rocky Fk @ Clark St Rd	Headwater	Whet Ck @ W-F-C Rd	Wadable
Rocky Fk @ Hamilton Rd	Headwater	Whet Ck dst Candlewood Lk WWTP	Wadable
Rocky Fk @ Thompson Rd	Headwater	Whet Ck Dst Cardington WWTP	Wadable
Sams Ck @ Sunfish Rd	Headwater	Whet Ck Dst Mt Gilead WWTP	Wadable

Table 8.3: Water quality results from Ohio EPA 2003 sampling efforts at locations in the Upper Olentangy Watershed.

Location	# Samples	Ave N	Median N	Ave P	Median P	TSS	Median TSS	Fecal Col	Median Fecal Col
Big Rn @ Card.-Western Rd	6	2.10	1.22	0.070	0.072	11.50	10.50	6911.0	2410.0
Cardington WWTP-001	6	8.67	6.79	1.880	1.750	5.00	5.00	10282.0	230.0
Cardington WWTP-Mix Zone	6	8.00	6.43	1.640	1.525	11.30	9.00	6988.0	1230.0
Claypool Rn @ Pros.Mt. Vernon Rd	6	6.73	6.73	0.110	0.114	20.67	14.50	2732.0	1725.0
E Br Whet Ck @ MG W. Point Rd	6	1.09	0.82	0.140	0.087	24.80	5.50	1542.0	400.0
Indian Run @ Horseshoe Rd.	6	0.50	4.94	0.080	0.073	9.50	7.00	638.0	590.0
Mitchell Rn @ Del.-Card. Rd	6	3.95	4.10	0.250	0.194	25.70	32.00	1877.0	780.0
Mt Gilead WWTP Mix Zone	6	3.54	3.67	3.110	0.588	202.50	10.00	26865.0	4050.0
Mt Gilead WWTP-001	6	5.97	5.55	4.510	1.193	94.50	5.00	29050.0	25400.0
Olen Rv @ Claridon	4	3.11	3.25	0.130	0.112	32.00	35.00	1030.0	1040.0
Olen Rv @ Crawford Marion Line Rd	4	2.63	2.71	0.240	0.228	108.00	56.50	2855.0	1410.0
Olen Rv ust Galion WWTP	4	2.42	2.09	0.070	0.063	18.80	16.50	7325.0	6400.0
Olen. Rv. @ Claridon	6	2.54	2.17	0.110	0.113	13.50	15.50	1083.0	440.0
Olentangy Rv @ SR 96	2	6.30	6.30	0.090	0.090	47.00	47.00	1590.0	1590.0
Rocky Fk @ Clark St Rd	10	0.94	0.51	0.090	0.076	19.20	5.00	1522.0	575.0
Rocky Fk @ Hamilton Rd	6	0.98	0.53	0.070	0.063	17.70	5.00	738.0	400.0
Rocky Fk @ Thompson Rd	6	1.37	1.68	0.110	0.097	60.80	8.50	1422.0	600.0
Sams Ck @ Sunfish Rd	6	1.73	1.67	0.070	0.057	14.50	9.00	15383.0	3800.0
Shaw Ck @ Beatty Rd	6	3.30	0.95	0.586	0.105	21.80	19.00	1730.0	1185.0
Shaw Ck @ S Canaan Rd	5	3.54	4.27	0.110	0.055	102.80	11.00	14378.0	2700.0
Shaw Ck @ SR 529	6	3.26	1.74	0.070	0.076	33.70	26.50	4735.0	3950.0
Shaw Ck @ Thatcher Rd	9	2.93	3.47	0.100	0.048	29.70	8.00	7276.0	680.0
Thorn Rn @ W. Pt. Bellville Rd	2	2.78	2.78	0.140	0.140	25.00	25.00	7100.0	7100.0
U.T. to Whet. Ck @ RM 33.71	6	2.20	1.33	0.150	0.100	116.20	5.00	8872.0	520.0

Whet Ck @ Bennett Rd	6	1.34	1.12	0.190	0.171	17.30	10.00	2392.0	375.0
Whet Ck @ Loren Rd	6	0.95	0.85	0.080	0.066	21.70	5.00	14868.0	375.0
Whet Ck @ Marion-Williamsport Rd	6	1.69	1.26	0.140	0.104	30.30	7.00	5775.0	345.0
Whet Ck @ McKibben Rd	12	1.58	1.07	0.140	0.059	31.40	27.50	2523.0	2700.0
Whet Ck @ SR 229	6	3.18	2.09	0.130	0.132	33.00	30.00	640.0	450.0
Whet Ck @ SR 61	6	0.97	0.82	0.080	0.051	17.20	6.50	1750.0	500.0
Whet Ck @ SR 95	17	1.03	1.09	0.050	0.045	16.60	5.00	701.0	370.0
Whet Ck @ W-F-C Rd	6	2.07	0.98	0.170	0.177	16.50	12.00	482.0	500.0
Whet Ck dst Candlewood Lk WWTP	11	1.21	1.14	0.140	0.065	13.00	9.00	1525.0	160.0
Whet Ck Dst Cardington WWTP	5	1.35	1.26	0.220	0.225	27.80	32.00	2448.0	1200.0
Whet Ck Dst Mt Gilead WWTP	6	1.34	1.23	0.290	0.275	24.80	16.50	11865.0	1735.0

Nitrate

Following the statewide criteria by Ohio EPA (1999), only 4 of 35 (approx. 89%) sampling sites had median nitrate concentrations below statewide criteria. Based on our knowledge of land use and management practices, this type of result is likely representative of the entire Upper Olentangy watershed. Therefore, BMP's that reduce nitrate levels particularly in highly agricultural watersheds should be strongly considered.

Phosphorus

Median phosphorus concentrations exceeded statewide criteria at 24 or 35 (approx. 69%) sampling sites. Associations between elevated phosphorus levels and biological attainment status have been shown and most watersheds throughout the Upper Olentangy are above statewide criteria. Therefore, BMP's that reduce phosphorus levels should be strongly considered.

Fecal Coliform

Statewide criteria for fecal coliform differ based on recreational use designation. Sites designated as bathing waters including beaches and other swimming sites must maintain fecal coliform levels below 200 cfu/100ml. Sites not designated with a recreational use have statewide criteria of 1000 cfu/100ml. To the best of our knowledge none of the sites included in this subset of the Ohio EPA TMDL study were designated as bathing waters. Therefore, any site with a median concentration above 1000 cfu/100 ml is considered an area of concern. In the Upper Olentangy watershed 17 of 35 (approx. 49%) of sampled sites exceeded the statewide criteria. We are unable to distinguish the exact source for many of the problems, but WWTP, failing septic systems, and unrestricted livestock access to streams has been documented throughout the watershed. The 2003 sampling year was particularly wet with many high flows. A known source of elevated fecal coliform in the watershed can be attributed to inability of several WWTP to effectively treat waste during high flow events. Many problems could be alleviated by improvements to these facilities, but does not eliminate the need to address problems related to livestock and failing septic treatment systems.

It is evident from the water quality data collected as a component of this project and data from Ohio EPA sampling that many of the water quality problems are very broad across the Upper Olentangy watershed. Therefore, BMP's for each of the aforementioned constituents can and should be applied to critical sites in appropriate 14-digit subwatersheds.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Chapter 9 – Demographics

The Upper Olentangy watershed is home to approximately 88,000 residents and is the primary source of drinking water for many more residents outside of the watershed serviced by the City of Galion, City of Delaware, and Del-Co water utilities. The watershed encompasses all or portions of 28 townships (Table 9.1), 3 cities (Table 9.2), and 6 villages (Table 9.3).

In order to determine the approximate number of residents in the watershed several simplifying assumptions were made because census data is reported by jurisdictional boundaries which do not coincide with watershed boundaries. Therefore, in order to estimate the number of residents in a city, village, or township was multiplied by the percentage of the city, village, or township land area that is within the watershed. For example, if 40% of Township X, which has a population of 1000 residents, was within the watershed then 400 people (40% * 1000) were included in the population estimate for the watershed. The percentage of a city, township, or village in the watershed was visually estimated from maps of jurisdictional and watershed boundaries overlaid in a GIS. The visual estimates are likely to be accurate to ±10%. While this error may seem significant, no data exist that could, in a reasonable amount of time, provide more precise information on the specific spatial location of residents within the watershed.

Table 9.1: Townships within the Upper Olentangy watershed, the percentage of the township located within the Upper Olentangy watershed, and the number of residence in the township.

Township	% of Watershed Area	# of Residents
Bucyrus	5	828
Whetstone	70	2365
Dallas	15	455
Jefferson	30	1677
Polk	90	2334
Sandusky	25	856
North Bloomfield	70	1866
Washington	100	1227
Congress	50	2128
Gilead	85	5868
Canaan	100	897
Cardington	95	2790
Westfield	90	1100
Lincoln	5	1955
Scott	45	521
Claridon	90	2587
Marion	30	44908
Richland	100	1663
Pleasant	40	4368

Waldo	85	1079
Prospect	5	2207
Tully	100	738
Radnor	10	1335
Marlboro	90	227
Oxford	70	854
Brown	25	1297
Troy	95	2665
Delaware	40	26149

Table 9.2: Cities within the Upper Olentangy watershed, the percentage of the city located within the Upper Olentangy watershed, and the number of residence in the city.

City	% of Watershed Area	# of Residents
Galion	100	11341
Marion	10	35318
Delaware	50	25243

Table 9.3: Villages within the Upper Olentangy watershed, the percentage of the village located within the Upper Olentangy watershed, and the number of residence in the village.

Village	% of Watershed Area	# of Residents
Caledonia	100	578
Edison	100	437
Mt. Gilead	100	3290
Cardington	100	1849
Waldo	100	332
Ashley	50	1216

Population trends (Figure 9.1) for the counties in which the watershed is located show that Crawford, Marion, and Morrow counties have had relatively stable populations over the last several decades. However, during the same time period the population of Delaware County has roughly doubled with much of the development along the Olentangy River. Improvements to infrastructure (roads, utilities, etc.) suggest that much of the development in the county would occur in the Olentangy watershed, with primary focus being on the Lower Olentangy watershed. Population projections (Figure 9.2) estimate that the populations of Crawford, Marion, and Morrow counties will remain relatively unchanged until 2030 while the population of Delaware County is expected to increase by well over 200% in 2030 from the 2000 Census results.

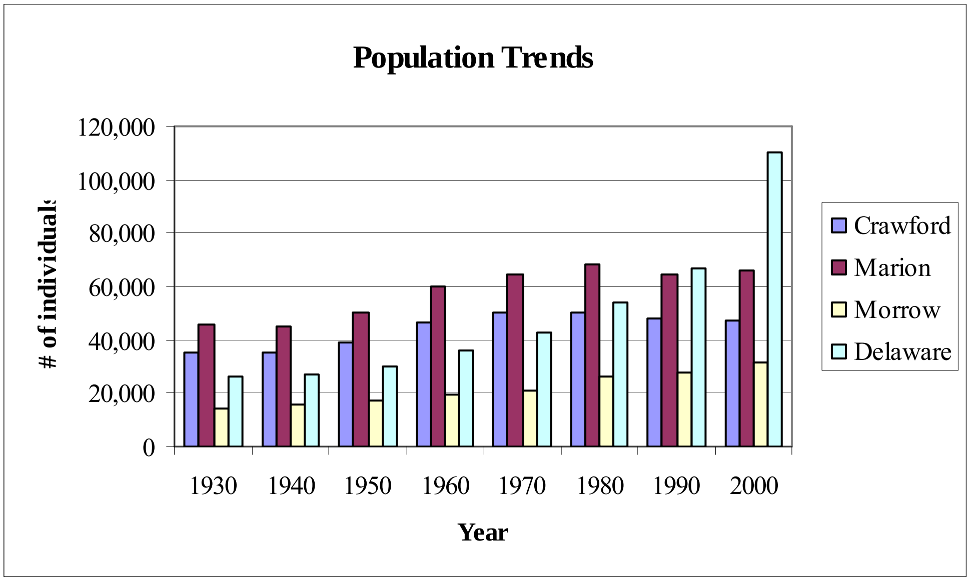


Figure 9.1. Population trends for Crawford, Marion, Morrow, and Delaware counties (data source: http://www.osuedc.org/) for the time period 1930-2000.

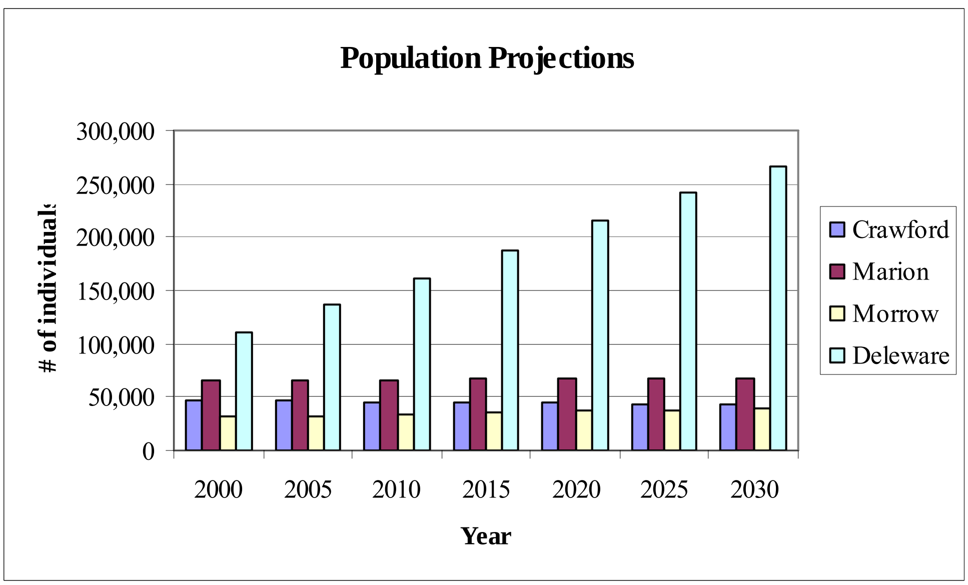


Figure 9.2. Population projections for Crawford, Marion, Morrow, and Delaware counties (data source: http://www.osuedc.org/) for the time period 2000-2030.

Cultural History

From the early days of European settlement in the watershed until present much of the Upper Olentangy watershed has been in agricultural production. Prior to European settlement the watershed consisted largely of wooded wetlands and wet prairie environments. Drainage improvements, both surface and subsurface drainage, facilitated agricultural production and continue to be an important component of many farm enterprises. In this region of the US, efficient drainage of excess soil moisture is critical for reliable crop production. In addition, agricultural statistics show that the number of farms in this area is decreasing and the average farm size is increasing. It is not uncommon for farms to exceed several thousand acres in size. Drainage practices can be particularly important to larger farmers to increase the window of opportunity to complete essential field operations. While agricultural drainage has been show to be a pathway for nutrients to enter waterways the importance of drainage practices should not be underestimated by a watershed community or coordinator attempting to implement a management plan. Several drainage water management practices (see watershed management plan section) have been developed and initial research results suggest that these practices can reduce impacts to receiving waters.

During two years of working with the watershed community, the importance of local agencies (in particular Soil and Water Conservation Districts, the Natural Resources Conservation Districts, Ohio State University Extension Services, Health Departments, etc.) was apparent. These local agencies work with the watershed community on a daily basis and are the first point of contact for most conservation or health related issues in the watershed. Successful implementation of a watershed plan in this watershed would require a strong and close relationship with these organizations. Also, residents repeatedly cited that they prefer that conservation programs remain voluntary. Some resentment between residents and regulatory agencies exists and stems from issues that arose during the oil and gas production period during the 1950's and 1960's particularly in the Whetstone Creek portion of the watershed.

Areas of Historical Importance or Significance to the Water Resources of the Olentangy

Delaware Lake and Delaware State Park – Delaware Lake is one of a system of dams throughout the Scioto and Ohio River Basins constructed to reduce flood stages. The dam was authorized by the Flood Control Act of 1938 for the purposes of flood reduction, water supply, recreational activities, and wildlife management. The dam was originally constructed from 1947 to 1951 at a cost of $4,307,000 and is currently operated by the Army Corps of Engineers, Huntington District. The Delaware State Park is located on the southwest side of the reservoir and provides camping, picnicing, and boat launching facilities.

Delaware Wildlife Area – The Delaware Wildlife Area is located adjacent to the Delaware Reservoir and provides a variety of grassland and wooded habitats for wildlife management. The wildlife area covers 4,670 acres north of the City of Delaware and south of the City of Marion. The wildlife management plan for the area provides for a diversity of habitats for upland wildlife. Management techniques include sharecropping, planting of permanent nesting cover, manipulating timber stands, and periodic burning to control succession. Wetland wildlife habitat has been improved by the construction of 54 ponds and the flooding of 159 acres of seasonal wetlands. The Olentangy Wildlife Research Station, which serves as the headquarters for statewide upland wildlife research, is located here. Many field research projects have been carried out on this area since 1951.

Populations of black bass, bluegill, crappie, white bass, saugeye, and catfish occur in the reservoir. A great variety of both nesting and migrant birds utilize the area. Of particular interest is the spring migration of waterfowl and songbirds and the fall migration of hawks. Red-tailed hawks, American kestrels, and Northern harriers (marsh hawks) are common summer sights over the open fields and woodlots. Large numbers of turkey vultures are also present during summer. Among the rare and unusual birds which have been observed are the bald eagle, Northern goshawk, osprey, king rail, snowy owl, long-eared owl, great egret, cattle egret, and sandhill crane. In 1994, wild turkeys were relocated from eastern Ohio to the Delaware Wildlife Area. Bird observation is a popular activity at Delaware. Cottontail rabbit, ring-necked pheasant, mourning dove, squirrels, woodchuck, raccoon, muskrat, mink, and opossum are the principal upland game and fur species. Resident populations of Canada geese, wood ducks, and mallards occur on the area. During the spring and fall migrations, these and other waterfowl species can be found in large numbers on the reservoir, ponds, and seasonally flooded marsh.

Appendices

Appendix A - Chapter 3

Watershed Resources Inventory for the Upper Olentangy River Watershed

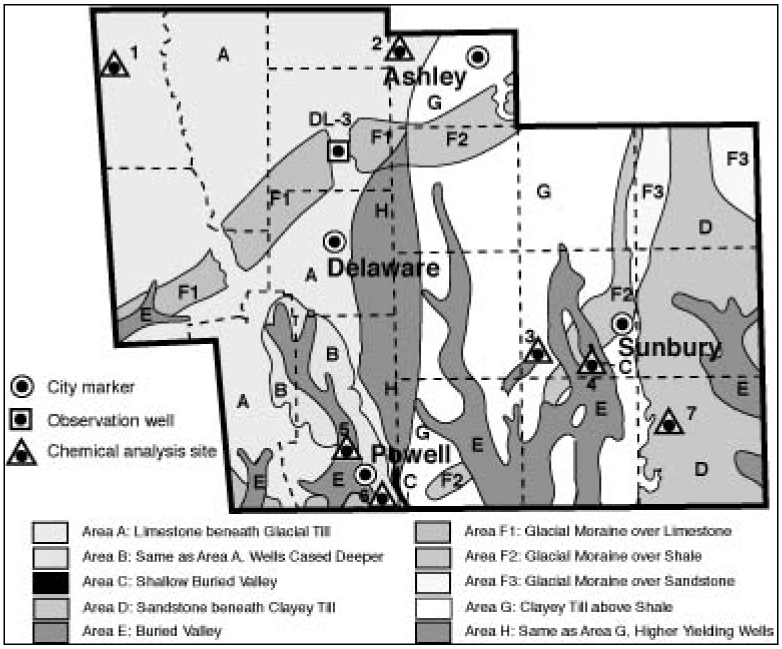


Figure A3.1: Aquifer types for Delaware County (Putnam et al., 1992).

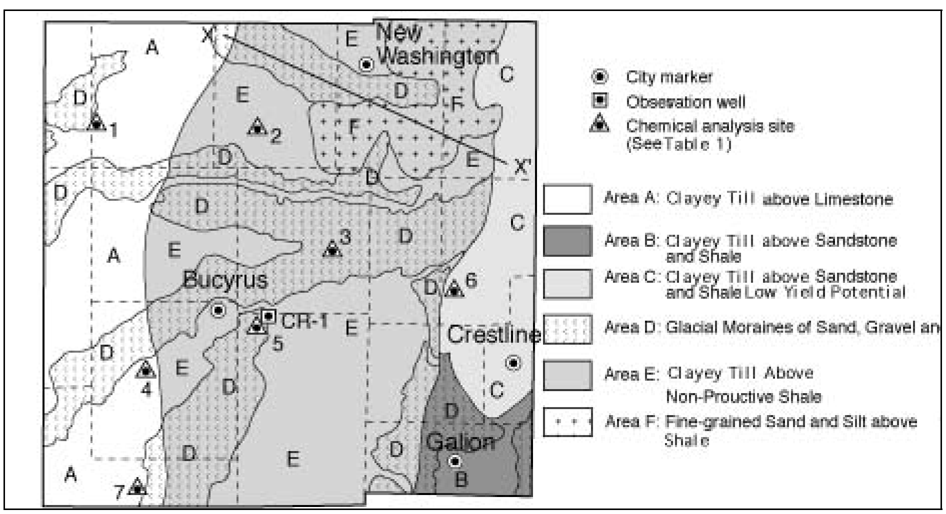


Figure A3.2: Aquifer types for Crawford County (Prochaska et al., 1993).

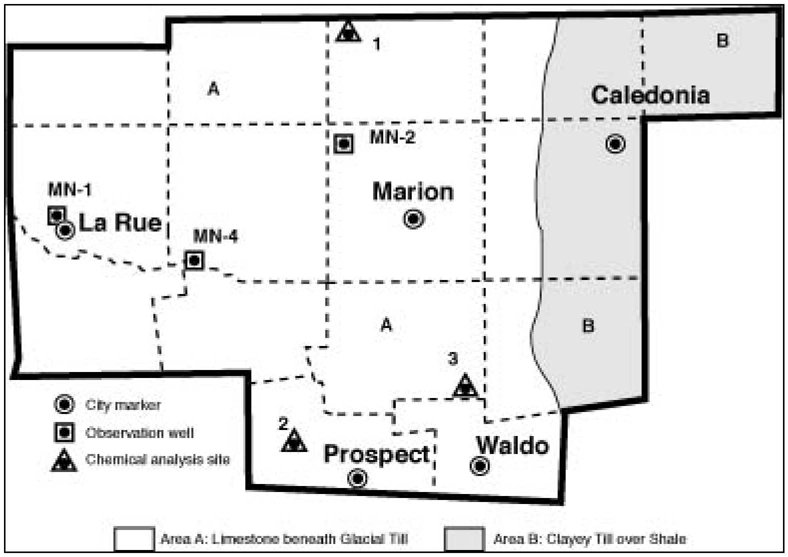


Figure A3.3: Aquifer types for Marion County (Breece et al., 1992).

Appendix B - Chapter 4

Watershed Resources Inventory for the Upper Olentangy River Watershed

Table B4.1: Percentages of land use by watershed (following figures display detailed breakdown of land use by subwatershed).

5060001	%
Open Water	0.78
Low Density Residential	1.82
High Density Residential	0.30
Commercial/Industrial/Transportation	0.74
Quarries/Strip Mines/Gravel Pits	0.00
Deciduous Forest	14.35
Evergreen Forest	0.16
Mixed Forest	0.03
Pasture/Hay	14.93
Row Crops	66.06
Urban/Recreational Grasses	0.34
Woody Wetlands	0.31
Emergent Herbaceous Wetlands	0.19

5060001090010	%
Open Water	0.49
Low Density Residential	4.65
High Density Residential	0.63
Commercial/Industrial/Transportation	1.18
Deciduous Forest	15.73
Evergreen Forest	0.28
Mixed Forest	0.04
Pasture/Hay	20.21
Row Crops	55.35
Urban/Recreational Grasses	0.93
Woody Wetlands	0.28
Emergent Herbaceous Wetlands	0.23

5060001090020	%
Open Water	0.03
Low Density Residential	0.70
High Density Residential	0.08
Commercial/Industrial/Transportation	0.07
Deciduous Forest	14.06
Evergreen Forest	0.03
Mixed Forest	0.01
Pasture/Hay	15.58
Row Crops	68.63
Woody Wetlands	0.47
Emergent Herbaceous Wetlands	0.36

5060001090030	%
Open Water	0.005
Deciduous Forest	5.281
Evergreen Forest	0.012
Mixed Forest	0.014
Pasture/Hay	7.597
Row Crops	86.67
Woody Wetlands	0.249
Emergent Herbaceous Wetlands	0.173

5060001090040	%
Open Water	0.154
Low Density Residential	0.248
High Density Residential	0.028
Commercial/Industrial/Transportation	0.075
Quarries/Strip Mines/Gravel Pits	0.03
Deciduous Forest	14.8
Evergreen Forest	0.153
Mixed Forest	0.012
Pasture/Hay	16.03
Row Crops	68.07
Woody Wetlands	0.295
Emergent Herbaceous Wetlands	0.105

5060001100010	%
Open Water	0.928
Low Density Residential	1.853
High Density Residential	0.214
Commercial/Industrial/Transportation	0.523
Deciduous Forest	23.29
Evergreen Forest	0.432
Mixed Forest	0.087
Pasture/Hay	21.62
Row Crops	50.74
Urban/Recreational Grasses	0.165
Woody Wetlands	0.072
Emergent Herbaceous Wetlands	0.078

5060001100020	%
Open Water	0.031
Low Density Residential	0.007
Commercial/Industrial/Transportation	0.056
Deciduous Forest	12.59
Evergreen Forest	0.09
Mixed Forest	0.013
Pasture/Hay	14.92
Row Crops	72.18
Woody Wetlands	0.083
Emergent Herbaceous Wetlands	0.031

5060001100030	%
Open Water	1.14
Low Density Residential	0.03
High Density Residential	0.01
Commercial/Industrial/Transportation	0.10
Deciduous Forest	14.57
Evergreen Forest	0.05
Mixed Forest	0.02
Pasture/Hay	11.75
Row Crops	71.81
Woody Wetlands	0.26
Emergent Herbaceous Wetlands	0.28

5060001110010	%
Open Water	0.04
Low Density Residential	0.07
High Density Residential	0.01
Commercial/Industrial/Transportation	0.03
Deciduous Forest	8.59
Evergreen Forest	0.06
Mixed Forest	0.02
Pasture/Hay	10.88
Row Crops	79.76
Woody Wetlands	0.34
Emergent Herbaceous Wetlands	0.19

5060001110020	%
Open Water	0.337
Low Density Residential	0.133
High Density Residential	0.002
Commercial/Industrial/Transportation	0.022
Deciduous Forest	12.75
Evergreen Forest	0.021
Mixed Forest	0.009
Pasture/Hay	14.44
Row Crops	70.83
Urban/Recreational Grasses	0.652
Woody Wetlands	0.512
Emergent Herbaceous Wetlands	0.285

5060001110020	%
Open Water	0.337
Low Density Residential	0.133
High Density Residential	0.002
Commercial/Industrial/Transportation	0.022
Deciduous Forest	12.75
Evergreen Forest	0.021
Mixed Forest	0.009
Pasture/Hay	14.44
Row Crops	70.83
Urban/Recreational Grasses	0.652
Woody Wetlands	0.512
Emergent Herbaceous Wetlands	0.285

5060001110030	%
Open Water	0.058
Low Density Residential	0.134
High Density Residential	0.019
Commercial/Industrial/Transportation	3.079
Deciduous Forest	5.122
Mixed Forest	0.005
Pasture/Hay	9.567
Row Crops	81.71
Urban/Recreational Grasses	0.013
Woody Wetlands	0.236
Emergent Herbaceous Wetlands	0.056

5060001110040	%
Open Water	0.469
Low Density Residential	6.692
High Density Residential	0.56
Commercial/Industrial/Transportation	3.982
Deciduous Forest	8.646
Evergreen Forest	0.025
Mixed Forest	0.002
Pasture/Hay	14.31
Row Crops	63.99
Urban/Recreational Grasses	0.638
Woody Wetlands	0.476
Emergent Herbaceous Wetlands	0.204

5060001110050	%
Open Water	3.97
Low Density Residential	0.668
High Density Residential	0.121
Commercial/Industrial/Transportation	0.324
Deciduous Forest	15.18
Evergreen Forest	0.204
Mixed Forest	0.037
Pasture/Hay	11.53
Row Crops	66.83
Urban/Recreational Grasses	0.335
Woody Wetlands	0.471
Emergent Herbaceous Wetlands	0.33

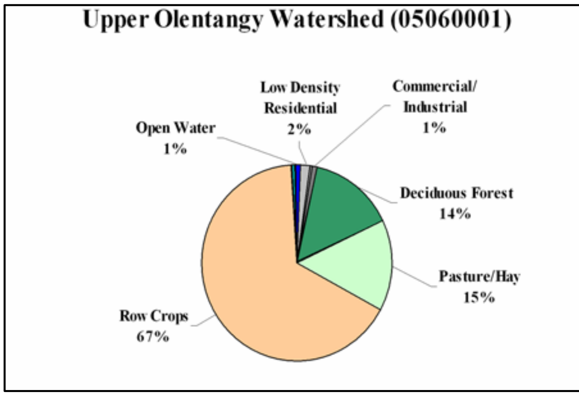
5060001110060	%
Open Water	0.066
Low Density Residential	5.454
High Density Residential	0.3
Commercial/Industrial/Transportation	2.082
Deciduous Forest	10.63
Evergreen Forest	0.051
Mixed Forest	0.003
Pasture/Hay	15.94
Row Crops	63.5
Urban/Recreational Grasses	1.57
Woody Wetlands	0.343
Emergent Herbaceous Wetlands	0.057

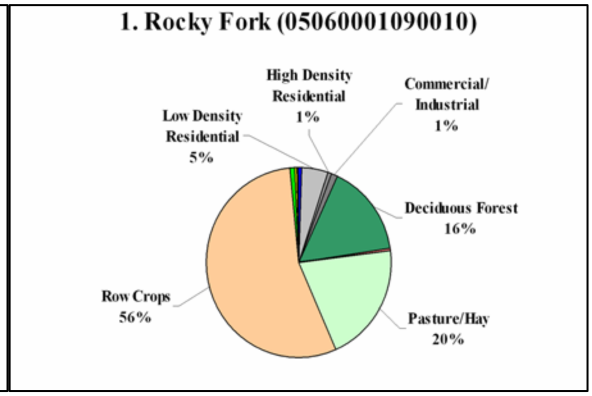
5060001110070	%
Open Water	0.163
Low Density Residential	0.011
Commercial/Industrial/Transportation	0.011
Deciduous Forest	11.47
Evergreen Forest	0.038
Mixed Forest	0.004
Pasture/Hay	8.706
Row Crops	78.9
Woody Wetlands	0.49
Emergent Herbaceous Wetlands	0.21

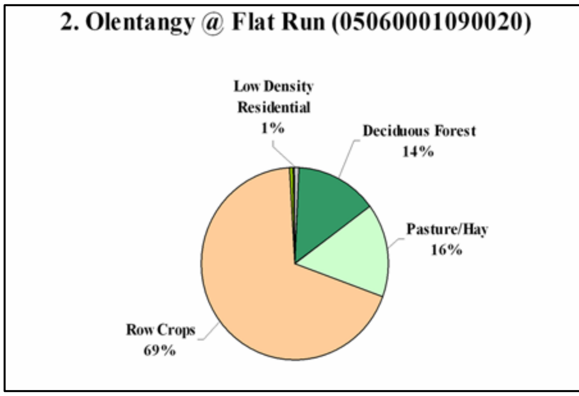
5060001110090	%
Open Water	0.873
Low Density Residential	5.458
High Density Residential	1.718
Commercial/Industrial/Transportation	1.45
Deciduous Forest	13.41
Evergreen Forest	0.121
Mixed Forest	0.015
Pasture/Hay	13.18
Row Crops	62.72
Urban/Recreational Grasses	0.648
Woody Wetlands	0.228
Emergent Herbaceous Wetlands	0.185

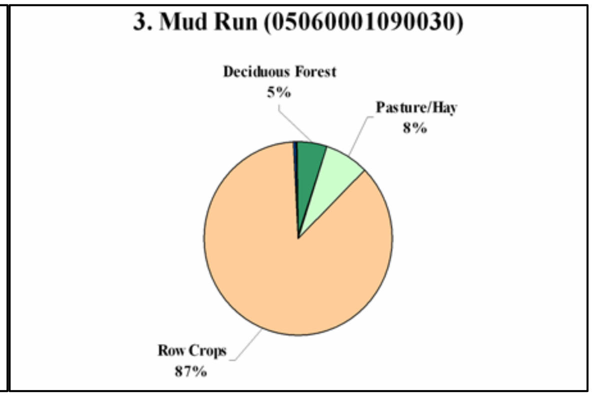
5060001110100	%
Open Water	0.10
Low Density Residential	0.55
High Density Residential	0.11
Commercial/Industrial/Transportation	0.22
Deciduous Forest	11.16
Evergreen Forest	0.19
Mixed Forest	0.02
Pasture/Hay	13.69
Row Crops	73.12
Urban/Recreational Grasses	0.01
Woody Wetlands	0.62
Emergent Herbaceous Wetlands	0.20

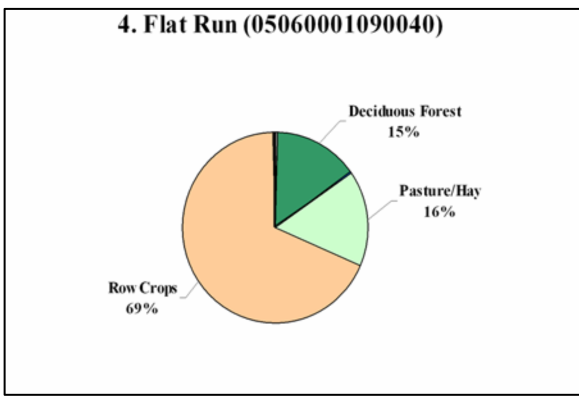
5060001110110	%
Open Water	0.38
Low Density Residential	7.751
High Density Residential	2.415
Commercial/Industrial/Transportation	3.477
Deciduous Forest	12.62
Evergreen Forest	0.233
Mixed Forest	0.017
Pasture/Hay	14.27
Row Crops	56.4
Urban/Recreational Grasses	1.796
Woody Wetlands	0.5
Emergent Herbaceous Wetlands	0.144

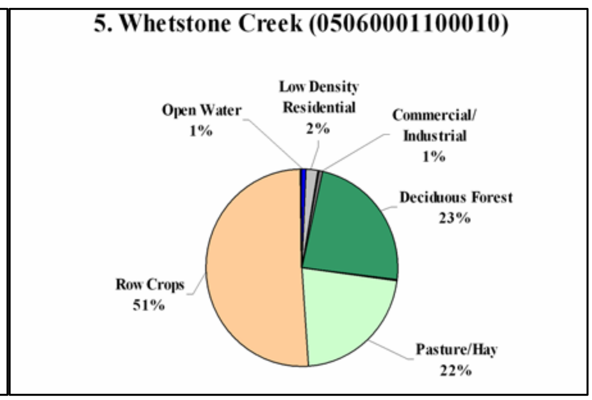

Upper Olentangy Watershed (05060001)
Open Water 1%
Low Density Residential 2%
Commercial/ Industrial 1%
Deciduous Forest 14%
Pasture/Hay 15%
Row Crops 67%

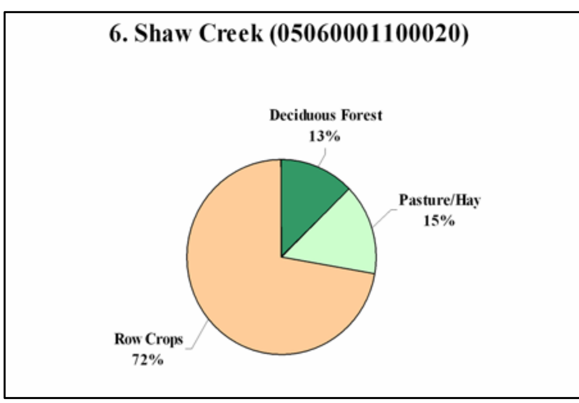

1. Rocky Fork (05060001090010)
High Density Residential 1%
Low Density Residential 5%
Commercial/ Industrial 1%
Deciduous Forest 16%
Pasture/Hay 20%
Row Crops 56%

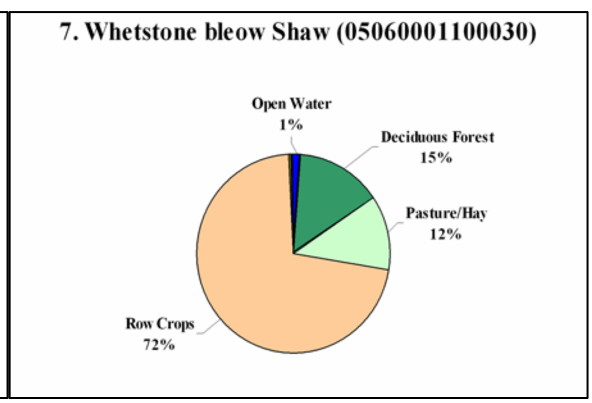

2. Olentangy @ Flat Run (05060001090020)
Low Density Residential 1%
Deciduous Forest 14%
Pasture/Hay 16%
Row Crops 69%

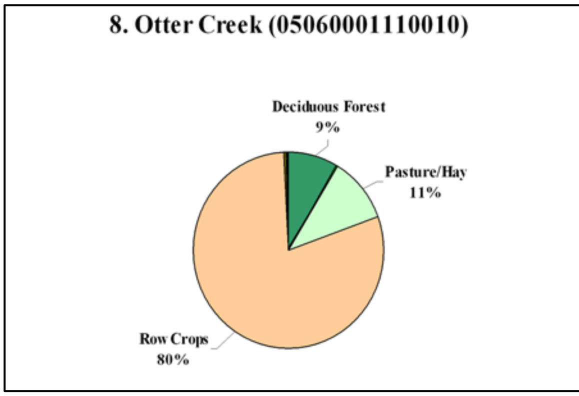

3. Mud Run (05060001090030)
Deciduous Forest 5%
Pasture/Hay 8%
Row Crops 87%

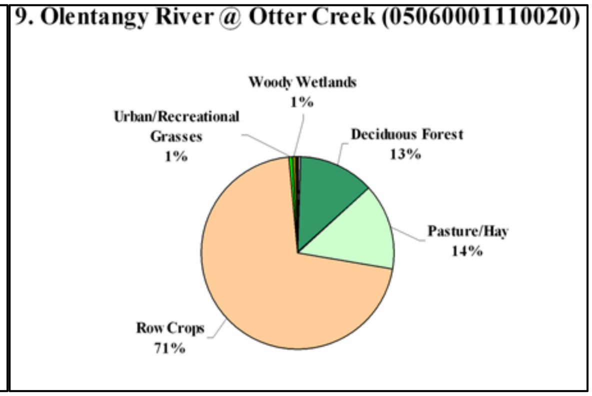

4. Flat Run (05060001090040)
Deciduous Forest 15%
Pasture/Hay 16%
Row Crops 69%

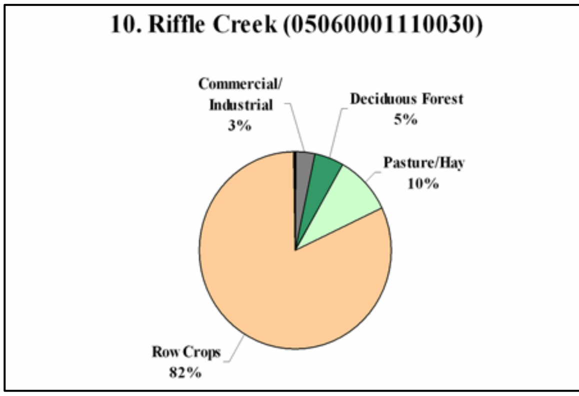

5. Whetstone Creek (05060001100010)
Open Water 1%
Low Density Residential 2%
Commercial/ Industrial 1%
Deciduous Forest 23%
Pasture/Hay 22%
Row Crops 51%

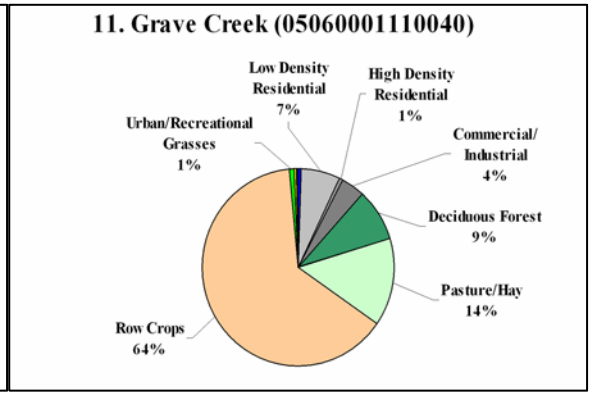

6. Shaw Creek (05060001100020)
Deciduous Forest 13%
Pasture/Hay 15%
Row Crops 72%

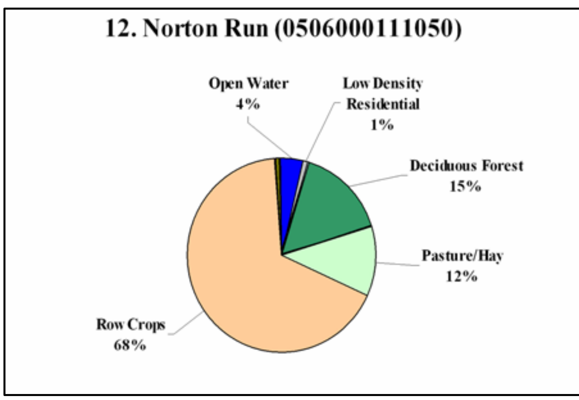

7. Whetstone bleow Shaw (05060001100030)
Open Water 1%
Deciduous Forest 15%
Pasture/Hay 12%
Row Crops 72%

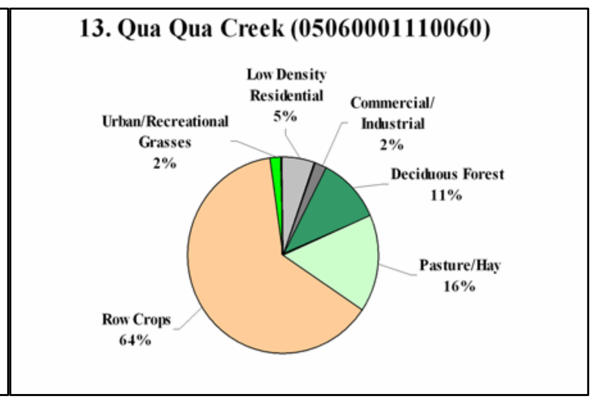

8. Otter Creek (05060001110010)
Deciduous Forest 9%
Pasture/Hay 11%
Row Crops 80%

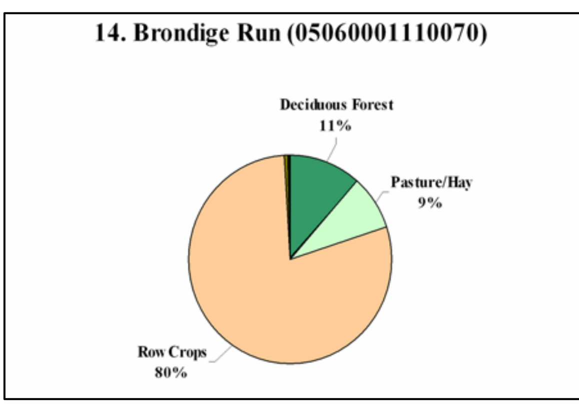

9. Olentangy River @ Otter Creek (05060001110020)
Woody Wetlands 1%
Urban/Recreational Grasses 1%
Deciduous Forest 13%
Pasture/Hay 14%
Row Crops 71%

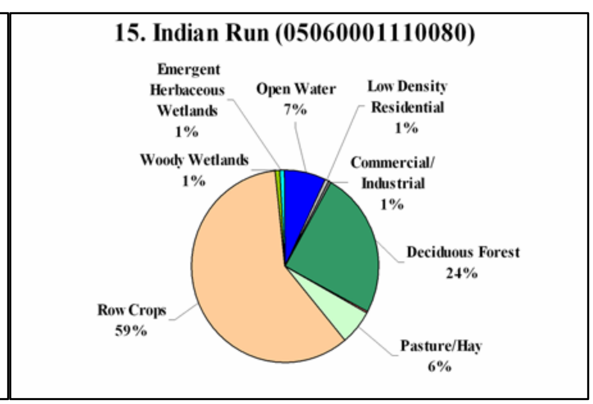

10. Riffle Creek (05060001110030)
Commercial/ Industrial 3%
Deciduous Forest 5%
Pasture/Hay 10%
Row Crops 82%

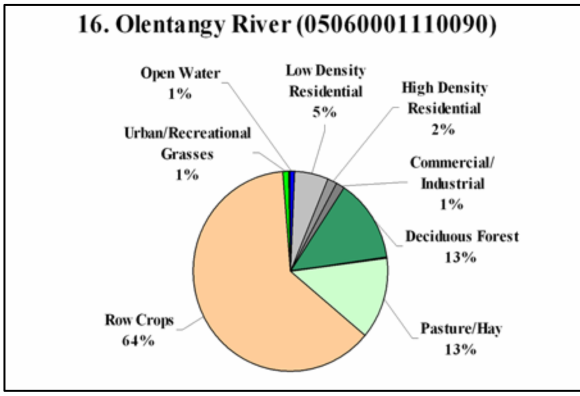

11. Grave Creek (05060001110040)
Low Density Residential 7%
High Density Residential 1%
Urban/Recreational Grasses 1%
Commercial/ Industrial 4%
Deciduous Forest 9%
Pasture/Hay 14%
Row Crops 64%

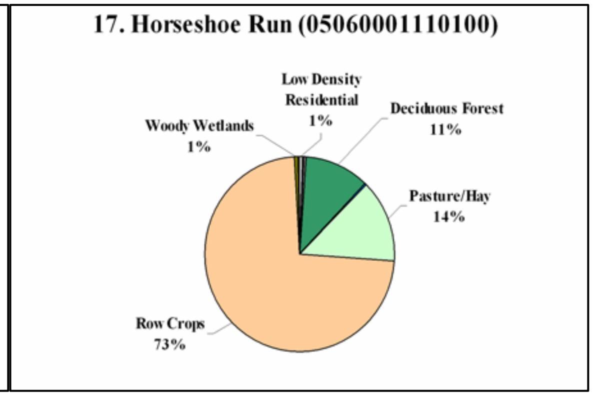

12. Norton Run (0506000111050)
Open Water 4%
Low Density Residential 1%
Deciduous Forest 15%
Pasture/Hay 12%
Row Crops 68%


13. Qua Qua Creek (05060001110060)
Low Density Residential 5%
Commercial/ Industrial 2%
Urban/Recreational Grasses 2%
Deciduous Forest 11%
Pasture/Hay 16%
Row Crops 64%


14. Brondige Run (05060001110070)
Deciduous Forest 11%
Pasture/Hay 9%
Row Crops 80%


15. Indian Run (05060001110080)
Emergent Herbaceous Wetlands 1%
Open Water 7%
Low Density Residential 1%
Woody Wetlands 1%
Commercial/ Industrial 1%
Deciduous Forest 24%
Row Crops 59%
Pasture/Hay 6%





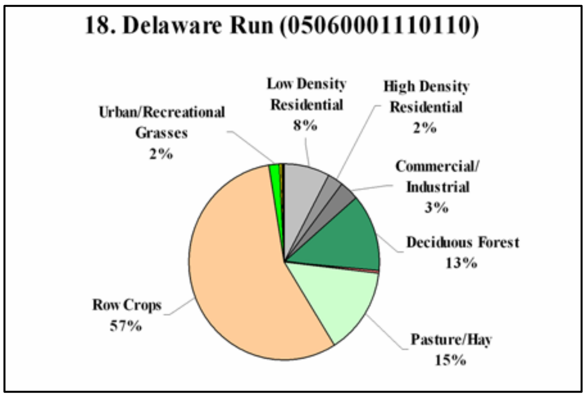


Figure B4.1: Land use percentages by subwatershed in the Upper Olentangy Watershed (1994 Land Use from National Land Use Classification Dataset).

Table B4.2: Crop types on agricultural landing the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Corn/Soybeans/Wheat/Hay/CRP %
Rocky Fork	05060001090010	40/43/12/4/1
Olentangy River @ Flat Run	05060001090020	30/55/10/5
Mud Run	05060001090030	30/55/10/5
Flat Run	05060001090040	30/55/10/5
Whetstone Creek	05060001100010	40/40/15/5/0
Shaw Creek	05060001100020	40/43/15/2/0
Whetstone Creek below Shaw Creek	05060001100030	41/46/10/3/0
Otter Creek	05060001110010	55/25/5/15
Olentangy River @ Otter Creek	05060001110020	55/30/10/5
Riffle Creek	05060001110030	60/25/10/5
Grave Creek	05060001110040	65/25/5/5
Norton Run	05060001110050	60/30/10
Qua Qua Creek	05060001110060	60/30/10
Brondige Run	05060001110070	50/35/10/5
Olentangy River below	05060001110080	45/40/10/5/0

Whetstone Creek		
Indian Run	05060001110090	40/40/10/10/0
Horseshoe Run	05060001110100	45/40/10/5/0
Delaware Run	05060001110110	45/40/10/5/0

Table B4.3: Tillage types on agricultural land in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Tillage Type
Rocky Fork	05060001090010	Conventional-42%; Reduced-29%; No-till 29%
Olentangy River @ Flat Run	05060001090020	Corn-conventional; Soybeans/wheat-No-till
Mud Run	05060001090030	Conventional-20%; Reduced-50%; No-till 30%
Flat Run	05060001090040	Conventional-20%; Reduced-50%; No-till 30%
Whetstone Creek	05060001100010	Conventional-60%; No-till-40%
Shaw Creek	05060001100020	Conventional-65%; No-till-35%
Whetstone Creek below Shaw Creek	05060001100030	Conventional-20%; Reduced-50%; No-till 30%
Otter Creek	05060001110010	Conventional-20%; Reduced-50%; No-till 30%
Olentangy River @ Otter Creek	05060001110020	Conventional-20%; Reduced-50%; No-till 30%
Riffle Creek	05060001110030	Conventional-20%; Reduced-45%; No-till 35%
Grave Creek	05060001110040	Conventional-20%; Reduced-45%; No-till 35%
Norton Run	05060001110050	Conventional-20%; Reduced-50%; No-till 30%
Qua Qua Creek	05060001110060	Conventional-20%; Reduced-50%; No-till 30%
Brondige Run	05060001110070	Conventional-15%; Reduced-55%; No-till 30%
Olentangy River below Whetstone Creek	05060001110080	Corn-conventional; Soybeans/wheat-No-till
Indian Run	05060001110090	Corn-conventional; Soybeans/wheat-No-till
Horseshoe Run	05060001110100	Corn-conventional; Soybeans/wheat-No-till
Delaware Run	05060001110110	Corn-conventional; Soybeans/wheat-No-till

Table B4.4: Summary of animal feeding operations in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Type	# of animals
Rocky Fork	05060001090010	Swine Horses Cattle Sheep	2500 50 160 100
Olentangy River @ Flat Run	05060001090020	Unknown	Unknown
Mud Run	05060001090030	Unknown	Unknown
Flat Run	05060001090040	Unknown	Unknown
Whetstone Creek	05060001100010	Swine Horses Cattle Sheep Chickens	1500 100 1450 50 12000
Shaw Creek	05060001100020	Swine Horses Cattle	2500 40 450
Whetstone Creek below Shaw Creek	05060001100030	Horses	Few
Otter Creek	05060001110010	Cattle	<200
Olentangy River @ Otter Creek	05060001110020	Horses Cattle Sheep	<100 <100 <100
Riffle Creek	05060001110030	Dairy	200
Grave Creek	05060001110040	Unknown	Unknown
Norton Run	05060001110050	Dairy Hogs	1000 2000
Qua Qua Creek	05060001110060	Dairy Hogs	1000 2000
Brondige Run	05060001110070	Horses Cattle Sheep	<100 <100 <100
Olentangy River below Whetstone Creek	05060001110080	Horses	Few
Indian Run	05060001110090	Dairy Cattle Horses	100 50 Few
Horseshoe Run	05060001110100	Cattle Horses	50 Few
Delaware Run	05060001110110	Cattle Horses	200 Few

Table B4.5: Grazing acreage estimates for the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	# of acres
Rocky Fork	05060001090010	70
Olentangy River @ Flat Run	05060001090020	120
Mud Run	05060001090030	100
Flat Run	05060001090040	60
Whetstone Creek	05060001100010	1000
Shaw Creek	05060001100020	150
Whetstone Creek below Shaw Creek	05060001100030	_
Otter Creek	05060001110010	100
Olentangy River @ Otter Creek	05060001110020	30
Riffle Creek	05060001110030	70
Grave Creek	05060001110040	20
Norton Run	05060001110050	-
Qua Qua Creek	05060001110060	-
Brondige Run	05060001110070	-
Olentangy River below Whetstone Creek	05060001110080	<100
Indian Run	05060001110090	-
Horseshoe Run	05060001110100	<100
Delaware Run	05060001110110	-

Table B4.6: Summary of septic systems in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Number of systems	Percent failing
Rocky Fork	05060001090010	865	12
Olentangy River @ Flat Run	05060001090020	*	*
Mud Run	05060001090030	*	*
Flat Run	05060001090040	*	*
Whetstone Creek	05060001100010	2000	15
Shaw Creek	05060001100020	310	25
Whetstone Creek below Shaw Creek	05060001100030	430	20
Otter Creek	05060001110010	*	*
Olentangy River @ Otter Creek	05060001110020	*	*
Riffle Creek	05060001110030	*	*
Grave Creek	05060001110040	*	*
Norton Run	05060001110050	*	*
Qua Qua Creek	05060001110060	*	*
Brondige Run	05060001110070	*	*
Olentangy River below Whetstone Creek	05060001110080	100	30
Indian Run	05060001110090	250	25
Horseshoe Run	05060001110100	100	25
Delaware Run	05060001110110	200	20

*Have not received Marion estimates.

Watershed Resources Inventory for the Upper Olentangy River Watershed

Appendix C - Chapter 6

Table C6.1: Id number, name, hazard potential, river, purpose, year built and height for dams in the Upper Olentangy Watershed.

ID #	Dam Name	Hazard Potential	River	Purpose	Year Built	Height (ft)
0	Delaware Dam	High	Olentangy River	Flood Control	1948	92
1	Powers Upground Reservoir	High	Offstream	Water Supply	1954	32
2	Amicks Upground Reservoir	High	Offstream	Water Supply	1968	49
3	Amann Reservoir Dam	Low	Rocky Fork	Water Supply	1904	32
4	Candlewood Lake Dam	High	Whetstone Creek	Recreation	1974	70
5	Mount Gilead Lower Lake Dam	High	Sams Creek	Recreation	1930	20
6	Harding Area Council Bsa Dam	Low	Tr-Whetstone Creek	Recreation	1973	39
7	Strait's Lake Dam	Significant	Tr-Sams Creek	Recreation	1965	24
8	Camp Greenwood Lake Dam	Significant	Sugar Run	Recreation	1875	34
9	Gleason Kamp Pond Dam	Low	Tr-Horseshoe Run	Recreation	1964	25
10	Dogwood Valley Camp Lake Dam	Low	Tr-Whetstone Creek	Recreation	1956	26
11	Mount Gilead Upper Lake Dam	Low	Sams Creek	Recreation	1930	15
12	Homestead Neighbors Lake Dam	Significant	Tr-Delaware Run	Recreation	1949	16
13	Laurel Lake Dam	Significant	Tr-Sams Creek	Recreation	1955	20
14	Jury Lake Dam	Significant	Tr-Whetstone Creek	Recreation	1972	28
15	Lexington Glen Dam	High	Delaware Run	Recreation	1990	32

Watershed Resources Inventory for the Upper Olentangy River Watershed

Appendix D - Chapter 7

Table D7.1: Facilities regulated by the National Pollutant Discharge Elimination System in the Upper Olentangy River watershed (*Source Ohio EPA/DSW/EAS, 2003)*.

Facility Name	Ohio EPA Permit Number	Receiving Stream	River Mile	Description
Swiss Village MHP	2PR00099-001	Unnamed Trib., Olentangy River	90.04	sanitary sewage treated by package plant
Galion WWTP	2PD00030-001	Olentangy River	86	sanitary sewage treated by activated sludge system
Spring Valley MHP	2PY00023-001	Unnamed Trib., Olentangy River	81.18	sanitary sewage treated by package plant
Marathon Ash-land Pipeline	2IG00028-001	Unnamed Trib., Olentangy River	65.6	storm water and hydrostatic test water
Pillsbury Co.	2IH00106-001	Shumaker Ditch, Olentangy River	1.92 63.89	sanitary sewage treated by package plant
Caledonia WWTP	2PA00035-001	Olentangy River	59.7	sanitary sewage treated by package plant
GlenGery Brick	2IJ00074-001	Flat Run, Olentangy River	7.9 59.28	process, storm and ground waters treated by series of settling ponds
GlenGery Brick	2IJ00074-002	Flat Run	8.24	sanitary sewage treated by package plant
United Mobile Homes	2PY00015-001	Unnamed Trib., Olentangy River	57.8	sanitary sewage treated by package plant
Marion County Sewer Dist. 7	2PJ00002-001	Grave Creek, Olentangy River	3.16 45.35	sanitary sewage treated by activated sludge system
Blue Willow MHP	2PR00039-001	Ulsh Ditch Riffle Creek Grave Creek	4.15 4.50 0.21	sanitary sewage treated by package plant
Verizon North	2PR00115-001	Ulsh Ditch	4.05	sanitary sewage treated by package plant
Marion County Sewer Dist. 5A	2PG00035-001	QuQua Creek, Olentangy River	5.50 41.32	sanitary sewage treated by package plant
Waldo Duchess Store	2PR00062-001	Unnamed Trib., Olentangy River	40.4	sanitary sewage treated by package plant
Ashland Pipeline Co.	4IN00029	UT to Shaw Creek	0.38 10.37	dike containment water, hydrostatic test water
Candlewood Lake WWTP[a]	4PU00005	Whetstone Creek	30.49	sanitary wastewater, 15,000 gpd lagoon
Village of Cardington WWTP	4PA00100	Whetstone Creek	13.70	sanitary wastewater, 0.5 mgd design flow
Village of Edison WWTP	4PA00000	Whetstone Creek	18.80	sanitary wastewater, 70,000 gpd controlled discharge lagoons

Facility Name	Ohio EPA Permit Number	Receiving Stream	River Mile	Description
Village of Mt. Gilead WWTP[b]	4PB00102	Whetstone Creek	21.70	sanitary wastewater, 0.47 mgd design flow
Northmoor Local Schools	4PT00110	UT to Whetstone Creek	1.50 33.80	sanitary wastewater, 7,500 gpd package plant
Specialty Fertilizer Products	4IF00100	UT to Thorn Run	1.20 8.85	sanitary wastewater, 2,000 gpd package plant storm water outfalls
Iberia Elementary School	4GS00004	UT to Flat Run	8.55	sanitary wastewater, 5,000 gpd package plant
USDA Forest Experiment Station	4PN00001	UT to Olentangy River	32.12	sanitary wastewater, 12,000 gpd package plant
Crystal Lake MHP	4PV00010	Horseshoe Run	1.85	sanitary wastewater, 24,000 gpd package plant
Buckeye Valley School	4PT00107	UT to Olentangy River	2.35 28.80	sanitary wastewater, 35,000 gpd package plant
Delaware WTP	4IW00050	Olentangy River	32.30	Lime sludge lagoon discharge, sanitary wastewater package plant
Chef Is In Inc.	4PX00001	UT to Olentangy River	RM*	sanitary wastewater, 3,500 gpd package plant
Delaware MHP	4PV00106	Olentangy River	29.00	sanitary wastewater, 10,000 gpd package plant
Shroyers MHP	4PV00095	Olentangy River	28.50	Sanitary wastewater, 20,000 gpd package plant
BP Oil Co.	4IN00168	Olentangy River via storm sewer	RM*	dike containment water
Wilamette Industries	4IN00031	Olentangy River via storm sewer	RM*	non-contact cooling water
Delaware WWTP[c]	4PD00004	Olentangy River	25.26	sanitary wastewater, 5.5 mgd design flow

a - Facility is currently upgrading plant to 300,000 gpd
b- Proposed upgrade to 820,000 gpd
c - Proposed upgrade to 10.0 mgd
*-River Mile location currently unavailable

Table D7.2: Summary of Fish Kills in the Upper Olentangy Watershed (OEC, 2002)

Stream/Tributary	Date	County	# of Fish Killed	Type of Operation
Zimmerman Ditch	8/25/1997	Crawford	2670	Residential Home
Mud Run	6/28/1997	Crawford	unknown	Government
Mud Run	8/19/1999	Crawford	1200	Government
Mud Run	11/13/2001	Crawford	8	Agricultural
Olentangy River	9/26/1997	Crawford	unknown	Agricultural
Olentangy River	6/29/199	Crawford	6	Unknown
Turkey Run	9/28/2000	Morrow	6	Agricultural
Shaw Creek	4/2/2001	Morrow	31,964	Agricultural
Turkey Run	7/31/2001	Morrow	3	Natural Kill
Trib. Whetstone Creek	11/3/2003	Morrow	unknown	Agricultural

Table D7.3: Summary of new home building in the Upper Olentangy Watershed.

Subwatershed	14-digit HUC	Number of homes	Comment
Rocky Fork	05060001090010	8	
Olentangy River @ Flat Run	05060001090020	*	Unknown
Mud Run	05060001090030	*	Unknown
Flat Run	05060001090040	*	Unknown
Whetstone Creek	05060001100010	37	
Shaw Creek	05060001100020	15	
Whetstone Creek below Shaw Creek	05060001100030	14	
Otter Creek	05060001110010	8	
Olentangy River @ Otter Creek	05060001110020	5	
Riffle Creek	05060001110030	10	5 acre lots around SR229
Grave Creek	05060001110040	5	Comm. & Res.
Norton Run	05060001110050	8	Weiser Rd. 5-10 acre lots
Qua Qua Creek	05060001110060	10	Commercial Dev.
Brondige Run	05060001110070	15	Subdivisions
Olentangy River below Whetstone Creek	05060001110080	2	Few 5 acre lots
Indian Run	05060001110090	10	350-500 acres over next 5 years
Horseshoe Run	05060001110100	5	Rural 5 acre lots
Delaware Run	05060001110110	NA	150-200 acres over next 5 years

Table D7.4: Summary of animal feeding operations in the Upper Olentangy Watershed.

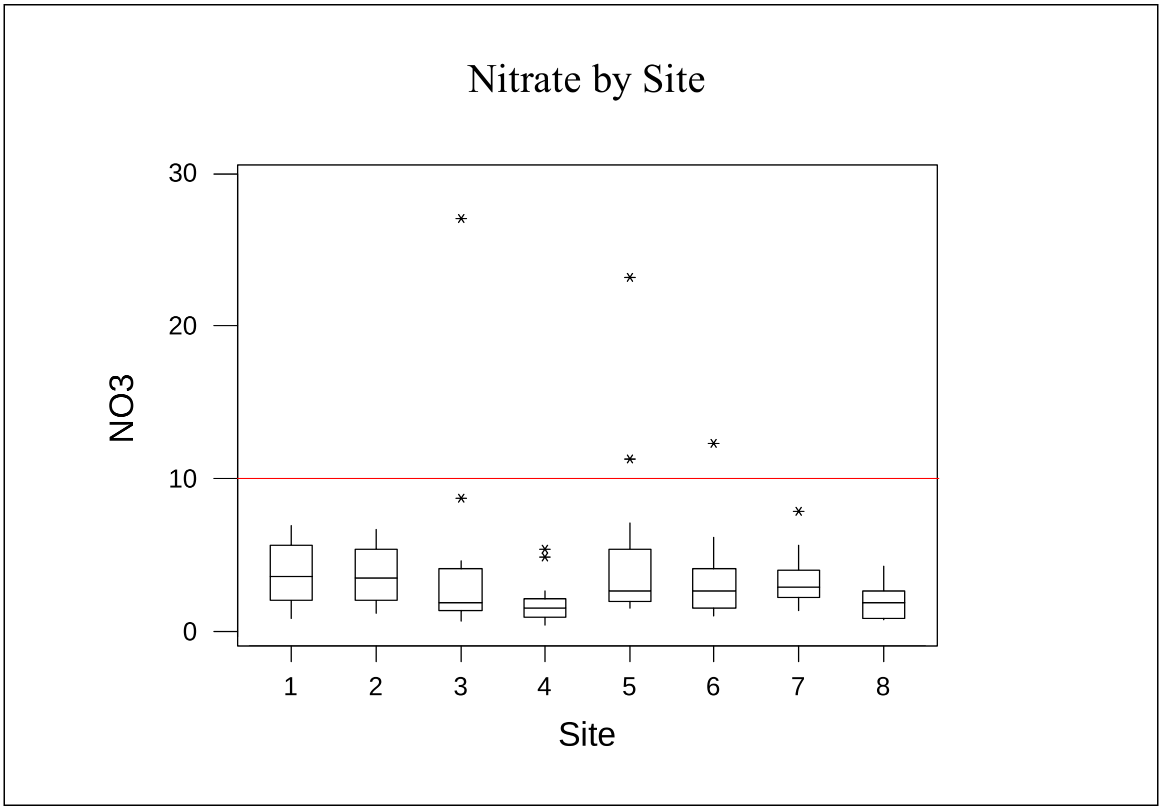
Subwatershed	14-digit HUC	Type	# of animals
Rocky Fork	05060001090010	Swine Horses Cattle Sheep	2500 50 160 100
Olentangy River @ Flat Run	05060001090020	Unknown	Unknown
Mud Run	05060001090030	Unknown	Unknown
Flat Run	05060001090040	Unknown	Unknown
Whetstone Creek	05060001100010	Swine Horses Cattle Sheep Chickens	1500 100 1450 50 12000
Shaw Creek	05060001100020	Swine Horses Cattle	2500 40 450
Whetstone Creek below Shaw Creek	05060001100030	Horses	Few
Otter Creek	05060001110010	Cattle	<200
Olentangy River @ Otter Creek	05060001110020	Horses Cattle Sheep	<100 <100 <100
Riffle Creek	05060001110030	Dairy	200
Grave Creek	05060001110040	Unknown	Unknown
Norton Run	05060001110050	Dairy Hogs	1000 2000
Qua Qua Creek	05060001110060	Dairy Hogs	1000 2000
Brondige Run	05060001110070	Horses Cattle Sheep	<100 <100 <100
Olentangy River below Whetstone Creek	05060001110080	Horses	Few
Indian Run	05060001110090	Dairy Cattle Horses	100 50 Few
Horseshoe Run	05060001110100	Cattle Horses	50 Few
Delaware Run	05060001110110	Cattle Horses	200 Few

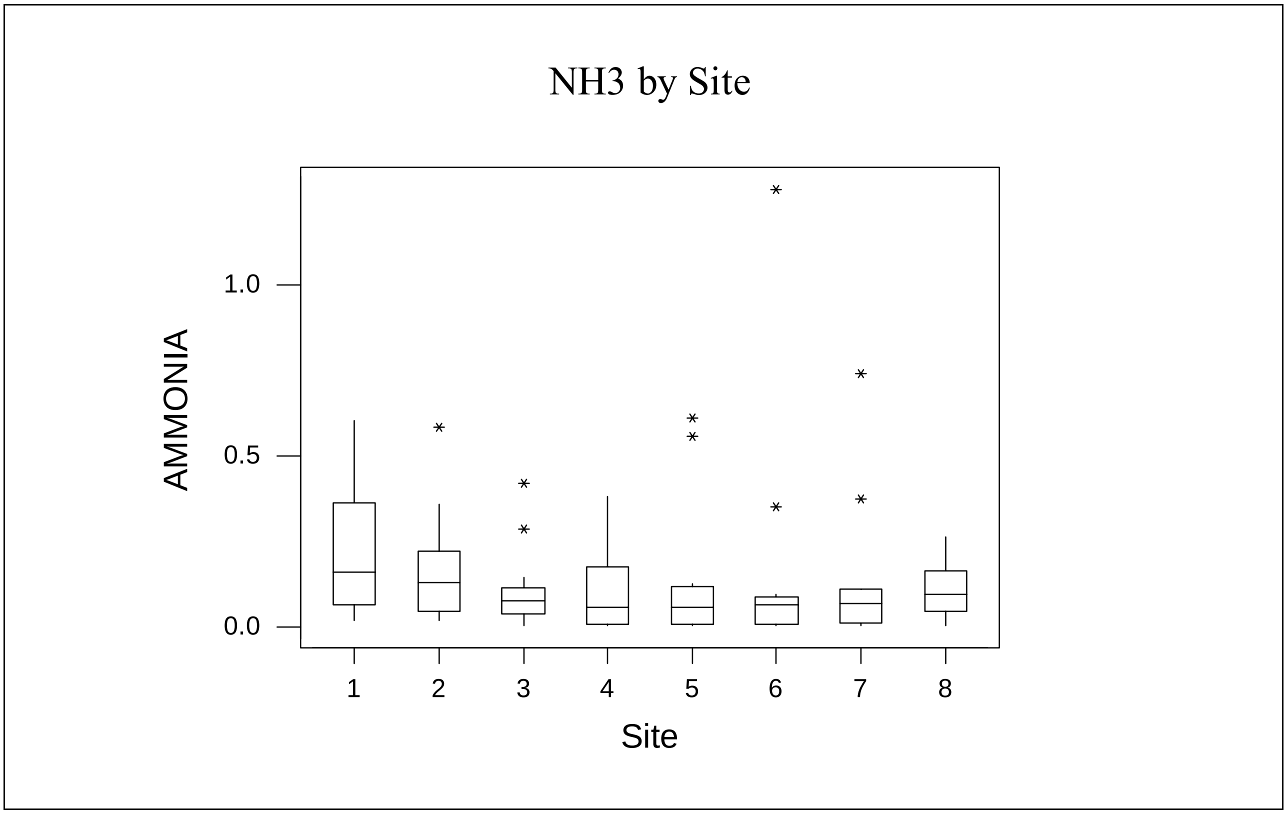
Table D7.5: Bridge crossings and culverts by subwatershed in the Upper Olentangy Watershed.

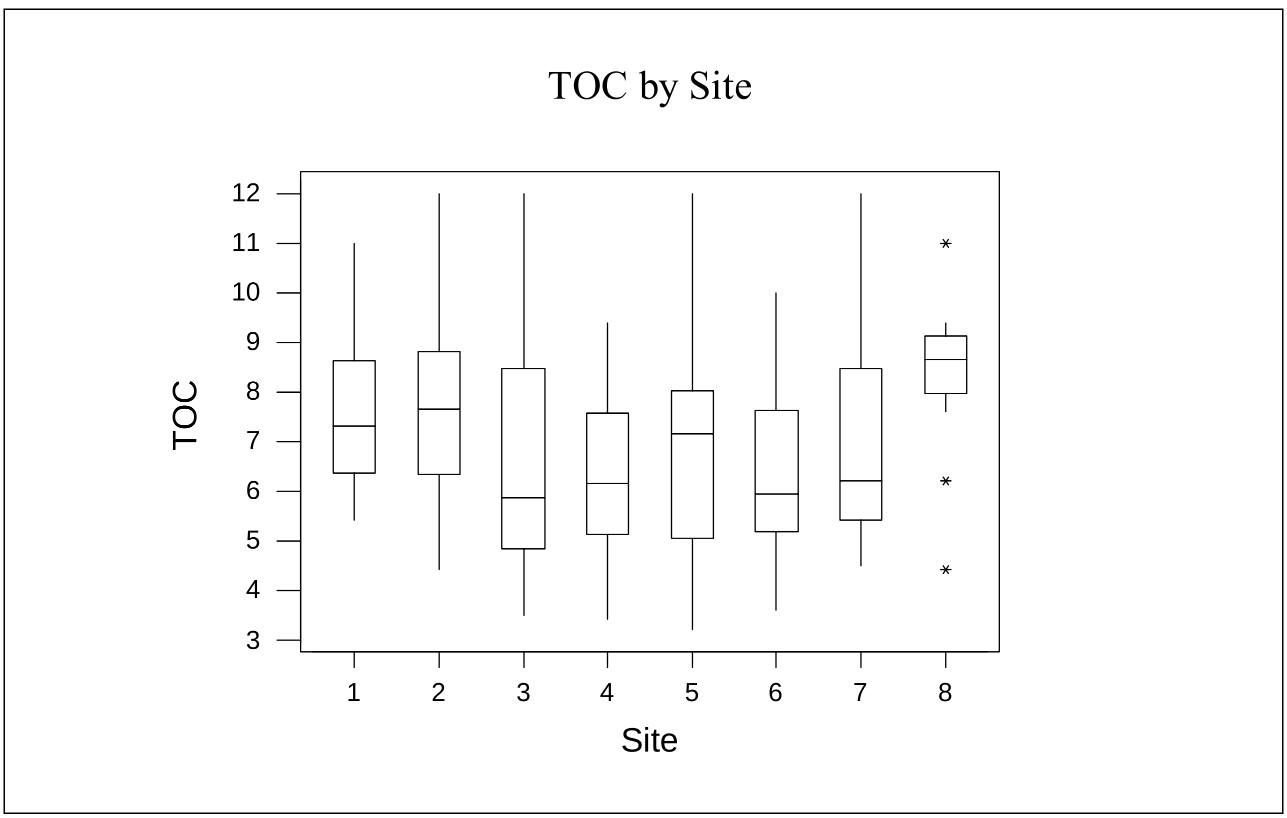
Bridge Crossings	
Watershed	
05060001090010	101
05060001090020	38
05060001090030	18
05060001090040	81
05060001100010	123
05060001100020	55
05060001100030	33
05060001110010	29
05060001110020	42
05060001110030	24
05060001110040	15
05060001110050	16
05060001110060	19
05060001110070	16
05060001110080	9
05060001110090	24
05060001110100	12
05060001110110	14
Grand Total	669

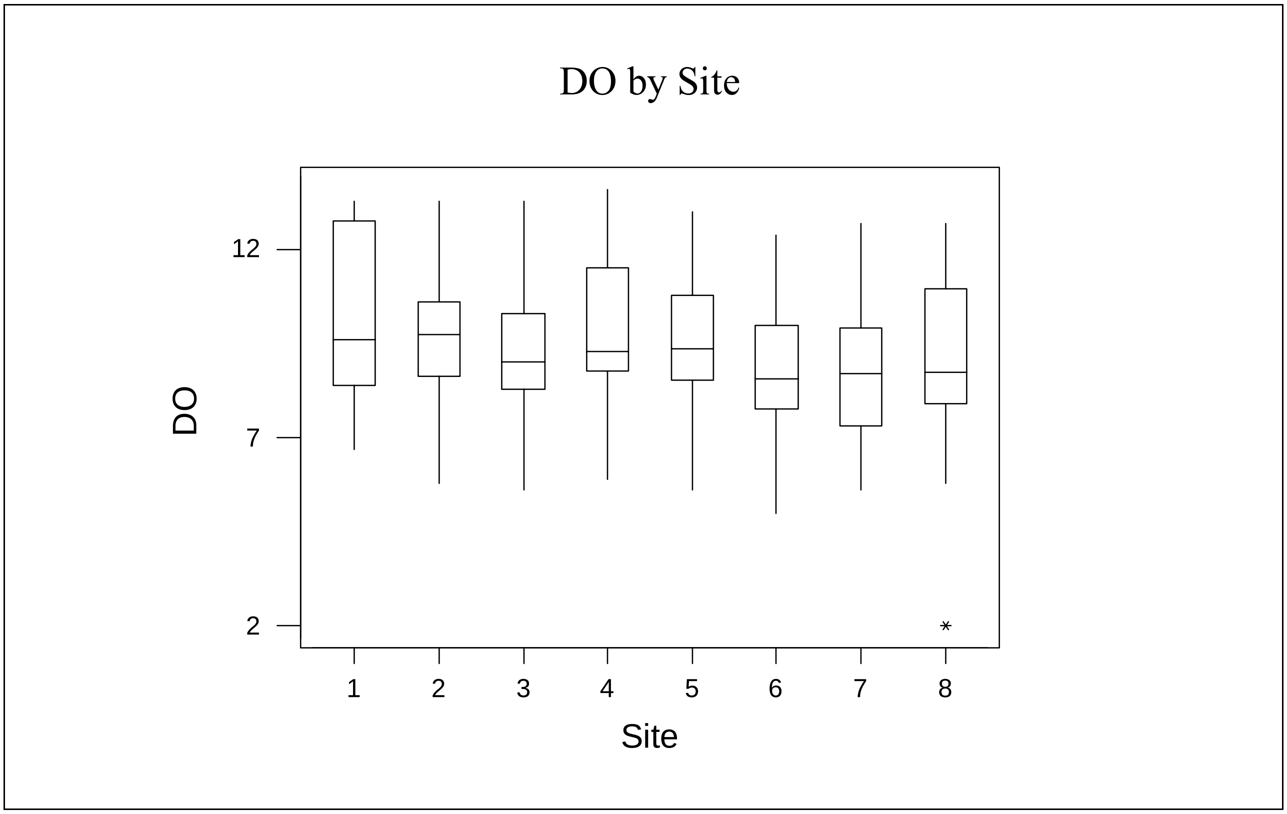
Watershed Resources Inventory for the Upper Olentangy River Watershed

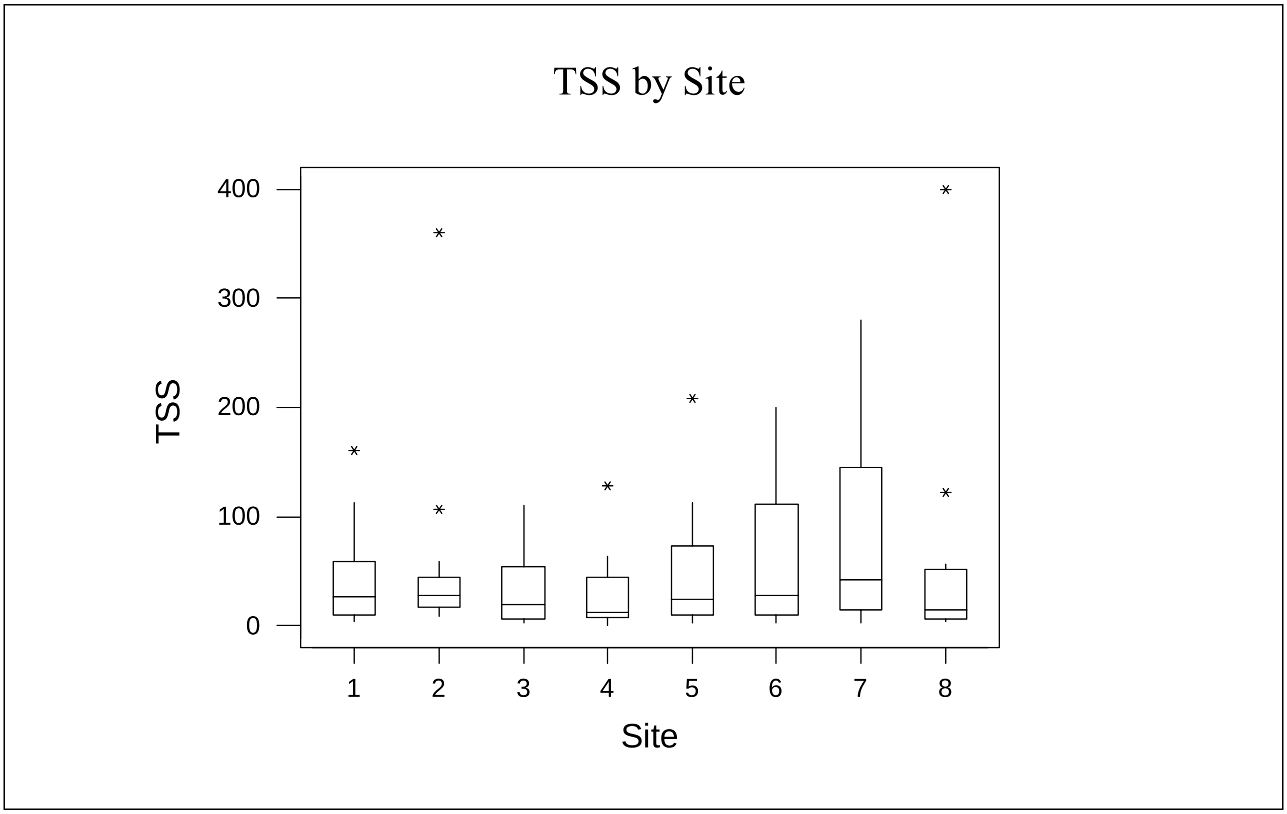
Appendix E - Chapter 8

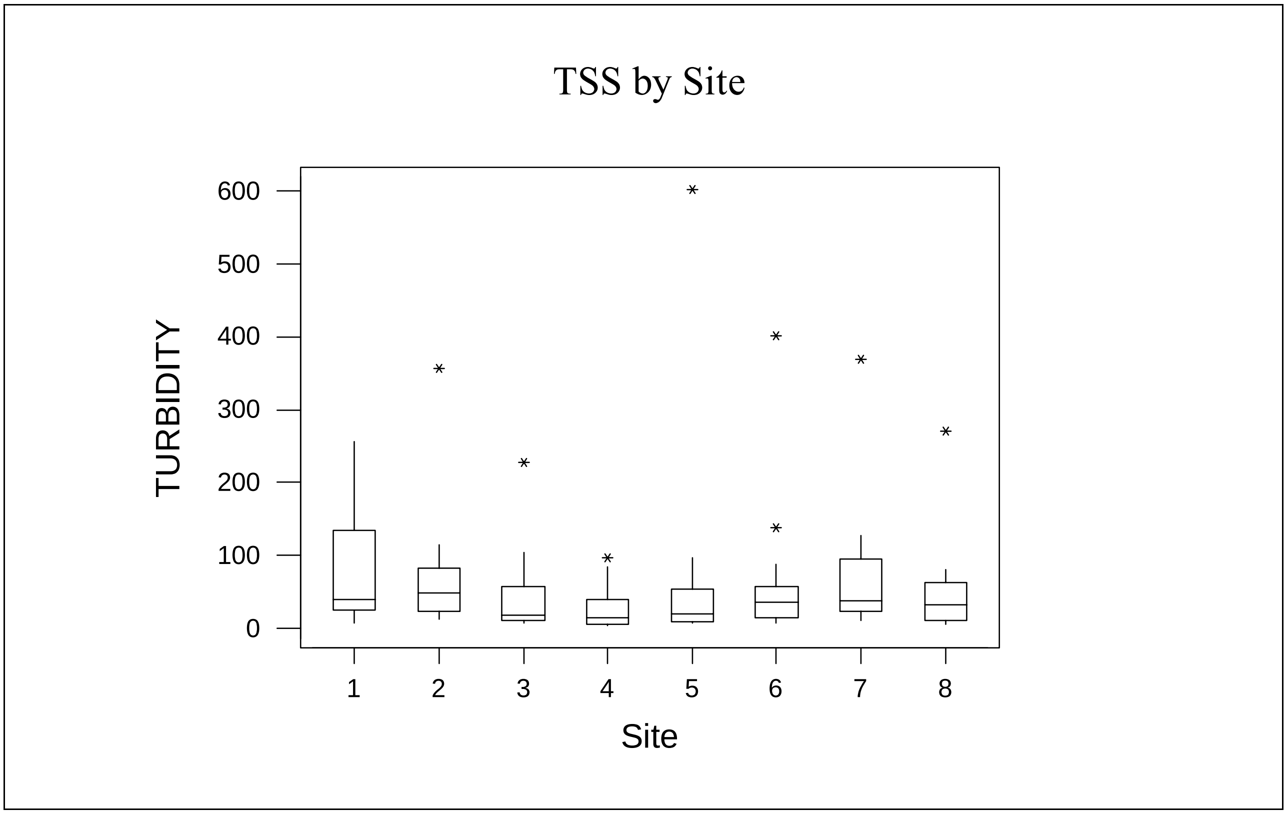


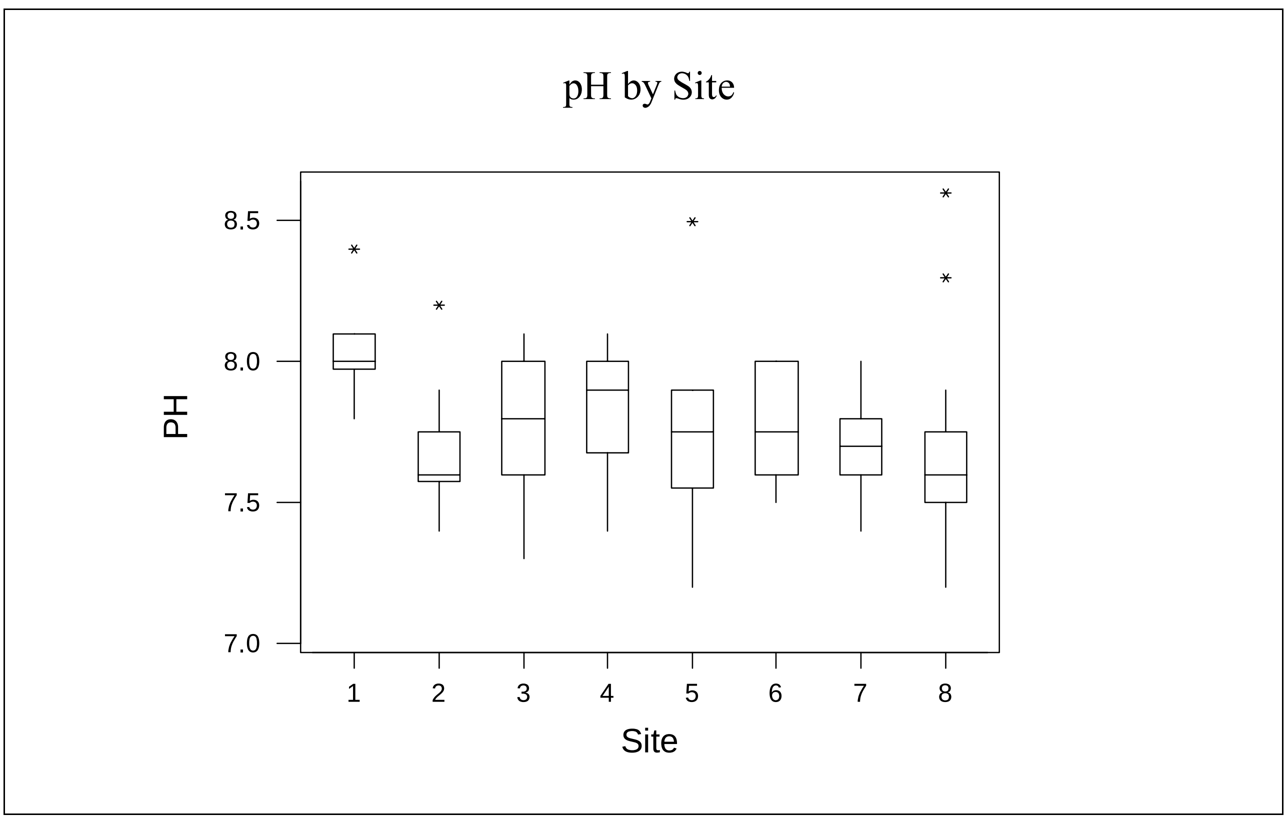

NH3 by Site
AMMONIA
1.0
0.5
0.0
1
2
3
4
5
6
7
8
Site


TOC by Site
TOC
12
11
10
9
8
7
6
5
4
3
1
2
3
4
5
6
7
8
Site

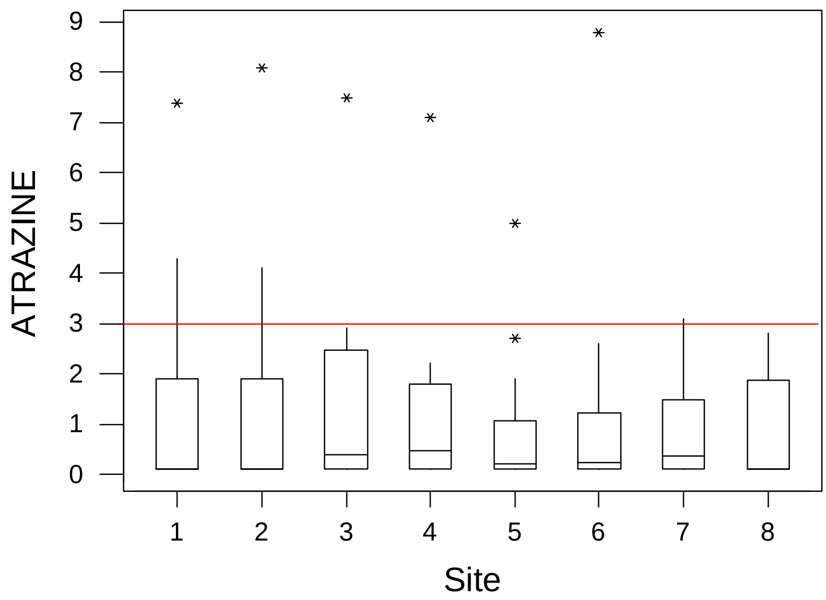

DO by Site
DO
12
7
2
1
2
3
4
5
6
7
8
Site


TSS by Site
TSS
400
300
200
100
0
1
2
3
4
5
6
7
8
Site


TSS by Site
TURBIDITY
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
Site

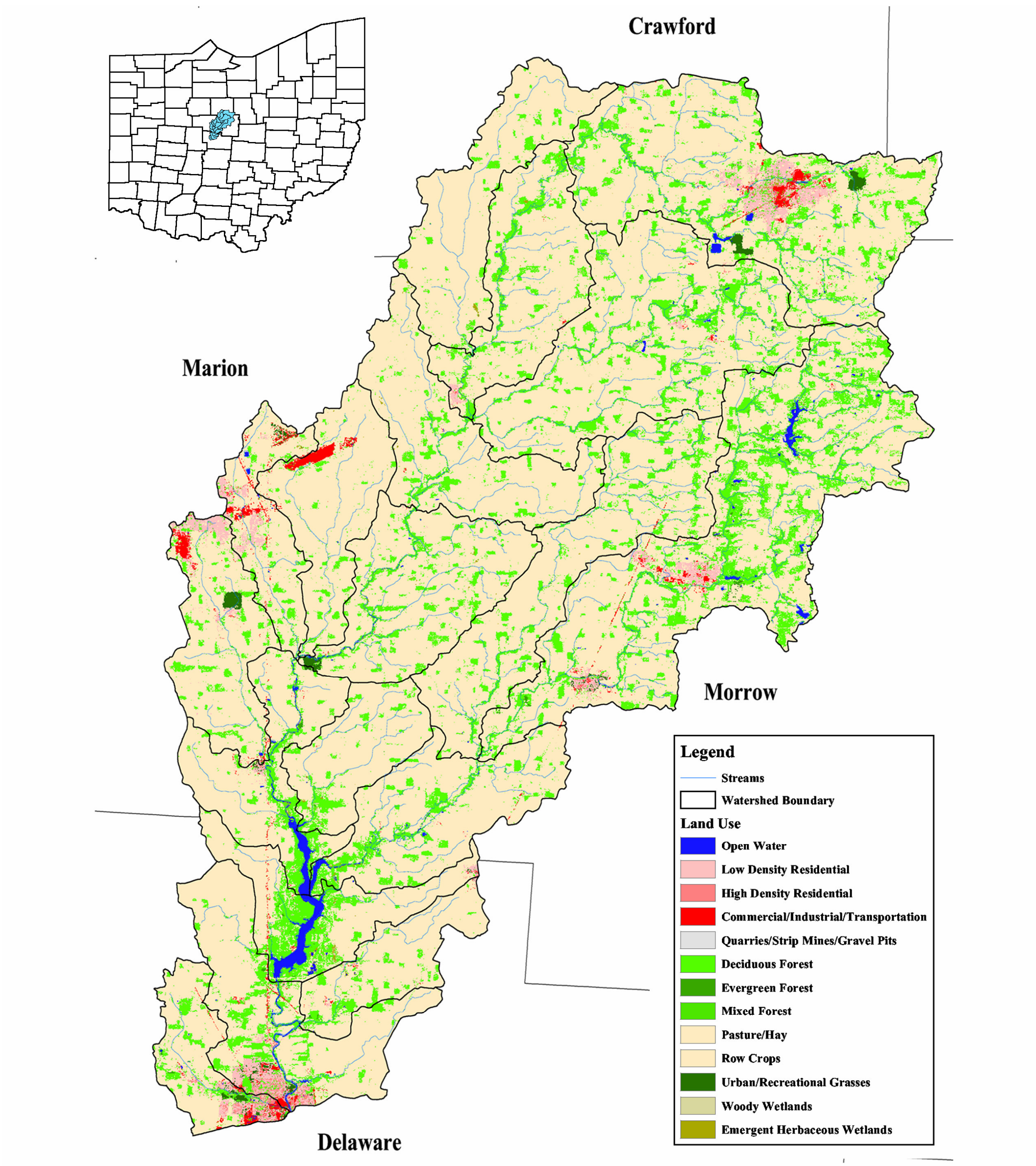

pH by Site
PH
8.5
8.0
7.5
7.0
1
2
3
4
5
6
7
8
Site

Atrazine by Site



Upper Olentangy River Watershed: Watershed Resources Inventory and Management Plan

Section B - Watershed Management and Action Plan



Submitted to Olentangy Watershed Alliance, City of Delaware, Ohio Environmental Protection Agency, and Ohio Department of Natural Resources

December 2006

Jon Witter, Larry C. Brown, and Katherine M. Skalak, Editors, The Ohio State University

In cooperation with the Upper Olentangy River Project Team

Section B: Watershed Management Plan and Action Plan

Table of Contents

Upper Olentangy Watershed

HUC 05060001 090, 05060001 100, and 05060001 110

Physical Description:

Figure 1: Olentangy River near Galion, OH

The Upper Olentangy Watershed including Whetstone Creek covers over 280,000 acres throughout Crawford, Morrow, Marion, and Delaware counties. The Upper Olentangy Basin is part of the Clayey High-Lime Till Plains characterized by clay-rich, low permeability soils. The Upper (05060001 090) and Middle (05060001 110) subwatersheds generally have low slopes (0-2%) with Tiro, Bennington, Pewamo, Milford soils. The Whetstone Basin has higher relief (0-6%) slopes and Centerburg and Canfield soils dominate.

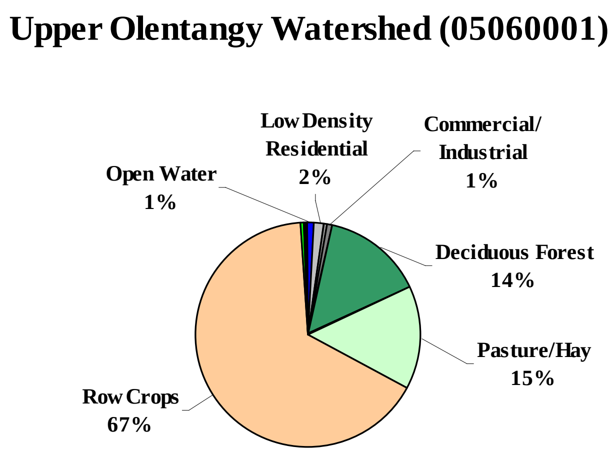
The fertile soils of the Olentangy Watershed make it well suited for agriculture which dominates land use. Approximately, 67% of the watershed is currently used for row crop and 15% in hay or pastureland. Forest (15%), open water (1%), and urban land use (2%) constitute the remainder of land use in the Upper Olentangy watershed. As a result of the extensive amount of agriculture in the watershed, approximately 395 miles of stream and tributaries are channelized in the watershed although only a portion of those streams have regular maintenance.

Figure 2: Tributary to the Olentangy River through an agricultural field.

Figure 3: Middle Olentangy River.

The Upper Olentangy does have a significant amount of riparian cover in many of its' subwatersheds. Riparian areas were divided into width categories of 0-10 ft, 10-33 ft, and 33+ ft to inventory riparian areas present versus riparian or buffer needed. It should be noted that this scheme is somewhat arbitrary and an appropriate riparian area should be a function of the drainage area and likely follow the streamway procedure of Ward and Mecklenberg (2002).

The Upper Olentangy was very distinct with respect to the integrity of riparian area. Approximately 41.5% of the stream/ditch miles had little (0-10 ft) of riparian or buffer area. Conversely, 49% of the watershed had riparian or buffer area in excess of 33 feet. The remaining 10.5% had a riparian area between 10 and 33 feet.



Land Use	%
Open Water	0.78
Low Density Residential	1.82
High Density Residential	0.30
Comm./Ind./Trans.	0.74
Quarries/Strip Mines	0.00
Deciduous Forest	14.35
Evergreen Forest	0.16
Mixed Forest	0.03
Pasture/Hay	14.93
Row Crops	66.06
Urban/Recreational Grasses	0.34
Woody Wetlands	0.31
Emergent Herb. Wetlands	0.19

Figure 4: Land use breakdown of Upper Olentangy Watershed.

Conservation Practices and Expected Benefits

The Natural Resources Conservation Service (NRCS) has a long history with research and implementation of BMP's. Table 1 shows a list of management practices and expected benefits. The list is a subset of the NRCS practices outlined in the NRCS Electronic Field Guide. The table included in this report is adapted from the Conservation Practice Physical Effects Table in Section V of the NRCS field guide. The practices selected were determined to be the most appropriate based on our knowledge of the Upper Olentangy watershed and stakeholder input. Stakeholder input gathered at public meetings was used to develop a list of practices that are acceptable to the watershed community based on their responses. Table A1 (Appendix A) provides the expected range of benefits of applying a NRCS approved practice.

Table 1: NRCS Relative effectiveness of approved conservation practices.

Water Resource Problem	Cause of Problem	Sources and conditions leading to causes
Excessive sediment deposition in stream systems adversely affects aquatic habitats and increases flooding; suspended sediment in streams increases water treatment costs, adversely affects aquatic life, and decreases recreational values;	Sediment	Sheet erosion of cropland; gully erosion on farmland; stream bank erosion; sheet and gully erosion at construction sites; movement of deposited sediments through drainage networks; down-cutting of streams; higher peak flow increases erosion and lower base flow allows increased deposition in stream channels.

Can stimulate excessive growth of aquatic plants, giving rise to oxygen problems, taste and odor problems, nuisance conditions, and possible release of toxins from blue-green algae.	Phosphorus	Attached to eroding sediments, especially from cropland; fertilizer; manure; human wastes, through sewage, combined sewer overflows, and failed septic tanks; urban storm runoff.
Drinking water contaminant in surface and in some ground water; Can stimulate excessive growth of aquatic plants, but this effect is more likely in marine than in fresh water environments.	Nitrate	Fertilizer; nitrogen fixation, especially by legumes; manure; human wastes; rainfall; delivery of nitrate from cropland to streams is enhanced by tile drainage systems.
Direct toxicity to aquatic life; contributes to oxygen deficiencies in streams.	Ammonia	Manure; human wastes via failed septic tanks and inadequate sewage treatment; spills of concentrated animal wastes, fertilizers, and industrial chemicals.
Some drinking water risk in surface water supplies and ground water supplies.	Pesticides	Herbicides, primarily from agricultural uses; some herbicides from urban land uses;
Can deplete oxygen concentrations in streams and lakes; can result in sludge beds on stream bottom	Organic wastes	Untreated sewage from bypasses and combined sewer overflows; septic tank effluents; manure runoff; food processing wastes; industrial wastes; spills; biomass decomposition.
Health risks to recreational users; drinking water contaminants, especially private water supplies.	Fecal bacteria, as indicated by presence of fecal coliform bacteria.	Failed septic tanks; combined sewer overflows; cross connections between water and sewer lines; loss of pressure in water lines, often due to broken water mains, allows infiltration of contaminated water; animal wastes/manure; wildlife.
Wildlife kills; drinking water contamination; fish consumption advisories.	Other toxic chemicals (metals and organic chemicals)	Sewage effluents; industrial effluents; spills; fires; pipeline breaks; leaking hazardous waste sites; atmospheric deposition.
Flood damages to crops, housing, businesses, bridges and roads; increased stream bank erosion; habitat and channel modifications.	Higher peak flows than for natural stream flows	Agricultural land use increases surface runoff; agricultural drainage projects and ditch maintenance speed delivery of water to downstream sites resulting in higher peak flows; impervious surfaces associated with urban and industrial land uses increase surface runoff; urban storm runoff.
Inadequate public water supplies during dry weather flows; limits aquatic habitats; less dilution of point sources; slow water movement facilitates growth of algae in streams; higher water temperatures.	Lower base flows than for natural stream flows	Agricultural land use; agricultural drainage projects, including tile drainage and surface drainage; wetland conversions to cropland or urban uses; impervious surfaces associated with urban and industrial land uses. All of above reduce ground water recharge, lowering water tables and diminishing spring water discharges that provide dry weather (base) flows in streams.

Increases water temperatures; reduces source of large woody debris, root masses, and log jams, all of which enhance stream habitat; breaks continuum of forest habitat that benefits wildlife; adverse aesthetic effects for stream users; increases erosion and downstream flooding.	Lack of forested riparian corridors	Agricultural, suburban, urban, and industrial land uses which encroach on stream banks.
Simplify stream habitats; alter stream substrates; decrease local flooding/increases downstream flooding. Reduces flood plain function.	Channel modifications	Constructed to support local agricultural or urban land uses; reduce local flooding; provide stream bank protection.
Stream gradients affect distribution of pools and riffles; local soils and bedrock affect stream substrates (bedrock, fine sediments, sand, gravel, etc.); affects ecoregional aquatic life standards.	Natural habitat limitations	Natural geographical features that predated human impacts.
Provide habitat diversity in streams, reduce downstream flowing; Can aggravate local flooding and bank erosion.	Logjams	Logjams are natural features of streams having forested riparian corridors. Logjam removal is common to reduce local flooding that can adversely affect land uses.
Reduce aesthetic values of streams; can pose hazards to recreational users of water resources.	Trash and debris	Careless human behavior.
Reduce diversity of native flora and fauna; direct economic damages.	Exotic species	Globalization of commerce and travel; deliberate human introductions (carp, multiflora rose)
Alter stream habitat; often prevent longitudinal migration of fish	Dams	Often dams no longer serve the purposes for which they were originally constructed. In the mean time, developments upstream from dams benefit from the ponded conditions created by the dam.

Overall BMP List for the Upper Olentangy Watershed

The general strategy for this action plan is to develop a list of acceptable and useful Best Management Practices to improve water quality. An overall list follows in Tables 2 to 6. Not all practices are appropriate for any given subwatershed therefore we have made recommendations for priority BMP's on a subwatershed (14-digit HUC) basis. Cost-share funds and grants should not be limited to the priority practices only. Local agencies and staff should have flexibility to address conservation planning and funding and not be limited by boundaries set out in this action plan. Improvements in water quality will best be met by applying economical, effective solutions to land or management practices when appropriate.

Table 2: Code list for following tables.

Problem	Code
Nutrients	**N**
Nitrate	**N03**
Flow Alteration	**F**
Low DO	**DO**
Habitat Alteration	**H**
Elevated temperature	**T**
Sediment/Erosion	**S**

Table 3: Conservation practices for livestock operations.

Livestock			
	NRCS	**Resources**	**Problems**
Practice	**Code**	**($ Range)**	**Addressed**
Waste Treatment Lagoon (Anaerobic)	359	$40-$75 per 1000 cubic ft	N, DO
Waste Storage Facility	313	Variable by practice	N, DO
Composting	317	$1.50-$17 per square ft	N
Livestock Use Protection Area	757i	$1-$3 per square ft	S, H
Fencing	382	$0.85-$2.60 per ft	S, N, H
Watering Facility	614	$415-$1500 each	-
Drainage Water Management	554	$450-$2500 each	N03
Structure for Water Control	587	$450-$2500 each	N03

A more recent BMP for subsurface drained cropland where liquid manure is applied is the combination of Drainage Water Management (Practice Standard 554) with Structure for Water Control (Practice Standard 587). Ohio State University in cooperation with the USDA-NRCS, will release guidelines for installation and management of these practices. The goal is to be able to monitor subsurface drainage outlets and retain any drainage waters with liquid manure.

Table 4: Conservation practices for row crops.

Row Crop Agriculture			
	NRCS	**Resources**	**Problems**
Practice	**Code**	**($ Range)**	**Addressed**
Grassed Waterway	412	Variable by component	S
Nutrient Management	590	Variable by component	N
Pasture and Hayland Planting	512	$75-$195 per acre	S, N
Pumping Plant for Water Control	533	$1000-$1500 each	N
Tree and Shrub Establishment	612	$20-$660 per acre	S, N, DO, T, H
Heavy Use Protection Area	561	$1-$3 per square ft	S
Residue Management, Mulch Till	329B	$8 per acre	S, N
Residue Management, No-till, Strip-till	329A	$8-$12 per acre	S, N
Riparian Forest Buffer	391	$20-$660 per acre	S, N, DO, T, H
Stripcropping	586	$10 per acre	S, N
Subsurface Drain	606	$0.80-$4 per ft	N
Structure for Water Control	587	$750-$2900 each	N
Conservation Cover	327	$75-$230 per acre	S, N

Contour Buffer Strips	332	$12 per acre	S, N
Cover and Green Manure Crop	340	$15 per acre	S, N
Critical Area Planting	342	$300-$600 per acre	S, N
Water and Sediment Control Basin	638	$2500-$3500 each	S
Filter Strips	393	$230-$660	S, N
Precision Agriculture Practices	-	Variable by component	-
Innovative Crop Rotations	-	Variable by component	-
Drainage Water Management	554	$450-$2500 each	N03
Structure for Water Control	587	$450-$2500 each	N03

Table 5: BMP's for urban and wildlife areas.

Urbanization, In-stream, Wildlife			
		Resources	Problems
Practice	**NRCS Code**	**($ Range)**	**Addressed**
Grade Stabilization Structure	410	$400-$5400 each	S
Wetland Development or Restoration	657	$95-$660 per acre	S,N
Sediment Basin	350	$5000 each	S
Drainage Water Management	554	$450-$2500 each	N03, Habitat
Structure for Water Control	587	$450-$2500 each	N03, Nabitat
Two-Stage and Overwide Drainage Ditch Construction	-	-	-

Table 6: Septic system replacement or upgrade costs.

Septic System Replacement and Upgrade		
Practice	**Resources ($ Range)**	**Problems Addressed**
Septic System Replacement/Upgrade	$2,000-$20,000 each	B

Innovative BMP's

There are several conservation practices that may require additional explanation. These might be considered innovative in terms of addressing water quality concerns, and could be appropriate for this project. A brief description follows.

Drainage Water Management (Controlled Drainage)

Subsurface drainage is an essential water management practice on many highly productive fields in Ohio and across the Midwest. However, nitrate carried in drainage water can lead to local water quality problems and contribute to hypoxia in the Gulf of Mexico, so strategies are needed to reduce the nitrate loads while maintaining adequate drainage for crop production.

Practices that can reduce nitrate loads on subsurface-drained soils include growing winter forage or cover crops, fine-tuning fertilizer application rates and timing, bioreactors, treatment wetlands, and modifying drainage system design and operation. Drainage water management is one of these practices, and is described as the practice of using a water control structure in a subsurface drainage main, submain, or lateral drain to vary the depth of the drainage outlet. The water table must rise above the outlet depth for drainage to occur, as illustrated below. The outlet depth, as determined by the control structure, is:

- Raised after harvest to limit drainage outflow and reduce the delivery of nitrate to ditches and streams during the off-season. (Figure 5)
- Lowered in early spring and again in the fall so the drain can flow freely before field operations such as planting or harvest. (Figure 6)
- Raised again after planting and spring field operations to create a potential to store water for the crop to use in midsummer. (Figure 7)

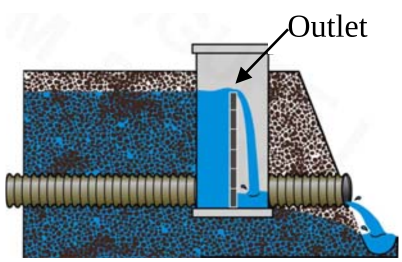


Figure 5: The outlet is raised after harvest to reduce nitrate delivery.

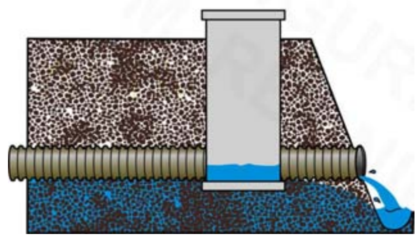


Figure 6: The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.

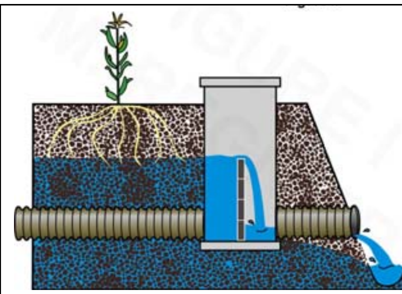


Figure 7: The outlet is raised after planting to potentially store water for crops.

The practice is only suitable on fields that need drainage, and is most appropriate where a pattern drainage system (as opposed to a random system) is installed or is feasible. The field should be flat (generally less than 0.5% slope) so that one control structure can manage the water table within 1 to 2 feet for as many acres as possible. If drainage laterals are installed on the contour, the practice could be used with greater slopes. The producer must be able to manage the drainage system without affecting adjacent landowners. The practice can be used with any drain spacing; however, a narrower drain spacing reduces the risk of yield loss due to excess wetness during the growing season. If a new drainage installation is being planned for a field, drains should be designed for minimum grade (along the contours), so each control structure can control the maximum possible area of the field.

The number of acres that can be effectively managed with one structure depends on field topography and the desired uniformity of water table management. Flatter fields require fewer overall structures and allow each structure to manage a larger area. A field is typically divided into “drainage management zones”, each managed by one control structure. The zones are delineated by the desired feet of elevation change within the zone, which corresponds to the desired uniformity of water table management. For example, to maintain control of the water table to within 1 foot of the desired depth, a structure must be placed in a drainage management zone with 1 foot or less of elevation change. One structure can typically control at least 10 or 20 acres, and the larger the area that can be controlled with one structure, the more economical the practice.

The USDA NRCS has approved conservation practice standards that support drainage water management in some states. The standards are 554, Drainage Water Management; and 587, Structure for Water Control. Farm Bill programs, including the Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP), may provide some of the cost of structure installation and/or a management incentive for a number of years in some states. The Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) may provide funding for the installation of structures in riparian buffers in some states. For more information, talk with your local District Conservationist.

The above information on drainage water management was abstracted from a new publication, Bulletin WQ-44 "Questions and Answers about Drainage Water Management for the Midwest. This bulletin was produced by land-grant universities and the USDA-ARS scientists from Indiana, Minnesota, Illinois, Iowa, Missouri, and Ohio. The bulletin can be downloaded as a PDF at: http://www.ces.purdue.edu/extmedia/WQ/WQ-44.pdf.

Two-Stage, and Overwide Drainage Ditch Construction

Benefits of a two-stage ditch (Figure 8) over a conventional ditch are potentially both improved drainage function and ecological function. Drainage benefits may include increased ditch stability and reduced maintenance. Evidence and theory both suggest that ditches prone to filling with accumulated sediment may require less frequent "dipping out" if constructed in a two-stage form. The two-stage ditch has the potential to create and maintain better habitat. The narrow deep fluvial channel provides better water depth during periods of low flow. Grass on the benches can provide quality in-stream cover and shade. The substrate in the fluvial channel is improved as the two-stage form increases sediment conveyance and sorting, with fines deposited on the benches and courser material forming the bed. Two-stage ditches might also be useful in improving water quality particularly for nutrient assimilation. Work has been initiated on the ecology of these ditches and the role of the channel and benches in improving water quality and habitat.

The primary costs of two-stage ditches are increased width and more initial earthwork. Creating a low bench typically requires the top width of ditch to be greater. If a two-stage ditch is commonly in the range of 10-20 feet wider then the loss of potentially farmable land might be 1 to 3 acres per mile of ditch, depending on watershed size and the size of the existing ditch. The increased width however, will usually increase the capacity (amount of flow it can carry) by 25 to 100 or more percent. With the loss of farmable acreage in mind, we have proposed that the establishment of the low bench be included in the same way as establishing a grass filter adjacent to the top of the ditch. It is probable that establishment or retention of this feature will have a similar or greater benefit than a grass filter. However, it does not negate the benefit of also having a grass filter along the top bank of the ditch. Conceptually, this practice may yield large benefits for the stream system, which have not be well documented. Demonstrations in a number of subwatersheds are desired.

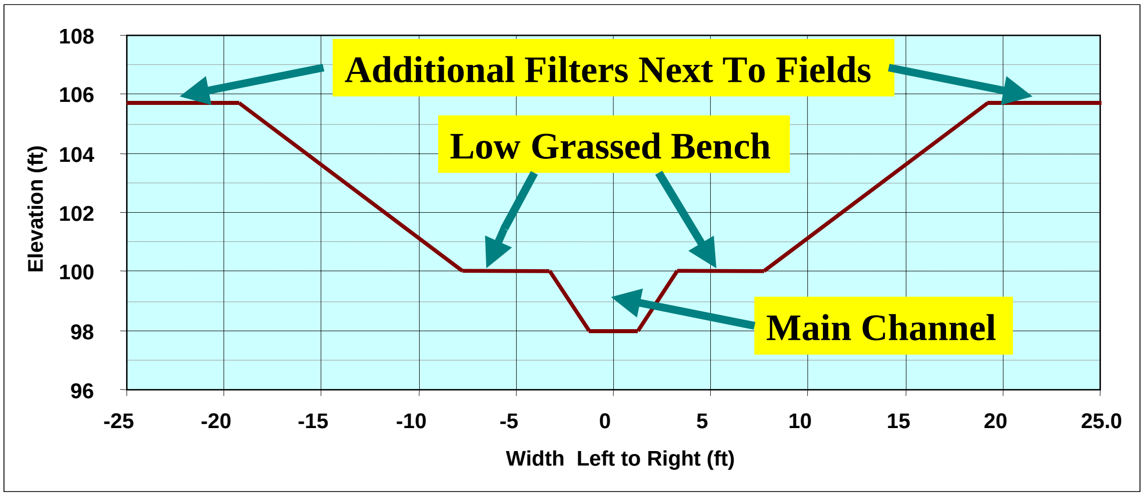
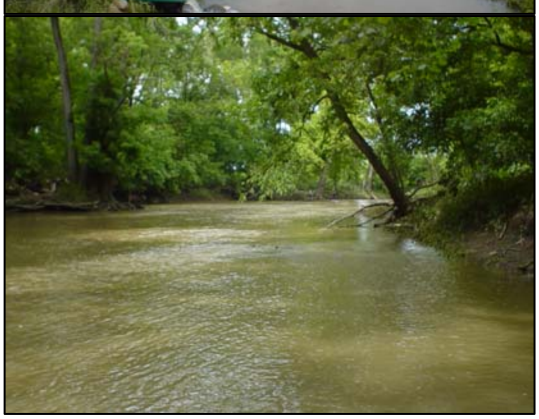


Figure 8: A two-stage ditch with a small main channel and low grassed bench.

The following images illustrate various stream and ditch channel morphology that may be seen in the Upper Olentangy Watershed.



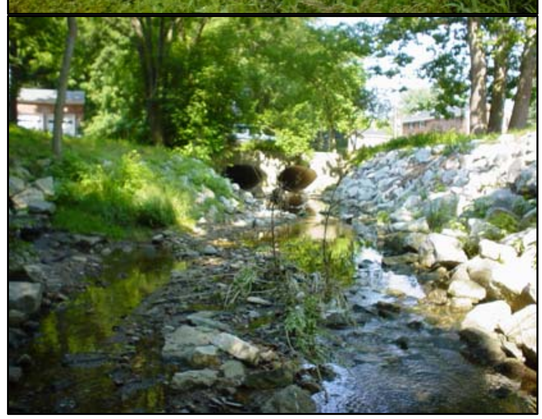



Figure 9. Various stream and ditch channel morphology that may be seen in the Upper Olentangy Watershed.

Modified Relay Intercropping (MRI)

Wheat is a flexible, adaptable plant (H. Lafever, 1990) with a growing season that starts with planting in the fall and ends with harvest in the early summer. This adaptability allows farmers to capture some 66% of the traditional growing season — May 1 to September 30 — to produce a second crop through the interplanting of soybeans into wheat in June. This practice is known as Modified Relay Intercropping (MRI). An MRI system involves the production of two different crops, with different growth and development requirements, in one growing season (see Figure 10). In an MRI system, soybeans are planted into standing wheat between 20 and 30 days prior to wheat harvest. In addition to allowing the harvesting of two crops in the same year, the MRI cropping system has the potential to increase farm income while hedging production risk and protecting the environment at the same time.

Figure 10: Modified Relay Intercropping (MRI) permits the planting of soybeans into standing wheat, allowing farmers to harvest two crops in the same year. This system hedges risks and protects the environment.

MRI is sometimes confused with Relay Intercropping (RI), another cropping system. Relay Intercropping recommends the planting of polymer-coated soybeans from May 1 to May 15 (Beuerlein, 2001). In contrast, MRI recommends the planting of regular soybeans from around June 1 to June 20. The goal of this planting date is to have a well-established soybean plant of 6 to 8 inches in height (V2 to V4 growth stage) at wheat harvest. In the MRI system, two crops — wheat and soybeans — are harvested in the same year. However, because of the difference in crop growth requirements and grain markets, farmers can effectively hedge production and price risk in an MRI system in most years. Producers considering using an MRI system should plan to grow wheat in such a manner (wheat rows less than 15 inches in width) that yield is not significantly reduced from wheat grown in a conventional system.

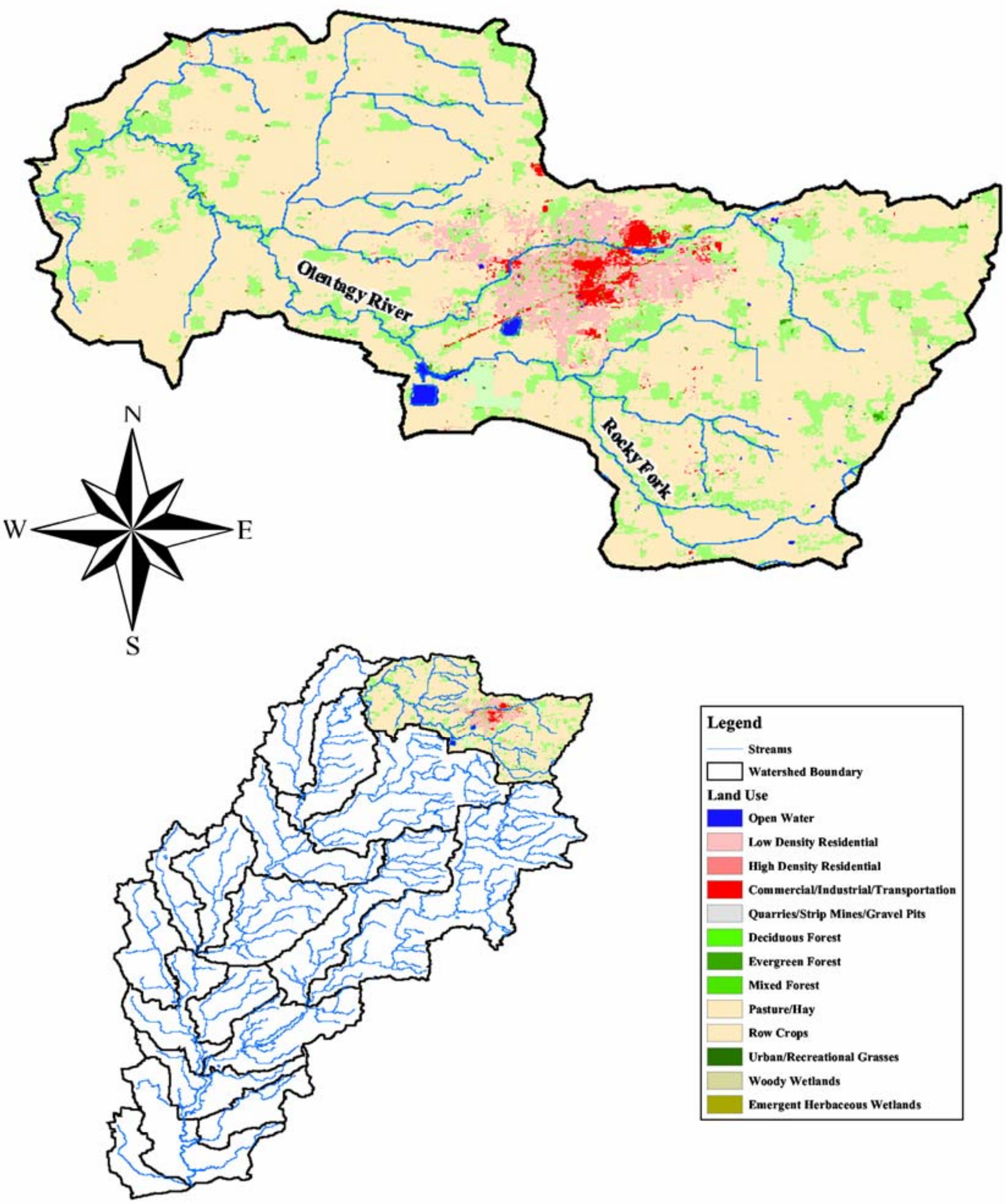
Long-term research at The Ohio State University's Ohio Agricultural Research and Development Center (OARDC) (D. Jeffers, 1995), in Crawford County (Prochaska, 2003), and other locations in Indiana (Kline et al., 2001) has shown that MRI or RI wheat will yield about 90 percent of conventional wheat.

The above information on modified relay intercropping was abstracted from Ohio State University Extension Fact Sheet "Modified Relay Intercropping" - AGF-504-04, by Dr. Steven C. Prochaska, Associate Professor and Extension Agent, Agriculture and Natural Resources, Ohio State University Extension – Crawford County. The publication can be viewed at http://ohioline.osu.edu/agf-fact/0504.html. The Upper Olentangy Watershed project team wants to identify other alternative cropping and precision agricultural systems that local farmers suggest as being economical and environmentally sensitive.

Upper Olentangy Watershed Goal

The overall Upper Olentangy Watershed goal is to maintain water quality of water resources that meet or exceed designated uses and have acceptable quality, and to improve and enhance water quality of all other water resources to bring them under acceptable water quality goals, as well as to meet designated uses and enhance the overall quality of the resources. In the sections below for each subwatershed, specific water quality improvement objectives and tasks are presented, as well as potential prioritized implementation objectives.

Rocky Fork Watershed
HUC 05060001090010



Rocky Fork Subwatershed

HUC 05060001 090 010

Physical Description:

Figure .11: Olentangy River upstream of Galion, OH.

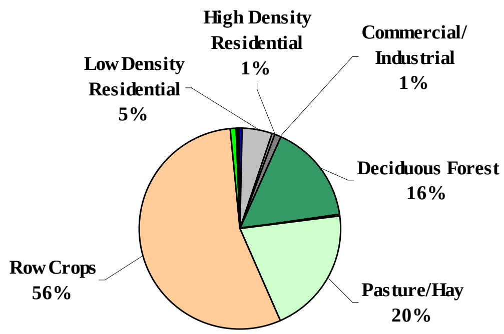
The Rocky Fork subwatershed comprises the headwaters for the Olentangy River. The watershed drains 31,580.1 acres of primarily agricultural and forested land. It is designated as a Warm Water Habitat and meets use designation at sampling locations expect at river mile 79.7 where effects from the Galion WWTP and unrestricted livestock access caused nutrient enrichment and siltation (Appendix B). Results of water quality sampling show violates for fecal coliform, e. coli., phosphorus, nitrate-nitrite, and strontium.

.

There are approximately 61.3 miles of streams and tributaries in the Rocky Fork subwatershed. Roughly 44.9 miles of which were channelized at some time. Twelve miles of ditch were reported to be under active maintenance on a five year cycle. The watershed is primarily agricultural with 56% of the watershed in row crops. Pasture (20%), forest (16%), open water (0.5%), wetlands (0.5%), and urban (7%) constitute the remaining land use. Several farms include small livestock operations including cattle, sheep, and/or horses. Approximately 2,500 head of swine are spread across several confined animal feeding operations (CAFO's). Percentage of crop types grown includes 40%, 43%, 12%, and 5% for corn, soybeans, wheat, and hay respectively. Pasture land is estimated at 740 acres. Conventional tillage (42%), no-till (29%), and reduced till (29%) are the most common tillage types.

Figure 12: Tributary ditch to the Olentangy River.

A survey of aerial photos showed 877.8 acres of riparian buffer and 173.4 acres of riparian or buffer area needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 104 septic systems that require upgrade or replacement particularly in the Sugar Grove area were plans to build a package treatment plant are underway.



Land Use	%
Open Water	0.49
Low Density Residential	4.65
High Density Residential	0.63
Comm./Ind./Trans.	1.18
Deciduous Forest	15.73
Evergreen Forest	0.28
Mixed Forest	0.04
Pasture/Hay	20.21
Row Crops	55.35
Urban/Recreational Grasses	0.93
Woody Wetlands	0.28
Emergent Herb. Wetlands	0.23

Figure 13: Land use breakdown of Rocky Fork Subwatershed.

Rocky Fork Subwatershed
HUC 05060001 090 010

IMPAIRMENT: Nutrients and Sediment, Flow and Habitat Alterations

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, impairment or threat of impairment to the Rocky Fork subwatershed include nutrient enrichment and siltation. Row crop and livestock agriculture, municipal waste treatment, bank destabilization, and urban runoff have been identified as significant sources for nutrients and sediment.

Problem Statement

Row crop agriculture and unrestricted livestock access are a significant source of sediment and nutrient enrichment in this subwatershed. Unrestricted livestock access and point source discharges from the City of Galion create elevated levels of bacteria including fecal coliform and e. coli.. Channel maintenance and livestock access cause habitat and flow alterations.

Figure 14: Sedimentation and habit alteration from livestock access.

Goals

The overall goals are to reduce sedimentation, nutrient enrichment, and habitat alterations by improving manure management and restricting livestock use; improve pasture management by getting landowners to follow an approved Prescribed Grazing System to reduce sedimentation and manure runoff; reduce sedimentation and nutrient runoff from cropland areas; and improve riparian condition by adding riparian or buffer strips, etc. Potential implementation objectives are presented below, and Table 7 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Rocky Fork Subwatershed**.** Table 8 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Rocky Fork Subwatershed

- Reduce phosphorus and sediment loading by 6.1 and 13.3 tons/year, respectively, through the adoption of 2,000 acres of residue management; 2,000 acres cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 15 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, 8 watering facilities, and adoption of 370 acres of Prescribed Grazing Plans with priority to lands adjacent to streams.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 124 acres of filter strips; 50 acres riparian buffers; and, constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (9.39E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for 25 of the 865 systems with improved on-site treatment systems or collection sewers.

Table 7: Cause of impairment, and approach to addressing problem and documenting improvement in the Rocky Fork Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in subwatershed where livestock have unrestricted access to stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$242,000 for fence and other practices * $90,000 (6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Nutrients, Sediment	2. Establish Prescribed Grazing Plans on 370 acres of pastureland with priority to lands adjacent to streams	$5,550 for Prescribed Grazing Plans $15 per acre	EQIP, 319 grant funds	Jan. 2006 to January 2009	Document acres under plans Calculate load reductions
Habitat Alteration, Sediment, Nutrients, Temperature	3. Establish 50 acres of riparian corridor	$138,000 50 acres * $660 per acre + 50 acres * $140 per acre per year * 15 years	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2011	Document acres of riparian planted Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	4. Establish 123.4 acres of filter strip	$215,000 123.4 acres * $230 per acre for installation + 123.4 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	5. Residue management, cover and green manure crop, conservation tillage	$540,000 2,000 acres of residue management * $12/acre * 10 years + 2000 acres of cover crop *	Farm Bill, EQIP, CRP, CSP, 319 Funds	Jan. 2006 to Dec. 2015	Document acres of cover planted and conservation crop rotation Calculate load reduction

		$15/acre * 10 years			
Sediment, Nutrients	6. Intercropping and innovative crop rotation	$240, 000 2,000 acres * $12/acre * 10 years	Farm Bill, EQIP, CRP, CSP, 319 Funds	January 2007 to Dec 2017	Document acres of treated cropland Estimate pollutant load reductions
Nitrate	7. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstration, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Habitat and Flow Alterations	8. Two-stage ditch design and construction	$111,000 3 miles of channel *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathagens	9. Septic system replacement or upgrade	$300,000 25 systems * $12,000 per system	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathagen load reductions
Atrazine, pesticides	10. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients	11. Composting facility for livestock wastes	$25,000 1 facility			
Wetland Habitat	12. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Figure 15: Representative stream settings in the Rocky Fork Subwatershed.

Table 8: Summary of Ohio EPA water quality and biological sampling results from the Rocky Fork Subwatershed.

Upper Olentangy Watershed Inventory
Rocky Fork Subwatershed
HUC 05060001 090 010

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Rocky Fork Watershed	323,664	237,072				877.8[1]	173.4[2]/342.7[3]	Yes	8	Yes	101
Rocky Fork											
Olentangy River											
6 Unnamed Tributaries					63,369						
TOTAL	323,664	237,072			63,360						
Miles =	61.3	44.9			12						

Livestock Inventory	Cattle	Dairy	Swine	Sheep	Chickens	Horses
Totals	160	NA	2500	100	NA	50

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing systems	Estimated # of failing systems
865	12	104

* Estimates based on survey given to County Health Departments

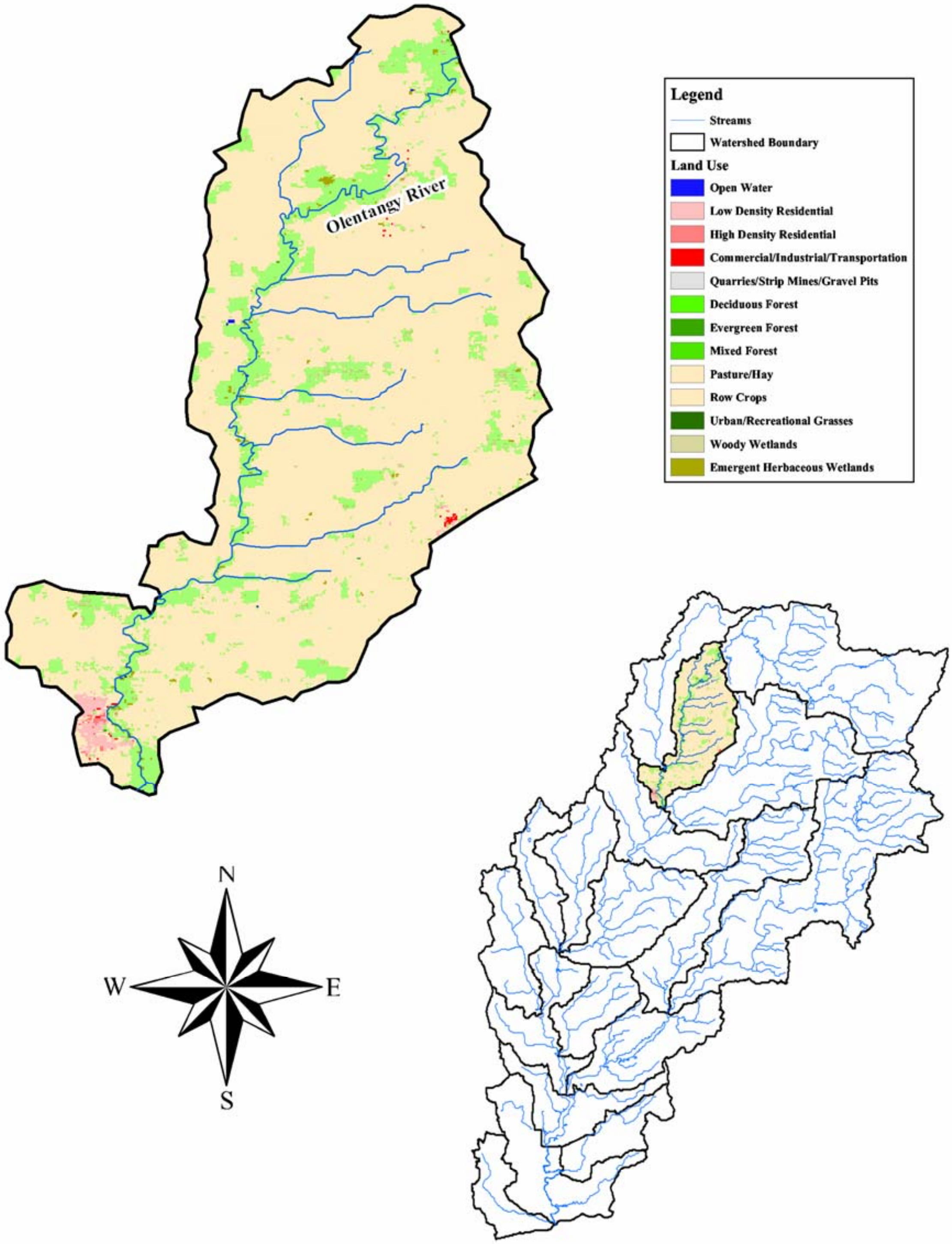
Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
40%	43%	12%	5%	740	29%	0%	29%	42%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
31,580.1

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks

Olentangy River to Flat Run
HUC 05060001090020



Olentangy River to Flat Run Subwatershed

HUC 05060001 090 020

Physical Description:

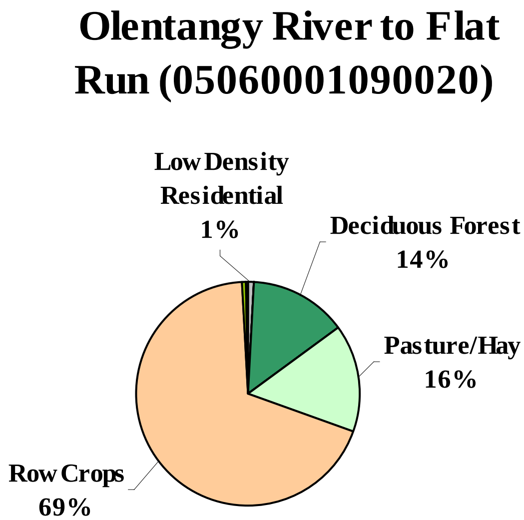
Figure 16: Olentangy River off Goldsmith Road

The Olentangy River to Flat Run subwatershed begins near the Olentangy RM 75 and ends just above Flat Run. The watershed drains 13,594.2 acres of agricultural and forested land. It is designated as a Warm Water Habitat and none of the 2003 sample sites met their use designation (Appendix B). Causes of impairment are agriculture, livestock, and failing septic treatment systems. Results of water quality sampling show violations of f. coliform, e. coli., phosphorus, nitrate-nitrite, and metals.

Figure 17: Channelized tributary to the Olentangy River.

There are 29.9 miles of streams and tributaries in the Olentangy River to Flat Run subwatershed. Approximately 14.4 miles are channelized and 3.5 miles are actively maintained. Land use includes row crops (69%), pasture (15.5%), and forest (14%). A few farms include cattle, dairy, and goats while swine make up the largest portion of livestock in the watershed. Approximately 7400 head of swine and land application of that manure is a suspected source of water quality problems. The most common crops grown in the watershed are corn (35%), soybeans (50%), wheat (10%), and hay (5%). Common tillage types include no-till (28%), mulch tillage (34%), reduced tillage (9%) and conventional tillage (29%).

A survey of aerial photos showed 360.6 acres of riparian buffer and 118.5 acres of riparian or buffer area needed to have a minimum of 33 feet of buffer on all stream banks. Other problems include an estimated 21 septic systems that require upgrade or replacement.



Land Use	%
Low Density Residential	0.70
High Density Residential	0.08
Comm./Ind./Trans.	0.07
Deciduous Forest	14.06
Evergreen Forest	0.03
Mixed Forest	0.01
Pasture/Hay	15.58
Row Crops	68.63
Woody Wetlands	0.47
Emergent Herb. Wetlands	0.36

Figure 18: Land use breakdown of Olentangy to Flat Run Subwatershed.

Olentangy River to Flat Run Subwatershed
HUC 05060001 090 020

IMPAIRMENT: Nutrients, Sediment, Pathogens, and Habitat Alteration

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, all segments of the Olentangy to Flat Run subwatershed are not meeting expected use designation. Row crop and livestock agriculture, poorly maintained septic systems, and removal of riparian vegetation are identified as significant sources of nutrients, sediment, and bacteria.

Figure 19: Grassed waterway in need of repair.

Figure 20: Livestock access area and erosion.

Livestock access to streams also causes habitat degradation. Not only do eroding banks serve as a source of sediment to the river, but failing banks change the character of the stream by becoming wider and shallower. This reduces habitat heterogeneity and protection for native species and often provides and opportunity for non-native species to invade. Removal of riparian areas results in elevated water temperatures, lowered DO, and reduction in food materials available to the biology.

Goals

The overall goals are to reduce sedimentation, nutrient enrichment, and habitat alterations by improving manure management and restricting livestock use; reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nutrient export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 9 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Olentangy River to Flat Run Subwatershed**.** Table 10 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Olentangy River to Flat Run Subwatershed

- Reduce phosphorus and sediment loading by 1.2 and 0.3 tons/year, respectively, through the adoption of 1,500 acres of residue management; 1,500 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, and 8 watering facilities.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 88.5 acres of filter strips; 30 acres riparian buffers; and, constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.

- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (1.96E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***21*** (of 212) systems with improved on-site treatment systems or collection sewers.

Table 9: Cause of impairment, and approach to addressing problem and documenting improvement in the Olentangy River to Flat Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$242,000 for fence and other practices $90,000 (6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of stream bank fencing installed. Load reductions calculated from modeling activities
Habitat Alteration, Sediment, Nutrients, Temperature	2. Establish 30 acres of riparian corridor	$82,800 * 30 acres * $660 per acre + 30 acres * $140 per acre per year * 15 years	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2011	Document acres of riparian planted Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	3. Establish 88.5 acres of filter strip	$207,000 88.5 acres * $230 per acre for installation + 88.5 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	4. Residue management, cover and green manure crop, conservation tillage	$405,000 1,500 acres of residue management * $12/acre * 10 years + 1500 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, conservation tillage, crop rotations Calculate load reduction

Atrazine, pesticides	5. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Sediment, Nutrients	6. Intercropping and innovative crop rotation	$240, 000 2,000 acres * $12/acre * 10 years	Farm Bill, EQIP, CRP, CSP, 319 Funds	January 2007 to Dec 2017	Document acres of treated cropland Estimate pollutant load reductions
Nitrate	7. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Nutrients, Habitat	8. Construction of 2 miles of two-stage ditch	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
	9. Septic system replacement or upgrade	$252,000 21 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and coliform load reductions
Wetland Habitat	10. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Figure 21: Representative edge of field and stream setting in the Olentangy River to Flat Run Subwatershed.

Table 10: Summary of Ohio EPA water quality and biological sampling results from the Olentangy River to Flat Run Subwatershed.

Upper Olentangy Watershed Inventory
Olentangy River to Flat Run Subwatershed
HUC 05060001 090 020

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Olentangy River to Flat Run Watershed	157,872	76,032				360.6[1]	118.5[2]/245.3[3]	Yes	NA	No	38
Olentangy River											
Unnamed Tributary					10,560						
OR @ Kerr Road					7,920						
TOTAL	157,872	76,032			18,480						
Miles =	29.9	14.4			3.5						

Livestock Inventory	Cattle	Dairy	Swine	Goat	Chickens	Horses
Totals	20	100	7400	500	NA	NA

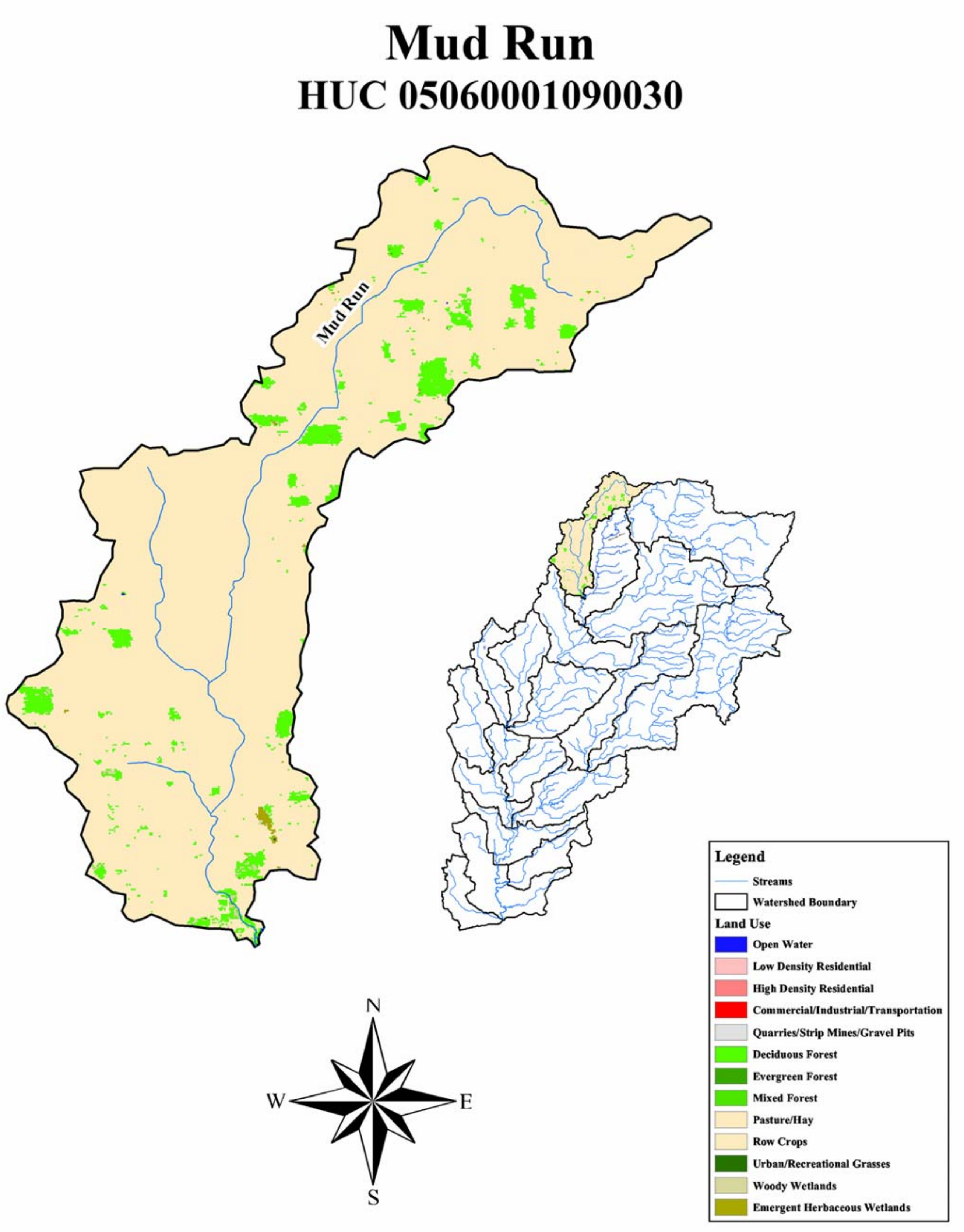
Estimated # of septic systems	Estimated % failing systems	Estimated # of failing systems
212	10	21

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
35%	50%	10%	5%	40	28%	34%	9%	29%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres 13,594.2

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Mud Run
HUC 05060001090030
Mud Run
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
N
W
E
S

Mud Run Subwatershed

HUC 05060001 090 030

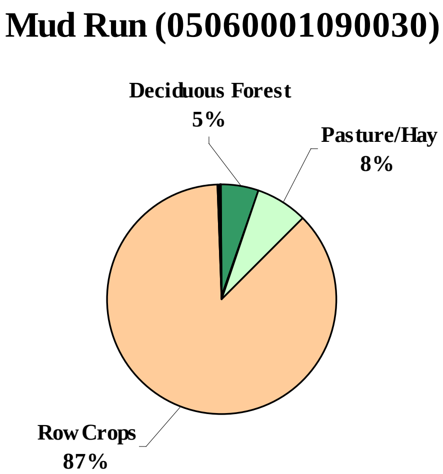
Physical Description:

Figure 22: Agricultural ditch in Mud Run watershed.

The Mud Run watershed enters the Olentangy River near river mile 62.6. The watershed drains 13,139.3 acres of mostly row crop agriculture. Except for a small reach near the confluence with the Olentangy River, Mud Run is designated as a Modified Warm Water Habitat. Biological sampling results from 2003 suggested that Mud Run met its' designated use, but habitat scores (QHEI) were particularly low (Appendix B). Water quality samples had violations of f. coliform, e. coli., nitrate-nitrite, and phosphorus.

The Mud Run watershed contains 16.4 miles of tributaries to the Olentangy, all of which are channelized. All ditch miles are actively maintained under petition by the Crawford County Engineer's Office. Row crop agriculture dominates land use with approximately 87% of land used to grow corn, soybeans, wheat, or other small grains. About 950 acres are used to produce hay crops and 40 acres used as pastureland. Forested land constitutes a small portion of land use (5.3%) or ~700 acres. Corn and soybean rotations dominate with 35% and 50% of crop acres, respectively. Some form of reduced tillage is practiced on 71% of the watershed while the remaining 29% (~3800 acres) is tilled with conventional methods.

A survey of aerial photos showed 57.2 acres of riparian or buffer and 109.9 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 16 septic systems that require upgrade or replacement.



Land Use	%
Open Water	0.01
Deciduous Forest	5.28
Evergreen Forest	0.01
Mixed Forest	0.01
Pasture/Hay	7.60
Row Crops	86.67
Woody Wetlands	0.25
Emergent Herb. Wetlands	0.17

Figure 23: Land use breakdown of Mud Run Subwatershed.

Mud Run Subwatershed
HUC 05060001 090 030

IMPAIRMENT: Nutrients, Sediment, Pathogens, and Habitat Alteration

Background

Figure 24: Recently maintained section of Mud Run.

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, various segments of the Mud Run subwatershed are not meeting expected use designation. Row crop and livestock agriculture, municipal waste treatment, bank destabilization, and urban runoff have been identified as significant sources of nutrients and sediment.

Livestock access to streams also causes habitat degradation. Not only do eroding banks serve as a source of sediment to the river, but failing banks change the character of the stream by becoming wider and shallower. This reduces habitat heterogeneity and protection for native species and often provides and opportunity for non-native species to invade. Removal of riparian areas results in elevated water temperatures, lowered DO, and reduction in food materials available to the biology

Goals

The overall goals are to reduce sedimentation, nutrient enrichment, and habitat alterations by improving manure management and restricting livestock use; .reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nutrient export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 11 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Mud Run Subwatershed**.** Table 12 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Mud Run Subwatershed

- Reduce phosphorus and sediment loading by 4.6 and 4,184 tons/year, respectively, through the adoption of 1,600 acres of residue management; 1,000 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, and 8 watering facilities.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 109.9 acres of filter strips; 30 acres riparian buffers; and, constructing 2 lineal

miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.

- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (1.49E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***21*** (of 160) systems with improved on-site treatment systems or collection sewers.

Table 11: Cause of impairment, and approach to addressing problem and documenting improvement in the Mud Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$242,000 for fence and other practices $90,000 (6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Habitat Alteration, Sediment, Nutrients,	2. Establish 109.9 acres of filter strip	$257,000 109.9 acres * $230 per acre for installation + 109.9 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	3. Residue management, cover and green manure crop, conservation tillage	$342,000 1,600 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, and conservation tillage Calculate load reduction
Sediment, Nutrients	4. Intercropping and innovative crop rotation	$240, 000 2,000 acres * $12/acre * 10 years	Farm Bill, EQIP, CRP, CSP, 319 Funds	January 2007 to Dec 2017	Document acres of treated cropland Estimate pollutant load reductions
Nitrate	5. Agricultural Drainage Management	$150,000 500 acres, on 10 25-	EQIP, 319 funds, CSP,	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-

		to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	industry, potential for CIG demonstration, others		nitrogen load reductions
Sediment, Nutrients, Habitat	6 Construction of 2 miles of two-stage ditch	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Atrazine, pesticides	7. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients, Pathogens	8. Septic system replacement or upgrade	$252,000 21 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Wetland Habitat	9. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Table 12: Summary of Ohio EPA water quality and biological sampling results from the Mud Run Subwatershed.

Upper Olentangy Watershed Inventory
Mud Run Subwatershed
HUC 05060001 090 030

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Mud Run Watershed Mud Run	86,592	86,592			86,592	57.2[1]	109.9[2]/231.9[3]	Yes	10	Yes	18
TOTAL Miles =	86,592 16.4	86,592 16.4			86,592 16.4						

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	<50	200	6800	NA	NA	NA

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing systems	Estimated # of failing systems
160	10	16

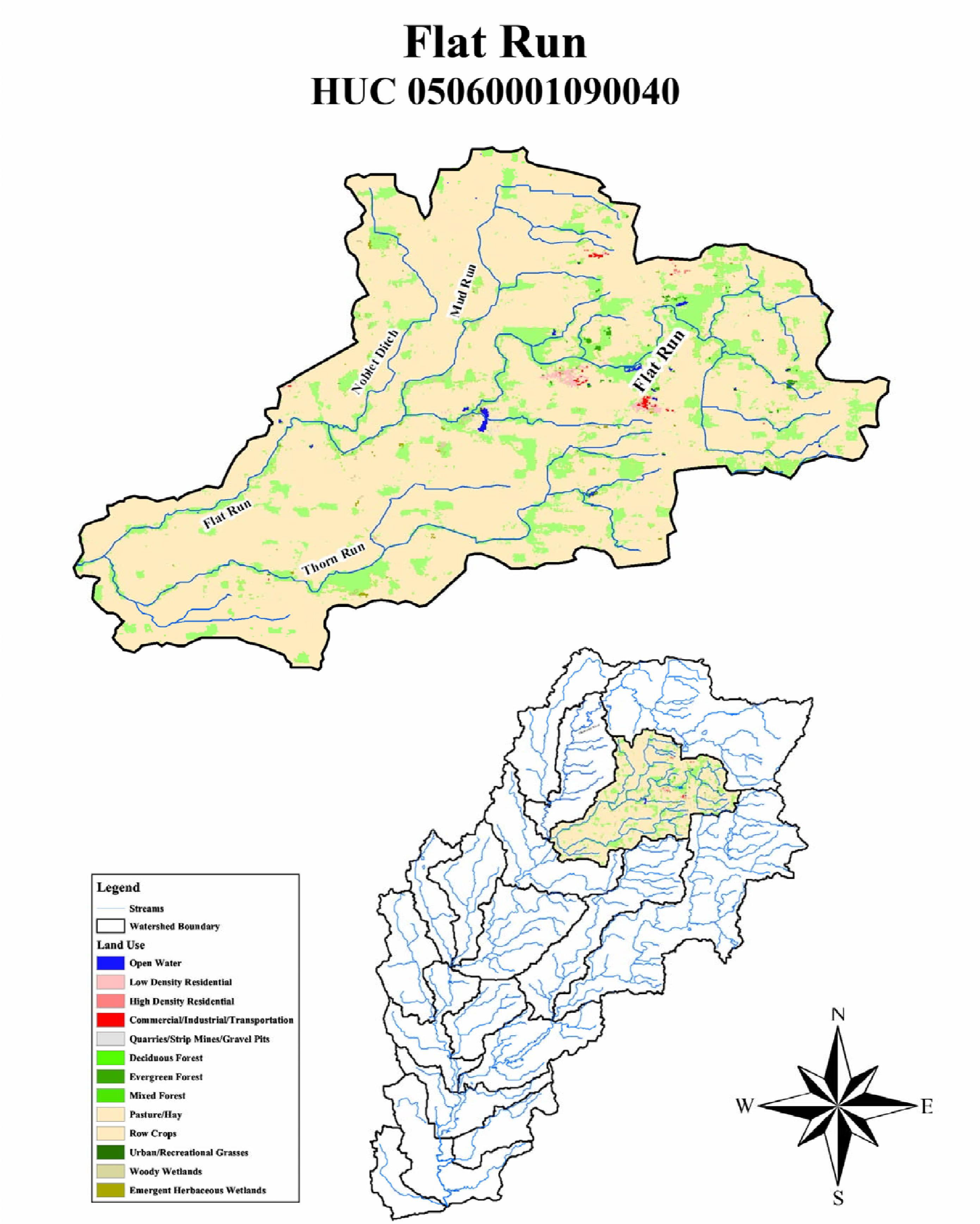
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
35%	50%	10%	5%	40	28%	34%	9%	29%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA)

Subwatershed Total Acres
13,139.3

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 35-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Flat Run
HUC 05060001090040
Mud Run
Noblet Ditch
Flat Run
Flat Run
Thorn Run
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
N
W
E
S

Flat Run Subwatershed

HUC 05060001 090 040

Physical Description:

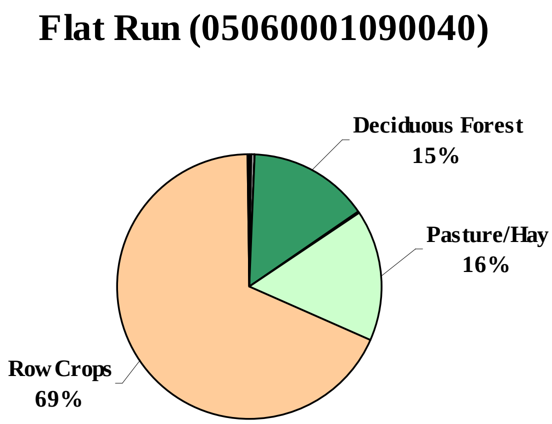
Figure 25: Flat Run with a well attached floodplain running through a wooded area

The Flat Run subwatershed is a predominantly agricultural watershed, but streams and ditches in the watershed were natural or have recovered from channelization. The watershed is 27,211.9 acres and 84% of which is agricultural lands. It is designated as a Warm Water Habitat and met this designation for both 1994 and 2003 biological sampling(Appendix B). Channel modifications were listed as a threat to impairment and several sites had low QHEI scores. Water quality results show violations of f. coliform, e. coli., phosphorus, and nitrate-nitrite

There are approximately 68.2 miles of natural streams and ditches in the Flat Run subwatershed, some of which were channelized at some time and no active maintenance on agricultural ditches was reported. It was noted that several landowners did maintain small sections, but on a small scale. About 15% of the watershed is forested and a large portion of that is located adjacent to Flat Run and other tributaries. No adverse impacts from livestock were noted which is consistent with our estimates of <100 cattle in the watershed.

Number of acres in row crop agriculture was calculated to be approximately 18,500 acres with corn, soybeans, wheat, and hay at 35%, 48%, 13% and 4%, respectively. Tillage types include 40% conventional tillage, 35% no-till, and 25% mulch tillage.

A survey of aerial photos showed 3936.1 acres of riparian buffer and 229.0 acres of riparian or buffer area needed to have a minimum of 33 feet of buffer on all streambanks. Because of the large amount of riparian buffer on Flat Run filter strips should be adequate to reduce sediments. While other tributaries like Thorn Run may suffer from legacy impacts of channelization and removal of riparian vegetation. Other problems include an estimated 40% of the 900 septic systems that require upgrade or replacement. Much public comment was received regarding septic systems and several small communities including Iberia and Martel are good candidates for package treatment system construction.



Land Use	%
Open Water	0.15
Low Density Residential	0.25
Comm./Ind./Trans.	0.08
Deciduous Forest	14.80
Evergreen Forest	0.15
Pasture/Hay	16.03
Row Crops	68.07
Woody Wetlands	0.30
Emergent Herb. Wetlands	0.10

Figure 26: Land use breakdown of Flat Run Subwatershed.

Flat Run Subwatershed
HUC 05060001 090 040

IMPAIRMENT: Nutrients, Sediment, and Pathogens

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, all segments of the Rocky Fork subwatershed are meeting expected use designation. Row crop agriculture, lack of proper waste treatment, channel modifications, and embedded substrates has been identified as significant sources of nutrients, sediment, and pathogens.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nutrient export from subsurface drains; reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 13 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Flat Run Subwatershed**.** Table 14 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Flat Run Subwatershed

- Reduce phosphorus and sediment loading by 6.6 and 10,550 tons/year, respectively, through the adoption of 1,500 acres of residue management; 1,500 acres of cover and manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 50 acres of filter strips; 30 acres riparian buffers; and, constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (3.41E+15 count/ml) from home sewage treatment systems (HSTS) by replacing or upgrading 100 systems and construction of a centralized sewer collection and treatment system.

Table 13: Cause of impairment, and approach to addressing problem and documenting improvement in the Flat Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients, Temperature	1. Establish 30 acres of riparian corridor	$82,800 30 acres * $660 per acre + 30 acres * $140 per acre per year * 15 years	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2011	Document acres of riparian planted Calculate load reduction

Habitat Alteration, Sediment, Nutrients,	2. Establish 50 acres of filter strip	$116,500 50acres * $230 per acre for installation + 50 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	3. Residue management, cover and green manure crop, conservation tillage	$405,000 1,500 acres of residue management * $12/acre * 10 years + 1500 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crops, crop rotation, conservation tillage Calculate load reduction
Nitrate	4. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstrat ion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Nutrients, Habitat	5. Construction of 2 miles of two-stage ditch	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathogens	6. Septic system replacement or upgrade	$1,200,000 100 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Atrazine, pesticides	7. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
	8. Construction of treatment facility		DEFA		
Wetland Habitat	9. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Figure 27: Representative edge of field and drainage ditch settings in the Flat Run Subwatershed.

Table 14: Summary of Ohio EPA water quality and biological sampling results from the Flat Run Subwatershed.

Upper Olentangy Watershed Inventory
Flat Run Subwatershed
HUC 05060001 090 040

Check this table it

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Flat Run Watershed	360,096	52,800			NAMR*	936.1[1]	229.0[2]/473.1[3]	Yes	NA	No	81
Flat Run					NAMR*						
Thara Run					NAMR*						
Noble Ditch					NAMR*						
Mud Run					NAMR*						
TOTAL	360,096	307,296			NAMR*						
Miles =	68.2	10.0			NAMR*						

*NAMR = No Active Maintenance Reported

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	<100	NA	NA	NA	NA	NA

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % Failing systems	Estimated # of failing systems
900	40	360

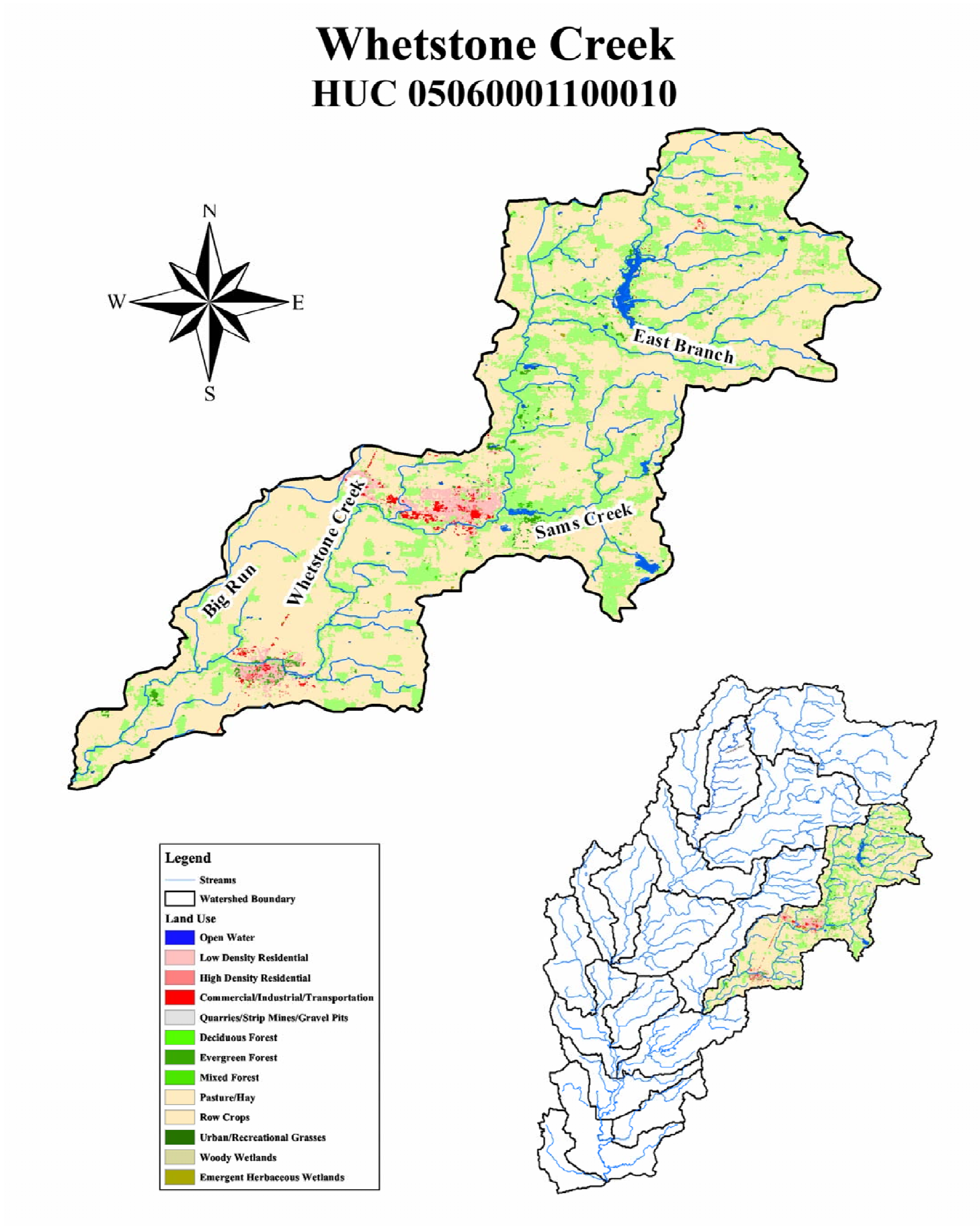
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
35%	48%	13%	4%	50	35%	25%	0%	40%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
27,211.9

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Whetstone Creek
HUC 05060001100010
N
W
E
S
East Branch
Sams Creek
Whetstone Creek
Big Run
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands

Whetstone Creek Subwatershed

HUC 05060001 100 0010

Physical Description:

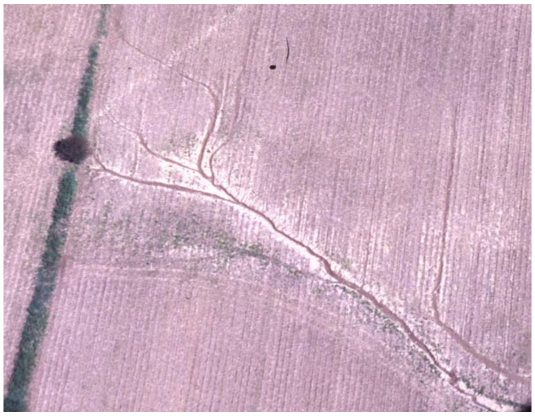


Figure 28: Ephemeral gully erosion from farm fields.

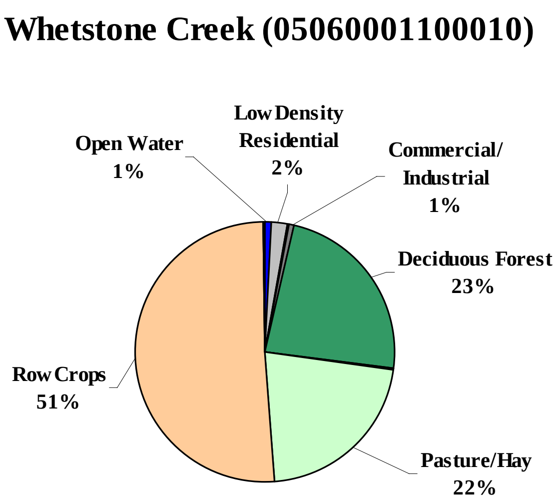
The Whetstone Creek subwatershed is the largest subwatershed in the Upper Olentangy watershed at 40,206.9 acres. Although this watershed is highly agricultural a fair amount of riparian area (23.3%) remains because of the rolling topography and greater difficulty for farming operations near streams. Portions of the Whetstone River main stem were designated Exceptional Warm Water Habitat during the 1994 sampling season (Appendix B). Biological sampling did show evidence of non attainment at several locations and nutrient enrichment from point source discharges and livestock are primary causes of impairment. Agriculture was also listed as a source of sediment. Results from water quality sampling showed repeated violations of water quality standards for bacteria. Recent development and inability to treat large volumes of waste including urban runoff are suspected for violations.

Figure 29: A dam outside of Cardington, OH.

There are approximately 104.6 miles of streams and ditches in the Whetstone Creek subwatershed. A review of aerial photos indicates that 79.9 of stream miles were channelized at some time. Field surveys tend to indicate that many stream miles are recovering and little active cleaning or maintenance is performed on ditches. About 50% (20,400 acres) of the watershed is used to produce row crops and corn, soybeans, wheat, and hay constitute 40%, 40%, 15%, and 5% of production. Roughly 12,240 acres are conventionally tilled. Unrestricted livestock access is a problem with cattle operations causing a majority of sediment and habitat impairments.

A survey of aerial photos showed 1709.2 acres of riparian buffer and 339.7 acres of riparian or buffer area needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 300 septic systems that require upgrade or replacement. Many of these problems could be improved if residents near Mt. Gilead and Cardington were required to hook into existing sewerage systems. This could increase problems though as the City of Mt. Gilead and Village of Cardington was noted to have difficulty treating waste loads during high flow conditions in 2003. Rapid development is also a concern and expected to continue to grow.

Many of the soils in Morrow County are not well suited for septic systems, but home buyers looking for 5 acre lots continue to install.



Land Use	%
Open Water	0.93
Low Density Residential	1.85
High Density Residential	0.21
Comm./Ind./Trans.	0.52
Deciduous Forest	23.29
Evergreen Forest	0.43
Mixed Forest	0.09
Pasture/Hay	21.62
Row Crops	50.74
Urban/Rec. Grasses	0.16
Woody Wetlands	0.07
Emergent Herb. Wetlands	0.08

Figure 30: Land use breakdown of Whetstone Creek Subwatershed.

Whetstone Creek Subwatershed
HUC 05060001 100 010

IMPAIRMENT: Nutrients, Sediment, Habitat Alteration, and Pathogens

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, many segments of the Whetstone Creek subwatershed are not meeting expected use designation. Point source discharges from municipal waste treatment, failing septic systems, and row crop and livestock agriculture are significant sources of nutrients, sediment, and bacteria.

Goals

The overall goals are to reduce sedimentation, nutrient enrichment, and habitat alterations; reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; and reduce nutrients derived from failing septic systems. Potential implementation objectives are presented below, and Table 15 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Whetstone Creek Subwatershed**.** Table 16 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Whetstone Creek Subwatershed

- Reduce phosphorus and sediment loading by 5 and 10,399 tons/year, respectively, through the installation of 30,000 lineal feet of grassed waterways; adoption of 1,500 acres of residue management; 1,500 acres cover and green manure crop; 500 new acres of no-till or other conservation tillage practice: 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 3 waste facilities, 4 manure compost facilities, 20 livestock use protection areas, and 5 watering facilities.
- Improve riparian habitat and QHEI scores, decrease temperature, reduce nutrients, and sediment loads by implementing 249.7 acres of filter strips; 90 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (2.79E+15 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***300*** (of 2000) systems with improved on-site treatment systems or collection sewers.

Table 15: Cause of impairment, and approach to addressing problem and documenting improvement in the Whetstone Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$324,500 for fence and other practices $45,000 (3 waste facilities * $15,000 per facility) + $52,000 (20,000 ft * $2.60/ft) for fencing + $60,000 ($15, 000 per composting facility * 4 facilities) + $160,000 (20 livestock use protection areas * $8,000) + $7,500 (5 watering facilities * $1,500)	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Atrazine, pesticides	2. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Habitat Alteration, Sediment, Nutrients, Temperature	3. Establish 90 acres of riparian corridor	$249,000 90 acres * $660 per acre + 90 acres * $140 per acre per year * 15 years	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2011	Document acres of riparian planted Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	4. Establish 249.7 acres of filter strip	$581,800 249.7 acres * $230 per acre for installation + 249.7 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	5. Residue management, cover and green manure crop, conservation tillage	$405,000 1,500 acres of residue management * $12/acre * 10 years + 1500 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crops, crop rotation, and conservation tillage Calculate load reduction
Sediment, Nutrients	6. Grass waterways	$105,000 30,000 ft * $3/ft + $15,000 for auxiliary practices	Farm Bill	Jan. 2006 to January 2009	Document amount of grassed waterway installed

Nutrients, Pathogens	7. Septic system replacement or upgrade	$3,600,000 300 systems @ $12,000 each	DEFA	Jan. 2006 to January 2015	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Wetland Habitat	8. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nitrate	9. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstrat ion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions

Figure 31: Representative edge of field and drainage ditch settings in the Whetstone Creek Subwatershed.

Table 16: Summary of Ohio EPA water quality and biological sampling results from the Whetstone Creek Subwatershed.

Upper Olentangy Watershed Inventory
Whetstone Creek Subwatershed
HUC 05060001 100 010

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Whetstone Creek Watershed	552,288	421,872			NAMR*	1709.2[1]	350.7[2]/700.2[3]	Yes	37	Yes	123
Whetstone Creek					NAMR*						
Big Run					NAMR*						
Sams Creek					NAMR*						
East Branch					NAMR*						
TOTAL	552,288	421,872			NAMR*						
Miles =	104.6	79.9			NAMR*						

*NAMR = No Active Maintenance Reported

Livestock Inventory	Cattle	Dairy	Swine	Sheep	Chickens	Horses
Totals	1450	NA	1500	50	12,000	100

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
2000	15	300

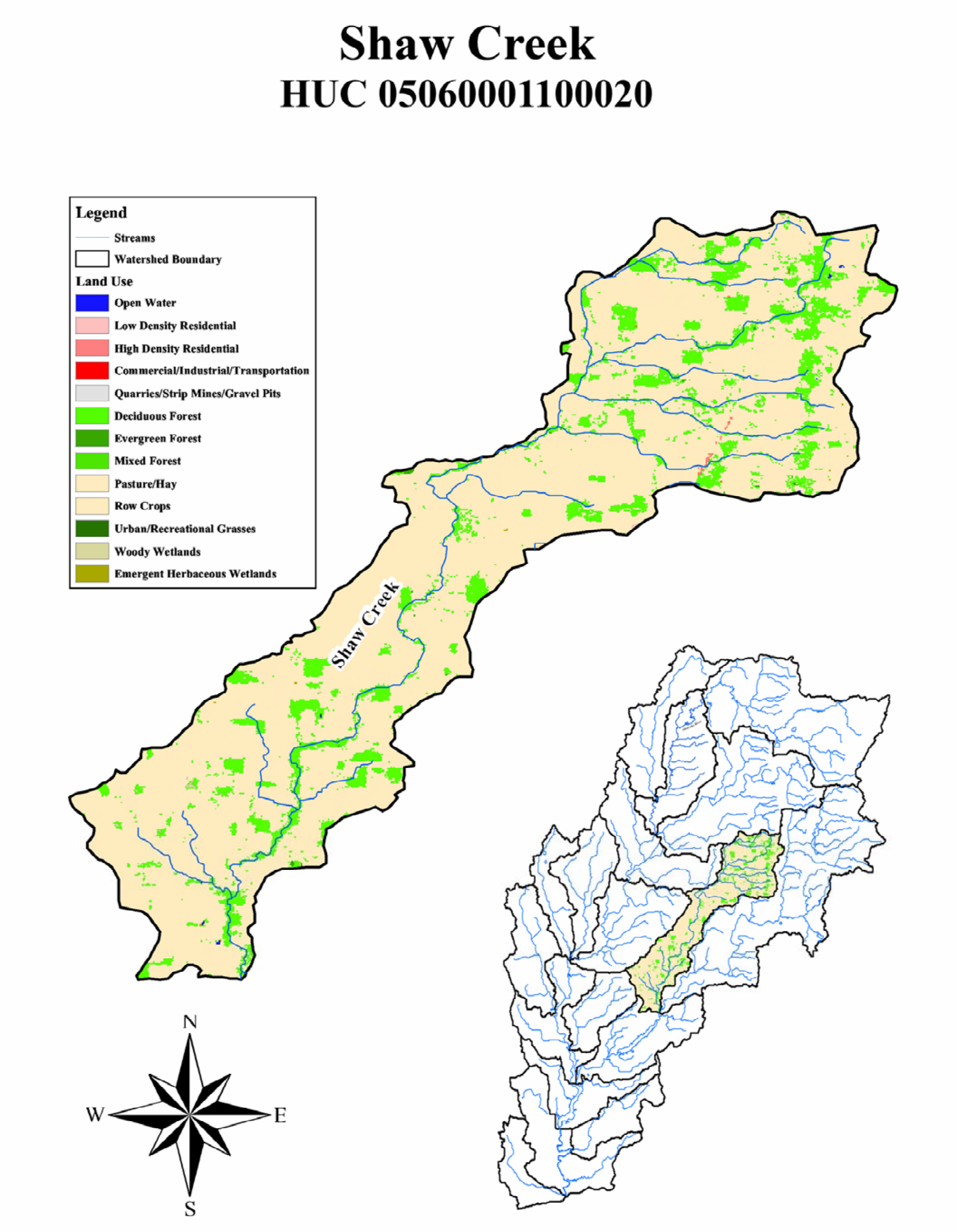
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
40%	40%	15%	5%	1000	40%	0%	0%	60%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
40,206.9

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Shaw Creek
HUC 05060001100020
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
Shaw Creek
N
W
E
S

Shaw Creek Subwatershed

HUC 05060001 100 0020

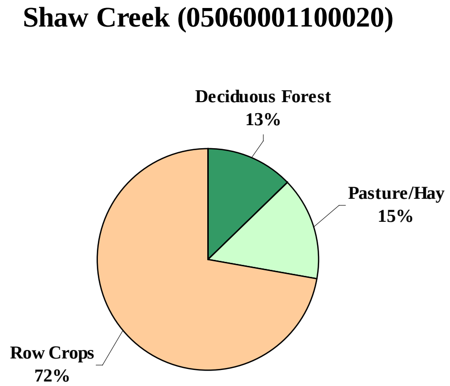
Physical Description:

Figure 32: Channelized section of Shaw Creek

The Shaw Creek subwatershed is a 19,182. 8 acre watershed designated as an Exceptional Warm Water Habitat. Biological sampling in 2003 showed two reaches that were not meeting use designation (Appendix B). Impairments from channel modification, siltation, nutrient enrichment, and bacteria were caused by agricultural activities and failing septic systems. Results from water quality sampling showed numerous violations of water quality standards for fecal coliform and E. coli.

There are 46.2 miles of streams and tributaries in the Shaw Creek subwatershed. Roughly 27.0 miles appear to have been channelized at some time although little active maintenance occurs and some ditches are recovering. Crops grown in the watershed include corn (40%), soybeans (43%), wheat (15%), and hay (2%). A large portion (65%) of row crop production utilizes conventional methods for tillage operations. Several sites were identified to have unrestricted livestock access and likely contribute nutrients, sediment, bacteria, and degraded habitat conditions.

A survey of aerial photos showed 480.4 acres of riparian buffer and 185.8 acres of riparian or buffer area needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 78 septic systems that require upgrade or replacement.



Land Use	%
Open Water	0.03
Low Density Residential	0.01
Comm./Ind./Trans.	0.06
Deciduous Forest	12.59
Evergreen Forest	0.09
Mixed Forest	0.01
Pasture/Hay	14.92
Row Crops	72.18
Woody Wetlands	0.08
Emergent Herb. Wetlands	0.03

Figure 33: Land use breakdown of Shaw Creek Subwatershed.

Shaw Creek Subwatershed
HUC 05060001 100 020

IMPAIRMENT: Nutrients, Sediment, Habitat Alterations, and Pathogens

Goals

The overall goals are to reduce sedimentation, nutrient enrichment, and habitat alterations; reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; and reduce nutrients derived from failing septic systems. Potential implementation objectives are presented below, and Table 17 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Shaw Creek Subwatershed**.** Table 18 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Shaw Creek Subwatershed

- Reduce phosphorus and sediment loading by 4.3 and 6,425 tons/year, respectively, through the installation of 30,000 lineal feet of grassed waterways; adoption of 1,500 acres of residue management; 1,500 acres cover and green crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or

riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.

- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 2 waste facilities, 2 manure compost facilities, 5 livestock use protection areas, and 5 watering facilities.
- Improve riparian habitat and QHEI scores, decrease temperature, reduce nutrients, and sediment loads by implementing 145.8 acres of filter strips; 40 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (7.27E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***78*** (of 310) systems with improved on-site treatment systems or collection sewers.

Table 17: Cause of impairment, and approach to addressing problem and documenting improvement in the Shaw Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$128,300 for fence and other practices $30,000 (2 waste facilities * $15,000 per facility) + $20,800 (8,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $40,000 (5 livestock use protection areas * $8,000) + $7,500 (5 watering facilities * $1,500)	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Habitat Alteration, Sediment, Nutrients, Temperature	2. Establish 40 acres of riparian corridor	$110,400 40 acres * $660 per acre + 40 acres * $140 per acre per year * 15 years	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2011	Document acres of riparian planted Calculate load reduction

Habitat Alteration, Sediment, Nutrients,	3. Establish 145.8 acres of filter strip	$340,000 145.8 acres * $230 per acre for installation + 145.8 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	4. Residue management, cover and green manure crop, conservation tillage	$405,000 1,500 acres of residue management * $12/acre * 10 years + 1500 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crops, crop rotation, and conservation tillage Calculate load reduction
Sediment, Nutrients	5. Grassed waterways	$70,000 20,000 ft * $3/ft + $10,000 for auxiliary practices	Farm Bill,	Jan. 2006 to January 2009	Document amount of grassed waterway installed
Nutrients, Pathogens	6. Septic system replacement or upgrade	$936,000 78 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Atrazine, pesticides	7. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Wetland Habitat	8. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nitrate	9. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstration, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions

Figure 34: Representative edge of field, drainage ditch, and cattle settings near streams in the Shaw Creek Subwatershed.

Table 18: Summary of Ohio EPA water quality and biological sampling results from the Shaw Creek Subwatershed.

Upper Olentangy Watershed Inventory
Shaw Creek Subwatershed
HUC 05060001 100 020

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Shaw Creek Watershed	243,936	142,560			NAMR*	488.4[1]	185.8[2]/385.4[3]	Yes	15	Yes	55
Shaw Creek					NAMR*						
TOTAL	243,936	142,560			NAMR*						
Miles =	46.2	27			NAMR*						

*NAMR = No Active Maintenance Reported

Livestock Inventory	Cattle	Dairy	Swine	Sheep	Chickens	Horses
Totals	450	NA	2500	NA	NA	40

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
310	25	78

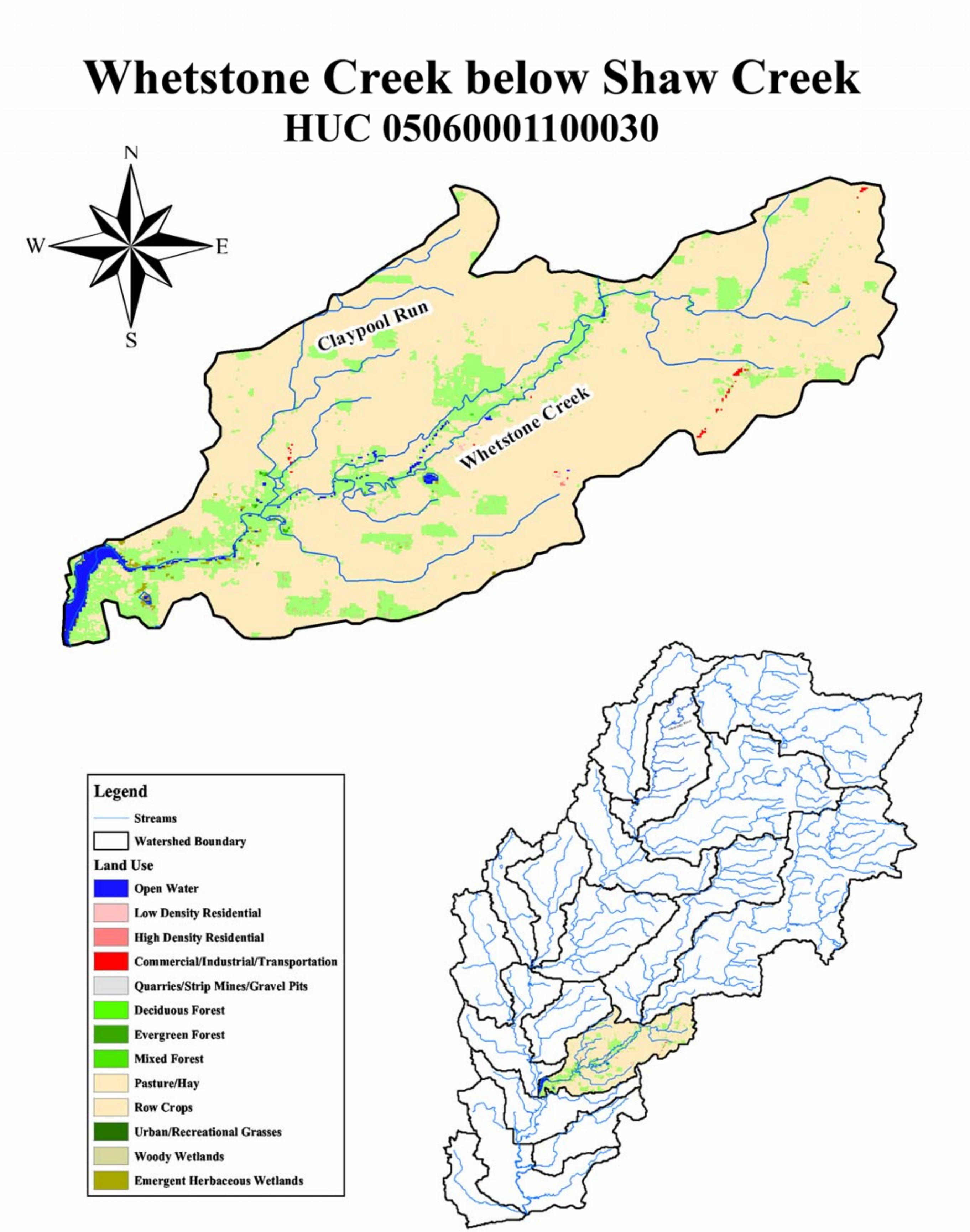
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
40%	43%	15%	2%	150	35%	0%	0%	65%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA)

Subwatershed Total Acres
19,182.8

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Whetstone Creek below Shaw Creek
HUC 05060001100030
N
W
E
S
Claypool Run
Whetstone Creek
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands

.

Whetstone Creek below Shaw Creek Subwatershed

HUC 05060001 100 0030

Physical Description:

Figure 35: A wooded section of Whetstone Creek.

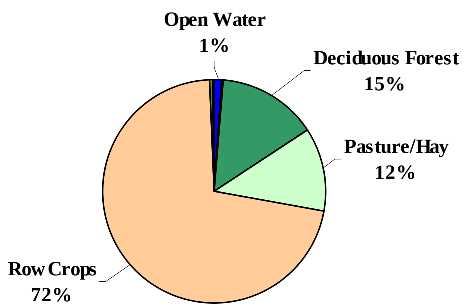
The Whetstone Creek below Shaw Creek mainstem is designated as an Exceptional Warm Water Habitat. It did not meet its' designated use at the only biological sampling site in 2003. Tributaries to the Whetstone are designated as Warm Water Habitat and the only site sampled did not meet expected use status (Appendix B). Water quality sampling revealed violations of bacteria including fecal coliform and e. coliform at several locations. Siltation and flow alteration from Delaware Dam are listed as primary sources of impairment in this watershed.

Figure 36: Agricultural ditch tributary to Whetstone Creek.

The watershed drains 13,890.7 acres of mostly agricultural land. An estimated 9974.1 acres of row crops are divided between corn (41%), soybeans (46%), wheat (10%), and hay (3%). Conventional methods are for 40% of tillage operations. Horses (<50), owned by private residents, were the only livestock reported in the watershed and no unrestricted access to streams was identified during watershed surveys. There are 29.4 miles of streams and tributaries in the watershed. An estimated 20.8 miles which appear to have been channelized or constrained by development at some time. No active maintenance was reported and is not thought to be a systematic problem throughout the watershed.

A survey of aerial photos showed 317.9 acres of riparian buffer and 97.6 acres of riparian or buffer area needed to have a minimum of 33 feet of buffer on all stream banks. Other problems include an estimated 86 septic systems that require upgrade or replacement.

Whetstone Creek below Shaw Creek (05060001100030)



Land Use	%
Open Water	1.14
Low Density Residential	0.03
High Density Residential	0.01
Comm./Ind./Trans.	0.10
Deciduous Forest	14.57
Evergreen Forest	0.05
Mixed Forest	0.02
Pasture/Hay	11.75
Row Crops	71.81
Woody Wetlands	0.26
Emergent Herb. Wetlands	0.28

Figure 37: Land use breakdown of Whetstone Creek below Shaw Creek Subwatershed.

Whetstone Creek below Shaw Creek Subwatershed HUC 05060001 100 030

IMPAIRMENT: Nutrients, Sediment, Habitat Alteration, and Pathogens

Background

Results of water quality sampling suggest that bacteria related impairment and flow alteration are the most significant sources of impairment in the watershed. QHEI scores did appear low at the sampled sites and improvement in riparian condition and channel geomorphology could provide benefits to these systems.

Figure 38: Small channel with attached floodplain.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 19 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Whetstone Creek below Shaw Creek Subwatershed**.** Table 20 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Whetstone Creek below Shaw Creek Subwatershed

- Reduce phosphorus and sediment loading by 2.9 and 3,386 tons/year, respectively, through the installation of 8,000 lineal feet of grassed waterways; adoption of 1,000 acres of residue management; 1,500 acres cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, decrease temperature, reduce nutrients, and sediment loads by implementing 67.6 acres of filter strips; 30 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (8.02E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***86*** (of 430) systems with improved on-site treatment systems or collection sewers.

Table 19: Cause of impairment, and approach to addressing problem and documenting improvement in the Whetstone Creek below Shaw Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients, Temperature	1. Establish 30 acres of riparian corridor	$82,800 30 acres * $660 per acre + 30 acres * $140 per acre per	Farm Bill, USDA, Division of Wildlife, EQIP, US	Jan. 2006 to January 2011	Document acres of riparian planted Calculate load reduction

		year * 15 years	Fish and Wildlife Service		
Habitat Alteration, Sediment, Nutrients,	2. Establish 67.6 acres of filter strip	$157,500 67.6 acres * $230 per acre for installation + 67.6 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Wetland Habitat	3. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, USFW	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Atrazine, pesticides	4. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Sediment, Nutrients	5. Residue management, cover and green manure crop, conservation tillage	$345,000 1,000 acres of residue management * $12/acre * 10 years + 1500 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crops, crop rotation, conservation tillage Calculate load reduction
Nitrate	6. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstrat ion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Nutrients	7. Grassed waterways	$29,000 8,000 ft * $3/ft + $5,000 for auxiliary practices	Farm Bill	Jan. 2006 to January 2009	Document amount of grassed waterway installed
Nutrients, Pathogens	8. Septic system replacement or upgrade	$1,032,000 86 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Sediment, Habitat and Flow Alterations	9. Two-stage ditch design and construction	$111,000 3 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide

					load reductions, habitat development, flood storage increase

Table 20: Summary of Ohio EPA water quality and biological sampling results from the Whetstone Creek below Shaw Creek Subwatershed.

Upper Olentangy Watershed Inventory
Whetstone Creek below Shaw Creek Subwatershed
HUC 05060001 100 030

Stream Name	Length (ft)	Channelized (ft)	Leveed (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Whetstone Creek below Shaw Creek Watershed	155,232	109,824			NAMR*	317.9[1]	97.6[2]/203.5[3]	Yes	14	Yes	33
Whetstone Creek					NAMR*						
Claypool Run					NAMR*						
TOTAL	155,232	109,824			NAMR*						
Miles =	29.4	20.8			NAMR*						

*NAMR = No Active Maintenance Reported

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	NA	NA	NA	NA	NA	<50

* [illegible]

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
430	20	86

* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
41%	46%	10%	3%	NA	60%	0%	0%	40%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
13,890.7

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks

Otter Creek Subwatershed

HUC 05060001 110 010

Physical Description:

Figure 39: Olentangy River in Otter Creek subwatershed.

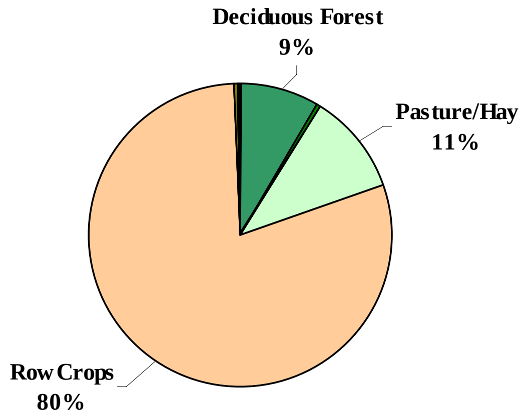
The Otter Creek subwatershed includes a portion of the Olentangy River, Otter Creek, Bee Run, and Muskrat Ditch. The watershed drains 14,906.6 acres including 11,889.5 acres of row crops. It is designated as a Warm Water Habitat and did not fully meet its use designation at Olentangy RM 56.6 because of nutrient enrichment, siltation, and habitat alteration (Appendix B). Livestock and point source discharges from the Caledonia Waste Treatment Plant were cited as causes of impairment. Results from water quality samplings in 2003 indicate nutrient enrichment from phosphorus and nitrate-nitrite. Elevated bacteria levels exceeded or violated recreational and aquatic water quality standards at all sites. Various metal concentrations did exceed criteria, but are not considering the primary source of impairment.

There are approximately 26.7 miles of streams and tributaries in the Otter Creek subwatershed. Historically, much of the watershed (21.9 miles) was channelized, but little active maintenance is performed and many channels are recovering, albeit at a slow rate. As mentioned earlier the watershed is highly devoted to agriculture with over 90% of acreage in production. Forested lands make up ~8.5% of land use and the remaining area is open water, wetlands, and a small amount of development. There is a small amount of livestock in the watershed and several instances of unrestricted access were noted. These problems were not widespread and could be easily remedied with exclusion fencing with a few other auxiliary practices. The acreage in agricultural production is primarily corn and soybeans with 35% and 50% respectively. The remainder of agricultural land is planted in hay, wheat, or other small grains. It is estimated that 40% or 4755.8 acres of land is conventionally tilled. Most acres conventionally tilled are for corn.

Figure 40: A recovering agricultural ditch in the watershed.

A survey of aerial photos showed 241.5 acres of riparian or buffer and 125.9 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 50 septic systems that require upgrade or replacement.

Otter Creek (05060001110010)



Land Use	%
Open Water	0.04
Low Density Residential	0.07
High Density Residential	0.01
Comm./Ind./Trans.	0.03
Deciduous Forest	8.59
Evergreen Forest	0.06
Mixed Forest	0.02
Pasture/Hay	10.88
Row Crops	79.76
Woody Wetlands	0.34
Emergent Herb. Wetlands	0.19

Figure 41: Land use breakdown of Otter Creek Subwatershed.

Otter Creek Subwatershed
HUC 05060001 110 010

IMPAIRMENT: Nutrients, Sediment, Habitat Alteration, and Pathogens

Background

Figure 42: Agricultural ditch flanked by corn fields.

Based on water quality and biological sampling completed 2003 by the Ohio EPA, segments of the Otter Creek subwatershed are not meeting expected use designation. Row crop and livestock agriculture, and municipal waste treatment have been identified as significant sources of nutrients and sediment. QHEI scores were typically below the recommended level for Warm Water Habitat. Although some ditches are recovering these low energy systems may not have a geometry that would allow quicker recovery with enhanced water quality benefits.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 21 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Otter Creek Subwatershed**.** Table 22 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Otter Creek Subwatershed

- Reduce phosphorus and sediment loading by 3.4 and 3,352 tons/year, respectively, through the adoption of 1,600 acres of residue management; 1,000 acres cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, and 8 watering facilities.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 89.5 acres of filter strips; 40 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (4.65E+15 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***50*** (of 200) systems with improved on-site treatment systems or collection sewers.

Table 21: Cause of impairment, and approach to addressing problem and documenting improvement in the Otter Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and	1. Identify livestock producers in the subwatershed	$242,000 for fence and other practices $90,000	Farm Bill, USDA, Division of Wildlife,	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated

Flow Alterations	where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	(6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	EQIP, US Fish and Wildlife Service		from modeling activities
Habitat Alteration, Sediment, Nutrients,	2. Establish 89.5 acres of filter strip	$181,000 89.5 acres * $230 per acre for installation + 85.9 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	3. Residue management, cover and green manure crop, conservation tillage	$342,000 1,600 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crops, crop rotation, and conservation tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	4. Establish 40.0 acres of riparian buffer	$111,000 40.0 acres * $660 per acre for installation + 40.0 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Nitrate	5. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstration, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Habitat and Flow Alterations	6. Two-stage ditch design and construction	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathogens	7. Septic system replacement or upgrade	$600,000 50 systems * $12,000 per system	Revolving loan fund, federal grant, state	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient

			grant		and pathogen load reductions
Atrazine, pesticides	8. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions

Figure 43: Representative drainage ditches and modified stream in the Otter Creek Subwatershed.

Table 22: Summary of Ohio EPA water quality and biological sampling results from the Otter Creek Subwatershed.

Upper Olentangy Watershed Inventory
Otter Creek Subwatershed
HUC 05060001 110 010

Stream Name	Length (ft)	Channelized (ft)	Leveed (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Otter Creek Watershed	140,976	115,632			Unknown	241.5[1]	125.9[2]/243.3[3]	Yes	8	Yes	29
Otter Creek					Unknown						
Olentangy River					Unknown						
Muskrat Ditch					Unknown						
Bee Run Ditch					Unknown						
TOTAL	140,976	115,632			Unknown						
Miles =	26.7	21.9			Unknown						

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	<200	NA	NA	NA	NA	NA

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
200	25	50

* Estimates based on survey given to County Health Departments

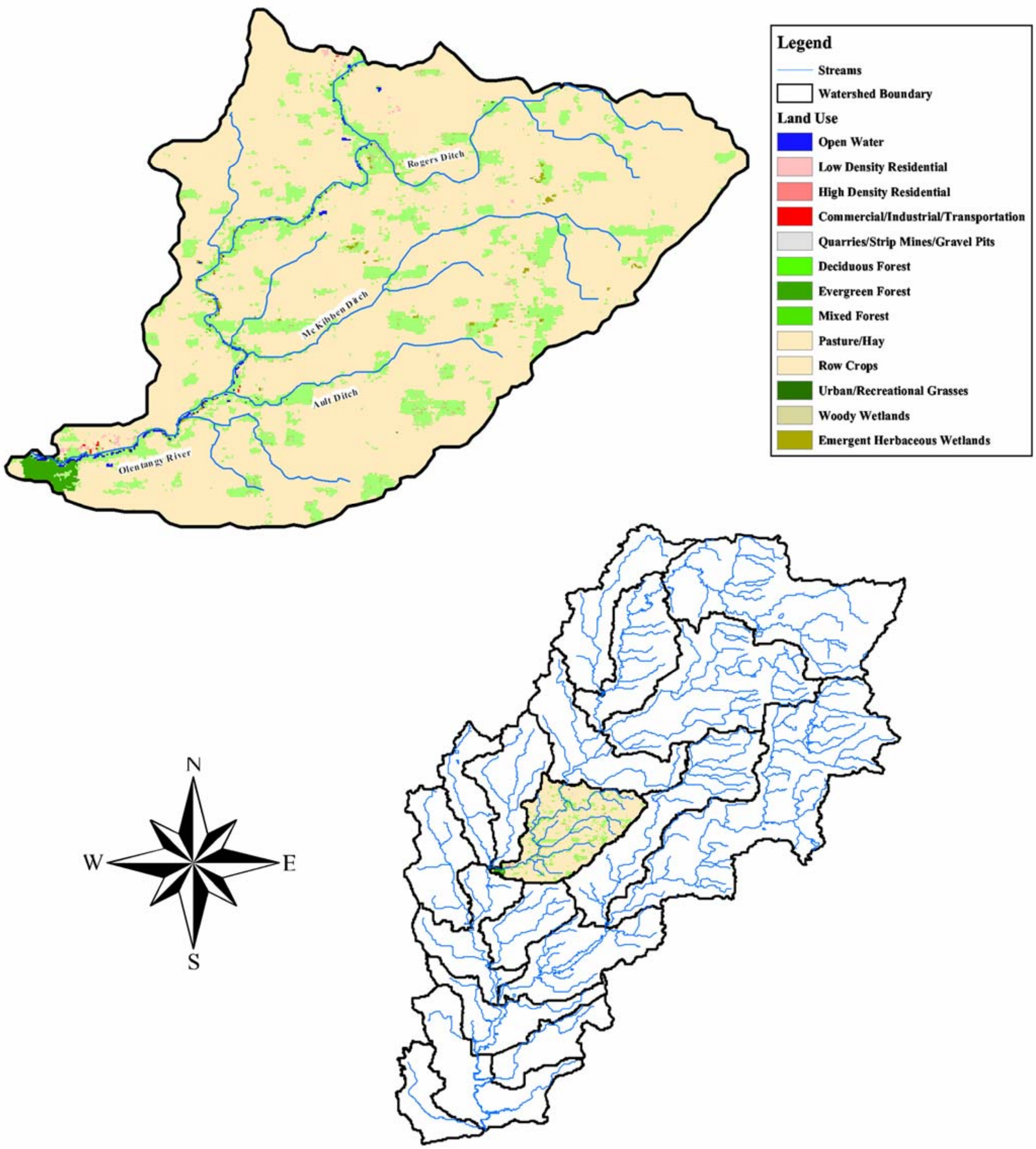
Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
35%	50%	7%	8%	800	30%	30%	0%	40%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
14,906.6

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33 ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66 ft buffer on all streambanks

Olentangy River at Otter Creek
HUC 05060001110020



Olentangy River at Otter Creek Subwatershed

HUC 05060001 110 020

Physical Description:

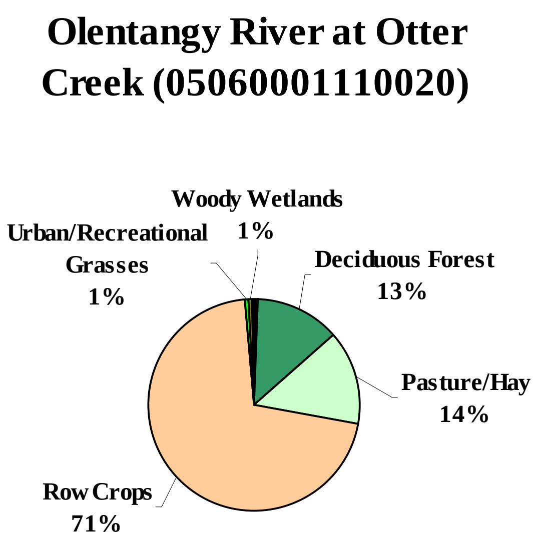
Figure 44: Olentangy River in the Olentangy River at Otter Creek subwatershed.

The Olentangy River at Otter Creek subwatershed extends from Otter Creek to Olentangy River Mile 45.5. The watershed drains 15,276.3 acres and 10,820 (71%) of which are in row crop agriculture. The watershed is designated a Warm Water Habitat and biological sampling sites met use designation except for Olentangy River RM 54.7 (Appendix B). This section was impaired from discharges at the Caledonia Waste Treatment Plant. Results from water quality sampling showed violations of F. coliform, e. coli., nitrate-nitrite and phosphorus.

There are approximately 33.1 miles of streams and tributaries in the watershed. About 25.6 miles of which appear to have some degree of channelization at some time, although many miles have recovered and no stream miles were reported as actively maintained. Row crops comprise the largest land use with corn, soybeans, wheat, and hay making up 35%, 50%, 7%, and 8%, respectively. Other land uses include forest (13%), wetlands (1%), and pasture or hay (14.5%). Very little livestock is raised in the watershed with less than 100 head each of cattle, sheep, and horses. Approximately 40% of the row crop agriculture is conventional tilled (4328 acres) with most of conventional tilled acres being corn.

Figure 45: Channelized tributary to the Olentangy River.

A survey of aerial photos showed 398.9 acres of riparian or buffer and 75.2 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 60 septic systems that require upgrade or replacement.



Land Use	%
Open Water	0.34
Low Density Residential	0.13
High Density Residential	0.00
Comm./Ind./Trans.	0.02
Deciduous Forest	12.75
Evergreen Forest	0.02
Mixed Forest	0.01
Pasture/Hay	14.44
Row Crops	70.83
Urban/Recreational Grasses	0.65
Woody Wetlands	0.51
Emergent Herb. Wetlands	0.29

Figure 46: Land use breakdown of Olentangy River at Otter Creek Subwatershed.

Olentangy River at Otter Creek Subwatershed
HUC 05060001 110 020

IMPAIRMENT: Nutrients, Sediment, Pathogens, and Habitat Alteration

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, a portion of the Olentangy River at Otter Creek subwatershed are not meeting expected use designation. Other segments marginally meet expected use. Row crop agriculture, channel modifications and municipal waste treatment have been identified as significant sources of nutrients, sediment, and bacteria.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 23 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Olentangy River at Otter Creek Subwatershed**.** Table 24 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Olentangy River at Otter Creek Subwatershed

- Reduce phosphorus and sediment loading by 4.2 and 5,133 tons/year, respectively, through the adoption of 3,000 acres of residue management; 3,000 acres cover and green manure crop; 500 new acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%; sediment loading, nutrient loading; and, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, and 8 watering facilities.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 50.2 acres of filter strips; 25 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (5.65E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for ***60*** (of 300) systems with improved on-site treatment systems or collection sewers.

Table 23: Cause of impairment, and approach to addressing problem and documenting improvement in the Olentangy River at Otter Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$242,000 for fence and other practices $90,000 (6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Wetland Habitat	2. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Habitat Alteration, Sediment, Nutrients,	3. Establish 50.2 acres of filter strip	$117,00 50.2 acres * $230 per acre for installation + 50.2 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	4. Residue management, cover, green manure crop, conservation tillage	$810,000 3,000 acres of residue management * $12/acre * 10 years + 3000 acres of cover crop * $15/acre * 10 years	Farm Bill, CRP?, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crops, crop rotations, conservation tillage. Calculate load reduction
Atrazine, pesticides	5. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients	6. Establish Agricultural Drainage Water Management	$150,000 500 acres, on 10 25-	EQIP, 319 funds, CSP,	January 2007 to December	Document acres of treated cropland Calculate nitrate-

	Systems	to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	industry, potential for CIG demonstra tion, others	2010	nitrogen load reductions
Sediment, Nutrients, Habitat	7. Reduce sediment export and improve habitat with design and construction of 2 miles of two-stage ditch	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathogens	8. Septic system replacement or upgrade	$720,000 60 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Habitat Alteration, Sediment, Nutrients,	9. Establish 25 acres of riparian trees	$69,000 *25.0 acres * $660 per acre for installation + 25.0 acres * $140 per acre per year * 15 years	CRP, 319 Grant, Division of Wildlife	Jan. 2006 to January 2009	Document acres of riparian buffer planted Calculate load reduction

Figure 47: Representative drainage ditches and modified stream in the Olentangy River at Otter Creek Subwatershed.

Table 24: Summary of Ohio EPA water quality and biological sampling results from the Olentangy River at Otter Creek Subwatershed.

Upper Olentangy Watershed Inventory
Olentangy River at Otter Creek Subwatershed
HUC 05060001 110 020

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Olentangy River at Otter Creek Watershed	174,768	135,168			Unknown	398.9[1]	75.2[2]/160.8[3]	Yes	5	Yes	42
Olentangy River					Unknown						
Rogers Ditch					Unknown						
McKibben Ditch					Unknown						
Ault Ditch					Unknown						
TOTAL:	174,768	135,168			Unknown						
Miles =	33.1	25.6			Unknown						

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	<100	NA	NA	<100	NA	<100

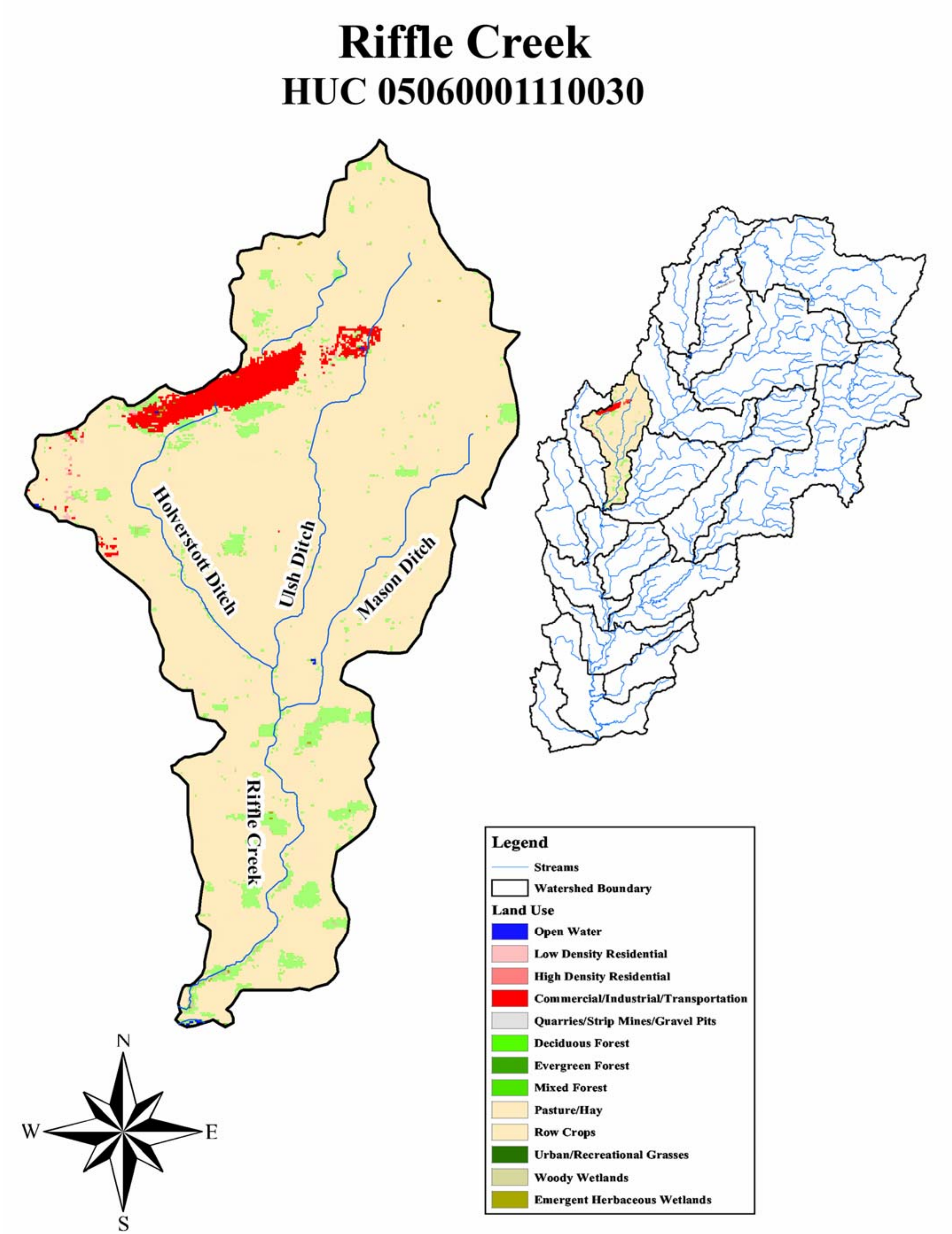
Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
300	20	60

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
35%	50%	7%	8%	360	30%	30%	0%	40%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
15,276.3

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Riffle Creek
HUC 05060001110030
Holverstott Ditch
Ulsh Ditch
Mason Ditch
Riffle Creek
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
N
W
E
S

Riffle Creek Subwatershed

HUC 05060001 110 030

Physical Description:

Figure 48: Agricultural ditch prior to maintenance.

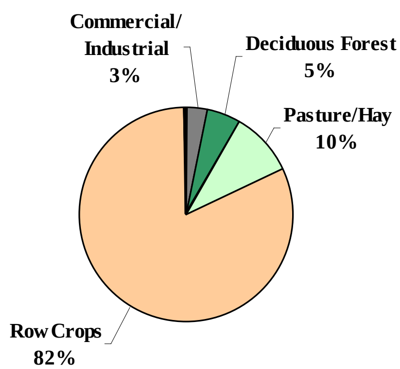
The Riffle Creek subwatershed located in Marion County drains 11,138.4 acres. Most of the watershed is in row crop agriculture, but some growth from the City of Marion is changing land use. Riffle Creek is designated a Modified Warm Water Habitat because of the extensive channelization of along its entire length and regular maintenance activities (Appendix B). A large portion of the watershed was recently maintained in 2004. None of the sample sites of the 2003 study met use designation. Channel modification and related habitat alteration and siltation from agricultural practices is cited as prime sources of impairment. Water chemistry results show violations in water quality standards for bacteria, phosphorus and nitrate-nitrite.

There are approximately18.1 miles of streams and tributaries in the subwatershed and most (~90%; visually estimated) appear to be actively maintained. The watershed is largely agricultural (82%) with corn, soybeans, wheat and hay with 25%, 65%, 5% and 5%, respectively. This watershed has largely adopted reduced methods of tillage, but 20% of the agricultural acres are conventionally tilled. Several farms include a small amount of livestock and several cases of unrestricted access were noted and caused local habitat degradation and sedimentation.

Figure 49: Unrestricted livestock access to a tributary.

A survey of aerial photos showed 97.6 acres of riparian or buffer and 121.8 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all streambanks.

Riffle Creek (05060001110030)



Land Use	%
Open Water	0.06
Low Density Residential	0.13
High Density Residential	0.02
Comm./Ind./Trans.	3.08
Deciduous Forest	5.12
Mixed Forest	0.00
Pasture/Hay	9.57
Row Crops	81.71
Urban/Recreational Grasses	0.01
Woody Wetlands	0.24
Emergent Herb. Wetlands	0.06

Figure 50: Land use breakdown of Riffle Creek Subwatershed.

Riffle Creek Subwatershed
HUC 05060001 110 030

IMPAIRMENT: Nutrients and Sediment

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, various segments of the Grave Creek subwatershed are not meeting the Modified Warm Water Habitat expected use designation. Row crop agriculture has been identified as the most significant source of nutrients and sediment. QHEI scores at several of the sampling sites were quite low and habitat scores likely declined with maintenance activities. Development in the watershed does pose some concern.

Figure 51: Riffle Creek outside of Marion, OH

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 25 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Riffle Creek Subwatershed**.** Table 26 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Riffle Creek Subwatershed

- Reduce phosphorus and sediment loading by 3.2 and 2,856 tons/year, respectively, through the adoption of 1,600 acres of residue management; 1,000 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice, 1,000 acres of reduced rate phosphorus application, and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%, sediment and nutrient loading, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, and 8 watering facilities.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 89.5 acres of filter strips; 40 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (5.19E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for an unknown number of failing systems of the estimated 185 noted, with improved on-site treatment systems or collection sewers. Conduct a survey to document the number of failing systems.

Table 25: Cause of impairment, and approach to addressing problem and documenting improvement in the Riffle Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$242,000 for fence and other practices $90,000 (6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Habitat Alteration, Sediment, Nutrients,	2. Establish 89.5 acres of filter strip	$191,000 81.8 acres * $230 per acre for installation + 81.8 acres * $140 per acre per year *15yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	3. Residue management, cover and green manure crop, conservation tillage	$342,000 1,600 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop*$15/acre*10yrs	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	4. Establish 40.0 acres of riparian buffer	$111,000 40.0 acres * $660 per acre for installation + 40.0 acres * $140 per acre per year *15yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Nitrate	5. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Atrazine, pesticides	6. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions

Sediment, Nutrients, Habitat	7. Reduce sediment export and improve habitat with design and construction of 3 miles of two-stage ditch	$111,000 3 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Wetland Habitat	8. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathogens	9. Septic system replacement or upgrade	$600,000 **Estimated 50** systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions

Figure 52: Representative stream channel in the Riffle Creek Subwatershed.

Table 26: Summary of Ohio EPA water quality and biological sampling results from the Riffle Creek Subwatershed.

Upper Olentangy Watershed Inventory
Riffle Creek Subwatershed
HUC 05060001 110 030

Stream Name	Length (ft)	Channelized (ft)	Leveed (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Riffle Creek Watershed Riffle Creek Holverstott Ditch Ulsh Ditch Mason Ditch	95,568	95,568			55,568	97.6[1]	121.8[2]/262.1[3]	Yes	10	Yes	24
TOTAL	95,568	95,568			95,568						
Miles =	18.1	18.1			18.1						

Livestock Inventory	Cattle	Dairy	Swine	Sheep	Chickens	Horses
Totals	NA	200	NA	NA	NA	NA

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
NA	NA	NA

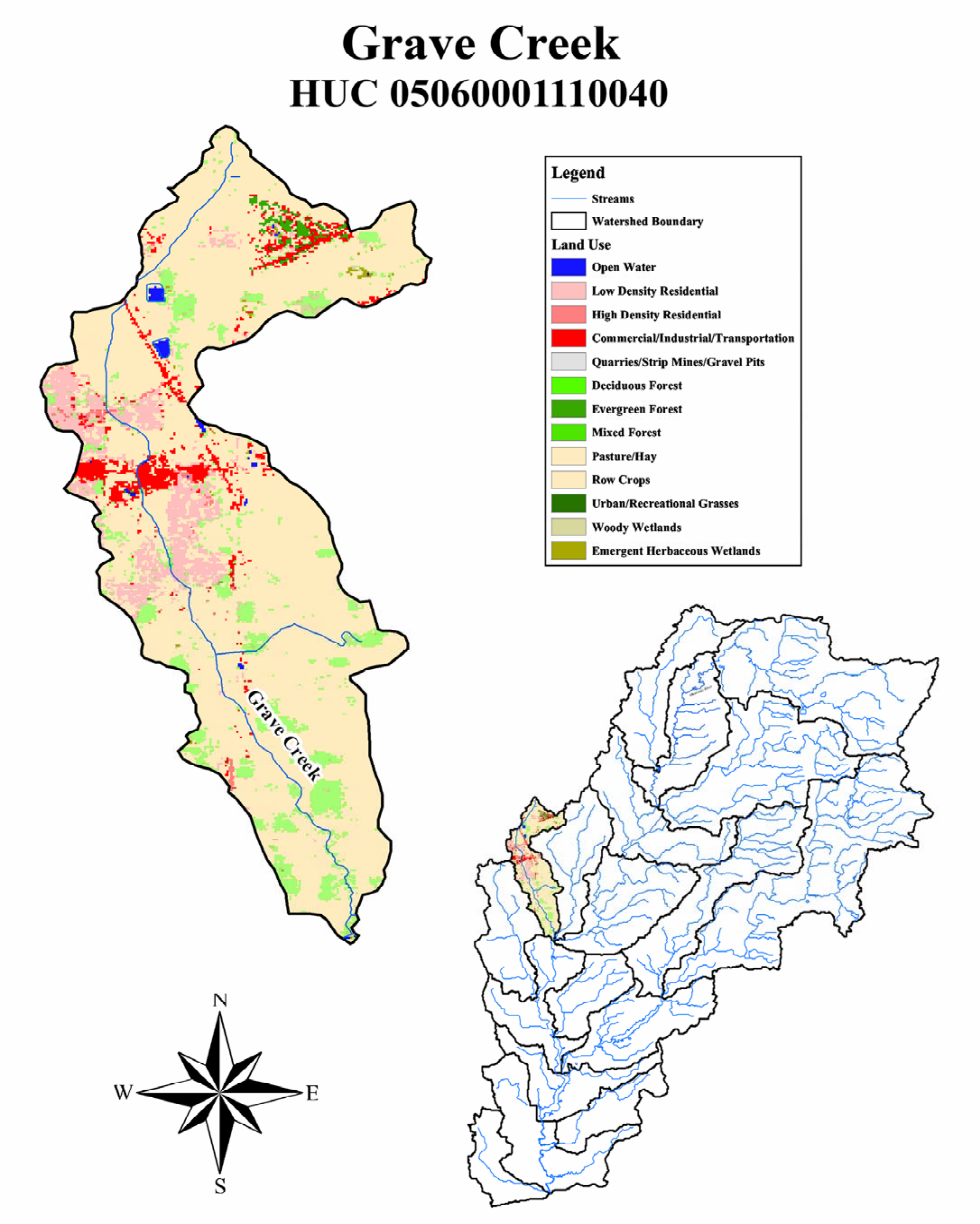
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
25%	65%	5%	5%	550	35%	45%	0%	20%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
11,138.4

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Grave Creek
HUC 05060001110040
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
Grave Creek
N
W
E
S

Grave Creek Subwatershed

HUC 05060001 110 040

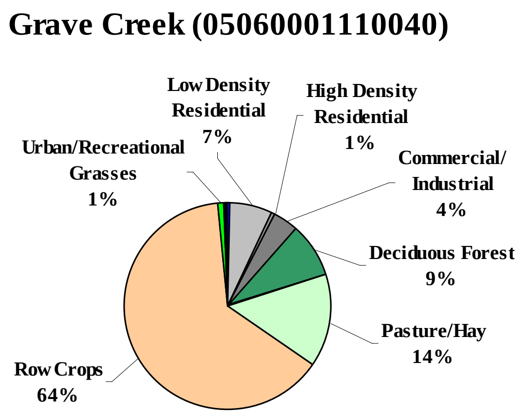
Physical Description:

Figure 53: Grave Creek south of Ohio State University-Marion Campus.

The Grave Creek subwatershed runs through the City of Marion and has been severely modified in several areas. It drains a total of 7,303.7 acres. According to 1992 satellite imagery, ~78% of land was used for row crops and hay, but that percentage appears to be declining with a concomitant increase in urban/suburban/commercial land use. Grave Creek is designated as a Modified Warm Water Habitat and Warm Water Habitat. No reaches met their designated use according to Ohio EPA biological sampling results (Appendix B). Water chemistry sampling showed elevated levels of nitrate-nitrite and phosphorus that exceeded water quality standards for recreational and aquatic life use. Primary contact standards for e.coli were exceeded at Grave Creek RM 0.3.

Although development is increasing, ~4673.6 acres are is row crop agricultural production. Corn, soybeans, wheat and other small grains, and hay account for 25%, 65%, 5%, and 5% of crop production. Much of the tillage for crop production utilizes some form of residue management, but 20% of land is still conventionally tilled.

There are approximately 10.8 miles of streams and tributaries in the watershed, a large portion of which are channelized. Estimates were made from aerial photos and checked in the field and channelization occurred at ~8.9 miles of the total length.



Land Use	%
Open Water	0.47
Low Density Residential	6.69
High Density Residential	0.56
Comm./Ind./Trans.	3.98
Deciduous Forest	8.65
Evergreen Forest	0.02
Mixed Forest	0.00
Pasture/Hay	14.31
Row Crops	63.99
Urban/Recreational Grasses	0.64
Woody Wetlands	0.48
Emergent Herb. Wetlands	0.20

Figure 54: Land use breakdown of Grave Creek Subwatershed.

Grave Creek Subwatershed
HUC 05060001 110 040

IMPAIRMENT: Nutrients, Sediment and Habitat Alteration

Background

Figure 55: Constructed channel section of Grave Creek.

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, most segments of the Grave Creek subwatershed are not meeting expected use designation. Row crop agriculture and point source discharges from municipal waste treatment have been identified as significant sources of nutrient enrichment and sediment. Extensive channel modification, particularly in the Modified Warm Water portion of Grave Creek have cause poor habitat and low QHEI scores that impact biology. Riparian removal may have some impact as extensive reaches of Grave Creek have little or no shading.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 27 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Grave Creek Subwatershed**.** Table 28 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Grave Creek Subwatershed

- Reduce phosphorus and sediment loading by 2.3 and 2,061 tons/year, respectively, through the adoption of 1,000 acres of residue management; 1,000 acres of cover and green manure crop; 500 new acres of no-till or other conservation tillage practice, 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 63.6 acres of filter strips; 20 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (5.19E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for an unknown number of failing systems of the estimated 185 noted, with improved on-site treatment systems or collection sewers. Conduct a survey to document the number of failing systems.

Table 27: Cause of impairment, and approach to addressing problem and documenting improvement in the Grave Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 63.6 acres of filter strip	$149,000 63.6 acres * $230 per acre for installation + 63.6 acres * $140 per acre per year*15yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Wetland Habitat	2. Constructed	$250,000	Farm Bill,	January	Document acres of

	wetlands on agricultural landscape	Establish 25 acres * $10,000 per acre	EQIP, CRP, CSP, 319 Funds, Division Wildlife, USFWS	2007 to Dec 2017	new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Sediment, Nutrients	3. Residue management, cover and green manure crop, conservation tillage	$270,000 1,000 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop *$15/ac*10yrs	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage. Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	4. Establish 20 acres of riparian buffer	$56,000 20 acres * $660 per acre for installation + 20 acres * $140 per acre per year*15 yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Nutrients	5. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstration, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Nutrients, Pathogens	6. Septic system replacement or upgrade	$600,000 **Estimated 50** systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Atrazine, pesticides	7. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Sediment, Nutrients, Habitat	8. Reduce sediment export and improve habitat with design and construction of 3 miles of two-stage ditch	$111,000 3 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Table 28: Summary of Ohio EPA water quality and biological sampling results from the Grave Creek Subwatershed.

Upper Olentangy Watershed Inventory
Grave Creek Subwatershed
HUC 05060001 110 040

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Grave Creek Watershed Grave Creek	57,024	46,992			46,992	109.1[1]	83.6[2]/175.0[3]	No	5	Yes	15
TOTAL	57,024	46,992			46,992						
Miles =	10.8	8.9			8.9						

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	NA	NA	NA	NA	NA	NA

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
NA	NA	NA

* Estimates based on survey given to County Health Departments

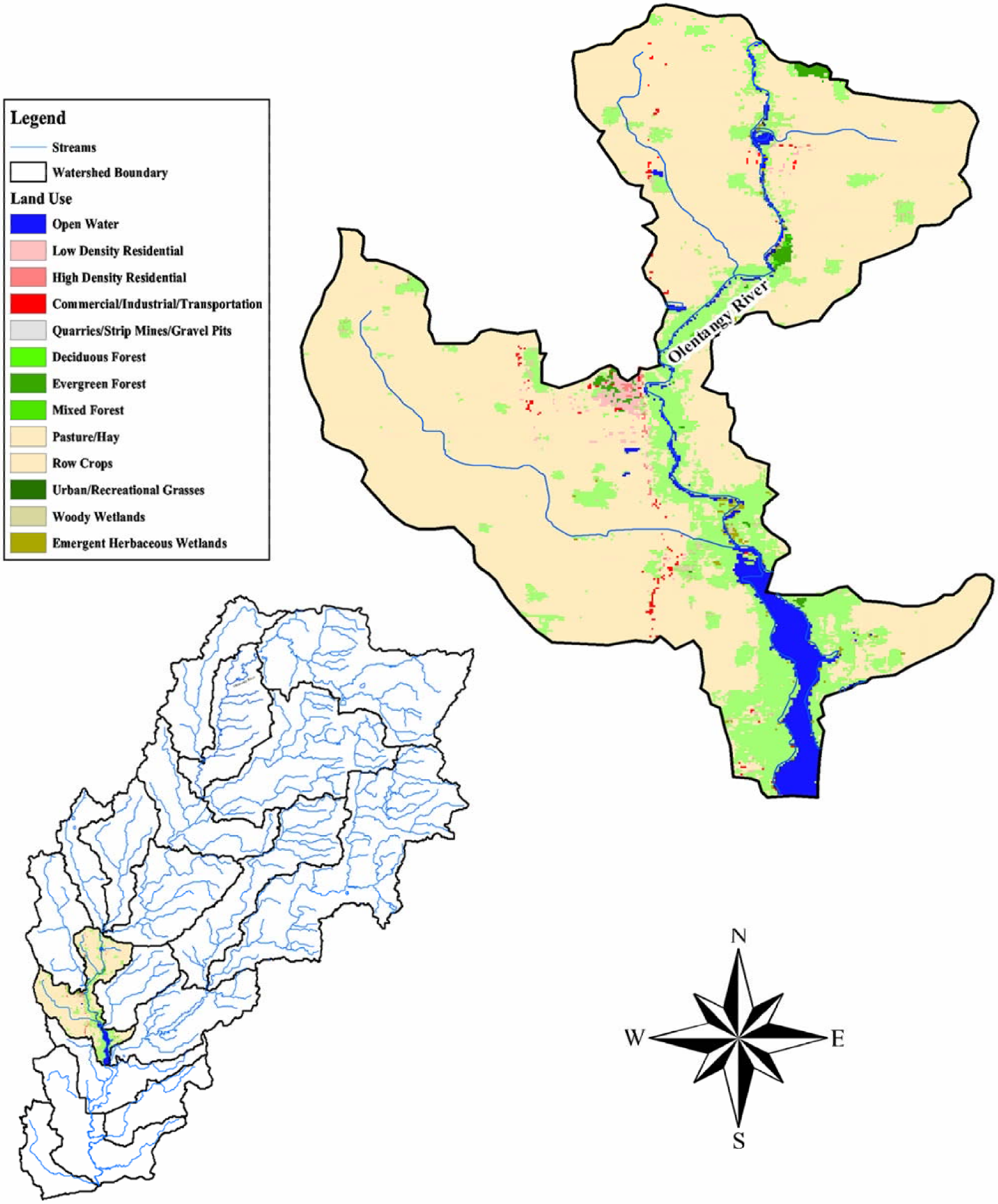
Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
25%	65%	5%	5%	<10	35%	45%	0%	20%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA)

Subwatershed Total Acres
7,303.7

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks

Norton Run
HUC 05060001110050



Norton Run Subwatershed

HUC 05060001 110 050

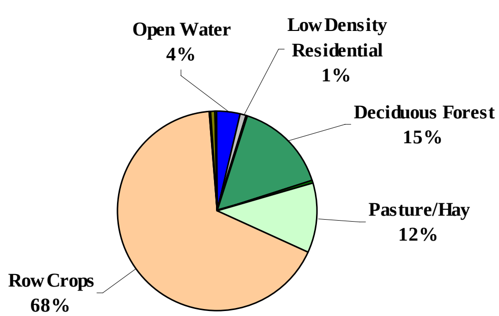
Physical Description:

The Norton Run subwatershed includes the northern portion of Delaware Reservoir which has modified flows and can often cause backwater effects on the Olentangy River through the Norton Run subwatershed. The watershed drains 11,105.4 acres and is designated as a Warm Water Habitat. The Olentangy River RM 40.8 was sampled during the 2003 Ohio EPA sampling season and was found to be in partial attainment (Appendix B). Cause of impairment was listed as hydromodification and siltation. Water chemistry results showed violations of water quality standards for bacteria, phosphorus, and nitrate-nitrite.

There are approximately 18.4 miles of streams and tributaries in the watershed and essentially all are channelized or constrained from meandering by adjacent land use. The watershed does have a significant amount of row crop agriculture (66.8%), but that is thought to be declining as development continues to increase. Corn, soybeans, wheat, and hay account for 30%, 55%, 10%, and 5% of agricultural land use. A significant amount of pasture land was evident in 1994 Land Use Classification Data, but this has significantly decreased since that time. Of the remaining agriculture, 20% was still conventionally tilled.

A survey of aerial photos showed 270.5 acres of riparian or buffer and 56.2 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all stream banks. Other problems include an estimated 36 septic systems that require upgrade or replacement particularly in the Waldo area.

Norton Run (0506000111050)



Land Use	%
Open Water	3.97
Low Density Residential	0.67
High Density Residential	0.12
Comm./Ind./Trans.	0.32
Deciduous Forest	15.18
Evergreen Forest	0.20
Mixed Forest	0.04
Pasture/Hay	11.53
Row Crops	66.83
Urban/Recreational Grasses	0.33
Woody Wetlands	0.47
Emergent Herb. Wetlands	0.33

Figure 56: Land use breakdown of Norton Run Subwatershed.

Norton Run Subwatershed
HUC 05060001 110 050

IMPAIRMENT: Nutrients and Sediment

Background

Based on water quality and biological sampling completed in 2003 by the Ohio EPA, the Norton Run watershed is not meeting expected use designation. Hydromodification and resulting siltation have been identified as significant sources of impairment. While it is unlikely that problems caused from modification will be altered, reduction in inputs of sediment and nutrients can attained.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 29 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Norton Run Subwatershed**.** Table 30 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Norton Run Subwatershed

- Reduce phosphorus and sediment loading by 4.4 and 3,141 tons/year, respectively, through the adoption of 750 acres of residue management; 1,000 acres of cover crop and green manure management; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 36,2 acres of filter strips; 40 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.

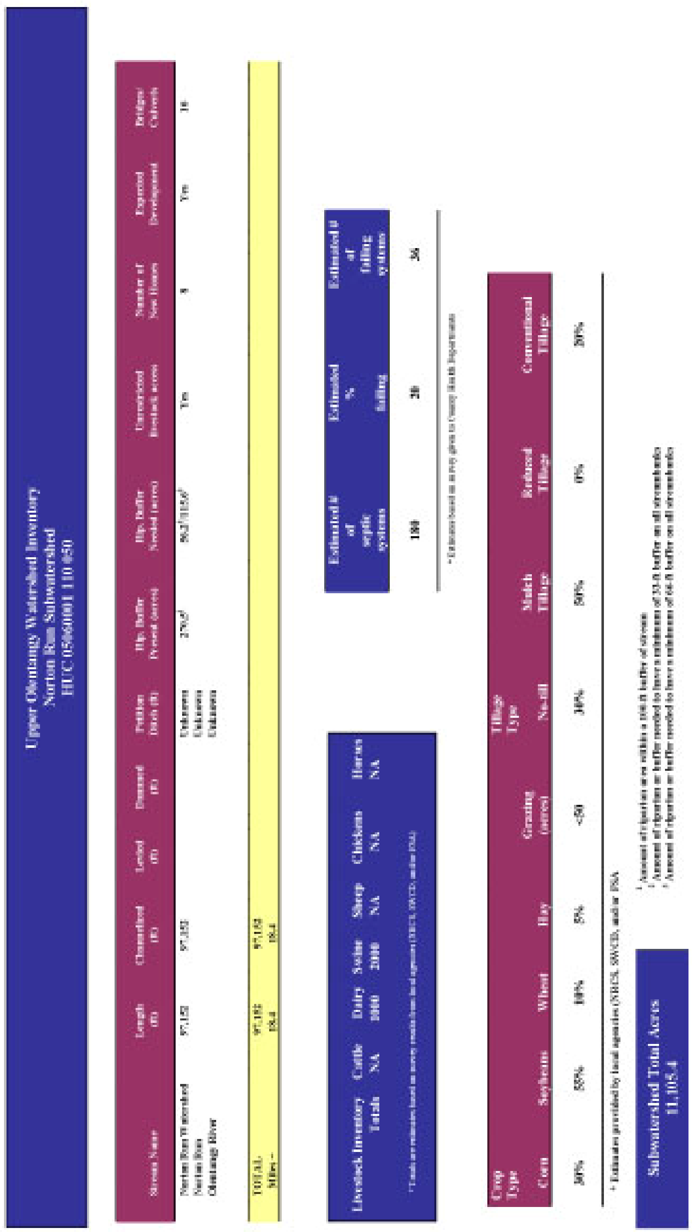
- Reduce pathogen loading by 100% (3.32E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for **36** (of 180) systems with improved on-site treatment systems or collection sewers.

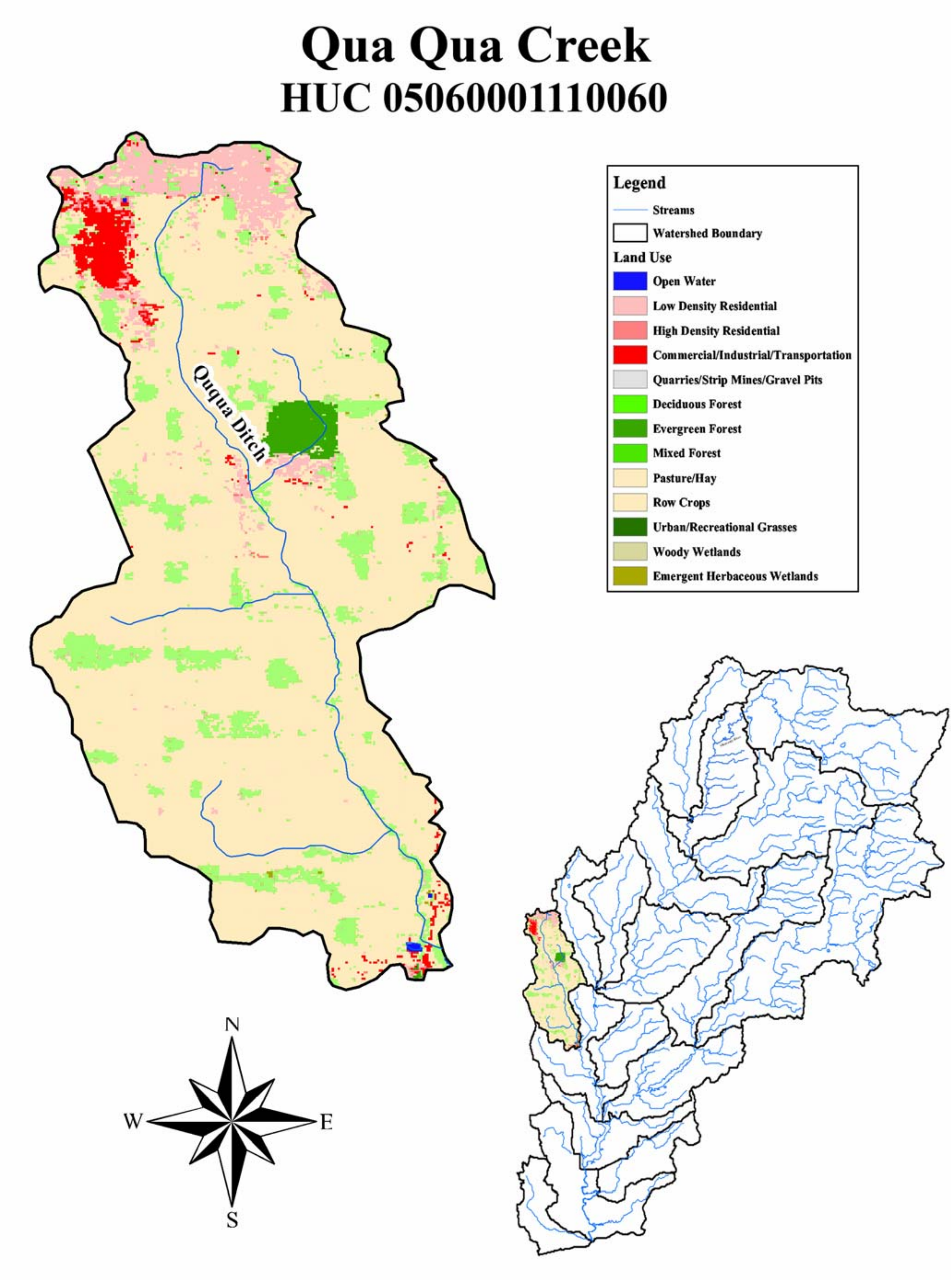
Table 29: Cause of impairment, and approach to addressing problem and documenting improvement in the Norton Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 36.2 acres of filter strip	$85,000 *36.2 acres * $230 per acre for installation + 36.2 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	2. Residue management, cover and green manure crop, conservation tillage	$240,000 750 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop *$15/ac*10 yrs	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage. Calculate load reduction
Nitrate	3. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Nutrients, Habitat	4. Reduce sediment export and improve habitat with design and construction of 3 miles of two-stage ditch	$111,000 3 miles of channel *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Atrazine, pesticides	5. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Wetland Habitat	6. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, USFWS	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Nutrients, Pathogens	7. Septic system replacement or upgrade	$432,000 36 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions

Table 30: Summary of Ohio EPA water quality and biological sampling results from the Norton Run Subwatershed.




Qua Qua Creek
HUC 05060001110060
Ququa Ditch
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
N
W
E
S

Qua Qua Creek Subwatershed

HUC 05060001 110 060

Physical Description:

Figure 57: Qua Qua Creek before maintenance.

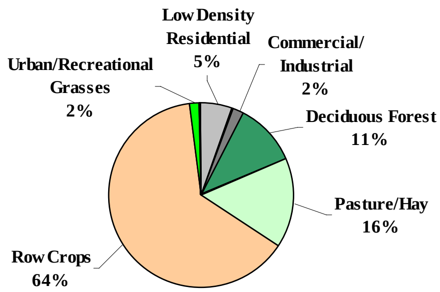
The Qua Qua Creek subwatershed has undergone significant change in recent years. Almost the entire length of the channel except a short reach before the confluence had maintenance performed in 2003. The entire length is designated as a Modified Warm Water Habitat and did not meet its' use at one of two sites sampled in 2003 (Appendix B). Channel modifications were listed as the primary cause of impairment. Results from water quality sampling showed water quality violations of bacteria, nitrate-nitrite, and phosphorus.

There are approximately 14.6 miles of streams and tributaries in the watershed and approximately 97% (14.2 miles) of Qua Qua is channelized and actively maintained. Crop rotations of typically corn-soybean or soybean-soybean-corn with an occasion wheat or small grain crop. Corn, soybeans, and wheat account for 30%, 60%, and 10% of crop production. Tillage practices in the watershed are largely reduced tillage methods, but 20% (1387.3 acres) are conventionally tilled. The livestock population includes 1000 head of dairy cattle and 2000 head of swine, but there were no instances of unrestricted livestock access documented.

Figure 58: Qua Qua Creek after channel maintenance.

A survey of aerial photos showed 130.9 acres of riparian or buffer and 69.3 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all stream banks.

Qua Qua Creek (05060001110060)



Land Use	%
Open Water	0.07
Low Density Residential	5.45
High Density Residential	0.30
Comm./Ind./Trans.	2.08
Deciduous Forest	10.63
Evergreen Forest	0.05
Mixed Forest	0.00
Pasture/Hay	15.94
Row Crops	63.50
Urban/Recreational Grasses	1.57
Woody Wetlands	0.34
Emergent Herb. Wetlands	0.06

Figure 59: Land use breakdown of Qua Qua Creek Subwatershed.

Qua Qua Creek Subwatershed
HUC 05060001 110 060

IMPAIRMENT: Nutrients, Sediment, Habitat Alteration, and Pathogens

Background

Based on water quality and biological sampling completed in 2003 by the Ohio EPA, one of two segments of the Qua Qua Creek subwatershed are not meeting expected use designation. Row crops and maintenance of agricultural ditches are the most serious causes of impairment. A QHEI score taken at the recently maintained portion of ditch had a score of 29 which is below minimum criteria.

Figure 60: Drainage channel just after maintenance.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 31 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Qua Qua Creek Subwatershed**.** Table 32 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Qua Qua Creek Subwatershed

- Reduce phosphorus and sediment loading by 4.4 and 3,141 tons/year, respectively, through the adoption of 750 acres of residue management; 1,000 acres of cover crop and green manure management; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 36,2 acres of filter strips; 40 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.

Table 31: Cause of impairment, and approach to addressing problem and documenting improvement in the Qua Qua Creek Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 49.3 acres of filter strip	$115,000 93 acres * $230 per acre for installation + 49.3 acres * $140 per acre per year *15 yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	2. Residue management, cover and green manure crop, conservation tillage	$345,000 1,000 acres of residue management * $12/acre * 10 years +	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage Calculate load

		1500 acres of cover crop *$15/acre*10yrs			reduction
Habitat Alteration, Sediment, Nutrients,	3. Establish 20 acres of riparian buffer	$56,000 *20 acres * $660 per acre for installation + 20 acres * $140 per acre per year*15 yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Atrazine, pesticides	4. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients	5. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Wetland Habitat	6. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Sediment, Nutrients, Habitat	7. Reduce sediment export and improve habitat with design and construction of 3 miles of two-stage ditch	$111,000 3 miles of channel *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase

Figure 61: Drainage channel – road culvert maintenance.

Table 32: Summary of Ohio EPA water quality and biological sampling results from the Qua Qua Creek Subwatershed.

Upper Olentangy Watershed Inventory
Qua Qua Creek Subwatershed
HUC 05060001 110 060

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Qua Qua Creek Watershed Ququa Ditch	77,088	77,088			77,088	130.9[1]	69.3[2]/147.7[3]	Yes	10	Yes	18
TOTAL	77,088	77,088			77,088						
Miles =	14.6	14.2			14.2						

Livestock Inventory	Cattle	Dairy	Swine	Sheep	Chickens	Horses
Totals	NA	1000	2000	NA	NA	NA

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
NA	NA	NA

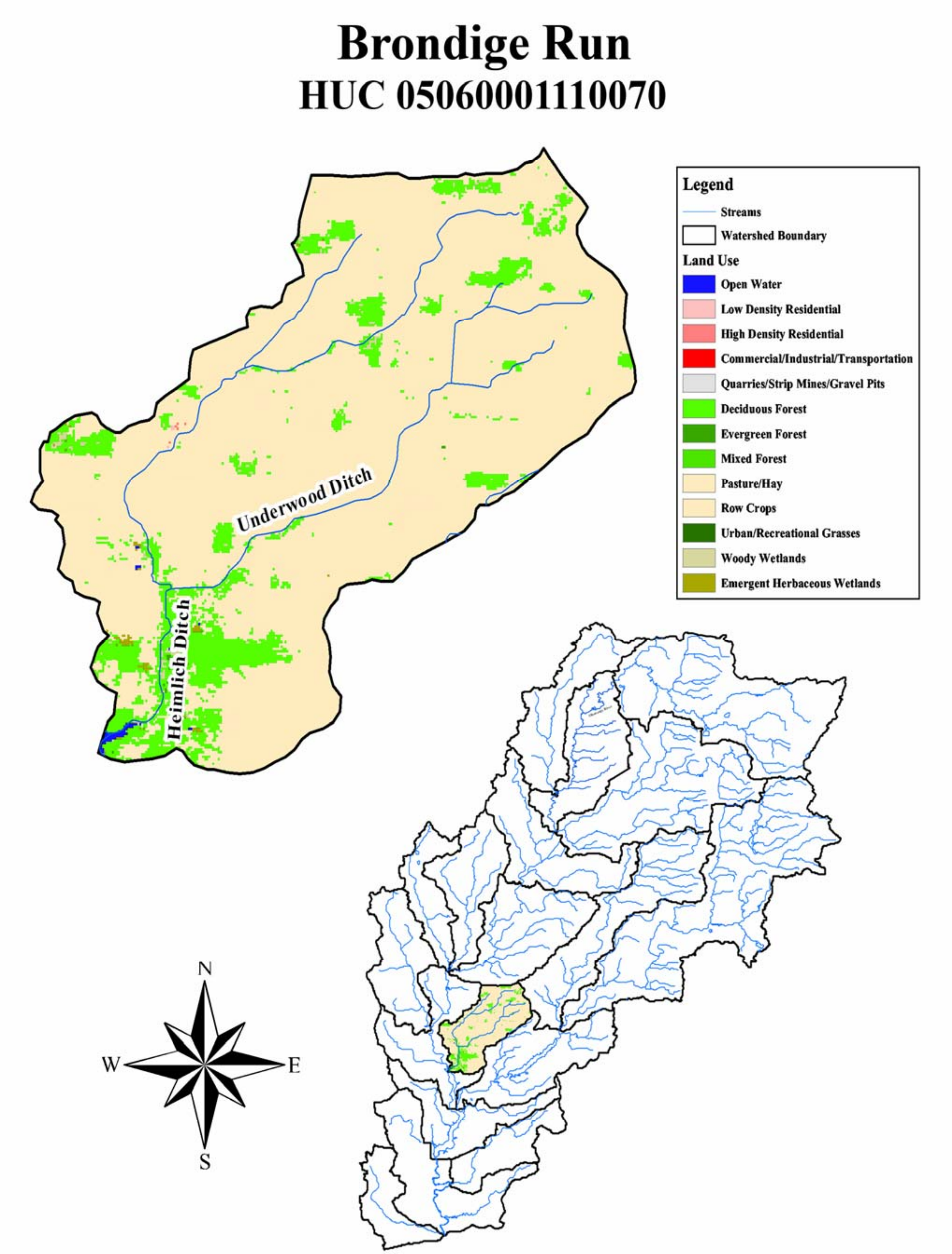
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
30%	60%	10%	0%	0	30%	50%	0%	20%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
10,923.3

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Brondige Run
HUC 05060001110070
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
Underwood Ditch
Heimlich Ditch
N
E
S
W

Brondige Run Subwatershed

HUC 05060001 110 070

Physical Description:

Figure 62: Tributary to Brondige Run.

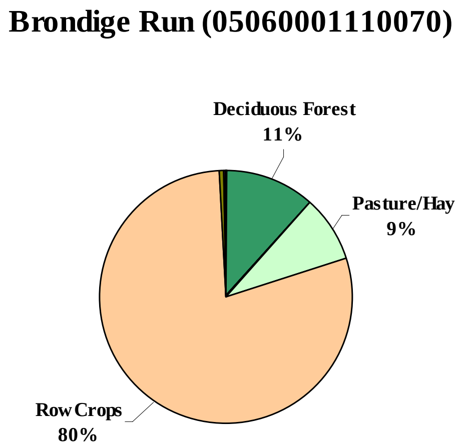
The Brondige Run subwatershed extends northeast and is a direct tributary to the Delaware Reservoir. The subwatershed drains 7,997.0 acres which is largely (78.9%) in row crop production. Underwood Ditch and Heimlich drain the majority of the watershed and the stream has not been designated. No biological sampling was conducted as part of the 2003 Ohio EPA biological sampling study. As a result, no segments were listed as impaired and no causes of impairment were identified (Appendix B). Water quality sampling was performed and bacteria, phosphorus, and nitrate-nitrite did exceed water quality criteria.

There are approximately 14.4 miles of stream in the watershed and 12.7 of those miles are channelized, particularly in the headwater portions of the watershed. No active maintenance of channelized sections was reported at this time. The watershed is primarily agricultural (78.9%). Corn, soybeans, wheat, and hay account for 35%, 49%, 12% and 4% of agricultural acreage, respectively. Reduced tillage practices dominate, yet 30% of agricultural crop production utilizes conventional tillage.

Livestock production is limited and <100 cattle and <100 horses are spread across the watershed.

Figure 63: Sediment deposition at a low spot near a roadside ditch.

A survey of aerial photos showed 94.3 acres of riparian or buffer and 74.2 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all stream banks. Other problems include an estimated 125 septic systems that require upgrade or replacement.



Land Use	%
Open Water	0.16
Low Density Residential	0.01
Comm./Ind./Trans.	0.01
Deciduous Forest	11.47
Evergreen Forest	0.04
Mixed Forest	0.00
Pasture/Hay	8.71
Row Crops	78.90
Woody Wetlands	0.49
Emergent Herb. Wetlands	0.21

Figure 64: Land use breakdown of Brondige Run Subwatershed.

Brondige Run Subwatershed
HUC 05060001 110 070

IMPAIRMENT: Nutrients, Sediment, Habitat Alteration, and Pathogens

Background

Figure 65: Drainage outlet along Brondige Run.

Based on water quality sampling completed in 2003 by the Ohio EPA, various segments of the Brondige Run subwatershed have violated water quality standards. Row crop and livestock agriculture, septic treatment systems, and rapid development have been identified by members of the watershed community as significant sources of nutrients, pathogens, and sediment.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 33 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Brondige Run Subwatershed**.** Table 34 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Brondige Run Subwatershed

- Reduce phosphorus and sediment loading by 3.2 and 2,856 tons/year, respectively, through the adoption of 1,600 acres of residue management; 1,000 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice, 1,000 acres of reduced rate phosphorus application, and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Reduce livestock pathogen loading by 100%, sediment and nutrient loading, improve stream riparian habitat and QHEI scores by installing 5.5 miles of livestock exclusion fencing, 6 waste facilities, 2 manure compost facilities, 4 livestock use protection areas, and 8 watering facilities.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 89.5 acres of filter strips; 40 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (5.19E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for 125 (of 500) on-site treatment systems or collection sewers.

Table 33: Cause of impairment, and approach to addressing problem and documenting improvement in the Brondige Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Sediment, Nutrients, Pathogens, Habitat and Flow Alterations	1. Identify livestock producers in the subwatershed where livestock have unrestricted access to the stream. Work with landowners to install 5.5 miles of stream bank fencing. Other practices will need to be installed.	$242,000 for fence and other practices $90,000 (6 waste facilities * $15,000 per facility) + $78,000 (30,000 ft * $2.60/ft) for fencing + $30,000 ($15, 000 per composting facility * 2 facilities) + $32,000 (4 livestock use protection areas * $8,000) + $12, 000 (8 watering facilities * $1,500	Farm Bill, USDA, Division of Wildlife, EQIP, US Fish and Wildlife Service	Jan. 2006 to January 2009	Document miles of streambank fencing installed. Load reductions calculated from modeling activities
Habitat Alteration, Sediment, Nutrients,	2. Establish 50 acres of filter strip	$116,500 50 acres * $230 per acre for installation + 50 acres * $140 per acre per year *15 yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	3. Residue management, cover and green manure crop, conservation tillage	$342,000 1,600 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop*$15/ac*10 yrs	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	3. Establish 24.2 acres of riparian buffer	$67,000 *24.2 acres * $660 per acre for installation + 24.2 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Wetland Habitat	11. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nitrate	6. Agricultural Drainage Management	$150,000 500 acres, on 10 25-	EQIP, 319 funds, CSP,	January 2007 to Dec 2010	Document acres of treated cropland

		to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	industry, potential for CIG demonstra tion, others		Calculate nitrate-nitrogen load reductions
Sediment, Nutrients, Habitat	7. Reduce sediment export and improve habitat with design and construction of 2 miles of two-stage ditch	$74,000 3 miles of channel *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Atrazine, pesticides	8. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients, Pathogens	9. Septic system replacement or upgrade	$1,500,000 125 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions

Table 34: Summary of Ohio EPA water quality and biological sampling results from the Brondige Run Subwatershed.

Upper Olentangy Watershed Inventory
Brondige Run Subwatershed
HUC 05060001 110 070

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Brondige Run Watershed	76,032	67,056			NAMR*	94.3[1]	74.2[2]/154.9[3]	Yes	15	Yes	16
Heimlich Ditch					NAMR*						
Underwood Ditch					NAMR*						
TOTAL	76,032	67,056									
Miles =	14.4	12.7									

*NAMR – No Active Maintenance Reported

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	<100	NA	NA	<100	NA	<100

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
500	25	125

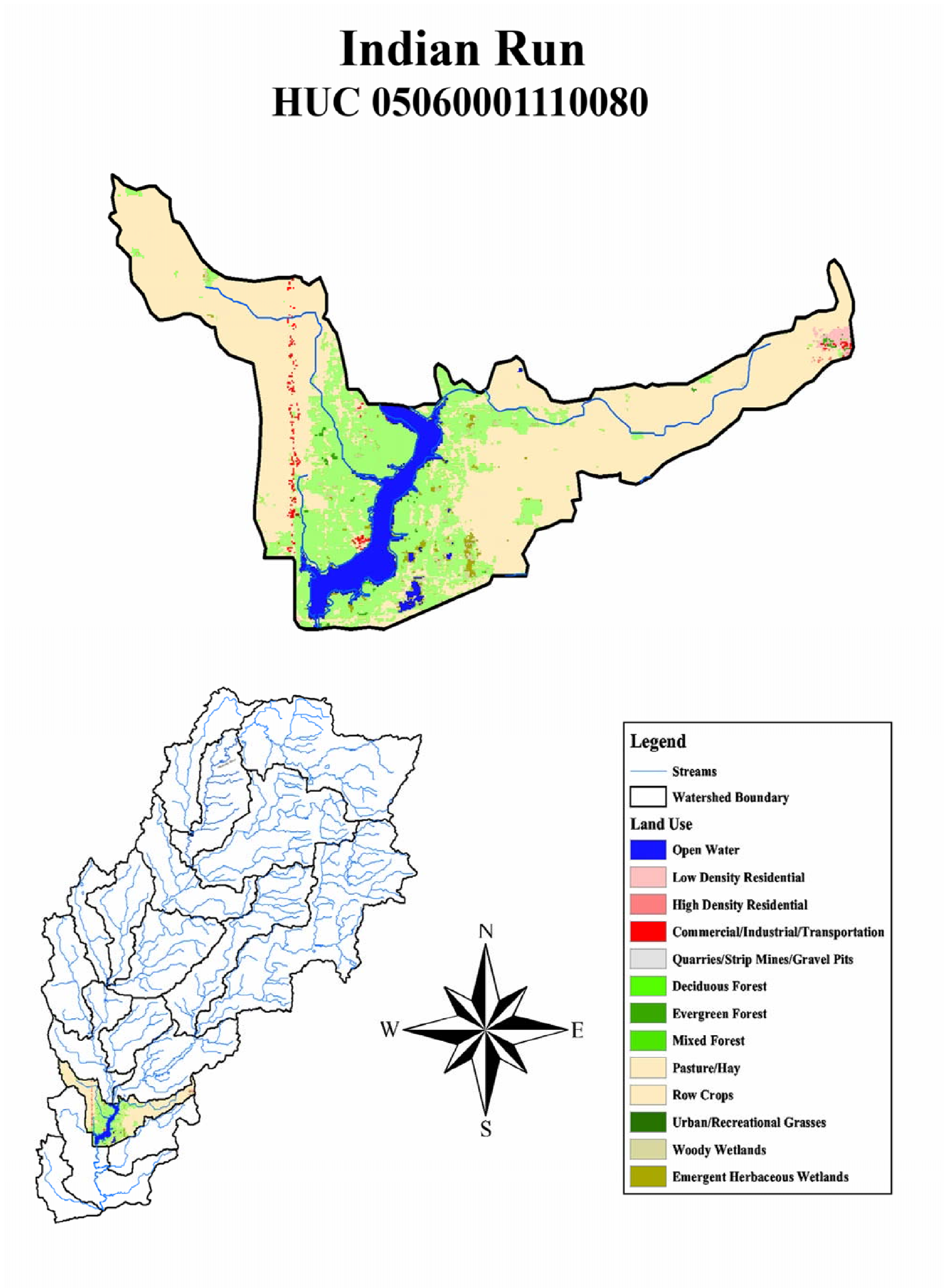
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
35%	49%	12%	4%	200	40%	30%	0%	30%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA)

Subwatershed Total Acres
7,997.0

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks


Indian Run
HUC 05060001110080
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
N
W
E
S

Indian Run Subwatershed

HUC 05060001 110 080

Physical Description:

Figure 66: Indian Run through Delaware State Park.

The Indian Run subwatershed contains the lower portion of Delaware Reservoir and the Indian Run tributary. The watershed drains 9,562.7 acres and a significant portion 24.5% is protected as part of the Delaware State Park and Wildlife Protection Area. It is designated as a Warm Water Habitat and met its' use designation at the only site sampled in 2003 by the Ohio EPA (Appendix B). Water quality sampling results showed violations of bacteria, phosphorus, and nitrate-nitrite water quality standards.

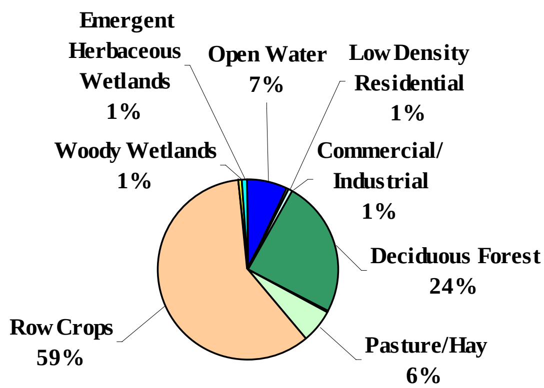
There are 14.4 miles of streams and tributaries in the Indian Run subwatershed. Most of the watershed has been channelized at some time and Indian Run (4.3 miles), Carter Ditch (3.05 miles), and Sherwood Ditch (0.48 miles) are actively maintained. Channelized portions in the Delaware Reservoir Protection area appear to have recovered. Much of the riparian corridor is well established near the confluence with the Olentangy, but the smaller headwater streams are impacted by removal of riparian vegetation.

Figure 67: Indian Run through the Delaware Protection Area.

No livestock production was reported in the watershed, except for several residents with horses used for recreational purposes. No instances of unrestricted access to streams were identified during reconnaissance surveys. A fair amount of agricultural activities continue to operate in the watershed in the headwater portions. Corn (45%), soybeans (40%) account for the majority of crop production with lesser amounts of wheat (10%) and hay (5%). Approximately 45% of tillage operations are by conventional methods.

A survey of aerial photos showed 371.7 acres of riparian or buffer and 46.9 acres of riparian or buffer area is needed to have a minimum of 33 feet of buffer on all streambanks. Other problems include an estimated 30 septic systems that require upgrade or replacement.

Indian Run (05060001110080)



Land Use	%
Open Water	7.10
Low Density Residential	0.58
High Density Residential	0.05
Comm./Ind./Trans.	0.56
Deciduous Forest	24.49
Evergreen Forest	0.17
Mixed Forest	0.02
Pasture/Hay	5.83
Row Crops	59.45
Urban/Recreational Grasses	0.06
Woody Wetlands	0.86
Emergent Herb. Wetlands	0.82

Figure 68: Land use breakdown of Indian Run Subwatershed.

Indian Run Subwatershed
HUC 05060001 110 080

IMPAIRMENT: Nutrients and Sediment

Background

Based on water quality and biological sampling completed in 1994 and 2003 by the Ohio EPA, various segments of the Rocky Fork subwatershed are not meeting expected use designation. Row crop and livestock agriculture, municipal waste treatment, bank destabilization, and urban runoff have been identified as significant sources of nutrients and sediment.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; and reduce sediment export and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 35 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Indian Run Subwatershed**.** Table 36 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Brondige Run Subwatershed

- Reduce phosphorus and sediment loading by 3.2 and 2,856 tons/year, respectively, through the adoption of 1,600 acres of residue management; 1,000 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice, 1,000 acres of reduced rate phosphorus application, and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.

- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 89.5 acres of filter strips; 40 acres riparian buffers; constructing 3 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (5.19E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for 30 (of 100) on-site treatment systems or collection sewers.

Table 35: Cause of impairment, and approach to addressing problem and documenting improvement in the Indian Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 36.9 acres of filter strip	$86,000 36.9 acres * $230 per acre for installation + 36.9 acres * $140 per acre per year *15 yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	2. Residue management, cover and green manure crop, conservation tillage	$342,000 1,600 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop *$15/ac*10 yrs	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	3. Establish 10.0 acres of riparian buffer	$28,000 10.0 acres * $660 per acre for installation + 10.0 acres * $140 per acre per year *15 yrs	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Nitrate	4. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and	EQIP, 319 funds, CSP, industry, potential for CIG	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions

		installation) one-time cost, plus $20 per acre * 15 years	demonstra tion, others		
Sediment, Habitat and Flow Alterations	5. Two-stage ditch design and construction	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Wetland Habitat	6. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, USFWS	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Atrazine, pesticides	7. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients, Pathogens	8. Septic system replacement or upgrade	$360,000 30 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions

Table 36: Summary of Ohio EPA water quality and biological sampling results from the Indian Run Subwatershed.

Upper Olentangy Watershed Inventory
Indian Run Subwatershed
HUC 05060001 110 080

Stream Name	Length (ft)	Channelized (ft)	Leveed (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Indian Run Watershed	76,032	76,032				371.7[1]	46.9[2]/95.0[3]	Yes	2	Yes	9
Indian Run					22,704						
Sherwood Ditch					2,534						
Carter Ditch					16,104						
TOTAL	76,032	76,032			41,342						
Miles =	14.4	14.4			7.83						

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses <50

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
100	30	30

* Estimates based on survey given to County Health Departments

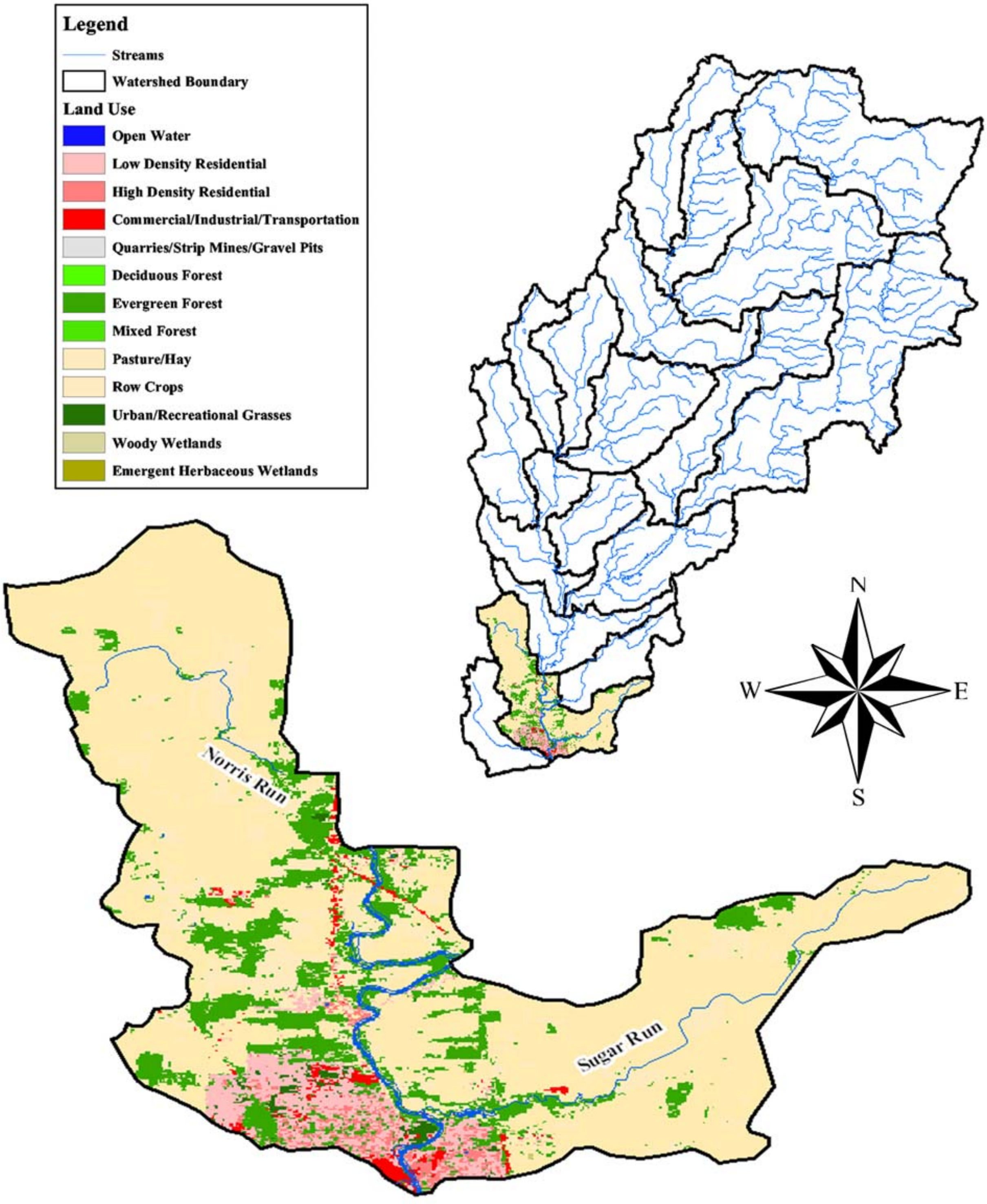
Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
45%	40%	10%	5%	<100	55%	0%	0%	45%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
9,562.7

[1] Amount of riparian area within a 100-ft buffer of stream
[2] Amount of riparian or buffer needed to have a minimum of 33-ft buffer on all streambanks
[3] Amount of riparian or buffer needed to have a minimum of 66-ft buffer on all streambanks

Olentangy River below Delaware Dam
HUC 05060001110090



.

Olentangy River below Delaware Dam Subwatershed

HUC 05060001 110 090
Physical Description:

The Olentangy River below Delaware Dam subwatershed includes the Olentangy River and two main tributaries south of the Delaware Dam to Delaware Run. Major tributaries include Norris Run and Sugar Run. The watershed drains 15,147.5 acres of most of which is agricultural or forested land; however, this watershed is developing rapidly and an estimated 500 acres will become residential in the next 5 years. All stream segments in this reach have been designated as capable of supporting Warm Water Habitat biological communities. Water quality sampling has revealed violations of the primary contact recreation limits for bacteria at several locations in the watershed (Appendix B). Elevated concentrations of Lindane and Dieldrin were sampled on the Olentangy mainstem.

Figure 69: Norris Run (River Mile 1.3) at Penry Road.

There are approximately 17.3 miles of streams and tributaries in the watershed and according to an analysis of aerial photography it appears that at least 7.9 miles are impacted by some degree of channelization. Currently, 3.73 miles of Sugar Run is under maintenance through the petition ditch process.

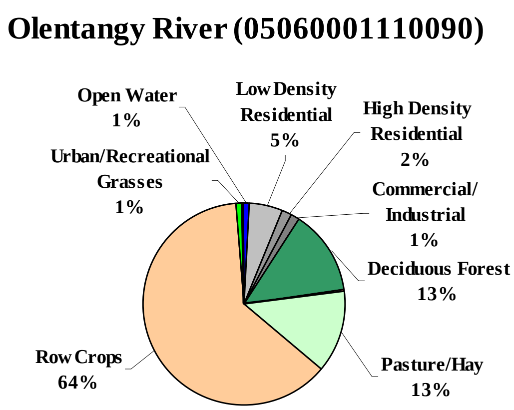
Livestock production is limited in this watershed (~50 head of cattle; small number of horses) and does not appear to be causing any significant water quality impacts. Corn (40%), soybean (40%), wheat (10%), and hay (10%) are the primary crops produced in the watershed.

Figure 70: Sugar Run (River Mile 1.3) upstream of Peters Road.

Most cropland used for corn production is conventionally tilled and overall approximately 46% of the cropland receives conventional tillage practices. Most cropland used for soybean production is planted with no-till methods and no-till is practiced on approximately 41% of all crop acres. Reduced tillage is used on the remaining 13% of cropland in the watershed.

A survey of aerial photographs showed that approximately 163.3 acres of riparian or buffer strips exist within a 100-foot zone of the streams in this watershed. An additional 22.9 acres of riparian or buffer strip are needed to have a minimum of 33-feet of buffer on all stream banks; however, it should be noted that a small buffer on a large stream, such as the Olentangy, is probably not sufficient to protect the channel morphology and biological communities in many areas. Additional guidance on stream setbacks is available in the Ohio Department of Natural Resources Rainwater and Land Development Manual available at http://www.ohiodnr.com/soilandwater/Rainwater.htm.

The Delaware County Health Department estimated that 25 septic systems are currently failing and need repaired, upgraded, or repaired.



Land Use	%
Open Water	0.88
Low Density Residential	5.46
High Density Residential	1.72
Comm./Ind./Trans.	1.45
Deciduous Forest	13.41
Evergreen Forest	0.12
Mixed Forest	0.02
Pasture/Hay	13.18
Row Crops	62.72
Urban/Recreational Grasses	0.65
Woody Wetlands	0.23
Emergent Herb. Wetlands	0.19

Figure 71: Land use breakdown of Olentangy River below Delaware Dam Subwatershed.

Olentangy River below Delaware Dam Subwatershed
HUC 05060001 110 090

IMPAIRMENT: Urban Runoff, Onsite Waste Treatment, Flow Alterations

Background

Based on water quality and biological sampling completed in 1999 and 2003 by the Ohio Environmental Protection Agency (EPA) parts of the Olentangy River below Delaware Dam watershed are not meeting their assigned designated use. While the Olentangy River mainstem is impacted by hydromodification and urbanization downstream from the dam all of the locations sampled were fully or partially meeting the biological criteria standards set for the river.

However, the two main tributaries, Norris Run and Sugar Run, were not meeting biological criteria. Urban runoff, failing onsite waste treatment systems, and flow alterations were identified by the Ohio EPA as the primary sources of impairment.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; reduce nutrient runoff from urban grasses and residential lawns; and reduce sediment export; reduce peak discharges and runoff volume; and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 37 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Olentangy River below Delaware Dam Subwatershed**.** Table 38 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Olentangy River below Delaware Dam Subwatershed

1. Reduce phosphorus and sediment loading by 4.4 and 6,122 tons/year, respectively, through the adoption of 300 acres of residue management; 500 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice, 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
2. Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
3. Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
4. Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 50 acres of filter strips; 15.0 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
5. Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
6. Reduce pathogen loading by 100% (1.18E+15 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair for 63 (of 427) systems with improved on-site treatment systems or collection sewers.
7. Improve riparian habitat by increasing QHEI score in the Olentangy River through the removal of the Central Avenue Dam
8. Rain barrels
9. Education of lawn fertilizer reduction and composting

Table 37: Cause of impairment, and approach to addressing problem and documenting improvement in the Olentangy River below Delaware Dam Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 7.9 acres of filter strip	$18,407 7.9 acres * $230 per acre for installation + 7.9 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Sediment, Nutrients	2. Residue management, cover and green manure crop, conservation tillage	$111,000 300 acres of residue management * $12/acre * 10 years + 500 acres of cover crop*$15/acre*10 yrs	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients	3. Establish 15.0 acres of riparian buffer	$41,400 15.0 acres * $660 per acre for installation + 15.0 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Wetland Habitat	4. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nitrate	5. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Habitat and Flow Alterations	6. Two-stage ditch design and construction	$74,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Habitat	7. Remove Central	$150,000 (Est.)	319,	2009	Removal of dam

Alteration, Sediment, Nutrients	Avenue Dam		USACOE, Ohio EPA, USEPA, City Del.		
Nutrients, Pathogens	8. Septic system replacement or upgrade	$756,000 63 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions
Atrazine, pesticides	9. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Nutrients	10. Education program on lawn fertilizer reduction and composting	$7,000 Informational brochures, workshop costs, and cost-share for composters	319, OEEF, Ohio EPA, ODNR, USEPA	2007-2010	Document workshops held, composters installed, and survey workshop participants to document behavior changes
Runoff volume and peak discharge	11. 30% cost-share for rain barrels and rain gardens	$12,500 100 rain barrels * $100 per barrel + 25 rain gardens * $100 rain garden	319, OEEF, Ohio EPA, ODNR, USEPA	2007-2010	Document number of rain barrels and gardens installed

Table 38: Summary of Ohio EPA water quality and biological sampling results from the Olentangy River below Delaware Dam Subwatershed.

Upper Olentangy Watershed Inventory
Olentangy River below Delaware Dam Subwatershed
HUC 05060001 110 090

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Olentangy River and all tributaries	91,344	41,712				163.5	22.9		10	Yes	24
Sugar Run					19,700						
TOTAL	91,344	41,712			19,700						
Miles =	17.3	7.9			3.73						

*NAMR = No Active Maintenance Reported

Livestock Inventory	Cattle	Dairy	Swine	Sheep	Chickens	Horses
Totals	50	100	None	None	None	<20

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

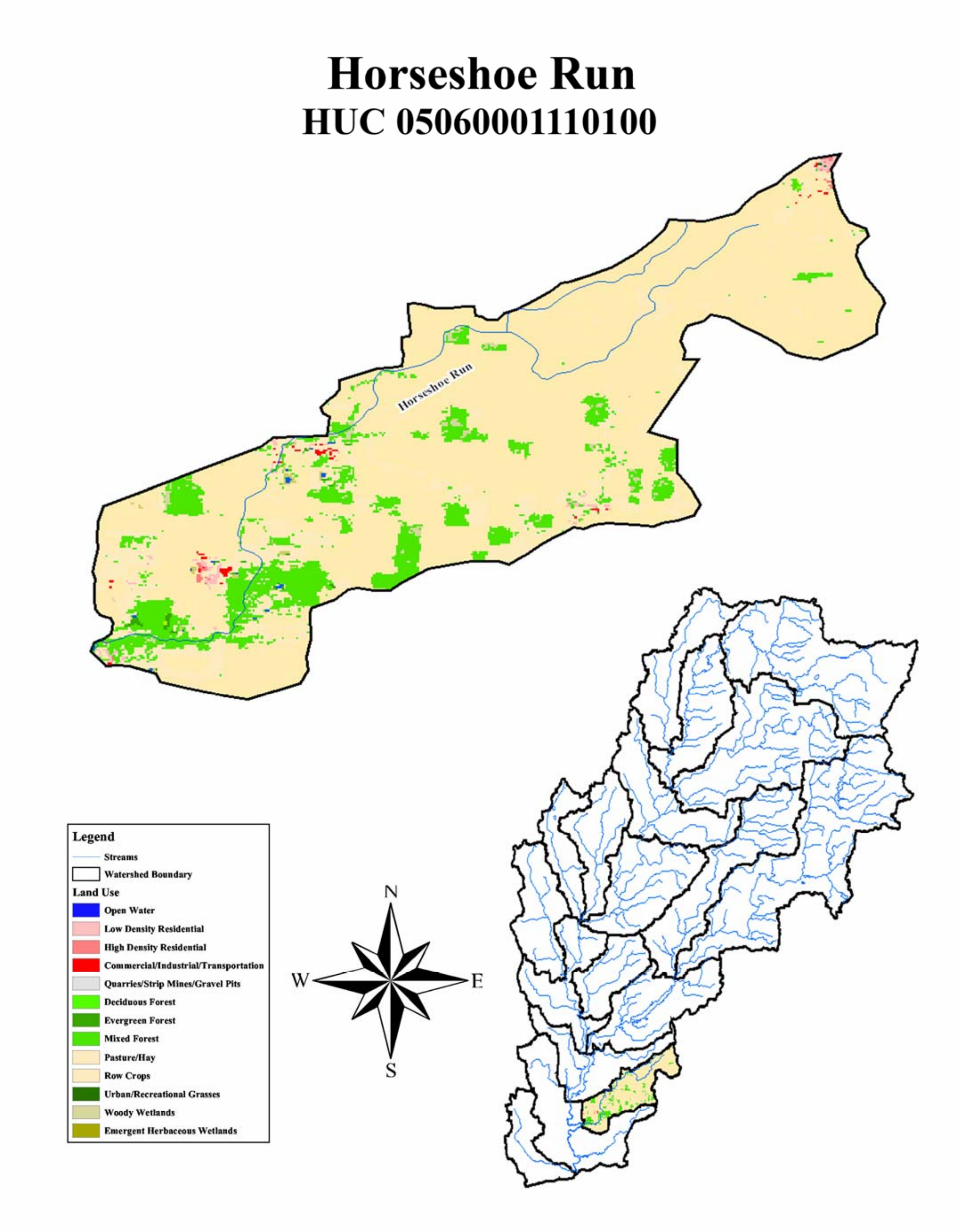
Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
250	25	63

* Estimates based on survey given to County Health Departments

Crop Type					Tillage Type			
Corn	Soybeans	Wheat	Hay	Grazing (acres)	No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
40%	40%	10%	10%	None	41%		13%	46%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA)

Subwatershed Total Acres
15147.5


Horseshoe Run
HUC 05060001110100
Horseshoe Run
Legend
Streams
Watershed Boundary
Land Use
Open Water
Low Density Residential
High Density Residential
Commercial/Industrial/Transportation
Quarries/Strip Mines/Gravel Pits
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Row Crops
Urban/Recreational Grasses
Woody Wetlands
Emergent Herbaceous Wetlands
N
W
E
S

Horseshoe Run Subwatershed

HUC 05060001 110 100
Physical Description:

Figure 72: Horseshoe Run (River Mile 0.9) at Horseshoe Rd.

The Horseshoe Run subwatershed is located on the eastern side of the Olentangy River just north of the City of Delaware. Horseshoe Run empties into the Olentangy River at river mile 29.44. The watershed drains approximately 7250.4 acres of land used mostly for agriculture. Horseshoe Run has been designated by the Ohio Environmental Protection Agency to be capable of supporting Warm Water Habitat biological communities (Appendix B). Currently, this designation is being partially met at Horseshoe Run river mile 0.30. Water quality sampling from June 1999 to August 1999 revealed violations of the bacteria (E. Coli) secondary contact criterion and the dissolved oxygen Warm Water Habitat criterion.

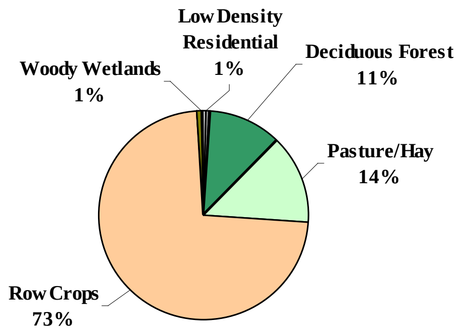
There are approximately 11.0 miles of streams and tributaries in the Horseshoe Run subwatershed. According to an analysis of aerial photography it appears that at least 9.8 miles have been channelized at some time. Many of the stream miles continue to be impacted by channelization and ditch maintenance activities; however, some reaches exhibit characteristics of natural recovery of channel form. Currently, 1.66 miles of Horseshoe Run and 2.22 miles of Knuckles Ditch are petition ditches under active maintenance.

A small number of livestock including 50 head of cattle and a small number (<20) horses are raised in the watershed. The primary agricultural crops include corn (45%), soybeans (40%), wheat (10%), and hay (5%). Most cropland used for corn production is conventionally tilled and overall approximately 48% of the cropland receives conventional tillage practices. Most cropland used for soybean production is planted with no-till methods and no-till is practiced on approximately 40% of crop acres. Reduced tillage is used on the remaining 12% of cropland in the watershed.

A survey of aerial photographs showed that approximately 89.5 acres of riparian or buffer strips exist within a 100-foot zone of Horseshoe Run and its tributaries. An additional 51.3 acres of riparian or buffer strip are needed to have a minimum of 33-feet of buffer on all streambanks of Horseshoe Run and its tributaries. The Delaware County Health Department estimated that 25 septic systems are currently failing and need repaired, upgraded, or repaired.

Horseshoe Run Land Use

Horseshoe Run (05060001110100)



Land Use	%
Open Water	0.10
Low Density Residential	0.55
High Density Residential	0.11
Comm./Ind./Trans.	0.22
Deciduous Forest	11.16
Evergreen Forest	0.19
Mixed Forest	0.02
Pasture/Hay	13.69
Row Crops	73.12
Urban/Recreational Grasses	0.01
Woody Wetlands	0.62
Emergent Herb. Wetlands	0.20

Figure 73: Land use breakdown of Horseshoe Run Subwatershed.

Horseshoe Run Subwatershed
HUC 05060001 110 100

IMPAIRMENT: Onsite Waste Treatment and Agriculture

Background

Based on water quality and biological sampling completed in 1999 by the Ohio EPA, the section of Horseshoe Run near river mile 0.3 is partially attaining its designated use. Onsite waste treatment and agriculture were identified as the primary sources of impairment in the watershed. Flow and habitat alteration are also likely sources of impairment. Some development is occurring in this watershed and is generally low density with most homes being placed on 5-acre lots. This trend is likely to continue as Delaware County is growing at a rapid pace, and therefore, proper management of stormwater will become more important if higher density development begins.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; reduce nutrient runoff from urban grasses and residential lawns; and reduce sediment export; reduce peak discharges and runoff volume; and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 39 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Horseshoe Run Subwatershed**.** Table 40 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Horseshoe Run Subwatershed

- Reduce phosphorus and sediment loading by 2.7 and 2,598 tons/year, respectively, through the adoption of 1,000 acres of residue management; 1,000 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 30 acres of filter strips; 21.3 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (7.10E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair of 25 (of 251) systems with improved on-site treatment systems or collection sewers.

Table 39: Cause of impairment, and approach to addressing problem and documenting improvement in the Horseshoe Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 30.0 acres of filter strip	$69,900 30.0 acres * $230 per acre for installation + 30.0 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Atrazine, pesticides	2. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Sediment, Nutrients	2. Residue management, cover and green manure	$270,000 1,000 acres of residue	Farm Bill, CRP, 319 Funds	Jan. 2006 to January 2009	Document acres of cover crop, crop rotation, conservation

	crop, conservation tillage	management * $12/acre * 10 years + 1000 acres of cover crop*$15/acre*10 yrs			tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	3. Establish 21.3 acres of riparian buffer	$58,788 21.3 acres * $660 per acre for installation + 21.3 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Nitrate	7. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Habitat and Flow Alterations	8. Two-stage ditch design and construction	$74,,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Wetland Habitat	11. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathogens	8. Septic system replacement or upgrade	$300,000 25 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions

Table 40: Summary of Ohio EPA water quality and biological sampling results from the Horseshoe Run Subwatershed.

Upper Olentangy Watershed Inventory
Horseshoe Run Subwatershed
HUC 05060001 110 100

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges/ Culverts
Horseshoe Run and all tributaries Knuckles Ditch	58,080	51,744			8,765 11,722	88.5	51.3		5	Yes	12
TOTAL Miles =	58,080 11.0	51,744 9.8			20,486 3.88						

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	50	None	None	None	None	<20

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
100	25	25

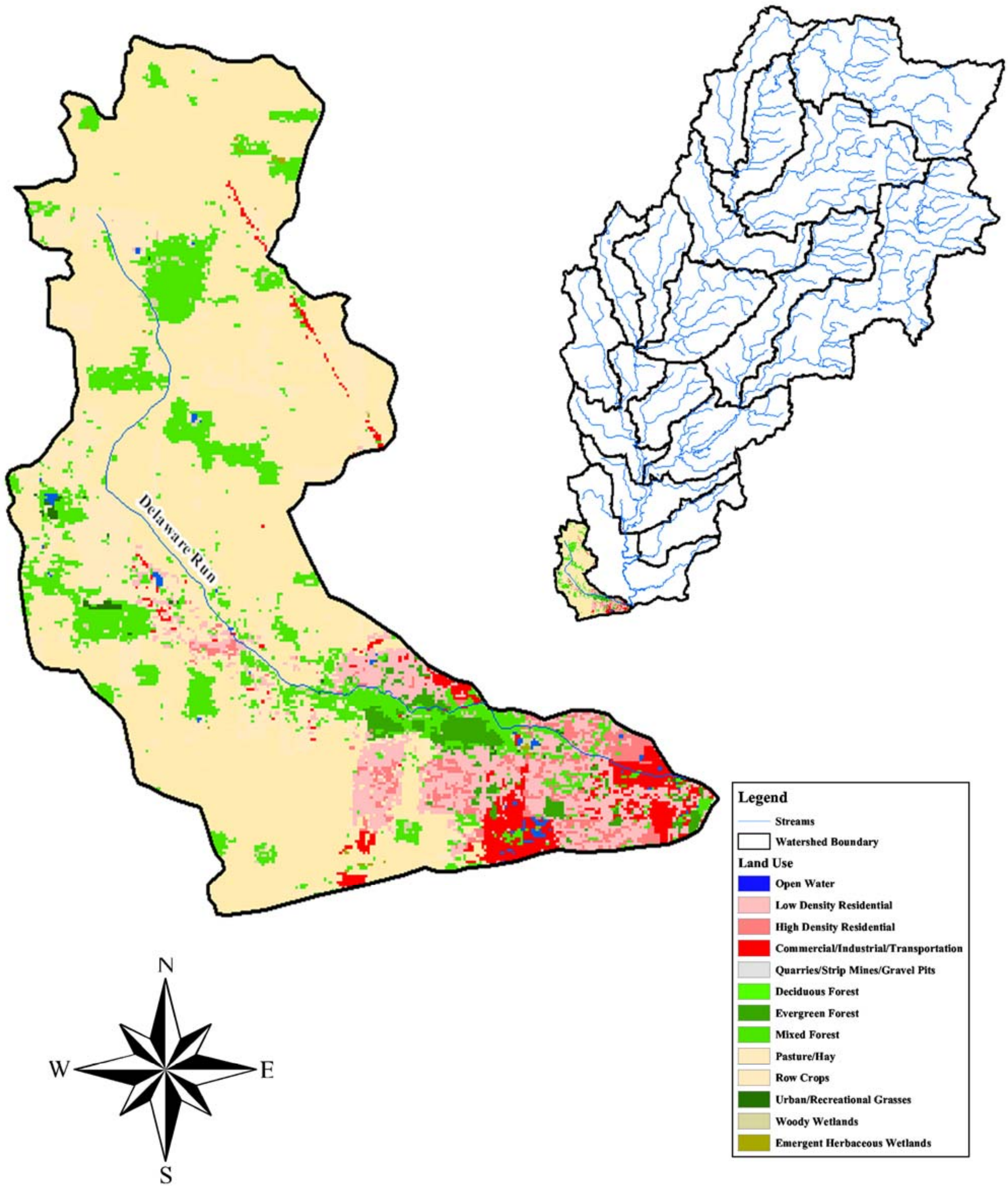
* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
40%	40%	10%	10%	~100	40%		12%	48%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
7250.4

Delaware Run
HUC 05060001110110



Delaware Run Subwatershed

HUC 05060001 110 110
Physical Description:

Figure 74: Delaware Run (River Mile 0.9) at Blue Limestone Park in the City of Delaware.

The Delaware Run subwatershed is located on the west side of the Olentangy River in the City of Delaware. Delaware Run flows through the campus of Ohio Weslyan University before emptying into the Olentangy River just south of E. William Street. The watershed drains 6485.1 acres and the landuse is dominated by agricultural uses in the headwaters and urban or residential landuses nearer it's confluence with the Olentangy. It has been designated as a Warm Water Habitat stream by the Ohio EPA. Water quality sampling results during 1999 revealed violations of bacteria (E. coli) for the secondary contact recreation criterion (Appendix B).

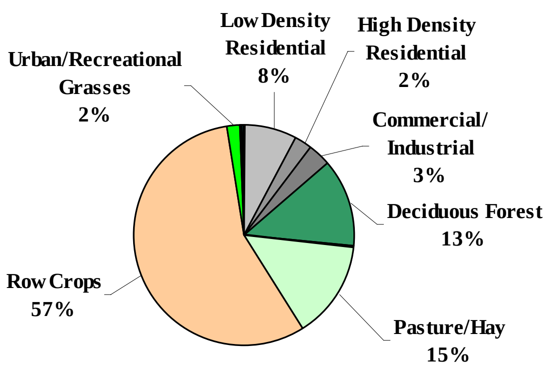
There are approximately 6.5 miles of streams and tributaries in the Delaware Run subwatershed. Many of the streams (~4.8 miles) in the watershed have been channelized to some degree in the last century. About 1.31 miles of the headwaters of Delaware Run were recently "cleaned" and will be maintained as a petition ditch.

A small amount of livestock production was reported in the watershed with approximately 200 head of cattle being raised. Several property owners have a small number of horses for recreational purposes. Corn (45%) and soybeans (40%) are the dominant agricultural commodities grown in the watershed while wheat (10%) and hay (5%) are produced in lesser amounts. In this watershed most corn production (~75%) is accomplished using conventional tillage methods that leave <15% residue coverage on fields. Soybeans are primarily (70%) planted using no-till which typically leaves >30% residue coverage on cropland. Overall, conventional tillage methods is applied to approximately 48% of cropland, no-till is applied to 40% of cropland, and reduced tillage methods (e.g. ridge-till or mulch-till) are applied to 12% of cropland.

A survey of aerial photographs showed 97.8 acres of buffer strips within 100 feet of streams and 14.7 acres of buffers strips are needed to have a minimum of 33 feet of buffer on all streambanks. However, the aerial photographs used to make these estimates were taken circa 1995 and development and ditch maintenance (including clearing of riparian areas) in recent years means that the number of buffer strips is overestimated and the amount of buffer strip needed is likely underestimated. However, no data source was available (to the authors) at the time of this study to make a more accurate estimate. The Delaware County Health Department estimated that approximately 40 septic systems are failing and require upgrades or replacement. Personnel at the Delaware Soil and Water

Conservation District and Natural Resources Conservation District estimated that in the next five years approximately 150-200 acres of new development will occur.

Delaware Run (05060001110110)



Land Use	%
Open Water	0.38
Low Density Residential	7.75
High Density Residential	2.42
Comm./Ind./Trans.	3.48
Deciduous Forest	12.62
Evergreen Forest	0.23
Mixed Forest	0.02
Pasture/Hay	14.27
Row Crops	56.40
Urban/Recreational Grasses	1.80
Woody Wetlands	0.50
Emergent Herb. Wetlands	0.14

Figure 75: Land use breakdown of Delaware Run Subwatershed.

Delaware Run Subwatershed
HUC 05060001 110 110

IMPAIRMENT: Urban Runoff, Onsite Waste Treatment, Agriculture

Background

Based on water quality and biological sampling completed in 1999 and 2003 by the Ohio EPA, portions of the Delaware Run subwatershed are not meeting the assigned use designation. Agriculture, urban runoff, and failing onsite waste treatment systems were identified as the primary sources of impairment in the watershed. Flow and habitat alteration are also suspected sources of impairment as ditch maintenance and development alter the watershed hydrology and stream morphology.

Goals

The overall goals are to reduce sedimentation and nutrient runoff from cropland areas; improve riparian condition by adding riparian or buffer strips; reduce nutrients derived from failing septic systems; reduce nitrate export from subsurface drains; reduce nutrient runoff from urban grasses and residential lawns; and reduce sediment export; reduce peak discharges and runoff volume; and improve habitat in channelized tributaries. Potential implementation objectives are presented below, and Table 41 provides a summary of the cause of impairment, and approach to addressing problem and documenting improvement in the Delaware Run

Subwatershed**.** Table 42 provides a summary of Ohio EPA's water quality and biological sampling results.

Potential Implementation Objectives for the Horseshoe Run Subwatershed

- Reduce phosphorus and sediment loading by 0.6 and 1,110 tons/year, respectively, through adoption of 300 acres of residue management; 900 acres of cover and green manure crop; 500 acres of no-till or other conservation tillage practice; 1,000 acres of reduced rate phosphorus application; and, the implementation/improvement of 25 nutrient/manure management plans for cropland and livestock operations.
- Reduce nitrogen loading by 30% through the installation of 10 new acres of filter strips and/or riparian buffers on non-subsurface drained cropland, 10 new acres of filter strips and/or riparian buffers on subsurface drained cropland in conjunction with drainage water management, 50 acres of cropland (no filters/buffers) with drainage water management, and the implementation/improvement of 10 nutrient/manure management plans for cropland and livestock operations.
- Reduce atrazine (and other pesticides) loading by 50% through the implementation/improvement of 25 pesticide management plans.
- Improve riparian habitat and QHEI scores, reduce nutrients, and sediment loads by implementing 4.7 acres of filter strips; 10.0 acres riparian buffers; constructing 2 lineal miles of alternative drainage channel improvements, i.e., two-stage and/or over-wide channel designs.
- Improve wetland habitat and flood storage capability by installing 25 new acres of constructed woody and/or emergent herbaceous wetlands, thus also helping reduce sediment, phosphorus and nitrogen loading.
- Reduce pathogen loading by 100% (5.86E+14 count/ml) from home sewage treatment systems (HSTS) by implementing system replacement and/or repair of 40 (of 212) systems with improved on-site treatment systems or collection sewers.
- Rain barrels
- Education on lawn fertilizer reduction and composting

Table 41: Cause of impairment, and approach to addressing problem and documenting improvement in the Delaware Run Subwatershed.

Pollutant (cause of impairment)	Task Description	Resources	How	Time Frame	Performance Indicator
Habitat Alteration, Sediment, Nutrients,	1. Establish 30.0 acres of filter strip	$69,900 30.0 acres * $230 per acre for installation + 30.0 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Atrazine, pesticides	2. New or improved pesticide management plans	$100,000 2000 acres @$ 10/ac * 5 year	Farm Bill, EQIP, CRP, CSP, 319 Funds,	January 2007 to Dec 2012	Document acres of treated cropland Calculate atrazine load reductions
Sediment, Nutrients	2. Residue management, cover	$270,000	Farm Bill, CRP, 319	Jan. 2006 to January	Document acres of cover crop, crop

	and green manure crop, conservation tillage	1,000 acres of residue management * $12/acre * 10 years + 1000 acres of cover crop*$15/acre*10 yrs	Funds	2009	rotation, conservation tillage Calculate load reduction
Habitat Alteration, Sediment, Nutrients,	3. Establish 21.3 acres of riparian buffer	$58,788 21.3 acres * $660 per acre for installation + 21.3 acres * $140 per acre per year * 15 years	CRP, 319 Grant	Jan. 2006 to January 2009	Document acres of buffer planted Calculate load reduction
Nitrate	7. Agricultural Drainage Management	$150,000 500 acres, on 10 25- to 80-acre fields; $2,000 per field (materials and installation) one-time cost, plus $20 per acre * 15 years	EQIP, 319 funds, CSP, industry, potential for CIG demonstra tion, others	January 2007 to Dec 2010	Document acres of treated cropland Calculate nitrate-nitrogen load reductions
Sediment, Habitat and Flow Alterations	8. Two-stage ditch design and construction	$74,,000 2 miles of channel * *37,000/mile ($7/ft)	319 funds	January 2007 to Dec 2017	Document miles of new constructed channel Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Wetland Habitat	11. Constructed wetlands on agricultural landscape	$250,000 Establish 25 acres * $10,000 per acre	Farm Bill, EQIP, CRP, CSP, 319 Funds, Division Wildlife, US Fish and Wildlife	January 2007 to Dec 2017	Document acres of new constructed wetland Calculate sediment, nutrient, pesticide load reductions, habitat development, flood storage increase
Nutrients, Pathogens	8. Septic system replacement or upgrade	$480,000 40 systems @ $12,000 each	Revolving loan fund, federal grant, state grant	January 2007 to Dec 2017	Document numbers of systems repaired or replaced per year Calculate nutrient and pathogen load reductions

Table 42: Summary of Ohio EPA water quality and biological sampling results from the Delaware Run Subwatershed.

Upper Olentangy Watershed Inventory
Delaware Run Subwatershed
HUC 05060001 110 110

Stream Name	Length (ft)	Channelized (ft)	Levied (ft)	Dammed (ft)	Petition Ditch (ft)	Rip. Buffer Present (acres)	Rip. Buffer Needed (acres)	Unrestricted livestock access	Number of New Homes	Expected Development	Bridges
Delaware Run	34,320	25,344			6917	97.8	14.7		NA	Yes	14
TOTAL Miles =	34,320 6.5	25,344 4.8			6917 1.31						

*NAMR = No Active Maintenance Reported

Livestock Inventory Totals	Cattle	Dairy	Swine	Sheep	Chickens	Horses
	200	None	None	None	None	<20

* Totals are estimates based on survey results from local agencies (NRCS, SWCD, and/or FSA)

Estimated # of septic systems	Estimated % failing	Estimated # of failing systems
200	20	40

* Estimates based on survey given to County Health Departments

Crop Type: Corn	Soybeans	Wheat	Hay	Grazing (acres)	Tillage Type: No-till	Mulch Tillage	Reduced Tillage	Conventional Tillage
45%	40%	10%	5%	None	40%		12%	48%

* Estimates provided by local agencies (NRCS, SWCD, and/or FSA

Subwatershed Total Acres
6485.1

Appendices

Appendix A – NRCS Conservation Practices, Table A1.

Conservation Practices	Soil Erosion; Sheet & Rill	Soil Erosion; Concentrated Flow	Soil Erosion Streambank	Soil Erosion; Roadbanks, Const. Sites, & Scour Areas	Soil Condition; Tilth, Crusting, Infiltration, Organic Matter	Water Quantity; Runoff & Flooding	Water Quantity, Subsurface; Excess Water	Water Quality, Groundwater; Pesticides, Nutrients, Organics	Water Quality, Surface Water; Pesticides, Nutrients, Organics, Sediment	Animal Habitat, Wildlife: Food, Water, Cover, Shelter
Clearing & Snagging-326	0	0	Sl to Mod Decrease	0	0	Sig Decrease	0	0	0	Sl increase0
Composting Facility	0	0	0	0	0	0	0	Sl to Mod Decrease	Sl to Mod Decrease	0
Conservation Cover	Mod to Sig Decrease	Mod to Sig Decrease	0	0	Sig Decrease	Sl Decrease	0	Sl to Sig Decrease	Mod to Sig Decrease	Mod to Sig Decrease
Conservation Crop Rotation	Sl to Sig Decrease	Situational	0	0	Sig Decrease	Sl Decrease	0	Sl to Mod Decrease	Sl to Mod Decrease	Situational
Constructed Wetland	0	0	0	0	0	SL Decrease	SL Increase	SL to Mod Decrease	Mod to Sig Decrease	Sig Decrease
Contour Buffer Strips	Sl to Sig Decrease	Sl to Sig Decrease	0	0	Mod Decrease	Sl Decrease	Sl Increase	Sl to Mod Decrease	Mod to Sig Decrease	Sl Decrease
Contour Farming	Sl to Mod Decrease	Sl to Sig Decrease	0	0	Mod Decrease	Sl Decrease	Sl Increase	Sl to Mod Decrease	Mod to Sig Decrease	Sl Decrease
Cover & Green Manure Crop 340	Sl to Mod Decrease	Sl Decrease	0	0	Mod Decrease	Sl Decrease	Situational	Sl to Mod Decrease	Mod to Sig Decrease	Sl Decrease
Critical Area Planting	Sig Decrease	Sl to Sig Decrease	Sl to Sig Decrease	Sig Decrease	Mod Decrease	Insignificant	0	Sl Decrease	Mod to Sig Decrease	Sl Decrease
Dike 356	Sl to Mod Decrease	0	Sl Increase	Sl to Sig Decrease	0	Sig Decrease	Sl Decrease	0	Mod to Sig Decrease	Sl Decrease
Diversion 362	Sl to Mod Decrease	0	0	Situational	0	Sl to Sig Decrease	Sl Decrease	0	Mod to Sig Decrease	0
Fence 382	Situational	0	Situational	0	0	0	0	Situational	Situational	Facilitating
Field Border 386	Insignificant	Insignificant	Situational	0	0	0	0	Sl Decrease	Sl Decrease	Sl to Sig Decrease
Filter Strip 393A	0	Insignificant	Situational	Sl Decrease	0	0	0	Mod to Sig Decrease	Sl Decrease	Sl to Sig Decrease
Grade Stabilization Structure 410	0	Sl Decrease	Mod to Sig Decrease	Sl to Sig Decrease	0	0	0	Facilitating	Sl Decrease	0
Grassed Waterway 412	0	Sig Decrease	0	Sl to Sig Decrease	0	0	0	Facilitating	Mod Decrease	Sl decrease

Heavy Use Area Protection 561	Sig Decrease	Mod to Sig Decrease	0	Sl to Sig Decrease	0	0	0	Sl to Mod Decrease	Sl Decrease	Situational
Livestock Use Area Protection 757i	Mod to Sig Decrease	Situational	Sl to Mod Decrease	0	0	0	0	Sl Decrease	Sl Decrease	0
Mulching 484	Sig Decrease	Sig Decrease	0	Sl to Sig Decrease	Mod Decrease	Insignificant	Sl to Mod Increase	0	Mod Decrease	Sl Decrease
Nutrient Management 590	Facilitating	0	0	0	Facilitating	0	0	Sig Decrease	Sig Decrease	Sl Decrease
Open Channel 582	0	0	Sig Decrease	0	0	Sig Decrease	Facilitating	0	Sl Increase	Sig Increase
Pasture & Hayland Planting 512	Mod to Sig Decrease	Mod to Sig Decrease	Facilitating	0	Mod Sig Decrease	Sl Decrease	0	Sl Decrease	Mod Decrease	Sl Decrease
Pest Management 595	0	0	0	0	0	0	0	Sig Decrease	Sig Decrease	Sl Decrease
Pumping Plant for Water Control 533	0	0	0	0	0	0	Mod Decrease	Sl Decrease	0	0
Recreation Area Improvement 562	Mod Decrease	0	0	0	Mod Decrease	0	0	0	Sl Decrease	Situational
Residue Management, Mulch till 329B	Sl to Sig Decrease	Sl Decrease	0	0	Mod to Sig Decrease	Sl Decrease	Sl Increase	Facilitating	Sig Decrease	Sl Decrease
Residue Management, No-till & Strip Till 329A	Sl to Dig Decrease	Sl Decrease	0	0	Mod to Sig Decrease	Sl Decrease	Sl Increase	Facilitating	Sig Decrease	Sl Decrease
Residue Management, Ridge Till 329C	Sl to Sig Decrease	Mod to Sig Decrease	0	0	Mod to Sig Decrease	Sl Decrease	Sl Increase	Facilitating	Sig Decrease	Sl Decrease
Residue Management, Seasonal 344	Sl to Sig Decrease	Sl Decrease	0	0	Sl Decrease	Sl Decrease	Sl Increase	Facilitating	Sl Decrease	Sl Decrease
Restoration and Management of Declining Habitats 643	Sl to Mod Decrease	Mod Decrease	0	0	Mod to Sig Decrease	Sl Decrease	0	Facilitating	Sl Decrease	Sig Decrease
Riparian Forest Buffer 391	0	0	Sig Decrease	Sl to Mod Decrease	0	Sl Decrease	0	Sl Decrease	Sig Decrease	Sig Decrease
Roof Runoff Management 558	0	0	0	0	0	0	0	0	Sl to Sig Decrease	0
Sediment Basin 350	0	Sl to Sig Decrease	Situational	Sig Decrease	0	Sig Decrease	0	0	Sl to Sig Decrease	0
Streambank &	0	0	Mod to Sig	0	0	0	0	0	Sl to Sig	Facilitating

Shoreline Protection 580			Decrease						Decrease	
Stripcropping-Contour 585	Sl to Sig Decrease	Sl to Mod Decrease	0	0	Mod Decrease	Sl Decrease	Sl Increase	Facilitating	Sl to Sig Decrease	Sl Decrease
Stripcropping-Field 586	Sl to Mod Decrease	Sl to Mod Decrease	0	0	Mod Decrease	Sl Decrease	Sl Increase	Facilitating	Sl to Sig Decrease	Sl Decrease
Structure for Water Control 587	0	0	0	0	0	Sl Decrease	Situational	Facilitating	Sl to Sig Decrease	0
Subsurface Drain 606	Sl Decrease	Facilitating	0	0	Sig Decrease	Sl Decrease	Sig Decrease	Sl Decrease	Sl Increase	0
Surface Drainage-Field Ditch 607	0	SI Increase	0	0	Sl Decrease	Sl Decrease	Mod Decrease	0	Sl Increase	0
Surface Drainage-Main or Lateral 608	0	0	0	0	Sl Decrease	Sig Decrease	Sl Decrease	0	Sl Increase	Sl Increase
Terrace 600	Sig Decrease	Sig Decrease	0	0	Mod Decrease	Sl to Mod Decrease	Sl Increase	Sl Increase	Sl to Sig Decrease	0
Tree/Shrub Establishment 612	Sig Decrease	Mod Decrease	0	0	Sig Decrease	Mod Decrease	0	Sig Decrease	Sl to Sig Decrease	Sig Decrease
Underground Outlet 620	Facilitating	Situational	0	0	0	Facilitating	Facilitating	0	Sl to Mod Increase	0
Upland Wildlife Habitat Management 645	Situational	Situational	0	0	0	Sl Decrease	0	0	0	Sig Decrease
Use Exclusion 472	Mod to Sig Decrease	Situational	0	0	Sl Decrease	Sl Decrease	0	0	Sl to Mod Decrease	Sig Decrease
Waste Storage Facility 313	0	0	0	0	0	0	0	Mod Decrease	Sig Decrease	0
Waste Treatment Lagoon 359	0	0	0	0	0	0	0	Mod Decrease	Sig Decrease	0
Waste Utilization 633	0	0	0	0	0	0	0	Sig Decrease	Sig Decrease	0
Water & Sediment Control Basin 638	Facilitating	Sig Decrease	0	Sl to Sig Decrease	0	Sl Decease	0	Sl Decrease	Sig Decrease	0
Watering Facility 614	Sl to Sig Decrease	0	0	0	0	0	0	0	0	0
Wetland Creation 658	0	0	0	0	0	Sl Decrease	Mod Increase	Sl Sig Decrease	Sl to Mod Decrease	Sig Decrease
Wetland Restoration 657	Sl to Sig Increase	0	0	0	0	Sl Decrease	Mod Increase	Sl to Sig Decrease	Sl to Mod Decrease	Sig Decrease
Wetland Wildlife Habitat Management 644	0	0	0	0	0	Sl Decrease	Mod Increase	Sl to Sig Decrease	Sl to Mod Decrease	Sig Decrease

Appendix B – Ohio EPA Biological Sampling Results Tables.

Rocky Fork Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Olentangy River	91.1	1994	39	6.3	62.5	WWH	Full	-	-
Olentangy River	89.3	2003	49	-	84	WWH	Full	-	-
Olentangy River	89.3	1994	47	-	80.5	WWH	Full	-	-
Olentangy River	87.3	1994	42	-	56.5	WWH	Partial	-	-
Olentangy River	86.4	1994	46	-	57	WWH	Full	-	-
Olentangy River	85.9	2003	38	-	79	WWH	Full	-	-
Olentangy River	85.9	1994	44	-	89	WWH	Full	-	-
Olentangy River	86.1	2003	38	-	58.5	WWH	Full	-	-
Olentangy River	85.2	1994	45	-	83.5	WWH	Full	-	-
Olentangy River	84.5	2003	32	6.9	82.5	WWH	Partial	Reservoir & Galion WWTP	Nutrients, Low DO
Olentangy River	84.2	1994	38	8.1	80	WWH	Full	-	-
Olentangy River	79.8	1994	31	7.5	61.5	WWH	Non	Septic, Urban Runoff	Riparian removal, Flow Alteration
Olentangy River	79.7	2003	34	7.8	69.5	WWH	Partial	Galion WWTP, Livestock	Nutrients, Siltation, Cadmium
Rocky Fork	2.9	2003	36	-	74	WWH	Full	-	-
Rocky Fork	0.4	2003	34	-	75	WWH	Non	Dam (Galion)	Channel & Flow Alterations

Table B17.1: Rocky Fork Watershed Biological Sampling Results

Olentangy River to Flat Run Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Olentangy River	74	2003	40	7.2	57.5	WWH	Partial	Agriculture	Siltation, Channelization
Olentangy River	68.1	2003	33	7.7	58	WWH	Non	Livestock, Poor Riparian	Nutrients, Siltation, Habitat Alteration
Olentangy River	63.4	2003	45	7.3	57.5	WWH	Partial	Agriculture	Nutrient Enrichment, Siltation
Olentangy River	63.4	1994	38	8.8	45.5	WWH	Full	-	-
Olentangy River	60	1994	50	9.4	86	WWH	Partial	Agriculture, Septic	Siltation, Nutrient Enrichment, Flow Alteration

Table B17.2: Olentangy River to Flat Run Watershed Biological Sampling Results

Mud Run Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Mud Run	6.7	2003	30	4.9	35	MWH	Full	-	-
Mud Run	2.7	2003	40	8.0	38	MWH	Full	Ditch Maintenance	Channelization
Mud Run	0.8	1994	33	-	27.5	WWH	Partial	Flow Alteration, Habitat Alteration, Riparian Removal	-

Table B17.3: Mud Run Watershed Biological Sampling Results

Flat Run Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Flat Run	13	2003	42	-	57	WWH	Full	-	-
Flat Run	7.3	2003	49	-	85	WWH	Full	-	-
Flat Run	1.1	2003	42	5.3	57.5	WWH	Full	-	Channel Modifications, Embeddedness
Flat Run	0.6	2003	50	9.1	72.5	WWH	Full	-	Channel Modifications, Embeddedness
Flat Run	0.5	1994	51	9.8	63	WWH	Full	Agriculture, Livestock	-

Table B17.3: Flat Run Watershed Biological Sampling Results

Whetstone Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Whetstone Creek	31	2003	50	-	78.5	EWH	Partial	Candlewood WWTP	Elevated Temperature, Nutrient Enrichment
Whetstone Creek	29	2003	43	-	73	EWH	Non	Candlewood WWTP	Nutrient Enrichment, Bacteria
Whetstone Creek	28	2003	48	-	80	EWH	Full	-	-
Whetstone Creek	26	2003	46	9	74.5	EWH	Full	-	-
Whetstone Creek	25	1994	51	8.9	77	WWH	Full	-	-
Whetstone Creek	22	2003	50	9	72	EWH	Full	-	-
Whetstone Creek	22	1994	46	9.2	71	WWH	Full	-	-
Whetstone Creek	22	2003	50	8.1	66.5	EWH	Partial	-	Natural
Whetstone Creek	22	2003	41	8.6	68	EWH	Non	Mt. Gilead WWTP	Nutrient Enrichment
Whetstone Creek	21	1994	80	8.9	90	WWH	Full	-	-
Whetstone Creek	19	1994	45	8.9	78.5	WWH	Full	-	-
Whetstone Creek	18	2003	50	9.2	64	EWH	Full	-	-
Whetstone Creek	16	1994	49	9.4	78	WWH	Full	-	-
Whetstone Creek	14	2003	45	8.4	66.5	EWH	Partial	Cardington, Urbanization	Nutrients, Riparian
Whetstone Creek	13	1994	50	10.2	90	WWH	Full	-	-
Whetstone Creek	10	1994	37	8.3	45.5	WWH	Full	-	-
Whetstone Creek	9.2	2003	40	8	69	EWH	Partial	Agriculture, Livestock	Nutrient Enrichment
Whetstone Creek	9.1	1994	42	9.1	38.5	WWH	Full	-	-
E. Branch Whetstone Creek	0.4	2003	45	-	78	WWH	Full	-	-
Sams Creek	1.4	2003	44	-	66.5	WWH	Full	-	-

Table B17.4: Whetstone Creek Watershed Biological Sampling Results

Shaw Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Shaw Creek	13.2	2003	40	5.1	39.5	EWH	Partial	-	Channel Modifications, Nutrient Enrichment
Shaw Creek	10.6	2003	38	4.6	52.5	EWH	Full	-	-
Shaw Creek	5.2	2003	30	4.8	61.5	EWH	Non	Septic, Agriculture	Nutrient Enrichment, Siltation, Riparian
Shaw Creek	1.6	2003	46	8.5	68.5	EWH	Full	-	-
Shaw Creek	0.4	1994	44	8.9	60	WWH	Full	-	-

Table C1.5: Shaw Creek Watershed Biological Sampling Results

Whetstone Creek below Shaw Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Tributary to Whetstone Creek (RM 33.71)	0.4	2003	40	4.9	56.5	WWH	Partial	-	-
Whetstone Creek	2.5	2003	36	8.7	61.5	EWH	Partial	Delaware Dam	Siltation, Low Flow

Table C1.6: Whetstone Creek below Shaw Creek Watershed Biological Sampling Results

Otter Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Olentangy River	56.6	2003	42	6.9	40.5	WWH	Partial	Caledonia Waste, Livestock	Siltation, Habitat Alteration, Nutrient Enrichment
Otter Creek	1.1	2003	38	-	44	WWH	Full	-	Channel Modifications

Table C1.7: Otter Creek Watershed Biological Sampling Results

Olentangy River at Otter Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Olentangy River	54.7	2003	36	7.3	77.5	WWH	Partial	Caledonia Waste	Channelization, Siltation
Olentangy River	54.6	1994	49	9.9	74.5	WWH	Full	-	-
Olentangy River	50.1	2003	38	8.2	84.5	WWH	Full	-	-
Olentangy River	45.5	2003	40	8	84.5	WWH	Full	-	-

Table C1.8: Olentangy River at Otter Creek Watershed Biological Sampling Results

Riffle Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Riffle Creek	4.4	2003	26	-	34.5	MWH	Non	-	Habitat Alteration, Siltation
Riffle Creek	1.4	2003	31	-	53.5	MWH	Non	Agriculture	Siltation, Habitat Alteration

Table C1.9: Riffle Creek Watershed Biological Sampling Results

Grave Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Grave Creek	3.2	2003	28	-	42	MWH	Non	Maintenance	Channelization, Nutrient Enrichment
Grave Creek	1.4	2003	29	-	44.5	MWH	Partial	Marion WWTP	Channelization
Grave Creek	0.9	1994	37	-	80.5	WWH	Partial	Point Source	-
Grave Creek	0.3	2003	42	8	76	WWH	Full	-	Siltation

Table C1.10: Grave Creek Watershed Biological Sampling Results

Norton Run Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Olentangy River	40.8	2003	35	7.8	64	WWH	Partial	Delaware Dam	Impounded, Siltation

Table C1.11: Norton Run Watershed Biological Sampling Results

Qua Qua Creek Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Qua Qua Creek	4.6	2003	22	-	29	MWH	Partial	-	Channel Modifications
Qua Qua Creek	0.1	2003	44	-	75	MWH	Full	-	-

Table C1.12: Qua Qua Creek Watershed Biological Sampling Results

Brondige Run Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Not Sampled	-	-	-	-	-	-	-	-	-

Table C1.13: Brondige Run Watershed Biological Sampling Results

Indian Run Watershed

Stream	RM	Year	IBI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Indian Run	0.9	2003	36	-	69	WWH	Full	-	Nutrient Enrichment

Table C1.14: Indian Run Watershed Biological Sampling Results

Horseshoe Run Watershed

Stream	RM	Year	IBI /ICI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Horseshoe Run	0.3	1999	38/Fair	n/a	63.5	WWH	Partial	None identified	None identified

Olentangy River below Delaware Dam Watershed

Stream	RM	Year	IBI /ICI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Olentangy River	32.0	1999	42/34	9.4	69.0	WWH	Full	None identified	None identified
Olentangy River	27.5	1999	42/48	8.8	82.5	WWH	Full	None identified	None identified
Olentangy River	25.4	1999	43/M. Good	9.8	66.5	WWH	Full		
Norris Run	1.3	2003	23/Low Fair	n/a	62.0	WWH	Non	Habitat Alteration, Nutrient Enrichment, Siltation	Urban influences
Sugar Run	1.3	2003	29/Low Fair	n/a	69.0	WWH	Non	Sitation, Nutrient Enrichment	Urban influences
Olentangy River	32.1	2003	42/40	10.2	66.0	WWH	Full		
Olentangy River	28.1	2003	36/28	6.2	55.5	WWH	Partial	Impounded, Siltation	Panhandle Rd. Dam
Olentangy River	27.5	2003	40/44	8.1	76.5	WWH	Full		

Delaware Run Watershed

Stream	RM	Year	IBI /ICI	MiWB	QHEI	Use Designation	Use Attainment	Impairment Source	Impairment Cause
Delaware Run	0.2	1999	30/Poor	n/a	40.0	WWH	Non	None identified	None identified
Delaware Run	1.2	1999	34/Poor	n/a	61.0	WWH	Non	None identified	None identified

Horseshoe Run Watershed

Stream	RM	Parameter	# of Samples	Exceeds/Violates
Horseshoe Run	0.3	Dissolved Oxygen	6	Minimum warm water DO criterion (<4.0 mg/l)
Horseshoe Run	0.3	E. Coli	6	Secondary Contact Recreation criterion

Olentangy River below Delaware Dam Watershed

Stream	RM	Parameter	# of Samples	Exceeds/Violates
Olentangy River	32.0	E.Coli	6	Primary Contact Recreation criterion
Olentangy River	32.0	Lindane	6	Ohio River drainage basin water quality criteria
Olentangy River	32.0	Dieldrin	6	Ohio River drainage basin water quality criteria
Olentangy River	27.9	E. Coli	6	Primary Contact Recreation criterion
Olentangy River	25.4	E. Coli	6	Primary Contact Recreation criterion

Delaware Run Watershed

Stream	RM	Parameter	# of Samples	Exceeds/Violates
Delaware Run	1.2	E. Coli	6	Secondary Contact Recreation criterion

Olentangy Watershed Alliance
Bylaws Approved 12/6/99
Last Revised 5/16/02

Olentangy Watershed Alliance
BYLAWS

ARTICLE I Name

This organization shall be known as the Olentangy Watershed Alliance, hereinafter referred to as OWA.

ARTICLE II Purpose

1. OWA is a group of citizens, public officials and special interest groups organized for non-profit purposes work in partnership with farming, urban, and other local communities to understand, appreciate and responsibly use the Olentangy River, its tributaries and watershed. The OWA vision is to enhance and preserve the water quality, natural integrity, scenic beauty and recreational value of the Olentangy River watershed in partnership with local communities. OWA is not formed for political lobbying or campaigning purposes.

ARTICLE III Offices

3.1 **Registered Office and Registered Agent**. The registered office of the corporation shall be located in the State of Ohio at such place as may be fixed from time to time by the Board of Directors upon filing of such notices as may be required by law. The registered agent shall have a business office identical with such registered office.

3.2 **Other Offices**. The corporation may have other offices within or outside the State of Ohio at such place or places as the Board of Directors may from time to time determine.

ARTICLE IV Board of Directors

4.1 **Formation.** Nominations for and elections of The Board of Directors will begin following an affirmative vote of the Officers. A decision to proceed with forming a Board will be made by the Officers within the first year of OWA operation

4.2 **Numbers and Powers**. The management of all the affairs, property, and interests of the corporation shall be vested in a Board of Directors consisting of seven (7) persons. The Board of Directors elected at the initial annual meeting of Board of Directors shall be divided into three classes (Class A, Class B and Class C) each consisting, as nearly as possible, of one-third (1/3) of the total number of directors elected at that time. The term of office of Class A directors shall expire at the next annual meeting following the annual meeting at which they are elected. The term of office of the Class B directors shall expire at the next annual meeting thereafter. The term of office of the Class C directors shall expire at the third annual meeting following the annual meeting at which they are elected. At each annual meeting after the initial annual meeting, directors shall be elected for a term of three years to succeed the directors whose terms expire at such meeting. In addition to the powers and authorities expressly conferred upon it by these Bylaws and Articles of Incorporation, the Board of Directors may exercise all such powers of the corporation and do all such lawful acts and things as are not by statute or by the Articles of Incorporation or by these Bylaws otherwise prohibited.

4.3 **Change of Number**. The number of directors may at any time be increased or decreased by amendment of these Bylaws, but no decrease shall have the effect of shortening the term of any incumbent director.

4.4 **Vacancies**. All vacancies in the Board of Directors, whether caused by resignation, death or otherwise, may be filled by the affirmative vote of a majority of the remaining directors even though less than a quorum of the Board of Directors. A director elected to fill any vacancy shall hold office for the unexpired term of his or her predecessor and until a successor is elected and qualified.

4.5 **Regular Meetings**. Regular meetings of the Board of Directors may be held at the registered office of the corporation or at such other place or places, either within or without the State of Ohio, as the Board of Directors may from time to time designate. The annual meeting shall be held each year in April, or at such other time and place as the Board of Directors shall designate by written notice. In addition to the annual meeting, there shall be regular meetings of the Board of Directors, held, with proper notice, not less frequently than once each calendar quarter.

4.6 **Special Meetings**. Special meetings of the Board of Directors may be called at any time by the President or upon written request by any two directors. Such meetings shall be held at the registered office of the corporation or at such other place or places as the directors may from time to time designate. Notice of special meetings will be given by letter, phone call, E-mail or telegram.

4.7 **Notice**. Notice of all special meetings of the Board of Directors and of all regular meetings other than the annual meetings to be held at the place and time designated in Section 2.4 shall be given to each director by three (3) days prior service of the same by telegram, by letter, or personally. Such notice shall specify the business to be transacted or the purpose of the meeting.

4.8 **Quorum**. A majority of the whole Board of Directors shall be necessary and sufficient at all meetings to constitute a quorum for the transaction of business.

4.9 **Waiver of Notice**. Attendance of a director at a meeting shall constitute a waiver of notice of such meeting, except where a director attends for the express purpose of objecting to the transaction of any business because the meeting is not lawfully called or convened. A waiver of notice signed by the director or directors, whether before or after the time stated for the meeting, shall be equivalent to the giving of notice.

4.10 **Registering Dissent**. A director who is present at a meeting of the Board of Directors at which action on a corporate matter is taken shall be presumed to have assented to such action unless the director shall file a written dissent or abstention to such action with the person acting as the secretary of the meeting before the adjournment thereof, or shall forward such dissent by registered mail to the Secretary of the corporation immediately after the adjournment of the meeting. Such right to dissent or abstain shall not apply to a director who voted in favor of such action.

4.11 **Executive and Other Committees**. The Board of Directors may appoint, from time to time, from its own number, standing or temporary committees consisting each of no fewer than one (1) director. Such committees may be vested with such powers as the Board may determine by resolution passed by a majority of the full Board of Directors, provided however, that no such committee shall have the authority of the Board of Directors to reference:
(a) Amending, altering, or repealing these Bylaws;
(b) Electing, appointing, or removing any director or officer of the corporation;
(c) Amending the Articles of Incorporation.
(d) Adopting a plan of merger or consolidation with another corporation.
(e) Authorizing the sale, lease, exchange or mortgage, of all or substantially all of the property and assets of the corporation;
(f) Authorizing the voluntary dissolution of the corporation or revoking proceeds therefor; or
(g) Amending, altering, or repealing any resolution of the Board of Directors which by its term provides that it shall not be amended, altered, or repealed by such committee.

All committees so appointed shall keep regular minutes of the transactions of their meetings and shall cause them to be recorded in books kept for that purpose in the office of the corporation. The designation of any such committee and the delegation of authority thereto, shall not relieve the Board of Directors of any responsibility imposed by law.

Committee chairpersons, length of service and other guidance shall be determined by the Board. If the Board has not yet been formed, the officers shall act in the same capacity to set up necessary committees.

4.12 **Remuneration**. No stated salary shall be paid directors, as such, for their service, but by resolution of the Board of Directors, a fixed sum and expenses of attendance, if any, may be allowed for attendance at each regular or special meeting of such Board; provided, that nothing herein contained shall be construed to preclude any director from serving the corporation in any other capacity and receiving compensation therefore.

4.13 **Loans**. No loans shall be made by the corporation to any director.

4.14 **Removal**. Any director may be removed at any time, with or without cause, by the affirmative vote of four (4) members of the Board of Directors.

ARTICLE V Officers

5.1 **Designations**. The officers of the corporation shall be a President, one or more Vice Presidents (one or more of whom may be Executive Vice Presidents), a Secretary/ Treasurer, and such Assistant Secretaries and Assistant Treasurers as the Board may designate. All officers shall be elected for terms of one year by the participants at an advertised meeting of the Alliance. Officers shall be nominated by a steering committee prior to the advertised meeting. Such officers shall hold office until their successors are elected and qualified. Any two or more offices may be held by the same person, except the offices of President and Secretary/Treasurer. The officers elected shall also serve as the Board of Directors until such Board is appointed.

5.2 **The President**. The President shall preside at all meetings of the Board of Directors, shall have general supervision of the affairs of the corporation, and shall perform such other duties as are incident to the office or are properly required of the President by the Board of Directors.

5.3 **Vice Presidents**. During the absence or disability of the President, the Executive Vice Presidents, if any, or any of the Vice Presidents in the order designated by the Board of Directors, shall exercise all the functions of the President. Each Vice President shall have such powers and discharge such duties as may be assigned to him or her from time to time by the Board of Directors.

5.4 **Secretary/Treasurer** . The Secretary/Treasurer shall issue notices for all business meetings, except for notices of program or special meetings of the Board of Directors which are called by the requisite number of directors, shall keep minutes of all meetings, and shall have charge of the seal and the corporate books. The Secretary/Treasurer shall have the custody of all monies and securities of the corporation and shall keep regular books of account. The Secretary/Treasurer shall disburse the funds of the corporation in payment of the just demands against the corporation or as may be ordered by the Board of Directors (taking proper vouchers for such disbursements) and shall render to the Board of Directors from time to time as may be required, an account of all transactions undertaken as Secretary/Treasurer and of the financial condition of the corporation. The Secretary/Treasurer shall make such reports and perform such other duties as are incident to the office, or are properly required of the Secretary/Treasurer by the Board of Directors.

5.5 **The Assistant Secretaries and Assistant Treasurers**. The Assistant Secretary, or Assistant Secretaries, in the order designated by the Board of Directors, shall perform all of the duties of the Secretary, and at other times may perform such duties as are directed by the President or the Board of Directors. The Assistant Treasurer, or Assistant

Treasurers, in the order designated by the Board of Directors, shall perform all of the duties of the Treasurer in the absence or disability of the Treasurer, and at other times may perform such other duties as are directed by the President or the Board of Directors.

5.6 **Watershed Coordinator/Project Coordinator**. Watershed Coordinator(s), who are employees of the Board or who are hired by another non-profit organization or a government agency with a job assignment(s) which relates to the Olentangy River, will have ex-officio appointment to the Board of Directors. The Watershed Coordinator(s) may administer and conduct business of the Board of Directors pursuant to guidelines established by the Board. The Watershed Coordinator/Project Coordinator shall have full authority for direction of the employees of the corporation, if any. The Watershed Coordinator Project Coordinator, if selected, may be compensated for his or her services in that capacity in such amount and manner as the Board of Directors shall determine. The Watershed Coordinator(s) have full voting privileges except for Board hired coordinators when those matters relate to the appointment and evaluation of the board hired Watershed Coordinator(s).

5.7 **Delegation**. If any officer of the corporation is absent or unable to act and no other person is authorized to act in such officer's place by the provisions of these Bylaws, the Board of Directors may from time to time delegate the powers or duties of such officer to any other officer or any director or any other person it may select.

5.8 **Vacancies**. Vacancies in any office arising from any cause may be filled by the Board of Directors at any regular or special meeting of the Board.

5.9 **Other Officers**. The Board of Directors may appoint such other officers or agents as it shall deem necessary or expedient, who shall hold their offices for such terms and shall exercise such powers and perform such duties as shall be determined from time to time by the Board of Directors.

5.10 **Loans**. No loan shall be made by the corporation to any officer.

5.11 **Term** - Removal. The officers of the corporation shall hold office until their successors are chosen and qualified. Any officer or agent elected or appointed by the Board of Directors may be removed at any time, with or without cause, by the affirmative vote of a majority of the whole Board of Directors, but such removal shall be without prejudice to the contract rights, if any, of the person so removed.

5.12 **Bonds**. The Board of Directors may, by resolution, require any and all of the officers to provide bonds to the corporation, with surety or sureties acceptable to the Board, conditioned for the faithful performance of the duties of their respective offices, and to comply with such other conditions as may from time to time be required by the Board of Directors.

5.13 The first elected officers shall assume the duties of the Board of Directors until the

Board is elected. Officers shall give up their Board duties as soon as Board members are elected.

ARTICLE VI Membership and Dues

16.1The membership shall be open to all persons interested in the purposes of OWA. Members may be any citizen, agency, organization or business as registered by OWA.

16.2 Members join by registering with OWA and paying annual membership dues, unless determined an honorary member.

16.3 Membership classes include: student (<21 years old), senior (> or = 60), regular, family, senior family, organization, government agency, business, honorary, and sustaining with dues for each class determined by the Board of Directors when formed or Officers until then.

16.4Honorary members may be elected by a majority vote of the Board of Directors and serve for life.

16.5An annual meeting of the membership shall occur as referenced in article 4.5 as determined by the Board of Directors or Officers until the Board is formed. Notice of meetings of the membership and issues to be discussed, must be sent to each member and must be mailed or delivered at least thirty (30) days prior to the day such meeting is held. Membership meetings will be conducted by the president or another appropriate officer. Each paying or honorary member receives one vote during any business of any membership meeting of the Alliance. Absentee votes are eligible. Motions made by the membership will pass with a simple majority vote.

ARTICLE VII Fiscal Year

The corporation's fiscal year shall be from July 1st through June 30th.

ARTICLE VIII Depositories

The monies of the corporation shall be deposited in the name of the corporation in such bank or banks or trust company or trust companies as the Board of Directors shall designate, and shall be drawn from such accounts only by check or other order for payment of money signed by such persons, and in such manner, as may be determined by resolution of the Board of Directors or officers if there is no Board.

ARTICLE IX Notices

Except as may otherwise be required by law, any notice to any director may be delivered personally or by mail or by electronic mail. If mailed, the notice shall be deemed to have been delivered when deposited in the United States mail, addressed to the addressee at his or her last known address in the records of the corporation, postage prepaid.

ARTICLE X Corporate Seal and Logo

The corporate seal of the corporation and logo, if any, shall be in such form and bear such inscription as may be adopted by resolution of the Board of Directors, or by usage of the officers on behalf of the corporation.

ARTICLE XI
Indemnification of Officers, Directors, Employees and Agents

The corporation shall indemnify its officers, directors, employees and agents to the greatest extent permitted by law. The corporation shall have power to purchase and maintain insurance on behalf of any person who is or was a director, officer, employee, or agent of the corporation or who is or was serving at the request of the corporation as an officer, employee, or agent of another corporation, partnership, joint venture, trust, other enterprise, or employee benefit plan, against any liability asserted against such person and incurred by such person in any such capacity or arising out of any status as such, whether or not the corporation would have the power to indemnify such person against such liability under the provisions of this Article.

ARTICLE XII Conflicting Interest Transactions

12.1 **Definitions**. For purposes of this Article:

(a) "Conflicting interest" means the interest a director has respecting a transaction effected or proposed to be effected by the corporation or any other entity in which the corporation has a controlling interest if:

(1) The director knows at the time the corporation takes action that the director or a related person is a party to the transaction or has a significant beneficial financial interest in or so closely linked to the transaction that a reasonable person would expect the interest to influence the director's judgment if the director were called upon to vote on the transaction; or

(2) The transaction is brought before the Board for action, and the director knows at the time the Board reviews the transaction that any of the following persons is either a party to the transaction or has a significant beneficial financial interest in or so closely linked to the transaction that a reasonable person would expect the interest to influence the director's judgment if the director were called upon to vote on the transaction:

A) An entity of which the director is a director, general partner, agent or employee;

(B) An entity that controls, is controlled by, or is under common control with one or more of the entities specified in (A); or

(C) An individual who is a general partner, principal, or employer of the Director.

(b) "Director's conflicting interest transaction" means a transaction effected or proposed to be effected by the corporation or any other entity in which the corporation has a controlling interest respecting which a Director of the corporation has a conflicting interest.

(c) "Qualified Director" means any Director who does not have either:

(1) A conflicting interest respecting the transaction; or

(2) A familial, financial, professional, or employment relationship with a second Director who does have a conflicting interest respecting the transaction, which relationship would, in the circumstances, reasonably be expected to exert an influence on the first Director's judgment when voting on the transaction.

(d) "Related person" of a Director means:

(1) A child, grandchild, sibling, parent, or spouse of, or an individual occupying the same household as, the Director, or a trust or estate of which any of the above individuals is a substantial beneficiary; or

(2) A trust, estate, incompetent, conservatee, or minor of which the Director is a fiduciary.

(e) "Required disclosure" means disclosure by the Director who has a conflicting interest of:

(1) The existence and nature of the Director's conflicting interest; and

(2) All facts known to the Director respecting the subject matter of the transaction that an ordinarily prudent person would reasonably believe to be material to a judgment about whether or not to proceed with the transaction.

12.2 **Directors' Action.**

(a) **Majority Vote**. Directors' action respecting a Director's conflicting interest transaction is effective if the transaction received the affirmative vote of a majority of (but no fewer than two) qualified Directors who voted on the transaction after either required disclosure to them or compliance with Paragraph (b) below.

(b) **Director's Disclosure**. If a Director has a conflicting interest respecting a transaction, but neither the Director nor a related person of the Director is a party to the transaction, and if the Director has a duty under law or professional canon, or a duty of confidentiality to another person, which would prevent that Director from making the disclosure described in Paragraph 9.1(e), then disclosure is sufficient if the Director:

(1) Discloses to the Directors voting on the transaction the existence and nature of the Director's conflicting interest and informs them of the character and limitations imposed by that duty before their vote on the transaction; and

(2) Plays no part, directly or indirectly in their deliberations or vote.

(c) **Quorum**. A majority (but no fewer than two) of the qualified Directors constitutes a quorum for purposes of action that comply with this Article. Directors' action that otherwise complies with this Article is not affected by the presence or vote of a Director who is not a qualified Director.

ARTICLE XIII Books and Records

13.1 The corporation shall keep correct and complete books and records of account and shall keep minutes of the proceedings of its Board of Directors; and shall keep at its registered office or principal place of business, or at the office of its transfer agent or registrar, a record of its Directors, giving the names and addresses of all Directors.

13.2 All official records shall be dated with the day, month and year.

ARTICLE XIV Amendments

Changes to the ByLaws may be proposed at any OWA meeting. The proposed amendments will be voted on at the next annual meeting of the Association. Proposed changes to the ByLaws must be distributed 30 days in advance of the meeting. A majority vote of the members present is necessary for passage of the amendment. The amended ByLaws shall be available to the Association membership at the next monthly meeting of the Alliance. The Board of Directors, or Officers if no Board exists, shall have power to make, alter, amend, and repeal the Bylaws of this corporation; provided, that the Board will not approve any such alteration, amendment, or repeal that would adversely impact the rights of any class of Directors unless such alteration, amendment, or repeal shall first have received the approval of two-thirds (2/3) of the Directors of such class.

ARTICLE XV Dissolution

16.1 Only during an annual meeting of the membership can a vote to dissolve this organization. The Alliance shall be considered dissolved if three-fourths (75%) of the total membership, by secret ballot, vote in favor of dissolution.

16.2 The effective date of the dissolution shall be thirty (30) days from the date of the vote, thus allowing for the disposal of assets and liabilities.

16.3 In the event of dissolution of OWA, all assets of the association remaining after payment of all obligations shall be distributed to a similar conservation organization with a mission similar to OWA.

Adopted by vote of the membership on May 16, 2002.

____

Bob Bargar
President

____

Susan Logan
Secretary

Initially approved by the participants at the 12.6.99 OWA meeting, Delaware Public Library, Delaware, Ohio.

Revised at the 5 April 2001 Annual Olentangy Watershed Alliance meeting, Delaware Public Library, Delaware, OH.

Approved by vote at the 16 May 2002 Membership meeting, Delaware Township Hall, Delaware OH