NINE-ELEMENT NONPOINT SOURCE IMPLEMENTATION STRATEGY (NPS-IS)

HEADWATERS TWIN CREEK HUC-12 (050800020202)

Twin Creek confluence with Miller's Fork

PREPARED FOR THREE VALLEY CONSERVATION TRUST

PREPARED BY ENVIRONMENTAL SOLUTIONS AQ

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Chapter 1: Introduction

The Nine-Element Nonpoint Source Implementation Strategies Plan (NPS-IS) is a strategic document that provides assurance to nonpoint source grant programs and institutions (i.e., United States Environmental Protection Agency [U.S. EPA]) that a proposed water quality improvement project meets the nine essential elements per U.S. EPA §319 Program Guidance (April 2013). The NPS-IS ensures that potentially funded projects are scientifically evaluated, that they are located in areas that will address the worst problems; and that that they have the administrative, evaluation, and educational components needed to ensure that the water resources will achieve as much long-term benefit as possible. The NPS-IS is a living strategic planning document that summarizes causes and sources of impairment, establishes critical areas, identifies quantifiable objectives to address causes and sources of impairment, and describes projects designed to meet those objectives.

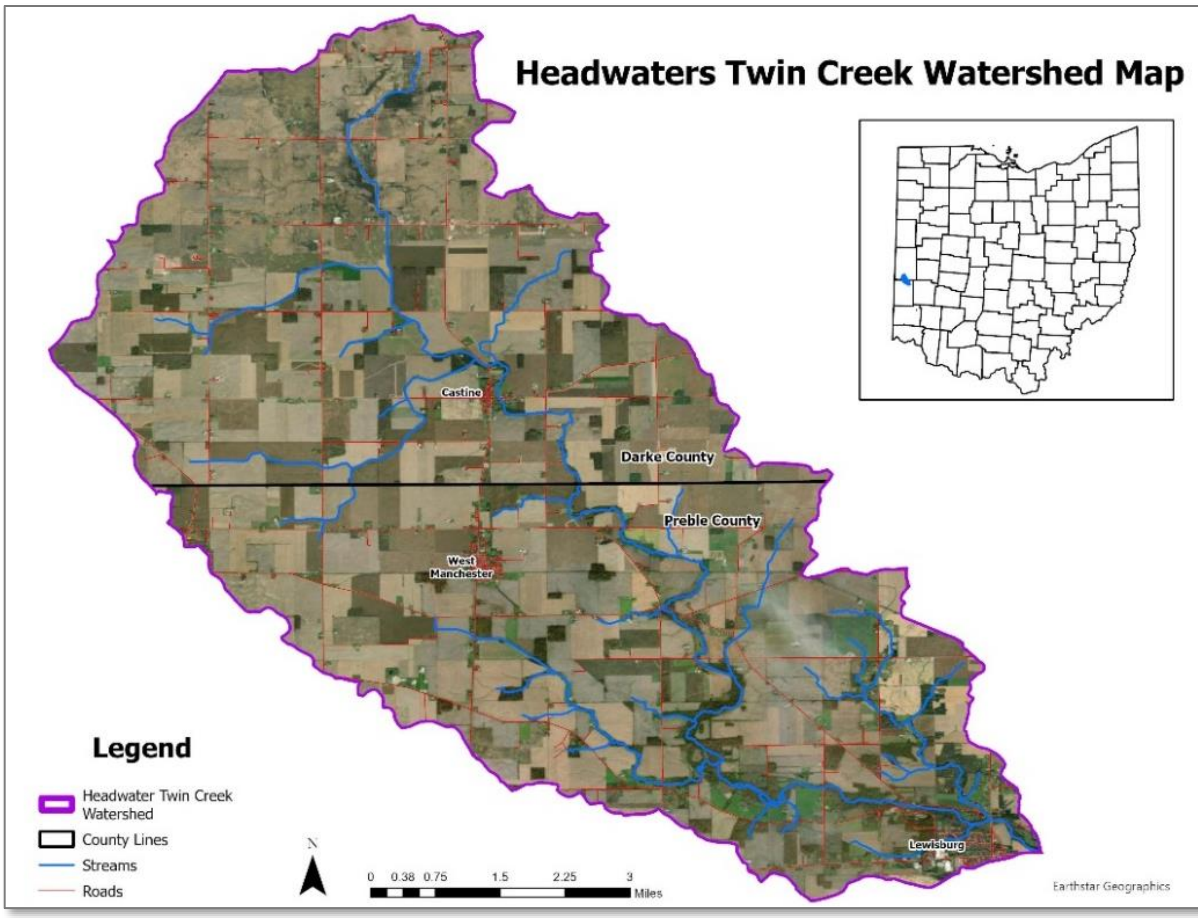

FIGURE 1-1 HEADWATERS TWIN CREEK HUC-12 WATERSHED MAP

The Headwaters Twin Creek Hydrologic Unit Code (HUC)-12 (050800020202) (Figure 1-1) has been identified as one of the priority watersheds where United States Department of Agriculture (USDA) models suggest there is high contribution of nutrient loading from agricultural lands. Headwaters Twin Creek is located within the Great Miami River watershed which is a major contributor of nutrients to the Gulf of Mexico (OEPA, 2020a; Goolsby et al., 1999). The Great

Miami River basin watershed had the highest soluble reactive phosphorus concentrations and the highest time-weighted average total P concentration amongst 10 streams studied in Ohio (Baker, 2006).

Three Valley Conservation Trust (TVCT) has partnered with Environmental Solutions AQ, a local environmental consultant, for the preparation of this Nine-Element NPS-IS for Headwaters Twin Creek HUC-12 watershed.

One important element of Nine-Element NPS-IS is the education and outreach activities that has been conducted while implementing the plan. TVCT is dedicated to engaging the public and informing them of important events and projects as well as educating them about the existing condition of the streams. Key partners, the soil and water conservation districts of Darke and Preble counties, are also dedicated to educating landowners and agricultural producers about managing nutrient loads by implementing Best Management Practices (BMPs) and about improving and preserving the quality of streams. In addition, partners including Miami Valley Regional Planning Commission, Miami Conservancy District and health departments of Darke and Preble counties are all willing partners to engage the communities to address drinking water source protection and Home Sewage Treatment Systems (HSTS) in unsewered communities.

FIGURE 1-2 THE MOST UPSTREAM PORTION OF THE HEADWATERS TWIN CREEK WATERSHED IS MAPLE SWAMP DITCH

1.1. Report Background

Ohio has been leading Watershed-Based Planning (WBP) for a long time. It is a process that often results in a document used to guide projects within a geographic area defined by the flow of water. WBP is used to coordinate activities related to water resources including: water quality and/or quantity management, ecological protection and restoration, or the strategic guidance of development, infrastructure improvement, transportation, and recreation among others. WBP is an effective approach to solving difficult water-related problems because it is locally led, collaborative, data driven, and consensus based (OEPA, 2016a).

Ohio Environmental Protection Agency (OEPA) developed the Ohio Guide for Development of Watershed Action Plans in 1997 and in 2016, in collaboration with Ohio Department of Agriculture, the Nine-Element NPS-IS template was issued to guide the completion of a state and federal approvable Nine-Element NPS-IS (OEPA, 2016b).

A Nine-Element NPS-IS is a specific type of watershed-based planning that will allow local entities to effectively propose and implement nonpoint source pollution projects utilizing funding made available through the Clean Water Act Section 319 (§319), H2Ohio or the Great Lakes Restoration Initiative. In Ohio, eligibility for these grant programs is strongly preferred or restricted to projects delineated within a critical area of an approved NPS-IS.

Nine Elements of NPS-IS
Source: OEPA, 2016a

a) An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan.

b) An estimate of the load reductions expected for the management measures described under paragraph (c) below.

c) A description of the NPS management measures (solutions) that will need to be implemented to achieve the load reductions estimated under paragraph (b) above and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan.

e) An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

g) A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

h) A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS Total Maximum Daily Load (TMDL) has been established, whether the NPS TMDL needs to be revised.

i) A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Headwaters Twin Creek Watershed (a subwatershed of Twin Creek) was characterized in the 2010 endorsed Twin Creek Watershed Action Plan (WAP). The Twin Creek WAP concluded that although much of the watershed was very high quality, portions of Twin Creek and its tributaries were not meeting aquatic life and recreational use standards (IES, 2010). During OEPA's 2005 study reported in the Biological and Water Quality Study of Twin Creek and Selected Tributaries, Headwaters Twin Creek mainstem was fully attaining Exceptional Warmwater Habitat (EWH) Aquatic Life Use (ALU). In the 2010 Twin Creek Watershed Total Maximum Daily Load (TMDL) report, OEPA concluded that the Maple Swamp Ditch, a tributary at the upper portion of the Headwaters Twin Creek HUC-12, was recommended for Modified Warmwater Habitat (MWH) and partial attainment status. The sources of the impairment included channelization, loss of riparian habitat and crop production with subsurface drainage. The causes of impairment to aquatic life and primary recreational use in Maple Swamp Ditch of Headwaters Twin Creek HUC-12 included sedimentation/siltation, and excess algal growth (OEPA, 2007).

Chapters 1 and 2 of the Headwaters Twin Creek HUC-12 Nine-Element NPS-IS have been prepared based on knowledge from the Twin Creek WAP, OEPA's 2007 report, TMDL documents, and other published water quality documents. Chapters 3 and 4 were developed via engagement with stakeholders, including partner organizations, agricultural producers, and landowners. The NPS-IS follows the OEPA Nine-Element NPS-IS template (OEPA, 2016b).

1.2. Watershed Profile & History

The Headwaters Twin Creek HUC-12, located in Preble and Darke counties, Ohio is one of the subwatersheds of the Twin Creek Basin located in southwest Ohio (Figure 1-3). The Headwaters Twin Creek watershed drains an area of 44.19 mi^2 in southwestern Ohio. Twin Creek, 47.03 miles long, has been categorized as an Outstanding State Water in OAC 3745-1-05 (ODA, 2023). Twin Creek originates in Darke County and flows southeast into Preble County and generally south through the eastern portion of the county, then southeast through the southwest corner of Montgomery County, and then into Warren County, Franklin Township, where it meets the Great Miami River. The Twin Creek watershed drains an area of 316 mi^2 in southwestern Ohio. The Headwaters Twin Creek and Twin Creek watersheds are part of the Lower Great Miami Watershed HUC 05080002 (Figure 1-4).

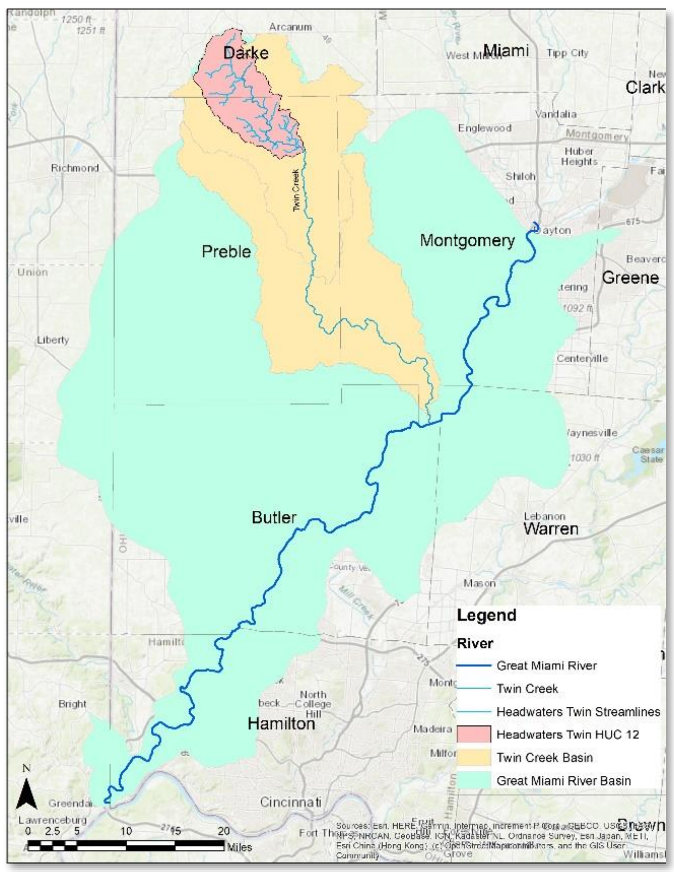

FIGURE 1-3 HEADWATERS TWIN CREEK HUC-12 IN THE UPPER REACHES OF THE TWIN CREEK WATERSHED (ESRI)

Approximately 10 miles of Twin Creek has been modified through channelization, riparian removal or leveed (Twin Creek WAP, 2010). The Headwaters Twin Creek HUC-12 watershed is 28,288 acres in size. Tributaries flow from Hollansburg-Arcanum Rd and 127 in the northwest to southeast where it joins Millers Fork near Lewisburg, east of the intersection of US Route 40 and Ohio 503. Significant tributaries in the Headwaters Twin Creek HUC-12 watershed include Maple Swamp Ditch, Dry Fork, Lick Run and several unnamed tributaries.

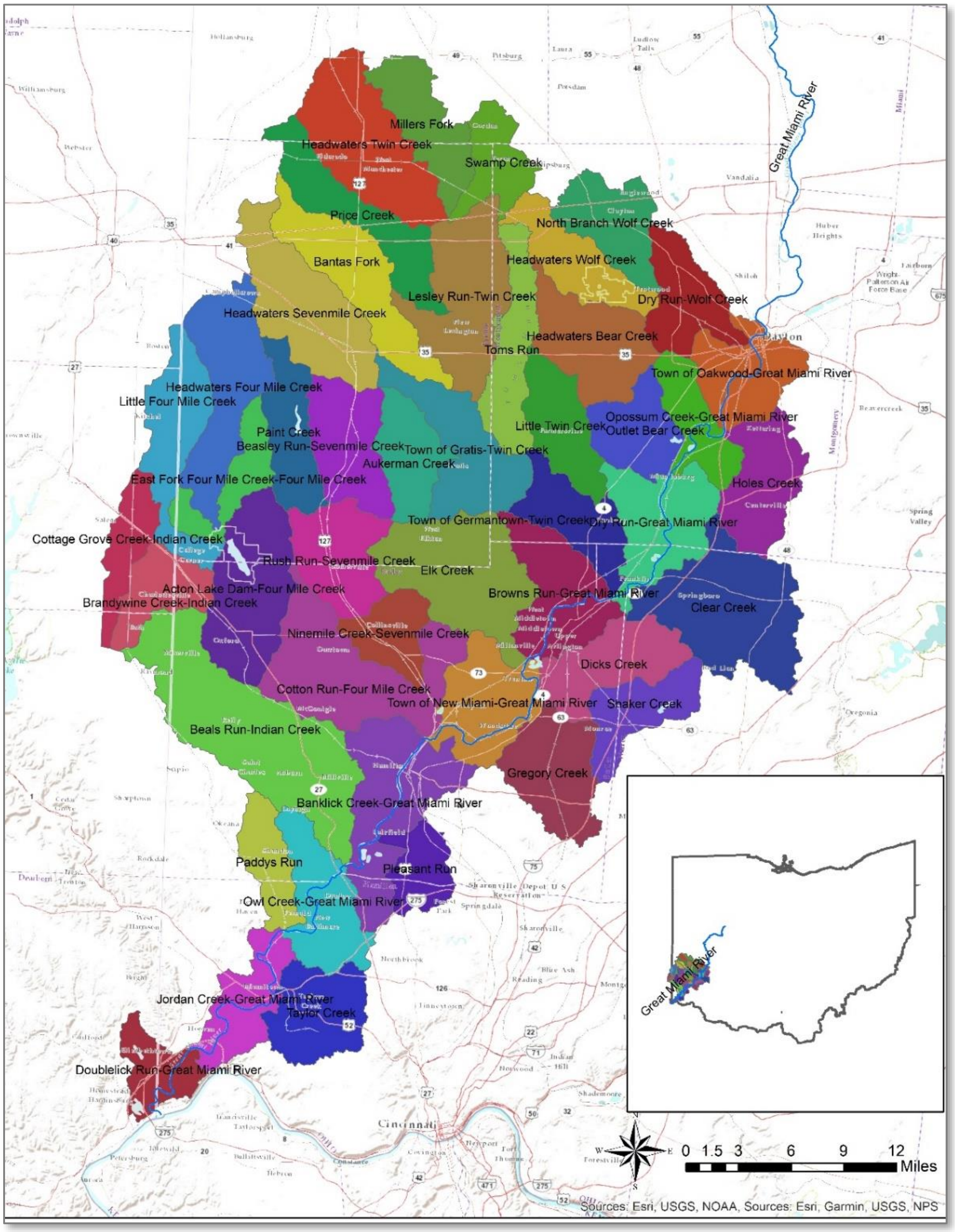

FIGURE 1-4 LOWER GREAT MIAMI RIVER HUC-8 WITH TWIN CREEK HIGHLIGHTED (ESRI)

HUMAN HISTORY

A path taken by indigenous people is known and it is called the “Wabash Trail.” Shawnee and Miami tribes populated the region during the American colonial period. Wolves, panther, and dense forests of walnut, oak, ash, elm, and maple impeded travel in this section of the Northwest Territory during the early days of white settlement (Wilson, 1914).

During the Indian Wars of 1790-1795, American troops led by generals Arthur St. Clair and Anthony Wayne traversed the Headwaters Twin Creek watershed. General St. Clair traveled north from the Ohio River, establishing Fort St. Clair near what is now Eaton in Preble County and then Fort Jefferson south of Greenville. Their route roughly followed the Wabash Trail the indigenous people used -- a path roughly parallel to and west of today’s Ohio State Route 127. Though the 1795 Treaty of Greenville technically opened the Twin Creek watershed – and all of the southern two-thirds of Ohio -- to white settlement, skirmishes with the natives as well as sickness and other difficulties of frontier life discouraged much permanent white settlement until the end of the War of 1812 and the death of Tecumseh. This local Shawnee had united numerous tribes to resist the settlers’ western expansion (Ohio Historical Society).

The National Road (also known as the Cumberland Road), authorized by the US Congress in 1806 during the Jefferson Administration, meant white settlers could travel to western Ohio from as far east as Baltimore, Maryland. Completed all the way to Illinois by the 1830s and now known as US Route 40, the road passes through the southern edge of the watershed, through the former community of Euphemia, which is now part of Lewisburg. It brought business and families to the area early in the 1800s and continued to be a busy interstate route until the parallel Interstate Route 70 was completed during the middle of the 20th century (Longfellow, 2017).

Today, the Headwaters Twin Creek watershed is primarily a rural, agricultural watershed in Preble and Darke counties. Most of the land use of the watershed is composed of farmland that is owned by private landowners. Agricultural production is primarily focused on row crops. Swine are raised in a handful of facilities in the upstream or Darke County portion of the watershed.

The villages of West Manchester (415 people, according to the 2020 U.S. Census) and Castine (110 people, 2020 US Census) are the only populated areas completely within the Headwaters Twin Creek HUC-12, though portions of Eldorado and Lewisburg also drain to Headwaters Twin Creek. There are only a few industrial, or large-scale commercial facilities within the watershed. West Manchester Wastewater Treatment Plant, which provides sewage treatment services for the village, is the only permitted National Pollutant Discharge Elimination System (NPDES) facility within the Headwaters Twin Creek HUC-12 watershed.

In 2005, Twin Creek was in full attainment of EWH ALU along the mainstem in this HUC-12, but the major upstream tributary Maple Swamp Ditch was only in partial attainment of MWH ALU. The stream was channelized sometime in the past to aid drainage through poorly drained Crosby and Brookston soils. This waterway has no riparian buffer and is relatively flat. Nutrient enrichment has occurred, likely caused by adjacent row cropping and likely scattered failing septic systems draining to the ditch.

The Darke County Ditch Maintenance Department manages the Maple Swamp Ditch and other ditches and small creeks within the county. Darke County Ditch Maintenance began to maintain ditches on a regular program in the watershed since 1957 and Maple Swamp Ditch was one of their first projects in 1957 (Personal interview 8-7-23, Jeff McMiller, Darke County Ditch Maintenance). However, the ditch maintenance office also noted that many of the ditches have existed long before the 1950s.

1.3. Public Participation and Involvement

Public participation and involvement are critical to the success of implementing the recommendations of any NPS-IS. In 2007, the Twin Creek Advisory Committee was formed, and meetings were held regularly to collaborate in the preparation of the Twin Creek WAP and review of the OEPA prepared Twin Creek TMDL. The Twin Creek watershed projects were operated as a collaborative group of organizations, individuals, and agencies with a goal of protecting and improving water quality in Twin Creek and its tributaries. Various partners engaged in the decision-making process, documentation and plan strategy endorsements, and events including education, public outreach, and stream monitoring. The decision-making process was informal, but consensus driven. The public involvement for the Headwaters Twin Creek HUC-12 Nine-Element NPS-IS development is built on this already established working relationship and trust.

In April, 2023, TVCT and its partners, the Preble and Darke soil and water conservation districts (SWCDs) issued the first press release regarding the Headwaters Twin Creek HUC-12 NPS-IS development in the local newspaper. An invitation postcard or letter was sent to 491 landowners who reside in the Headwaters Twin Creek, Miller's Fork, or Swamp Creek HUC-12 watersheds and who own properties larger than 5 acres. NPS-IS for Miller's Fork and Swamp Creek HUC-12 watersheds are also currently being prepared. TVCT contacted the owners of easements they hold, to inform them of the project and invite them to the public meeting. TVCT and other partners also posted to social media (Figure 1-5). The announcement and invitation received immediate positive responses. TVCT and its partners received emails and phone calls inquiring about the project. The progress of the plan preparation was posted on social media and TVCT's website.

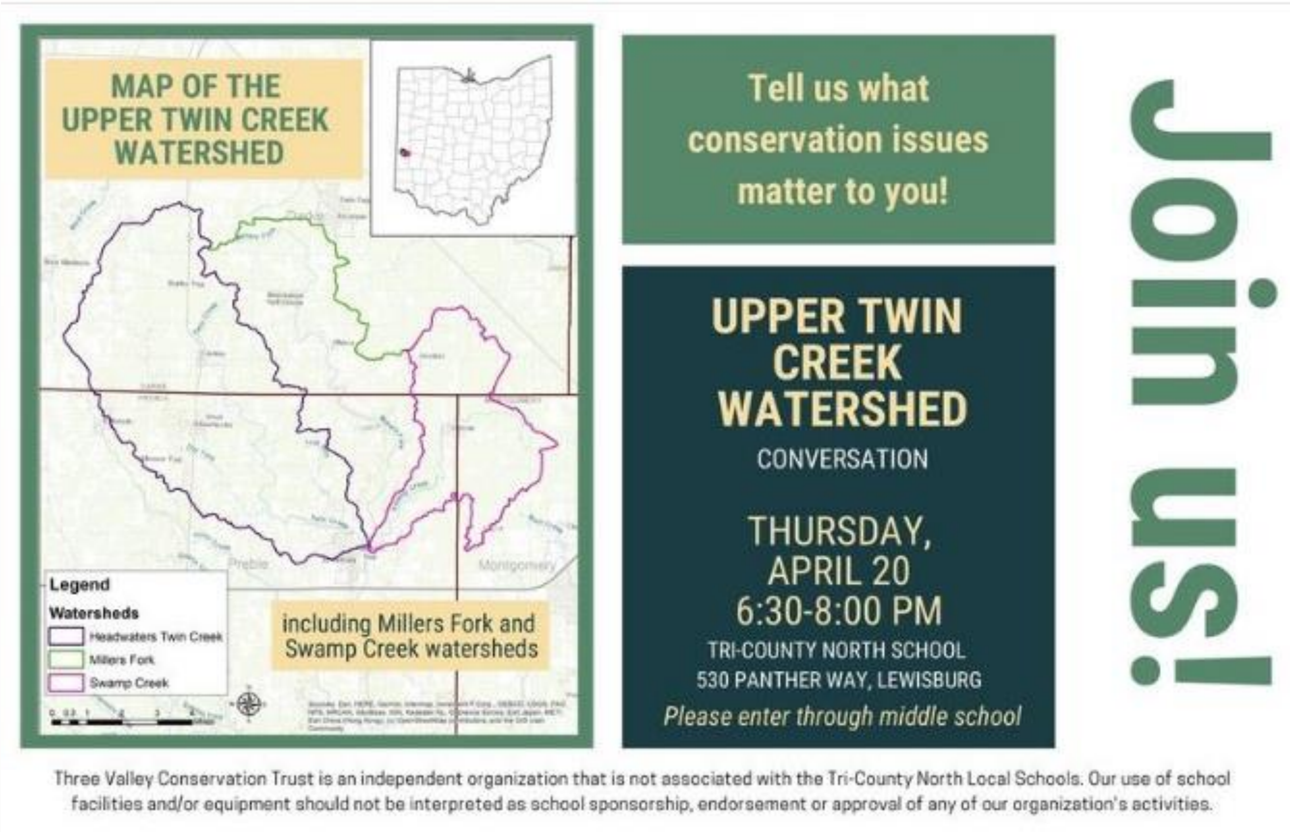

FIGURE 1-5 A FACEBOOK POST FOLLOWS THE DESIGN OF A POSTCARD SENT TO LANDOWNERS

On April 20, 2023, a public meeting was held in the lecture room of Tri-County North High School in Lewisburg. About 30 landowners participated in the in-person public meeting. During the meeting, a presentation was given and then the public discussed the scope of the Nine-Element NPS-IS. The meeting presentation and discussion included three HUC-12 watersheds adjacent to one another because the partners are working on these plans simultaneously. Also, many local agricultural producers own or farm land in two or more of these adjacent watersheds. The Miami Conservancy District, as a major stakeholder interested in water conditions, also sent a staff person to the meeting. Representatives from all three county health departments and the Preble County Park District were also present.

At the public meeting, landowners asked questions and discussed the water quality issues at Headwaters Twin Creek HUC-12 as well as potential funding opportunities for implementing conservation and restoration projects. In addition, landowners were invited to complete a 10-item questionnaire. Four completed questionnaires were collected after the meeting from landowners in the Headwaters Twin Creek HUC-12. In summary, the landowners were most concerned about log jams in the stream, failing septic systems, and agricultural nutrients running off into streams. If funding were available, the landowners would participate in installing streambank stabilization, surface drainage improvements, and wetland rehabilitation.

On May 11, 2023 an interview was held with the Darke County Economic Development Director to discuss water resource needs in the northern part of the watershed as related to development plans. None of the Darke County communities in the watershed appear to be seeking new commercial, industrial, or residential development. The Darke County Comprehensive Land Use Plan is under development at the time of publication, Preble County has a published comprehensive land use plan. According to the Board of Preble County Commissioners’ plan, additional plans are needed that focus on sewer and water infrastructure to attract development.

On May 25, 2023 a discussion was held with health department environmental staff members from Preble, Darke and Montgomery counties and Matt Lindsay of the Miami Valley Regional Planning Commission (MVRPC) regarding the problem of failing septic systems and unsewered communities. The Darke County General Health District (DCGHD) staff members provided data about suspected noncompliant Home Sewage Treatment Systems (HSTS) in an unsewered community. An unsewered community is a populated place where small lot size prevents conventional replacement strategies for failing HSTS. The Preble County Public Health (PCPH) staff members provided a general overview of complaints, conditions, and possible solutions for failing HSTS in their respective jurisdictions. MVRPC requested assistance from the health departments in contacting leadership of the unsewered communities. MVRPC has offered free planning assistance to these communities to develop customized wastewater treatment options in the form of a General Plan. The plan would look at potential solutions and recommend the most effective option for solving the problem. The plan, which includes preliminary engineering estimates, would lay the groundwork for funding opportunities and will be the first and important step toward possibly building a new or connecting to a nearby wastewater treatment plant.

The announcement of the NPS-IS project and the April public meeting prompted more landowners’ interest and inquiries about implementing conservation practices. Field visits were conducted on June 20, 27, and 30, 2023, to discuss conservation practices within the watershed. During the site visits, the NPS-IS core team met with agricultural producers with large row-crop operations regarding their challenges and successes with various conservation practices, as well as problem areas on their properties. The team also met with Preble County Park district that manages a nature preserve within this watershed. (see Section 2.1.2. for Public Land discussion).

TVCT is committed to continue its mission to conserve natural habitats, waterways and agricultural lands in Southwestern Ohio, for the benefit of present and future generations, through partnerships with people and communities. Preble and Darke SWCDs are dedicated to continuing to promote conservation practices with public involvement through education and outreach activities. The SWCDs engage with the public in several ways, including publishing newsletters, in-person farm visits and regularly updating social media outlets such as Facebook, as well as updating their websites.

FIGURE 1-6 PUBLIC MEETING ON APRIL 20, 2023 FOR UPPER TWIN CREEK

Two regional watershed partners, The Nature Conservancy District and Miami Conservancy District have engaged in the review and discussion of the draft Headwaters Twin Creek HUC-12 NPS-IS and also provided funds (in kind and cash) to complete the modeling of the Agricultural Conservation Planning Framework (ACPF) for Headwaters Twin Creek HUC-12 (see Section 2.5).

A second press release was issued on October 20, 2023, informing the public that the Draft Nine-Element NPS-IS is complete. The public is encouraged to request a copy of the plan, review it and provide comments. Once comments are received and reviewed, the next version of the Headwaters Twin Creek HUC-12 Nine-Element NPS-IS will be updated to incorporate the comments

Chapter 2: Watershed Characterization and Assessment Summary

The Headwaters Twin Creek HUC-12 watershed includes several unnamed tributaries, Maple Swamp Ditch, Lick Run, and Dry Fork (Figure 1-1). In 2005, OEPA conducted the Biological and Water Quality Study of Twin Creek and Selected Tributaries which included Headwaters Twin Creek (OEPA, 2007). The report stated that the three sampling locations on the mainstem of Headwaters Twin Creek fully attained their designated EWH ALU designation. Two of the three sampling sites on tributaries Maple Swamp Ditch and Dry Fork fully attained their WWH ALU designation, but the most upstream site only partially attained a recommended MWH designation.

The Headwaters Twin Creek HUC-12 is located within the Eastern Corn Belt Plains (ECBP) ecoregion (Figure 2-1). The ECBP ecoregion is a rich agricultural producing area and primarily a rolling till plain with local end moraines that were associated with glacial deposits of Wisconsinian age (7,500 to 11,000 years ago). This region’s nutrient-rich soils significantly influence water quality including elevated concentrations of nitrate and phosphorus in many watersheds (USEPA, 2000).

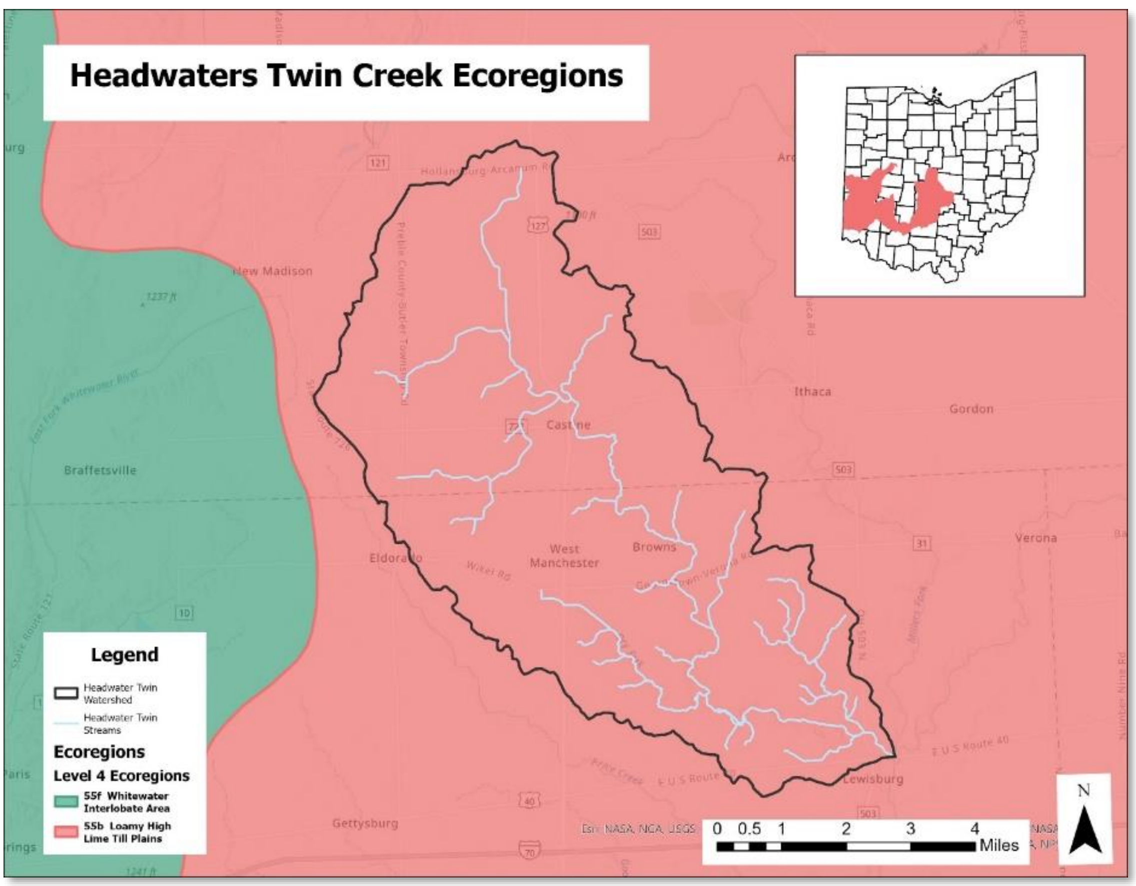

FIGURE 2-1 ECOREGION OF HEADWATERS TWIN CREEK HUC-12 (US EPA)

2.1. Summary of Watershed Characterization for Headwaters Twin Creek HUC-12

2.1.1. Physical and Natural Features

FIGURE 2-2 MAPLE SWAMP DITCH AT GRUBBS-REX ROAD

In the Headwaters Twin Creek HUC-12 watershed, deposits of glacial till composed of cobbles, gravel, sand, silts, and clays overlay sedimentary bedrock of limestone and shale formations or interbedded limestones and shales (Ohio Geological Survey, 2005). Glacial till, visible as moraines or depositional ridges of glacial outwash, formed lobate ridges according to glacial advance and retreat. Wisconsinian Era end moraine and ground moraine compose most of the unconsolidated sediments in the watershed (Ohio Geological Survey, 2005). Drift thickness, the amount of glacial deposition that occurs above bedrock, varies from as thin as 20 feet in the watershed's uplands to as thick as 200 feet in the outwash areas and bedrock cut valleys that cover ancient river valleys (Ohio Geological Survey, 2005). Bedrock is commonly visible in the Headwaters Twin Creek streambed in the lower portion of the watershed.

Upland soils in the watershed are primarily loamy glacial till that are generally high in fertility and have poor to moderate drainage. Over 70% of the watershed is very limited in drainage (NRCS, 2023). The dominant upland soil association consists of Brookston and Crosby silt loams (Appendix B) which represent soils that have slow and very slow infiltration when thoroughly wet. These soils have a very slow rate of water transmission (Figure 2-3).

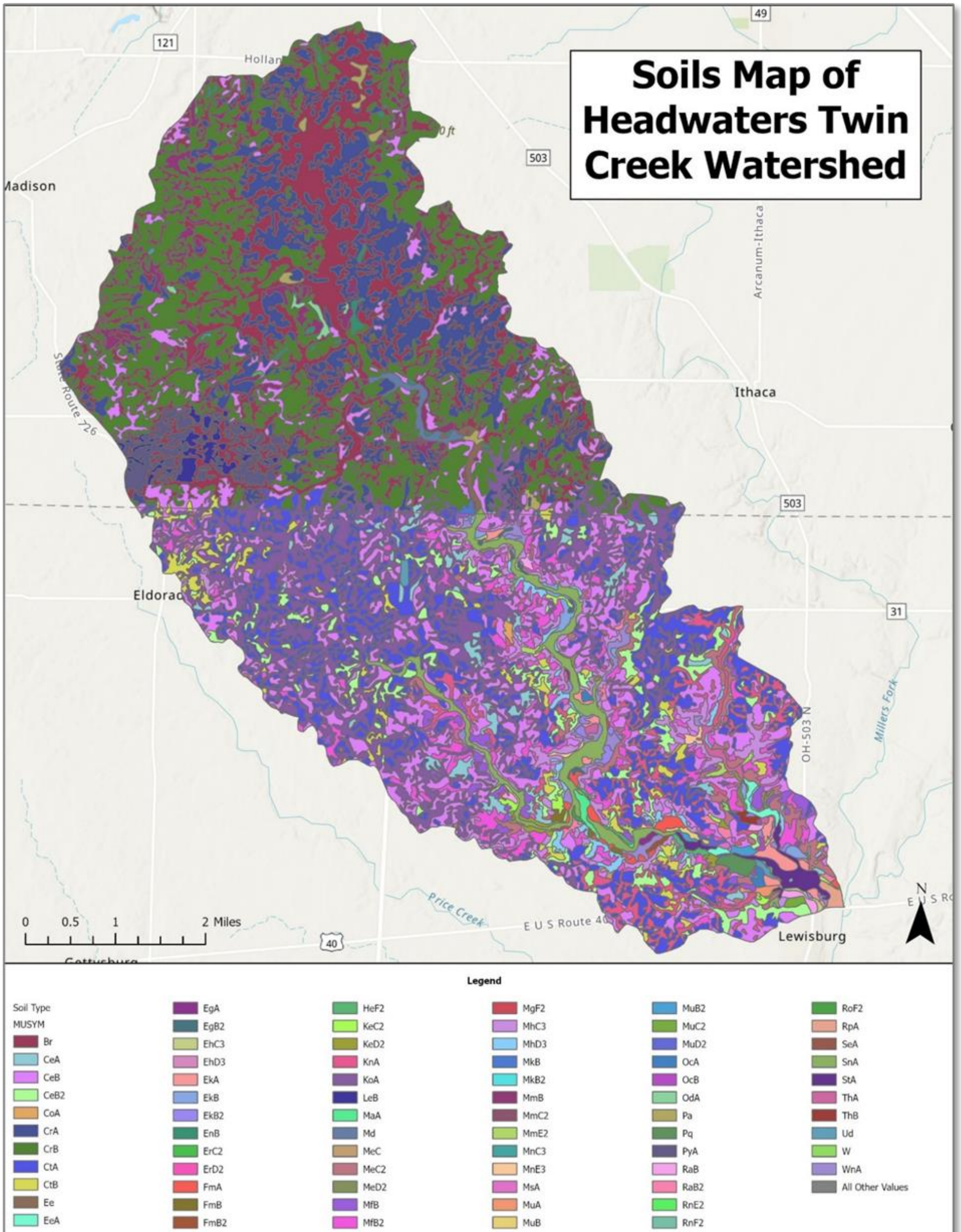

FIGURE 2-3 SOILS MAP OF HEADWATERS TWIN CREEK HUC-12 (USDA-NRCS)

The watershed soils are cultivated in large acreages and are important to farming in this watershed. The control of runoff and soil erosion are the main concern in managing these soils for farming while moderately slow permeability and slope are the dominant limitations to many nonfarm uses (NRCS, 2023). Soils along Headwaters Twin Creek primarily are derived from fine to coarse-grained floodplain deposits that overlie older alluvial or outwash sediments. Such floodplain soils tend to be fertile and well-drained (Figure 2-4).

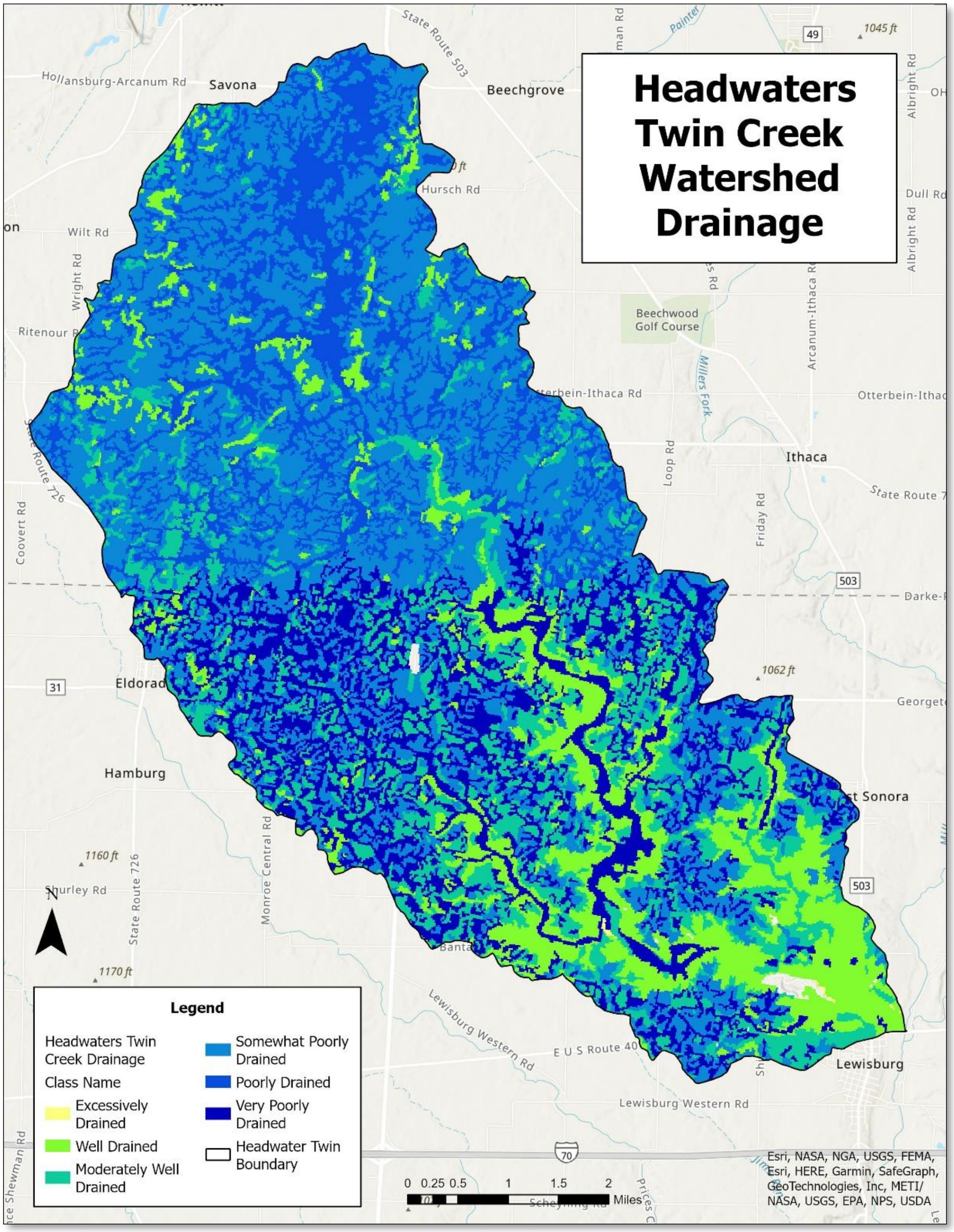

FIGURE 2-4 DRAINAGE CLASS OF HEADWATERS TWIN CREEK HUC-12 (USDA-NRCS, ESRI)

It appears that there is not an abundance of wetlands in the Headwaters Twin Creek HUC-12 (Figure 2-5). Most natural wetlands in the Headwaters Twin Creek HUC-12 watershed were likely lost with the installation of field drainage systems that began as long ago as the early to mid-19th century.

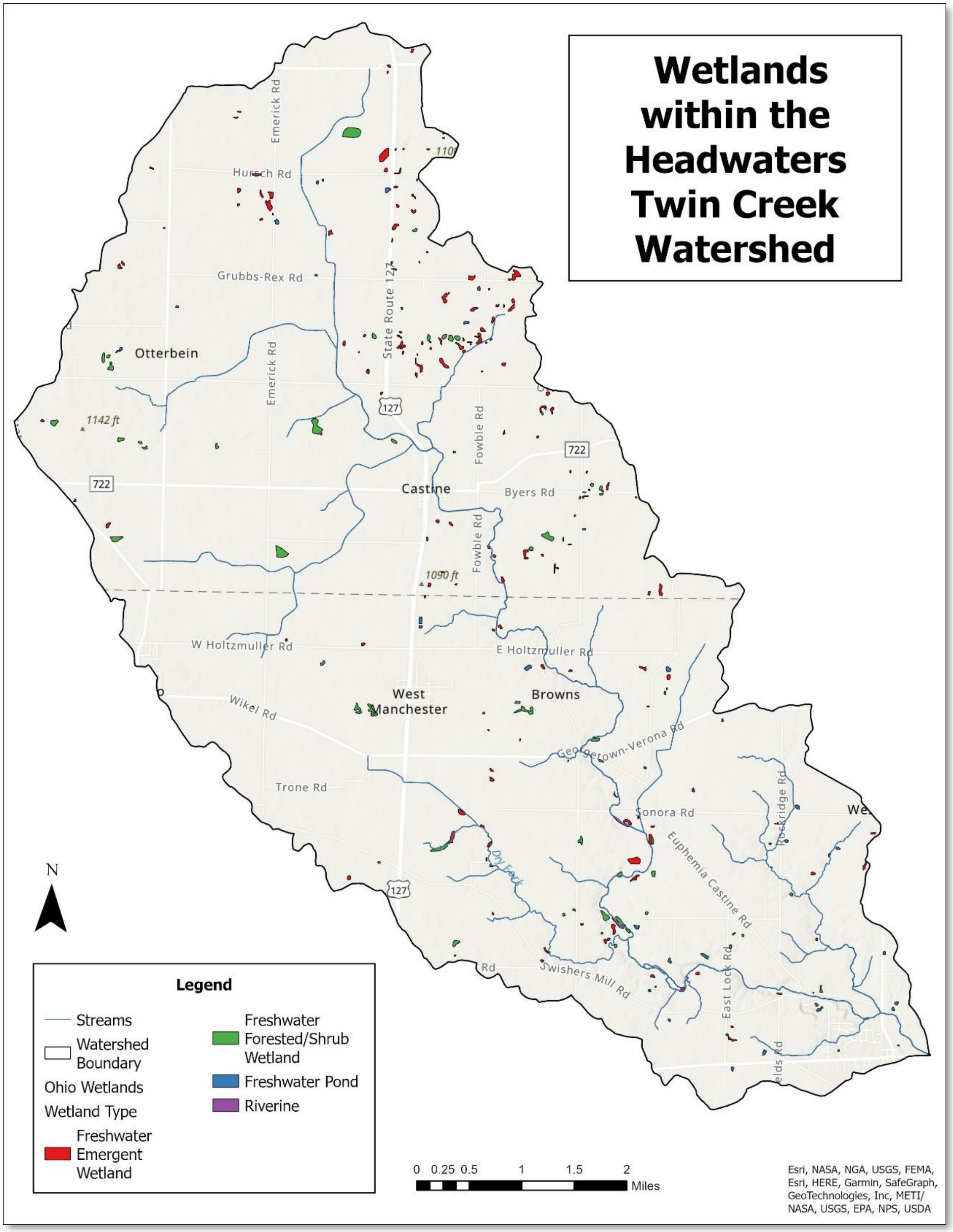

FIGURE 2-5 WETLANDS WITHIN THE HEADWATERS TWIN CREEK HUC-12 (USFWS)

The watershed's topography is nearly flat with most slopes described as 0.1 to 1%. Almost no Highly-Erodible Land (HEL) acreage exists (Figure 2-6). Maple Swamp Ditch was a stream flowing through poorly drained Crosby and Brookston soils, but has been channelized and has no riparian buffer. Darke County Ditch Maintenance Department manages Maple Swamp Ditch. Individual landowners are also known to clear trees and shrubs from the stream corridor to promote efficient drainage of their adjacent and upstream farm fields. Though there is little erosion due to the low gradient and maintenance regime, it is likely that nutrient enrichment due to adjacent row cropping and scattered HSTS that may not be functioning well.

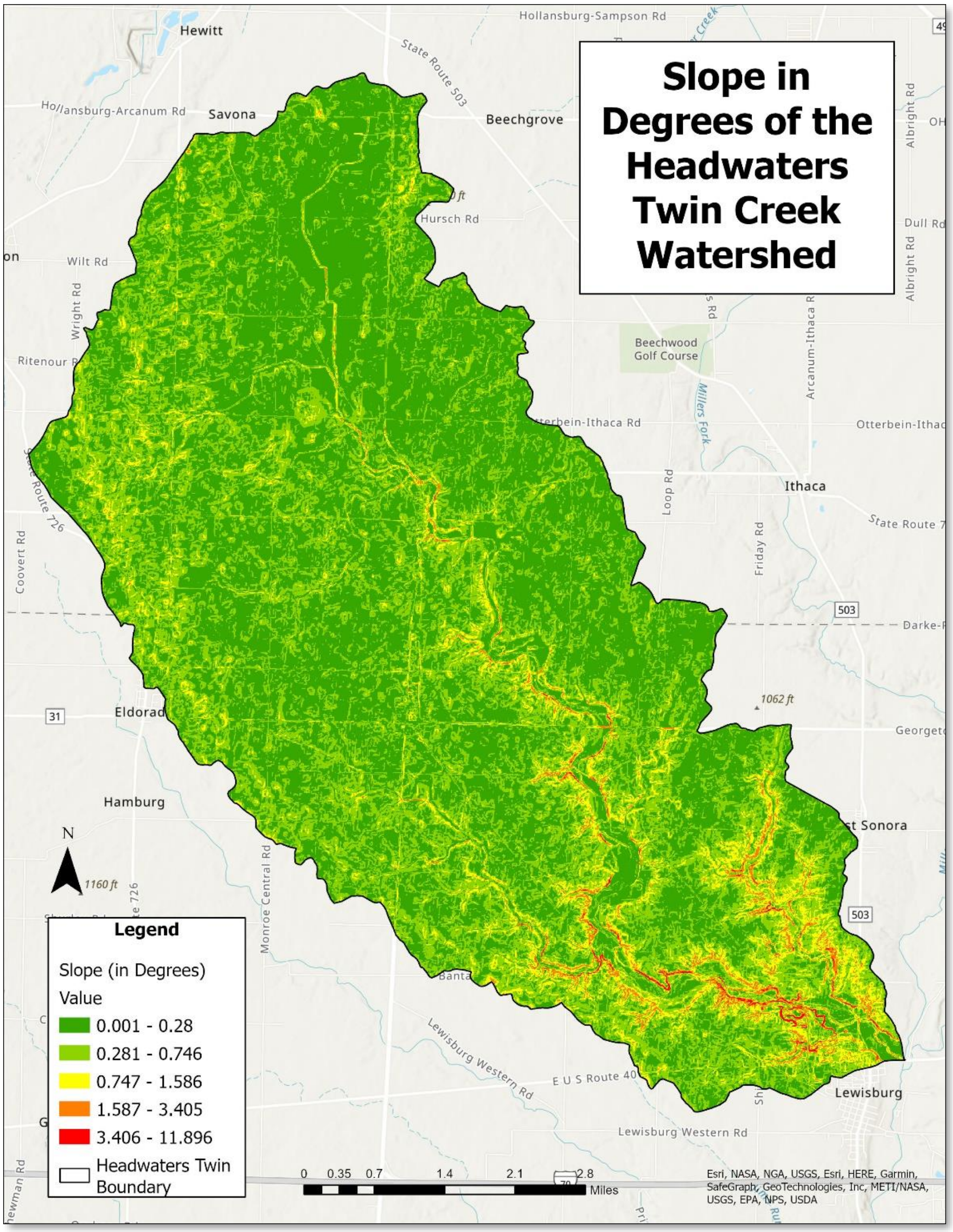

FIGURE 2-6 SLOPES IN DEGREES OF HEADWATERS TWIN CREEK HUC-12 (USDA)

2.1.2. Agricultural Land Use and Conservation Practices

Agriculture is the predominant land use in the Headwaters Twin Creek HUC-12 watershed and will continue to be for the foreseeable future (Figure 2-7).

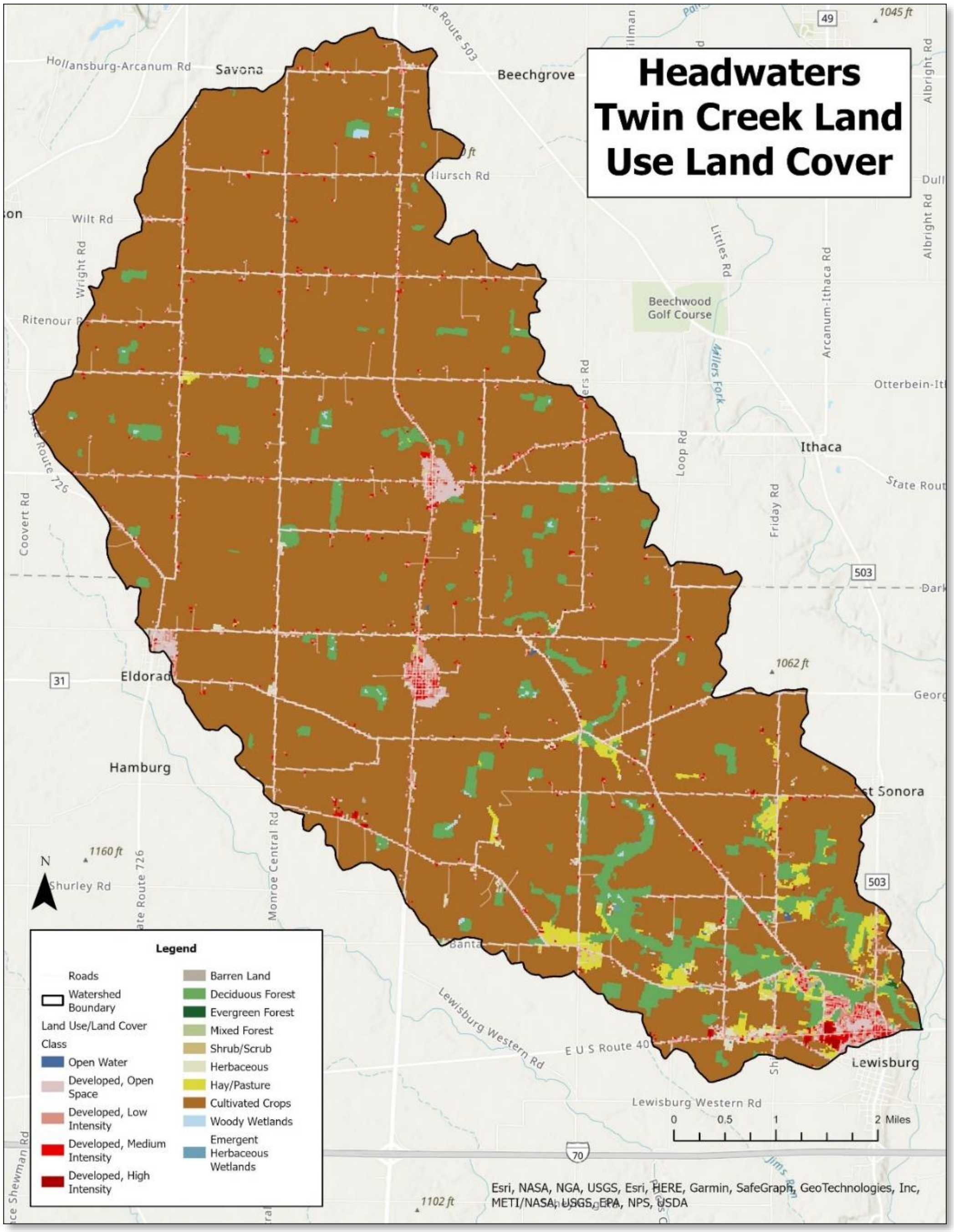

FIGURE 2-7 LAND USE MAP OF HEADWATERS TWIN CREEK HUC-12 (USGS, 2021)

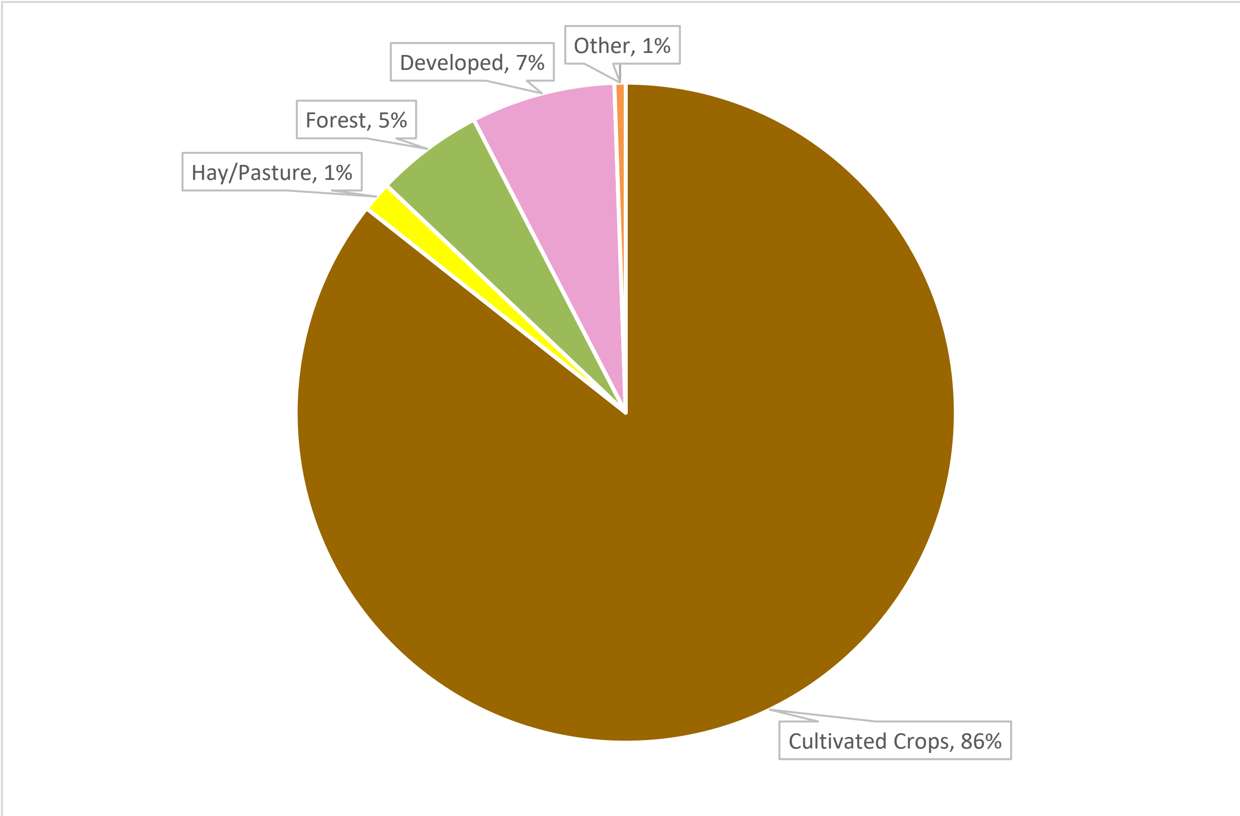

FIGURE 2-8 LAND USE BY PERCENTAGE IN HEADWATERS TWIN CREEK HUC-12 (USGS, 2021)

Figure 2-8 indicates 86% of the watershed land use is in row crop production, 1% in hay and pasture, 5% is forested and 7% is developed (NLCD, 2011). The majority of the farmland is classified as prime farmland or prime farmland if drained. (ODA, 2023)

The deciduous forests in the Headwaters Twin Creek HUC-12 only occupy about 5% of the watershed and are primarily located in the riparian zone of Twin Creek and its tributaries, especially in the southern portion of the HUC-12 watershed. The riparian area is also where the steeper slopes are within the southern section of this watershed (Figure 2-6). Forested areas positively impact water quality by slowing down precipitation, filtering nutrients and other pollutants flowing across the land's surface, decreasing streambank erosion, and cooling adjacent surface water (ODA, 2023) The quality of the riparian zone is moderate with a mixture of high-quality native trees and grasses as well as the dominant invasives such as bush honeysuckle.

According to the 2020 U.S. Census, Castine, a small Darke County village with a population of 110 and West Manchester, a small Preble County village with a population of 415 are the only villages fully within the HUC-12 (Figure 1-1).

West Manchester holds an NPDES permit to operate a wastewater treatment plant. Lewisburg and Eldorado are partially within this HUC-12 and each hold an NPDES permit to operate a wastewater treatment plant. Castine is not served by any wastewater treatment plant, so all of the businesses, churches, and homes in Castine -- as well as homes on large acreage outside of these populated areas -- are served by HSTS.

Row-Crop Agriculture

Corn and soybeans are the major crops produced in the Headwaters Twin Creek HUC-12. In between 2016 and 2022 there was a combined average of approximately 22,591 acres of corn and soybeans produced in this watershed each year.

TABLE 2-1 CROPLAND ACREAGE IN THE HEADWATERS TWIN CREEK HUC-12

Crop	2022	2020	2018	2016
Soybeans	12,906	12,812	13,122	13,151
Corn	9,354	9,955	9,569	9,494
Winter Wheat	550	308	342	393
Alfalfa	275	396	240	213
Other Hay/Non Alfalfa	107	145	105	48
Fallow/Idle Cropland	98	8	1	10
Double Crop Winter Wheat/Soybeans	53	18	51	26

Source: USDA NASS CropLandCROS, 2023

Livestock Operations

No concentrated animal feeding facility (CAFF) and no permitted concentrated animal feeding operations (CAFOs) are in the Headwaters Twin Creek HUC-12. About fourteen small-sized livestock operations were identified (Table 2-2), and one medium-sized operation was identified. These estimates were provided by the Darke and Preble soil and water conservation district staff members in June 2023.

TABLE 2-2 LIVESTOCK OPERATIONS IN THE HEADWATERS TWIN CREEK HUC-12

Livestock Species	Operations	Average no. of animals per operation
Horses	5	3
Dairy cattle	1	60
Beef Cattle	3 to 5	15 to 50
Poultry	0	0
Hog	5	544

Most land within the Headwaters Twin Creek HUC-12 is privately owned; therefore, agency knowledge of the individual conservation practices may not be up to date. Some conservation practices can be estimated through program enrollment initiated through the SWCD/NRCS and Farm Service Agency, as well as the annual crop tillage survey performed by Miami University, Oxford OH. Current and recent past (1-5 years) estimates of several practices provided by Preble and Darke SWCDs within the Headwaters Twin Creek HUC-12 are provided in Table 2-

3. As documented by Miami University tillage survey, with 25% (corn fields) and 75% (soybean field) of the Upper Twin watershed currently implementing conservation tillage, this watershed has already made good progress in nutrient management. The Ohio Department of Agriculture published survey results of SWCD personnel, estimating 14% adoption of cover crops and 26% adoption of buffers along relevant waterways in southwest Ohio (ODA, 2023) The total estimate of nitrogen load reduction when combining all of the current and recent past (1-5 years) conservation practices is 25,653 lb/yr using STEPL tool (Table 2-3).

TABLE 2-3 CURRENT AND RECENT PAST CONSERVATION PRACTICE ESTIMATES USING STEPL*

Practice Type	Estimated Acreage Treated	Estimated Nitrogen Load (lb/yr)	Estimated Phosphorous Load (lb/yr)
Conservation Tillage (no till, reduced till)	16,000	23,546	9,707
Cover Crops	700	408	39
Buffer - Whole-Field Warm Season Grass, Cool Season Grass Filter Strip, Warm Season Grass Field Border, Grassed Waterways (including grade stabilization structures)	120	175	45
Gypsum Application	560	NA	NA
Nutrient Management (Variable Rate Fertilization)	2,800	1,418	654
Land Retirement (CRP easement)	31.7	105	20

**Estimates calculated using Spreadsheet Tool for Estimating Pollutant Loads (STEPL), Version 4.4 (USEPA, 2020).*

2.1.3. Protected Land and Endangered Species

Conservation easements

Two properties, totaling approximately 127.8 acres located within the Headwaters Twin Creek HUC-12 is currently protected from development through the TVCT easement program (Figure 2-9). The properties are located on the mainstem of Twin Creek in the lower portion of the watershed.

Conservation easements held by TVCT require the landowner to follow the Conservation Plan prepared by the local Natural Resources Conservation Service staff and the Woodland Stewardship Plan prepared by the State Forester for wooded properties.

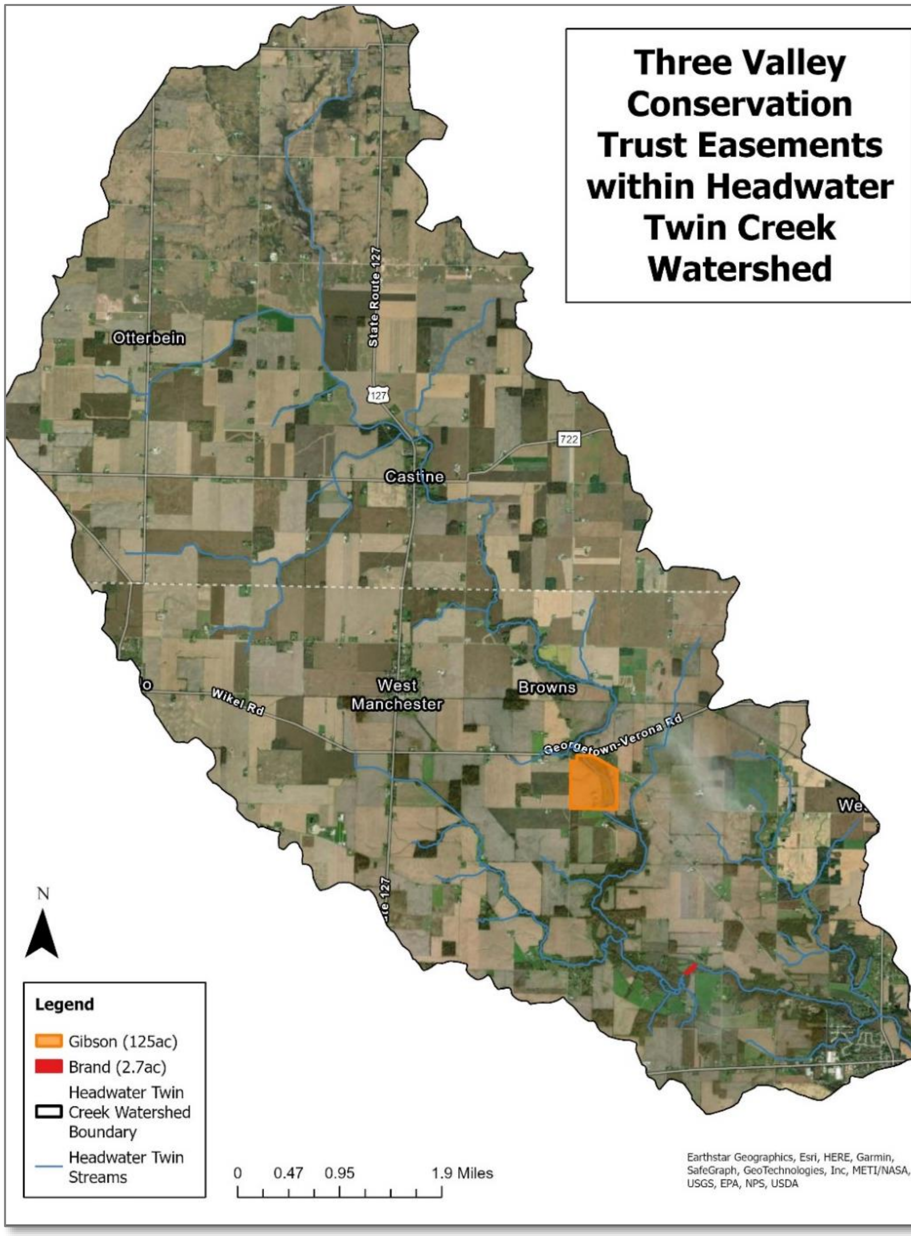

FIGURE 2-9 TVCT EASEMENTS IN THE HEADWATERS TWIN CREEK HUC-12 (TVCT, 2023)

Park Land

For twenty years, Preble County Park District has held and managed a 100-acre parcel, operated as the Garber Nature Center (https://preblecountyparks.org/garber-nature-center). Approximately 80 percent of the park is in the Headwaters Twin Creek HUC-12. Within the park are several small tributaries to Twin Creek. The project team visited the property with park board and staff members on June 27, 2023.

FIGURE 2-10 GARBER NATURE CENTER WETLAND

Discussions centered around maintenance of the small existing upland wetland, agricultural production leased on the site, and related tile and erosion issues. Habitat in these protected tributaries appears to conform with high quality conditions. It was noted that there is potential to enhance conservation agriculture education and watershed education opportunities at the site.

The Village of Lewisburg holds a four-acre parcel on the south side of an unnamed tributary less than a mile west of the village. This parcel is in the process of being restored ecologically after serving as a private salvage yard. Funding from the Clean Ohio Green Space Conservation Program made this acquisition possible.

Other Set-Aside Land

One property has been set aside through the Pheasants Forever State Acres for Wildlife Enhancement (SAFE) partnership with the Conservation Reserve Program for a contract period of 10 years. The parcel size is 31.7 acres and is located in the upper portion of the watershed.

Endangered Animal Species

Several rare, threatened, and endangered plant and animal species are known to live in the Headwaters Twin Creek HUC-12 and have some level of state or federal protection or concern (Table 2-4). Loss of riparian and poor water quality conditions can contribute to the degradation of their natural habitats.

TABLE 2-4 FEDERALLY RARE, THREATENED, AND ENDANGERED ANIMAL SPECIES BY COUNTY

Species	Status	County	Habitat Characteristics
Indiana bat (*Myotis sodalis*)	Endangered	Preble	Hibernates in caves and mines and forages in small stream corridors with well-developed riparian woods, aswell as upland forests
Northern long-eared bat (*Myotis septentrionalis*)	Threatened	Preble	Hibernates in caves and mines and swarms in surroundingwooded areas in autumn; roosts and forages in upland forests during late spring and summer
Snuffbox mollusk *(Epioblasma triquetra)*	Endangered	Darke	Found in small-to medium-sized creeks, burrowed deep in sand, gravel or cobble substrates; affected by sedimentation, agricultural run-off, and failing septic systems.
Clubshell mollusk *(Pleurobema clava)*	Endangered	Darke	Prefers clean, loose sand and gravel in medium to small rivers and streams; burrowed in the bottom substrate up to four inches; affected by agricultural run-off and industrial waste.
Eastern massasauga *(Sistrurus catenatus)*	Threatened	All	Live in wet areas including wet prairies, marshes and low areas along rivers and lakes. In many areas massasaugas also use adjacent uplands during part of the year. They often hibernate in crayfish burrows but may also be found under logs and tree roots or in small mammal burrows.

Source: ODNR Division of Wildlife, 2020; US Fish and Wildlife Service, 2017

Numerous invasive plant species occur throughout the Headwaters Twin Creek HUC-12. Common invasive species include bush honeysuckle (*Lonicera species*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and garlic mustard (*Alliaria petiolata*), These Invasive plants have negative impacts on native vegetation and animals within the watershed. Bush and Japanese honeysuckle out-compete and displace native plants and alter natural habitats by decreasing light availability and depleting soil moisture and nutrient content.

Exotic bush honeysuckle competes with native plants for pollinators, resulting in a reduced seed set for native species. Multiflora rose forms dense thickets, excluding most native shrubs and herbs from establishing, and may be detrimental to nesting of native birds. Garlic mustard invades areas disturbed by human activities and displaces many native wildflowers.

2.1.4. Home Sewage Treatment Systems

HSTS are small wastewater treatment units that serve individual homes or businesses. The effectiveness of each HSTS depends on its age, maintenance practices, and characteristics of the site -- including lot size, soil drainage, depth to water table, bedrock depth, land slope, and household size. Five-percent of total phosphorus and 3-percent of total nitrogen loading to the Great Miami River were from HSTS between 2017 and 2021 (ODA, 2023). While non-functioning HSTS contribute a small percentage of nutrient pollution, the high bacteria levels they discharge negatively impact stream recreational uses due to potential human health impacts (ODA, 2023). HSTS are considered a major bacteria contributor affecting the water quality of Headwaters Twin Creek as indicated in the 2007 OEPA report. The Natural Resources Conservation Service (NRCS) Soil Web Survey for Septic Tank Absorption Fields for Headwaters Twin Creek HUC-12 indicated that 73.4% of the watershed is very limited. The evaluation is based on soil properties that affect adsorption of the effluent, construction and maintenance of the system and public health.

The 2020 OKI report on management of onsite systems concluded that better septic system management was recommended for the entire Twin Creek Watershed (OKI, 2020).

HSTS in the watershed are regulated by the Darke County General Health District (DCGHD) and Preble County Public Health (PCPH) in compliance with the Ohio Administrative Code (OAC) 3701-29-19. Since 2003, DCGHD has made great strides in collecting data about the location and type of HSTS in their jurisdiction, thanks to 319 funding for the project. According to DCGHD staff, the Village of Castine has 67 households and nearly two-thirds of those households either have no secondary treatment (e.g. leach field) or the leach field is more than fifty years old. Those systems are

FIGURE 2-11 TWIN CREEK AT STATE ROUTE 722 CROSSING NEAR THE VILLAGE OF CASTINE

likely discharging waste to a storm sewer or field tiles that discharge to nearby Twin Creek. Small lot size limits the ability of many homeowners to install new or replacement leach fields. The OEPA's 2007 technical report on the water quality of Twin Creek states that analytical results from a sample taken from a suspicious tile draining to the creek near the Castile village tested high for ammonia, fecal coliform, and *E. coli,* confirming the presence of failing septic systems in the watershed near Castine (OEPA 2007). In 2015, MVRPC contacted village officials to offer no-cost wastewater facility planning assistance. The offer was not accepted at that time, but MVRPC may have funds in the near future to make this offer again (April 14, 2023, personal communication with Matt Lindsay).

PCPH has applied for and been awarded approximately $300,000 in 2012 to assist residential sewage system owners in handling the cost of fixing their sewage treatment systems.

Education is key to reducing the effects of failing HSTS on the stream. Darke SWCD and DCGHD recently have trained 60 contractors in proper HSTS installation procedures. To educate the public about failed HSTS and water quality, a septic system workshop was hosted by Preble SWCD in partnership with the Ohio Farm Bureau in 2021. The workshop was attended by 25 participants and featured talks from a soil scientist who does investigations for septic systems at Ohio State University and Preble SWCD staff.

Because of the poor soil drainage and shallow depth to bedrock, it is likely that failed HSTS are prevalent and widespread in this watershed. Better resources and coordination from local partners are needed to address the failed HSTS in this rural community and in the region.

2.1.5. Groundwater Vulnerability and Source Water Protection

There are two basic types of aquifers in the Great Miami River Watershed: the buried valley aquifers – a glacial deposit largely consisting of sand and gravel -- and bedrock aquifers where significant amounts of water are stored in the fractures of the rock formation. Some groundwater exists at shallow depths and is unprotected by a confining clay layer. Protecting this shallow groundwater from nutrients and pesticides is a major concern. (ODA, 2023)

The Great Miami River and some of its tributaries including Twin Creek are located along the path of the buried valley aquifers. The Great Miami Buried Valley Aquifer was designated a Sole Source Aquifer in 1988. Ohio Department of Natural Resources (ODNR) published the groundwater pollution potential maps for the State using the DRASTIC system in early 2000. Recently, a GIS based modified DRASTIC model was published by ODNR in 2022. DRASTIC parameters include Depth to Water, Net Recharge, Aquifer Media, Soil Media, Topography, Impact of Vadose Zone Media and Hydraulic Conductivity and provide an important tool to evaluate the groundwater vulnerability of an area including communities served by HSTS. Figure 2-10 shows the Groundwater Vulnerability Index (GVI) of the Headwaters Twin Creek HUC-12. The majority of the watershed is at the medium to high GVI.

Rural communities, including villages and unincorporated populated areas, without a public water system -- and the surrounding rural homes -- rely on both HSTS and private wells in close proximity to one another and are thus at risk of contaminating their drinking water resources with nitrate and bacteria (Swann, 2001). The Village of Castine is such an area relying on HSTS and private drinking water wells.

In the Headwaters Twin Creek HUC-12, the public drinking water supply is entirely from groundwater sources. Many of these sources lie within the floodplain areas of local streams. The villages of Lewisburg, Eldorado and West Manchester, plus Castine Church are the public water systems in the Headwaters Twin Creek HUC-12 watershed or with supposed source water protection areas in the watershed.

Lewisburg, Eldorado and West Manchester have drinking water source assessments, developed by the OEPA in and around 2002. In addition to the OEPA assessment, the Village of Lewisburg had also completed a Wellhead Protection Plan in the mid- to late-1990s which mentions the potential negative impact of HSTS. The Village of Lewisburg's wellfields are down-gradient from this watershed, but the wellfield's five- and ten-year time-of-travel zones include agricultural areas in the downstream portion of the watershed. The Lewisburg system was identified as having a high susceptibility to contamination due to less than 20 feet depth to groundwater, less than 20 feet thickness of confining layer, and potential significant contamination sources existing within the protection area, including agricultural activities (OEPA 2003). These contamination sources included NPS agricultural activities (chemical applications and field runoff) and failing HSTS (OEPA 2002).

The Eldorado wellfields are outside of the Headwaters Twin Creek HUC-12, but the wellfield's five-year time-of-travel zone continues into the watershed. Eldorado's public water system was determined to have a low susceptibility to contamination (OEPA 2002). The West Manchester public wellfields are located within the Headwaters Twin Creek HUC-12.

The West Manchester Drinking Water Source Assessment indicated that West Manchester's source of drinking water had a moderate susceptibility to contamination due to the unknown nature of the limestone aquifer and the potential significant contamination sources existing in the area. These contamination sources included NPS agricultural activities (chemical applications and field runoff) and failing HSTS (OEPA 2002).

Castine Church has a Drinking Water Source Protection Checklist, which serves as this public water supply's Source Water Protection Plan. None of the municipal public water systems currently has an OEPA-endorsed Source Water Protection Plan, though Lewisburg has a Wellhead Protection Plan in addition to the 2003 OEPA assessment. Source Water Protection Plans and similar studies would help determine the degree of exchange – if any -- between groundwater and surface water in the local geology. These plans would also determine other risk factors and practices to reduce those risks.

In summary, to address the non-point source pollution that is associated with failed septic systems and to protect the water resources in this sparsely populated and rural Headwaters Twin Creek watershed is an important and yet challenging task that requires local cooperation, and investment in time and effort. As noted previously, education and outreach are critical and there are resources that can assist the county health departments if the communities are supportive. In this NPS-IS, it is recommended that all public water systems in the Headwaters Twin Creek HUC-12 obtain an OEPA-endorsed Source Water Protection Plan. When these plans are complete, protecting drinking source water may become a new critical area of a future version of this NPS-IS Plan.

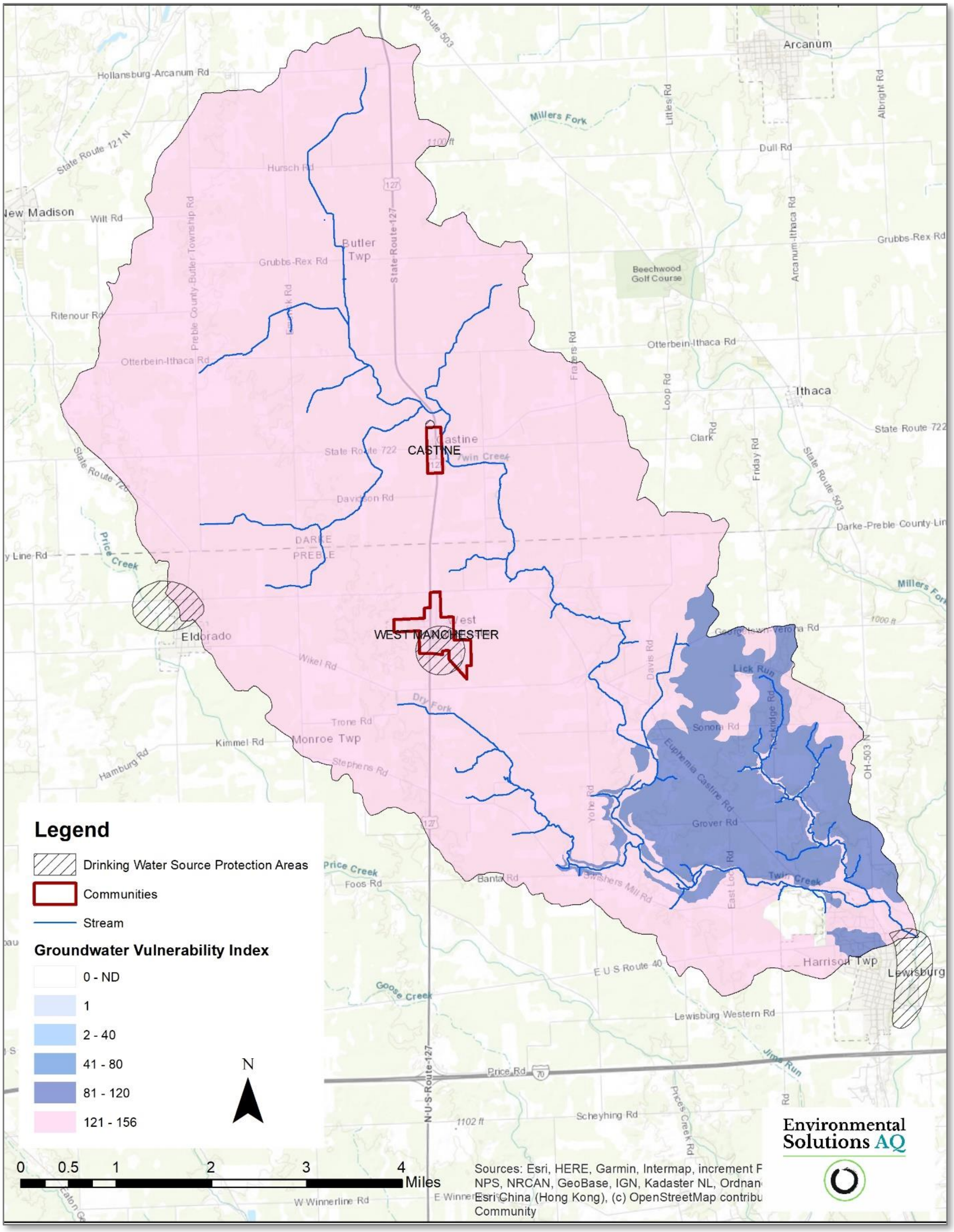

FIGURE 2-12 GROUNDWATER VULNERABILITY INDEX AND SOURCE WATER PROTECTION AREAS OF HEADWATERS TWIN CREEK HUC-12 (ODNR, ESRI)

2.2. Summary of Biological Trends for Headwaters Twin Creek HUC-12 Watershed

OEPA Biological and Water Quality Study of the Twin Creek and Selected Tributaries 2007 was the only comprehensive sampling data analysis of Twin Creek and Headwaters Twin Creek HUC-12 watershed. Using the data from this report, OEPA prepared the TMDL for the Twin Creek Watershed. This section summarizes the findings of the 2005 OEPA sampling report (OEPA, 2007) and the OEPA TMDL Report (OEPA, 2010).

Six sampling locations were selected in the Headwaters Twin Creek HUC-12 during the 2005 OEPA sampling event (Figure 2-14; Table 2-5). Three sampling locations are located along Twin Creek, two along the tributary Maple Swamp Ditch and one along tributary Dry Fork. Table 2-6 shows the biological indices scores for the six sampling sites in Headwaters Twin Creek HUC-12. Overall, the biological indices scores indicated that the main stem Twin Creek were all in full attainment of the designated ALU of EWH. The tributaries' lower reach samples from Maple Swamp Ditch and Dry Fork were in full attainment of designated ALUs, but with WWH. However, the upper reach Maple Swamp Ditch sample, at Stream Mile 2.4, was in partial attainment of recommended MWH ALU designation. No recent samples have been taken and evaluated since 2005 in this watershed.

TABLE 2-5 2005 OEPA SAMPLING LOCATIONS WITHIN HEADWATERS TWIN CREEK HUC-12

Stream Mile	Drainage Area (mi^2)	Cross Road	Longitude	Latitude
Twin Creek Main Stem				
46.5	19.7	State Route 722	-84.6228	39.9313
42.1*	28.0	Euphemia-Castine Rd.	-84.5953	39.8962
38.0	38.0	East Lock Rd.	-84.5984	39.8660
Maple Swamp Ditch – Tributary to Twin Creek at RM 47.03				
2.4	5.5	Grubbs-Rex Rd.	-84.6416	39.9603
1.4	10.2	Otterbein-Ithaca Rd.	-84.6399	39.9458
Dry Fork – Tributary to Twin Creek at RM 39.35				
0.8	5.4	Locke Rd.	-84.5956	39.8669

**Biological and conventional water chemistry sampling*
Source: OEPA, 2007

TABLE 2-6 BIOLOGICAL INDICES SCORES FOR SIX OEPA SAMPLING LOCATIONS IN HEADWATERS TWIN CREEK HUC-12

Twin Creek Stream Mile Fish/Invertebrate	IBI	MIwb	ICI	QHEI	Aquatic Life Use Designation	Attainment Status
Twin Creek Main Stem						
46.5/46.6	50	N/A	Very good	43.0	EWH	Full
42.1	48	9.1	46	75.5	EWH	Full
38.0/38.1	46	9.0	50	61.0	EWH	Full
Maple Swamp Ditch – Tributary to Twin Creek at RM 47.03						
2.4/2.4	38	N/A	Poor	21.0	MHW recommended	Partial
1.4/1.4	44	N/A	Good	38.5	WWH recommended	Full
Dry Fork – Tributary to Twin Creek at RM 39.35						
0.8/0.8	40	N/A	Good	50.0	WWH	Full

Source: OEPA, 2007

IBI Index of Biotic Integrity

The Modified Index of Well Being (MIwb) is not applicable to headwater sites (drainage ≤20 mi2).

ICI - Invertebrate Community Index (G=Good; MG=Marginally Good; H Fair =High Fair; F=Fair; L Fair=Low Fair; P=Poor; VP=Very Poor).

QHEI - Qualitative Habitat Evaluation Index

WWH Warmwater Habitat – ECBP Ecoregion

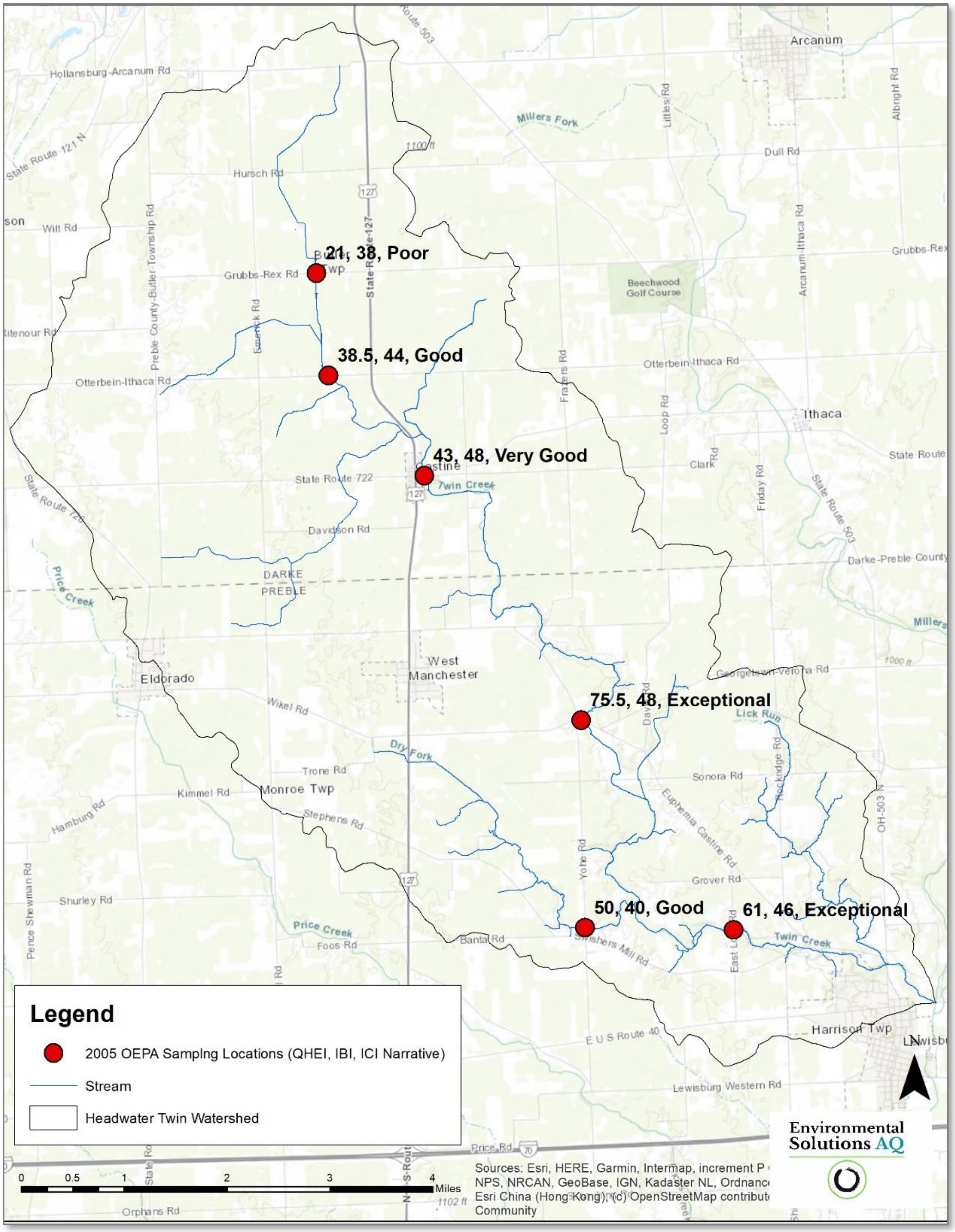

FIGURE 2-13 2005 OEPA SAMPLING LOCATIONS IN HEADWATERS TWIN CREEK HUC-12 (OEPA, 2007)

2.2.1. Biological Assessment: Fish Assemblages

The fish assemblages of Twin Creek and its tributaries which included Headwaters Twin Creek were surveyed and assessed by OEPA in 2005. A total of 35,596 fish comprising 42 species and six hybrids was collected from all Twin Creek tributaries, between July and September 2005. Based on aggregated catch statistics from the mainstem of Twin Creek, numerically predominant species included Central stoneroller (24.4%), rosyface shiner (9.0%), bluntnose minnow (7.8%), rainbow darter (6.8%), greenside darter/sand shiner (5.9%), and Northern hog sucker (4.9%).In terms of relative biomass (kg/0.3km), dominant species were, Central stoneroller (30.2%), Northern creek chub (23.6%), white sucker (14.1%), striped shiner (6.4%), rockbass (3.6%), and mottled sculpin (3.2%). In terms of ranked abundance and biomass measures, these dominant species are typical associates of headwater or brook environments. Community indices and accompanying narrative evaluations from these waters ranged between very good (IBI=48/MIwb=9.1) and marginally good (IBI=38/N/A) (Table 2-7). Taken together with the entire Twin Creek tributaries, the fish assemblages were collectively characterized in the narrative as very good. The Twin Creek tributaries including Headwaters Twin Creek were found to support fish assemblages fully consistent with the biocriteria applicable to existing and recommended ALUs, with the exception of Maple Swamp Ditch's furthest upstream sampling site.

TABLE 2-7 FISH COMMUNITY AND DESCRIPTIVE STATISTICS FOR HEADWATERS TWIN CREEK

Stream River Mile	Mean Number Species	Cumu-lative Species	Mean Rel. No. (No./km)	Mean Rel. Wt. (Wt./km)	MeanIBI	MeanMIwb	QHEI	Narrative Evaluation
Twin Creek Main Stem								
46.5	18.0	18	1406.00	10.63	48	N/A	43.0	Very Good
42.1	23.0	23	1524.00	32.16	48	9.1	75.5	Very Good
38.0	20.0	20	2569.50	27.31	46	9.0	61.0	Very Good
Maple Swamp Ditch – Tributary to Twin Creek at RM 47.03								
2.4	10.0	10	140.00	0.37	38	N/A	21.0	Marginally Good
1.4	23.0	23	1234.00	10.63	44	N/A	38.5	Good
Dry Fork – Tributary to Twin Creek at RM 39.35								
0.8	21.0	21	1672.00	6.76	40	N/A	50.0	Good

Source: OEPA 2007

2.2.2. Biological Assessment: Macroinvertebrate Community

The macroinvertebrate community on Twin Creek in Headwaters Twin Creek HUC-12 was evaluated at three sampling locations. All three met the current EWH ALU and received very good or exceptional qualitative evaluation (Table 2-8). All or nearly all of the community at this site were sensitive taxa intolerant or moderately intolerant of pollution, with *Elimia* snails, riffle beetles, two types of mayflies, *Petrophila* moths and two types of caddisflies comprising the majority of the organisms identified.

A Wright State University mussel study conducted in 2004 found that nine live and fresh-dead species of mussel lived in the upper reaches of the Twin Creek mainstem, including four species found live only at upper Twin sites. OEPA also encountered mussels at the three main stem sites evaluated. Their presence correlated to a high percent canopy cover, even in heavily agricultural stream segments (OEPA, 2007).

The upstream site at channelized tributary Maple Swamp Ditch lacks habitat to foster communities of sensitive species intolerant to pollution and poor conditions. Tolerant species outweighed sensitive ones by a ratio of 11:2 and earned only a Poor qualitative designation, plus a recommendation to designate the site as MWH. However, the downstream site at RM 1.4 boasts a small riffle habitat that is home to 13 sensitive and 13 EPT taxa. Groundwater influence there and the cooler groundwater the stream gains seems to help the riffle support a more intolerant set of macroinvertebrate species, despite the lack of riparian cover. This site fully attained its WWH designation.

Dry Fork is another tributary of Twin Creek, and its one sampling site contained 16 sensitive and 10 EPT taxa., and gaining the qualitative designation of Good as it fully attained its WWH ALU designation.

TABLE 2-8 MACROINVERTEBRATE SAMPLING RESULTS FOR HEADWATERS TWIN CREEK HUC-12

Stream RM	Dr. Area (Sq. mi.)	Data Codes	Qual. Taxa	EPT Ql/Total	Sensitive Taxa Ql./Total	Density Ql. Qt.	CW Taxa	Predominant Organisms on the Natural Substrates With Tolerance Category(ies) in Parentheses	ICI	Narrative Evaluation
Twin Creek										
46.6	19.7	-	53	20	19	H-M	0	Flatworms (F), riffle beetles (F,MI), Elimia snails (MI)	-	Very Good
42.0	28.0	15	72	22/22	32/38	M/116	1	Baetid mayflies (F,I), hydropsychid, caddisflies (F,MI)	46	Exceptional
38.1	38.0	-	49	19/20	22/25	M/139	0	Net-spinning caddisflies (F,MI), Petrophila moths (MI), mayflies (F,MI)	50	Exceptional
Maple Swamp Ditch -Trib to Twin Creek @ RM 47.03										
2.4	5.5	-	21	2	2	M-L	0	Midges (MT, MI), Aquatic worms (T), Fingernail clams (F)	-	Poor
1.4	10.2	-	49	13	13	M	0	Hydropsychid caddisflies (F,MI), baetid mayflies (F,I), midges (T,F,MI), Helicopsyche mayflies (MI)	-	Good
Dry Fork -Trib to Twin Creek @ RM 39.35										
0.8	5.4	-	49	10	16	M	0	Net-spinning caddisflies (F,MI), Helicopsyche caddisflies (MI), Elimia snails (MI)	-	Good

Source: OEPA. 2007
RM: River Mile.
Dr. Ar.: Drainage Area
Data Codes: 8=Non-Detectable Current, 9=Intermittent or Near-Intermittent Conditions, 12=Suspected High Water Influence/Disturbance, 13=Suspected Disturbance by Vandalism, 15=Current >0.0 fps but <0.3 fps, 29=Primary Headwater Habitat Stream.
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the OEPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.

2.2.3. Physical Habitat - Qualitative Habitat Evaluation Index QHEI

In 2005, OEPA assessed the habitat characteristics through the Qualitative Habitat Evaluation Index (QHEI), which provides an understanding of the habitat features, existing at that time, important to fish communities and is based upon methodologies established by Rankin's habitat assessments (Rankin 1989, Rankin 1995, OEPA 2006). During this evaluation, several habitat characteristics were assessed on the stream reach, such as type/quality of substrate, amount/quality of in-stream vegetative cover, channel morphology, extent/quality of riparian vegetation, pool/run/riffle quality, etc.

Mean QHEI values from rivers or river segments equal to or greater than 60.0 generally indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the WWH ALU designation. Average reach values at greater than 75.0 are generally considered adequate to support fully exceptional (EWH) communities (Rankin 1989 and Rankin 1995). Values between 55 and 45 indicate limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily exclude WWH or even EWH assemblages. Values below 45 indicate a higher probability of habitat-derived ALU impairment.

From the 2005 OEPA sampling results, the QHEI scores (43.0 to 75.5) at Twin Creek were determined to support the EWH ALU designation. Sampling sites in Maple Swamp Ditch had QHEI scores of 21.0 and 38.5, partially attaining recommended MWH ALU designation at the upstream site and fully attaining a recommended WWH designation at the downstream site.

Biological performance for Headwaters Twin Creek HUC-12 was determined to have exceptional to marginally good communities. From State Route 722 in Darke County downstream through the lower stretches of the creek was designated EWH based upon the recommendations of the 1995 Twin Creek survey (OEPA 1997). All other sampling locations were determined to be WWH. Results from the 2005 sampling survey found similar conditions, confirming the absence of reasonable EWH potential upstream of Castine and in the tested tributaries. The furthest upstream site in the tributary Maple Swamp Ditch was recommended in the 2007 report to be downgraded to MWH.

TABLE 2-9 QHEI MATRIX AND SCORES FOR HEADWATERS TWIN CREEK HUC-12

		Main Stem	Twin Creek		
Key QHEI Elements		River Mile	46.5	42.1	38.0
		QHEI Score	43.0	75.5	61.0
		Gradient (ft/mi)	3.11	5.81	21.28
WWH Attributes		Not Channelized or Recovered		•	•
		Boulder/Cobble/Gravel Substrates		•	
		Silt Free Substrates			
		Good/Excellent Development		•	
		Moderate/High Sinuosity		•	
		Extensive/Moderate Cover		•	
		Fast Current/Eddies			
		Low/Normal Embeddedness		•	•
		Max Depth >40 cm	•	•	•
		Low/Normal Riffle Embeddedness		•	•
		WWH Attributes	1	8	4
MWH Attributes	Hi Influence	Channelized/No Recovery	•		
		Silt/Muck Substrates			
		No Sinuosity	•		
		Sparse/No Cover	•	•	•
		Max Depth <40 cm			
		Hi-Influence Modified Attributes	3	1	1
	Moderate Influence	Recovering Channel			
		Heavy/Moderate Silt Cover	•	•	
		Sand Substrate (Boat)			
		Hardpan Substrate Origin			
		Fair/Poor Development	•	•	•
		Low Sinuosity		•	•
		Only 1 or 2 Cover types			
		Intermittent/Poor Pools			
		No Fast Current	•	•	•
		High/Moderate Overall Embeddedness	•	•	
		High/Moderate Riffle Embeddedness	•		
		No Riffle			
M.I. MWM Attributes			5	5	3
MWH H.I.+1/WWH+1 Ratio			2.00	0.22	0.40
MWH M.I.+1/WWH+1 Ratio			4.50	0.78	1.00

Continued next page

		Table 2-9 continued from previous page			
Key QHEI Elements		**Tributaries to Twin Creek**	**Maple Swamp Ditch**		**Dry Fork**
		River Mile	2.4	1.4	0.8
		QHEI Score	21.0	38.5	50.0
		Gradient (ft/mi)	3.41	3.11	23.26
WWH Attributes		Not Channelized or Recovered			•
		Boulder/Cobble/Gravel Substrates			
		Silt Free Substrates			
		Good/Excellent Development			
		Moderate/High Sinuosity			
		Extensive/Moderate Cover			
		Fast Current/Eddies			
		Low/Normal Embeddedness			•
		Max Depth >40 cm	•	•	
		Low/Normal Riffle Embeddedness		•	
		WWH Attributes	1	2	1
MWH Attributes	Hi Influence	Channelized/No Recovery	•	•	
		Silt/Muck Substrates	•	•	
		No Sinuosity	•	•	•
		Sparse/No Cover	•	•	•
		Max Depth <40 cm			•
		Hi-Influence Modified Attributes	4	4	3
	Moderate Influence	Recovering Channel			
		Heavy/Moderate Silt Cover	•	•	•
		Sand Substrate (Boat)			
		Hardpan Substrate Origin			
		Fair/Poor Development	•	•	•
		Low Sinuosity			
		Only 1 or 2 Cover types	•		
		Intermittent/Poor Pools			
		No Fast Current	•	•	•
		High/Moderate Overall Embeddedness	•	•	
		High/Moderate Riffle Embeddedness			
		No Riffle	•		•
M.I. MWM Attributes			6	4	4
MWH H.I.+1/WWH+1 Ratio			2.50	1.67	2.00
MWH M.I.+1/WWH+1 Ratio			5.50	3.00	4.00

Source: OEPA, 2007

2.2.4. Water Quality

In addition to the biological and physical monitoring discussed above, OEPA collected water samples from Twin Creek and selected tributaries and analyzed the water quality to understand existing conditions in 2005. Results from the study indicated conventional water chemistry was good and all samples taken for cadmium, chromium, copper, mercury, nickel, and selenium were below the detection limit (BDL) in water column samples. Water column calcium, iron, manganese, magnesium, zinc, hardness, BOD5, chloride, and sulfate were within acceptable ranges.

Sediment samples at Maple Swamp Ditch and furthest downstream Dry Fork contained arsenic. A significant percentage of local groundwater contained naturally occurring arsenic (OEPA, 2007).

A sample from a tile discharging near Castine on SR 722, at RM 46.55, contained 10 mg/l ammonia and an excessively high number of colonies/100 ml of fecal coliform and *E. coli*. OEPA considered this result as documentation of failing septic systems. Filamentous green algae was abundant in Maple Swamp Ditch, likely due to potential nutrients stored in the heavy sediment load. However, only two of ten sampling events found ammonia over the 90th percentile in the water column of Maple Swamp Ditch and none of the nitrate or phosphorous samples exceeded the 90th percentile (OEPA, 2007).

Water column samples of Dry Fork found ammonia levels over the 90th percentile two of five times and phosphorous over the 90th percentile three of five times. Despite these exceedances, most water column samples were below the 90th percentile background level for total phosphorus, NH3-N and NO3-N in the Headwaters Twin Creek HUC-12 samples (Table 2-10) (OEPA, 2007).

TABLE 2-10 NUTRIENT SAMPLING RESULTS FOR HEADWATERS TWIN CREEK HUC-12

Stream (RM)	area mi^2	Frequency of Phosphorus >90th Percentile	Phosphorus Median (mg/l)	Frequency of NH_3>90th Percentile	NH_3 Median (mg/l)	Frequency of NO_3 >90th Percentile	NO_3 Median (mg/l)
Twin Creek (42.1)	28.0	0/5	0.075	3/5	0.121	0/5	0.24
Maple Swamp Ditch – Tributary to Twin Creek at RM 47.03							
Maple Swamp Ditch (2.40)	5.5	0/5	0.037	1/5	0.059	0/5	0.1
Maple Swamp Ditch (1.4)	10.2	0/5	0.028	1/5	0.060	0/5	0.1
Dry Fork – Tributary to Twin Creek at RM 39.35							
Dry Fork (0.80)	5.4	3/5	0.210	2/5	0.087	0/5	0.27

Source: OEPA 2007

2.3. Summary of TMDL

The Twin Creek watershed TMDL was required because portions of the Twin Creek and its tributaries did not attain their water quality goals for aquatic life and recreation (OEPA, 2010). The TMDL stated that low DO, ammonia, phosphorus, bacteria (recreation use) and low flow are the causes of impairment. The sources of the impairment included row-crop agricultural practices at the upper reach of the watershed. Grazing livestock with stream access was also considered a source of high bacteria in the upper portion of Twin Creek, according to the TMDL.

In addition to increasing conservation easements and education and outreach, the TMDL recommended the following restoration strategies for Headwaters Twin Creek HUC-12 (Table 2-11):

Table 2-11 Restoration Strategies for Headwaters Twin Creek HUC-12

Impairment	Agricultural BMPs	Bank and Riparian Restoration	Stream Restoration	Wetland Restoration
Channelization (sedimentation/siltation, algae) Loss of riparian (sedimentation/siltation, algae) Crops with subsurface drainage (sedimentation/siltation, algae	Plant cover crops Install grassed waterways Install vegetated buffer areas/strips Install location-specific conservation buffers Conduct soil testing Install nitrogen reduction practices Develop nutrient management plans Install controlled drainage system Implement manure management practices Construct animal waste storage structures Develop whole farm management plans	Restore streambank using bio-engineering Restore streambank by recontouring or regrading Plant native grasses and trees/shrubs in riparian areas Remove/treat invasive species	Restore stream channel Install in-stream habitat structures Construct 2-stage channel	Reconnect wetland to stream Reconstruct & restore wetlands Plant wetland species

2.3.1. Baseline Load Estimates

Estimated baseline nutrient loads and estimated target load reduction for the Headwaters Twin Creek HUC-12 were calculated using a mass balance equation provided by Rick Wilson, OEPA (Table 2-12). The goal loads presented are 20 percent of the total estimated baseline loads for annual contributions in the Headwaters Twin Creek watershed.

Table 2-12 Estimated Nitrogen and Phosphorus Loadings from Contributing NPS Sources in Headwaters Twin Creek HUC-12

	Agricultural Load (lbs Nitrogen/acre)	Agricultural Load (lbs Phosphorus/acre)	Development Load (lbs Nitrogen/acre)	Development Load (lbs Phosphorus/acre)
Current Estimates*	473,792	30,002	19,186	1,215
Target Reduction Goals (20%)	94,759	6,000	3,837	243

*Estimates provided by Rick Wilson, OEPA in July 2023

The source of nutrient impairment in this watershed is assumed to be primarily agriculture with 86% of the land use is row crops. HSTS was estimated to contribute to only 5% of total phosphorus and 3% of total nitrogen and NPDES contributed to 29% of total phosphorus and 14% of total nitrogen in the Great Miami River watershed (OEPA, 2020). The number of failing HSTS is unknown, though in the 2010 TMDL, the percentage is assumed to be 50% due to soil limitations, the age of many systems, and the lack of enforcement resources at the two local health departments. Water quality modeling of the Lower Great Miami River Basin was performed by Miami Conservancy District in 2017 and provided insights into the significant nutrient loadings and reduction scenarios and single point sampling limitation in this watershed (MCD, 2017).

2.4. Summary of Pollution Causes and Sources

Headwaters Twin Creek HUC-12 and Twin Creek were surveyed in 2005 and the results showed that Headwaters Twin Creek had good and marginally good water quality and was able to support EWH throughout the mainstem (Figure 2-14). The biological indicators suggested that water quality improvement through BMPs in the upland and nutrient management are important and required to support high-quality habitats in Twin Creek and its tributaries. In the Headwaters Twin Creek HUC-12, row crop agriculture is the main source of impairment locally. Nutrients in the form of nitrogen and phosphorus support the growth of algae and

Figure 2-14 Twin Creek near Euphemia-Castine Road

aquatic plants, which provide food and habitat for fish, shellfish and smaller organisms that live in water but too much nutrients in the water causes algae to grow faster than ecosystems can handle (USEPA, 2022). Nitrogen loss from row crop agriculture in rural watersheds which drain to the Gulf of Mexico is also the primary source of Gulf Hypoxia -- caused by excess nutrient (Nitrogen) loading, siltation/sedimentation from cropland, and intense runoff delivery via drainage tiles to the waterbodies.

2.5. Additional Information for Determining Critical Areas and Developing Implementation Strategies

2.5.1. Logjams

Within the Headwaters Twin Creek HUC-12, mainly small forested areas exist along stream corridors, along with scattered upland farm woodlots. Forested riparian areas generally have a positive impact on water quality, and the OEPA habitat and biological indicator data demonstrates that ALU attainment is higher in the areas of Headwaters Twin Creek HUC-12 with riparian tree cover (See Figure 2-13). Trees in the riparian area absorb pollutants and hold nutrients in the soil, prevent soil erosion, and shade streams to keep water temperatures stable (ODA, 2023).

Unfortunately, trees in the riparian area may fall due to disease, pests, beaver activity, extreme weather, and erosion. When trees fall into the floodplain, they can be carried into the stream during high water. Woody debris in the stream provides cover for fish, improving habitat. Too much woody debris that blocks flow or dams up the stream is called a logjam. Logjams contribute to localized flooding during low to moderate intensity storms. They also impact the path of the stream as flowing water seeks the path of least resistance around fallen trees. When the stream path threatens roadways, bridges, power lines, or other infrastructure, the community may face a costly stream restoration project.

Since much of the Headwaters Twin Creek HUC-12 is flat and has poorly drained soils, many local landowners and agricultural producers place a high value on efficient drainage. Efficient drainage benefits agricultural production, especially where the soils have been classified as prime farmland when drained.

The need for efficient drainage has resulted in a decades-old ditch maintenance program within the Darke County government structure. The ditch maintenance program is funded through a petition structure that causes benefitting landowners to equitably share the cost of clearing riparian forest and maintaining the improved waterway (Surber). County ditch maintenance typically includes clearing trees and brush, straightening the channel, mowing, and spraying pesticides to prevent the return of woody vegetation. Some private landowners in the watershed choose to clear riparian forests and maintain the streams through their property in similar fashion as a county ditch. If clearing activity is performed without appropriate Best Management Practices, equipment can disturb the soil, increasing erosion, sedimentation, and watershed impairment (ODA, 2023).

Landowners can prevent the need for large stream restoration projects by regularly maintaining the natural stream channels on their properties (ODNR, 2005). Alternate means of providing adequate drainage without impairing streams might include:

- Conducting a snag-and-drag remedy when logjams block local streams.

- Clearing only dead trees from the riparian zone.
- Utilizing BMPs in conjunction with the ODNR Division of Forestry.
- Cutting only riparian trees on one side of the stream so shade benefits continue.

2.5.2. Climate Resilience

Rising average global temperatures are likely caused by rising greenhouse gases in the atmosphere. The effects of rising average temperatures can include extreme weather events, especially more frequent heavy rain and more severe drought (https://climate.nasa.gov/effects/).

Modifying land management practices has the potential to reduce nutrient runoff into waterways, which is the goal of this planning process. These same practices also mitigate greenhouse gases by sequestering carbon (ODA, 2023), making society more climate resilient (COMET-Planner, https://pln-50-ui-010109-dot-comet-201514.appspot.com/).

The degree of climate benefits of various conservation practices can be quantified. USDA's COMET-Planner estimates greenhouse gas emission reductions. For example, replacing 10 acres of cropland with woody plants -- near a stream in the Headwaters Twin Creek HUC-12 -- would remove 74 tons of carbon dioxide per year from the atmosphere. These additional benefits and potential climate resilience funding sources are important considerations for future projects and incentives.

Cropland management projects that might be considered as promoting climate resilience while also reducing nutrient runoff pollution – listed with their NRCS Conservation Practices code -- include grassed waterway (CPS 412), riparian buffer (CPS 391), contour buffer strips (CPS 332) cover crops (CPS 340), nutrient management (CPS 590), no-till (CPS 329), reduced till (CPS 345), riparian herbaceous cover (CPS 390), and filter strips (CPS 393) (http://comet-planner.com/).

2.5.3. Biosolid Applications

In the Headwaters Twin Creek HUC-12, there are more than 20 permits for biosolid application on agricultural fields, issued and regulated by the Ohio EPA's Biosolids Program. Biosolid application can be a sustainable way to manage the product of the treatment process at public wastewater treatment plants. When proper management techniques – including proper rates of application and proper environmental conditions -- are utilized, the potential for the organic nutrients of biosolids to leach into groundwater or runoff into surface water are reduced. Proper application rates and timing are key to reducing water quality problems that result from biosolid application. "Maintenance of buffer zones between application areas and surface water bodies and soil conservation practices will minimize impacts to surface water" (USEPA, 2000). The Village of West Manchester's drinking water source protection area is in close proximity to two of the biosolid application areas. A Source Water Protection Plan, if developed for the West Manchester public water system, would consider the proximity and potential risks associated with biosolid application. Though biosolid application is a regulated point source, conservation practices that capture and treat runoff from these fields are eligible for nonpoint source funding. Such projects should be prioritized.

2.5.4. Agricultural Conservation Planning Framework

The Agricultural Conservation Planning Framework (ACPF) is an agricultural watershed management tool using high-resolution spatial data and ArcGIS to identify opportunities for installing conservation practices within a watershed (Tomer et al., 2013). Developed by the US

Department of Agriculture, the ACPF is being used in hundreds of watersheds to inform and engage local communities in agricultural conservation. The program spatially combines high resolution terrain, drainage, soils, land use and crop land data, and identifies and prioritizes potential areas for conservation (ARS, 2019). ACPF can engage stakeholders in the watershed planning process by proposing conservation solutions. The program is not prescriptive but provides various options and scenarios that can be evaluated at watershed and farm levels including in-field, below-field and in the riparian zone (Tomer et al., 2013). The following ACPF conservation practices -- both for in-field and below-field -- and riparian buffers are found applicable in our region:

Grassed Waterway – NRCS Conservation Practice Standard (CPS) code 412
Nutrient Removal Wetlands – NRCS CPS code 658
Water and Sediment Control Basin (WASCOB) – NRCS CPS code 638
Riparian Buffer – NRCS CPS code 391
Streambank Stabilization – NRCS CPS code 580
Buffer Contour Strip – NRCS CPS code 332

Filter Strip – NRCS CPS code 393 - Filter Strips are not specifically identified in the ACPF but it is very applicable in this region. This practice would be situated parallel to a perennial stream and consists of a strip of dense perennial cool-season or warm-season grasses, often with additional broadleaf species mixed in. The thick vegetation removes nutrients and sediment from overland flow and stabilizes floodplains when out-of-bank-flow occurs. Suspended and dissolved solids in overland flow are intercepted and treated by a combination of proper slope placement, minimum 30-foot width, and maintenance -- to include annual plant material removal – are defined by the NRCS Field Office Technical Guide (NRCS, 2017).This has been a very effective nutrient removal and treatment practice in the watershed and will replace the Contour Buffer Strips identified in the ACPF.

As conservation practices are combined or “stacked” in a field, the total nutrient quantity removed increases (Lee, 2022). Therefore, incorporating multiple conservation practices draining to the same ditch or tributary are advantageous to meet the goals of the plan.

One of the important outputs generated by the ACPF is the riparian assessment. The ACPF riparian assessment (riparian buffer and streambank stabilization) utilizes a matrix of two variables: the width of the riparian zone and runoff delivery. This analysis provides better options to improve the effectiveness of riparian conservation planting where field runoff occurs. The output further provides specific riparian design types based on the cross-classification matrix which include critical zone for sensitive sites, multi-species buffer for water uptake, nutrient and sediment trapping, stiff-stemmed grasses for trapping runoff and sediment, deep-rooted vegetation tolerant of saturated soil. Some sections emphasize a recommendation for streambank stability because the buffer width is currently narrow. The purpose of this riparian management assessment is to provide the most water quality benefits by identifying segments to install permanent vegetation specifically designed to intercept surface runoff, protect shallow groundwater in low-lying areas and stabilize stream banks. This type of treatment is especially applicable in this watershed since the riparian zone is steep (**Error! Reference source not found.**) and many bare and exposed banks are the source of stream erosion and siltation/sedimentation.

2.5.5. ACPF modeling for Headwaters Twin Creek HUC-12

Miami Conservancy District, a major partner of this project, financially supported the ACPF effort of this HUC-12. The Nature Conservancy, also contributed time and effort in preparing and preprocessing of the datasets for running ACPF. The ACPF model was performed for the Headwaters Twin Creek HUC-12 using a 2.5 ft LIDAR DEM from Ohio Geographically Referenced Information Program (OGRIP) and a file geodatabase provided by ARS (USDA, 2020).

The ACPF model identified a number of possible in-field conservations practices, below-field practices and also riparian zone designs in the Headwaters Twin Creek HUC-12. In this HUC-12, 17% of the fields are considered high and very high runoff risks and 97% of the watershed is tile-drained agricultural fields as estimated by the ACPF (Table 2-13). Figures 2-15 to 2-18 depict the ACPF model results.

Outputs from the ACPF model were discussed at a stakeholder meeting on June 5, 2023, and at follow up field visits and ground verification at selected locations on June 20, 27, and 30. The ACPF maps provide a visual tool, making field visits and discussions more effective and efficient. It is noted that although the ACPF recommended contoured buffer strips, it is not a practice that is common in the region. Therefore, instead of contoured buffer strips, the in-field practice of riparian filter strips is more appropriate.

The ACPF output shows an abundance of grassed waterways as a significant way to improve water quality in this watershed. The recommendation was based on the topography and drainage of the watershed. These locations were field-verified on June 20, 27 and 30, 2023.

TABLE 2-13 CONSERVATION PRACTICES IN HEADWATERS TWIN CREEK HUC-12, SUGGESTED BY THE ACPF (ACPF MAPS AND ESTIMATES ARE FOR PLANNING PURPOSES ONLY

Practice	Unit	Length (miles)	Total Area (Acres)
In-Field Practices			
Grassed Waterways	3,679 sites	421	NA
Contoured Buffer Strips	68 sites	14.3	NA
Tile Drainage Management	274 sites	NA	9,140
Depressions (potential wetland restoration sites)	186 depressions	NA	724
Below-Field Practices			
Nutrient Removal Wetlands	10 wetlands	NA	1,690* Pools:25.8 Buffers: 69.1
WASCOBs	30 sites	NA	377
Denitrifying Bioreactors	180 sites	NA	44.5**
Farm Ponds	4	NA	70.7* Pools: 3.7 Buffer: 2.2
Riparian Zone Practices			
High Nutrient Sensitive Buffers	NA	2.6	NA
Riparian Buffers Filters (various plants)	NA	76	NA
Stream Bank Stabilization	NA	19	NA
Saturated Buffer	NA	13.8	NA
Saturated Buffer Requiring Carbon Enhancement	NA	2.4	NA

** Contributing area*
*** Average surface area of potential bioreactor*
NA – Not applicable

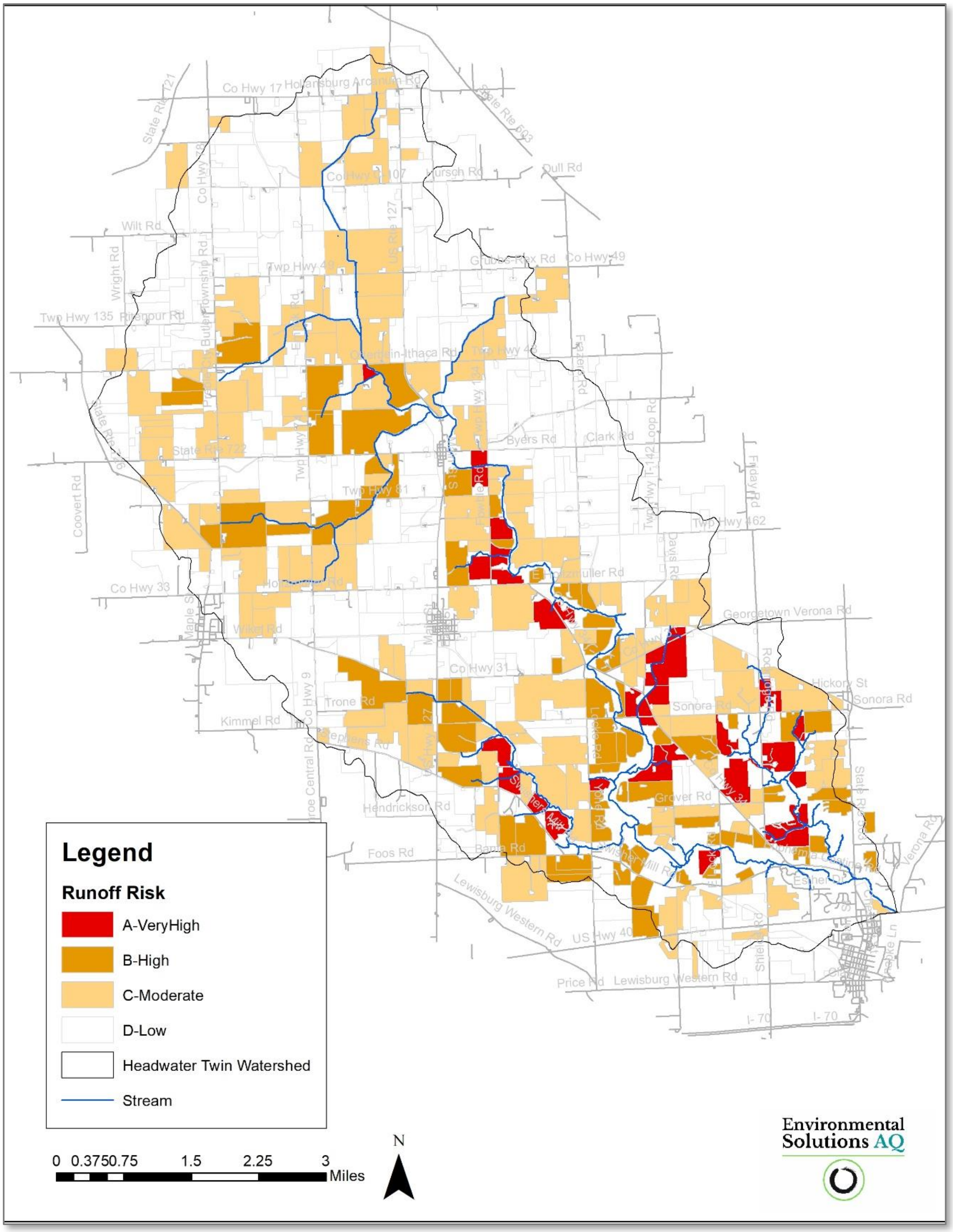

FIGURE 2-15 ACPF RUN-OFF RISK IN HEADWATERS TWIN CREEK HUC-12 WATERSHED

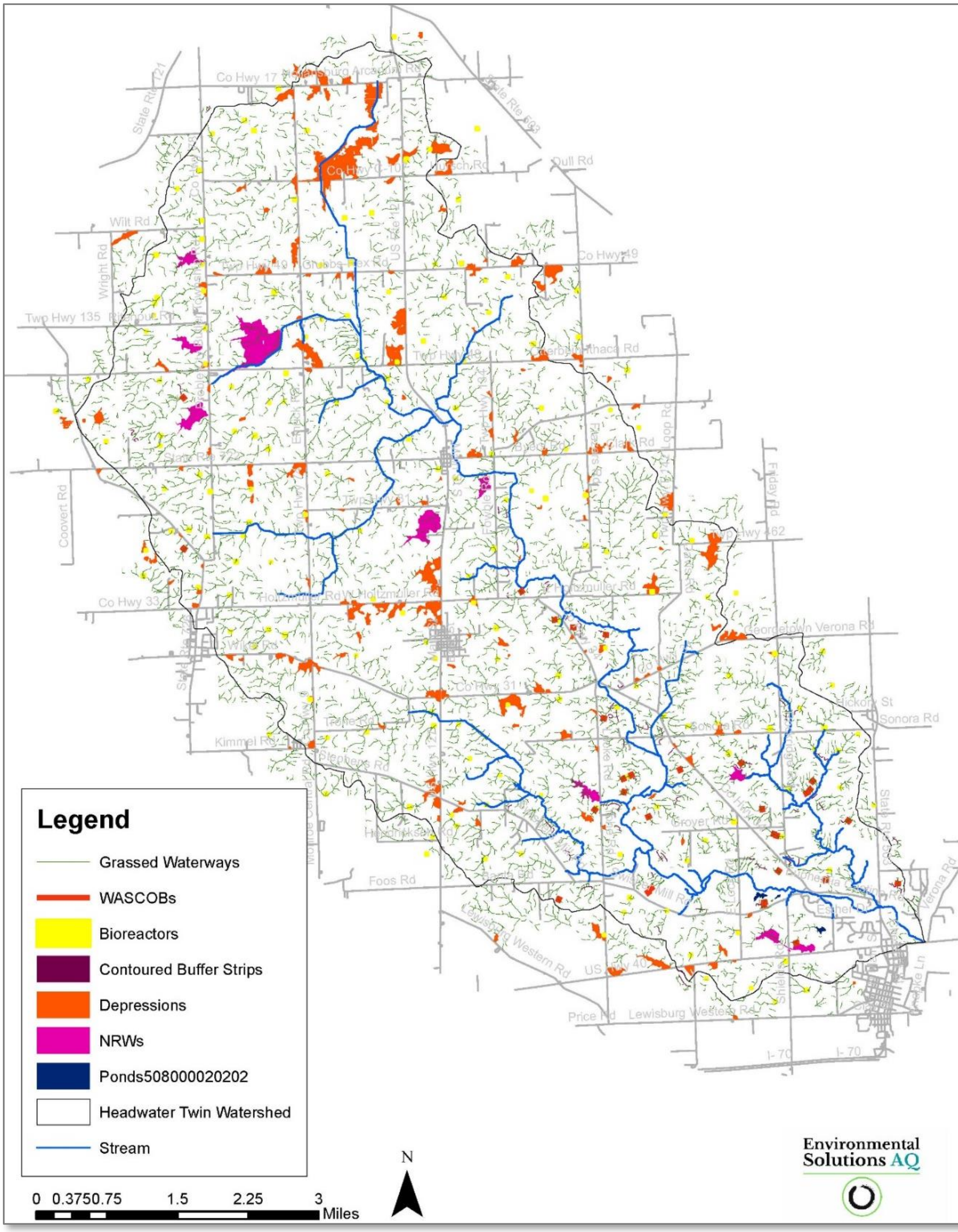

FIGURE 2-16 IN-FIELD & BELOW-FIELD PRACTICES SUGGESTED BY ACPF FOR HEADWATERS TWIN CREEK HUC-12 WATERSHED

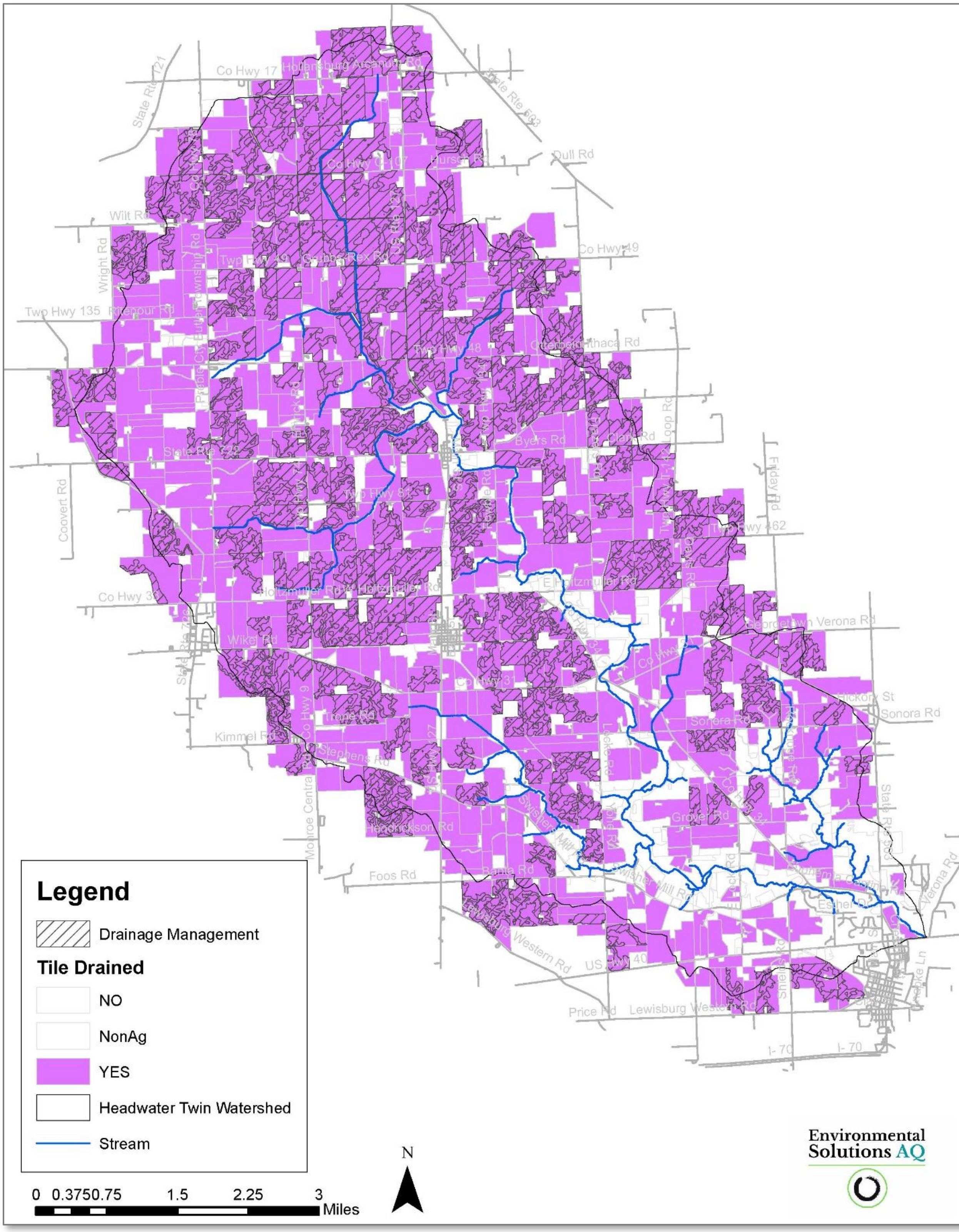

FIGURE 2-17 TILE DRAINAGE CONTROL AND IN-FIELD PRACTICES SUGGESTED BY ACPF FOR HEADWATERS TWIN CREEK HUC-12 WATERSHED

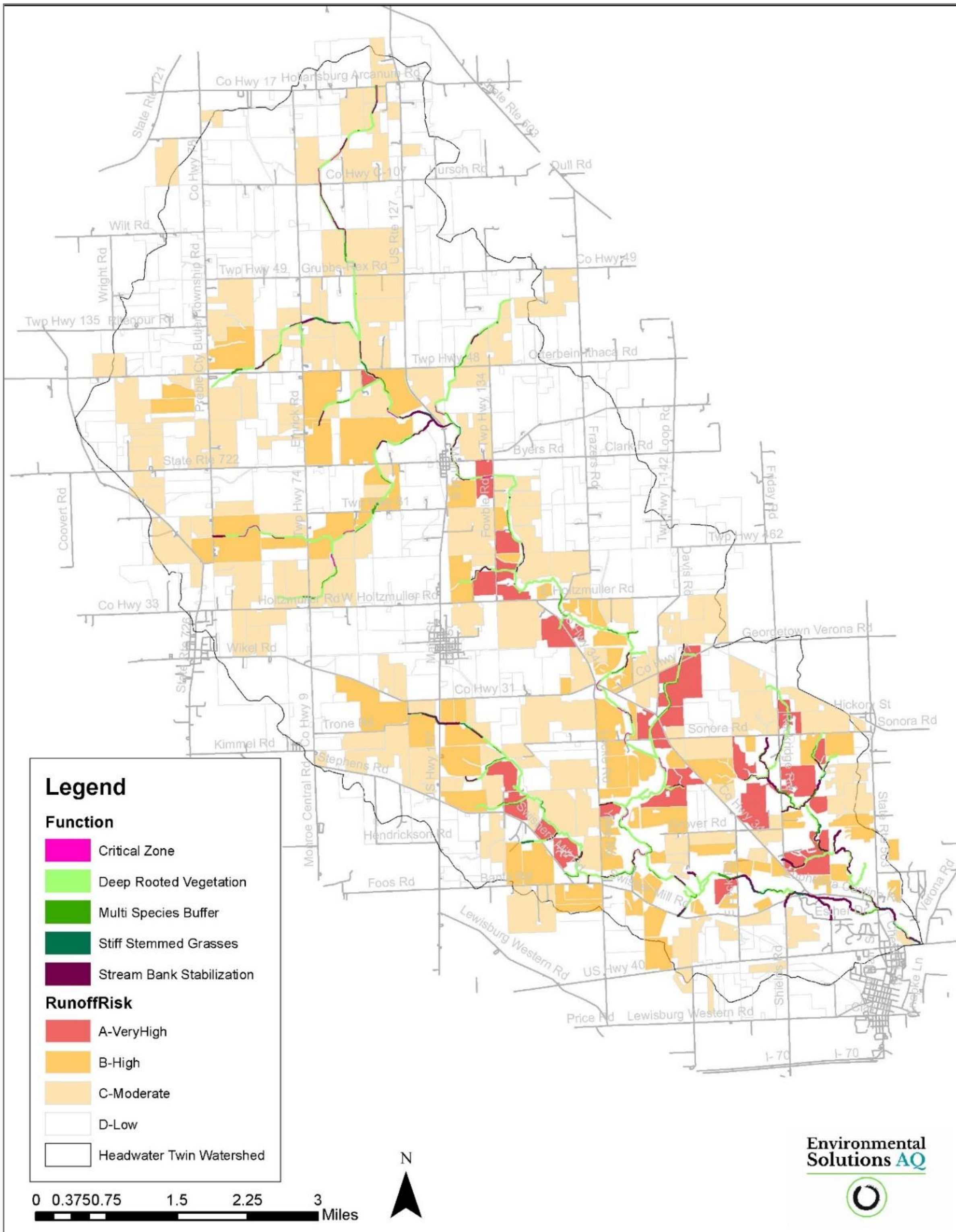

FIGURE 2-18 RIPARIAN FUNCTIONS SUGGESTED BY ACPF FOR HEADWATERS TWIN CREEK HUC-12 WATERSHED

Chapter 3: Conditions & Restoration Strategies for Headwaters Twin Creek HUC-12 Critical Areas

3.1. Overview of Critical Areas

Headwaters Twin Creek, Maple Swamp Ditch, and Dry Fork were assessed during OEPA's 2005 Twin Creek and selected tributaries survey (OEPA, 2007). Of the six samples taken, five of them were in full attainment of EWH or WWH ALU, and the sample from the furthest upstream site of the watershed on Maple Swamp Ditch was in partial attainment of recommended MWH.

The 2010 TMDL provided impairment causes and restoration strategies. Meeting the goal of nutrient reductions requires targeted programs that expand existing partnerships and build new partnerships while supporting education and outreach to promote on-the-ground implementation (USEPA, 2014). Implementation of effective actions and progress must be verified with improved tracking mechanisms, watershed monitoring, and modeling tools (USEPA, 2014).

Headwaters Twin Creek HUC-12 is dominated by tile-drained agricultural fields and landowners voiced their concerns about flooding, severe erosion and streams contaminated by raw sewage during the public meeting and through other forms of communication. This HUC-12 is very large watershed (28,288 acres with 86% row crop) and with 25,052 acres of tile-drained fields (determined by ACPF).

Three critical areas have been identified within the Headwaters Twin Creek HUC-12 in this NPS-IS. The critical areas were identified to address the in-field and below-field nutrient management (Table 3-1).

Critical Area 1 is tile-drained row-crop agricultural fields. Conservation practices reduce nutrient loading that impacts the far-field (Gulf of Mexico) and near-field (local waterways).

Critical Area 2 is the riparian zone. This critical area targets improving the 17 miles of the riparian zone and restoring stream functions, as well as improving and protecting sensitive riparian habitats.

Critical Area 3 is failing HSTS in the unsewered community of Castine. This critical area addresses bacteria and nutrient reduction from the systems that directly discharge human waste to Twin Creek.

TABLE 3-1 CRITICAL AREAS OF HEADWATERS TWIN CREEK HUC-12

Critical Area	Area Description	Impairment Being Addressed	Size
1	**Tile-drained row crop agricultural fields** as determined by ACPF	Near-Field and Far-Field impairment – Gulf of Mexico hypoxia with N and P reduction) - Nutrient management in prioritized agricultural lands using BMPs	25,052 Acres
2	Maple Swamp Ditch and upper most Twin Creek **riparian corridor** with insufficient riparian zones and loss of functioning floodplain	Near-Field and Far-Field impairment – Gulf of Mexico hypoxia - Improve habitat scores of QHEI and stream health by reducing nutrients and associated sedimentation.	17 miles (34 miles both sides) of Maple Swamp Ditch, upper Twin and small tributaries in Darke County
3	**Failing HSTS,** especially in the unsewered community of Castine in close proximity to Twin Creek.	Near-Field - Reduce ammonia, bacteria, N and P discharging directly to local streams or to tiles that lead to steams from an unsewered community.	The unsewered community (Castine) –36 known failing HSTS

3.2. Critical Area 1: Conditions, Goals, & Objectives for Nutrient Reduction and Management in Headwaters Twin Creek HUC-12 Tiled Agricultural Fields.

3.2.1. Detailed Characterization

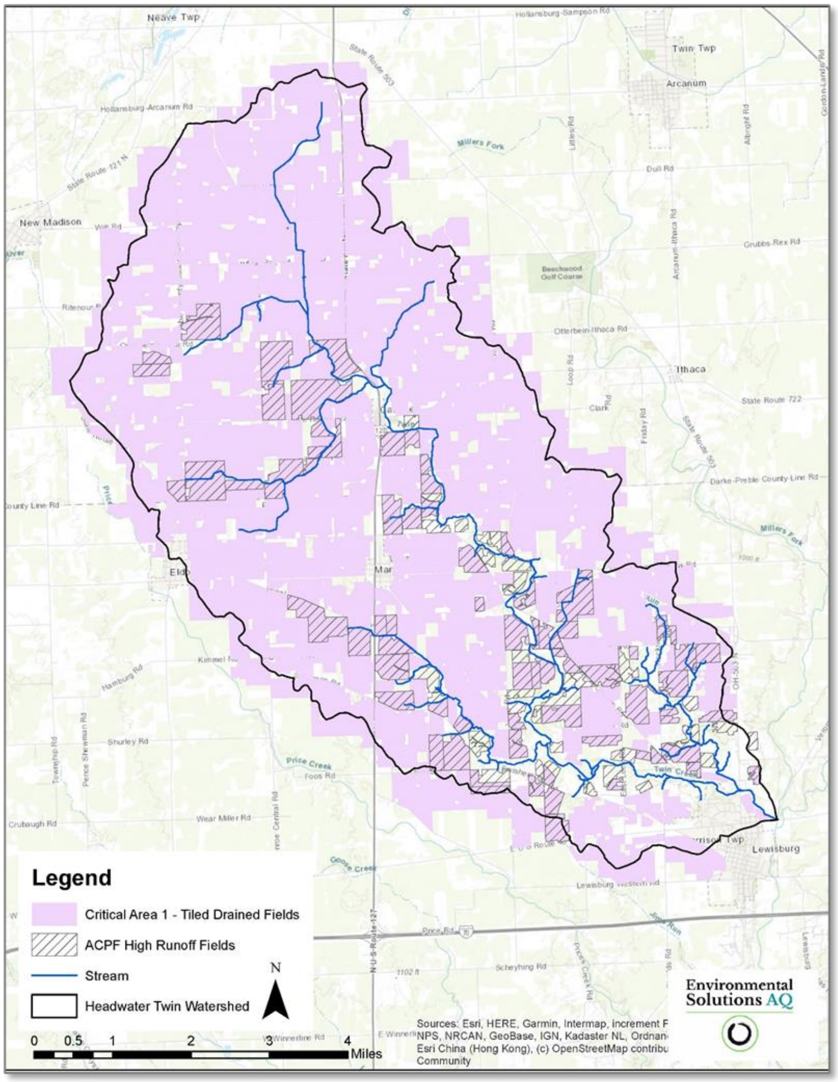

FIGURE 3-1 CRITICAL AREA 1: TILE-DRAINED FIELDS IN HEADWATERS TWIN CREEK HUC-12

Given the dominance of agricultural land use in the Headwaters Twin Creek HUC-12, agricultural nutrient management BMPs implemented in high runoff, tile-drained fields is the best way to reduce nutrients to nearby waterways. Although BMPs are encouraged on all agricultural lands, certain lands are more susceptible to nutrient loss and erosion than others are; and therefore, they need to be prioritized for BMP implementation. Critical Area 1 is comprised of all tile-drained agricultural fields as determined by the ACPF model (Figure 3-1). ACPF also determined the specific high runoff fields based on slope steepness and the fields' close proximity to the stream. The ACPF model was used to identify 118 very high and high runoff fields covering 4,182 acres of the agricultural land (17 %) within the Headwaters Twin Creek HUC-12 watershed.

Based on stakeholders' input and the watershed characteristics, the prioritized areas and potential projects should meet at least one of the following criteria:

- Lands identified as high and very high runoff fields by ACPF;
- Lands directly adjacent to Twin Creek or its tributaries;
- Lands currently under conventional tillage regimes and/or underutilizing cover crops;
- Lands without current nutrient management plan

3.2.2. Detailed Biological Conditions

The 2005 sampling conducted by OEPA show that five of the six sampling points in this HUC-12 possessed conditions that were suitable for supporting WWH and EWH. The upper most watershed sampling location at Maple Swamp Ditch was suitable for MWH. Table 3-2 illustrates the attributes of the fish sampled in 2005 at each monitoring location, resulting in IBI scores of 38 (Maple Swamp Ditch) and 40-48 at the other five locations. Table 3-2 also includes the habitat assessment scores, represented by QHEI values.

TABLE 3-2 FISH COMMUNITY AND HABITAT DATA FOR HEADWATERS TWIN CREEK HUC-12 CRITICAL AREA 1

Stream River Mile	Mean Number Species	Cumu-lative Species	Drainage Area (mi^2)	Predominant species (% of catch)*	IBI	QHEI	Narrative Evaluation
Twin Creek Main Stem							
46.5	18.0	18	19.7	Longear Sunfish (19%), White Sucker (16%), Rock Bass (15%)	48	43.0	Very Good
42.1	23.0	23	28	White Sucker (45%), Ross Bass (16%), Longear Sunfish (11%)	48	75.5	Very Good
38.0	20.0	20	38	Central Stoneroller (39%), Smallmouth Bass (15%), Creek Chub (15%)	46	61.0	Very Good
Maple Swamp Ditch – Tributary to Twin Creek at RM 47.03							
2.4	10.0	10	5.5	Blackstripe Topminnow (50%), Longear Sunfish (15%), Creek Chub (10%)	38	21.0	Marginally Good
1.4	23.0	23	10.2	White Sucker (19%), Rock Bass (16%), Blentnose Minnow (14%)	44	38.5	Good
Dry Fork – Tributary to Twin Creek at RM 39.35							
0.8	21.0	21	5.4	Creek Chub (61%), Western Blacknose Dace (12%)	40	50.0	Good

Source: OEPA, 2007

From the 2005 OEPA sampling results, the QHEI scores (43.0 to 75.5) at main stem Twin Creek were determined to support the EWH ALU designation. Upstream sampling site in Maple Swamp Ditch had QHEI scores of 21.0, with partial attainment and recommended for MWH ALU designation at upstream site and full attainment and recommended for WWH designation at the downstream site. The OEPA report that the macroinvertebrate community on Twin Creek in Headwaters Twin Creek watershed met the current EWH ALU and received very good or exceptional qualitative evaluation. All or nearly all of the community at this site were sensitive taxa intolerant or moderately intolerant of pollution, with Elimia snails, riffle beetles, two types of mayflies, Petrophila moths and two types of caddisflies comprising the majority of the organisms identified. The OEPA reported that filamentous green algae was abundant in Maple Swamp Ditch, likely due to potential nutrients stored in the heavy sediment load. Maple Swamp Ditch sampling location received the lowest QHEI, ICI and IBI scores of all six sampling locations.

TABLE 3-3 MACROINVERTEBRATE DATA FOR HEADWATERS TWIN CREEK HUC-12 CRITICAL AREA 1

Stream RM	Dr. Area (Sq. mi.)	Density Ql. Qt.	Predominant Organisms on the Natural Substrates With Tolerance Category(ies) in Parentheses	ICI	Narrative Evaluation
Twin Creek					
46.6	19.7	H-M	Flatworms (F), riffle beetles (F,MI), Elimia snails (MI)	-	Very Good
42.0	28.0	M/116	Baetid mayflies (F,I), hydropsychid, caddisflies (F,MI)	46	Exceptional
38.1	38.0	M/139	Net-spinning caddisflies (F,MI), Petrophila moths (MI), mayflies (F,MI)	50	Exceptional
Maple Swamp Ditch -Trib to Twin Creek @ RM 47.03					
2.4	5.5	M-L	Midges (MT, MI), Aquatic worms (T), Fingernail clams (F)	-	Poor
1.4	10.2	M	Hydropsychid caddisflies (F,MI), baetid mayflies (F,I), midges (T,F,MI), Helicopsyche mayflies (MI)	-	Good
Dry Fork -Trib to Twin Creek @ RM 39.35					
0.8	5.4	M	Net-spinning caddisflies (F,MI), Helicopsyche caddisflies (MI), Elimia snails (MI)	-	Good

Source: OEPA, 2007
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant.

3.2.3. Detailed Causes and Associated Sources

The 2005 OEPA survey demonstrated that most the streams in this HUC-12 were of good to very good/exceptional, aside from one location that was poor, therefore, nutrient management is necessary to improve and maintain stream health. One partial attainment status was assigned for Maple Swamp Ditch due to sedimentation/siltation and excess algal growth caused by channelization, loss of riparian habitat, and crop production with subsurface drainage (OEPA, 2007). Cropland activities in the Great Miami River basin can contribute to excessive nutrient loadings to local streams and small tributaries and ultimately contribute to Gulf Hypoxia (OEPA, 2020). Practical and property specific BMPs can help reduce the amount and concentration of nutrient-laden surface runoff. These BMPs can also address the loss of sediment /topsoil from agricultural lands and retain and maximize the nutrients in the fields. The implementation of BMPs on tiled agricultural lands can address the causes of topsoil and nutrient loss in the fields and reduce the sources of this excess nutrient and sediment into the waterways.

3.2.4. Outline Goals and Objectives for the Critical Area

The goal of the NPS-IS is to improve water quality, meet nutrient reduction goals, and improve impairment status. In Critical Area 1, the samples collected in 2005 showed that Headwaters Twin to be in partial attainment at the upper watershed tributary Maple Swamp Ditch sampling location and full attainment at the other five sampling locations. However, nearly 90% of the Critical Area 1 is tile-drained agricultural fields. Drain tiles can act as conduits and directly transport nutrients to waterways. They must be well-managed to reduce risk of nutrient loss and to maximize fertilizer use efficiency. To address the impairment, the nutrient reduction goal is set at levels 20% of the current estimated nutrient loadings for the agricultural watersheds within the GMR basin, including the Headwaters Twin Creek HUC-12. To achieve the nutrient loading goals, the following goal and objectives have been established:

Goal 1 – Reduce nitrogen loading contributions in Critical Area 1 by 20%.

NOT ACHIEVED: Current total nitrogen load is estimated to be 473,792 lb and the reduction goal is 94,758 lb.

Goal 2 – Reduce phosphorus loading contributions in Critical Area 1 by 20%.

NOT ACHIEVED: Current total phosphorus load is estimated to be 30,002 lb and the reduction goal is 6,000 lb.

Goal 3 – Improve ALU to full attainment of EWH throughout the watershed.

NOT ACHIEVED: Full attainment of WWH is at Otterbein-Ithaca Road and partial attainment of MWH is at Grubbs-Rex Road. Downstream of these two sites is full attainment of EWH. One other tributary – Dry Run – is fully attaining WWH ALU.

Objectives

In order to reach the load reduction goal of 20% within the Headwaters Twin Creek HUC-12 and improve ALU attainment, effort will include implementing a variety of appropriate BMPs within Critical Area 1. However, the effort must also balance resources and willing landowners. With the ACPF output, a number of in-field and below-field practices are identified that are applicable in this region (Table 3-4).

Objective 1: Implement an additional 800 acres of conservation tillage yearly to the current 16,000 acres estimated under continuous conservation tillage, until nearly 100% of all row-crop agricultural fields utilizing conservation tillage.

Objective 2: Plant an additional 1,000 acres of cover crops over the 700 acres that are already planted per year.

Preble and Darke SWCDs believe cover crops is a practice that has the potential to increase in the watershed with appropriate resources and incentives. They each have a list of interested agricultural producers who would implement the practice with some support. Ducks Unlimited and Farmers for Soil Health are among the funding sources for the practice, in addition to the traditional federal programs.

Objective 3: Reduce nutrient loss through the installation of in-field BMPs such as grassed waterways and filter strips (NRCS code 393, see page 32 for description) on at least 25 acres per year. Project locations are suggested by the ACPF model. These practices would treat an average of 750 acres of cropland combined. Grassed waterways are deemed most effective in removing and treating nutrient runoff in this region because:

- They reduce soil movement and thus the phosphorus chemically bound to the soil.
- Producers easily adopt the practice as a means to manage in-field gully erosion.

Objective 4: Reduce nutrient loss from subsurface tile drainage or below-field practices through the installation of drainage water management structures at 5 locations. The project locations are suggested by the ACPF model.

Table 3-4 Estimated Nutrient Loading Reductions from Each Objective

Objective Number	Best Management Practice	Acreage Treated per year	Estimated Nitrogen (N)/Phosphorus (P) Load Reduction (lbs/yr)*
1	**Conservation Tillage**	800	1,157 lbs/yr (N)/477 lbs/yr (P)
2	**Cover Crops**	1000	1,446 lbs/yr (N)/596 lbs/yr (P)
3	**In-field BMPs: Grassed Waterway (17 acres planted)**	510	788 lbs/yr (N)/202 lbs/yr (P)
3	**In-field BMPs: Filter Strips (8 acres planted)**	240	372 lbs/yr (N)/95 lbs/yr (P)
4	**Below-field BMPs: Controlled drainage BMP such as nutrient removal wetlands or WASCOBs (5 structures)**	150	189 lbs/yr (N)/27 lbs/yr (P)
TOTAL		2700	3,952 lb/yr (N)/1,397 lb/yr (P)

**Estimates calculated using Spreadsheet Tool for Estimating Pollutant Loads (STEPL), Version 4.4 (USEPA, 2020)*

These objectives will be directed towards implementation on prioritized tile-drained agricultural lands using the stakeholders/landowners agreed criteria. The implementation of BMPs included in these objectives, as well as BMPs implemented through federal and state programs and other voluntary efforts will be recorded to track progress towards nutrient reduction goals within Headwaters Twin Creek HUC-12.

There are significant demands for grassed waterway installation in this HUC-12 especially in the northern portion of the watershed. The SWCD staff has limited resources to keep up with the grass waterway installation requests.

The practices of nutrient removal wetlands and WASCOBs are uncommon in this region due to the soils and drainage conditions and the lack of examples in the area. Extra outreach effort will be required in the coming years to promote these water management practices.

Conservation easements have been successfully used in the region to protect local water resources and prime farmland from degradation caused by overdevelopment and unsuitable land management. This legal tool limits the impervious surface cover permitted on agricultural lands, encourages implementation of BMPs and permanently protects sensitive areas including prairies, forested stream buffers and wetlands filtering agricultural runoff. The TVCT will continue to promote conservation easements to help farmers permanently protect their land and improve overall health of Headwaters Twin Creek watershed.

Currently there is no routine monitoring or sampling in the Headwaters Twin Creek HUC-12. But the future project-specific monitoring efforts will verify progress towards meeting the goals identified in the plan. The objectives, projects and implementation strategies presented herein will be reevaluated and modified if determined necessary, as several versions of this NPS-IS are expected.

This Headwaters Twin Creek NPS-IS presents an adaptive and living watershed planning approach and is anticipated to be dynamic as critical areas are identified and objectives are implemented, and other objectives recognized. The objectives listed above will be reevaluated, fine-tuned and modified as necessary when more information becomes available or conditions change. Additional objectives may also be included to make progress towards further reduction goals, as new and additional BMPs can improve nutrient reduction.

The OEPA Nonpoint Source Management Plan Update, which includes a full list of nonpoint source management strategies, will be utilized. Strategies, as presented in the overview tables of Chapter 4, include the following:

- Urban Sediment and Nutrient Strategies;
- Altered Stream and Habitat Restoration Strategies;
- Agricultural Nonpoint Source Reduction Strategies; and
- High Quality Waters Protection Strategies

3.3. Critical Area 2: Conditions, Goals, & Objectives for Nutrient Reduction and Management in Headwaters Twin Creek and Tributaries' Riparian Zones.

3.3.1. Detailed Characterization

In 2005, six samples were collected from the streams and sampled for biological indices and water quality. The sample from the upper watershed tributary, Maple Swamp Ditch, showed that the location was in partial attainment for recommended MWH ALU and the other five samples from the lower watershed and main stem showed full attainment. The biological indicators showed the main stem to be good/very good and Maple Swamp Ditch and Dry Fork were in good/marginally good and poor conditions.

FIGURE 3-2 MAPLE SWAMP DITCH AT OTTERBEIN-ITHACA ROAD

Because of the extensive tile-drained agricultural fields, nutrients from upland are transported directly into the streams and at high speed and large volume during and after storms -- which appear to be more intense in recent years. In the upper portion of the watershed, Headwaters Twin Creek and Maple Swamp Ditch are typically channelized and with very narrow or no riparian buffer. The lack of riparian buffer affects the water quality and habitat.

The high-quality riparian habitats including riparian buffers, wetlands and floodplains connected to the streams are critical for mitigating the negative impacts of nutrients, siltation/sedimentation, and excessive runoff volume from the surrounding agricultural lands. These habitats also support a wide range of wildlife, including some threatened or endangered species identified in the watershed. Therefore, it is critical to protect these areas from further habitat degradation caused by invasive species and agriculture activities.

In Critical Area 2, the ACPF offers riparian design using the two variables of runoff delivery and width of the shallow water table zone. By applying these strategies, the riparian zone will have better function in nutrient removal, water quality improvement, and will restore natural stream functions.

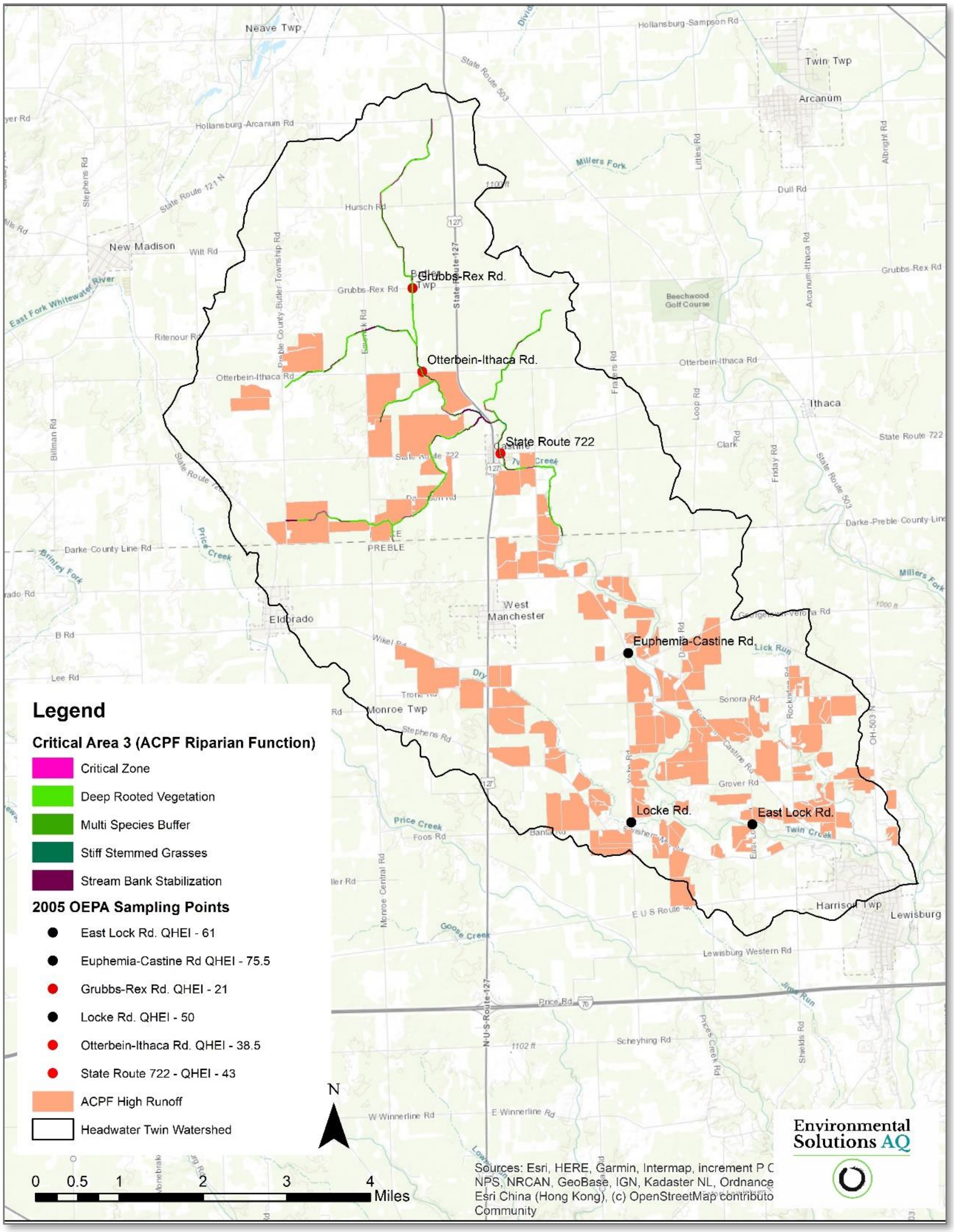

FIGURE 3-3 CRITICAL AREA 2 - RIPARIAN ZONE

Based on inputs from landowners and stakeholders, the prioritized areas and potential projects in Critical Area 2 may meet the following criteria:

- Riparian areas of Twin Creek and tributaries at the upper reach upstream of the OEPA sampling station that did not receive full attainment (Maple Swamp Ditch)
- Riparian areas of Twin Creek and tributaries near the high runoff fields
- Riparian areas with narrow, lack of vegetation or with little or no riparian buffer
- Riparian areas suitable for floodplain/wetland enhancement and/or restoration

3.3.2. Detailed Biological Conditions

As previously shown in Section 2, the 2005 sampling conducted by OEPA at six sampling points in this HUC-12 indicates the QHEI scores (43.0 to 75.5) at Twin Creek were determined to support the EWH ALU designation. Sampling sites in Maple Swamp Ditch had QHEI scores of 21.0 and 38.5, partially attaining recommended MWH ALU designation at the upstream site and fully attaining a recommended WWH designation at the downstream site. The QHEI score at Dry Fork, also a tributary to Twin, was 50 and in full attainment of its WWH designation.

3.3.3. Detailed Causes and Associated Sources

The biological indices, habitat and water quality data collected in 2005 showed the lower main stem of Twin has very good quality. The majority of Headwaters Twin Creek and tributaries in the upper section of the watershed has been channelized and with narrow or no riparian buffer. One partial attainment status was assigned for the upper Maple Swamp Ditch due to sedimentation/siltation and excess algal growth caused by channelization, loss of riparian habitat, crop production with subsurface drainage (OEPA, 2007). Crops are planted very close to the stream and excess nutrients are directly flows into the creek. The implementation of planting of riparian buffers and stream restoration can slow the runoff from the fields and reduce the amount of nutrients washing directly into the streams.

For the high-quality riparian corridors in the lower portion of the watershed, it is important to maintain the quality level by ensuring the riparian area is protected, wetlands and floodplains are restored or enhanced, and buffers are vegetated with the appropriate plant species. For areas with severe streambank erosion, large amounts of sediments are washed down from the banks during and after intense storms. Many of the eroding banks are bare, steeply cut and not protected. The implementation of streambank stabilization and planting of riparian buffers can reduce erosion and siltation/sedimentation in the streams.

3.3.4. Outline Goals and Objectives for the Critical Area

The goal of the NPS-IS is to improve water quality and meet nutrient reduction goals and improve impairment status. Narrow stream buffers and severe stream erosion and siltation/sedimentation, which are common in the Headwaters Twin Creek watershed, might cause water quality degradation and contribute to Gulf of Mexico hypoxia. The Critical Area # 2 focuses on protection and management of riparian corridors and improving water quality and aquatic life in both near-field and far-field waterways.

Currently riparian BMPs are underutilized in this watershed. The floodplain and wetland restoration, stabilization of severely eroding banks and riparian buffer planting will provide great benefits to maintain and improve stream health and aquatic life attainment. No stream restoration projects have been implemented in this HUC-12.

Goal 1 – Achieve an IBI score at or above 40.

NOT ACHIEVED: IBI was 38 at the Maple Swamp Ditch stream mile 2.4 sampling site, though 40 or above at all other sites in the watershed.

Goal 2 – Achieve an ICI score at or above 36, which can be described as "good"

NOT ACHIEVED: ICI was described as "poor" at the Maple Swamp Ditch stream mile 2.4 sampling site, indicating the numeric score was 8 – 12.

Goal 3 – Achieve a QHEI score at or above 60 throughout the watershed.

NOT ACHIEVED: Only two of the six OEPA sampling sites exceeded a QHEI of 60. The Maple Swamp Ditch stream mile 2.4 site was the lowest at 21.

Objectives

The implementation of these objectives, coupled with implementation in Critical Area #1 will help ameliorate negative impacts from excessive nutrients and sediments and improve aquatic life in the near-field and far-field waterways.

Objective 1: Improve the biological habitats in Maple Swamp Ditch and Headwaters Twin Creek in Darke County by restoring the natural stream channel along at least 7 miles, or 42 acres reconnecting the stream with the floodplain and reducing sedimentation at *Critical Area #2*.

Objective 2: Improve the natural habitats in the upper portion of Headwaters Twin Creek by restoring the riparian buffer along 27 miles or 164 acres at *Critical Area #2.*

Objective 3: Protect with conservation easements or via land acquisitions 20 acres or at least 2 miles of Headwaters Twin Creek and its main tributaries.

TABLE 3-5 ESTIMATED NUTRIENT REDUCTIONS FROM EACH OBJECTIVE

Objective Number	Best Management Practice	Total Length/Acreage Treated	Estimated Load Reduction using STEPL*
1	Stream and floodplain restoration using ACPF modeling	7 miles/42 Acres (avg 50 feet wide)	87 lbs/yr (N)/18 lbs/yr (P)
2	Riparian Buffer as designed using ACPF modeling based on the width of the riparian zone and runoff delivery (see Section 2.5.1).	27 miles/164 Acres (avg 50 feet wide)	263 lbs/yr (N)/67 lbs/yr (P)
3	Protecting riparian areas and wetland with conservation easements and retire 20 acres.	20 Acres** (riparian corridor width: 100 feet at each side of the stream)	105 lb/yr (N)/20 lb/yr (P)
TOTAL		**226 acres**	**455 lb/yr (N) and 105 lb/yr (P)**

*Estimated using Spreadsheet Tool for Estimating Pollutant Loads (STEPL), Version 4.4 (USEPA, 2020)
N-Nitrogen; P-Phosphate
**20 acres of land retirement is used for this estimate

Currently there is no routine monitoring or sampling in the Headwaters Twin Creek HUC-12. But the future project-specific monitoring efforts will verify progress towards meeting the goals identified in the plan. The objectives, projects and implementation strategies presented herein will be reevaluated and modified if determined necessary, as several versions of this NPS-IS are expected.

This NPS-IS will employ an adaptive management process. As objectives and implementation projects are reevaluated, objectives listed above will be reevaluated, fine-tuned and modified as necessary when more information become available or conditions change. Additional objectives may also be included to make progress towards further reduction goals or water quality improvement goals, as new and additional BMPs can improve nutrient reduction and sedimentation in streams.

The OEPA Nonpoint Source Management Plan Update, which includes a full list of nonpoint source management strategies, will be utilized. Strategies, as presented in the overview tables of Chapter 4, include the following:

- Urban Sediment and Nutrient Strategies;
- Altered Stream and Habitat Restoration Strategies;
- Agricultural Nonpoint Source Reduction Strategies; and
- High Quality Waters Protection Strategies.

3.4. Critical Area 3: Conditions, Goals, & Objectives for Nutrient Reduction and Management from the Unsewered Community of Castine along Headwaters Twin Creek.

3.4.1. Detailed Characterization

According to the 2020 U.S. Census, Castine, a small Darke County village with a population of 110 and West Manchester, a small Preble County village with a population of 415 are the only villages fully within the HUC-12. West Manchester holds an NPDES permit to operate a wastewater treatment plant. Lewisburg and Eldorado are partially within this HUC-12 and both hold an NPDES permit to operate a wastewater treatment plant.

FIGURE 3-4 HEADWATERS TWIN CREEK AT CASTINE, WITH PLAYGROUND DIRECTLY ADJACENT

Castine, a village that has a total area of 51.2 acres and is located adjacent to Twin Creek, is not served by any wastewater treatment plant. Hence, all of the businesses, churches, and homes in Castine -- as well as homes, typically on larger lots outside villages -- rely on HSTS to treat sewage. The Clean Watershed Needs Survey conducted the Household Sewage Treatment System Failures in Ohio by the Ohio Department of Health in 2012 indicated the failure rate of HSTS in southwest Ohio was 18% (ODH, 2013). However, the Darke County General Health Department (DCGHD) stated the failure rate for the Village of Castine is estimated to be significantly higher. It was reported by a resident during the public meeting that raw sewage flows continually in Twin Creek at Castine and that children playing in the creek there are known to become ill. Rural homes throughout the watershed are also served by HSTS.

Ohio's Nutrient Mass Balance Study for Ohio's Major Rivers 2020 (OEPA, 2020) estimated the HSTS community in the Great Miami River Basin contributed 5% of the total P load and 3% of the total N load. HSTS are considered a major bacteria contributor affecting the water quality of Headwaters Twin Creek as indicated in the 2007 OEPA report. The NRCS Soil Web Survey for Septic Tank Absorption Fields for Headwaters Twin Creek HUC-12 indicated that 73.4% of the watershed is very limited. Because of the poor soil drainage and shallow depth to bedrock, it is likely that failed HSTS are prevalent and widespread in this watershed.

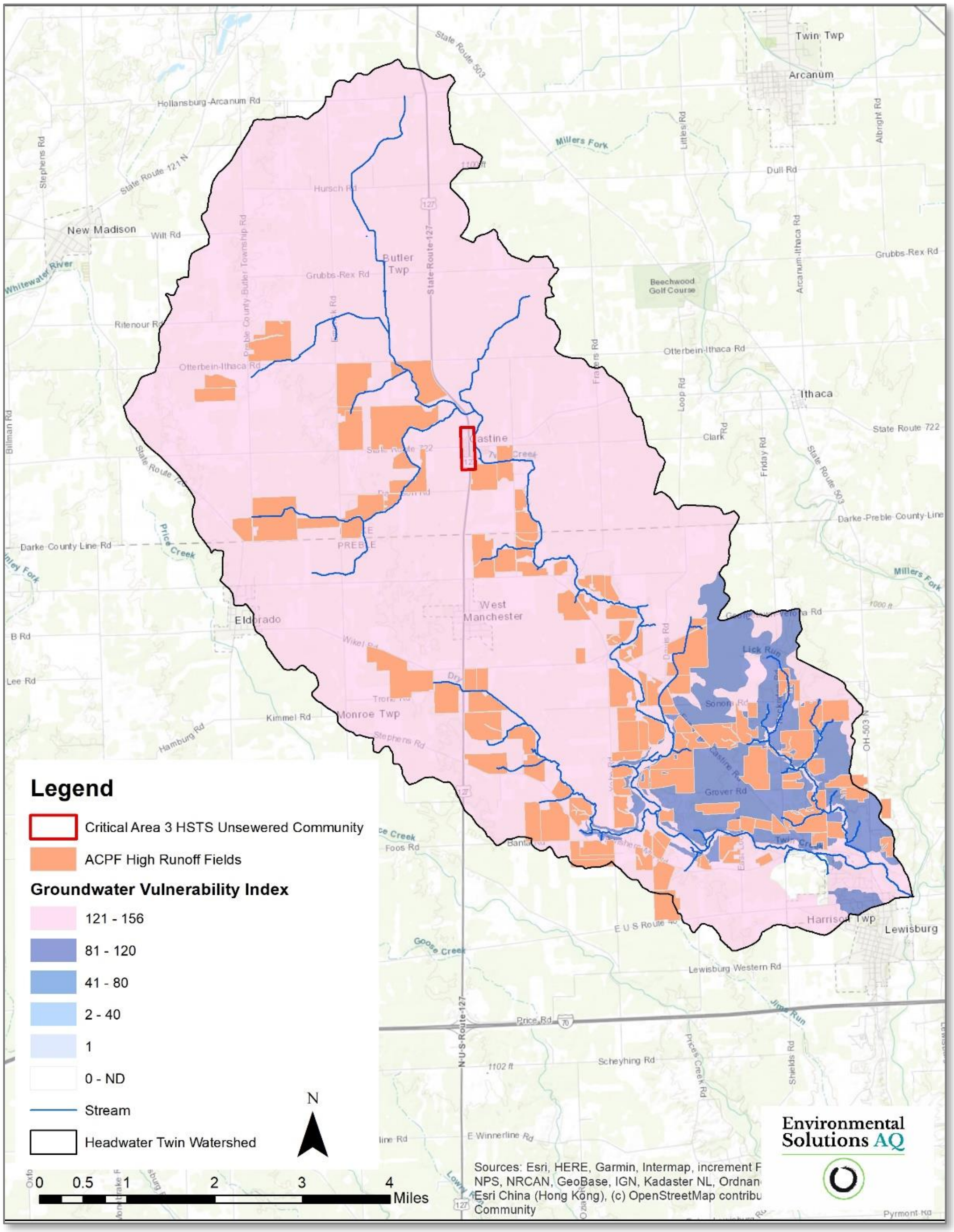

FIGURE 3-5 CRITICAL AREA 3 - UNSEWERED COMMUNITY OF CASTINE

3.4.2. Detailed Biological Conditions

Twin Creek flows adjacent to the Village of Castine. As previously shown in Section 2, the 2005 sampling conducted by OEPA found Twin Creek near State Route 722 at Castine to be fully attaining EWH. However, it also had a QHEI of 43, which is the lowest QHEI score of all designated EWH sampling sites in the Headwaters Twin. Macroinvertebrate and fish assemblages were perhaps more diverse than expected with the low percentage of canopy cover, but OEPA attributed the diversity to the cooling influence of groundwater.

3.4.3. Detailed Causes and Associated Sources

Upper Twin Creek is not attaining primary contact for recreational use (PCR) due to elevated bacteria levels. In the 30-day period of September 2005, OEPA *E. Coli* testing resulted in a Geometric mean of 285 colonies/100 ml, exceeding the 126 colonies/100 ml standard for PCR. These samples included a dry day result of 724 colonies/100 ml, indicating likely HSTS discharge.

Failing systems are likely discharging waste to a storm sewer pipes or field tiles that discharge directly to Twin Creek. OEPA's 2007 report also demonstrated the agency's concern about Castine:

"A sample was taken on September 15, 2005 to document an obviously contaminated drainage tile near the town of Castine on SR 722. This tile drained into Twin Creek at RM 46.55. Analytical results documented ammonia at 10 mg/l, fecal coliform at 60,000 colonies/100ml and *E. coli* at 67,000 colonies/100ml. Both bacteria samples were submitted past holding time, but are a good screening tool to document failing septic systems in the watershed near Castine." (OEPA, 2007). No follow up was pursued by OEPA nor any recent sampling was found. According to DCGHD staff, the Village of Castine has 57 HSTS serving homes, businesses, churches, etc. and approximately 63% of those systems are failing, or 36 HSTS. The systems either have no secondary treatment (e.g. leach field) or the leach field is more than fifty years old. Included in this failure rate are eight sandfilters that are more than 30 years old, six old aeration systems, and one dry well – a practice that is no longer permitted (OAC 3701-29-06, 2015).

Lot sizes smaller than one half acre severely limit the ability of homeowners to install new or replacement leach fields. Groundwater is also likely being impacted – a particular risk of nitrate contamination, especially in shallower wells (Swann, 2001).

To determine the annual nutrient load from HSTS to Twin Creek in Castine, an estimate of the concentration of Total N and Total P in septic tank effluent is needed. Since there are no nutrient concentrations determined in Castine, four studies with similar septic tank effluent concentrations were located from literature search (Swann, 2001). Table 3-6 provides an average of those studies' findings, plus the conversion to pounds per million gallons of water.

TABLE 3-6 ESTIMATED CONCENTRATIONS OF NUTRIENTS IN SEPTIC TANK EFFLUENT

	Average mg/L in septic tank effluent from four similar studies	**Ave.lbs./million gallons in septic tank effluent**
Total N	42.4	353.8
Total P	16	134

Source: Swann 2001

DCGHD estimated the number of septic systems they believe to be failing. Because Castine is adjacent to Twin Creek and has a municipal storm sewer system, DCGHD staff hypothesizes many if not all failing systems are connected by storm sewer or discharging directly by private pipe to Twin Creek. 2020 Census data and USGS estimates of average water use per day are also included in Table 3-7.

TABLE 3-7 CASTINE POPULATION, HSTS AND ESTIMATED WATER USE

Castine, Ohio					
Population (2020 US Census)	**Number of HSTS (DCGHD)**	**People per HSTS, based on US Census**	**Number of failing HSTS (DCGHD)**	**Total number of humans whose waste is discharging failed system**	**Gallons of water used per day at 82 gal/person (USGS)/M Gallion per year**
110	**57**	**1.9**	**36**	**68.4**	**5,608/2.05**

Source: US Census, DCGHD

****Pounds per year = AVE mg/L $_{N\ or\ P}$ -> Ave lbs./ M gal $_{N\ or\ P}$ * (<u>number of humans on failing septic systems * 82 gallons per day use * 365 days in a year</u>)**

This data provides the opportunity to estimate pounds per year of both total nitrogen and total phosphorus (Table 3-8).

TABLE 3-8 ESTIMATED ANNUAL NUTRIENT LOADS TO TWIN CREEK FROM FAILING SEPTIC SYSTEMS IN CASTINE, OHIO

	Million gallons effluent per year flowing from failing HSTS in Castine, Ohio	**Average concentrations of nutrients in mg/L (Swann)**	**Average concentrations of nutrients in lbs./million gallons***	**Estimated pounds per year of nutrients discharging HSTS from Castine to Twin Creek****
Total N	2.05	42.4	353.8	725.3
Total P		16	134	274.7

**https://www.unitconverters.net/concentration-solution/milligram-liter-to-pound-million-gallon-us.htm*

Better resources and coordination from local partners are needed to address the failed HSTS in this rural community and in the region.

3.4.4. Outline Goals and Objectives for the Critical Area

The goal of NPS-IS is to improve water quality and meet nutrient reduction goals. Reduction of HSTS nutrient contributions will lead to the reduction of bacteria and nutrients releasing to the environment and local waterways. The Headwaters Twin Creek HUC-12 is a large rural watershed (28,288 acres) and most of the watershed is unsewered.

Based on the watershed characteristics, the prioritized areas in Critical Area 3 and potential projects should meet at least one of the following criteria:

- Lands where the villages or other densely populated areas are unsewered (Castine);
- Lands directly adjacent to Twin Creek or its tributaries;
- Lands within the high Groundwater Vulnerability Index;
- Lands within the source water protection areas.

Baseline development loads for nitrogen is 19,186 lb and phosphorous is 1,215 lb (Table 2-13). In order to meet the 20% overall nutrient reduction goals, reductions in nutrient contributions from failing HSTS at Castine should be considered.

Goal 1 Reduce phosphorus loading contributions in Critical Area #3 to a level at or below 243 lbs/year (20% reduction).

NOT ACHIEVED: Currently 36 of 57 HSTS are failing in the Village of Castine. Phosphorus load contribution is estimated to be 274.7 lbs. annually.

Goal 2 Reduce nitrogen loading contributions in Critical Area #3 to a level at or below 3,837 lb (20% reduction).

NOT ACHIEVED: Currently 36 of 57 HSTS are failing in the Village of Castine. Nitrogen load contribution is estimated to be 725.3 lb.

Goal 3 Attain and maintain PCR use in Twin Creek above the Village of Lewisburg.

NOT ACHIEVED: 40% of *E. coli* sampling results at E. Lock Road in September 2005 exceeded 298 colonies/100 ml, and the standard is not more than 10% shall do so in a 30-day period. This finding replicates biological testing throughout the upper Twin watershed where 39% of samples exceeded the *E. coli* standard.

If all failing/discharging HSTS were replaced in Castine, it is estimated that 725.3 pounds of nitrogen and 274.7 pounds of phosphorus would be prevented from entering Twin Creek annually. Significant *E. coli* and fecal coliform bacteria and other pathogens would no longer discharge to Twin Creek, protecting the health of families in the Headwaters Twin Creek HUC-12.

Objectives

In order to make substantive progress toward the achievement of the phosphorous load reduction goal of 243 lbs for the HSTS contribution, effort must commence on more widespread implementation, according to the following objectives as first steps to address the failing HSTS within *Critical Area #3.*

Objective 1: Replace 36 HSTS in the Village of Castine or connect them to sanitary sewer infrastructure.

Objective 2: Enroll all HSTS in the HUC-12 in county health department permitting programs, including operation and maintenance systems.

Objective 3: Replace failing HSTS in the HUC-12, prioritizing those within 500 feet of Twin Creek and/or known to have no secondary treatment and to be discharging directly to surface water.

To achieve these objectives, Darke and Preble county health departments could pursue funding assistance from Ohio EPA to provide cost-share for income-eligible homeowners. Additional staff resources are needed to achieve universal compliance.

It is recommended that the Village of Castine commission an engineering study to explore the feasibility of connecting to a wastewater treatment plant -- the Village of West Manchester's plant is approximately two miles downstream -- or of building the village's own wastewater treatment plant.

Currently there is no routine stream monitoring or sampling in the Headwaters Twin Creek HUC-12. But the future project-specific monitoring efforts will verify progress towards meeting the goals identified in the plan. The objectives, projects and implementation strategies presented herein will be reevaluated and modified if determined necessary, as several versions of this NPS-IS are expected.

This NPS-IS will employ an adaptive management process. As objectives and implementation projects are reevaluated, objectives listed above will be reevaluated, fine-tuned and modified as necessary when more information become available or conditions change. Additional objectives may also be included to make progress towards further reduction goals or water quality improvement goals, as new and additional BMPs can improve nutrient reduction and sedimentation in streams.

The OEPA Nonpoint Source Management Plan Update, which includes a full list of nonpoint source management strategies, will be utilized. Strategies, as presented in the overview tables of Chapter 4, include the following:

- Urban Sediment and Nutrient Strategies;
- Altered Stream and Habitat Restoration Strategies;
- Agricultural Nonpoint Source Reduction Strategies; and
- High Quality Waters Protection Strategies

Chapter 4: Projects and Implementation Strategy

The Great Miami River Basin is one of the major nutrient contributors to Ohio River and Gulf Hypoxia (OEPA, 2020). It is important and beneficial for the NPS-IS initiatives to be implemented in this region as soon as possible. Headwaters Twin Creek HUC-12 is an agricultural watershed and implementation of proposed conservation practices is targeted to reduce nutrient load reduction by 20%. Based on the 2005 OEPA sampling, the Twin Creek main stem was very good quality but the tributaries Maple Swamp Ditch and Dry Fork were marginally good/good quality streams. Therefore, the goal is to improve and protect its stream and habitat health.

The Project and Implementation Strategy of the Headwaters Twin Creek HUC-12 NPS-IS includes an action plan based on the causes and sources of NPS pollution which are described in the previous Chapter. Chapter 3 presented the three Critical Areas and their goals, objectives, and potential projects. These critical areas will be reevaluated through time to monitor progress towards meeting their NPS goals and objectives. Some of the positive impacts may be slow and take years to show progress towards recovery.

4.1. Overview Tables and Project Sheets for Critical Areas

The critical areas provide a general concept and will be further evaluated as partners and landowners provide additional feedback on projects the team proposed. The estimated project costs and the time frame are both dependent upon funding opportunities and coordination with landowners and project partners. At such a time as a project becomes viable, the team will submit an updated NPS-IS with additional project summary sheets.

At such a time, the project summary sheets will outline how the nine minimum elements of watershed planning are being met by each opportunity, as shown in the first column of each table. Moreover, this NPS-IS will be updated periodically to address stakeholder input and additional project opportunities may be added at that time. If a future critical area is identified (e.g. Drinking Source Water Protection) within the Headwaters Twin Creek HUC-12, supplemental information will be provided.

4.2. Project Tables

The Project Overview Table for each Critical Area presents a summary of each strategy identified for each critical area. BMP strategies are divided into several categories, including urban storm water runoff management, altered stream and habitat restoration strategies, and other nonpoint source causes and associated sources of impairment.

TABLE 4-1 CRITICAL AREA 1 PROJECT OVERVIEW TABLE FOR HEADWATERS TWIN CREEK HUC-12

For Headwaters Twin HUC-12 (050800020202) Critical Area 1							
Goal	**Objective**	**Project**	**Project Title (EPA Criteria g)**	**Lead Organization (EPA Criteria f)**	**Time Frame (EPA Criteria f)**	**Estimated Cost (EPA Criteria d)**	**Funding/Actual Sources (EPA Criteria d)**
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
1,2	2	1	Agricultural BMP – 1,000 Acres Cover Crops	Preble & Darke SWCDs	Short to Medium (1-7 years)	40,000	EQIP-CIC, CSP, Ducks Unlimited, Farmers for Soil Health
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

TABLE 4-2 CRITICAL AREA 1 - PROJECT 1 TABLE: COVER CROPS

Project #1– Headwaters Twin Creek HUC-12 Critical Area 1		
Nine Element Criteria	**Information needed**	**Explanation**
n/a	Title	Agricultural BMPs – Cover Crops
criteria d	Project Lead Organization & Partners	Darke Soil and Water Conservation District Preble Soil and Water Conservation District
criteria c	HUC-12 and Critical Area	Headwaters Twin HUC-12 (050800020202) Critical Area 1
criteria c	Location of Project	Private landowners – exact location not disclosed
n/a	Which strategy is being addressed by this project?	Agricultural Nonpoint Source Reduction
criteria f	Time Frame	Short to Medium (1-7 years)
criteria g	Short Description	Administer cost-share program for cover crop installation
criteria g	Project Narrative	Darke and Preble SWCDs will administer a cost-share program to local landowners in prioritized agricultural lands to install about 1,000 acres of cover crops.
criteria d	Estimated Total cost	$40,000
criteria d	Possible Funding Source	EQIP-CIC, CSP, Ducks Unlimited, Farmers for Soil Health
criteria a	Identified Causes and Sources	Cause: Nutrient loadings Source: Agricultural land use activities
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?	**Objective 2:** Plant an additional 1,000 acres of cover crops annually in addition to the 700 acres that are already planted per year. The overall goal in Critical Area #1 is to reduce estimated total nitrogen load for agricultural lands by 20% (94,758 lb). In order to meet the Gulf of Mexico hypoxia reduction goals, the total nitrogen loadings must be reduced by additional 94,758 lb/year and the phosphorous load reduction needed is 6,000 lb./year.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	Goal: This project is expected to achieve 1.5% of the total nitrogen reduction goal and 9.9% of the total phosphorous reduction goal.
	Part 3: Load Reduced?	Estimate of 1,446 lbs/yr (N)/596 lbs/yr (P) load reduction based on STEPL 4.4b Spreadsheet Model for 10 Watersheds.

Table 4-3 Critical Area 2 Project Overview Table for Headwaters Twin Creek HUC-12

For Headwaters Twin Creek HUC-12 (050800020202) Critical Area 2							
Goal	**Objective**	**Project**	**Project Title (EPA Criteria g)**	**Lead Organization (EPA Criteria f)**	**Time Frame (EPA Criteria f)**	**Estimated Cost (EPA Criteria d)**	**Funding/Actual Sources (EPA Criteria d)**
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

Table 4-4 Critical Area 3 Project Overview Table for Headwaters Twin Creek HUC-12

For Headwaters Twin Creek HUC-12 (050800020202) Critical Area 3							
Goal	**Objective**	**Project**	**Project Title (EPA Criteria g)**	**Lead Organization (EPA Criteria f)**	**Time Frame (EPA Criteria f)**	**Estimated Cost (EPA Criteria d)**	**Funding/Actual Sources (EPA Criteria d)**
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

Chapter 5: APPENDIX

Appendix A – References

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APPENDIX B – Common Soil Types in the Headwaters Twin Creek HUC-12 watershed

Summary by Map Unit — Darke County, Ohio (OH037)				
Map unit symbol	**Map unit name and description**	**Drainage rating**	**Area (acres)**	**Percent of HUC-12**
Br	Brookston silty clay loam, fine texture, 0 to 2 percent slopes	Poorly drained	3,984.6	14.10%
CeA	Celina silt loam, 0 to 2 percent slopes	Moderately well drained	6.9	0.00%
CeB	Celina silt loam, 2 to 6 percent slopes	Moderately well drained	810	2.90%
CrA	Crosby silt loam, Southern Ohio Till Plain, 0 to 2 percent slopes	Somewhat poorly drained	2,628.6	9.30%
CrB	Crosby silt loam, Southern Ohio Till Plain, 2 to 6 percent slopes	Somewhat poorly drained	4,584.4	16.20%
CtA	Crosby-Celina silt loams, 0 to 2 percent slopes	Somewhat poorly drained	86.3	0.30%
CtB	Crosby-Celina silt loams, 2 to 4 percent slopes, eroded	Somewhat poorly drained	16.6	0.10%
Ee	Eel silt loam, occasionally flooded	Moderately well drained	41.1	0.10%
EnB	Eldean loam, 2 to 6 percent slopes	Well drained	59.6	0.20%
ErC2	Eldean-Miamian complex, 6 to 12 percent slopes, eroded	Well drained	4.6	0.00%
ErD2	Eldean-Miamian complex, 12 to 18 percent slopes, eroded	Well drained	2.3	0.00%
KoA	Kokomo silty clay loam, 0 to 1 percent slopes	Very poorly drained	256	0.90%
LeB	Lewisburg silt loam, 2 to 6 percent slopes	Moderately well drained	161.4	0.60%
Md	Medway silt loam, occasionally flooded	Moderately well drained	77.1	0.30%
MkB	Miamian-Celina silt loams, 2 to 6 percent slopes	Well drained	10.1	0.00%
MkB2	Miamian-Celina silt loams, 2 to 6 percent slopes, eroded	Well drained	1.3	0.00%
MmB	Miamian silt loam, 2 to 6 percent slopes	Well drained	525.9	1.90%
MmC2	Miamian silt loam, 6 to 12 percent slopes, eroded	Well drained	71.8	0.30%
MnC3	Miamian clay loam, shallow to dense till substratum, 6 to 12 percent slopes, severely eroded	Well drained	5	0.00%
OdA	Odell silt loam, 0 to 3 percent slopes	Somewhat poorly drained	33	0.10%

Pa	Patton silty clay loam, 0 to 2 percent slopes	Poorly drained	77.6	0.30%
PyA	Pyrmont silt loam, 0 to 3 percent slopes	Somewhat poorly drained	384.4	1.40%
SeA	Savona silt loam, 0 to 2 percent slopes	Somewhat poorly drained	1.3	0.00%
SnA	Sloan silt loam, sandy substratum, 0 to 1 percent slopes, frequently flooded	Very poorly drained	2.2	0.00%
Subtotals for Soil Survey Area			**13,832**	**48.90%**
Summary by Map Unit — Preble County, Ohio (OH135)				
Map unit symbol	Map unit name	Drainage Rating	Acres in AOI	Percent of AOI
CeA	Celina silt loam, 0 to 2 percent slopes	Moderately well drained	327.3	1.20%
CeB	Celina silt loam, 2 to 6 percent slopes	Moderately well drained	2,352	8.30%
CeB2	Celina silt loam, 2 to 6 percent slopes, eroded	Moderately well drained	764.2	2.70%
CoA	Corwin silt loam, 0 to 2 percent slopes	Moderately well drained	12	0.00%
CtA	Crosby-Celina silt loams, 0 to 2 percent slopes	Somewhat poorly drained	2,614.9	9.20%
CtB	Crosby-Celina silt loams, 2 to 4 percent slopes, eroded	Somewhat poorly drained	378.2	1.30%
EeA	Eel silt loam, gravelly substratum, 0 to 1 percent slopes, occasionally flooded	Moderately well drained	41.5	0.10%
EgA	Eldean gravelly loam, 0 to 2 percent slopes	Well drained	11.4	0.00%
EgB2	Eldean gravelly loam, 2 to 6 percent slopes, eroded	Well drained	20.6	0.10%
EhC3	Eldean gravelly clay loam, 6 to 12 percent slopes, severely eroded	Well drained	19.9	0.10%
EhD3	Eldean gravelly clay loam, 12 to 18 percent slopes, severely eroded	Well drained	6.7	0.00%
EkA	Eldean loam, 0 to 2 percent slopes	Well drained	109.4	0.40%
EkB	Eldean loam, 2 to 6 percent slopes	Well drained	66.5	0.20%
EkB2	Eldean loam, 2 to 6 percent slopes, eroded	Well drained	45.5	0.20%
FmA	Fox silt loam, till substratum, 0 to 2 percent slopes	Well drained	71.4	0.30%
FmB	Fox silt loam, till substratum, 2 to 6 percent slopes	Well drained	18.9	0.10%
FmB2	Fox silt loam, till substratum, 2 to 6 percent slopes, eroded	Well drained	9	0.00%

HeF2	Hennepin-Miamian silt loams, 25 to 50 percent slopes, eroded	Well drained	28.4	0.10%
KeC2	Kendallville-Eldean silt loams, 6 to 12 percent slopes, eroded	Well drained	54.8	0.20%
KeD2	Kendallville-Eldean silt loams, 12 to 18 percent slopes, eroded	Well drained	44.2	0.20%
KnA	Kokomo silt loam, 0 to 1 percent slopes	Very poorly drained	764.8	2.70%
KoA	Kokomo silty clay loam, 0 to 1 percent slopes	Very poorly drained	3,158.5	11.20%
MaA	Medway silt loam, 0 to 1 percent slopes, occasionally flooded	Moderately well drained	28.2	0.10%
MeC	Miamian silt loam, 6 to 12 percent slopes	Well drained	9.3	0.00%
MeC2	Miamian silt loam, 6 to 12 percent slopes, eroded	Well drained	371.5	1.30%
MeD2	Miamian silt loam, 12 to 18 percent slopes, eroded	Well drained	25.9	0.10%
MfB	Miamian-Celina silt loams, 2 to 6 percent slopes	Well drained	245.5	0.90%
MfB2	Miamian-Celina silt loams, 2 to 6 percent slopes, eroded	Well drained	875.5	3.10%
MgF2	Miamian-Kendallville silt loams, 25 to 50 percent slopes, eroded	Well drained	5.3	0.00%
MhC3	Miamian-Losantville clay loams, 6 to 12 percent slopes, severely eroded	Well drained	578.6	2.00%
MhD3	Miamian-Losantville clay loams, 12 to 18 percent slopes, severely eroded	Well drained	168.3	0.60%
MmE2	Miamian-Hennepin silt loams, 18 to 25 percent slopes, eroded	Well drained	32.5	0.10%
MnE3	Miamian-Hennepin clay loams, 18 to 25 percent slopes, severely eroded	Well drained	27.5	0.10%
MsA	Millsdale silt loam, 0 to 2 percent slopes	Very poorly drained	4.8	0.00%
MuA	Milton silt loam, 0 to 2 percent slopes	Well drained	16.6	0.10%
MuB	Milton silt loam, 2 to 6 percent slopes	Well drained	13.2	0.00%
MuB2	Milton silt loam, 2 to 6 percent slopes, eroded	Well drained	22.5	0.10%
MuC2	Milton silt loam, 6 to 12 percent slopes, eroded	Well drained	15.7	0.10%
MuD2	Milton silt loam, 12 to 18 percent slopes, eroded	Well drained	14.4	0.10%
OcA	Ockley silt loam, Southern Ohio Till Plain, 0 to 2 percent slopes	Well drained	21.9	0.10%
OcB	Ockley silt loam, Southern Ohio Till Plain, 2 to 6 percent slopes	Well drained	9.5	0.00%
Pq	Pits, quarry		42.5	0.20%

RaB	Rainsville silt loam, 2 to 6 percent slopes	Moderately well drained	43.4	0.20%
RaB2	Rainsville silt loam, 2 to 6 percent slopes, eroded	Moderately well drained	45.3	0.20%
RnE2	Rodman gravelly loam, 18 to 25 percent slopes, eroded	Excessively drained	1.4	0.00%
RnF2	Rodman gravelly loam, 25 to 50 percent slopes, eroded	Excessively drained	3.3	0.00%
RoF2	Rodman-Kendallville complex, 25 to 50 percent slopes, eroded	Excessively drained	5.3	0.00%
RpA	Rossburg silt loam, moderately wet, sandy substratum, 0 to 1 percent slopes, occasionally flooded	Well drained	28.1	0.10%
SnA	Sloan silt loam, sandy substratum, 0 to 2 percent slopes, frequently flooded	Very poorly drained	488.7	1.70%
StA	Stonelick loam, gravelly substratum, 0 to 1 percent slopes, frequently flooded	Well drained	125.7	0.40%
ThA	Thackery silt loam, 0 to 2 percent slopes	Moderately well drained	56.9	0.20%
ThB	Thackery silt loam, 2 to 6 percent slopes	Moderately well drained	15.1	0.10%
Ud	Udorthents		28.1	0.10%
W	Water		10	0.00%
WnA	Westland silt loam, 0 to 2 percent slopes	Very poorly drained	155.3	0.50%
Subtotals for Soil Survey Area			**14,455.9**	**51.10%**
Totals for Headwaters Twin Creek HUC-12			**28,287.9**	**100.00%**

Source: USDA, 2023