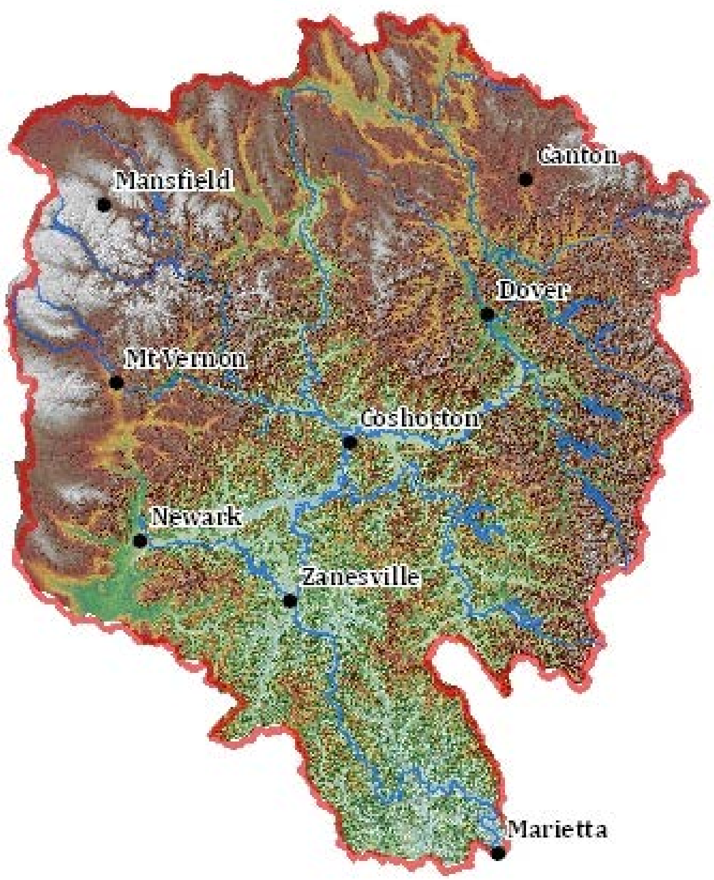
Section 729
Muskingum River Basin
Final Watershed Assessment and Watershed Management Plan



Draft
August 2018

MUSKINGUM WATERSHED CONSERVANCY DISTRICT

~this page left intentionally blank~

Executive Summary

The Section 729 Muskingum River Basin Final Watershed Assessment (FWA) was completed under authority of Section 729 of the Water Resources Development Act (WRDA) of 1986 (Public Law 99-662), which later was amended by Section 202 of WRDA 2000 and Section 2010 of WRDA 2007. It is a follow on study to the Section 729 Initial Watershed Assessment (IWA) for the Muskingum River Basin by Huntington District in 2012.

The Muskingum River Basin lies in the eastern portion of Ohio, covering roughly 1/5 of the state. The Muskingum River is the largest stream in the state and drains approximately 8,000 square miles. The Basin at its widest point is about 100 miles from east to west and a length of approximately 120 miles from north to south.

The goal of the FWA was the development of a Watershed Management Plan (WMP) for the Muskingum River Basin which addresses water resource related issues such as flooding, water quality (including wastewater management), stormwater management, education of the general public on watershed function and the regulatory process, operation of USACE Flood Risk Management (FRM) projects in the Basin and sedimentation in USACE reservoirs. These issues were identified through extensive stakeholder engagement, including meetings and workshops held with local officials such as mayors, city managers and city and county engineers, as well as representatives from various State of Ohio resource agencies, and the non-Federal cost share partner, the Muskingum Watershed Conservancy District (MWCD).

Once the water resource issues were identified, the Huntington District Project Delivery Team (PDT), in continued partnership with the stakeholders, began to identify potential solutions, as well as programs and authorities which may be utilized to address these issues. Given the large geographic size of the Basin, these recommendations take the form of broad, policy based plans and solutions made at the sub-basin level. Smaller, site specific recommendations and targeted actions are recommended where practicable.

The FWA/WMP will serve as a guide for local decision makers, as well as Federal and state resource agencies to prioritize investments in water resource projects in the Basin. The WMP describes a comprehensive plan for managing land and water resources within the Basin via a holistic process which reflects the interdependency of land owners and water users, competing demands on water resources and desires of the stakeholders.

~this page left intentionally blank~

Table of Contents

Table of Contents

Table of Contents

List of Tables

List of Tables

List of Figures

List of Figures

List of Appendices

1. Introduction

1.1 Study Authority

The authority for this assessment of water resource issues in the Muskingum River Basin derives from Section 729 of the Water Resources Development Act (WRDA) of 1986 (Public Law 99-662), which was later amended by Section 202 of WRDA 2000 (Public Law 106-541) and Section 2010 of WRDA 2007 (Public Law 100-114).

In general terms, Section 729, as amended, allows the U.S. Army Corps of Engineers (USACE) to assess the water-resources needs of entire river basins and watersheds of the United States, in consultation with appropriate Federal, state, and local agencies and stakeholders:

> *"The Secretary may assess the water resources needs of river basins and watersheds of the United States, including needs relating to ecosystem protection and restoration; flood damage reduction; navigation and ports; watershed protection; water supply; and drought preparedness."*

1.2 Background

The Ohio River Basin Comprehensive (ORBC) Reconnaissance Report, which examined the entire Ohio River Basin, was completed in December of 2009 and approved by the Great Lakes and Ohio River Division Commander for implementation of its recommendations. The authority for the ORBC study was based on a U.S. Senate Committee on Public Works Study Resolution, dated 16 May 1955.

The report identified problems, issues, and opportunities throughout the Basin; formulated numerous alternatives for future studies; and recommended 20 separate actions. The report also recommended development of a programmatic management plan as well as an unspecified number of Section 729 Watershed Assessments throughout the Ohio River Basin. One of those watershed assessments was assigned to the Muskingum River Basin within the USACE's Huntington District.

Subsequently, the Huntington District completed a Section 729 IWA (Initial Watershed Assessment) for the Muskingum River Basin (approved 6 January 2012) in accordance with Engineering Circular (EC) 1105-2-411, Watershed Plans. Several recommendations were made in the IWA. Among them were recommendations to pursue Final Watershed Assessments (FWA) for the Nimishillen Creek Watershed, the Chippewa Creek Watershed, the Headwaters of the Tuscarawas River Watershed, the Killbuck Creek Watershed, as well as for the Muskingum River Basin as a whole.

To date, the Huntington District has completed the FWA for the Nimishillen Creek Watershed. This FWA was completed in April of 2015 and several recommendations made in the report have been successfully implemented. Most notably, the FWA recommended a full Hydraulic and Hydrology (H&H) update for the entire watershed. Utilizing the FWA, the cities of Louisville, Canton and North Canton were able to work with the MWCD and United States Geological Survey (USGS) to leverage over $1M dollars for a watershed level H&H model update. The FWA is considered a success in watershed planning by not only USACE and Muskingum Watershed Conservancy District (MWCD) – who served as the non-Federal cost share partner) - but also by local stakeholders.

1.3 Study Area

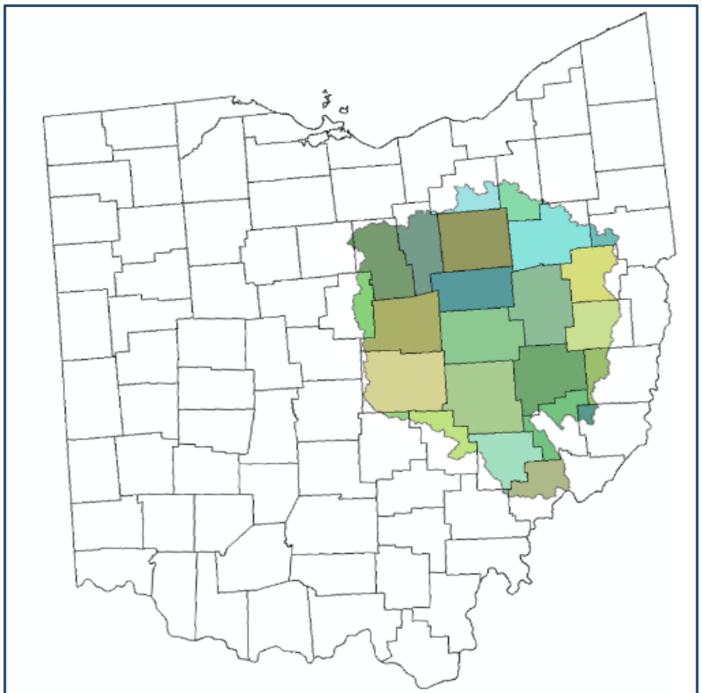


Figure 1.1 - Location of the Muskingum River Basin within the State of Ohio.

As seen **Figure 1.1**, the Muskingum River Basin lies in the eastern portion of Ohio, covering roughly 1/5 of the state. The Muskingum River is the largest stream in the state and drains approximately 8,000 square miles. The Basin at its widest point is about 100 miles from east to west and a length of approximately 120 miles from north to south.

The Muskingum River Basin encompasses portions of, or all of, the following counties shown in **Table 1.1** and **Figure 1.2** below.

Table 1.1 - Counties Contributing to the Muskingum River Basin

County	Square Miles in Basin	Percent in Basin
Ashland	335	82.2
Athens	4	0.6
Belmont	118	21.7
Carroll	333	79.3
Columbiana	51	9.7
Coshocton	574	100
Crawford	6	1.5
Fairfield	19	4.1
Guernsey	540	99.2
Harrison	317	73.2
Holmes	452	100
Knox	538	98.9
Licking	626	93.7
Medina	140	33.9
Monroe	41	8.6
Morgan	383	83.1
Morrow	150	34.6
Muskingum	691	100
Noble	219	52.2
Perry	171	43.2
Portage	2	0.4
Richland	443	88.2
Stark	423	87.6
Summit	91	37.5
Tuscarawas	588	100
Washington	230	34.6
Wayne	566	100

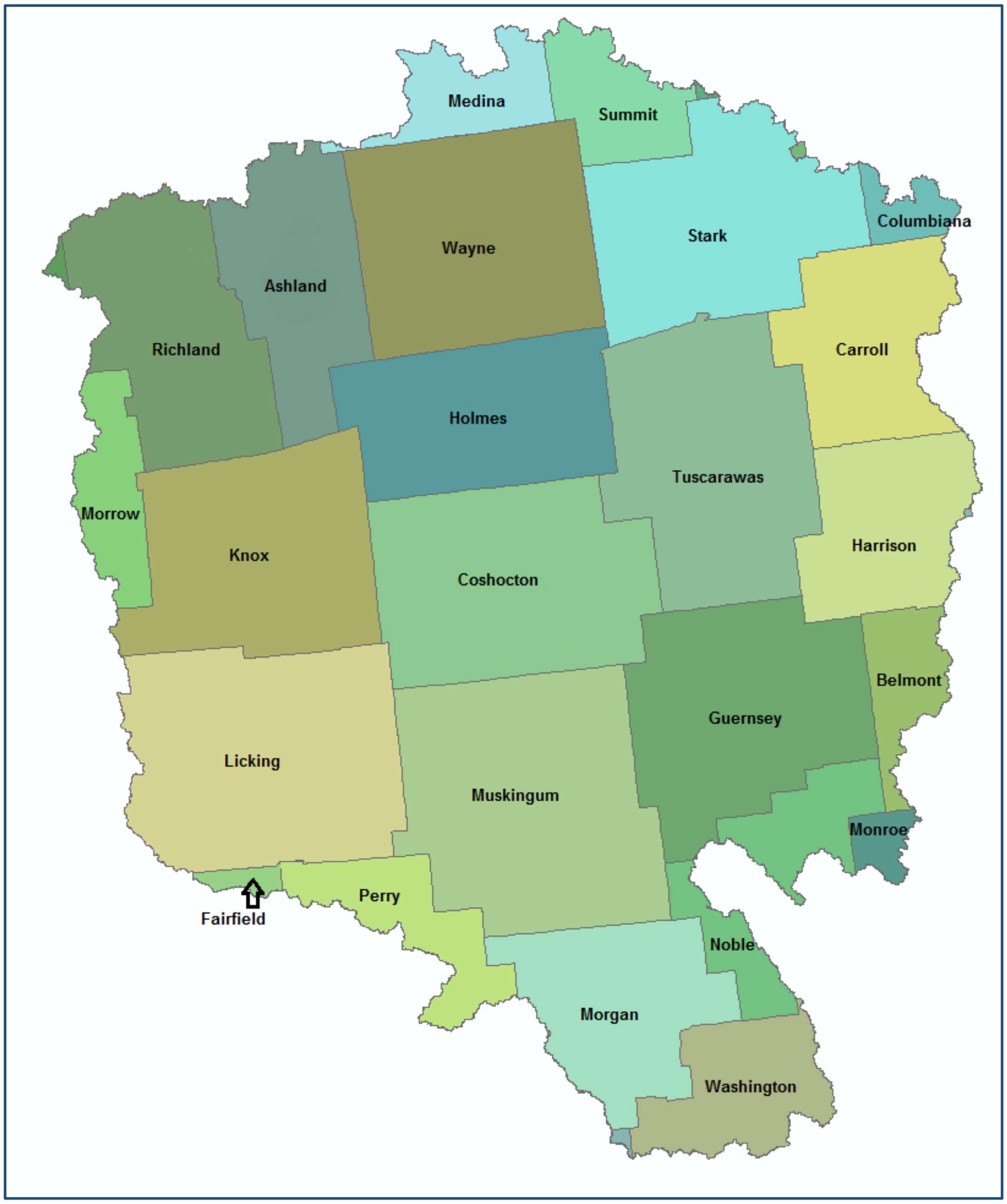
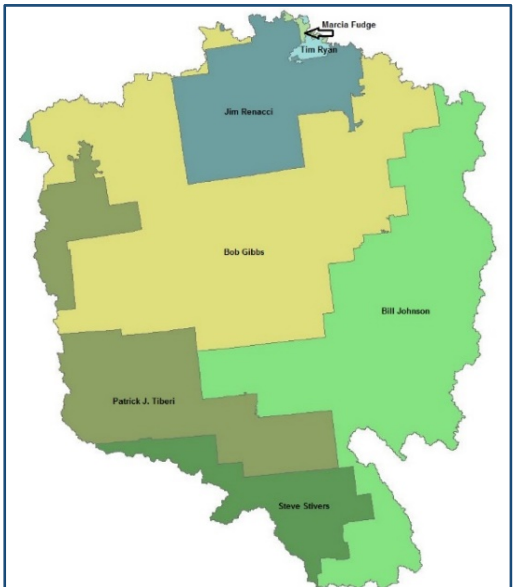


Figure 1.2 - Counties Within the Muskingum River Basin

1.4 Congressional Districts

The Muskingum River Basin lies within the geographical area of the following congressional interests and districts, as shown below in **Figure 1.3**:



<u>House of Representatives</u>

- Ohio District 4 (Jim Jordan – R)
- Ohio District 6 (Bill Johnson – R)
- Ohio District 7 (Bob Gibbs – R)
- Ohio District 11 (Marcia Fudge – D)
- Ohio District 12 (Patrick Tiberi – R)
- Ohio District 13 (Tim Ryan – D)
- Ohio District 15 (Steve Stivers – R)
- Ohio District 16 (Jim Renacci – R)

<u>Senate</u>

- Senator Sherrod Brown (D)
- Senator Robert Portman (R)

1.5 Sponsors

Per EC 1105-2-411, the FWA is cost shared 75% Federal and 25% non-Federal. The non-Federal cost share partner for this FWA is the MWCD, a regional agency with a long-standing relationship with the Huntington District. The total project cost for the FWA is $458,061. The Federal portion is $343,545. The MWCD's portion is $114,515, with approximately half being provided as in-kind services.

2. Study Purpose and Scope

2.1 Study Purpose and Scope

The primary purpose of this FWA is the development of a Watershed Management Plan (WMP) for the Muskingum River Basin. In accordance with EC 1105-2-411 and Corps of Engineers Policy Guidance Letter #61, dated January 1999, watershed planning focuses on a specific watershed. Defining the appropriate watershed size or study area is critical as the study area needs to be broad enough to:

- Capture the impacts and influences of problems and likely solutions for the significant resources under study, to ensure complete analysis of potential impacts and interactions; and
- Identify regional man-made and natural systems and assess complex interactions that influence the use and development of land and water resources.

The Muskingum River Basin is a Hydrologic Unit Code (HUC)[1] 4 river basin, encompassing six HUC-8 watersheds. Watershed assessments are typically performed on HUC-8 or smaller watersheds as described in EC 1105-2-411. However, unique conditions within the watershed, and the needs of the sponsor and public, may dictate a departure from this guidance, as is the case with this study.

Since the construction of the Muskingum River System of dams in the 1930s (further discussed below in Section 4.1.3.1), the USACE has often treated the Muskingum River Basin as a large, single watershed. Moreover, the Basin has the potential to operate more holistically than most, given the overarching authority of the MWCD and the role they play in sub-watershed decision making. Simply put, the Muskingum River Basin differs from others in that there is a potential framework in place which allows for more cohesive management of the Basin's water resources. However, despite the holistic nature of the governance of the Basin, it should be noted the Basin is geographically large. As will be discussed in more detail below, it covers nearly 1/5 of the State of Ohio, making it difficult to compile and analyze data at a detailed level.

For these reasons the USACE, in partnership with the MWCD, made the decision to develop a FWA for the entire Basin, despite its size, recognizing the limitations this would place on the amount of

[1] For additional information on the HUC Classification system, please see Section 4.1.1 below.

technical detail which could be included in the study. To that end, *the scope of the FWA/WMP is on the recommendation of broad, policy based plans and solutions made at the sub-basin level*. Smaller, site specific recommendations and targeted actions may be recommended where practicable. The FWA/WMP will serve as a guide for local decision makers, as well as Federal and state resource agencies to prioritize investments in water resource projects in the Basin.

2.2 Problems and Opportunities

There are a variety of water resource issues throughout the Muskingum River Basin. The overarching *problem* associated with water resource management in the Basin is the lack of a shared vision and plan for management of water resources in the future. The Basin is geographically large in size and diverse in land use and demographic makeup. Given the size and the number of municipalities, agencies and other groups working within the Basin, the approach to water resource management over the years has been piece-meal and fragmented at best. Perhaps the best example of overall governance of the Basin is the MWCD, which has the primary mission areas of flood reduction, conservation and recreation, as discussed below in **Section 3.1.2**.

Ultimately, this FWA/WMP presents an *opportunity* to bring together a wide array of stakeholders to develop a holistic, balanced and sustainable approach for the management of the water resources of the Basin, guided by a joint vision for long term success. The development of this FWP/WMP is a valuable opportunity to ensure all stakeholders' views are represented in the future management of the water resources of the Basin.

2.3 Goals

Specifically, the goals of the FWA/WMP are to:

- Further refine, through stakeholder engagement and inter-agency coordination, water and land issues, problems and opportunities within the Muskingum River Basin, as originally defined by the Muskingum River Basin IWA dated January 2012;
- Develop a shared vision[2] for the Basin through collaboration and coordination with a broad range of stakeholders and the MWCD, who serves as the project cost share partner;
- Inventory and forecast existing conditions;

[2] The development of a shared vision is a required component of the Section 729 Watershed Planning guidance and is meant to provide a common strategic goal for the future of the watershed and to establish the framework for the components of the watershed study.

- Formulate and evaluate potential solutions to address identified land and water resources issues (including issues identified in the IWA and additional issues identified by further stakeholder involvement); and
- Recommend broad, policy-level strategies and holistic plans at the sub-basin level which utilize creative solutions to land and water problems and lead to long-term realization of the shared vision of the stakeholders and the cost share partner.

2.4 Objectives and Constraints

Study objectives play a key role in the development of any study. The objectives discussed below are the practical, specific steps necessary to develop a successful FWA/WMP, which will be useful for the management of water resources in the Muskingum River Basin for years to come. The study objectives were developed by USACE in partnership with the MWCD during the scoping process for the study and are as follows:

- Develop, through review of the IWA and extensive stakeholder involvement a vetted, comprehensive list of water resource issues, problems and opportunities.
- Bring together a wide range of stakeholders operating within the Basin in order to ensure the inclusion and participation of as many entities as possible in the watershed planning process.
- Develop an inventory and forecast of the environmental factors and conditions which are the most impacted by the identified water resource issues.
- Develop a specific, written shared vision statement in partnership with all stakeholders to guide the long term management of the water resources of the Basin.
- Develop a list of critical areas impacted by each water resource issue and identify short and long term alternative plans and solutions to address the issues in these areas.
- Develop policies and practices which support environmentally and economically resilient and sustainable communities through the restoration and management of water resources and enhancement of recreational opportunities.
- Work with Federal and state resource agencies, non-governmental entities, watershed associations and other applicable groups in order to identify broad, policy-level strategies and holistic plans at the sub-basin level aimed at addressing the key identified water resource issues. Specifically:

- Establish contacts between local officials in the aforementioned critical areas and representatives from resource agencies which have programs and authorities to address the water resource issues in those critical areas; and
- Develop a "touch-back" plan in cooperation with the MWCD, local officials, and Federal and state resource agencies to ensure progress towards the goals set forth in the FWA is being made.

Study constraints are restrictions which limit the extent of the planning process. As discussed above, the study area for this FWA/WMP is considerably larger than what would normally be analyzed in a watershed assessment and the Project Delivery Team[3] (PDT) has analyzed broad, policy based strategies and plans to address wide spread water resource issues at the sub-basin level.

The second constraint pertains to the number of stakeholders engaged during the study process. Again, given the size of the Basin, it is impossible to obtain feedback from every town, village and city. The PDT has made every effort to contact every major municipality, all county engineers, county conservationists, county commissioners, resource agency representatives, etc., as documented in the discussion on stakeholder involvement below, however some stakeholders may have been inadvertently omitted, and some may not have taken advantage of the opportunity to participate. In an effort to capture feedback and input from as many stakeholders as possible, the PDT will continue stakeholder involvement efforts until the final draft of this FWA/WMP is submitted for approval.

2.5 Guidance and Process

This report was prepared in accordance with Engineering Regulation (ER) 1105-2-100, *The Planning Guidance Notebook*, which governs the overall direction by which USACE civil works projects are formulated, evaluated, and recommended for implementation. In addition to describing the Corps' missions and programs, planning process, and applicable policies, ER 1105-2-100 provides clear guidance regarding preparation and review of decision documents.

[3] Use of the term Project Delivery team, or PDT, should be understood to include both USACE and MWCD team members.

While ER 1105-2-100 serves as the primary resource for development of this report, EC 1105-2-411, *Watershed Plans*, supplemented by Planning Bulletin (PB) 2016-03 "*Watershed Studies*," serves as the foundation for applying a comprehensive watershed approach. Additionally, PB 2016-03 defines a six-step process for effective watershed planning, which his similar to the iterative six-step planning process described in ER 1105-2-100. The six steps in the watershed planning process include (1) identifying problems and opportunities; (2) inventorying and forecasting; (3) identifying and screening measures; (4) formulate the initial array of strategies; (5) refine the initial array and evaluate a focused array of strategies; and (6) compare and select strategies.

Summarily, watershed planning (1) addresses problems, needs, and opportunities within a watershed or regional context; (2) strives to achieve integrated water resources management; and (3) results generally in non-project specific, holistic plans or strategies to address watershed needs. Watershed planning goes beyond planning for specific Corps projects and focuses on comprehensive and strategic evaluations, analyses, and solutions. In addition, EC 1105-2-411 broadens the planning horizon to address issues pertaining to both land and water resources as well as the multiple, interconnected systems that frequently come into play within watersheds. Watershed planning may consider:

- river and drainage systems;
- geomorphic and subterranean systems;
- weather (including climate preparedness);
- transportation systems;
- power grids;
- water supply and wastewater systems;
- economic systems;
- recreation systems;
- institutional systems and legal frameworks;
- regulatory frameworks;
- floodplain management;
- ecosystems;
- water management systems;
- navigation systems;
- human resources; and/or
- any other system pertinent to the needs of the watershed effort.

This "broadening" of traditional emphases on water resources provides opportunities to assess the complex interactions of the landscape and both surface water systems and sub-surface water systems at work in the watershed.

While more traditional USACE projects may be identified during the development of the FWA/WMP, the desired outcome of a watershed assessment is the development of a WMP. As previously stated, this FWA/WMP will be used by local decision makers to address identified water resource issues in a manner which supports the joint vision of stakeholders within the Basin.

It should be noted the USACE planning process has undergone significant revision in recent years. This has impacted watershed planning in that what was originally a two phase study process is now a single phase. The Muskingum River Basin IWA was completed prior to the issuance of Planning Bulletin 2015-05 "Single Phase Planning Studies which eliminated separate reconnaissance and feasibility phase studies, therefore this study is being completed as a follow on phase. New guidance outlined in PB 2016-03 has been implemented where applicable.

3. Study Framework and Shared Vision Statement

3.1 Roles and responsibilities

3.1.1 USACE

USACE is the lead agency responsible for the preparation of the FWA/WMP. USACE is responsible for the day to day management of the study and developing the report in collaboration with the stakeholders. Upon completion of the study the MWCD and stakeholders will be responsible for implementation of the recommended plans, unless a potential USACE project is identified during the study process. If a USACE project is identified during the study process, the USACE would work to identify a cost share partner and seek funds for a feasibility study.

3.1.2 MWCD

As previously stated, the MWCD serves as the cost share partner for this FWA. On June 3, 1933, Ohio created the MWCD for perpetual existence, by Conservancy Court decree, under authority of the Ohio Conservancy Act. The MWCD is responsible for flood reduction, conservation and recreation. The MWCD covers almost all of the 8,038 square miles of drainage area of the Muskingum River and its tributaries.

The MWCD frequently partners with USACE on water resource projects within the Basin. The most significant of these projects is the management of the Muskingum River System of dams and reservoirs. As part of this unique partnership, which has been in existence since the construction of the original 14 Flood Risk Management (FRM) projects in the 1930's, USACE owns the dams and land immediately adjacent while the MWCD owns the reservoirs themselves.

Given the MWCD's role in water resource management within the Basin, they are uniquely suited to serve as not only the cost share partner for this study, but also as the main point of contact for the development of the WMP. The MWCD has intimate knowledge of the water resource issues within the Basin, as well as valuable working relationships with the various municipalities, groups and agencies operating throughout the Basin and in the State.

The MWCD has been actively involved in every stakeholder engagement meeting, and have participated in regular calls and working sessions geared towards the development of the WMP. They will also participate in vertical team meetings during the life of the study. Ultimately, the MWCD will "own" the WMP and its implementation, as appropriate.

3.1.3 Stakeholders

There are many stakeholders involved in the development of this FWA/WMP. These include representatives from Federal and state resource agencies, watershed associations, as well as local representatives such as county commissioners, mayors, county and city engineers and local emergency and floodplain managers.

USACE has hosted numerous opportunities for stakeholder engagements during the course of the study, as documented in Appendix C to this report. These have included rounds of face to face meetings, held across the Basin, as well as participation in watershed association conferences, partnering with the Ohio Silver Jackets program, email and written correspondence and teleconferences. The purpose and goals of the study, as well as the criticality of stakeholder participation has been stressed at each of these various engagements.

Given the large geographical size of the Basin it is impossible to gather all stakeholders together at a single site at a single time. For this reason specific groups of stakeholders have been identified as critical to specific portions of the FWA/WMP. For example, as water quality issues are being discussed and alternative solutions being evaluated it is necessary to work closely with district conservationists and representatives from The Farm Service and Soil and Water Conservation Districts (SWCDs). Alternatively, when evaluating issues associated with stormwater management, city and county engineers are a more applicable group of stakeholders to engage with.

These groups of stakeholders, as documented in Appendix C, have been and will continue to be engaged as the study progresses, specifically in order to ensure the list of identified water resource issues are as complete as necessary, and to vet potential solutions to those problems. Finally, all stakeholders will have an opportunity to comment on the draft report before it is finalized.

3.2 Shared Vision Statement

As previously stated, the goal of watershed planning is to address identified water resource issues in a given watershed and provide a joint vision of a future water resource management. This vision statement has been developed in cooperation with the cost share sponsor and coordinated with project stakeholders with the goal of defining the overall vision for the watershed and its water related resources.

This watershed management plan shall be used to guide the future stewardship of water resources in the watershed. The Muskingum River Watershed shall be a region fostering environmental and economic sustainability through the management of flood risk and water resources, enhancement of outdoor recreational opportunities and the restoration of water quality and biological integrity of rivers, streams, lakes, wetlands and riparian areas throughout the watershed.

In order to achieve this shared vision there many objectives which need to be met. These objectives cannot be achieved by a single entity, but must be the common goal of the stakeholders operating within the Basin. These include the minimization of flood risk by maintaining unimpeded floodplains such that high water events may occur with minimal flood damages; encouraging energy development without sacrificing natural resources such as healthy water bodies which are swimmable, fishable and drinkable and restoring areas which have been negatively impacted by natural resource extraction; and investing in environmental infrastructure in an effort to restore degraded water quality, and achieving healthy water bodies that are swimmable, fishable, and drinkable. Most importantly, through continuous partnering in education of and effective communication with officials, business owners and residents, it is necessary to increase awareness of ecosystem and watershed function throughout the Basin.

This shared vision statement represents achievable objectives for the long term management of the Muskingum River Basin. The achievement of these objectives will help to ensure a future for the Basin encompassing resilient communities with minimized flood risk to critical infrastructure, businesses and residents; a healthy balance between environmental sustainability and economic development, specifically pertaining to the development of energy resources and traditional land and water uses; and a population actively engaged in the conservation of the watershed's natural resources, with officials, business owners, the agricultural community, landowners and residents aware of their individual role in maintaining watershed health.

It is important to note the Muskingum River Basin and its resources cannot be managed in a vacuum. Continuous education of and effective communication with officials, business owners and residents is necessary to increase awareness of ecosystem and watershed functions, In light of expected population growth and climate change, the Basin must be managed in a manner which is adaptable to outside pressures in order to preserve the water resources of the Basin for generations to come.

4. Existing and Expected Future Conditions

To better understand problems and opportunities within the Muskingum River Basin, the existing and expected future conditions of the study area were inventoried and forecasted.

4.1 Hydrologic Features

4.1.1 Overview of the Hydrologic Unit Code (HUC) System

The HUC System was created by the USGS as a means of identifying the various river basins and watersheds within the county. Each hydrological unit (or watershed), is given a numerical code which denotes its placement within a larger watershed or basin. There are six levels in the "hierarchy" and each level is identified by a two digit code as shown in **Table 4.1** below:

Table 4.1 - HUC Classification System

Name	Digit	Example Code
HUC-2	2	01
HUC-4	4	0102
HUC-6	6	010203
HUC-8	8	01020304
HUC-10	10	0102030405
HUC-12	12	010203040506

The most commonly used units are the HUC-4, HUC-8 and HUC-12. As an example, the Ohio River Basin is identified by the code 05. Within the Ohio River Basin lie a number of smaller units, such as the Muskingum River Basin, which is identified by the code 0504, which signifies it is in the Ohio River Basin. Within the Muskingum River Basin there are six HUC-8s, including the Tuscarawas River Watershed, which is denoted by the code 05040001, signifying it is in the Muskingum River Basin, within the Ohio River Basin. Finally, within the Tuscarawas River Watershed, there are a number of HUC-12s, including the East Sparta Watershed, labeled 050400010501, which signifies it is in the Nimishillen Creek Watershed, within the Tuscarawas River Watershed, within the Muskingum River Basin, within the Ohio River Basin[4].

[4] For more explanation on HUC codes please visit the following website: https://nas.er.usgs.gov/hucs.aspx

4.1.2 Hydrologic Features of the Muskingum River Basin

The Muskingum River Basin is a HUC-4 watershed, which is part of the Ohio River Basin, which encompasses six HUC-8 sub-basins as shown below in Figure 4.1. These include: the Tuscarawas River sub-basin; Mohican River sub-basin; Walhonding River sub-basin; Muskingum River sub-basin; Wills Creek sub-basin; and Licking River sub-basin. All of these sub-basins will be described in greater detail in subsequent chapters.

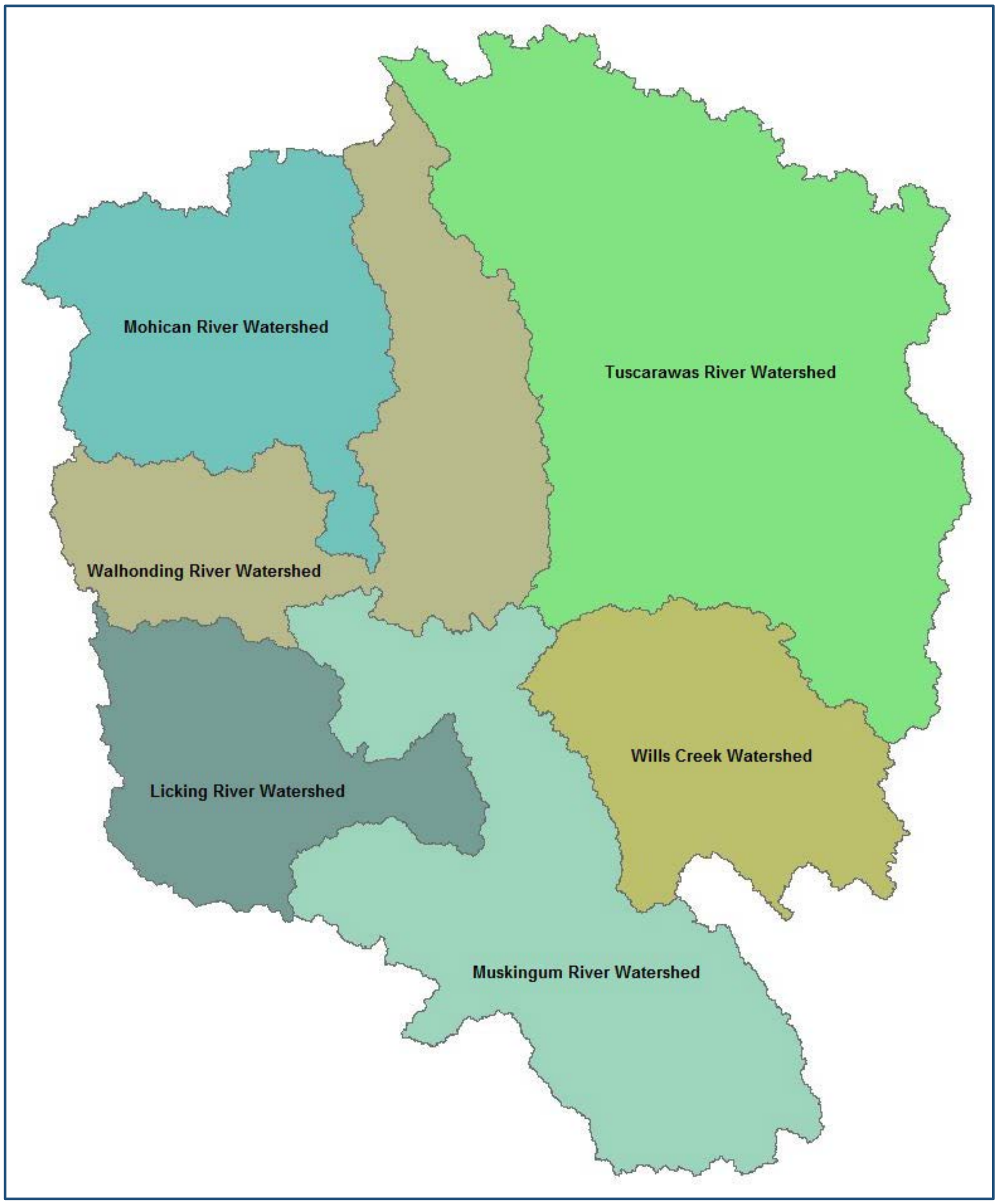


Figure 4.1 - HUC-8 Watersheds in the Muskingum River Basin.

The Muskingum River forms at the confluence of the Tuscarawas and Walhonding Rivers near the city of Coshocton in Coshocton County and flows 112 miles to the south and east, entering the Ohio River at the city of Marietta in Washington County. The banks of the river average about 20 to 30 feet in height, with extreme variations from less than 10 feet to more than 60 feet. The width between banks varies between 300 and 1,000 feet. From its source at Coshocton to its mouth at Marietta, the Muskingum River has a total fall of about 160 feet, or an average slope of about 1.4 feet per mile. The flows at the mouth are approximately:

- Minimum flow at mouth = 250 cubic feet per second (cfs)
- Mean flow at mouth = 8,000 cfs
- Maximum flow at mouth = 276,000 cfs

There are 25 major tributaries to the Muskingum River (shown below in **Figure 4.2** and **Table 4.2**), however, the principal tributaries are the Tuscarawas and Walhonding Rivers. The larger of these is the Tuscarawas River which drains approximately 2,600 square miles in the northeastern portion of the Basin. The Tuscarawas River forms southwest of Hartville in northern Stark County and flows westward through Uniontown and into southern Summit County. It then runs to the south of Akron and the city of Barberton, where it turns southward to continue its run through Stark and Tuscarawas Counties, including the towns of Clinton, Canal Fulton, Massillon, Navarre, Bolivar, Zoar, Dover, and New Philadelphia. Once past New Philadelphia, it bends southwest, flowing past Tuscarawas, Gnadenhutten, Port Washington, and Newcomerstown in Coshocton County, to meet the Walhonding River (for a total of 129 river miles).

The other primary tributary, the Walhonding River is much shorter than the Tuscarawas River, measuring only 23 river miles, but draining approximately 2,500 square miles in the northwestern portion of the Basin. The Walhonding River mainstem is located entirely in Coshocton County, rising at the confluence of the Mohican and Kokosing Rivers and flowing east to southeast through the villages of Nellie and Warsaw, to meet the Tuscarawas River at Coshocton and form the Muskingum River mainstem.

Figure 4.2 - Muskingum River Basin tributaries.

Table 4.2 - Major Tributaries to the Muskingum River

Stream Name	Length	Drainage Area (Sq. Miles)
Muskingum River	111.9	8038
Tuscarawas River	129.9	2590
Walhonding River	23.5	2252
Mohican River	64.2	999
Wills Creek	92.2	853
Licking River	67.5	781
Killbuck Creek	81.7	613
Sandy Creek	41.3	503
Stillwater Creek	63.5	485
Kokosing River	57.2	482
Sugar Creek	45	356
Black Fork/Mohican	58.4	351
Lake Fork	14.7	344
Moxahala Creek	29.1	301
S. Fork Licking River	33.9	288
Conotton Creek	38.7	286
N. Fork Licking River	38.4	239
Wakatomika Creek	42.6	234
Wolf Creek	47.4	231
Clear Fork/Mohican	36.6	219
Jonathan Creek	26.1	193
Chippewa Creek	26.7	188
Nimishillen Creek	24.5	187
Salt Fork	32	161
Jerome Fork	24.5	159
Seneca Fork	30.3	151

4.1.3 Water Control in the Basin

There are a number of dams located within the Basin. Of these dams, 16 are owned and operated by the USACE, in cooperation with the MWCD, as the Muskingum River System. The other dams in the Basin are owned and operated by the State, local municipalities and private entities for a number of purposes, including but not limited to: flood risk management, water supply, recreation, and irrigation. These dams are shown by type in **Figure 4.3** below.

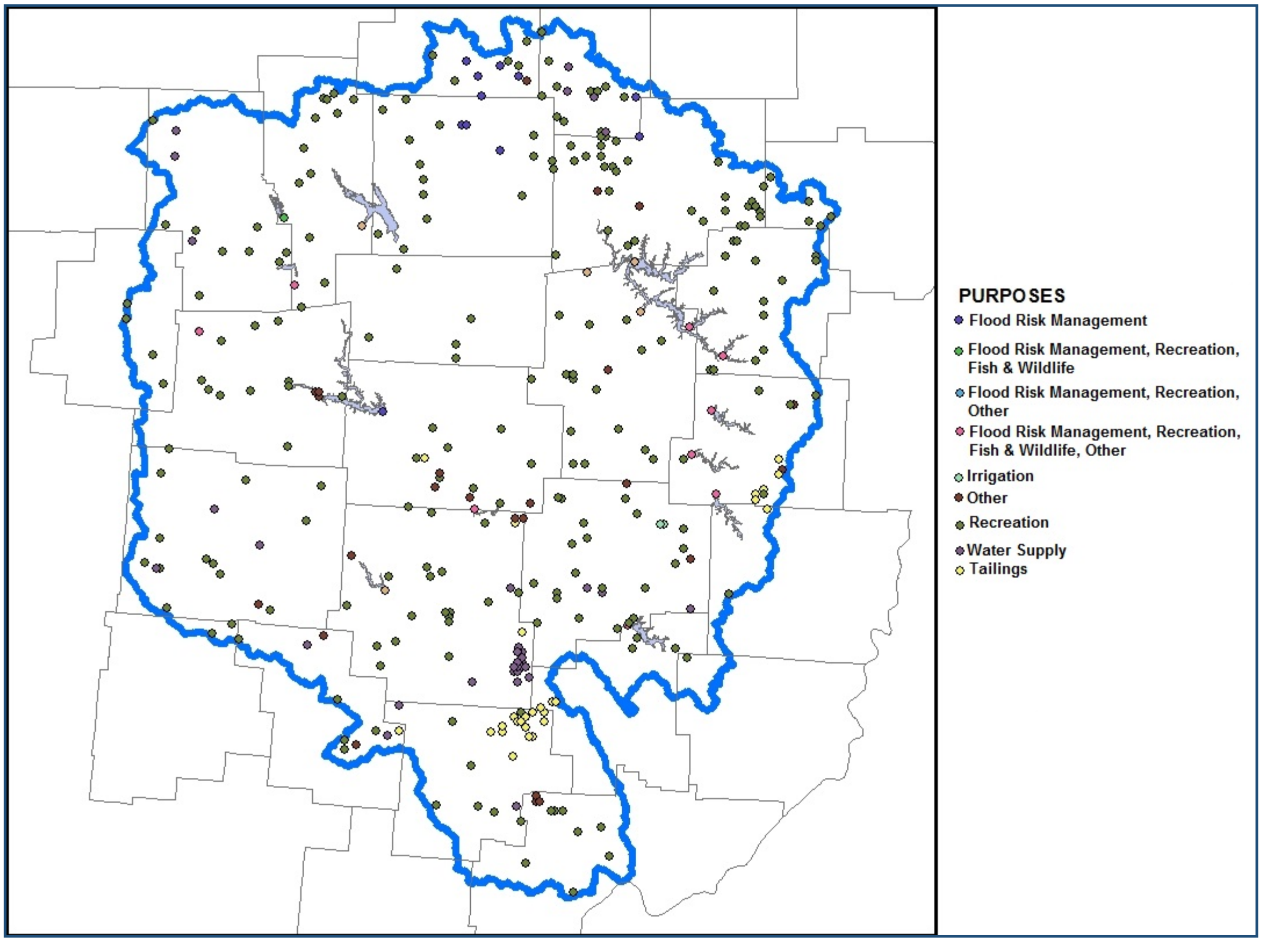


Figure 4.3 - Muskingum River Basin Dams by type.

These non-Federally owned dams play significant roles in water supply (both for commercial, residential and agricultural purposes) and recreation across the Basin. In the State of Ohio dams which are not Federally owned and operated fall under the jurisdiction of the Ohio Department of Natural Resources (ODNR)'s Dam Safety Program. These dams are inspected on five year intervals and deficiencies reported to the owner for modifications as needed.

The 14 dams in the Muskingum River System (shown below in **Figure 4.4**) play a major role in the management of water resources within the Basin, specifically with respect to flood risk management and water supply.

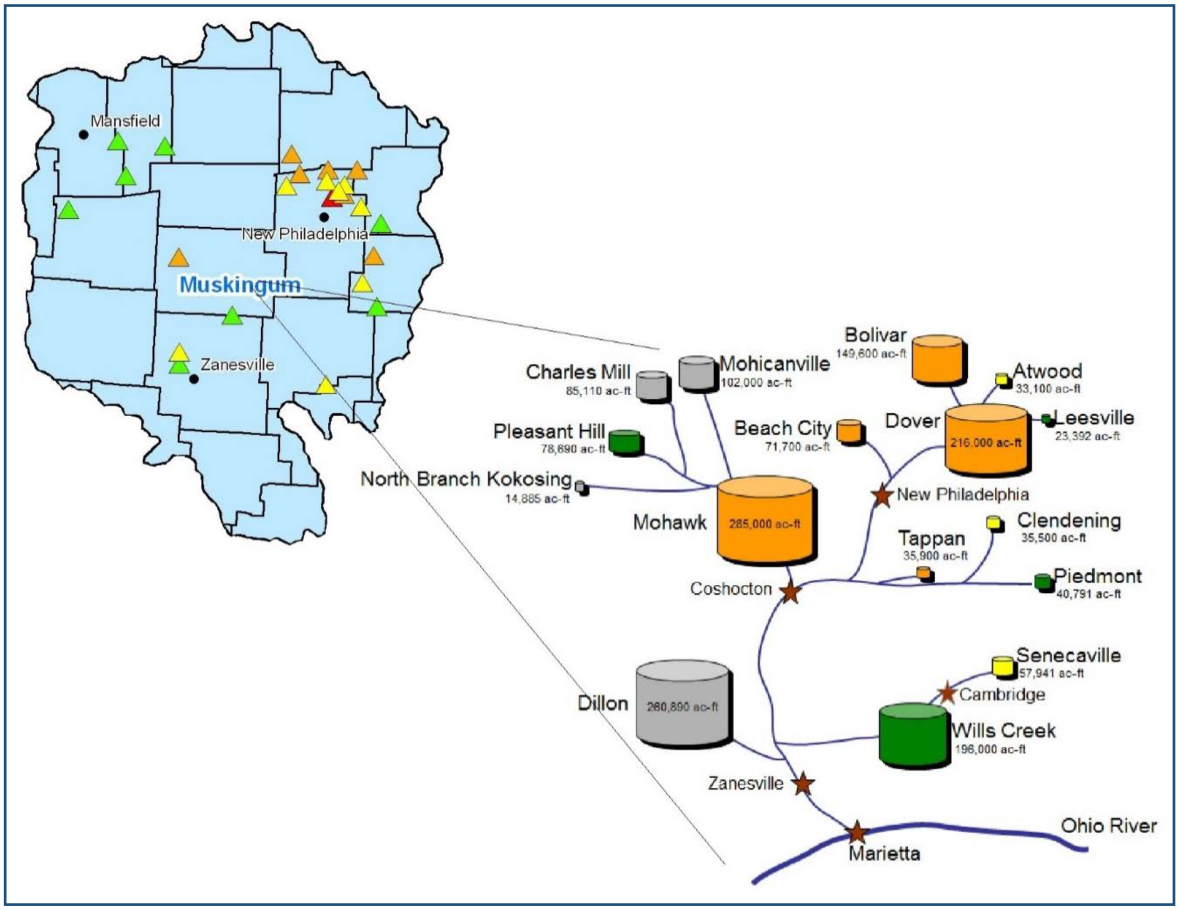


Figure 4.4 - Muskingum River Basin System dams.

4.1.3.1 History of the Muskingum River Basin System Dams

In 1914, the Ohio legislature enacted the Conservancy Act of Ohio, after the Great Flood of 1913. The Act, which is presumed to be the first legislation of its kind enacted in America, has since been copied by other states. The Act authorized the creation of conservancy districts, authorized use of eminent domain to accomplish stated public objectives, established the procedure for financial administration for local participation, and authorized the conservancy districts to enter into contracts with state and Federal governments. Subsequently, pioneers of the project created various organizations, such as the Muskingum-Tuscarawas Improvement Association — whose efforts caused the Ohio Department of Public Works to initiate a preliminary investigation of the Muskingum and Tuscarawas Rivers in 1930, with reference to the use and control of the drainage area's waters.

The survey revealed that it would be feasible to plan and execute a comprehensive flood-control and water-conservation program for the entire watershed. The control measures would cost more than local interests could afford; however, the investigation further revealed that controlling the Muskingum River Basin flood waters would measurably reduce flood crests on the Ohio River and benefit navigation — a benefit of interest to other states and the Federal government. Interested local citizens raised $25,000 to pay for development of a comprehensive flood-control and water-conservation plan to present to the Public Works Administration (PWA).

The previously referenced plan was now titled A Plan of Flood Control and Water Conservation Reservoirs for the MWCD. Upon completion of the plan in August 1933, the MWCD applied to the Administrator of the Federal Emergency Administration of PWA, to include the project in the comprehensive program of public works and to obtain aid for financing and construction.

In December of that same year, PWA allocated $22 million to USACE to help finance construction of a flood-control system and water-conservation reservoirs. On March 29, 1934, MWCD and PWA signed a formal agreement, and the Zanesville District of USACE began work immediately. Surveys and foundation investigations were made at approximately 150 tentative dam sites, 14 of which were selected to provide maximum flood protection and conservation, consistent with available funds and legislative authority. The Official Plan was prepared by the USACE and approved by the Conservancy Court on November 19, 1934; meanwhile, detailed designs and contract drawings were prepared, and bids were accepted on three dams by the end of the year. Construction began in 1935, and the completed system of 14 dams was turned over to MWCD in 1938. The following year, however, the Flood Control Act of 1939 returned the original 14 dams to the Federal government and returned flood-control operations to USACE. This arrangement has resulted in a unique partnership where the USACE owns and operates the dam, as well as the immediate footprint around the dam, while MWCD continues to own and manage the reservoirs and surrounding lands for authorized purposes. Two more dams were added to the system later — Dillon Dam in 1961, and North Branch of Kokosing Dam in 1972. However, these two dams are not considered part of MWCD's system. **Table 4.3** below lists the dams, as well as their locations, drainage areas, and other pertinent information.

Of the original 14 dams, four are "dry" dams (that is, dams that do not maintain permanent pools) — Mohicanville, Bolivar, Dover, and Mohawk. These dams retain water only during high-flow events; otherwise, they are operated as "run of river" structures. Additionally, Beach City's recreation pool has been silted in with sediment so that it only functions for flood control.

Table 4.3 - USACE Owned Muskingum River Basin Dams

Project Name	Tributary	Drainage Area (Sq. Miles)	Flood Control Storage (Ac-Ft)	Conservation Storage (Ac-Ft)	Lake Surface (Acres)
Tuscarawas River Watershed					
Dover	Mainstem	777	203,000	0	0
Bolivar	Sandy Creek	502	149,6000	0	0
Leesville	McGuire Creek	48	17,900	19,500	1,000
Atwood	Indian Fork	70	26,100	23,600	1,540
Beach City	Sugar Creek	300	70,000	1,700	420
Tappan	Little Stillwater	71	26,500	35,100	2,350
Clendening	Stillwater Creek	70	27,500	26,500	1,800
Piedmont	Stillwater Creek	84	31,400	33,600	2,270
Walhonding River Watershed					
Mohawk	Mainstem	817	285,000	0	0
Mohicanville	Lake Fork	269	102,000	0	0
Charles Mill	Black Fork	216	80,600	7,400	1,350
Pleasant Hill	Clear Fork	199	74,200	13,500	850
North Branch of Kokosing	North Branch	45	13,800	3,850	150
Licking River Watershed					
Dillon	Mainstem	748	260,900	32,800	2,2440
Wills Creek Watershed					
Wills Creek	Mainstem	723	190,000	6,000	900
Senecaville	Seneca Fork	121	45,000	43,500	3,554

4.2 Eco-Regions

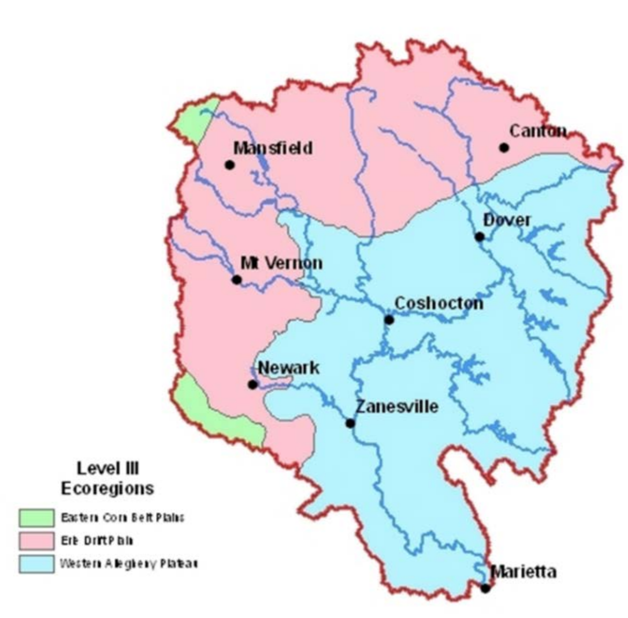


Figure 4.5 - Muskingum River Basin ecoregions.

According to the EPA, the Muskingum River Basin is comprised of three Level III ecoregions — Eastern Corn Belt Plains, Erie Drift Plain, and Western Allegany Plateau.

As seen in **Figure 4.5** to the left, approximately 56% of the Basin lies within the Western Allegheny Plateau. The Western Allegheny Plateau ecoregion — which covers portions of eastern Ohio, southwestern Pennsylvania, northwestern West Virginia, and a small piece of northeastern Kentucky — consists of a mixture of deciduous forest and agricultural land cover. The forest area is mostly mixed oak and mixed temperate forests. Dairy, livestock, and general farming (as well as rural residential or isolated urban developments) are concentrated in the valleys. The river systems in the ecoregion have been adversely affected by acid mine drainage and industrial pollution, which have caused historical degradation of the stream habitats and loss of aquatic species.

The Erie Drift Plains ecoregion is located mainly in northeastern Ohio and extends into the northwestern corner of Pennsylvania and the southwestern corner of New York. Common geographic features of the ecoregion include low rounded hills, scattered end moraines, kettles, and wetlands, some of which are remaining landforms from past glaciations of the region. The ecoregion is a mix of agricultural, forested, and developed land. Agriculture includes livestock and dairy farms in rural areas; major crops include wheat, corn, oats, hay, and soybeans. Market produce such as sweet corn, sweet peppers, pumpkins, onions, mustard greens, kale, and herbs thrive in this area. Apple and peach orchards, as well as maple syrup from sugar maples, contribute to the diversity of agricultural goods produced. Other hardwood trees are harvested for pulp.

Agricultural production in the Basin is noted to have a negative impact on water resources, as discussed in subsequent sections. The large annual amounts of fertilizer, pesticides, and sedimentation from nonpoint source runoff, as well as loss of riparian buffers from cultivation practices that encroach into riparian habitat, have increased nutrient loading in the basin. Nutrient loading has decreased water quality in most of the streams in the basin that adjoin agricultural land, as well downstream from these nonpoint sources.

The smallest of the ecoregions in the Basin is the Eastern Corn Belt Plains, which is primarily a rolling plain with local end moraines. Another area affected by past glaciations, this region has loamy, well drained soils. Today, extensive cultivation for corn, soybean, and livestock production, along with their management practices have caused negative affects to stream chemistry and turbidity.

4.3 Climate and Climate Change Projections

4.3.1 Current Climate Conditions

The climate of the Muskingum River Basin may be described as humid with warm summers and mildly cold winters. Many factors interact to influence the climate as it varies with the season. Among those factors are latitude, elevation, proximity to large bodies of water, ocean currents, topography, vegetation and prevailing winds. The Basin lies between latitudes 39.5 and 41 degrees. There are no abrupt changes in topography such as significant mountain ranges to cause great differences in climate.

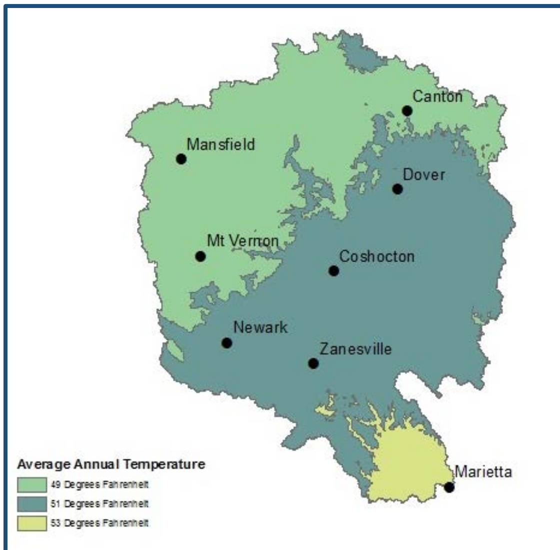


Figure 4.6 - Average annual temperature in the Muskingum River Basin.

Other factors which have a major influence on climate include prevailing winds, cloudiness and snow cover. The Basin is located in the belt of prevailing westerly winds. Storm traces from western Canada and the Rockies move eastward by way of the Great Lakes and the Ohio Valley. In passing over large land masses the air becomes greatly chilled in winter due to snow cover and heated in summer, thus subjecting the basin to temperature extremes.

For the Muskingum River Basin, for the years 1930-2011, the mean annual temperature varies from 53°F near the Ohio River to 49°F in the northernmost part of the Basin, as illustrated above in **Figure 4.6**. Maximum temperatures recorded in the area range from 103°F to 107°F, and minimum temperatures range from -33°F in the highlands to -17°F in low areas.

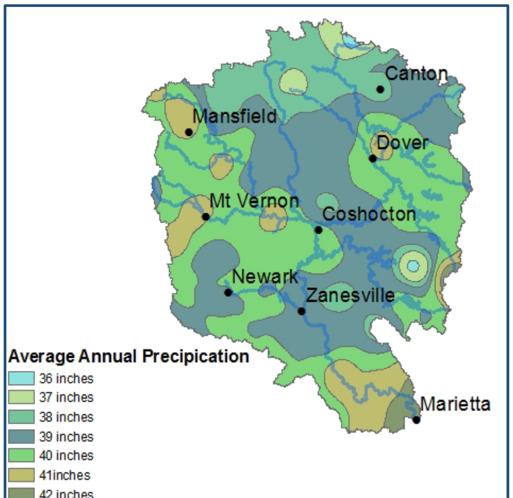


Figure 4.7 - Average annual precipitation within the Muskingum River Basin.

Most of the moisture which falls as rain or snow over the Basin has its origins from the Pacific Ocean. It is estimated 12-14 percent of the atmospheric moisture is acquired over land as air masses move from west to east. Passage of cold or warm fronts and their associated centers of low pressure occur frequently and precipitation often results.

Annual precipitation data for the State of Ohio is available from the National Climatic Data Center for the years 1930-2011. Over this 80 year time period annual precipitation for the state has remained stable, with an average of 39.1 inches. Average annual precipitation for the Muskingum River Basin itself varies by location from 36 to 42 inches. Yearly precipitation for the State of Ohio is recorded below in **Table 4.4**, while a map of the average annual precipitation for the basin is shown in **Figure 4.7**.

Table 4.4 - Average Annual Precipitation for the State of Ohio

Year	Precipitation	Year	Precipitation	Year	Precipitation	Year	Precipitation
1930	46.39	1951	42.49	1972	32.12	1993	42.22
1931	22.46	1952	40.41	1973	42.21	1994	38.74
1932	41.37	1953	33.25	1974	43.22	1995	35.36
1933	34.13	1954	27.67	1975	42.46	1996	39.97
1934	37.04	1955	37.52	1976	41.72	1997	45.53
1935	28.52	1956	37.24	1977	30.25	1998	40.21
1936	40.16	1957	38.53	1978	41.35	1999	41.11
1937	40.65	1958	38.25	1979	40.04	2000	32.48
1938	37.52	1959	44.77	1980	41.51	2001	37.64
1939	41.83	1960	37.71	1981	41.07	2002	38.81
1940	34.89	1961	28.83	1982	41.53	2003	40.12
1941	36.15	1962	42.43	1983	33.92	2004	48.09
1942	32.99	1963	29.22	1984	41.5	2005	50.03
1943	38.04	1964	28.16	1985	37.19	2006	37.3
1944	35.41	1965	40.37	1986	41.12	2007	45.89
1945	34.36	1966	35.96	1987	36.61	2008	42.73
1946	43.92	1967	34.15	1988	34.1	2009	42.73
1947	36.69	1968	35.54	1989	32.76	2010	36.51
1948	40.57	1969	39.71	1990	44.45	2011	38.92
1949	44.84	1970	35.46	1991	48.96		
1950	41.84	1971	39.85	1992	31.06		

4.3.2 Climate Preparedness Literature Review

Several studies has been completed which can be used to forecast climate change in the Muskingum River Basin over the next 50 years. The most recent and applicable to the Basin is the Ohio River Basin Climate Change Impact and Adaptation Pilot Study, sponsored by the USACE Institute for Water Resources. An initial draft of this study was completed in 2015, has undergone peer review and was approved in May 2017. The findings of this study, as it pertains to the Basin is presented below.

In terms of general trends in climate change in the Basin, the study found despite some general warming and increased precipitation in the fall season, climatic conditions during the period between 2011 and 2040 will closely resemble what has been experienced during the historic period between 1952 and 2001. There will likely be drought and flood events in the Basin similar to what has occurred in the past, however, these are not anticipated to be any more extreme than what has occurred in recent history. After 2040, the study found increases in mean annual air temperature and associated changes in precipitation may make flood events and drought conditions more extreme with measurable changes in the Basin's overall mean annual air temperature and mean annual and seasonal precipitation amounts.

With specific regard to air temperature, downscaled model projections increased air temperatures within the Muskingum River Basin of at least 0.5°F per decade between 2011 and 2040 and at least 1.0°F per decade between 2041 and 2099. At these rates, the increase in mean annual air temperature in the Basin could be 1.6°F by 2020, 2.8°F by 2040, 4.6°F by 2050, 5.0°F by 2070 and 8.3°F by 2099[5]. It is likely this gradual atmospheric warming will begin to raise water temperatures within the several of the Muskingum River Basin reservoirs as well as in free-flowing rivers and streams.

With regard to the intensity of precipitation, the study showed a trend towards heavier downpours over the last 30 years for the Midwest region where the Muskingum River Basin is located. Future projections indicate the potential for more intense rainfall during high frequency events leading to possible flash flooding on small tributary streams and urban areas in the affected area, but the modeling data from sources investigated does not indicate longer duration rainfall events – events associated with the 1% annual chance flood, 0.5% annual chance flood, or longer recurrence events would be directly affected by these changes. Local atmospheric convection processes which lead to high-intensity thunderstorm development or "training storms" occur at too small a geographic scale for downscaled global circulation models to accurately predict.

In terms of changes in precipitation/runoff and streamflow, the study indicates increases in annual and seasonal precipitation in the Basin and resultant higher flows in the Muskingum River and its major tributaries for the 2011 - 2099 time frame. Projected increases in stream flow at the control point for the Basin indicate the Muskingum River mainstem and its tributaries could experience flows ranging from 5% to 15% higher in the spring season and between 15% and 25% higher in the fall season by 2070. Overall, the Basin could experience an increase in mean annual flows which are between 5% and 15% greater than those experienced between the base years 1952 and 2001.

Aside from these the obvious effects of increasing temperatures throughout the four seasons (i.e. potentially more days exceeding 90 degrees in summer, warmer winter temperatures with more

[5] Recorded mean annual air temperature at the McConnellsville, Ohio gage in 2001 was 51.5° F and 52.6° F in 2011.

precipitation in the form of rain rather than snow and decreasing lake ice), increases in air temperature will begin to warm surface waters in the many reservoirs, lakes, ponds and rivers during the period of analysis. A shift in aquatic species composition in lakes and rivers within the Basin may occur as a result of warming surface waters. Aquatic species commonly associated with cool-water environments would likely migrate upstream into cooler headwater streams at higher elevations in the basin. Warm-water fishes would become the predominant species in the lakes. In addition, warmer water temperatures may encourage invasive aquatic species (macroinvertebrates, fishes, mussels, vegetation, etc.) to migrate into these previously cool-water habitats thus competing with indigenous species for resources and habitat. In-stream impediments (low-head dams) to these adverse migrations may merit further consideration of long-term operation and maintenance during studies regarding dam removal.

The incidence and duration of algae blooms due to combination of warmer water and ongoing introduction of nutrients and other pollutants into the lakes from upstream locations (as a result of increased precipitation) could become problematic from a water quality standpoint. Warmer air temperatures could result in a lengthened recreation season at the lakes but unseasonably higher summer temps may also reduce day-use visitation during the hottest months. Warmer temperatures may also result in gradual shifts in vegetative species composition in the region and the introduction of invasive plants, insect pests and diseases that could be detrimental to the forest community within the Basin.

4.3.3 Historic Hydrologic Trends

Historic hydrologic trends were analyzed using the USACE Climate Hydrology Assessment Tool and the Nonstationary Detection Tool. While there are 29 stream gages located throughout the Basin, the one chosen for this analysis is the one located on the Tuscarawas River at Massillon, Ohio. This gage was chosen its location on a primary tributary of the Muskingum River, as well as its position above the Muskingum River System of FRM projects. The period of analysis is 1939-2014 as the first year with available data is 1939, and no data is available in the Climate Hydrology Assessment Tool after 2014. The average annual peak streamflow for this period of analysis is approximately 4,447 cfs. Figure 4.8 shows the annual peak streamflow as increasing modestly across the period of analysis. A linear regression of the annual peak streamflow data has a p-value equal to 0.988, which indicates the trend is not statistically significant and no changes in mean annual peak flows are evident for the historic period.

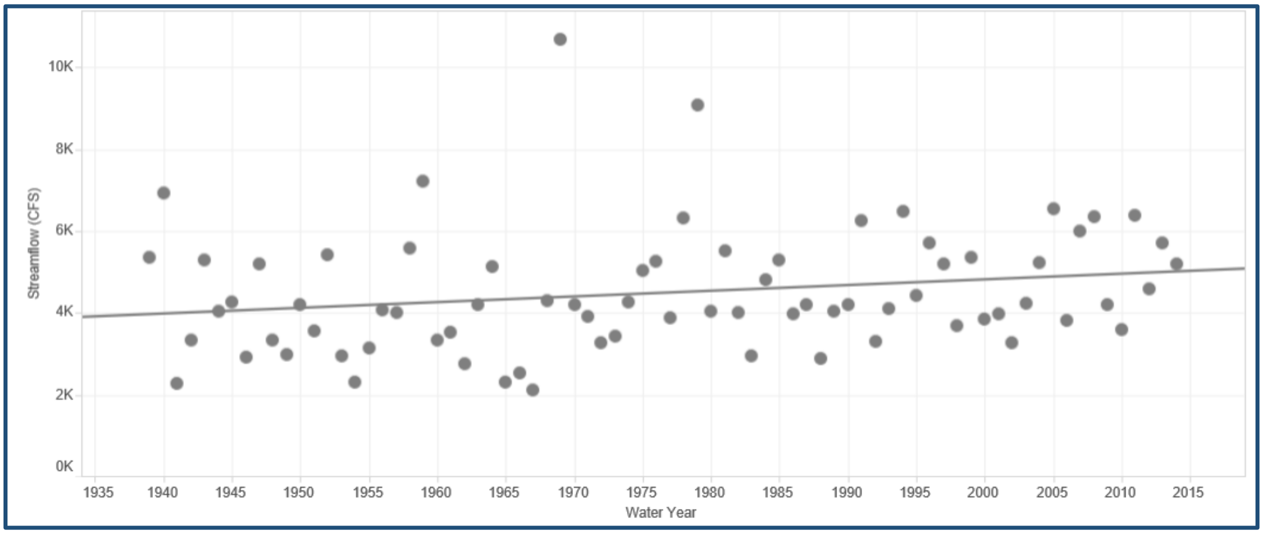


Figure 4.8 - Historic annual peak streamflow on the Tuscarawas River near Massillon.

The Nonstationary Tool correctly identified changes to stream flows due to construction of the previously mentioned Muskingum River System of dams in the 1930's, as shown below in **Figure 4.9** (based on a stream gage on the Muskingum River near Coshocton). Changes to the mean, variance and trend were all detected, however they are indicated as occurring in the 1950s. This is most likely an artifact of how the nonstationarity statistics are calculated (requiring a minimum number of values to pass before a nonstationarity can be detected). Consequently, as previously stated, the period of record was limited to 1940-2014 in an effort to avoid the statistical changes imposed on the stream by the construction of the dams. The remaining nonstationarities indicated in **Figure 4.9** are not significant, having only been detected by one or two metrics. An evaluation of the nonstationarity of unregulated flow could be conducted for a more rigorous study, but is beyond the scope of this FWA/WMP.

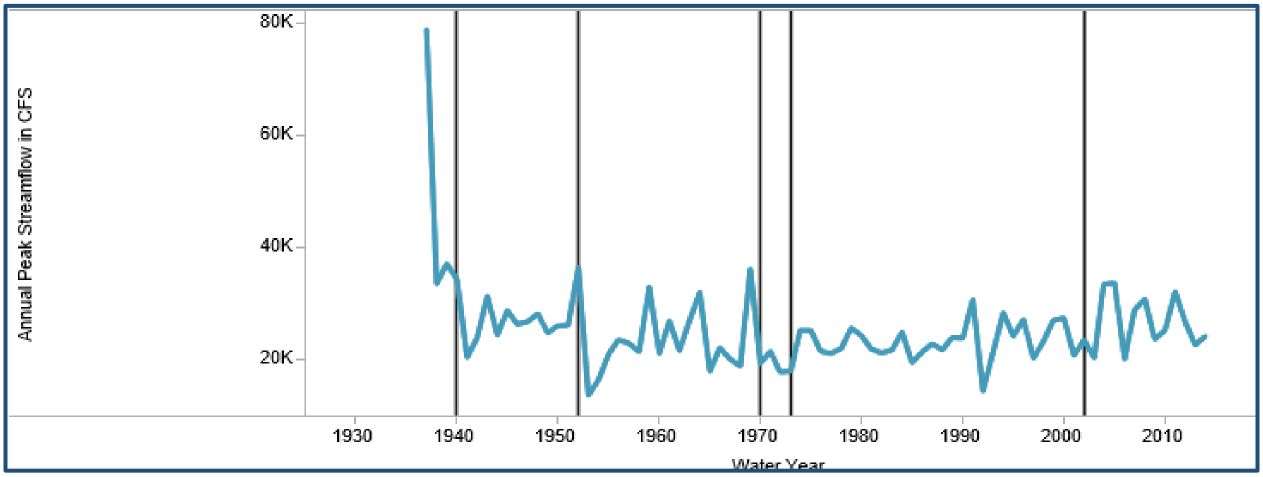


Figure 4.9 – Impacts of construction of upstream dams on streamflow.

4.3.4 Projected Changes to Watershed Hydrology and Assessment of Vulnerability to Climate Change

The USACE Climate Hydrology Assessment Tool was used to investigate potential future changes to flood flows in the region. **Figure 4.10** below displays the range of the forecast annual peak instantaneous monthly streamflows computed by 93 different hydrologic climate models for a period of 2000-2099. These forecasted flows display trends consistent with that of observed data as well as available literature. Looking closer at the trend of mean projected annual maximum monthly streamflows, a statically significant, positive trend is observed, as shown below in **Figure 4.11**.

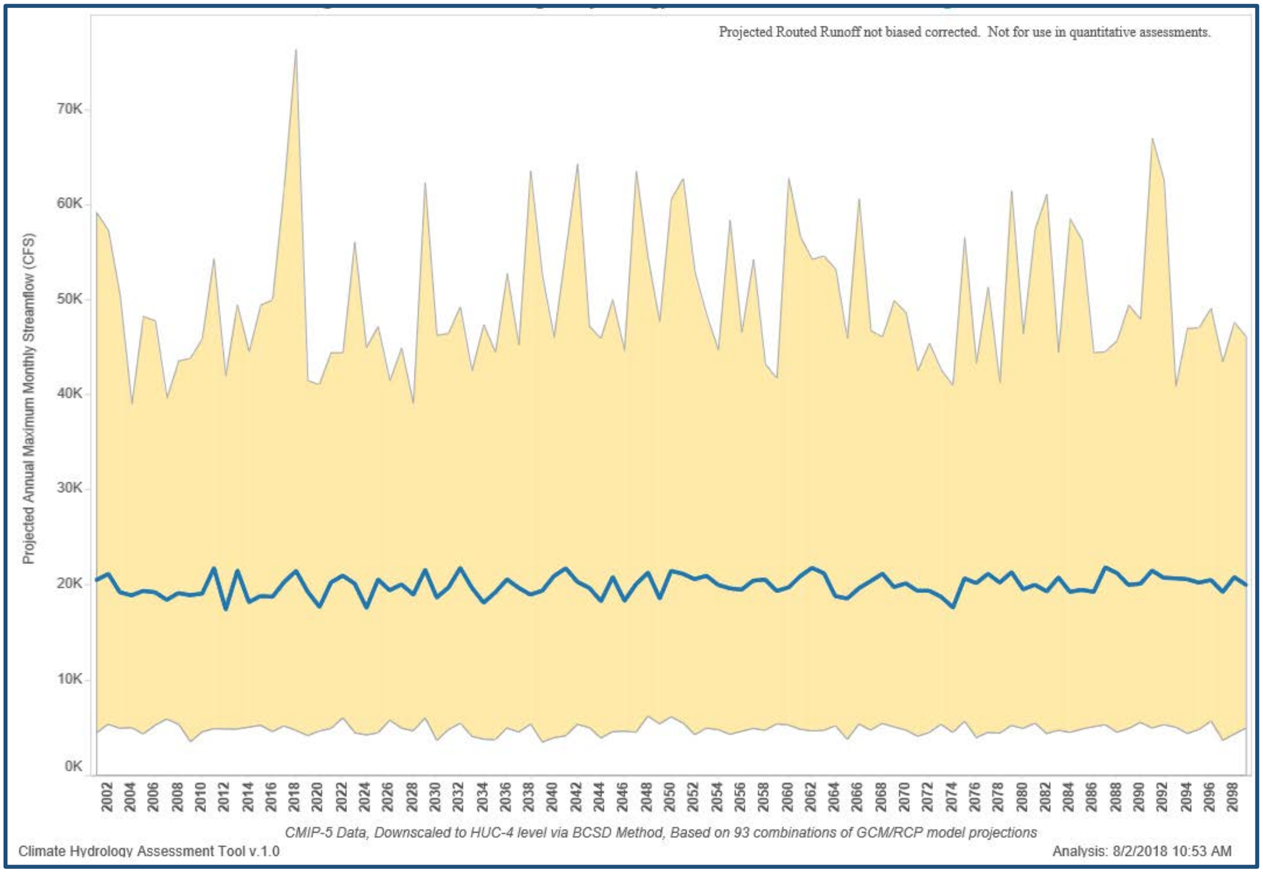


Figure 4.10 - Range of 93 Climate-changed hydrology models of the Muskingum River Basin.

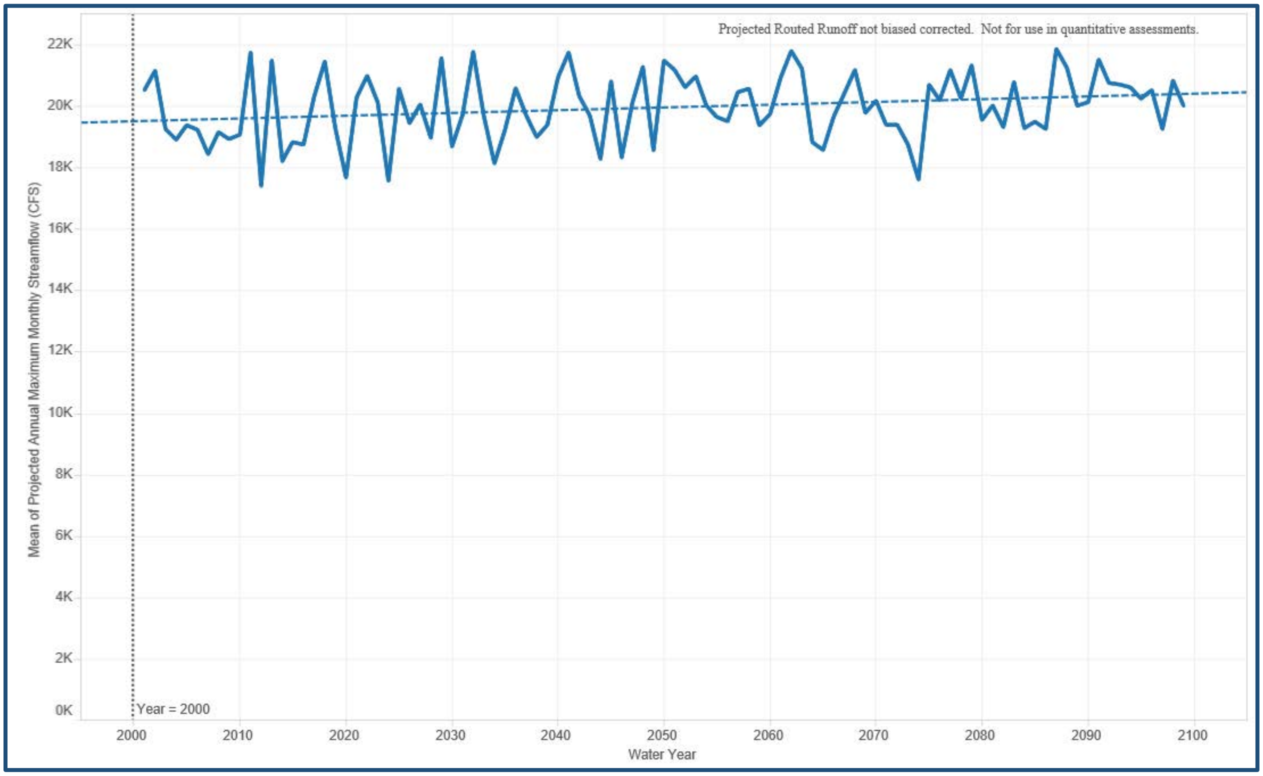


Figure 4.11 - Range of projected annual maximum monthly streamflow.

4.3.5 Climate Resiliency

Overall, no strong signal exists within the qualitative analysis to indicate what definitive impacts climate change will hold for Basin hydrology. Literature indicates an increase in observed precipitation and there appears to be an increase in observed streamflow, although there is great variance. Anecdotally, stakeholders across the Basin report storm events increasing in intensity and duration.

4.3.6 Climate Change Conclusion

Ultimately, increases in precipitation and stream flow will result in increased risk of flooding both in terms of stormwater runoff and riverine flooding, as well as increased soil erosion, increased sediment runoff into stream and water quality degradation. These water resource issues are discussed in greater detail in subsequent chapters.

4.4 Land Use and Development

4.4.1 Existing Land Use and Land Cover

As previously stated, the Muskingum River Basin encompasses approximately 8,000 square miles (5.1 million acres). It is a diverse area which accommodates a variety of land cover types and uses, as inhabitants have taken advantage of productive, largely free-draining soils and moderate to gently sloping terrain. Current land use is a mixture of forested lands, agricultural uses, urban developed areas (high, medium and low density), transportation corridors and extensive water bodies (lakes, rivers, ponds and wetlands). Information on land use categories for Ohio is found in databases provided by USGS (general land cover categories) and U.S. Department of Agriculture (USDA) (land cover categories with specific crop types).

Table 4.5 below shows the current distribution of land use categories in the Basin based upon latest available USGS/USDA satellite data. As the table indicates, the three largest land use categories are deciduous and evergreen forested land (46.69% of total), crop land (19.74% of total) and grass/pasture land (19.53% of total). Together these three types cover 85.96% of the total 5.1 million acres within the Basin. This predominance of vegetated land accounts for the Basin's highly-valued scenic quality which supports a variety of recreation pursuits, annual productivity in terms of agricultural output and timber harvesting, as well as the Basin's ability to absorb and transpire significant amounts of rainfall. The predominance of vegetated land also enables the Basin to act as an effective carbon sequestration feature in the region. Figure 4.12 shows the most recent pattern of land uses within the Basin.[6] The interior dark lines define the boundaries of the six HUC 8 watersheds described in Section 1.3 above.

[6] These figures are provided by the USGS and the USDA.

Table 4.5 - Acres and Square Miles of Land Use in the Muskingum River Watershed

Land Use Categories	Acres	Square Miles	Percent Total
Open Water	66,188	103	1.29%
Developed/Open Space	390,568	610	7.59%
Developed/Low Intensity	148,881	233	2.89%
Developed/Med Intensity	53,873	84	1.05%
Developed/High Intensity	22,914	36	0.45%
Barren	10,791	17	0.21%
Deciduous Forest	2,377,357	3,715	46.17%
Evergreen Forest	26,947	42	0.52%
Mixed Forest	11	0	0.00%
Shrubland	15,550	24	0.30%
Fallow/Idle Cropland	7,878	12	0.15%
Christmas Trees	15	0	0.00%
Grass/Pasture	1,005,744	1,571	19.53%
Crops	1,016,406	1,588	19.74%
Woody Wetlands	4,721	7	0.09%
Herbaceous Wetlands	906	1	0.02%
Totals	**5,148,750**	**8,045**	-

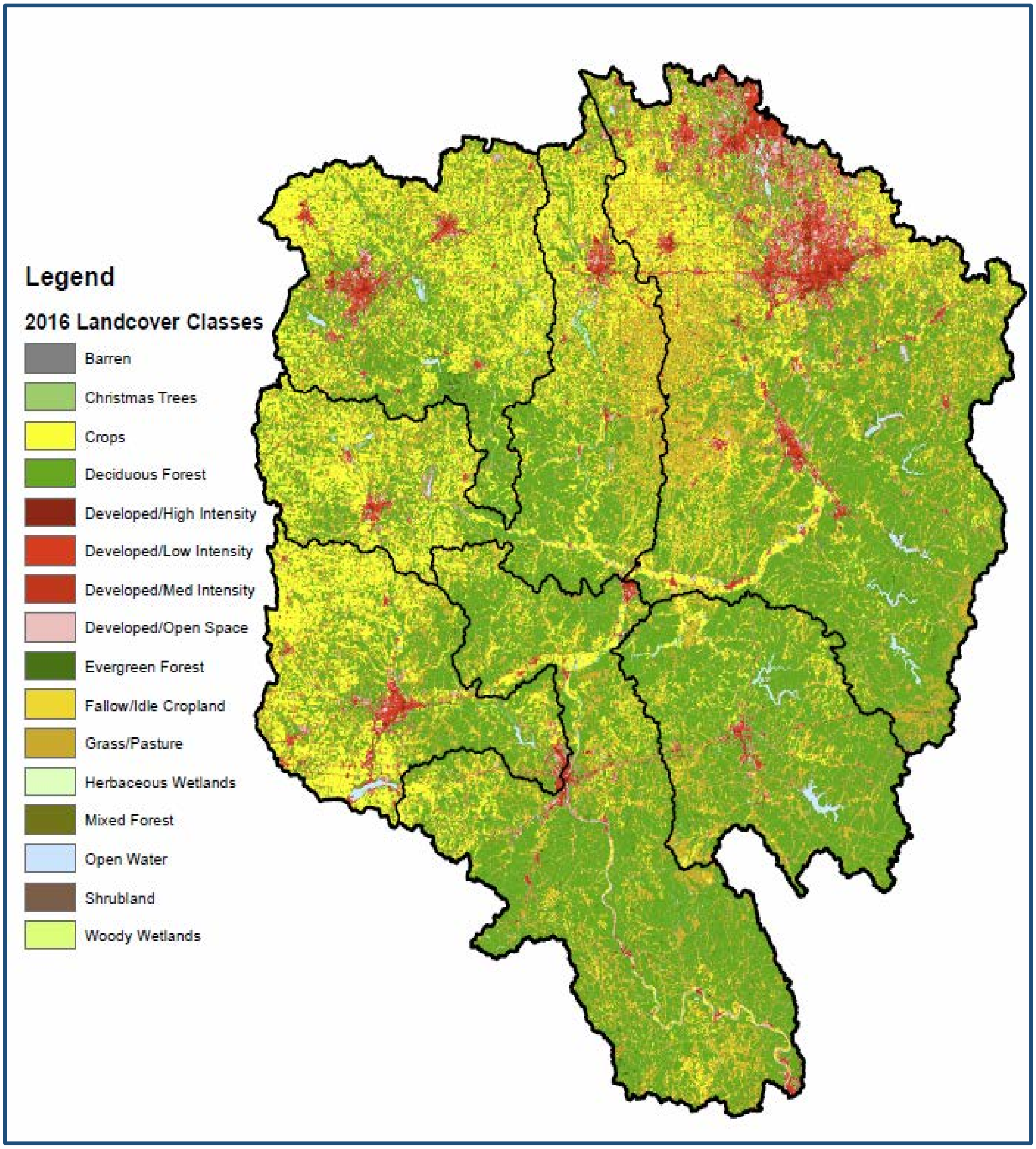


Figure 4.12 - Most recent land cover map of the Muskingum River Basin.

4.4.2 Land Use Transitions 2010-2016

While several of the urban areas in the Basin have witnessed moderate to significant growth in recent years, vast areas of the Basin have experienced no change in land use over relatively long periods of time. Approximately 90% of land in the Basin did not change uses between 2010 and 2016, as shown below in Table 4.6. These figures show a relatively stable land use pattern over a seven year period with the exception of land cover categorized as barren, shrubland and fallow/idle cropland, each showing significant changes over this period.

Table 4.6 - Acres of Land Experiencing No Change By Type

Land Use Categories	2010	% of Total[7]	2013-2016	% of Total
Open water	54,267	82	56,209	85
Developed/Open Space	340,472	87	372,209	95
Developed/Low Intensity	130,280	88	131,415	88
Developed/Medium Intensity	40,279	75	41,853	77
Developed/High Intensity	18,625	81	19,154	84
Barren	197	2.0	888	8.0
Deciduous Forest	2,333,216	98	2,321,505	97
Evergreen Forest	15,253	57	18,064	67
Shrubland	4	0.1	45	0.2
Fallow/Idle Cropland	19	0.2	129	1.6
Grass/Pasture	1,067,614	NA	937,622	93
Crops	653,631	64	796,629	78
Woody Wetlands	218	4.6	442	9.3
Total	**4,654,075**	**90**	**4,696,162**	**91**

Table 4.7 below shows the transition of various land use types in the Basin, as opposed to **Table 4.6** above, which showed cumulative total in land use change.

[7] Basin totals used in the calculations of percentage were from the 2016 USGS and USDA data.

Table 4.7 - Transitions in Land Use 2010-2013/2013-2016 (acres)[8]

Land Use Type	2010 to 2013	2013 to 2016
Open Water to Developed Open Space	852	0
Developed Open Space to Crops	1,971	128
Developed Open Space to Developed Low Intensity	0	4,683
Developed Open Space to Developed Med Intensity	224	3,413
Developed Low Intensity to Developed open space	1,922	0
Developed Low Intensity to Developed Med Intensity	270	2,767
Developed Low Intensity to Developed High Intensity	2	1,007
Developed Low Intensity to Crops	700	0
Deciduous Forest to Open Water	0	3,355
Deciduous Forest to Barren	1,517	2,921
Deciduous Forest to Crops	7,965	1,059
Deciduous Forest to Developed Open Space	15,308	0
Deciduous Forest to Developed Low Intensity	1,226	0
Deciduous Forest to Grass/Pasture	1,175	0
Deciduous Forest to Woody Wetlands	1,288	1,594
Deciduous Forest to Evergreen Forest	7,269	0
Evergreen Forest to Deciduous Forest	0	3,274
Grass/Pasture to Crops	68,178	149,297
Grass/Pasture to Barren	797	3,387
Grass/pasture to Fallow/Idle Cropland	632	3,674
Grass pasture to Deciduous Forest	0	23,908
Grass/pasture to Developed Low Intensity	3,629	2,515
Grass/pasture to Shrubland	99	14,661
Grass/Pasture to Open Water	1,159	2,070
Grass/Pasture to Developed Open Space	20,234	5,672
Grass/Pasture to Developed Medium Intensity	1,155	1,927
Grass/Pasture to Herbaceous Wetlands	0	734
Crops to Fallow/Idle Cropland	164	3,674
Crops to Developed Open Space	0	538
Totals	**137,736**	**236,258**

[8] Land use transitions totaling less than a square mile (640 acres) were generally not listed unless the corresponding time frame exceeded that amount.

Most notable in both three-year periods are the changes in deciduous forest to other uses (i.e. barren, open water, grass/pasture, woody wetlands, evergreen forest, developed low-intensity and developed open space), the transition of grass/pasture to other uses (i.e. developed/open space, barren, fallow/idle cropland, shrubland, deciduous forest and developed/low-intensity) and the transitions in intensity scale[9] for land uses designated as developed (i.e. open space, low, medium, and high). This transition in development intensity is most notable between 2013 and 2016 when over 18 square miles of land changed from a lower intensity of development to a higher intensity.

Absent enforcement of stormwater management regulations, this transition indicates increased placement of impervious surfaces generating greater amounts of runoff and thus greater chances for flooding in smaller urban stream corridors. Flood damages associated with stormwater runoff are a common problem in urban areas throughout the Basin, as discussed below.

Additionally, the 2013 to 2016 time period saw a relatively small transition of grass/pasture to crop use of over 149,000 acres (232 square miles). According to local stakeholders, this transition may be due to increasing commodity prices or additional corn production for ethanol fuel use. Overall, these recent changes in land use indicate a modest transition from lower runoff potential to higher runoff potential with added potential for additional non-point pollution (i.e. nutrients, sedimentation, bacteria, etc.) and ongoing quality impairment of the Basin streams.

Generally speaking, over the period between 2010 and 2016, most land use transitions in the HUC 8 watersheds moved from a more pervious (more absorption of precipitation) use type to a more impervious (less absorption, more runoff during precipitation events). Transitions from largely vegetated land areas (deciduous forest, evergreen forest, grass/pasture and shrubland) to developed open space, developed low, medium and high intensity land uses and barren lands forecasts ever-increasing amounts of runoff during precipitation events and decreasing opportunities for groundwater recharge.

Much of the agricultural community and many rural residents in the Basin rely on either surface water or groundwater resources for irrigation and drinking water supplies. Reductions in groundwater recharge due to additional placement of impervious pavements and reliance on efficient stormwater movement systems, threaten these dependent communities. This trend

[9] Intensity scale in this usage reflects the increasing density of residential and commercial development (units per acre) at the developed/open space and low, medium and high-intensity developed levels.

towards more placement of impervious surfaces also indicates the potential for more stormwater runoff and issues from flooding in the future.

4.4.3 Future Land Use and Development

Changes in the issuance of building permits (especially residential housing) usually signals changes in land use types. The issuance of building permits, especially for single and multi-family housing can occur as a result of real population growth signaling a housing need. These needs can be met in part by multi-family housing construction, new single-family housing construction or a reduction in the supply of vacant housing. Another aspect of the building permit process is meeting new housing demand, or demand generated by households with growing incomes and growing families buying up to larger, more expensive homes.

Research by the US Census Bureau for the year 2015 in counties which are wholly or partially within the Muskingum River Basin, indicates approximately 2,997 building permits[10] for new housing (single or multi-family units) construction were issued. **Table 4.8** shows the numbers of building permits issued in 2015 for these counties. The 2010 population for the largest municipality for each county is also shown. According to the descriptions of the 2015 building permit dataset in the US Census, the majority of the housing building permits occurred near the largest municipal area in most counties.

[10] Since building permits in and of themselves are no guarantee of the actual construction of a dwelling unit, they are primarily an indicator of residential building construction that may be occurring in that area.

Table 4.8 - Building Permits for Housing Construction in Counties Located Wholly or Partially within the HUC 4 Muskingum River Basin[11]

Counties	Housing Unit Permits	Primary Municipality	Primary Municipal Population
Stark	558	Canton	73,000
Carroll	0	Carrollton	3,241
Harrison	1	Cadiz	3,353
Guernsey	38	Cambridge	11,129
Tuscarawas	68	New Philadelphia	17,288
Wayne	211	Wooster	26,119
Holmes	5	Millersburg	3,025
Coshocton	13	Coshocton	11,216
Muskingum	79	Zanesville	25,487
Morgan	39	McConnellsville	1,784
Licking	280	Newark	47,573
Knox	121	Mount Vernon	16,990
Ashland	67	Ashland	20,362
Richland	62	Mansfield	47,821
Perry	42	New Lexington	4,731
Summit	561	Akron	199,110
Medina	676	Medina	26,678
Morrow	27	Mt. Gilead	3,660
Noble	26	Caldwell	1,748
Washington	21	Marietta	14,085
Belmont	52	St. Clairsville	5,184
Columbiana	50	Lisbon	2,821
Total	**2,997**		566,405

4.4.4 Population Growth and Land Use

Another method for forecasting future land use within a defined area such as the Muskingum River Basin is to use forecasts of future population growth. This growth is tempered and directed by the economic development and land use strategies found in county and municipal jurisdiction comprehensive plans. Population projections for the Basin area are based upon US Census and the Ohio Department of Development (ODOD) data for the counties in the Basin. For the purpose of forecasting future population, only those counties having a substantial portion of their land area within the Basin were used in the projection.

[11] U.S. Census 2015

US Census data indicates net future population in the Basin will rise by approximately 1.8% (or 37,000) persons by the year 2040. **Table 4.9** below shows anticipated population change per county. The three counties most likely to realize land use/land cover changes due to this additional population growth are Knox (22.86%), Licking (27.56%) and Medina (15.99%).

Table 4.9 - Population Projection by County

County	2010 Census	2040 Projection	Delta	% Increase/Decrease
Ashland	53,139	57,920	4,781	9.00%
Carroll	28,836	29,040	204	0.71%
Coshocton	36,901	33,390	-3,511	-9.51%
Guernsey	40,087	36,390	-3,697	-9.22%
Harrison	15,864	15,100	-764	-4.82%
Holmes	42,366	45,280	2,914	6.88%
Knox	60,921	74,850	13,929	22.86%
Licking	166,492	212,370	45,878	27.56%
Medina	172,332	199,890	27,558	15.99%
Morgan	15,054	13,820	-1,234	-8.20%
Morrow	34,827	41,170	6,343	18.21%
Muskingum	86,074	81,900	-4,174	-4.85%
Noble	14,645	15,703	1,058	7.22%
Perry	36,058	41,710	5,652	15.67%
Richland	124,475	115,160	-9,315	-7.48%
Stark	375,586	355,500	-20,086	-5.35%
Summit	541,781	523,190	-18,591	-3.43%
Tuscarawas	92,582	92,840	258	0.28%
Washington	61,778	53,720	-8,058	-13.04%
Wayne	114,520	113,240	-1,280	-1.12%
Totals	**2,114,318**	**2,152,183**	**37,865**	**1.8%**

Over a 30-year period of analysis (per the range of data available from the US Census), this amount of population increase should not result in significant changes in land use across the entire Basin, but will likely result in minor land use conversions in the three counties referenced above. Based upon past population increases in the Basin and the effects on land use types, this relatively small increase in population may result in some expansion of the developed/low-density and developed/medium-density land use categories to higher levels of residential density assuming that such expansion would be at the edges of existing urban areas where public infrastructure is located or in small, extra-urban subdivisions to which public infrastructure has been extended. In each case, county and municipal requirements for stormwater management (contained in comprehensive plans) would likely address runoff from all but the greatest precipitation events.

Generally speaking, Ohio counties have enacted Comprehensive Plans which describe existing development patterns (residential, commercial, industrial, recreation, transportation, open space, etc.) and anticipated future development based upon forecasted population growth. Those plans include provisions for the enactment and enforcement of county-wide stormwater management ordinances. Conversely, several counties are losing population over this period, a negative change which will not be immediately reflected in land cover transitions but may result in more for-sale and rental unit vacancies.

In summary, the land use/land cover patterns in the Muskingum River Basin have been fairly stable with approximately 90% of the land cover not changing significantly between 2010 and 2016. However, some categories of land use have changed quite regularly but in insufficient acreages to be largely noticeable when spread across the entirety of the Basin. Land cover categories such as crops, grass/pasture and deciduous forest have changed quite frequently during this six year period but much of the change in grass/pasture and crops has been a result of the normal annual/seasonal progression of agricultural (tillage and harvesting) and livestock uses of land. Generally speaking, total acreages dedicated to cropland have changed very little over the six year period. Some transition of deciduous forest and grass/pasture land cover have moved towards more developed uses such as developed open space and low-intensity development leading to potential for increased runoff due to placement of impervious pavements and roofscapes.

Only 2,997 building permits were issued across the 25 or so counties within the watershed in 2015 according to US Census data. This is a rather modest number of residential building permits when divided across 5 million acres of largely developable land and among an estimated population of 2.0 million persons. Those permits indicate an active construction market in the Basin but the majority (80%) of those permits were issued in just six of the 25 counties. Future housing demand spurred on by increasing household incomes and downsizing by older families will likely support additional housing development surrounding the municipal areas.

As previously mentioned, projections of future population growth in the watershed are modest at a forecasted 1.8% increase through 2040. The watershed forecast of an additional 37,000 people by 2040 is not likely to drive a huge upsurge in development which results in vast areas of the landscape being consumed for new housing and commercial development. It is possible the counties within the Basin where forecasted growth is above 10% (Knox, Licking, Medina, Morrow, and Perry) could experience some noticeable uptick in development resulting in losses to the grass/pasture and deciduous forest land cover areas for green-site subdivisions but a shift in the intensity of urban density from developed open space to developed low-intensity and medium intensity land use could signal an alternative growth pattern. Such transitions would likely occur at the edges of existing municipalities where infrastructure (utilities and roadways) are already present or easily extended.

4.5 Ecology

Land cover in the Muskingum River Basin provides ample and diverse habitats for a variety of wildlife species. In the northern and western basin counties where farmland is prevalent, cottontail rabbits, fox squirrels, mourning doves, bobwhite quail, and ring-necked pheasants are the most abundant game species. White-tailed deer, ruffed grouse, and gray squirrels also are present in these counties but are more abundant in the larger tracts of forest in the southern portion of the basin.

Wild turkey was introduced in southeastern Ohio in 1952 and has become re-established to a large degree. Wild turkeys have been found in the Perry, Morgan, and Washington County portions of the Muskingum River basin. Major furbearers in the basin are muskrat, raccoon, opossum, mink, red fox, skunk, weasel, gray fox, and beaver.

Ohio has about 250,000 acres of waterfowl habitat, much of which is found in the Muskingum River basin. The Ohio Division of Wildlife reports that mallards, black ducks, wood ducks, and greenwinged teal constitute about 70% of Ohio's annual harvest of waterfowl. Other ducks which pass through the Muskingum River basin include greater scaup, bufflehead, widgeon, pintail, blue-winged teal, and redhead. Canada geese are found in the basin as well.

The abundance of streams, reservoirs, and farm ponds well distributed throughout the basin provide much high quality warm water fish habitat. Game fish found in this area of Ohio include: Smallmouth bass, largemouth bass, white bass, bluegill, sunfish, white crappie, black crappie, channel catfish, muskellunge, northern pike, and walleye.

4.6 Water Quality

US waters are continually threatened by different sources and types of pollution. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain and improve the quality of the nation's surface waters. These standards represent a level of water quality which support the goal of "swimmable/fishable" waters. Water quality standards are ambient standards as opposed to discharge-type standards. These ambient standards, through a process of back calculation procedures known as Total Maximum Daily Loads (TMDLs) or waste-load allocations form the basis of water quality based permit limitations which regulate the discharge of pollutants into the waters under the National Pollutant Discharge Elimination System (NPDES) permit program.

Ohio's water quality standards, set forth in Chapter 372-1 of the Ohio Administrative Code (OAC), include four major components — beneficial use designations, narrative "free froms,"[12] numeric criteria, and anti-degredation provisions. Streams not meeting State water quality standards are placed on the EPA's 303(d) Impaired Waters List. Of the 11,735 miles of streams in the Muskingum River Basin, 7,242 miles are listed as impaired.

Based on the 303(d) list, the most prevalent impairments in the Basin include pathogens, siltation, habitat alterations, PCBs (polychlorinated biphenyls) in fish tissue, organic enrichment/low dissolved oxygen, nutrients, flow alterations, metals, hexachlorobenzene, and ammonia. The likely sources of these impairments are as follows:

- Pathogens — primarily from human and animals wastes, including runoff from agricultural land and feedlots, seepage or discharge from septic tanks, sewage treatment facilities and natural soil and plant bacteria.
- Siltation — likely from stream-bank erosion and soil degradation from inadequate agricultural practices in rural areas, and in urban areas from construction activities such as land clearing.
- Habitat alterations — resulting from land use changes, hydrologic modification, climate change, altered biologic diversity, and introduction of non-native species.
- PCBs in fish tissue — resulting from commercial manufacture, use, storage and disposal of industrial chemicals, primarily from historic releases.

[12] Narrative "free froms," located in rule 3745-1-04 of the Ohio Administrative Code, are general water quality criteria that apply to all surface waters. These criteria state that all waters shall be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal, or aquatic life; and nutrients in concentrations that may cause algal blooms.

- Organic enrichment/low dissolved oxygen — usually resulting from human activities that introduce large quantities of biodegradable organic materials into surface waters.
- Nutrients — resulting from fertilizer application, livestock waste, atmospheric deposition and various point sources.
- Flow alterations — primarily from the introduction of manmade structures such as dams, bridge supports/abutments, and agricultural stream crossings.
- Metals — primarily from industrial processes and mining operations.
- Hexachlorobenzene — primarily from the manufacture of other chlorine containing compounds and pesticides as well as in the incineration of municipal and hazardous wastes.

4.7 Threatened and Endangered Species

In accordance with the Endangered Species Act, the US Fish and Wildlife Service maintains a national list of endangered and threatened species. Species are added to the list when in danger of becoming extinct. Common factors threatening continued existence include destruction or modification of habitat, disease, and over-harvesting.

The Indiana bat and northern long-eared bat are found in all counties that are included in this study. The largest threat to the northern long-eared bat is white-nose syndrome; a fungal disease which has been documented in several hibernacula in Ohio. Indiana bats are also susceptible to white-nose syndrome. Both species are also affected by loss or degradation of summer habitat (maternity roost or foraging, roosting, and travel habitat) and human disturbance at mines and caves where the bats overwinter (hibernacula). Northern long-eared bats roost in both live trees and snags. Compared with Indiana bats, northern long-eared bats are more likely use crevices to roost, rather than hanging bark.

While the bald eagle was removed from the Federal list of endangered and threatened species in 2007, after many years of preservation efforts, this species remains protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Several nesting pairs of bald eagles can be found around Beach City and Bolivar Dams in Tuscarawas Counties.

Table 4.10 - Threatened and Endangered Species in the Muskingum River Basin

County	T&E Species
Ashland	Indiana bat (E), northern long-eared bat (T), eastern hellbender (SC), bald eagle (SC)
Athens	Indiana bat (E), northern long-eared bat (T), American burying beetle (E), fanshell (E), sheepnose (E), pink mucket pearly mussel (E), snuffbox (E), running buffalo clover (E), timber rattlesnake (SC), bald eagle (SC)
Belmont	Indiana bat (E), northern long-eared bat (T), running buffalo clover (E), eastern hellbender (SC), bald eagle (SC)
Carroll	Indiana bat (E), northern long-eared bat (T), bald eagle (SC)
Columbiana	Indiana bat (E), northern long-eared bat (T), eastern massasauga (T), eastern hellbender (SC), bald eagle (SC)
Coshocton	Indiana bat (E), northern long-eared bat (T), clubshell (E), fanshell (E), rayed bean (E),purple cat's paw pearly mussel (E), sheepnose (E), snuffbox (E), rabbitsfoot (T/CH), eastern hellbender (SC), bald eagle (SC)
Fairfield	Indiana bat (E), northern long-eared bat (T), running buffalo clover (E), eastern massasauga (T), bald eagle (SC)
Guernsey	Indiana bat (E), northern long-eared bat (T), bald eagle (SC)
Harrison	Indiana bat (E), northern long-eared bat (T), bald eagle (SC)
Holmes	Indiana bat (E), northern long-eared bat (T), eastern prairie fringed orchid (T), eastern massasauga (T), eastern hellbender (SC), bald eagle (SC)
Knox	Indiana bat (E), northern long-eared bat (T), eastern hellbender (SC), bald eagle (SC)
Licking	Indiana bat (E), northern long-eared bat (T), eastern massasauga (T), bald eagle (SC)
Medina	Indiana bat (E), northern long-eared bat (T), bald eagle (SC)
Monroe	Indiana bat (E), northern long-eared bat (T), eastern hellbender (SC), bald eagle (SC)
Morgan	Indiana bat (E), northern long-eared bat (T), American burying beetle (E), fanshell (E), pink mucket pearly mussel (E), sheepnose (E), snuffbox (E), bald eagle (SC)
Morrow	Indiana bat (E), northern long-eared bat (T), bald eagle (SC)

Table 4.10 - Threatened and Endangered Species in the Muskingum River Basin Continued

Muskingum	Indiana bat (E), northern long-eared bat (T), fanshell (E), sheepnose (E), snuffbox (E), rabbitsfoot (T), eastern hellbender (SC), bald eagle (SC)
Noble	Indiana bat (E), northern long-eared bat (T), bald eagle (SC)
Perry	Indiana bat (E), northern long-eared bat (T), American burying beetle (E), eastern massasauga (T), bald eagle (SC)
Portage	Indiana bat (E), northern long-eared bat (T), Mitchell's satyr (E), northern monkshood (T), eastern massasauga (T), bald eagle (SC)
Richland	Indiana bat (E), northern long-eared bat (T), eastern massasauga (T), eastern hellbender (SC), bald eagle (SC)
Stark	Indiana bat (E), northern long-eared bat (T), eastern massasauga (T), bald eagle (SC)
Tuscarawas	Indiana bat (E), northern long-eared bat (T), eastern hellbender (SC), bald eagle (SC)
Washington	Indiana bat (E), northern long-eared bat (T), fanshell (E), pink mucket pearly mussel (E), sheepnose (E), snuffbox (E), eastern hellbender (SC), timber rattlesnake (SC), bald eagle (SC)
Wayne	Indiana bat (E), northern long-eared bat (T), eastern prairie fringed orchid (T), eastern massasauga (T), bald eagle (SC)

E = Endangered, SC = Species of Concern, T = Threatened, CH = Critical Habitat, C = Candidate, P = Proposed (T/E/CH)

4.8 Floodplain

The Federal Emergency Management Agency (FEMA) is responsible for administering the National Flood Insurance Program (NFIP), which is a Federal program enabling property owners to purchase subsidized flood insurance. NFIP is based on a formal partnership between local jurisdictions (counties/communities) and the Federal government. Under this program, counties and communities adopt floodplain management regulations in order to reduce flood risks associated with future floodplain growth and rehabilitated floodplain structures and the Federal government in turn subsidizes flood insurance for property owners within the community.

NFIP is based on the established 1% annual chance flood, better known as the 100-year flood or Base Flood Elevation (BFE), which serves as the national standard for virtually every Federal and most state agencies. Flood Insurance Rate Maps produced by FEMA provide the official record of special flood hazard areas. The areal extent of the official special flood hazard area was determined for the Basin. Using digital flood data corresponding with published FIRMs, the 100-year floodplain was overlaid on a basic map of the Basin. While flooding is a reoccurring problem within the Basin, only 618 square miles or about 8% of the watershed lies within the 100-year floodplain. As seen in Figure 4.13 below the 100-year floodplain is nearly equally distributed along the basin. Larger, more prominent areas of the 100-year floodplain displayed on the map indicate the locations of USACE-operated lakes.

Figure 4.13 – 100-year Floodplain in the Muskingum River Basin.[13]

[13] Floodplain data for Morgan County was unavailable.

4.9 Cultural Resources

The State of Ohio is rich in historic and cultural resources. As the Muskingum River Basin covers approximately 1/5 of the state, many of these resources are located within the study area of this report. The Huntington District maintains a working relationship with the State Historic Preservation Office (SHPO) and coordinates all federal actions with their office. What follows is a discussion of several culturally historic sites within the Muskingum River Basin.

Big Bottom Memorial Park – The Big Bottom Memorial Park, named for the broad Muskingum river floodplain where it is located, is in Stockport, in Morgan County. The site commemorates the 1791 attack on settlers by American Indians which marked the start of four years of fighting in the State of Ohio. The American Indians were fighting the encroachment of white settlers onto their tribal lands. The site is memorialized by a 12 foot obelisk which marks the site of the attack. The Park itself is managed by the Ohio History Connection and local officials.

Custor Monument – the Custor Monument is dedicated to the memory of George Armstrong Custor, who was a cavalry commander for the Union army during the Civil War. He was also instrumental in the opening of the west in the years following the war between the states. Custor was born in December 1839 in New Rumley, Ohio, where the site is located.

Flint Ridge Ancient Quarries & Nature Preserve – The Flint Ridge Ancient Quarries and Nature Preserve is located in Glenford, in Licking and Muskingum counties. This is the location of hundreds of ancient quarry sites used by American Indians in search of flint, which was used to make tools and weapons. The site is managed by the Licking Valley Heritage Society.

Fort Laurens – Fort Laurens, located in Bolivar, is the site of Ohio's only Revolutionary War for, constructed in 1778 as wilderness outpost. The Americans hoped to use this site to attack the British garrison in Detroit. They also used the site to win over local American Indians to the Colonist's side of the dispute. The fort was abandoned in 1779, and part of the fort was demolished as part of the construction of the Ohio and Erie Canal. The Tomb of the Unknown Patriot of the American Revolution is also located here.

Newark Earthworks – The Newark Earthworks are located in the municipalities of Newark and Heath. They consist of three sections of preserved earthworks: the Great Circle Earthworks, the Octagon Earthworks and the Wright Earthworks. These earthworks were built by the Hopewell culture between 100 AD and 500 AD. This complex contains the largest earthen enclosures in the world, covering approximately 3,000 acres. The site is operated as a State Park by the Ohio Historic Connection and was designated as a National Historic Landmark in 2006.

Village of Zoar – The Village of Zoar is located upstream of Dover Dam in Tuscarawas County. The Village was founded in 1817 by German religious dissenters as a utopian community which survived until 1853. Much of the original layout and buildings survive to this day and the Village is located on the National Register of Historic Places in 1969. The Village is technically located in the flowage easement of Dover Dam. However, when the Dover Dam project was constructed in the 1930's the USACE made the decision to build a levee to protect the Village in place rather than relocating it. This was due to the historic significance of the Village.

4.10 Outdoor Recreation

Outdoor recreational opportunities are plentiful throughout the Muskingum River Basin, and are of great economic significance to the local economy. Common recreational opportunities include hunting, fishing, boating, camping, biking, canoeing, and hiking. The following sections highlight only a small percentage of the overall outdoor recreational opportunities available in the Basin.

4.10.1 Recreation at MWCD-Owned Property

As previously mentioned, the Flood Control Act of 1939 returned the 14 reservoirs built as part of the Muskingum River system to the Federal government, and the operation of those dams to USACE. The MWCD, however, retained all the property and easements associated with the reservoirs and continues to operate them for other authorized project purposes, including recreation (which draws millions of visitors every year).

The MWCD manages approximately 54,000 acres of property in the basin, including 16,000 acres of surface water on lakes and 38,000 acres of forest and open lands around the lakes, the majority of which is open to the public. Additionally, the MWCD has developed five parks located at Atwood, Charles Mill, Pleasant Hill, Seneca, and Tappan lakes, where overnight camping and cabins are available. The parks run a full schedule of activities from Memorial Day to Labor Day. Camping also is available adjacent to the marina areas at Clendening, Leesville, Piedmont, and the North Branch of Kokosing Lakes. Several of the reservoirs host various youth and organizational camps, attracting thousands of visitors each year. Most notable of these is the Alive Christian Musical festival held at Atwood Lake each summer.

4.10.2 State Parks

Another source of recreational opportunities in the basin is the various state parks. The basin plays host to ten state parks, including Portage Lakes, Quail Hollow, Wolf Run, Dillon, Muskingum River Parkway, Blue Rock, Mohican, Malabar Farms, Burr Oak, and Salt Fork. These parks offer a variety of outdoor recreational activities that include camping, boating, fishing, swimming, hiking, picnicking, and hunting. Most of the parks also offer the opportunity for winter recreational activities, which include ice skating, ice boating, ice fishing, snowmobiling, and cross-country skiing.

Quail Hollow State Park specializes in recreational study and programs that teach appreciation of Ohio's cultural and natural history. The H.B. Stewart family home on site is used for educational and community activities, while the Carriage House Nature Center features live animals and hands-on educational activities. The Park also holds workshops and events year round, including the Craft and Herb Fair, Reptile Day, and Christmas at the Hollow.

Dillon State Park features disc golf an archery course, and a modern sportsman's area that includes lighted trap and skeet fields, a 100-yard rifle range, and a 25-yard pistol range.

Finally, the Muskingum River Parkway State Park sits in an area that has been placed on the National Register of Historic Places and soon will be recognized as the Muskingum River Navigation Historic District. The State Park offers boaters a chance to pass through one of the Muskingum River's historic dam locks.

4.10.3 The Wilds

The Wilds, located in Muskingum County on 9,154 acres of reclaimed coal mine land, operates as a private, non-profit wildlife conservation center. Home to more than 25 non-native species and hundreds of native species, The Wilds is the largest conservation center for endangered species in North America. It is open to the public for a variety of tours from May through October.

The Wilds seeks to contribute to and enhance conservation medicine; animal management, husbandry, and health; restoration ecology; conservation science training; and conservation education. Some of the animals making their home at The Wilds include camels, bison, giraffes, cheetahs, zebras, and rhinos.

4.10.4 The Ohio and Erie Canalway Coalition

The Ohio & Erie Canalway Coalition was formed in 1989 as a private, non-profit organization working on development of the Ohio & Erie National Heritage Canalway. In addition to providing educational programs, events, and publications about the Heritage Canalway, the Coalition also owns and operates the Towpath Trail, which follows the old Ohio & Erie Canal (originally, the trail served as a path for the horses and mules pulling canal boats). Today the Towpath Trail is 25 miles long and facilitates biking, hiking, and horseback riding from Lake Erie south to New Philadelphia, Ohio.

4.11 Historical Locks and Dams on the Muskingum River Near Marietta

In recent years there has been a considerable amount of interest in the historical locks and dams located on the Muskingum River mainstem near Marietta. There are stakeholders in the Basin who are interested in remediating the dams and operating them for recreational purposes and as a cultural heritage sites and groups who would like to see the locks and dams removed for the purpose of fish passage and ecosystem restoration. An in-depth analysis of either alternative is beyond the measure and scope of this study. What follows is a brief history of the locks and dams, and a discussion of what would be necessary in terms of study for either alternative.

4.11.1 History of the Muskingum River Locks and Dams

The system of 11 locks and dams on the Muskingum River mainstem near Marietta was built in the late 1830's after the Ohio and Erie Canal bypassed the Muskingum River (see **Figure 4.14** below). Given the variation in the flow the Muskingum River, could not be utilized for water travel. In the spring, flooding would make the river unnavigable, and in the dry summer months the river would run dry. The project was originally known as the Muskingum River Improvement which allowed navigation between Marietta and Dresden, Ohio and connected to the Ohio and Erie Canal.

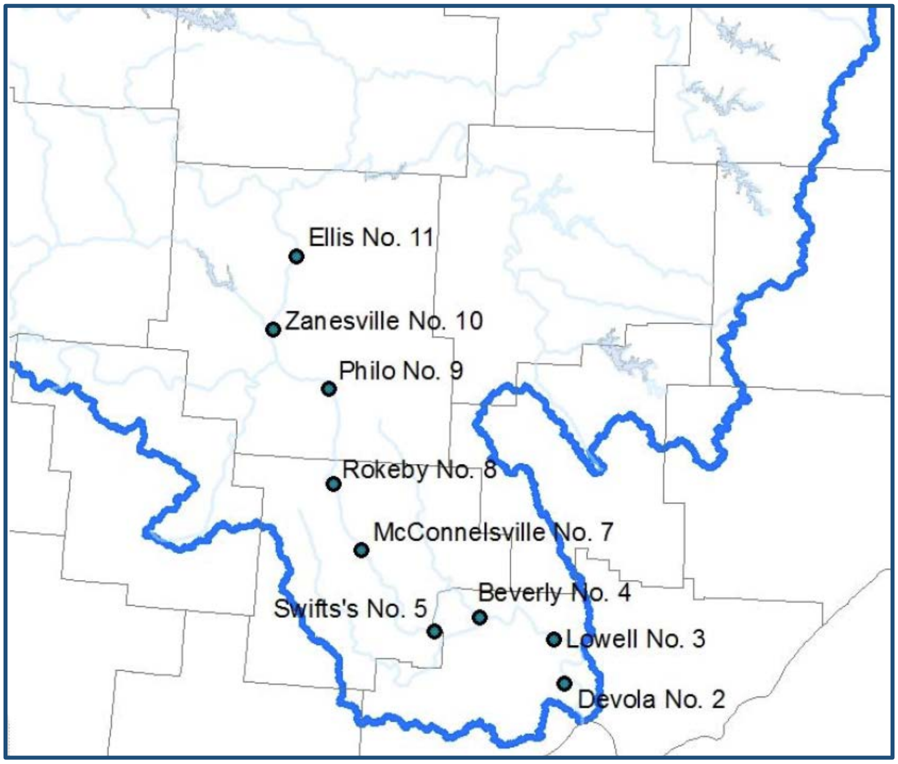


Figure 4.14 - Locations of Historical Locks and Dams on the Muskingum River.

The system was operated and maintained, at first by the State of Ohio and later USACE until the Great Flood of 1913. Damages were so extensive that it took five years to complete repairs. After re-opening to boat traffic in 1918, it was clear the system was no longer critical to economic development in the area, largely due to the development of the railway system. USACE stopped operating the system in 1948 and by 1958 the State of Ohio resumed ownership. Today, the Ohio Department of Natural Resources (ODNR) operates the locks and dams as the Muskingum River State Park for the purpose of recreation. It is recognized as the Muskingum River Navigation Historic District and is listed on the National Register of Historic Places.

4.12 Future Basin Conditions

The land uses of the Muskingum River Basin are a mixture of agriculture, forest and urban uses. This mixture has led to water quality deterioration through sedimentation and nutrient/bacterial loading from agricultural and livestock practices and increased impervious cover and stormwater management issues from urban sprawl. Although agricultural acreage has been reduced in past years and little growth in that sector of the economy is anticipated, water quality impacts due to land cultivation and livestock continue with limited abatement. Likewise, urban stormwater runoff and Combined Sewer Overflows (CSO) issues remain largely unabated in many watersheds. Future reductions in federal spending (national deficit reduction) for abatement programs promises continued water resources impacts.

Of more concern are the future effects of anticipated climate change on the land and water resources of the basin and its population. Current science-based predictions indicate that climatic changes in this region may include higher temperatures in summer and winter with measurably less annual rainfall, but more intensive rainfall events when they do occur.

Higher summer temperatures would generate greater rates of evaporation at Corps reservoirs and greater water supply needs for irrigation and potable water from those same shrinking resources. Higher summer temperatures raise the threat of reduced recreation usage on the waterways and reservoirs and higher temperatures throughout the year increase the threat of migration northward of warm-weather invasive terrestrial and aquatic species. The onslaught of both floral and faunal invasive species could negatively impact watershed and reservoir ecosystems and endanger potential ecosystem restoration projects. Higher winter temperatures would reduce any spring thaw benefits from accumulated snowpack in the upper portions of the basin.

Decreases in annual precipitation could endanger aquatic ecosystems and threaten groundwater supplies and conservation pools at reservoirs. The potential threat to aquatic ecosystems from sustained drought conditions would be increased for all watersheds in the basin. Increased intensity of rainfall events would raise the risks of flash flooding (and associated loss of life risks) in the sub-watersheds in the Upper Tuscarawas and increase the frequency of channel-modifying, bank full flows – flows that lead to bank instability, armoring and channel instability. Riparian resources throughout the basin could be threatened by these larger flows and their effects on the stream channel environment.

5. Identified Water Resource Issues

The previous chapter detailed the existing and future conditions of the Basin. The IWA (completed in 2012) identified an array of water resources issues within the Muskingum River Basin. These included water quality issues and the need for ecosystem restoration, land use and floodplain management issues, as well as riverine flooding concerns and infrastructure needs. These issues were examined at a cursory level during the development of the IWA with the understanding that the list of water resource issues would be refined during the FWA via more in depth stakeholder engagement.

Therefore, the initial step in the FWA process was to engage the MWCD and local stakeholders to collaboratively determine whether the previous issues were still relevant and to ascertain if there were other water resource concerns which warranted consideration.

The following water resource issues were selected for inclusion in the FWA:

- Flooding;
- Water quality (including wastewater management);
- Stormwater management;
- Need for education among the general public on watershed function and the regulatory process; and
- Issues associated with the 11 historical locks and dams located on the Muskingum River mainstem near Marietta.

While these water resource issues are common to the entire Muskingum River Basin, their impacts and corresponding solutions will vary based upon the location. Therefore, water resource issues are discussed at the sub-basin level in subsequent chapters to allow for a more in-depth analysis of issues, as well as more specific recommendations for implementation.

It should be noted it was unexpected for floodplain management not to be specifically identified as a significant water resource issues by stakeholders or the MWCD. However, this may be explained by the development composition of the Basin. The majority of the major urban areas in the Basin are located in the north, with a primary example being the Canton, North Canton and Akron areas. Floodplain management issues for this area were covered in detail in the Section 729 Nimishillen Creek FWA (completed in 2016). Major urban areas throughout the remainder of the

Basin are sparse and the majority of these municipalities have floodplain management ordinances in place.

For this reason floodplain management issues were excluded from this FWA. It is discussed in the following sections as a secondary issue, recognizing river basins are composed of interconnected natural and man-made systems where all resources – and therefore all issues – are related to one another in some fashion.

Several other concerns were identified during stakeholder engagement. These concerns include climate change, future growth and development, changes in USACE reservoir operations and sedimentation at USACE projects. Climate change and future growth and development are broad reaching, long term considerations which are best considered in light of their potential impacts on the identified water resource issue mentioned above. Potential recommendations with regard to these two issues are incorporated within the discussion of other water resources issues.

Likewise, changes in USACE reservoir operations and sedimentation at USACE projects are both concerns which are frequently mentioned by stakeholders throughout the Basin. While changes in USACE reservoir operations do not appear to be warranted at this time, a discussion of the operation of the projects and how changes in those operations would take place are discussed in depth in the following chapter, along with the subject of sedimentation at Corps projects, including impacts on authorized project purposes and sediment management.

6. Concerns Associated with USACE Projects

6.1 Stakeholder Concerns and Operation of the Muskingum River Basin Dams

Whether during stakeholder engagement for this study, or during other outreach events in the Basin, the MWCD and USACE frequently field questions about the operations of the dams. Land owners, residents and other stakeholders downstream of the projects perceive an increase in frequency and amount of water released from the dams. Additionally, agricultural producers are concerned with out of bank flooding on the rivers bordering their farms. These types of concerns, along with requests for permanent and/or temporary changes to water control at the projects have been voiced since the construction of the projects.

In terms of an increase in frequency and amount of water released from the projects, it is important to note the projects are managed in accordance with their water control plans (located in the water control manual for each individual project). There have been no significant changes to the original water control plans since they were placed into operation in the late 1930's. In accordance with the water control manual, USACE reservoirs in the Muskingum Basin are operated based upon their downstream controls as indicated by USACE and USGS river gages. This is done to reduce flood crest elevations downstream by operating to holding back or retain water in the reservoir, then releasing the excess water after the streams downstream of the reservoir have receded below their controls. Therefore, the flood crest elevation downstream is reduced. As a result, the overall impacts of flooding and associated damages downstream as much as possible. Recent precipitation patterns – both more intensive and frequent high water events – account for a perceived increase in releases. While the water control manuals are periodically revised and updated to include more up to date information on area gages, recreation opportunities and leasing arrangements, significant changes to the water control plan itself must be authorized by the United States Congress.

Deviations from the water control plan may be granted on a case by case basis and requests for these deviations are made regularly. These requests are typically granted so long as they do not interfere with project operations or impact the projects' ability to carry out the projects' primary purpose of flood control and flood reduction. Examples of the types of activities deviations are granted for include, annual canoe races by local groups, swift water rescue training by emergency responders and construction activities in downstream communities.

With regard to water release in terms of agricultural production, the water control manuals for the projects include provisions to reduce the likelihood of crop flooding during the growing season as much as possible. This is accomplished by adjusting water control procedures (per the water control plan) to future reduce the crests of floods during the growing season. As a result, growing crops are less likely to be inundated. It should be noted, the USACE studied the concept of further reducing releases in order protect against flooding during the growing season. These studies were the result of requests from local stakeholders. However, it was found that further reducing releases during these periods would actually have a negative impact the projects' storage capacity during high water events. Unless otherwise noted, USACE dams are always operated primarily to manage downstream flood risk. As a result of the current operational procedures, USACE Muskingum Basin projects have prevented a total of $4.9 billion in flood damages. However, if inflation adjustments are included in this value, the total climbs to $11.1 billion in prevented flood damages.

Significant changes to water control plans for USACE projects may be studied under the authority of Section 216 of the Flood Control Act of 1970 (Public Law 91-611), as amended, which states:

> *"The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

Under a Section 216 study, the USACE first prepares an Initial Appraisal Report to determine whether or not there is a Federal interest in undertaking the proposed modification. If Federal interest is found, a feasibility report is prepared, documenting the in-depth analysis of the proposed modification or change in operation, alternative measures to achieve the modification, and documenting any environmental impacts associated with the modification. Changes proposed by a Section 216 study are required to be authorized by Congress.

6.2 Sedimentation at USACE Projects

Concerns about sedimentation at USACE reservoirs in the Muskingum River Basin were frequently mentioned not only during stakeholder engagement for this study, but during many if not most, outreach events USACE holds in the area. A prime example of this concern is the siltation which has occurred at Beach City Dam over the years. What was originally a small reservoir is now almost completely silted in, limiting recreation immediately upstream of the dam.

Sedimentation issues exist more so for the projects in the Muskingum River Basin than in other Basin managed by the Huntington District USACE. These sedimentation issues are attributed primarily to agriculture activities in the upstream areas. Plowing, tilling, and other agriculture related activities which loosen or disturb the soil result in a larger than normal portion of the smaller soil particles to be carried into nearby streams and eventually the USACE projects downstream.

As previously mentioned, Beach City Dam has the most prevalent issues. Over time the recreational lake, caused by the dam and weir system, has slowly been filled in by sediment deposited by the Sugar Creek, a tributary of the Tuscarawas River. The sedimentation has caused a reduction in the amount of water stored in the lake at its normal pool elevation by 95%. The reservoirs at Wills Creek and Dillon Dams are examples of other lakes in the Basin with similar issues. As an example, Wills Creek and Dillon dams lost 81.3% and 39.3% of storage capacity respectively, due to sedimentation.

The best examples of projects within the Muskingum River Basin without sedimentation issues are the dry dams. These projects include; Bolivar Dam, Dover Dam, Mohawk Dam, and Mohicanville Dam. These dams are considered dry due to the fact that water is not regularly stored at these projects. Water is only stored at these projects during high water events. Therefore, sediment can only be deposited by water when the dams are being operated for flood risk management.

Unlike projects outside the Basin, the dams and reservoirs here do not experience the erosion problems caused by sediment starved water downstream from the dams. This is attributed to the sluice gates and outlet structures of the dams that draw water from the bottom of the lake. Drawing from the bottom of the lake allows some of the deposited sediment to be carried through and out of the project and downstream. This is further aided by the sediment rich water supplied to the projects in the Basin. As a result, no efforts are required to address downstream erosion issues caused by sediment at this time.

Although the reservoirs are occasionally dredged, USACE does not typically manage sediment in this manner. Potential solutions to sedimentation issues include transitioning the problematic projects to dry dams. Beach City is the most likely candidate for this approach due to the severity of the sedimentation issues. Sediment deposition has caused the floor of the lake to raise to within 2 feet of the water surface in several places. This has reduced the recreation value of the lake significantly. As a result, more recreation opportunities may be available in the forms of hunting and hiking, if the lake is drained to allow wetlands to form. However, it should be noted this would require additional study via a Section 216 Modification of Completed Works report and extensive coordination with the MWCD, resource agencies and local stakeholders.

Another potential approach to sedimentation problems is to drain the reservoirs and allow the built up sediment to dry. Removal of the dried sediment is less expensive than dredging the lakes. This method would likely incur significant environmental impacts and would also require extensive coordination with the MWCD, resource agencies and local stakeholders. This method is not currently utilized by the Huntington District.

7. Water Resource Issues Common to the Muskingum River Basin

7.1 Future Growth and Development in the Basin

Growth and development in the Basin, as well as associated impacts were frequently discussed during stakeholder engagement meetings. As previously discussed, although the Basin is predominantly rural, there are several urban areas (i.e. the Canton/Akron and North Canton and Louisville areas in the northern portion of the Basin) which have witnessed moderate to significant growth in the past decade. While these changes often have a positive impact on economic development, they may also negatively impact the environment. Several of the water resource issues identified for analysis as part of this study may be impacted either directly, or indirectly, by growth and development. These include water quality, stormwater management and wastewater management, both of which are discussed in subsequent sections.

Many cities, towns and villages struggle to manage increased wastewater and stormwater as they expand and grow. Storm sewer systems become overwhelmed and flood streets and viaducts. In cases where storm and sanitary sewers are combined floodwaters may contain human waste. Flooding as a result of stormwater runoff may damage homes and businesses, impede emergency personnel access, and destabilize streambanks.

Additionally, as cities, towns and villages grow and impervious surfaces are placed, water from rain events run across surfaces such as roads, parking lots and sidewalks where it picks up pollutants such as fertilizers, bacteria, pathogens, animal waste, metals and vehicle fluids. These pollutants eventually end up in nearby streams, negatively impacting water quality as discussed more in depth below.

7.2 Flooding

Flooding has long been an issue in the State of Ohio. To date, the flood of record, or largest recorded flood is the Great Flood of 1913[14], which occurred between March 23 and March 26. Five major rivers in the central and eastern United States flooded from several days of heavy rain resulting in excessive runoff. Loss of life and property damage was extensive. The official death toll for the State of Ohio was estimated to be between 422 and 470. It was this flood which led to

[14] The Great Flood is responsible for changing the way the country managed its waterways. This event increased congressional support for flood control measures. After subsequent major floods in the middle part of the 20th century the National Flood Insurance Program (NFIP) was created in 1968, followed by the Federal Emergency Management Agency (FEMA) in 1979.

the creation of the previously discussed Muskingum River Basin system of dams. It should be noted that even with the dams in place, approximately 55% of the streams in the Basin are uncontrolled, meaning flooding still has a substantial negative impact on the Basin.

7.2.1 Historical Flooding

Twenty four Presidential Disaster Declarations have been issued for counties within the Basin since 1959, and are listed in **Table 7.1** below.

Table 7.1 - Presidential Disaster Declarations

Declaration Number	Disaster Type	Date
DR-90	Floods	January 1959
DR-167	Severe Storms and Flooding	March 1964
DR-243	Heavy Rains, Flooding	June 1968
DR-630	Severe Storms and Flooding	August 1980
DR-642	Severe Storms, Flooding and Tornadoes	June 1981
DR-796	Severe Storms and Flooding	July 1987
DR-831	Severe Storms and Flooding	June 1989
DR-870	Flooding, Severe Storm and Tornadoes	June 1990
DR-951	Flooding, Severe Storm and Tornadoes	August 1992
DR-1065	Severe Storm and Flooding	August 1995
DR-1097	Storming and Flooding	January 1996
DR-1122	Flooding	June 1996
DR-1164	Severe Storms and Flooding	March 1997
DR-1227	Severe Storms, Flooding and Tornadoes	July 1998
DR-1444	Severe Storms and Tornadoes	November 2002
DR-1478	Severe Storms and Flooding	July 2003
DR-1507	Severe Storms, Flooding, Mudslides and Landslides	January 2004
DR-1519	Severe Storms and Flooding	June 2004
DR-1556	Severe Storms and Flooding	September 2004
DR-1580	Winter Storms, Flooding and Mudslides	January 2005
DR-1651	Severe Storms, Tornadoes, Straight-Line Winds and Flooding	June 2006
DR-1720	Severe Storms, Flooding and Tornadoes	August 2007
DR-4002	Severe Storms and Flooding	May 2011
DR-4077	Severe Storms and Straight-Line Winds	July 2012

Numerous other floods, which have not risen to the level of a federally-declared disaster, have also occurred across the Basin. Since 1996 these flood events have been documented by the National Climatic Data Center and the National Oceanic and Atmospheric Administration's (NOAA's) Satellite and Information Service. Property damage, as well as loss of life, are reported annually in **Table 7.2** below. **Table 7.3** provides information on a select few of these flood events.

Table 7.2 - Reported Property Damage and Life Loss by Year

Year	Reported Property Damage	Loss of Life
1996	4,996,000	1
1997	8,506,000	0
1998	88,570,000	7
1999	50,000	2
2000	939,000	0
2001	162,000	0
2002	1,214,000	0
2003	197,719,000	3
2004	84,453,000	2
2005	36,380,000	1
2006	19,437,000	1
2007	134,686,000	0
2008	722,000	0
2009	310,000	0
2010	1,450,000	2
2011	13,348,000	0
2012	397,000	1
2013	29,129,000	1
2014	26,217,000	0
2015	604,000	0
2016	122,000	0
2017	1,600,000	0

Table 7.3 - Other Flood Events Impacting the Muskingum River Basin[15]

Flood Date	Property Damage	Event Narrative
6-27-1998	5M	"Thunderstorms continued to move across Guernsey county on the 27th, bringing widespread flooding to the entire county. The town of Byesville was especially hard hit, as two cars were swept off the road in on the evening of the 27th, but both drivers were rescued. Thunderstorms continued on the 28th, forcing the closure of many roads across the county. Major flooding was reported in the town of Cambridge, as 9.71 inches of rain were recorded by the Cambridge cooperative observer from June 26th through 29th. Wills Creek at Cambridge crested at 26.92 feet at 6 PM EDT on June 29th, 14 feet above flood stage and nearly 2.5 feet above the previous flood of record. This flooding forced the evacuation of 2000 people in Cambridge alone. Of the estimated total damage across the county, around $14 million was in agricultural damage alone."
7-27-2003	52M	Thunderstorms dumped two to four inches of rain on Stark County during the early evening hours with the greatest amounts in the northern and central portions of the county. Rainfall rates peaked at more than two inches per hour and spotters measured nearly 3 inches of rain in Jackson Township between 5 and 7 p.m. For the day, 3.94 inches of rain fell at the Akron-Canton Airport just north of the Stark County line. A maximum of 4.50 inches of rain was measured in Louisville with 4.00 inches at both Massillon and in Lake Township… In Louisville, the worst flooding occurred in areas west of Broadway Avenue and north of Eastland Avenue with over 100 homes affected… In Canton, the worst flooding occurred along Mahoning Road NE between 9th and 12th Streets and in the Cook Park area. Most of the 300 people evacuated in the city lived in these neighborhoods. Hundreds of homes and business were affected by flooding in the city. A large factory located on Beldon Avenue sustained over $5 million in flood damages. Scattered areas of flooding and damage were also reported across the remainder of the county. Over 1,000 homes and 500 vehicles were damaged by flooding the county. At least three major bridges were washed out and damage to roads was over $3 million. Damage to homes and businesses in Canton alone topped $25 million."
1-1-2005	4.8M	"Heavy rain and runoff from snowmelt caused widespread flooding in Stark County the first half of January. January 2005 was the fifth wettest January ever at the Akron-Canton Airport with 5.62 inches of rain for the month… Major flooding also was reported along Little

[15] According to the National Climatic Data Center and NOAA's Satellite and Information Service

		Sandy and Sugar Creeks as a result of backups caused by record high water levels at reservoirs just south of the county line… Extensive flooding was also reported in Minerva, Navarre, East Sparta and Canal Fulton… All total, over a hundred homes were severely damaged by flooding with many hundreds more sustaining at least minor damage.”
8-21-2007	70M	“Heavy rain producing thunderstorms affected Richland County during the late evening hours of August 20th and early morning hours of August 21st. Rainfall rates with the strongest storms exceeded three inches per hour… Runoff from this rain combined with ground already saturated from earlier rains led to catastrophic flooding across portions of Richland County… Flood waters in some areas were as much as 8 feet deep. The Municipal Courthouse was a total loss and the Fire Department building was heavily damaged. Damage to city buildings in Shelby topped $1 million. Two schools in Shelby sustained an additional $1.5 million in damages… In Mansfield, flood waters heavily damaged the main Post Office on North Main Street. Water inside the building was up to 15 inches deep with flood waters in nearby parking lots as much as five feet deep. Areas surrounding the Post Office were also inundated… Dozens of business in the county were also damaged by the flooding. Most of these were along Main and North Gamble Streets in Shelby.”
5-12-2014	11M	“On the evening of May 12th a warm front tracking north over Lake Erie, reversed itself and moved back inland over northern Ohio. An organized convective complex with embedded supercells developed over north-central Ohio. Two confirmed tornadoes, one in Medina and the other in Lorain Counties, developed within this supercells. The slow movement of the storms combined with intense rainfall rates produced destructive flash floods across dozens of communities.”
4-9-2015	150K	“A cold front moving southeast from the eastern Great Lakes through the Upper Ohio Valley produced widespread showers and thunderstorms. Some of the thunderstorms were severe with damaging winds most commonly reported. The thunderstorms also produced torrential rainfall at times, with flash flooding reported across portions of eastern Ohio.”
1-12-2017	500k	“Heavy rainfall averaging 1.5-2.84 across the Nimishillen Creek basin resulted in major flooding in the Canton and Perry township areas. In all six homes were inundated displacing families. The river rose quickly along with its tributaries the East, West, and Middle Branches during the afternoon on the 12th. Water quickly

		surrounded apartment buildings in a low-lying area at the Gazebo Garden Apartments on Constitution Avenue in Louisville. About a dozen families were evacuated. The city parks in Canton were closed. In Perry Township two houses were surrounded by water off of Navarre Road SW. In Canton twenty families were evacuated from a mobile home park off Cleveland Avenue. The flood levels reached in this event were comparable with one in 2004 and 2011, yet due primarily to mitigation efforts the impacts were significantly less.”

7.2.2 Identified Flooding Issues

There are numerous factors which can contribute to flooding issues in a given river basin. These factors range from topography to land use to seasonal climate. Not all factors can be controlled or mitigated against entirely. However, it is helpful to have a general idea of what factors are contributing to continued flooding issues, in order to develop alternative plans and solutions to manage risk to downstream life and property.

During stakeholder involvement, efforts were made to identify both general flooding issues which are prevalent across the Basin, as well as critical, site specific areas which are often impacted during high water events. That is to say generally, flooding is an issue across the Basin, however, there are numerous areas which experience more frequent and damaging floods than others. General flooding issues are discussed below, while more specific flooding issues are discussed at the sub-basin level in subsequent chapters. It should be noted that this discussion is not exhaustive, and there may be other factors contributing to flooding issues which were not brought to light during the stakeholder involvement or study process.

The causes of flooding across the Basin are numerous. They include, but are not limited to: increased sedimentation in waterways, inadequate culverts and bridges, and upstream development which generates excessive runoff resulting in downstream out-of-bank flood flows. There is also a lack of stream and rain gages across the Basin.

7.2.2.1 Stream Sedimentation

The Muskingum River Basin changes dramatically in land use from north to south. The northern portion of the Basin is largely urban, with large metropolitan areas such as Akron and Canton, surrounded by smaller bedroom communities. However, the central and southern portion of the Basin are largely forested or utilized for agricultural purposes, combined with small cities and communities. For this reason, stream sedimentation tends to be a larger issue in the central and southern portions of the Basin.

Poor land management practices are typically responsible for sedimentation issues encountered downstream of agricultural land. These practices include cultivation encroachment on riparian zones and allowing grazing animals access to the streams. When the stream channel becomes clogged with sediment, there can be an increase in bank erosion and stream meandering, both of which contribute to not only flooding issues but also water quality issues.

7.2.2.2 Undersized Culverts and Bridge Abutments

Undersized culverts, constrictive bridge abutments and roadway embankments (including railroad bridges and crossings) can significantly contribute to flooding issues. Many of the bridges and culverts in the Basin are old, and constructed when areas were less developed. Consequently, they cannot accommodate the amount of flow generated during high water events. Increased development in urbanized areas leads to increased runoff, rendering many of the existing culverts and open channels between bridge abutments undersized. When these features are undersized flood levels upstream of the feature are increased due to the creation of a restriction in the stream. This can also lead to bank erosion and loss of floodplain as the restriction creates greater flow velocities and turbulence. These structures also gather stream-borne debris which further restricts channel flow and leads to further flooding and stream bank erosion.

7.2.2.3 Urban Growth and Development

Urban development has increased the frequency and severity of flooding in the northern portion of the Basin. Urbanization increases stream flow volume and the time to peak discharge is dramatically shortened resulting in flash flooding. As the land use within the area has transitioned from rural and/or agricultural to urban (urban sprawl), the Basin and its streams' responses to rainfall and snowmelt have changed dramatically.

Urban streams become unstable due to higher water volumes resulting in increased erosion of riparian zones. Armoring of the streams banks has reduced native vegetation which provide shade thus increasing stream temperatures. In less developed, rural areas, precipitation is absorbed and transpired by vegetation, infiltrated into the soil, and temporarily stored in surface depressions awaiting evaporation. However, in developed urban areas, where much of the land is covered by impermeable surfaces such as parking lots, roads and buildings, there is minimal infiltration or storage available. These surfaces do not store water, and they reduce infiltration and accelerate overland runoff. This often results in increased frequency and severity of out-of-bank flooding.

7.2.2.4 Debris and Log Jams

Debris and log jams are often cited as a cause of flooding. Stream obstructions such as woody vegetation and other debris may block a stream channel and create backwater pools. Many logjams form as a natural function, and provide beneficial stream structure, habitat for aquatic species and nutrient-rich sediment deposition on adjacent land. However, logjams also negatively impact drainage after high water events by taking up room in the stream channel which would otherwise be used for flood storage.

While flooding as a result of log jams tend to be small scale and localized, it can also cause significant damage to agricultural fields and structures built in low lying, flood prone areas. Due to slow drainage, log jams may also lengthen the duration of the flood event. Given the localized nature of flooding as a result of log jams, the removal of log jams is not an effective means of flood risk management during large scale, less frequent flood events.

7.2.2.5 Lack of Sufficient Rain/Stream Gages

The USGS and the USGS operate and maintain numerous rain and stream gages throughout the Basin. These gages are used to help manage USACE FRM projects, to advise local authorities about rising water and gather long term data on stream flow and precipitation. For these purposes, the majority of the gages are placed on major tributaries to the Muskingum River. However, during stakeholder engagement sessions several county and local representatives cited a lack of an appropriate number of precipitation/stream gages in their area to help inform emergency decision making during high water events. Many of these areas are located on a small tributary or in a sub-basin where there are no gages. The lack of gages makes it difficult to forecast flood conditions and proactively respond to flood threats. Increased warning time would allow residents and business owners to evacuate, relocate valuables, and pre-position emergency personnel, decreasing risk to life and property damages.

7.3 Water Quality

Water quality degradation is a common issue in all parts of the Basin. This became evident during the stakeholder engagement process, as research for the FWA/WMP was conducted and also from USACE's heavy involvement in the area. There are many potential causes of water quality degradation in any given river basin, both from point and non-point pollution sources. Point source pollution is more prevalent in developed areas, given the location of operations such as wastewater treatment plants and industrial complexes. Nonpoint source pollution is more common in undeveloped and agricultural areas.

The following sections describe pertinent laws, regulations and monitoring protocol regarding water quality, potential causes of water quality degradation, and future conditions with regard to water quality.

7.3.1 OEPA, the Clean Water Act and Total Maximum Daily Loads

7.3.1.1 Section 303(d) Total Maximum Daily Loads

US waters are threatened by different sources and types of pollution. Under the Clean Water Act (CWA), every state must adopt water quality standards to protect, maintain and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the goal of "swimmable/fishable" waters. Water quality standards are ambient standards as opposed to discharge-type standards. These ambient standards, through a process of back calculation procedures known as TMDLs or waste-load allocations form the basis of water quality based permit limitations that regulate the discharge of pollutants into the waters under the NPDES permit program.

Ohio's water quality standards, set forth in Chapter 372-1 of the Ohio Administrative Code (OAC), include four major components: beneficial use designations, narrative "free forms," numeric criteria, and anti-degradation provisions.

Streams not meeting state water quality standards are placed on the EPA's 303(d) Impaired Waters List. The OEPA lists reports of the Total Maximum Daily Loads for the Muskingum River Watershed. These reports list major sources of impairment as septic tanks, agriculture, acid mine drainage, and municipal waste water treatment plants.

Not all streams listed in the Muskingum River watershed have a TMDL in place. Pollutant sources are characterized as either a point source which receive a waste-load allocation or a nonpoint source that receive a load allocation. This would in turn allow for better decision making when resource agencies are issuing and managing water-related permits.

7.3.2 Section 402- National Pollution Discharge Elimination System

Storm water discharges are generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events. Storm water often contains pollutants in quantities that could adversely affect water quality. Most storm water discharges are considered point sources and require coverage by a NPDES permit under Section 402 of the CWA. In Ohio, the NPDES permit program is implemented by the Ohio Environmental Protection Agency (OEPA).

The primary method to control storm water discharges is through the use of Best Management Practices (BMPs). BMP is a term used to describe a type of water pollution control. Storm water BMPs are techniques, measures or structural controls used to manage the amount and improve the quality of the water runoff. The goal is to prevent these pollutants from entering the waterways because once the characteristics of the waterway has been altered it is more expensive and difficult to restore. Effective management of storm water runoff provides a multitude of benefits including: flood control, public health benefits, protection of water resources, including streams and wetlands, and overall water quality improvement.

7.3.3 Section 404- Discharge of Dredged and/or Fill Material

The Corps of Engineers is directed by Congress under Section 404 of the CWA to regulate the discharge of dredged and fill material into all waters of the United States, including wetlands. The intent of the law is to protect the nations' waters from the indiscriminate discharge of material capable of causing pollution and to restore and maintain their chemical, physical, and biological integrity. State Water Quality Certification (administered by OEPA) under Section 401 of the CWA is also required in association with the federal permit. Therefore, the discharge of dredged and fill material requires a permit from the Corps of Engineers and the State Water Quality Agency.

Applicants often must provide compensatory mitigation to offset unavoidable impacts due to the discharge of fill material into waters of the United States in order to obtain a permit. Compensatory mitigation in the form of Mitigation Banking, In-lieu Fee (ILF) mitigation, or Permittee responsible mitigation are forms of compensatory mitigation. Both Bank and ILF Sponsors must follow a defined process that is established by the 2008 Federal Rule on Compensatory Mitigation (33 CFR 332) to obtain an approved Instrument (procedural agreement).

7.3.4 Identified Water Quality Issues

As discussed above, there are numerous factors which can contribute to water quality degradation in a given Basin, and most of these are largely dependent on land use. As with issues pertinent to flooding, efforts were made to identify general water quality issues, as well as critical, site specific areas where water quality is a concern. General water quality issues are discussed here, while site specific water quality issues are discussed at the sub-basin level in subsequent chapters.

Also as with the discussion of flood issues, this discussion is not exhaustive, and there may be other factors contributing to water quality degradation which were not brought to light during the stakeholder involvement or study process.

7.3.4.1 Wastewater Management

The lack of adequate wastewater management is not an issue unique to the Muskingum River Basin, but was frequently mentioned as a topic of concern by local officials. The Muskingum River Basin is served by 149 Wastewater Treatment Plants (WWTPs), as shown below in **Figure 7.1**. Existing WWTPs are both aging, as well as operating at maximum capacity due to development in their service areas.

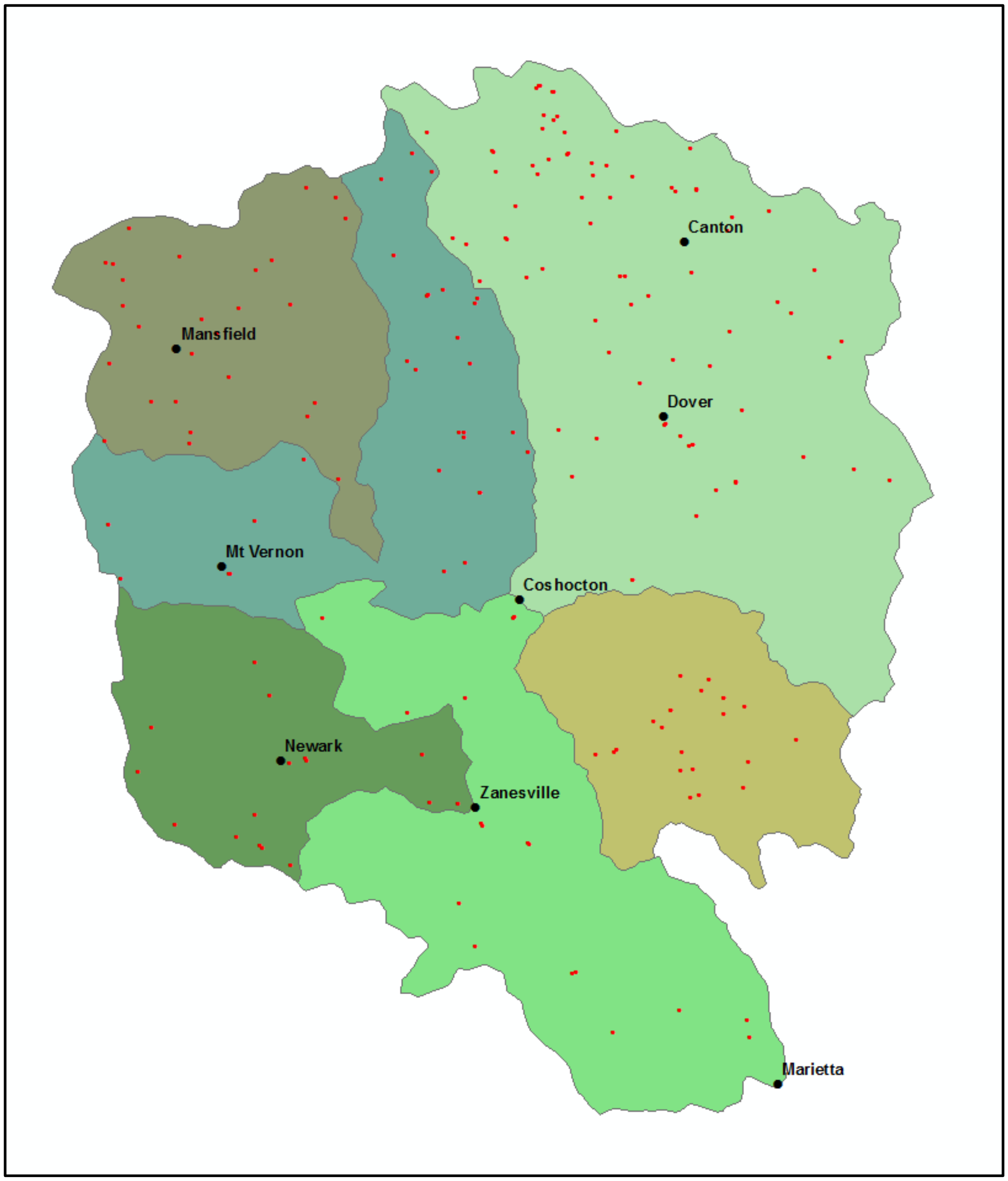


Figure 7.1 - Location of existing WWTPs in the Muskingum River Basin.

In 2014 the U.S. Environmental Protection Agency (EPA) released the updated "Recommended Standards for Wastewater Facilities." These standards include policies for the design, review and approval of plans and specifications for wastewater collection and treatment facilities. This plan covers 11 states including Ohio. The design criteria included in the Standards are intended for conventional municipal wastewater collection and treatment systems.

The concerns over WWTPs highlighted the need for upgrades to WWTPs across the Basin and the water quality issues related to threatened and failing WWTP components. Upgrades are necessary due to expanded urban and suburban development and fears the existing WWTPs may not meet current and/or future demands. Funding to complete the repairs and upgrades are usually a financial burden beyond what a small municipality is capable of paying, preventing them from making the repairs and upgrades on their own.

7.3.4.2 Water Quality Degradation as a Result of Failing Home Sewage Treatment Systems

Failing Home Sewage Treatment Systems (HSTSs) were discussed at nearly every stakeholder engagement session throughout the Basin. As evidenced by the land use data shown in Section 4.4, the majority of the Basin is not served by municipal sewer collection and wastewater treatment systems. The majority of the unserved Basin is located in rural and/or undeveloped areas where sewage is treated via HSTSs. These usually take the form of septic tanks with leach fields or aeration/digestion systems. In time and without adequate maintenance, these individual systems can fail to adequately filter effluent materials leading to a non-point source of largely untreated sewage entering streams and groundwater. Failing HSTSs were listed as a reason of impairment in six of the TMDL reports provided by OEPA.

There are no regulations for a schedule of inspections for these HSTSs, although efforts are underway throughout the Basin to address this issue. In the meantime, HSTSs are typically inspected when a home is built and whenever it is sold. However, if a home remains in a single owners hands for twenty or thirty years, the HSTS can go the same amount of time with no inspection.

OAC 3701-29-07 specifies requirements for construction of new septic systems, and OAC 3701-29-17 contains inspection requirements:

> *"(A) The health commissioner may at any reasonable time during the course of construction or any time thereafter inspect any household sewage disposal system or part thereof, sample the effluent, or take any other steps which he deems necessary to insure proper compliance with rules 3701-29-01 to 3701-29-21 of the Administrative Code (Ohio Sanitary Code). The health commissioner may utilize inspection reports or other data submitted or obtained from reliable sources to determine compliance.*

(B) No household sewage disposal system or part thereof shall be covered or put into operation until the system has been inspected and approved by the health commissioner."

If a septic inspection is conducted during original construction, and the system is not checked again for 10 or 15 years, owners may be unaware of damage (e.g., crushed or corroded pipes) or needed maintenance (e.g., clogged drain field or buildup of solid wastes in the tank).

If the HSTS is not working properly, it can leach pathogens (including bacteria, parasites, and viruses) into groundwater and nearby streams for long periods of time without notice. These pathogens can not only harm the aquatic habitat of species living in the water, but also impact terrestrial species which depend on the stream. Additionally, humans which come into contact with contaminated surface water may also become ill, exhibiting symptoms such as diarrhea, fever, gastritis and vomiting. Contaminated surface water is unsuitable for recreation such as swimming and fishing.

7.3.4.3 Agriculture and Water Quality

The USEPA states, "Agriculture has a greater impact on stream and river contamination than any other nonpoint source." Inappropriate cultivation techniques and improper grazing practices along riparian areas contribute to water quality issues such as increased sedimentation, nutrient loading, and streambank erosion. Cultivation practices which extend tilling to the edge of the stream channel virtually eliminate the riparian zone and remove any opportunities for filtering eroded soil, herbicides or pesticides that may be applied to crops or silage. These "non-point" pollution sources scattered through a watershed can affect miles of downstream aquatic habitat and water quality.

Animals have grazed along and around bodies of water for thousands of years; however, the original grazing animals were roamers such as bison, moose, and deer. Their intermittent use allowed riparian areas to re-grow following grazing periods. Today, however, the majority of grazers are domestic livestock (such as horses, cows, and sheep), which graze continually in the same area. Livestock congregate along streams, where temperatures are cooler and lush riparian vegetation grows — trampling the stream bank and overgrazing the surrounding vegetation. This continual-use pattern leaves no period of renewal and re-growth for the riparian areas. Further, livestock tend to stand in cool streams and ponds during hot weather, thus adding nutrients and pathogens to the water through feces and urine.

7.3.4.4 Acid Mine Drainage

Acid mine drainage (AMD) is polluted runoff from areas which have been mined for coal or other mineral ores. It often contains diluted sulfuric acid and high levels of heavy metals such as iron, aluminum and manganese. The water has low pH because of its contact with sulfur-bearing material and thus is harmful to aquatic organisms.

7.3.4.5 Oil and Gas Development

Oil and gas development is prevalent in Ohio, especially in the eastern Muskingum River Basin. Resource agencies and watershed groups voiced their concerns about impacts to water quality stemming from oil and gas development.

Hydraulic fracturing is the process of fracturing a rock layer by applying the pressure of fluid as a source of energy. Fracturing is accomplished by using a wellbore drill to bore into reservoir rock formations, with the objective of increasing extraction rates for oil, natural gas, or coal seam gas. Fluid-driven fractures are formed at depth in a borehole and extend into targeted formations. The fracture typically is held open after the injection by adding a "proppant" to the injected fluid. (Proppant is a particulate that prevents the fracture from closing when the injection stops.) Horizontal or directional drilling methods allow drilling to extend long distances from the original bore location, resulting in a larger affected area.

Due to its relatively recent implementation in the area, hydraulic fracturing lacks the strict regulations and permitting processes that accompany traditional oil and gas wells. For instance, EPA's Office of Water has jurisdiction over the waste disposal of flow-back fluids but limited jurisdiction over the fracturing fluids injected. The Energy Policy Act of 2005 went as far as to state "underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" are excluded from EPA jurisdiction. The uncertainty surrounding the hydraulic fracturing process has led many agencies to voice concerns over its potential impacts to basin water quality.

Many environmental and human health concerns are associated with hydraulic fracturing — chief among them is the risk of groundwater contamination. The potential costs associated with the environmental cleanup process are largely undetermined at this time. A 2010 EPA study found contaminants in drinking water (including arsenic, copper, vanadium, and adamantine) adjacent to drill operations. The report went on to list a broad range of potential sources, but noted hydraulic fracturing operations as a potential cause. Other concerns focus on the possibility that fracturing fluid (unregulated by the EPA) pumped under high pressure beneath the earth's surface may pollute aquifers and surface water, impact the rock shelf (causing seismic events), or lead to surface subsidence.

The enormous amount of water needed to complete the process — estimated to range from a few hundred thousand gallons to two million gallons per well — poses another concern. This amount of water taken from smaller water bodies could seriously jeopardize aquatic resources and surface water supplies for human consumption. Also, many people noted drillers transporting heavy drilling equipment may damage roads and surface resources, and fracturing may negatively impact private wells.

As previously mentioned, associated fluids (see **Table 7.4** below) remain largely unregulated by the EPA and have the potential to pollute aquifers and surface water.

Table 7.4 - Examples of Fluids Associated with Hydraulic-Fracturing Operations

Class	Purpose	Examples
Acid	Facilitates entry into rock formation	Hydrochloric acid
Breaker	Facilitates proppant entry	Peroxodisulfates
Clay stabilizer	Clay stabilization	Tetramethylammonium chloride
Corrosion inhibitor	Well maintenance	Methanol
Crosslinker	Facilitates proppant entry	Potassium hydroxide
Friction reducers	Improves surface pressure	Sodium acrylate, polyacrylamide
Gelling agents	Proppant placement	Guar gum
Iron control	Well maintenance	Citric acid, thioglycolic acid
Scale inhibitor	Prevention of precipitation	Ammonium chloride, ethylene glycol, polyaccrylate
Surfactant	Reduction in fluid tension	Methanol, isopropanol

7.3.4.6 Loss of Aquatic Habitat and Riparian/Wetland Areas

Stream and habitat modification as a result of urbanization, agricultural ditching practices, and channelization have resulted in a loss of aquatic habitat and riparian zones in the Basin. Many of the streams and water bodies in the Basin have been designated by the OEPA as Limited Resource

Water (LRW)[16]. Significant portions of the Basin have been classified as Modified Warmwater Habitat (MWH)[17]. Ditching[18] has long been a common practice in the north and northwestern portion of the Basin for the purpose of improving agricultural drainage. Channelization efforts and ditching have been performed to direct and convey water, consequently impacting habitat quality in many instances.

Riparian buffers are strips of grass, trees, shrubs, and other vegetation that thrive adjacent to streams, ditches, wetlands, and other water bodies. Riparian buffers consist of plant materials adapted to water-rich environments and contribute to the water detrital matter which is important for the aquatic food chain. These buffers benefit the environment by filtering nutrients from overland runoff, as well as intercepting and trapping contaminants from surface water and ground water. Riparian buffers provide important habitat and corridors for fish and wildlife, and ultimately help stabilize stream banks.

The primary source of lost riparian buffer in the Basin appears to stem primarily from agricultural land-use practices. Inappropriate cultivation techniques and improper grazing practices along riparian areas contribute to nonpoint source pollution. The overuse and misuse of the riparian zone leads to compacted soil, stream-bank failure, reduction in infiltration, increased surface runoff, erosion, sediments, and nutrient loading.

7.4 Stormwater Management

Stormwater management issues were mostly mentioned in the northern portion of the Basin in the more urbanized areas. There is a correlation between urban growth and the frequency and intensity of flooding. Increased urban expansion results in the placement of impervious surfaces, which is anything rain cannot penetrate. Examples of these include rooftops and driveways, parking lots, streets and sidewalks. As stormwater drains across these surfaces it is impacted in two ways. First, the quantity of the water is increased as there is nowhere for the water to infiltrate into the ground. Surface flow is then concentrated into a few locations due to surface grading. Secondly, the runoff picks up numerous pollutants (from contact with roads [vehicle and/or road maintenance residues] and structures). As previously discussed, these pollutants negatively impact the water quality of the receiving stream.

---

[16] The LRW is the lowest designation of biological integrity, which reflects poor and very poor habitats. In these habitats there is no potential for any aquatic life use due to natural background or irretrievable human-induced conditions.
[17] The MWH designation, per the Ohio Water Quality Standards, applies to extensively modified habitats which are capable of supporting the semblance of a warmwater biological community but which are still functionally and structurally deficient due to altered macrohabitat.
[18] Ditching is a way of irrigating or draining water from farmland.

7.4.1 Stormwater and Urban Flooding

Under natural conditions, absent developed land and impervious surfaces, the amount of runoff is less than 10% of the volume of rainfall from a vegetated site. Of the remaining rainfall approximately 50% seeps into the ground and 40% is evaporated[19]. In altered conditions, such as those found in urban areas, approximately 55% of the volume of rainfall flows quickly across impervious surfaces and is directed through storm sewers into nearby waterways. (See **Figure 7.2** below.) This can be costly to downstream communities, which must deal with the increased volume and velocity of floodwaters.

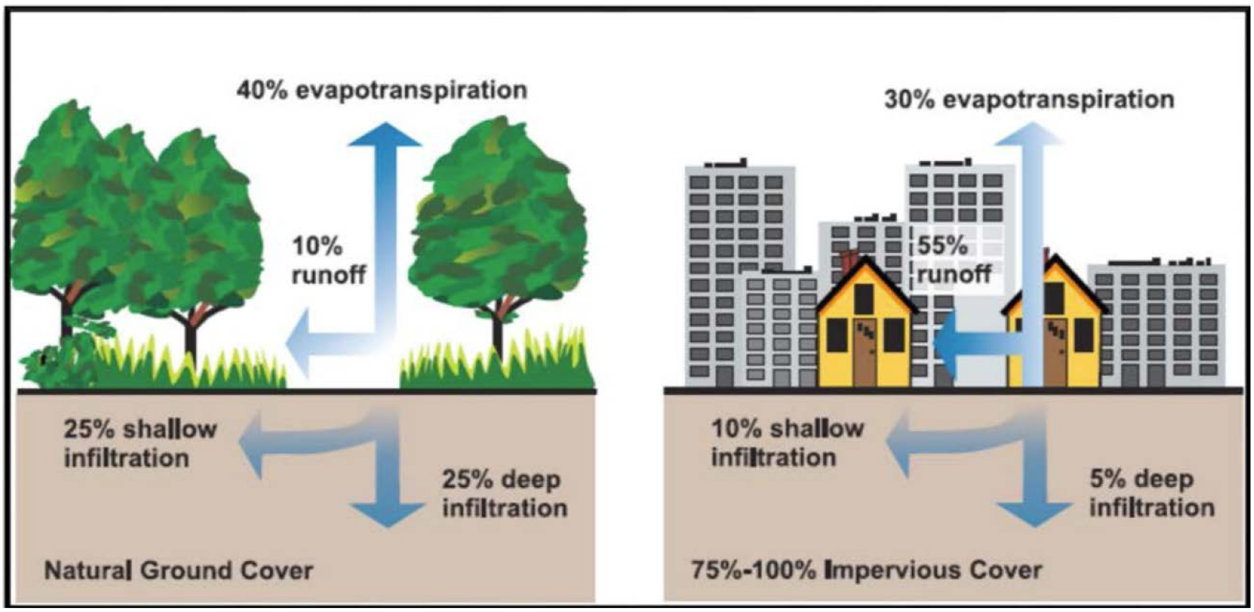


Figure 7.2 - Illustrations of Runoff on Natural Ground Cover vs. Impervious Cover[20]

7.4.2 Stormwater and Water Quality

As excess runoff flows across impervious surfaces it picks up many pollutants, including, but not limited to: fertilizers, bacteria, pathogens, animal waste, metals, vehicle fluids and oils. **Table 7.5** below shows some examples of the pollutants found in urban stormwater and their sources. These eventually end up in nearby streams, negatively impacting water quality.

[19] USEPA: Nonpoint Source Control Branch (2003). "Protecting Water Quality from Urban Runoff," EPA 841-F-03-003
[20] Source: USEPA

Table 7.5 - Pollutants in Urban Runoff[21]

Pollutant	Source
Bacteria	Pet waste, wastewater, collection systems
Metals	Automobiles, roof shingles
Nitrogen and Phosphorus	Lawns, gardens, atmospheric deposition
Oil and grease	Automobiles
Oxygen depleted substances	Organic matter, trash
Sediment	Construction sites, roadways
Toxic chemicals	Automobiles, industrial facilities
Trash and debris	Multiple sources

7.5 Watershed Education Needs

A common theme at all of the initial stakeholder engagement meetings was the need for watershed education amongst the general public. This need is not new, and many communities across the Basin are beginning to understand the importance of educating the public on the water resource issues discussed in this FWA and how these issues come together to contribute to the general health of a watershed or river basin. To that end, education efforts in the Basin should include information on watershed function, components of a healthy watershed, and balancing the competing needs of watershed users. Involving and educating the public on measures which communities and individuals can undertake to address water resource issues on a small scale can make a positive impacts in the long run, if individuals are willing to do their part.

7.6 Need for Repository of Regulatory Requirements Pertaining to In Stream Work

In addition to education on watershed function and management, the need for education on regulatory requirements pertaining to in stream work was universally identified at all stakeholder engagement meetings. Local officials, residents and business owners are often confused by the overlapping jurisdiction of Federal and state resource agencies, as well as what actions trigger the need for a permit.

7.6.1 Regulatory Permitting Process in the State of Ohio

The mission of the USACE Regulatory Program is to protect the Nation's aquatic resources, while allowing reasonable development through fair, flexible and balanced permit decisions. USACE evaluates permit applications for essentially all construction activities which occur in the Nation's

[21] Source: USEPA; Protecting Water Quality from Urban Runoff, Nonpoint Source Control Branch, EPA841-F-03-003, February 2003; and U.S. EPA, Report to Congress: Impacts and Control of CSOs and SSOs, Office of Water, EPA-833-R-04-001, August 2004.

waters, including wetlands. USACE has been given the authority under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the CWA of 1972.

Under Section 10, a USACE permit is required for work on structures in, over, or under navigable waters of the United States. Under Section 404, a USACE permit is required for the discharge of dredged or fill material into waters of the United States, which include streams and wetlands.

The Huntington District Regulatory program reviews proposed projects which may impact waters of the United States in a portion of Ohio, with field offices in Dover, Cincinnati, Columbus and Zanesville, Ohio. It should also be noted that projects on the Ohio River upstream of river mile 438 (West Virginia, Ohio and Kentucky) also fall within the Huntington District Regulatory boundaries.

8. Tuscarawas River Sub-Basin[22]

Figure 8.1 - Location of the Tuscarawas River Sub-Basin.

The Tuscarawas River Sub-Basin lies in the northwestern portion of the Basin as shown below in **Figure 8.1**. It is the largest of the six Sub-Basins, covering approximately 2,600 square miles. The Tuscarawas River is 130 miles long with four major tributaries which include Sandy Creek, Conotton Creek, Stillwater Creek and Sugar Creek. Its headwaters lie to the north and east of the Portage Lakes in northern Stark, Summit and Medina counties.

There are eight USACE FRM structures located within the sub-basin. These include Dover (located on the Tuscarawas River mainsteam); Bolivar (located on Sandy Creek); Leesville (located on McGuire Creek); Atwood (located on Indian Fork); Beach City (located on Sugar Creek); Tappan (located on Little Stillwater Creek); Clendening (located on Stillwater Creek); and Piedmont (also located on Stillwater Creek).

8.1 Tuscarawas River Sub-Basin Summary of Existing Conditions

The predominant land cover in the sub-basin is forest, agricultural land and urban development. Larger municipalities within the sub-basin include Barberton, Canton, Dover, Green, Massillon, North Canton, Norton, and Wadsworth, with respective populations shown below in **Table 8.1**. These cities and towns (and corresponding higher population densities) are located in the northern portion of the sub-basin. The metropolitan areas of Canton and Akron are located in the northern headwaters of the Basin in Stark and Summit Counties. Correspondingly, over half of the urban land use in this sub-basin is in these two counties. The southern portion of the sub-basin is much more rural.

[22] As the Tuscarawas River Sub-Basin is the most populated of the 6 HUC-8's within the Muskingum River Basin, there is substantially more information and data available pertaining to its history and development than there are the other sub-basins. For this reason, there is a greater level of detail incorporated into this analysis than for the other sub-basins.

Table 8.1 - Sizable Municipalities within the Tuscarawas Sub-Basin

Municipality	Population[23]
Barberton	26,120
Canton	71,323
Dover	12,843
Green	25,673
Massillon	32,258
New Philadelphia	17,462
North Canton	17,365
Norton	12,011
Wadsworth	23,136

In addition to many agricultural operations (discussed below), there is also a substantial oil and gas development presence in the sub-basin. Oil wells have been in production in this area since the late 1850's. Additionally several counties within the sub-basin lead the State of Ohio in coal production. These include Belmont, Harrison, Tuscarawas and Guernsey counties. Other mineral resources mined within the sub-basin include, but are not limited to, sand and gravel, salt, clay, and sandstone. Historical mining practices have a continued impact on water quality in the sub-basin today. This activity is not only economically important to the sub-basin but also impactful to water quality, including groundwater and surface water flow.

Water quality in the sub-basin has not only been adversely impacted by oil and gas development and mineral extraction. It has also been affected by the following sources: urban, suburban and rural agricultural activity, discharges from municipal and industrial wastewater treatment and to a lesser extent, thermoelectric power plants, and disposal of solid and hazardous wastes.

Wetlands, as mapped and cataloged by the USFWS are more abundant in the northern portion of the sub-basin. Notable wetland systems include Jackson Bog, Singer Lake Bog, Stillfork Swamp, Killbuck Marsh Wildlife Area, and Reifsnyder Wetlands. Stillfork Swamp is one of the largest inland marshes in Ohio, covering approximately 600 acres adjacent to Sandy Creek. The Killbuck Marsh Wildlife Area is owned by the ODNR and is the largest freshwater wildlife marsh in Ohio, covering approximately 5,500 acres. These wetlands provide valuable habitat for wildlife and a filter system for surface water.

[23] Unless otherwise noted, all population numbers in this report are from the 2016 census.

The Ohio and Erie Canal was constructed along the Tuscarawas River in the early 1800s and served the region until the spread of the railroad network in the 1850's. Today, these historic waterways are utilized for recreational purposes including hiking and biking.

8.2 Sub-Basin Water Resource Issues

8.2.1 Flooding

Flooding is a significant issue in the Tuscarawas River Sub-Basin. While there are several FRM projects located in the sub-basin, many streams remain uncontrolled. Flooding issues in the Muskingum River Basin were discussed above in previous chapters. Specific flooding issues and locations identified within the Tuscarawas River Sub-Basin are discussed in subsequent sections.

8.2.1.1 Stillwater Creek Watershed

The Stillwater Creek Watershed is located mostly in Harrison, Belmont, Guernsey and Tuscarawas Counties, with a small portion of the watershed in Carroll County, as shown below in **Figure 8.2**. Stillwater Creek is a major tributary to the Tuscarawas River. The land is mostly forested, pasture and hay lands, with some cultivated crops. Representatives attending the initial stakeholder meetings report repetitive flooding of homes and roads in the watershed. Road flooding has a negative impact on deployment of emergency vehicles and personnel during high water events, preventing first responders from assisting those in need.

Figure 8.2 - Stillwater Creek Watershed.

8.2.1.2 Barberton/Norton/Copley

The Barberton/Norton/Copley township area is located in Summit County (see **Figure 8.3** below), at the very northern border of the Muskingum River Basin, in the headwaters of the Tuscarawas River. The approximately populations of these areas are as follows, respectively: 26,500, 12,000 and 13,600. These municipalities are unique in the way they work together to solve problems holistically and as such, USACE has worked with them collectively to solve water resource issues.

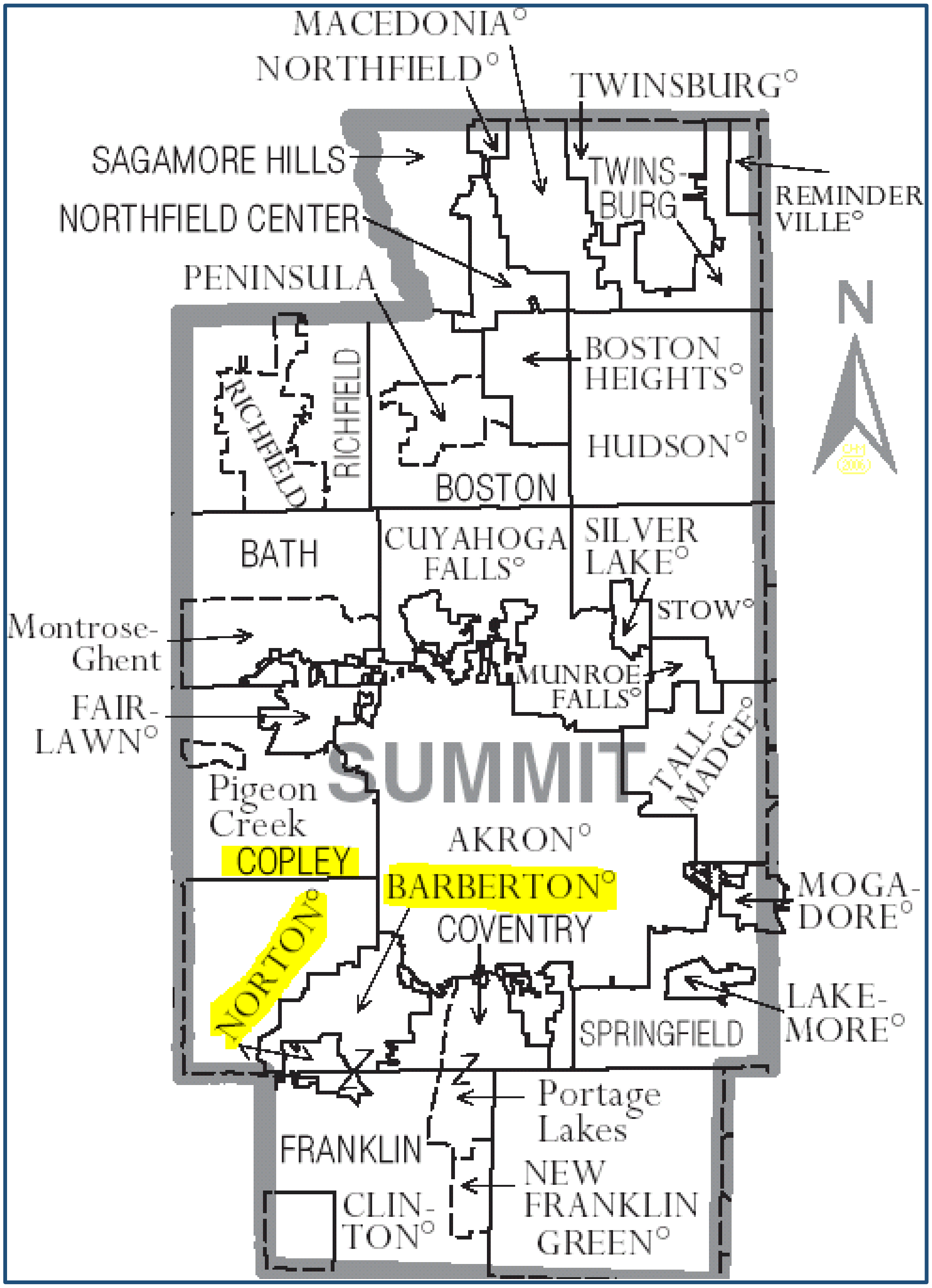


Figure 8.3 - Location of the Villages of Barberton and Norton and Copley Township.

This area experiences substantial, repetitive flooding, including damages to residential, commercial and public property, as well as emergency access delays for first responders.

A FWA for the Headwaters Tuscarawas Watershed was originally recommended in the Section 729 Muskingum River Basin IWA. Since that time local officials have worked towards forming a stand-alone conservancy district to allow them to cost-share with USACE for this work. They have submitted a Letter of Intent (LOI) to Huntington District expressing interest in participating in a Section 205 Flood Damage Reduction study to focus on the "Little Farms" area, which is where most of the flood impacts occur.

8.2.1.3 Louisville, Ohio

The City of Louisville is located in Stark County (see **Figure 8.4** below) in the northern part of the Basin. The City has a population of approximately 9,356 as of the 2016 census. It is part of the Canton-Massillon metropolitan statistical area. City officials note significant flooding issues stemming from heavy rain events (three to four in the last few years), increasing in both intensity and duration. Most of the flooding stems from the East Branch of Nimishillen Creek.

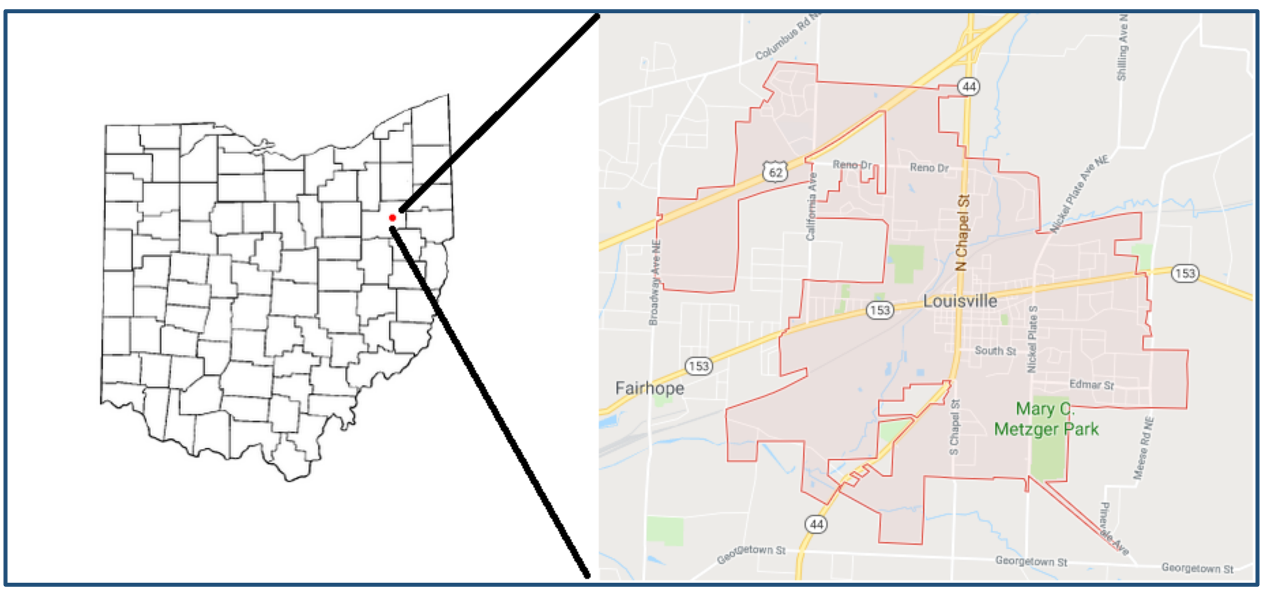


Figure 8.4 – Location of the City of Louisville.

8.2.1.4 Massillon, Ohio

Massillon is located in Stark County (see **Figure 8.5** below), in the northern most part of the Basin. The City has a population of approximately 32,000 as of the 2016 census. Massillon is largely urbanized, and home to the headquarters of businesses such as Campbell Oil and Midwestern Industries. Among the water resource issues related to flooding mentioned by representatives at stakeholder involvement session include sedimentation in the Tuscarawas River, and ponding areas associated with pump stations holding water year round.

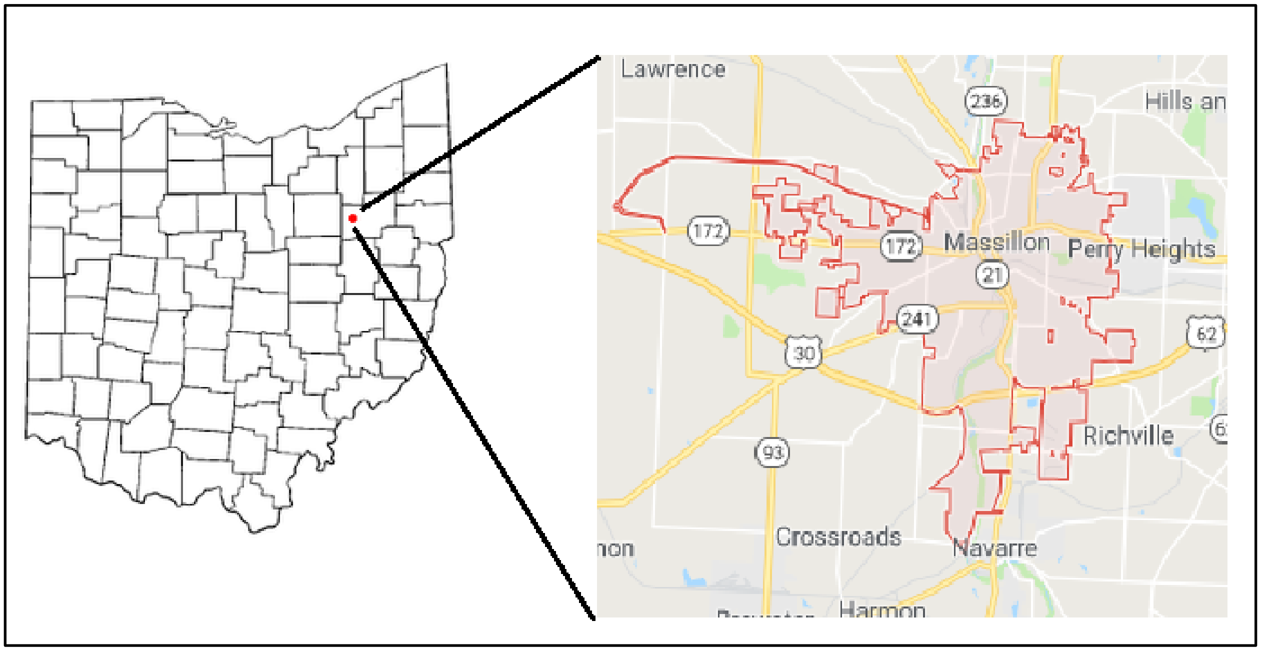


Figure 8.5 – Location of the City of Massillon.

The Third Century Committee and City representatives met with USACE representatives in March of 2016 to discuss problems and opportunities to improve the riverfront within the city limits. At the meeting, stakeholders expressed interest in removing what they referred to a low-head dam in conjunction with narrowing the channel by creating a "channel within a channel" to provide for channel depths sufficient for recreational crafts such as kayaks and canoes, and allowing the channel to return to a more sinusoidal natural state. The low-head dam referenced by the Committee is a component of the flood control project constructed by the Corps of Engineers. This component is a weir encasing a pipe, which was placed across the stream to address interior drainage and grade control. At the time of construction, the grade control weir was more cost effective than building a second pump station. The function of the weir in transporting flood water as well as its function as a grade control structure that prevents additional head-cutting upstream that would cause the de-stabilization of the levee toe and endanger the stability of the Local Protection Project. The project could be modified through the Section 408 process at the expense of a non-Federal entity (for more information on the Section 408 program, see Appendix E). Some of the alternatives to removing the weir discussed were: a hydraulic ladder, bypass canal, and additional pump station on the left descending bank of the channel. Interest in deepening the channel to allow sufficient water depth for recreational use was also raised. While dredging is one alternative for deepening the river, dredging typically only provides a short term solution to stream congestion. Depending on influent sediment loading, sediment will usually accrue within the waterway over the course of a few months or years following the dredging project.

At the downstream extent of the LPP, the Committee expressed interest in developing an area currently being used as a temporary pipe lay-down area. Within this area, opportunity for ecosystem restoration and recreational development exists. USACE could assist with this process via the Section 206 program (for more information on the Section 206 program, see Appendix E). Potential measures include wetland establishment, plantings to provide shade to the stream, and bio-stabilization technics to improve in-stream habitat. River access could be provided and an educational component discussing the plants, importance of aquatic ecosystem restoration, and history of the canal system could be incorporated as part of the project.

In addition to aquatic ecosystem restoration opportunities under the Section 206 authority the Corps also has the ability to provide planning services through the Planning Assistance to States (PAS) program (for more information see Appendix E). If the Committee would be interested in developing a given area for recreational use or other water resource related purposes, the Corps may help with alternative analysis and conceptual level designs.

8.2.1.5 New Franklin, Ohio

The City of New Franklin is located on the southern edge of Summit County (see Figure 8.6 below), also in the northern part of the Basin. As of the 2016 census, the population was approximately 14,149. New Franklin is a mostly rural community and home to Portage Lake State Park. Officials report significant flooding issues they believe are caused by the channelization of the Tuscarawas River in their area. They are interested in the utilization of oxbows for flood storage.

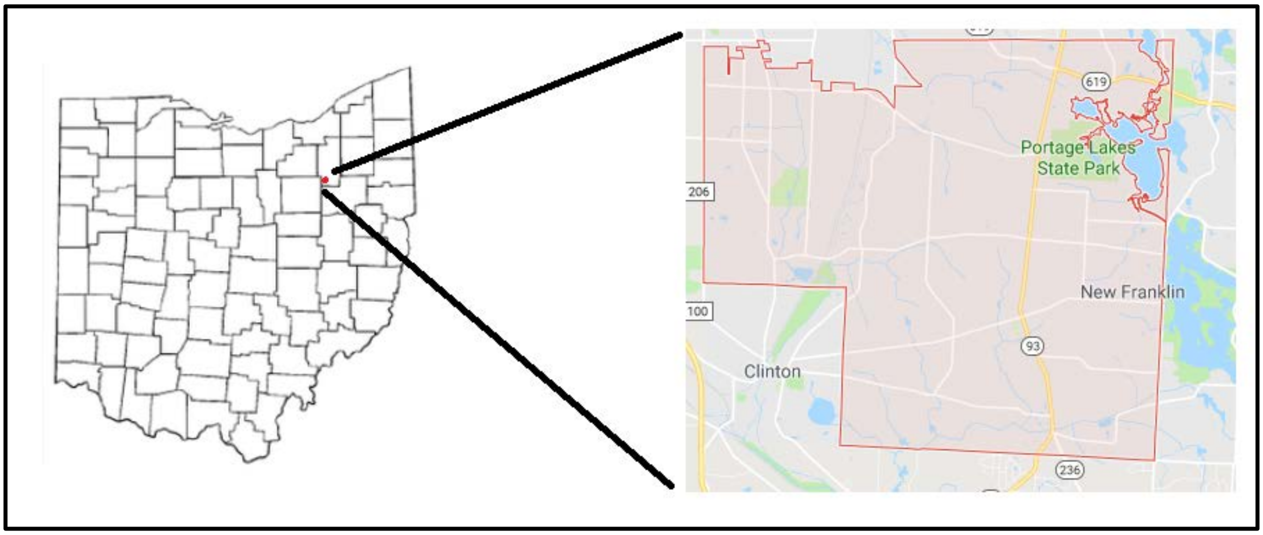


Figure 8.6 – Location of the City of New Franklin.

8.2.1.6 Wadsworth, Ohio

The City of Wadsworth is located in Medina County (see Figure 8.5 below), also in the northern part of the Basin. As of the 2016 census, the population was approximately 23,000. Wadsworth is a mostly urban area, considered a bedroom community to Akron. Stakeholders from this area report mostly localized flooding they believe could be remedied by the removal of a low-head dam.

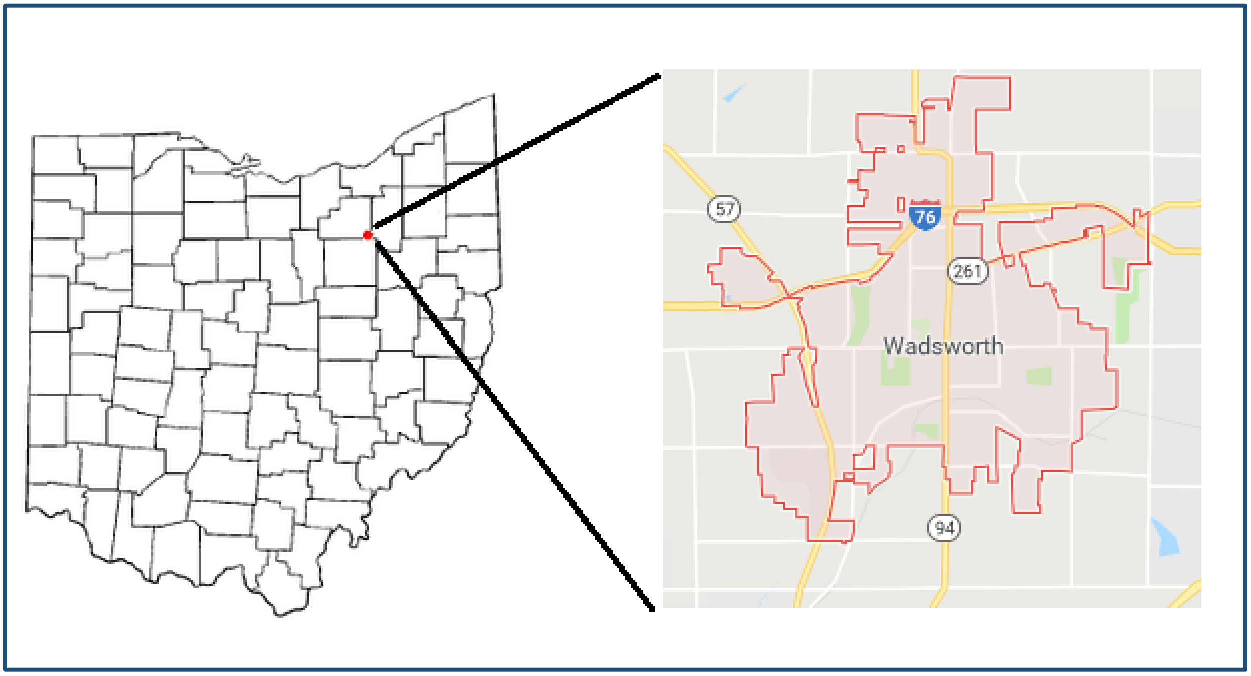


Figure 8.7 – Location of the City of Wadsworth.

8.2.1.7 Clinton, Ohio

The Village of Clinton is located in the southeastern portion of Summit County. The Village had a population of 1,229 as of the 2016 census. Officials from the building report repetitive flooding they believe is due to stream sedimentation.

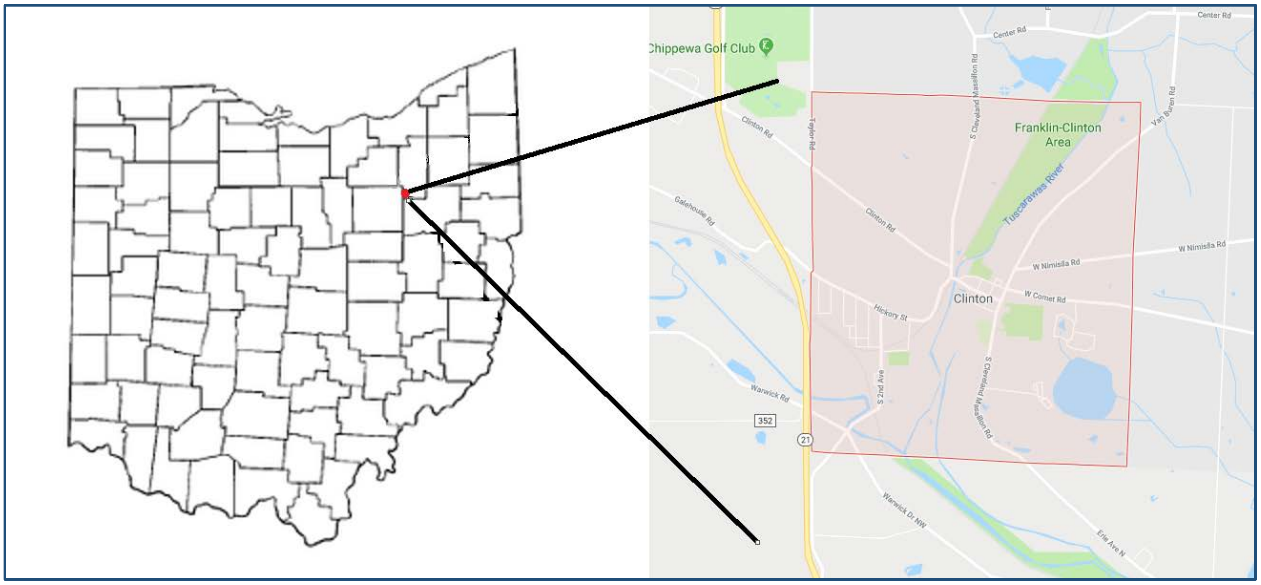


Figure 8.8 – Location of the Village of Clinton.

8.2.2 Water Quality

Previous studies of water quality in the sub-basin have been completed by the Ohio Department of Health, the Ohio Water Pollution Control Board (in conjunction with the Ohio Department of Healthy) and the ODNR. These studies, dating back to as early as 1958 document water quality issues relating to municipal and industrial waste, organic pollution and chloride contamination from salt mining and chemical processing. In more recent years, studies completed by organizations such as ODNR, OEPA, and USEPA indicate degraded water quality as a result of agricultural and mining practices and chemical spills. Pollutants present in the water include nutrients, metals, chloride, and numerous organic compounds.

There are several critical areas of concern with regard to water quality located within the sub-basin, however these areas different dramatically when comparing land development. The Sugar Creek Watershed, which is mostly rural is discussed below.

8.2.2.1 Sugar Creek Watershed

The Sugar Creek Watershed lies in the north central portion of the Muskingum River Basin, in Wayne, Stark, Holmes and Tuscarawas County, as shown below in **Figure 8.9**. The watershed covers approximately 360 square miles. The majority of the land in the watershed is in agricultural production (70%), including: Dairy, beef and poultry confined feeding operations, row crops and forage production. There are small pockets of urban, commercial and residential development.

Figure 8.9 - Sugar Creek Watershed.[24]

The OEPA has completed two TMDL projects for this watershed: Aquatic Life Use and Recreation Use in 2002 and 2007, respectively[25]. In the Aquatic Life Use TMDL, the OEPA notes the Sugar Creek Watershed is one of the most degraded basins in Ohio. It also states, "The most significant causes of aquatic life habitat impairment in the Sugar Creek basin [sic] are sediments/siltation, habitat alteration and nutrient enrichment." The most significant factors contributing to degraded water quality in the sub-basin is sedimentation from agricultural activities and streambank erosion.

8.2.3 Stormwater Management

As previously mentioned, stormwater management is a significant water resource issue affecting the urbanized and developing areas of the Basin. Within the Tuscarawas River Sub-Basin the municipalities which are particularly struggling with this issue include Carroll and Tuscarawas Counties, as well as the Village of Dennison.

[24] Figure source: OEPA
[25] The OEPA released a study plan for the "Biological and Water Quality Study of the Sugar Creek Watershed" in June 2013, and an updated TMDL is being developed.

8.2.3.1 Stormwater Management in Carroll County

Figure 8.10 - Location of Carroll County.

Carroll County (see **Figure 8.10** to the left) is located in the eastern portion of the Basin. As of the 2016 census, it had a population of approximately 27,500. The county is largely undeveloped, with forested and agricultural lands making up most of the land use. There are no cities in the county. The county seat is the Village of Carrollton, with a population of approximately 3,100.

Even though the county is mostly undeveloped, it is still part of the Canton-Massillon Metro-political area, meaning it may experience development in the future as the Canton-Massillon area continues to expand. County officials are not so much concerned about existing stormwater management issues as they are being prepared for future issues in the event of expanded development. Currently, there are no stormwater management plans on record for any of the municipalities within the county.

8.2.3.2 Stormwater Management in Tuscarawas County and the Village of Dennison

Tuscarawas County (see **Figure 8.11** below) is located in the north central portion of the Basin. Land cover is split between forested and agricultural, with pockets of sizable urban development. The most sizable developed areas in the County are the Cities of Dover, New Philadelphia and Urichsville.

Figure 8.11 - Location of Tuscarawas County.

During stakeholder engagement, Tuscarawas County (including the Village of Dennison) was repeatedly mentioned as an area which deals with stormwater management issues. The Cities of Dover and Urichsville, as well as the Village of Dennison) do not have codified stormwater management plans. The City of New Philadelphia's ordinances mention only the stormwater detention pond at Tuscora Park, with no mention of other off-site stormwater management measures.

8.3 Recommendations for the Tuscarawas River Sub-Basin

The following are recommended solutions related to the specific water resource issues identified within the Tuscarawas River Sub-Basin.

8.3.1 Flood Risk Management Recommendations for the Tuscarawas River Sub-Basin

1. Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of Flood Warning System (FWS)/Flood Warning Emergency Evacuation Plans (FWEEP) for communities within the Stillwater Creek Watershed, the municipalities of Barberton, Norton and Copley Township.
2. Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.
3. For areas experiencing growth and development, utilize green infrastructure to promote faster infiltration of stormwater runoff.

4. Develop a H&H Model for the Stillwater Creek Watershed.
5. Initiate a Section 205 Flood Damage Reduction study for the Barberton/Norton/Copley area.
6. Utilize the FEMA Hazard Mitigation Grant Program (HMGP) for the acquisition of repetitive damage structures. This land may then be managed as "green space," which will assist with the restoration of floodplain/wetland connectivity mentioned above.
7. In Massillon, develop detention structures which would allow for the slow release of floodwater, allowing for downstream flood risk management and reduction of sedimentation in the Tuscarawas mainstem.
8. Initiate a Section 206 Ecosystem Restoration Project to address the removal of the low-head dam on the Tuscarawas River at Massillon.
9. Initiate a Section 206 Ecosystem Restoration Project at Wadsworth, Ohio to address the removal of a low head dam with the goal of reduce downstream flood damages.
10. Initiate a Section 206 Ecosystem Restoration Project at the downstream extent of the existing Massillon LPP.

8.3.2 Water Quality Recommendations for the Tuscarawas River Sub-Basin

While all of the recommendations made below should be implemented across the sub-basin, particular emphasis should be placed on the implementation of these recommendations in the Sugar Creek Watershed.

1. Restore and enhance water quality by stabilizing stream banks and reducing sediment yield.
2. Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.
3. Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients.
4. Engage in extensive BMP education among agricultural producers in the sub-basin.
5. Utilize conservation practices on agricultural land.
6. Implement all recommendations made in the updated version of the TMDL for the Sugar Creek Watershed.

8.3.3 Stormwater Management Recommendations for the Tuscarawas River Sub-Basin

1. Utilize green infrastructure to increase infiltration of stormwater. This would especially be helpful in developing areas associated with the Canton-Massillon Metro-political area.
2. Develop and/or update stormwater management regulations in the municipalities of Dover, Urichsville, New Philadelphia and Dennison.
3. Develop a biorention basin for the City of Dover.
4. In the municipalities of Dover, Urichsville, New Philadelphia and Dennison, utilize the EPA's Stormwater Management Model (SWMM) to help understand the stormwater cycle and formulate management measures to mitigate for its impacts.

8.4 Screening Measure Criteria

These recommendations have been initially screen based on the study constraints, professional judgment, input from stakeholders to focus specifically on those which will contribute towards meeting the study objectives. The measures screening criteria included relevance to the shared vision statement, relevance to identified water resource issues, likelihood of implementation and complexity, and overall impact to the Basin.

8.5 Prioritization of Recommended Strategies for the Tuscarawas River Sub-Basin

The initial array of recommendations was further refined based on the screening criteria described above, with specific emphasis on availability of potential leads for actions and the biggest impact on the sub-basin, as well as stakeholder input. Consideration was given to those which met study objectives and had a high likelihood of implementation.

Table 8.2 - Flood Risk Management Recommendations

Recommendation	Potential Lead for Action
Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for communities within the Stillwater Creek Watershed, the municipalities of Barberton, Norton and Copley Township.	USGS, National Weather Service (NWS), NOAA, Local Municipalities
Develop a H&H Model for the Stillwater Creek Watershed.	FEMA, USACE, USGS, Local Municipalities
Utilize the FEMA HMGP for the acquisition of repetitive damage structures. This land may then be managed as "green space," which will assist with the restoration of floodplain/wetland connectivity mentioned above.	FEMA, Local Municipalities
Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.	USACE, The Nature Conservancy (TNC), Local Municipalities
For areas experiencing growth and development, utilize green infrastructure to promote faster infiltration of stormwater runoff.	U.S. Forest Service, EPA, USACE, Local Municipalities
Initiate a Section 205 Flood Damage Reduction study for the Barberton/Norton/Copley area.	USACE, Local Municipalities
In Massillon, develop detention structures which would allow for the slow release of floodwater, allowing for downstream flood risk management and reduction of sedimentation in the Tuscarawas mainstem.	USACE, Natural Resources Conservation Service (NRCS)
Initiate a Section 206 Ecosystem Restoration Project at the downstream extent of the existing Massillon Local Protection Project (LPP).	USACE, Local Municipalities
Initiate a Section 206 Ecosystem Restoration Project to address the removal of the low-head dam on the Tuscarawas River at Massillon.	USACE, Local Municipalities
Initiate a Section 206 Ecosystem Restoration Project at Wadsworth, Ohio to address the removal of a low head dam with the goal of reduce downstream flood damages.	USACE, Local Municipalities

Table 8.3 - Tuscarawas River Sub-Basin Flood Risk Management Recommendations

Recommendation	Potential Lead for Action
Implement all recommendations made in the updated version of the TMDL for the Sugar Creek Watershed.	TBD
Engage in extensive BMP education among agricultural producers in the sub-basin.	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients.	USACE, NRCS, OEPA, Local Municipalities
Utilize conservation practices on agricultural land.	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Restore and enhance water quality by stabilizing stream banks and reducing sediment yield.	Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers

Table 8.4 - Tuscarawas River Sub-Basin Stormwater Management Recommendations

Recommendation	Potential Lead for Action
In the municipalities of Dover, Urichsville, New Philadelphia and Dennison, utilize the EPA's SWMM to help understand the stormwater cycle and formulate management measures to mitigate for its impacts.	Local Municipalities
Develop and/or update stormwater management regulations in the municipalities of Dover, Urichsville, New Philadelphia and Dennison.	Local Municipalities
Utilize green infrastructure to increase infiltration of stormwater. This would especially be helpful in developing areas associated with the Canton-Massillon Metro-political area.	Local Municipalities
Develop a biorention basin for the City of Dover.	USACE; Local Municipalities

9. Mohican River Sub-Basin

Figure 9.1 - Location of the Mohican River Sub-Basin.

The Mohican River Sub-Basin covers approximately 1,000 square miles in the northwestern portion of the Basin as shown to the left in **Figure 9.1**. The major tributaries of the Mohican River include Clear Fork, Black Fork, Jerome Fork and Muddy Fork. The mainstem runs south to its confluence with the Kokosing River to form the Walhonding River near Loudonville in Ashland County. It should be noted the Mohican River Sub-Basin is uncontrolled in terms of FRM structures.

9.1 Mohican River Sub-Basin Summary of Existing Conditions

Land cover in the sub-basin consists mostly of cultivated crops, forest, pasture and hay-land. Only 11% of the sub-basin is developed. Counties either fully or partially within the sub-basin include Ashland, Crawford, Knox, Morrow, Richland, and Wayne. Within these counties sizeable municipalities include Mansfield, Ontario, Ashland and Shelby (see **Table 9.1** below).

Table 9.1 - Sizable Municipalities within the Mohican River Sub-Basin

Municipality	Population
Ashland	20,489
Mansfield	46,678
Ontario	6,079
Shelby	9,030

Agricultural practices account for the predominant land usage in the Basin. Unlike the Tuscarawas River sub-basin there is relatively little mineral extraction, and virtually no oil and gas development.

In terms of water quality, a significant portion of the sub-basin is meeting the biological goals of the CWA with 67% fully attaining, 16% partially attaining and 17% in non-attainment. The primary sources of impairment are bacteria from failing HSTSs and agricultural practices and nutrients, sediment and habitat alterations associated with agriculture, impoundments and urban land uses.

The Mohican River and its tributaries are heavily used for recreation purposes. As of December 2006, two segments of the Mohican River are designated as "scenic." These areas (totaling 32.3 miles) include the Clear Fork from outflow of Pleasant Hill Dam to its confluence with the Black Fork, and the entire main stem of the Mohican River from its confluence with the Clear Fork to the confluence with the Kokosing State Scenic River.

Wetlands, as mapped and cataloged by the U.S. Fish and Wildlife Service (USFWS) are more prevalent in the northern portion of the sub-basin. The most notable concentration of wetland occurs on the Black Fork of the Mohican River, upstream and downstream of Charles Mill Dam in Bloomington Township. As previously stated, these wetlands provide valuable habitat for wildlife and a filter system for surface water.

9.2 Mohican River Sub-Basin Water Resource Issues

9.2.1 Flooding

While there are several FRM projects located in the sub-basin, many of the streams remain uncontrolled. Specific flooding issues within the Mohican River Sub-Basin are concentrated in Richland County, as described below.

9.2.1.1 Richland County

Figure 9.2 - Location of Richland County.

Richland County is located (see **Figure 9.2** to the left) in the northwestern portion of the Basin and as of the 2016 census had a population of approximately 121,000. The cities of Shelby, Bellville and Mansfield all report repetitive flooding issues. In addition to the necessity of rooftop rescues, there have been several fatalities associated with these events. Road closures are also a significant issue during high water events. Officials report high water impacting emergency personnel access on Routes 30, 97, 96, 71, 42 and 13.

Local officials attending the stakeholder involvement meetings voiced the following specific concerns about the Village of Bellville:

- Growing urban development has increased the amount of impervious surfaces placed throughout the village, which has induced stormwater runoff issues (discussed in greater detail in subsequent chapters); and
- An additional 40 homes began to experience flooding issues after the removal of an abandoned railroad track.

There have been several efforts to study and address flooding issues in Richland County, which specific emphasis on the Bellville, Shelby and Mansfield areas. First, the City of Shelby has experienced severe floods throughout the years with recent flooding in 1987 and 2007 resulting in the downtown area being inundated and significant flood damages occurring to commercial and private structures. The USGS estimated the peak discharge for both these floods using indirect determination of discharge methods to assess the magnitude of these events. For both floods, the recurrence intervals were estimated to be in excess of a 500-year flood.

In May of 2011, MWCD's Board of Directors, at the request of Shelby officials, re-activated the Black Fork Subdistrict for the purpose of preparing an Official Plan, as required by the Ohio Revised Code, to address flooding within the Black Fork watershed and within the City of Shelby. The Board of Directors requested that as part of the formulation of an Official Plan, MWCD is to:

- Identify and characterize the flooding problem(s)
- Outline possible solutions
- Perform a cost/benefit analysis for solution implementation

Hydraulic and hydrologic analyses have been performed by USGS along with a HEC-HMS model of the study area. This model was then provided to EMH&T, Inc., Columbus, for use in preparing flood mitigation strategies. Strategies are currently being finalized which focus upon hydraulic improvements to the Black Fork and select tributaries along with detention using dry-dams upstream of Shelby.

Secondly, flooding has been a recurring theme along the Clear Fork of the Mohican River in Richland County. Though attempts have been made in the past to solve these flooding issues, a solution has never materialized. In July 2013, State Representatives hosted a meeting in Mansfield to discuss flooding issues and invited numerous Richland County officials and stakeholders. MWCD and the USACE participated in this meeting as well and provided presentations relating to each organization's flood mitigation programs and associated legal authorities.

Following the 2013 meeting, MWCD was contacted by local officials to learn more about conservancy district law and how it might assist with their flooding problems. To that end, several meetings were held in Bellville between MWCD officials and representatives from the villages of Bellville, Butler, and Lexington, the cities of Mansfield and Ontario, and also township officials and representatives from Richland SWCD. Officials from the City of Shelby also attended these meetings on behalf of the previously mentioned Black Fork Subdistrict of MWCD.

In February 2014, the Village of Bellville passed an ordinance requesting the creation of a Clear Fork Subdistrict of MWCD. Following that meeting and MWCD Board of Directors approval, the Conservancy Court of MWCD approved the creation of the Clear Fork Subdistrict. As with the Black Fork Subdistrict, the MWCD Board of Directors requested as part of the formulation of an Official Plan, MWCD is to:

- Identify and characterize the flooding problem(s)
- Outline possible solutions
- Perform a cost/benefit analysis for solution implementation

Additionally, hydraulic and hydrologic analyses are being performed by USGS along with a HEC-HMS model of the study area. The study is anticipated to be completed in September 2018.

Finally, the City of Mansfield has completed a flood damage reduction study in response to more frequent and intense flooding in the downtown area. Specifically, multiple floods projected to have been equivalent to the "100-year" (1% annual exceeded probability) have occurred since 2008. EMH&T developed a plan focusing on Touby Run which would include the construction of two upstream detention basins on the City's north side. The City is in the process of securing funding for construction.

9.2.2 Water Quality

The only site specific water quality concern identified in the Mohican River Sub-Basin is the Chippewa Creek (discussed below). This is not entirely unexpected, given water quality within the Mohican River sub-basin is not as bad (comparatively) as water quality in the other sub-basins within the larger Muskingum River Basin. However, water quality issues are discussed to support recommendations made below for the sub-basin in general.

Several studies on water quality within the Mohican River Sub-Basin have been completed in past years. The most pertinent of these include OEPA's *Biological and Water Quality Study of the Mohican River and Selected Tributaries* (2007), *OEPA's TMDL Report for the Mohican River Watershed* (2010), and OEPA's *Water Quality Report Issued for Mohican River Watershed* (2014). All of these studies point to failing HSTS, agricultural practices, impoundments and urban land use as being the most common sources of water quality impairments, as discussed above. These sources result in habitat and flow alterations, organic enrichment, dissolved oxygen, sedimentation and turbidity.

9.2.2.1 Chippewa Creek Watershed

The Chippewa Creek Watershed covers approximately 120,320 acres in Medina, Wayne, Summit and Stark Counties. The water quality concerns within this watershed center around Harmful Algal Blooms (HABs) and impacts from heavy channelization. HABs are overgrowths of algae which produce dangerous toxins in both fresh and salt water. These toxins may create dead zones in water where aquatic life cannot survive, negatively impact drinking water supplies, and make water unsuitable for recreational uses. HABs are often caused by sunlight, slow moving water and high levels of nutrients such as nitrogen and phosphorus.

Channelization within the watershed is a result of a 1950's flood control program undertaken by local citizens in partnership with the MWCD with the goal of reducing acreage prone to flooding and decreasing the inundation period after high water events.

9.2.3 Stormwater Management

Stormwater management issues occur in developed areas. As so little of the Mohican River Sub-Basin is developed, there were relatively few stormwater management issues identified during stakeholder engagement. However, local officials from Bellville cite concerns that urban development has increased the amount of impervious surfaces placed throughout the village, which as induced stormwater runoff issues.

9.3 Recommendations for the Mohican River Sub-Basin

The following are recommended solutions to the water resource issued identified within the sub-basin.

9.3.1 Flood Risk Management Recommendations for the Mohican River Sub-Basin

1. Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for the municipalities of Bellville, Shelby and Mansfield.
2. Utilize the FEMA HMGP for the acquisition of repetitive damage structures, with specific emphasis on the Village of Bellville. This land may then be managed as "green space," which will assist with the restoration of floodplain/wetland connectivity mentioned above.
3. Support the recommendations of the Officials Plans of the Black Fork and Clear Fork Subdistricts once they are completed.

9.3.2 Water Quality Recommendations for the Mohican River Sub-Basin

1. Expand wastewater and sewage treatment in the sub-basin.
2. Repair and/or replace failing HSTSs.
3. Implement agricultural BMPs to address nutrient, bacteria and sediment runoff
4. Utilize conservation practices on agricultural land.

5. Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.

9.3.3 Stormwater Management Recommendations for the Mohican River Sub-Basin

For the Village of Bellville:

1. Utilize green infrastructure to increase infiltration of stormwater.
2. Develop and/or update stormwater management regulations.
3. Utilize the EPA's SWMM to help understand the stormwater cycle and formulate management measures to mitigate for its impacts.

9.4 Screening Measure Criteria

These recommendations have been initially screen based on the study constraints, professional judgment, input from stakeholders to focus specifically on those which will contribute towards meeting the study objectives. The measures screening criteria included relevance to the shared vision statement, relevance to identified water resource issues, likelihood of implementation and complexity, and overall impact to the Basin.

9.5 Prioritization of Recommended Strategies for the Tuscarawas River Sub-Basin

The initial array of recommendations was further refined based on the screening criteria described above, with specific emphasis on availability of potential leads for actions and the biggest impact on the sub-basin, as well as stakeholder input. Consideration was given to those which met study objectives and had a high likelihood of implementation.

Table 9.2 - Mohican River Sub-Basin Flood Risk Management Recommendations

Recommendation	Potential Lead for Action
Support the recommendations of the Officials Plans of the Black Fork and Clear Fork Subdistricts once they are completed.	USACE, MWCD, NRCS, ODNR, Local Municipalities
Utilize the FEMA HMGP for the acquisition of repetitive damage structures, with specific emphasis on the Village of Bellville. This land may then be managed as "green space," which will assist with the restoration of floodplain/wetland connectivity mentioned above.	FEMA, Local Municipalities
Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for the municipalities of Bellville, Shelby and Mansfield.	USGS, NWS, NOAA, Local Municipalities

Table 9.3 - Mohican River Sub-Basin Water Quality Recommendations

Recommendation	Potential Lead for Action
Implement agricultural BMPs to address nutrient, bacteria and sediment runoff	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Utilize conservation practices on agricultural land.	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Repair and/or replace failing HSTSs.	County Health Services, Local Municipalities, County SWCDs, Homeowners
Expand wastewater and sewage treatment in the sub-basin.	USACE, Local Municipalities
Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers

Table 9.4 – Mohican River Sub-Basin Stormwater Management Recommendations

Recommendation	Potential Lead for Action
Develop and/or update stormwater management regulations.	Local Municipalities
Utilize green infrastructure to increase infiltration of stormwater.	Local Municipalities
Utilize the EPA's SWMM to help understand the stormwater cycle and formulate management measures to mitigate for its impacts.	Local Municipalities

10.Walhonding River Sub-Basin

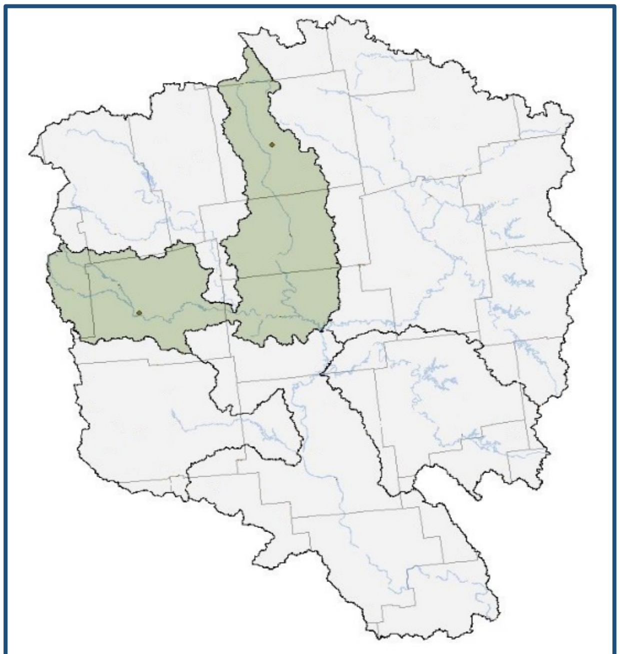


Figure 10.1 - Location of the Walhoniding River Sub-Basin.

The Walhonding River Sub-Basin covers approximately 1,250 square miles in the western and north central portion of the Basin. It is the second largest of the six sub-basins with the Muskingum River Basin. As shown to the left in **Figure 10.1** the Walhonding River Sub-Basin is oddly shaped, two nearly separate watersheds intersecting at a narrow point. These two seemingly separate watersheds are the Kokosing River Watershed and the Killbuck Creek Watershed. The Walhonding River mainstem is formed by the confluence of the Mohican and Kokosing Rivers and flows approximately 20 miles southeast, joining with the Tuscarawas River to form the Muskingum River at Coshocton. Its principle tributaries include the Kokosing River and Killbuck Creek.

There are five USACE FRM projects located within the sub-basin. These include Mohawk Dam (located on the mainsteam of the Walhonding River); Mohicanville Dam (located on Lake Fork); Charles Mill (located on Black Fork); Pleasant Hill (located on Clear Fork); and North Branch of Kokosing (located on the North Branch of Kokosing River).

10.1 Walhonding River Sub-Basin Summary of Existing Conditions

The Walhonding River Sub-Basin is mostly forested, with large amounts of cultivated crops, pasture and hay land, and a modest amount of urban development. Larger municipalities within the sub-basin include the Cities of Mount Vernon, Millersburg and Wooster.

Table 10.1 - Sizable Muncipalities within the Walhonding River Sub-Basin

Municipality	Population
Mount Vernon	16,620
Millersburg	3,100
Wooster	27,023

According to the Ohio Department of Natural Resources, the wetlands in the Killbuck Creek Watershed comprise the largest complex of wetlands remaining in Ohio, with the exception of Lake Erie. The Sub-Basin is also home to the Kokosing River Water Trail. The 27 mile scenic water trail was the first water trail to be recognized by the ODNR.

10.2 Walhonding River Sub-Basin Water Resource Issues

10.2.1 Flooding

While there are several FRM projects located in the sub-basin, many streams remain uncontrolled, however, within the Walhonding River Sub-Basin, flooding is an issue mostly identified by stakeholders as being concentrated within the Killbuck Creek Watershed.

10.2.1.1 Killbuck Creek Watershed

The Killbuck Creek Watershed lies in Medina, Wayne, Holmes and Coshocton County, and is a tributary to the Walhonding River, as shown to the right in **Figure 10.2**. The watershed is forested, with other major land uses being cultivated crops, pasture and hay land, and small pockets of developed and urban land. Communities of note within the watershed include Wooster and Millersburg. As previously stated, according to the ODNR, the "wetlands in the Killbuck Creek valley comprise the largest complex of wetlands remaining in Ohio, away from Lake Erie." The Killbuck Creek in Holmes County is largely unregulated and undeveloped. There is a growing movement in the area to use this area for ecosystem restoration, or at a minimum allow it to naturalize.

Figure 10.2 - Killbuck Creek Watershed.

10.2.2 Water Quality

For the Killbuck Creek watershed, the OEPA's 2011 "*Biological and Water Quality Study of the Killbuck Creek Watershed*" found that 60 of the 78 sites sampled were in full attainment for aquatic use designations. However, high bacteria levels have impacted water quality in terms of recreation usage. The sources of bacteria are thought to be failing WWTPs and HSTSs, and agricultural practices. A TMDL for the watershed is under development.

For the Kokosing and Walhonding River mainstem, the OEPA's 2010 "*Biological and Water Quality Study of Walhonding and Muskingum River Tributaries*", found that over half of the site sampled were fully attaining for aquatic life use. The source of impairment were determined to be primarily agricultural use, with some impacts from channelization, stream alterations and mining.

Only one site specific concerns were identified during stakeholder engagement (the Six-Mile Dam is discussed below). As previously stated, the Killbuck Creek Watershed has generally good water quality and there is interest in using areas within the watershed for ecosystem restoration and naturalization. When stakeholders were asked about water quality issues, there was general concern about water quality in the western portion of the sub-basin, but again, no site specific concerns were identified. General water quality recommendations are made below.

10.2.2.1 Six-Mile Dam

Six-Mile Dam is located on the Walhonding River near the Village of Warsaw in Coshocton County. The Dam was built in 1830 as part of the Walhonding Canal system and served as a water source for a mill and plant located in Roscoe Village which closed in 1953. The dam has been owned by ODNR since 1975. Six-Mile Dam is believed to be contributing to water quality degradation in the reach, as the stream is not meeting water quality standard for nearly a mile downstream of the structure. ODNR is currently studying the impacts of removing the dam.

10.2.3 Stormwater Management

As previously mentioned, stormwater management is a significant water resource issue affecting the urbanized and developing areas of the Basin. Within the Walhonding River Sub-Basin the municipalities which are particularly struggling with this issue include the Villages of Gambier and Millersburg, as well as the Cities of Mount Vernon and Wooster. As developed areas, these are the locations where stormwater runoff becomes problematic during high water events. The Village of Gambier has stormwater provisions in place as part of their zoning ordinance, the Village of

Millersburg has robust codified ordinances, but lacks a specific stormwater management plan. The Cities of Mount Vernon and Wooster both include a stormwater management plan as part of their codified ordinances.

10.3 Recommendations for the Walhonding River Sub-Basin

The following are recommended solutions related to the specific water resource issues identified within the Tuscarawas River Sub-Basin.

10.3.1 Flood Risk Management Recommendations for the Walhonding River Sub-Basin

1. Address log jams and stream debris to restore natural stream channel flow
2. Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.
3. Initiate ecosystem restoration projects to restore natural stream function and flow

10.3.2 Water Quality Recommendations for the Walhonding River Sub-Basin

1. Expand wastewater and sewage treatment in the sub-basin.
2. Repair and/or replace failing HSTSs.
3. Implement agricultural BMPs to address nutrient, bacteria and sediment runoff
4. Utilize conservation practices on agricultural land.
5. Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.
6. Support the recommendations made in the TMDL reports for the streams when they are made available.
7. Utilize stream buffers to filter pollutants and prevent stream erosion.
8. Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients with specific emphasis on the Killbuck Creek Watershed

10.3.3 Stormwater Management Recommendations for the Walhonding River Sub-Basin

1. Develop and/or update stormwater management regulations in the municipalities of Gambier, Millersburg, Mount Vernon and Wooster.

10.4 Screening Measure Criteria

These recommendations have been initially screen based on the study constraints, professional judgment, input from stakeholders to focus specifically on those which will contribute towards meeting the study objectives. The measures screening criteria included relevance to the shared vision statement, relevance to identified water resource issues, likelihood of implementation and complexity, and overall impact to the Basin.

10.5 Prioritization of Recommended Strategies for the Tuscarawas River Sub-Basin

The initial array of recommendations was further refined based on the screening criteria described above, with specific emphasis on availability of potential leads for actions and the biggest impact on the sub-basin, as well as stakeholder input. Consideration was given to those which met study objectives and had a high likelihood of implementation.

Table 10.2 – Walhonding River Sub-Basin Flood Risk Managmeent Recommendations

Recommendation	Potential Lead for Action
Address log jams and stream debris to restore natural stream channel flow	Local Municipalities, County SWCDs, NRCS
Initiate ecosystem restoration projects to restore natural stream function and flow	USACE, ODNR, NRCS, TNC
Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.	USACE, TNC, Local Municipalities

Table 10.3 - Walhonding River Sub-Basin Water Quality Recommendations

Recommendation	Potential Lead for Action
Repair and/or replace failing HSTSs.	County Health Services, Local Municipalities, County SWCDs, Homeowners
Expand wastewater and sewage treatment in the sub-basin.	USACE, Local Municipalities
Support the recommendations made in the TMDL reports for the streams when they are made available.	TBD
Implement agricultural BMPs to address nutrient, bacteria and sediment runoff	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients with specific emphasis on the Killbuck Creek Watershed	USACE, NRCS, OEPA, Local Municipalities
Utilize conservation practices on agricultural land.	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers
Utilize stream buffers to filter pollutants and prevent stream erosion.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers

Table 10.4 - Walhonding River Sub-Basin Stormwater Management Recommendations

Recommendation	Potential Lead for Action
Develop and/or update stormwater management regulations.	Local Municipalities

11.Wills Creek Sub-Basin

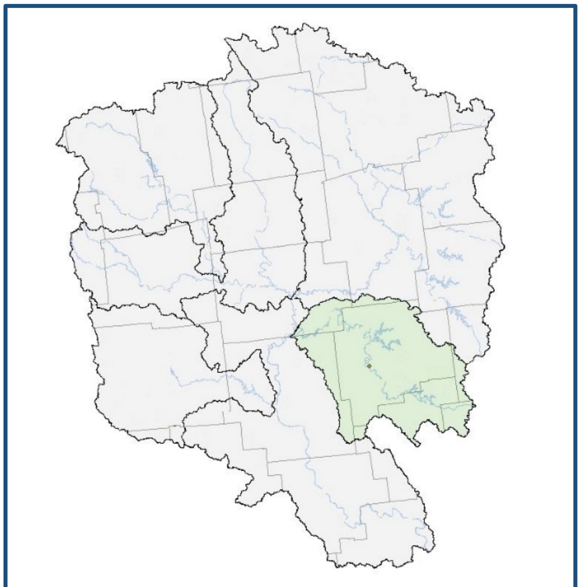


Figure 11.1 - Location of Wills Creek Sub-Basin.

The Wills Creek Sub-Basin is located in the southeastern portion of the Basin and covers approximately 850 square miles, as shown in **Figure 11.1** to the left. Measuring approximately 92 miles long, the stream rises near Pleasant City in Guernsey County and flows north through the municipalities of Byesville, Cambridge and Kimbolton, where it turns west and flows through portions of Coshocton and Muskingum Counties, through Plainfield to its confluence with the Muskingum River, south of the City of Coshocton.

Major tributaries to Wills Creek include Salt Fork, Seneca Fork, Buffalo Fork, Buffalo Creek and Leatherwood Creek. There are two USACE FRM projects located within the sub-basin: Wills Creek and Senecaville Dams, located on the Wills Creek mainstem and Seneca Fork, respectively.

11.1 Wills Creek Sub-Basin Summary of Existing Conditions

The predominant land cover in the sub-basin is forest, with large concentration of cultivated crop land, pasture and hay land. Large municipalities within the sub-basin includes Cambridge, Byesville and New Concord.

Table 11.1 - Sizeable Municipalities within the Wills Creek Sub-Basin

Municipality	Population (2016 Census)
Cambridge	10,433
Byesville	2,382
New Concord	2,355

In addition to extensive agricultural operations within the sub-basin, there is a large oil and gas development presence in the sub-basin. As with the Tuscarawas River sub-basin, oil wells have been in production in this area since the late 1850's. Historic mining practices continue to impact water quality within the sub-basin, as discussed below.

11.2 Wills Creek Sub-Basin Summary of Existing Conditions

11.2.1 Flooding

11.2.1.1 Village of Byesville and City of Cambridge

As with other sub-basins, despite the USACE FRM dams, flooding continues to be a significant issue in the region. The Village of Byesville and the City of Cambridge were two municipalities which were repeatedly mentioned as being negatively impacted by flooding. Representatives attending the initial stakeholder meetings report repetitive flooding of homes and roads in the watershed. Road flooding has a negative impact on deployment of emergency vehicles and personnel during high water events, preventing first responders from assisting those in need. Representatives cite a need for automated signage to help warn motorist of length detours.

11.2.2 Water Quality

Unlike the previously discussed Mohican River sub-basin, water quality throughout the Wills Creek sub-basin is severely degraded. Local officials report the appearance of HABs in the Salt Fork area and also report log jams contributing to stagnant streams. Water quality issues are discussed to support recommendations made below for the sub-basin in general.

The most recent comprehensive study of the Wills Creek Sub-Basin was conducted in 1994, by the OEPA. This study concluded the majority of the Wills Creek mainstem was in partial or non-attainment for warm water habitat due to poor habitat, sedimentation, and channel modifications. A TMDL for the Wills Creek Sub-Basin has not been completed, however, recent sampling from the region suggests impacts to water quality stem from mining (including AMD), agricultural activities, unsewered communities and oil and gas production, including hydraulic fracturing and pipeline construction.

11.2.3 Stormwater Management

There were few site specific stormwater management issue identified during stakeholder engagement for locations within the Wills Creek sub-basin. This is not surprising, given the overall lack of urban development in the area. General stormwater management recommendations are made below.

11.2.3.1 New Concord

New Concord is a village in Muskingum County, with a population of 2,491 as of the 2016 census (see Figure 11.2 below). The Village is home to the Muskingum University, which is a private liberal arts college. Village officials report issues associated with stormwater management, but site a lack of funding to address these issues.

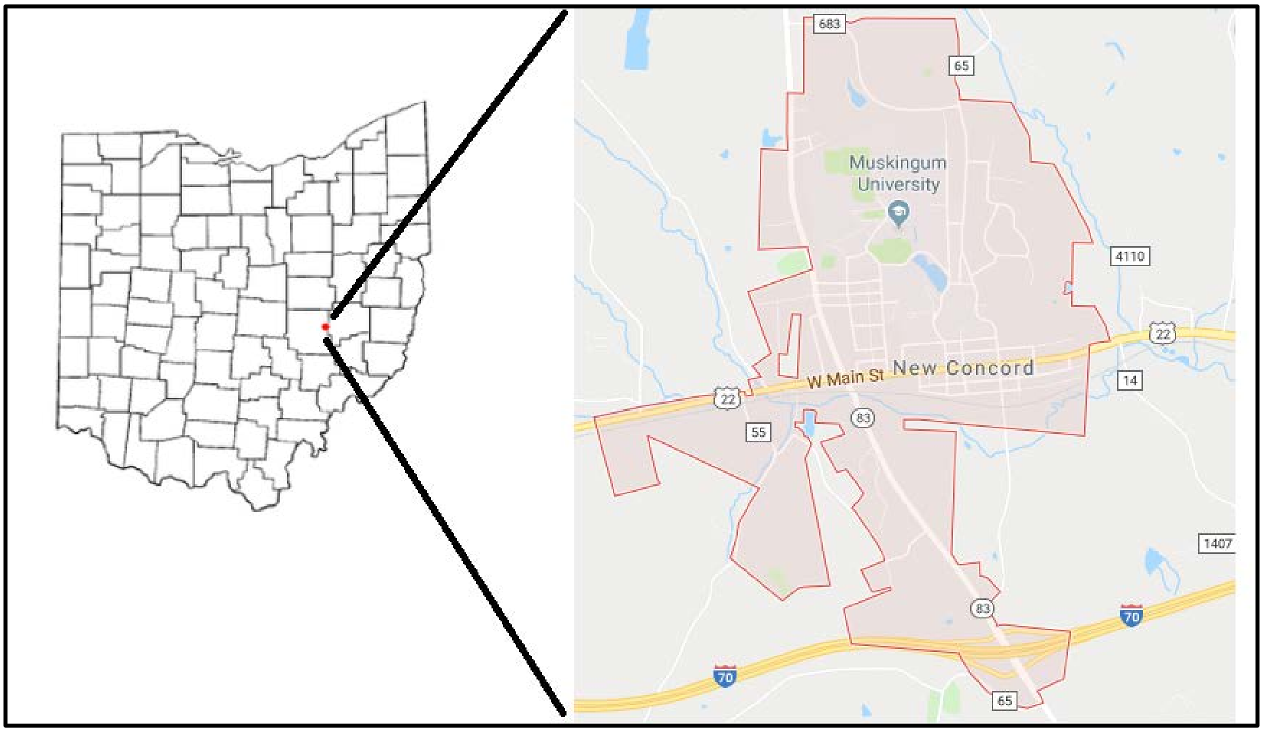


Figure 11.2 - Location of the Village of New Concord.

11.3 Recommendations for the Wills Creek Sub-Basin

The following are recommended solutions related to the specific water resource issues identified within the Wills Creek Sub-Basin.

11.3.1 Flood Risk Management Recommendations for the Wills Creek Sub-Basin

1. Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for communities of Byesville and Cambridge.
2. Utilize the FEMA HMGP for the acquisition of repetitive damage structures. This land may then be managed as "green space," which will assist with the restoration of floodplain/wetland connectivity mentioned above.

11.3.2 Water Quality Recommendations for the Wills Creek Sub-Basin

1. Develop appropriate TMDLs for the streams within the sub-basin.
2. Restore and enhance water quality by stabilizing stream banks and reducing sediment yield.
3. Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.
4. Utilize stream buffers to filter pollutants and prevent stream erosion.
5. Engage in extensive BMP education among agricultural producers in the sub-basin.
6. Utilize conservation practices on agricultural land.
7. Address failing HSTSs.
8. Extend sewer service into unsewered areas.

11.3.3 Stormwater Management Recommendations for the Wills Creek Sub-Basin

1. Update local land use policies so that stormwater runoff and infiltration is addressed in the event of new development.
2. Develop/Update Stormwater Management Regulations in municipalities within the sub-basin.

11.4 Screening Measure Criteria

These recommendations have been initially screen based on the study constraints, professional judgment, input from stakeholders to focus specifically on those which will contribute towards meeting the study objectives. The measures screening criteria included relevance to the shared vision statement, relevance to identified water resource issues, likelihood of implementation and complexity, and overall impact to the Basin.

11.5 Prioritization of Recommended Strategies for the Wills Creek Sub-Basin

The initial array of recommendations was further refined based on the screening criteria described above, with specific emphasis on availability of potential leads for actions and the biggest impact on the sub-basin, as well as stakeholder input. Consideration was given to those which met study objectives and had a high likelihood of implementation.

Table 11.2 - Wills Creek Sub-Basin Flood Risk Management Recommendations

Recommendation	Potential Lead for Action
Utilize the FEMA HMGP for the acquisition of repetitive damage structures. This land may then be managed as "green space," which will assist with the restoration of floodplain/wetland connectivity mentioned above.	FEMA; Local Municipalities
Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for communities of Byesville and Cambridge.	USGS, NWS, NOAA, Local Municipalities

Table 11.3 - Wills Creek Sub-Basin Water Quality Recommendations

Recommendation	Potential Lead for Action
Develop appropriate TMDLs for the streams within the sub-basin.	OEPA
Repair and/or replace failing HSTSs.	County Health Services, Local Municipalities, County SWCDs, Homeowners
Implement agricultural BMPs to address nutrient, bacteria and sediment runoff	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Expand wastewater and sewage treatment in the sub-basin.	USACE, Local Municipalities
Utilize conservation practices on agricultural land.	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Restore and enhance water quality by stabilizing stream banks and reducing sediment yield.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers
Utilize stream buffers to filter pollutants and prevent stream erosion.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers
Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers

Table 11.4 - Wills Creek Sub-Basin Stormwater Management Recommendations

Recommendation	Potential Lead for Action
Develop/Update Stormwater Management Regulations in municipalities within the sub-basin.	Local Municipalities
Update local land use policies so that stormwater runoff and infiltration is addressed in the event of new development.	Local Municipalities

12. Licking River Sub-Basin

Figure 12.1 - Location of the Licking River Watershed.

The Licking River Sub-Basin is the smallest sub-basin within the Muskingum River Basin, covering approximately 780 square miles in the south western portion of the Basin, as shown to the left in **Figure 12.1**. The sub-basin is located mostly in Licking County, including small areas in Morrow, Knox, Fairfield, Perry and Muskingum Counties. The mainstem of the Licking River is formed at the City of Newark, by the confluence of the North and South Forks of the Licking River, which are its primary tributaries. It flows east into Muskingum County, and then south where it joins the Muskingum River at Zanesville. Dillon Dam, on the Licking River mainstem, is the only USACE FRM project within the sub-basin.

12.1 Licking River Sub-Basin Summary of Existing Conditions

The predominant land cover in the sub-basin is mostly comprised of forest, cultivated cropland, pasture and hay, and developed space. Municipalities located in the sub-basin include, but are not limited to: Newark, Pataskala, Buckeye Lake, Heath, Hebron, Johnstown and Granville.

Table 12.1 - Sizable Municipalities within the Licking River Sub-Basin

Municipality	Population (2016)
Newark	49,134
Pataskala	15,458
Buckeye Lake	2,766
Heath	10,625
Hebron	2,402
Johnstown	4,970
Granville	5,771

Consistent with the other sub-basins located on the western side of the Muskingum River Basin there is relatively little mineral extraction, and virtually no oil and gas development.

12.2 Licking River Sub-Basin Water Resource Issues

12.2.1 Flooding

Flooding impacts several municipalities with the Licking River Basin. These site specific areas include the Village of Hebron (discussed in depth below), the Village of Heath and the City of Newark. While flooding concerns associated with the Village of Hebron were identified relatively early in the study process, the Village of Heath and the City of Newark were highlighted during a subsequent round of stakeholder engagement meetings. Given the interconnectedness of the flooding issues in these areas USACE working to develop a comprehensive flood risk management study for Licking County. The purported causes of flooding in this area are log jams, stream meandering and stream bank instability. It should also be noted that flooding frequently closes I-70 and routes interstate traffic through local communities.

There is also concern amongst the communities downstream of Dillon Dam about the timing of releases and subsequent flooding. Representatives from these communities cite the need for better public involvement, education and engagement.

12.2.2 Village of Hebron

Hebron is a Village in Licking County, in the western portion of the Basin. As of the 2016 Census, the population was 2,400. Hebron is a small community (see **Figure 12.2** below) based around a mix of industry and agriculture. Local officials report frequent, repeated flooding of low lying areas which damages homes and businesses, as well as cuts of emergency access. One of the areas which frequently floods cuts off access to a senior living community and subsidized housing.

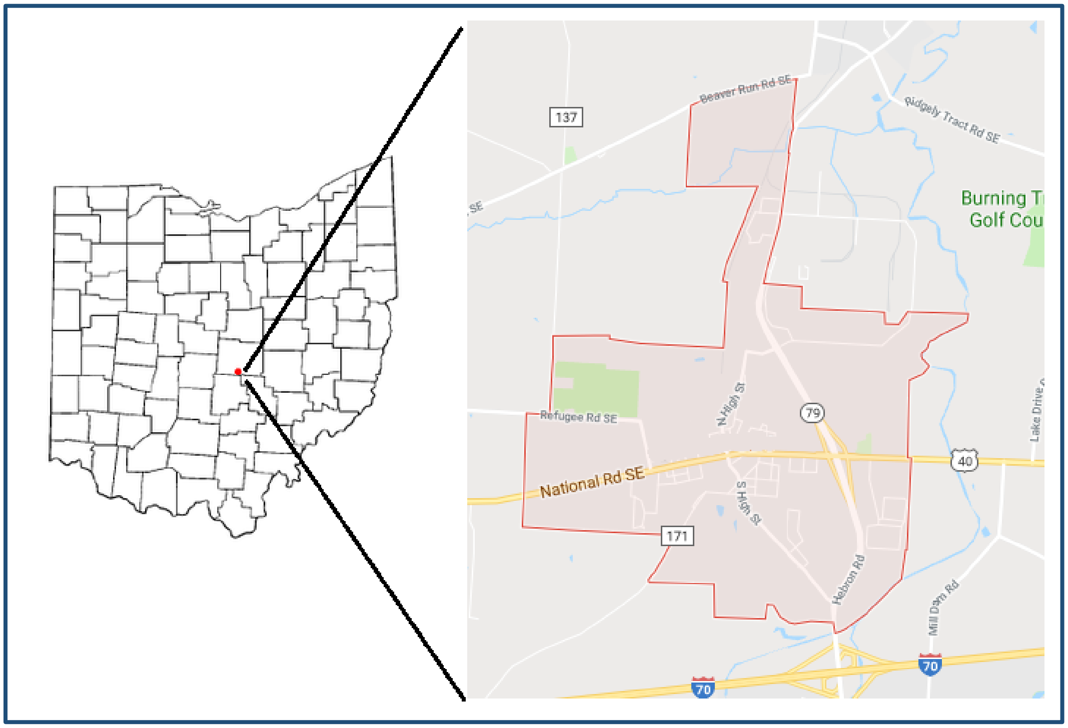


Figure 12.2 - Location of the Village of Hebron.

The Village has worked towards removing repetitive damage structures via FEMA's HGMP and has identified potential areas for upland retention.

The Village has also completed a Comprehensive Flood Study (2016) which focused on addressing these ongoing flooding issues. The findings of the study recommended clearing brush and debris from the stream channel, increasing the size and/or removing selected culverts, the construction of a bypass channel or upstream retention basin. The study stopped short of an economic analysis to determine which alternative would be most cost effective.

It should be noted that this area was not identified during stakeholder engagement, but as the result of a call to the District made by the Village Mayor. The Village has submitted a LOI to the Huntington District expressing interest in a Section 205 Flood Damage Reduction Study and the potential study is currently going through the budgetary process.

12.2.3 Water Quality

Water quality within the Licking River Sub-Basin is notably good. In 2008 OEPA sampled 90 sites across the sub-basin and found that 88% fully met the goals of the CWA for aquatic life. More recently, the results of OEPA's 2012 *"Biological and Water Quality Study of the Licking River"* show fish and other aquatic species "thriving" at the 40 sites tests by the agency.

OEPA also evaluated streams in the sub-basin for other uses, including the ability to provide safe drinking water and recreational opportunities. The majority of the large streams met both of these goals, however, recreational use on smaller tributaries was impaired by bacteria, mostly likely a result of failing HSTSs.

It should be noted that there is no existing TMDL for the Licking River, although one is under development. It is not clear when it will be complete.

One of the several site specific concern water quality issues identified in the Licking County Sub-Basin was for Log Pond Run. According to the aforementioned *"Biological and Water Quality Study of the Licking River,"* this was the only tributary where biological performance did not attain the prescribed biocriterion. This stretch of stream drains some of the older neighborhoods in the City of Newark, and is contained within concrete channels before it joins the North Fork of the Licking River in an industrial area. This has resulted in a stream which is too shallow for macroinvertebrates.

The water quality recommendations for the Licking River Sub-Basin made below take the form of preventative steps which may be taken to safe guard water quality in the future.

12.2.4 Stormwater Management

Stormwater management issues are numerous without the Licking River Sub-Basin, with specific emphasis on the municipalities within Licking County, as discussed above in Section 12.2.1. As stated, USACE will be meeting with officials to discussed a comprehensive plan. General stormwater management recommendations are made below.

12.3 Recommendations for the Licking River Sub-Basin

The following are recommended solutions related to the specific water resource issues identified within the Licking River Sub-Basin.

12.3.1 Flood Risk Management Recommendations for the Licking River Sub-Basin

1. Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for Hebron.
2. Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.
3. Continue to utilize the FEMA HMGP for the acquisition of repetitive damage structures.
4. Initiate a Section 205 Flood Damage Reduction study for the Village of Hebron.
5. Pursue a comprehensive flood risk management plan for Licking County.

12.3.2 Water Quality Recommendations for the Licking River Sub-Basin

1. Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients.
2. Implement agricultural BMPs to address nutrient, bacteria and sediment runoff
3. Complete development of appropriate TMDLs for the streams within the sub-basin.
4. Repair and/or replace failing HSTSs.
5. Expand wastewater and sewage treatment in the sub-basin.

12.3.3 Stormwater Management Recommendations for the Licking River Sub-Basin

1. Develop/Update Stormwater Management Regulations in municipalities within the sub-basin.

12.4 Screening Measure Criteria

These recommendations have been initially screen based on the study constraints, professional judgment, input from stakeholders to focus specifically on those which will contribute towards meeting the study objectives. The measures screening criteria included relevance to the shared vision statement, relevance to identified water resource issues, likelihood of implementation and complexity, and overall impact to the Basin.

12.5 Prioritization of Recommended Strategies for the Licking River Sub-Basin

The initial array of recommendations was further refined based on the screening criteria described above, with specific emphasis on availability of potential leads for actions and the biggest impact on the sub-basin, as well as stakeholder input. Consideration was given to those which met study objectives and had a high likelihood of implementation.

Table 12.2 - Licking River Flood Risk Management Recommendations

Recommendation	Potential Lead for Action
Continue to utilize the FEMA HMGP for the acquisition of repetitive damage structures in Hebron.	FEMA; Local Municipality
Initiate a Section 205 Flood Damage Reduction study for the Village of Hebron.	USACE, Local Municipality
Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for Hebron.	USGS, NWS, NOAA, Local Municipalities
Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.	USACE, TNC, Local Municipalities
Develop a comprehensive Flood Risk Management Plan for Licking County	USACE, Local Municipalities

Table 12.3 - Licking River Sub-Basin Water Quality Recommendations

Recommendation	Potential Lead for Action
Complete development of appropriate TMDLs for the streams within the sub-basin.	OEPA
Repair and/or replace failing HSTSs.	County Health Services, Local Municipalities, County SWCDs, Homeowners
Expand wastewater and sewage treatment in the sub-basin.	USACE, Local Municipalities
Implement agricultural BMPs to address nutrient, bacteria and sediment runoff	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients.	USACE, NRCS, OEPA, Local Municipalities

Table 12.4 - Licking River Sub-Basin Stormwater Management Recommendations

Recommendation	Potential Lead for Action
Develop/Update Stormwater Management Regulations in municipalities within the sub-basin.	Local Municipalities
Update local land use policies so that stormwater runoff and infiltration is addressed in the event of new development.	Local Municipalities

13.Muskingum River Sub-Basin

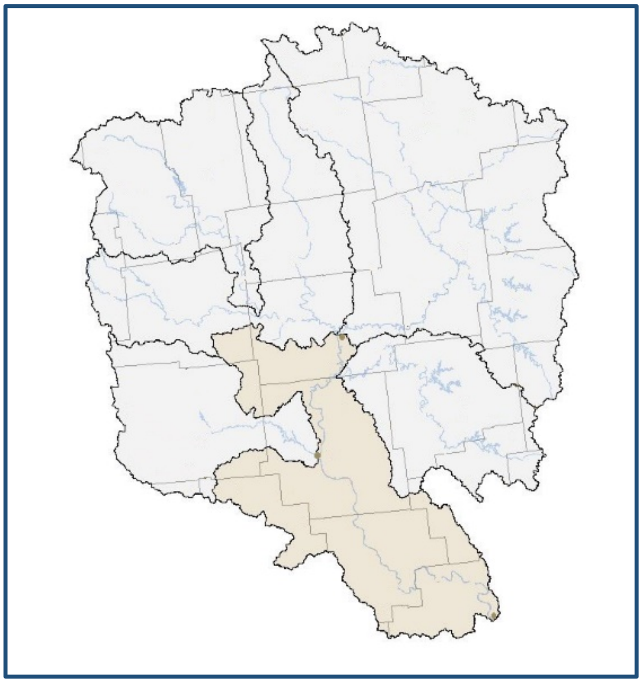


Figure 13.1 - Location of the Muskingum River Sub-Basin.

The Muskingum River Sub-Basin covers approximately 1,500 square miles in the southern portion of the Muskingum River Basin. Below the confluence of the Tuscarawas and Walhonding Rivers, the major tributaries to the Muskingum River are Moxahala Creek, Salt Creek and Wakatomika Creek. Moxahala Creek joins the Muskingum River near the City of Zanesville in Muskingum County. Salt Creek flows into the Muskingum River near the Village of Philo in Muskingum County, and Wakatomika Creek enters the Muskingum near the Village of Dresden. There are no USACE FRM structures within this sub-basin.

13.1 Muskingum River Sub-Basin Summary of Existing Conditions

The predominant land cover in the sub-basin is overwhelmingly forest, followed closely by pasture and hay land, cultivated crops and a modest amount of urban development. Sizable municipalities within the sub-basin include, but are not limited to: Zanesville, Marietta, Dresden, Crooksville, Roseville, Somerset, South Zanesville and Frazeysburg.

Table 13.1 - Sizable Municipalities within the Muskingum River Sub-Basin

Municipality	Population (2016)
Zanesville	25,465
Marietta	13,650
Dresden	1,683
Crooksville	2,497
Roseville	1,848
Somerset	1,463
South Zanesville	1,974
Frazeysburg	1,296

13.2 Muskingum River Sub-Basin Water Resource Issues

13.2.1 Flooding

As with several of the other sub-basins within the Muskingum River Basin flooding is a significant issue in the Muskingum River Sub-Basin. As there are no FRM projects located in the area, the streams in the sub-basin are uncontrolled. Specific flooding issues and locations identified within the Muskingum River Sub-Basin are discussed in the following sections.

13.2.1.1 Caldwell

The Village of Caldwell is located on the West Fork of Duck Creek in Noble County (see **Figure 13.2** below). As of the 2016 census the population was 1,705. It is a small, rural community. Village officials report more extreme flooding occurring more frequently and with longer durations. As with many other communities in the Basin, flooding frequently impacts emergency personnel access during high water events.

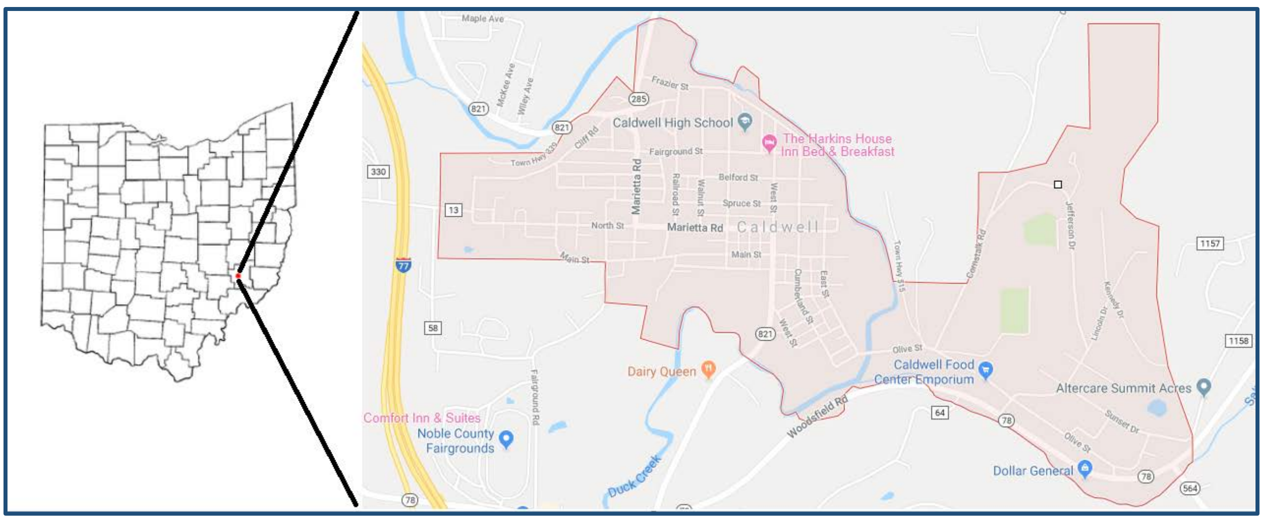


Figure 13.2 - Location of the Village of Caldwell.

13.2.1.2 Dresden

Dresden is a Village in Muskingum County (see **Figure 13.3** below), in the central portion of the Basin. The population was approximately 1,683 at the time of the 2016 Census. Dresden is largely at agricultural area, but is also the headquarters of the Longaberger Company. Representatives at stakeholder involvement meetings report extensive agricultural flooding issues as well as accessibility issues for emergency responders during high water events. As recently as January 2018, four people were rescued from flood waters via boats.

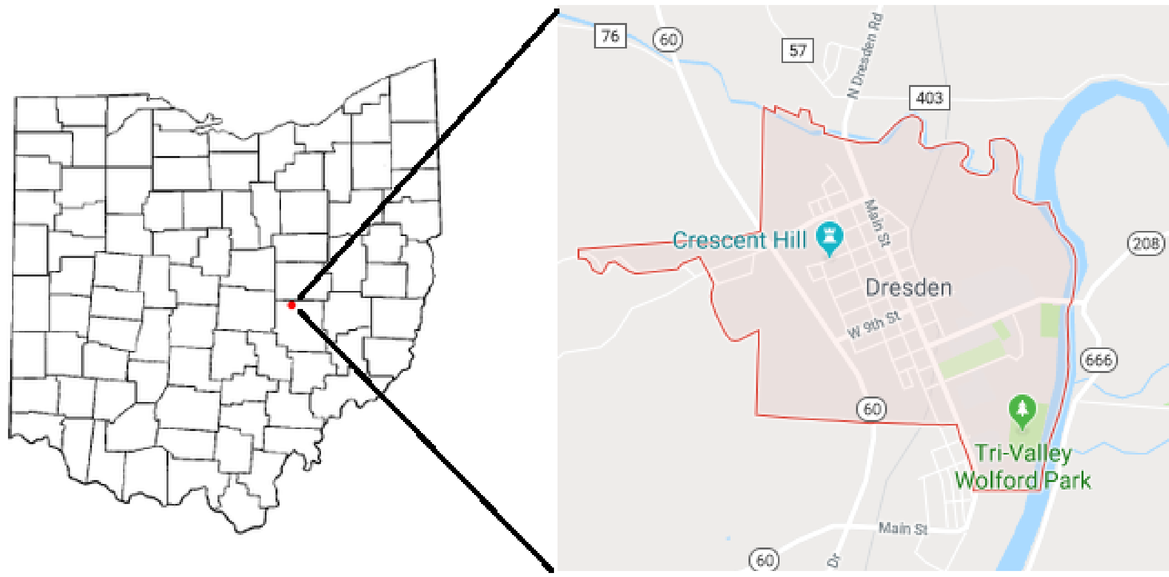


Figure 13.3 - Location of the Village of Dresden.

13.2.1.3 McConnellsville

The Village of McConnellsville is located in Morgan County (see Figure 13.4 below). As of the 2016 census the population was 1,784. It is the county seat. As with the Village of Caldwell, which was discussed above, village officials report flooding occurring more frequently and with longer durations. Flooding also impacts emergency personnel access during high water events.

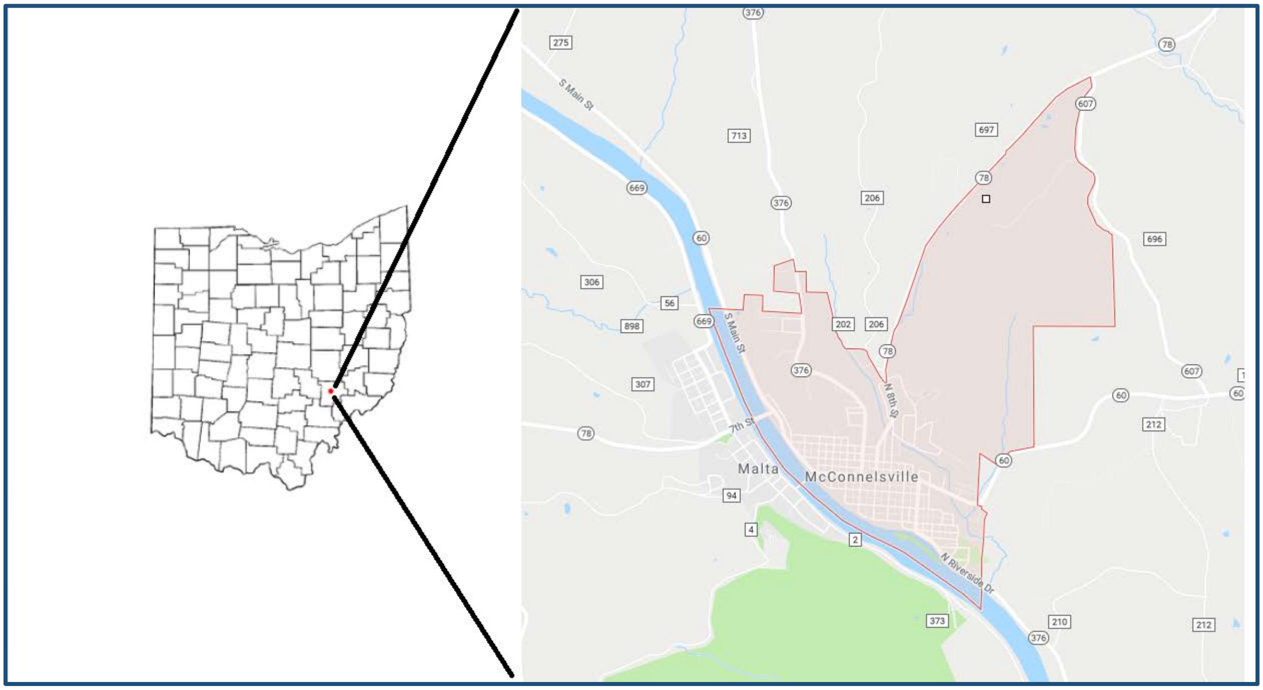


Figure 13.4 - Location of the Village of McConnellsville.

13.2.1.4 Zanesville

Zanesville, Ohio (see **Figure 13.5** below) is the county seat of Muskingum County, in the east-central portion of the Basin. As of the 2016 Census, the population was approximately 25,500. While the City of Zanesville is a sizable urban area, Muskingum County is composed largely of agricultural land. Officials attending the stakeholder engagement sessions reported mostly agricultural flooding as a primary concern.

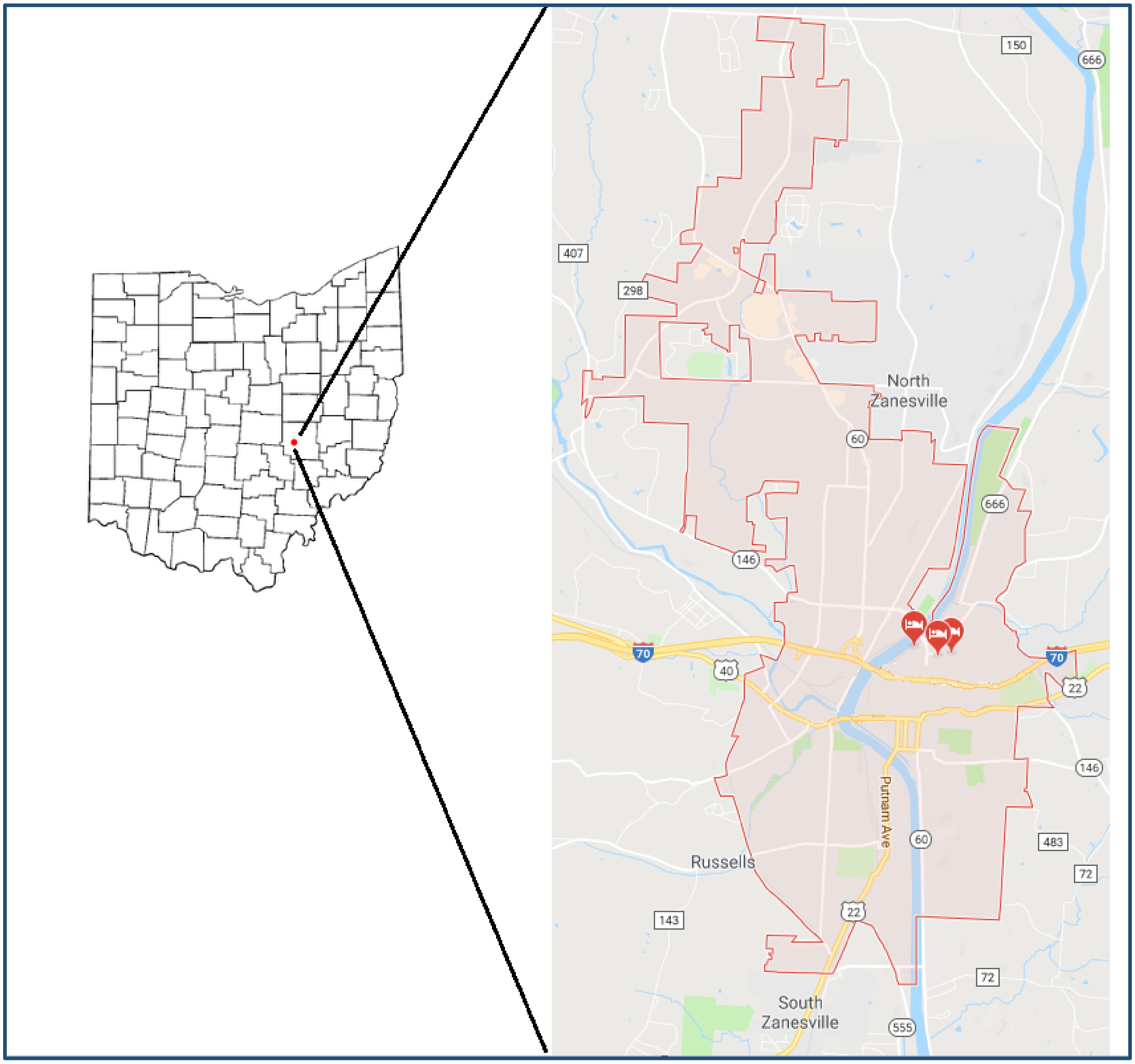


Figure 13.5 – Location of City of Zanesville.

13.2.1.5 Marietta

The City of Marietta is located at the southernmost point of the Muskingum River Basin at the confluence of the Muskingum and Ohio Rivers in Washington County (see **Figure 13.6** below). The population was approximately 13,673 at the time of the 2016 Census. Marietta is the oldest city in the State of Ohio.

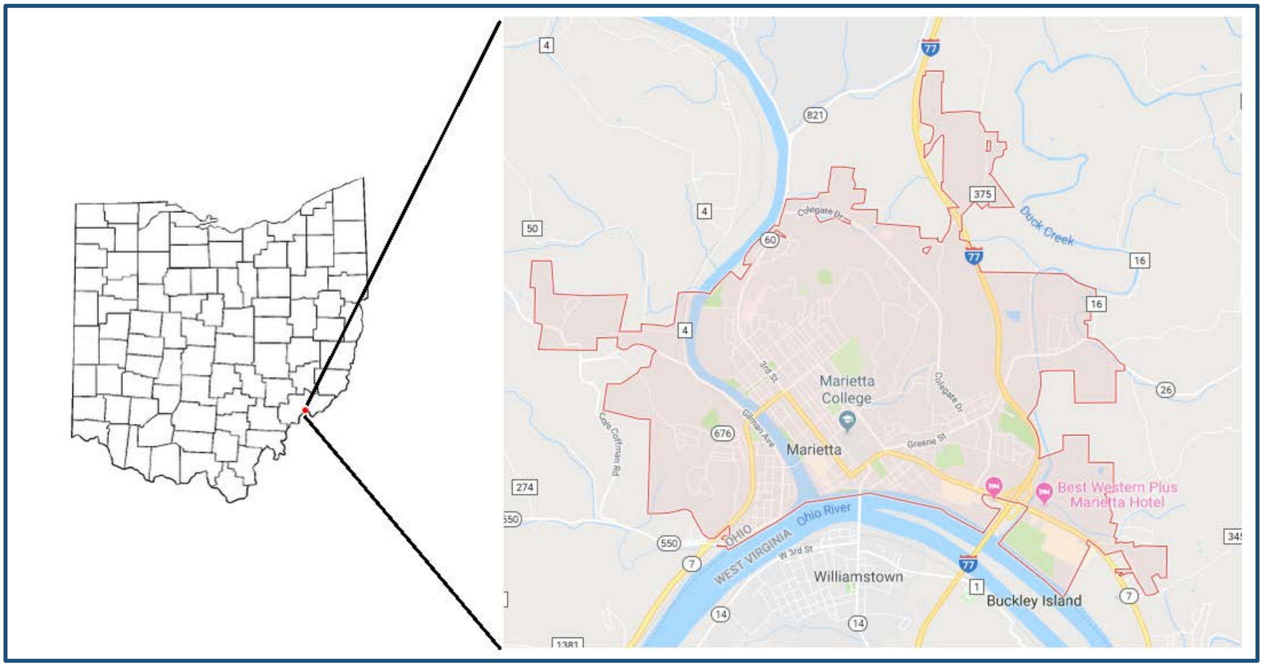


Figure 13.6 – Location of City of Marietta.

Representatives at stakeholder meetings report flooding issues stemming from the Muskingum River, as well as the Ohio River and Duck Creek. Ohio River flooding results in backwater flooding, exacerbating flooding issues associated with the other two streams – flash flooding from Duck Creek and basement flooding from the Muskingum River. Given the location of the town, a sizeable portion of the municipality is located within the 100-year floodplain. Flooding often cuts of emergency personnel access to outlying parts of the city. Representatives cite the need for better coordination and communication between the City and USACE regarding the release of upstream floodwater and additional flood warning preparedness.

13.2.2 Water Quality

It should first be noted water quality is not consistent across the Muskingum River Sub-Basin, although it has improved across the sub-basin as a whole in past years. As an example the Salt Creek and Moxahala Creek Watersheds are compared below.

The Salt Creek Watershed, located in Muskingum County, is not significantly impaired. The 2009 OEPA TMDL found the watershed met criteria for recreation use at 13% of sites, and at 100% of sites for aquatic life and public drinking water supply use. The primary cause of impairment in the Salt Creek Watershed is bacteria from agricultural practices and failing HSTSs.

Alternatively, the Moxahala Creek Watershed[26] has historically been more severely impaired due AMD from coal mining operations. Coal extraction in this area has historically been accomplished via underground and surface mining. As of 2008, for the 27 sites sampled by OEPA, 27.5% met criteria for recreation usage, 58% for aquatic life usages and 100% for public drinking water supply usage. Causes of impairment in this watershed include the previously mentioned AMD, habitat alterations, nonpoint source runoff, and failing HSTSs. Sources of these impairment are un-reclaimed coal mine land, an in-stream dam and agricultural practices.

Other impairments for the Muskingum River Sub-Basin as a whole include bacteria, sedimentation, habitat alteration, Total Dissolved Solids. The sources of these impairments are agricultural practices, failing HSTSs, riparian buffer removal, habitat alterations, development, stormwater runoff, and limited mining activities.

13.2.3 Stormwater Management

Again, there were no site specific stormwater management issues identified during stakeholder engagement for locations within the Muskingum River Sub-Basin, with the exception of the Village of Dresden (see Section 13.2.1.2 above). Officials from the Village of Dresden believe stormwater management issues in their community is caused by aging infrastructure. Stormwater runoff will often result in the closure of Route 60. General stormwater management recommendations are made below.

13.3 Recommendations for the Muskingum River Sub-Basin

The following are recommended solutions related to the specific water resource issues identified within the Muskingum River Sub-Basin.

13.3.1 Flood Risk Management Recommendations for the Muskingum River Sub-Basin

1. Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for the communities of Dresden and Zanesville.
2. Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events with specific emphasis on the communities of Caldwell, Dresden, McConnellsville and Zanesville.

[26] It should be noted that the Moxahala Creek is located mostly in Perry County, which is the fourth highest coal producing county in the State.

13.3.2 Water Quality Recommendations for the Muskingum River Sub-Basin

1. Repair and/or replace failing HSTSs.
2. Expand wastewater and sewage treatment in the sub-basin.
3. Implement agricultural BMPs to address nutrient, bacteria and sediment runoff
4. Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients.
5. Complete an AMD abatement and treatment plan for most impacted tributaries (Moxahala Creek Watershed).
6. Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.

13.3.3 Stormwater Management Recommendations for the Muskingum River Sub-Basin

1. Develop/Update Stormwater Management Regulations in municipalities within the sub-basin.

13.4 Screening Measure Criteria

These recommendations have been initially screen based on the study constraints, professional judgment, input from stakeholders to focus specifically on those which will contribute towards meeting the study objectives. The measures screening criteria included relevance to the shared vision statement, relevance to identified water resource issues, likelihood of implementation and complexity, and overall impact to the Basin.

13.5 Prioritization of Recommended Strategies for the Muskingum River Sub-Basin

The initial array of recommendations was further refined based on the screening criteria described above, with specific emphasis on availability of potential leads for actions and the biggest impact on the sub-basin, as well as stakeholder input. Consideration was given to those which met study objectives and had a high likelihood of implementation.

Table 13.2 - Muskingum River Sub-Basin Flood Risk Management Recommendations

Recommendation	Potential Lead for Action
Install and maintain rain and stream gages for the purposes of advance planning and to inform the development of FWS/FWEEPs for the communities of Caldwell, Dresden, McConnellsville and Zanesville.	USGS, NWS, NOAA, Local Municipalities
Restore floodplain/wetland connectivity to augment flood storage and reduce downstream flood stages during high water events.	USACE, TNC, Local Municipalities

Table 13.3 - Muskingum River Sub-Basin Water Quality Recommendations

Recommendation	Potential Lead for Action
Complete an AMD abatement and treatment plan for most impacted tributaries (Moxahala Creek Watershed).	OEPA, ODNR, USFWS, TNC, Local Municipalities
Enhance and protect existing wetlands and undertake wetland development projects to reduce runoff, sequester and transform nutrients.	USACE, NRCS, OEPA, Local Municipalities
Repair and/or replace failing HSTSs.	County Health Services, Local Municipalities, County SWCDs, Homeowners
Expand wastewater and sewage treatment in the sub-basin.	USACE, Local Municipalities
Implement agricultural BMPs to address nutrient, bacteria and sediment runoff	County SWCDs, Local Agricultural Producers, NRCS, OEPA, EPA, Local Municipalities
Restore riparian zones by planting endemic woody vegetation, reduce livestock access to stream corridors and enhance nutrient buffer strips.	Local Municipalities, NRCS, TNC, OEPA, ODNR, Local Agricultural Producers

Table 13.4 - Muskingum River Sub-Basin Stormwater Management Recommendations

Recommendation	Potential Lead for Action
Develop/Update Stormwater Management Regulations in municipalities within the sub-basin.	Local Municipalities

14.Potential Funding Sources and Additional Information

The following sections provide information on potential funding sources which may be utilized for implementation of the recommendations.

14.1 Potential Funding Sources

14.1.1 Potential Funding Sources for Flood Risk Management Recommendations

14.1.1.1 FEMA – Hazard Mitigation Grant Program

The goal of the HMGP is to enact mitigation measures which "reduce the risk of loss of life and property from future disasters." Specifically, this program is geared towards the removal of repetitive damage structures from the floodplain, as seems to be the issue in this watershed. Additionally, the HMGP supports risk reduction activities, builds resiliency, reduces the impact of future disaster events, and provides long term and cost effective solutions to problems. Funds may be utilized to either purchase or protect public or private property which is subject to or in danger of repetitive damage.

Additional information is available online at: FEMA - Hazard Mitigation Grant Program or at FEMA - Hazard Mitigation Assistance Guidance.

14.1.1.2 Guernsey County Community Development Corporation Stream Debris Removal Program

Both Byesville and Cambridge are located in Guernsey County. The Guernsey County CDC offers a flood debris removal program in partnership with the MWCD. The goal of the program is to decrease streambank erosion, restore water quality, and decrease flooding impacts to bridges and roadways. There is no cost to local governments associated with this program. Additional information on this program may be found online at: Guernsey County Stream Debris Removal Program.

14.1.1.3 NRCS Emergency Watershed Protection Program –

The Emergency Watershed Protection (EWP) Program exists with the goal of helping communities address watershed issues which pose risk to lives and property. Some of the water resource issues which may be addressed through this program include: stream channel debris, failing stream banks and at risk water control and public infrastructure. The program may also be used to purchase floodplain easements for "restoring, protecting, maintaining and enhancing the functions of floodplains, including associated wetlands and riparian areas…" More information is available online at NRCS - Emergency Watershed Protection Program.

14.1.1.4 NRCS - Watershed and Flood Prevention Operations (WFPO) Program.

The goal of the NRCS's Watershed and Flood Prevention Operations (WFPO) Program is to assist Federal, state and local governments with the protection and restoration of small watersheds, with specific objectives of preventing erosion, floodwater and sediment damage, further conservation and proper land use. Through this program, the NRCS offers financial and technical assistance for erosion and sediment control, watershed protection, flood prevention, water quality improvements, rural, municipal and industrial water supply, water management, fish and wildlife habitat enhancement, and hydropower sources. Watersheds larger than 250,000 acres are ineligible for this program.

Additional information on this program may be found online at: NRCS - Watershed and Flood Prevention Operations Program.

14.1.1.5 NRCS – Watershed Surveys and Planning Program.

The goal of this program is to assist Federal, state and local governments in protecting watersheds from "damage done by erosion, floodwater, and sediment to conserve and develop water and land resources." This program addresses water quality, conservation, wetland and water storage capacity, agricultural drought problems, rural development, municipal and industrial water needs, upstream flood damage, and water needs for fish, wildlife and forest-based industries. Products generated as part of this program include: watershed plans, basin surveys and studies, flood hazard analysis and floodplain management assistance. These studies focus on land management and nonstructural solutions to solve water resource problems. As with the WFPO Program, watersheds larger than 250,000 acres are ineligible for this program.

Additional information on this program may be found online at: NRCS - Revised Planning Policy in National Watershed Program Manual.

14.1.1.6 USACE – Planning Assistance to States

The PAS program allows for the USACE to aid States, local governments, Tribes and other non-Federal entities in the preparation of comprehensive plans for the development and conservation of water and related land resources. These studies are typically only undertaken at the planning level of detail and do not include detailed design for project construction. The studies generally involve the analysis of existing data for planning purposes, using standard engineering techniques. Most studies become the basis for State and local planning decisions. Examples of these types of studies include: water supply and demand studies, water quality studies, environmental conservation/restoration studies, wetland evaluation studies, dam safety/failure studies, flood risk management studies, and floodplain management studies. More information on the PAS study process can be found in **Appendix E**.

14.1.1.7 USACE – Section 205 Flood Damage Reduction

The Section 205 Flood Damage Reduction provides authority to USACE to plan and construct small scale flood damage reduction projects not specifically authorized by Congress. Section 205 studies may result in either structural or nonstructural projects. Structural projects include, but are not limited to, levees, flood walls, and diversion channels. Alternatively, examples of nonstructural projects are flood-proofing, structural relocation and flood warning systems. Additional information about this program is located in **Appendix E**.

With specific regard to Cambridge, USACE completed a feasibility level study for a LPP for this area in the 1960's. The study focused on a levee through the downtown residential and business reach of Wills Creek. Non-structural aspects of the project also were proposed to protect structures in areas of Cambridge and Guernsey County, where damages were not as concentrated. The report discussed several ecosystem restoration projects as well — including water release modification (from Wills Creek Dam), restoration and watershed management, acid mine drainage abatement, and comprehensive riparian system restoration. Finally, the report identified several recreation development alternatives in the form of flow augmentation, lake depth modification, and expanded facilities at existing projects. The project was never implemented.

If local interest remains in components of this study, it is likely they could be re-analyzed utilizing USACE programs such as the Section 205 Program or the Section 206 Ecosystem Restoration Program (discussed below).

14.1.1.8 USACE – Section 206 Ecosystem Restoration

The goal of the Section 206 Ecosystem Restoration program is to restore aquatic ecosystems in area which affect rivers, lakes and wetlands. Project benefits are evaluated through restoration, improvement and protection of aquatic habitats for plants, fish and wildlife. More information about this program can be located in **Appendix E**.)

14.1.1.9 USACE Section 729 – Watershed Assessment

As previously stated, a USACE Section 729 Watershed Assessment would provide for a more comprehensive analysis of the water resource issues in the watershed. While the Killbuck Creek watershed is a part of the Muskingum River Basin and therefore included in this FWA, the scope of this study is too broad for a detailed analysis of issues particular to a specific watershed. The goals and objectives of the Section 729 program can be found above in **Sections 1.1** and **2.5**.

14.1.2 Potential Funding Sources for Water Quality Recommendations

14.1.2.1 NRCS Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is a voluntary conservation program which offers landowners the means and opportunity to protect, restore, and enhance wetlands on their property through perpetual easements, 30-year easements, or Land Treatment Contracts. The NRCS manages the program and provides technical and financial support to participating landowners.

14.1.2.2 Ohio's Agricultural Pollution Abatement Program

The State of Ohio's Agricultural Abatement Program (APAP) provides farmers with cost share assistance to develop and implement BMPs to protect Ohio's streams, creeks, and rivers. This program has been successful in helping to alleviate concerns associated with agricultural production and silvicultural operations which can create soil erosion and manure runoff.

14.1.2.3 USDA – Farmable Wetland Program

The USDA's Farmable Wetlands Program (FWP) was created to "restore previously farmed wetlands and wetland buffer to improve both vegetation and water flow." This voluntary program involves wetland restoration and placing wetland type plant cover. This program is used to improve water quality, filter pollutants, prevent soil erosion, reduce downstream flooding, and provide wildlife habitat. Additional information on this program may be found online at: UDA - Farmable Wetlands Program.

14.1.2.4 USDA - Conservation Reserve Enhancement Program (CREP)

The Conservation Reserve Enhancement Program (CREP) is a Federal/state natural resource conservation program targeted at addressing state and nationally significant agricultural related environmental issues. Through CREP, program participants receive financial incentives from USDA to voluntarily enroll in the Conservation Reserve Program (CRP) in contracts of a minimum 14 to

15 years. Participants remove cropland from agricultural production and convert the land to native grasses, trees, and other vegetation. CRP is authorized by the Food Security Act of 1985, as amended. Additional information is available online at: USDA - Conservation Reserve Enhancement Program

14.1.2.5 USDA – Emergency Community Water Assistance Grants

Emergency Community Water Assistance Grants are administered by USDA to assist communities in rural areas to prepare for or recover from emergencies which impact drinking water. These grants are available to state and local governments, non-profit organization and Federally recognized tribes. Qualifying emergencies include: natural disasters, chemical spills and outbreak of disease. Funds from these grants may be used to construct water transmission lines, water sources, intakes and treatment facilities. Additional information may be found online at: USDA - Emergency Community Water Assistance Grants

14.1.2.6 USDA – Water and Waste Disposal Loan and Grant Program

The USDA's Water and Waste Disposal Loan and Grant Program provides funding for drinking water systems, sanitary sewage treatment, and stormwater drainage for communities in rural areas. This program is available to state and local governments, non-profit organization and Federally recognized tribes in the form of long term, low interest loans, or grants. Funds from these grants may be used to construct drinking water sourcing, treatment, storage and distribution, sewer collection, transmission, treatment and disposal, as well as stormwater collection, transmission and disposal. Additional information may be found online at: USDA – Water and Waste Disposal Loan and Grant Program

14.1.2.7 USACE – Section 594 Environmental Infrastructure Program

The primary objective of the Section 594 Program is to provide design-and-construction assistance to non-Federal interests, for carrying out water-related environmental infrastructure and resource protection and development projects in Ohio. This program has been utilized to carry out construction of, or upgrades to, multiple WWTPs and sewer lines in the State of Ohio.

14.1.2.8 The Conservation Fund – Conservation Loans

Conservation Loans are offered by the Conservation Fund to land trusts and other local organization for the purpose of preservation, increasing green and open space, restoration of natural habitat, and education. They not only offer financing, but technical assistance to borrowers. More information is available online at: Conservation Loans

14.1.2.9 National Association of Conservation Districts – Urban Agriculture Conservation Grant Initiative

The National Association of Conservation Districts (NACD) offers the Urban Agriculture Grant Initiative to help conservation districts advance conservation in developed and/or developing urban areas. The goal of the program is a help communities address issues such as water quality, habitat degradation, stormwater management, and urban erosion and sediment control. Additional information is available online at: NACD - Urban Agriculture Conservation Grant Initiative

14.1.2.10 Clean Ohio Fund – Green Space Conservation Program

The Clean Ohio Fund's Green Space Conservation Program helps local communities to fund the preservation of open space, sensitive ecological areas and stream corridors. Information on this program states special emphasis is given to projects which, among other things: preserves high quality wetlands, preserve streamside forests, natural stream channels, functioning floodplains, and secure easements to protect stream corridors. Additional information may be found online at: Clean Ohio Fund – Green Space Conservation Program

14.1.3 Potential Funding Sources for Stormwater Management Recommendations

14.1.3.1 National Urban and Community Forestry Challenge Cost-Share Program

The U.S. Forest Service's Urban and Community Forestry Challenge Cost-Share Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. The program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns. More information about this program may be found online at: NUCFAC Challenge Cost-Share Grant Program

14.1.3.2 Science to Achieve Results (STAR)

The USEPA enacted a program to improve the quality of science used in EPA's decision-making process. STAR funds are provided for research in several priority areas, including: community-based approaches to stormwater management using green infrastructure and performance and effectiveness of green infrastructure stormwater management approaches in the urban context. Additional information may be found online at: EPA - Science to Achieve Results

14.1.3.3 Appalachian Regional Commission (ARC)

A regional economic development partnership of federal, state, and local governments, the Commission has a competitive grant program for projects involving infrastructure developments to improve local stormwater and sewer systems. Terms and conditions of each grant vary and may require matching funds by the applicant.

14.2 Additional Information

The following are not funding sources, but potentially helpful resources which may be utilized in the implementation of the recommendations.

14.2.1 Additional Resources Relating to Flood Risk Management Recommendations

14.2.1.1 NWS "Flood Warning Systems Manual"

This is a source of information for communities interested in seeking funding for installation of FWSs. The manual includes information on different types of FWSs, potential sources of information and how to work with the NWS towards this goal. This manual is included in **Appendix D** to this report.

14.2.1.2 Department of Homeland Security Resources

The Department of Homeland Security's (DHS) Community Preparedness Toolkit is a free online resource for community which can be a first step towards a FWEEP. This toolkit stresses the involvement of the local community, who's buy-in is critical to the success of any emergency evacuation plan. More information may be found online at: Community Preparedness Toolkit.

14.2.1.3 FEMA Guides

To address a lack of flood preparedness, communities should take advantage of additional resources offered by FEMA to assist with emergency planning. While these are not funding sources in and of themselves, they are valuable tools to be utilized during development of Emergency Operations Plans (EOPs). The *Guide for All-Hazard Emergency Operations Planning* aids emergency management coordinators in developing and maintaining a "viable all-hazard emergency operations plan" which reflects what a community plans do to mitigate against foreseeable hazards with the resources it has on hand. This guide may be found online at: Guide for All-Hazard Emergency Operations Planning.

FEMA's *Comprehensive Preparedness Guide* (CPG 101) gives additional information on preparing EOPs by detailing information on the "fundamentals of risk-informed planning and decision making to help planners examine a hazard and produce integrated, coordinated and synchronized plans." This guide emphasizes the shared role and responsibility of the entire community in emergency planning and taking action to reduce risk associated with natural disasters to themselves and others. CPG 101 may be found online at: Developing and Maintaining Emergency Operations Plans.

14.2.2 Additional Resources Relating to Stormwater Management Recommendations

14.2.2.1 EPA - Stormwater Management Model

To help understand stormwater in a given municipality and to help formulate management measures to mitigate for its impacts, it is recommended local officials utilize the EPA's SWMM model[27]. This is a dynamic rainfall-runoff simulation model used for simulation of runoff quantity and quality from primarily urban areas. "SWMM tracks the quantity and quality of runoff, and the flow rate, flow depth, and quality of water in pipes and channels during a simulation period. SWMM is widely used throughout the world for planning, analysis and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems in urban areas, with many applications in non-urban areas as well." Unlike the hydrologic and hydraulic models previously discussed, SWMM can be utilized to analyze complex storm water runoff scenarios, including overland and underground systems, in densely populated urban areas consisting of complex piping networks to determine arrival time and ponding elevations with relative ease. SWMM should be used in conjunction with standard hydrologic and hydraulic modeling approaches.

This tool would be useful in quantifying the benefits associated with the implementation of various green infrastructure techniques described in subsequent sections. The SWMM model(s) as well as the other hydrologic and hydraulic models should be kept in a centralized location as these models are tools for the present decision makers and should be utilized for future expansion and development.

[27] More information on this tool can be found at: http://www.epa.gov/nrmrl/wswrd/wq/models/swmm/

14.2.2.2 Center for Watershed Protection – Clean Water Certificate Training Program

This program originated in Maryland in 2017. It helps participants gain knowledge in the construction, operation and maintenance of green infrastructure. It has a heavy focus on training under and unemployed workers for new jobs in the stormwater industry. More information on this program may be found online at: Clean Water Certificate Training Program.

14.2.2.3 Center for Watershed Protection – Consulting Services

The Center for Watershed Protection also offers consulting services to state and local governments, as well as watershed groups and other interested individuals. Some of the consulting services offered include: stormwater retrofit surveys, design and implementation, local development code and ordinance review, stormwater design manual development and guidance in complying with Federal, state and local water permits and requirements.

14.2.2.4 EPA – A Guide for Construction Sites

The EPA has developed a *Guide for Construction Sites: Developing Your Stormwater Pollution Prevention Plan*. It provides guidance to construction site operators which are required to develop a Stormwater Pollution Prevention Plan (SWPPP). The plan may be found online at: EPA - Developing Your Stormwater Pollution Prevention Plan.

15.Conclusion and Summary

Generally, the goal of watershed planning is to address problems, needs, and opportunities and plan for IWRM within a given watershed or river basin. Watershed planning can result in non-project specific, holistic plans and strategies, as well as agency-specific potential projects to address water resource needs.

Specifically, the goals of the FWA/WMP is to:

- Further refine, through stakeholder engagement and inter-agency coordination, water and land issues, problems and opportunities within the Muskingum River Basin, as originally defined by the Muskingum River Basin IWA dated January 2012;
- Develop a shared vision for the Basin through collaboration and coordination with a broad range of stakeholders and the MWCD, who serves as the project cost share partner;
- Inventory and forecast existing conditions;
- Formulate and evaluate potential solutions to address identified land and water resources issues (including issues identified in the IWA and additional issues identified by further stakeholder involvement); and
- Recommend broad, policy-level strategies and holistic plans at the sub-basin level which utilize creative solutions to land and water problems and lead to long-term realization of the shared vision of the stakeholders and the cost share partner.

Chapters 4 through 7 of this report document the existing and future expected conditions in the Muskingum River Basin, as well as the water resource issues identified which are overarching or common to the whole Basin. Chapters 8 through 13 provide a more detailed analysis of the water resource issues identified in each of the six sub-basins. These chapters also provide a prioritized list of recommendations so that as funding opportunities become available local decision makers can quickly determine which solutions can make the most positive impact on the Basin. Utilization of this FWA/WMP should provide a comprehensive method for managing land and water resources within the Basin via a holistic process which reflects the interdependency of land owners and water users, competing demands on water resources and the desires of the stakeholders.