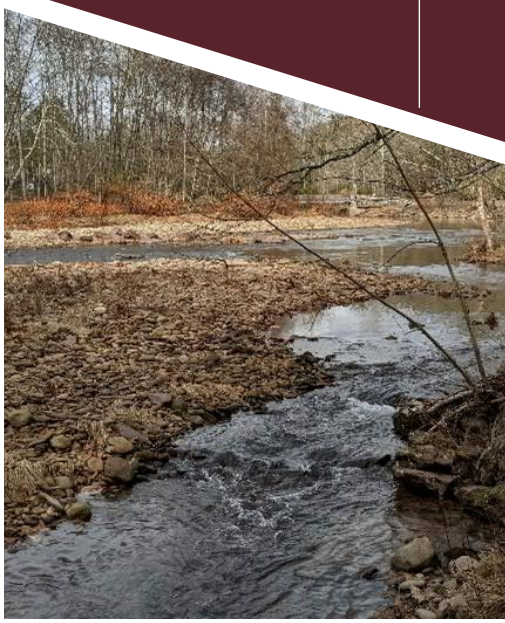
FISHING CREEK WATERSHED FLOODING ASSESSMENT AND MITIGATION STUDY

County of Columbia, Pennsylvania

June 2022





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Submitted to County of Columbia Resiliency Office

MAIN STREET COUNTY ANNEX
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ACKNOWLEDGEMENTS

The project team would like to thank the following individuals and agencies for their assistance and support of this project:

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SECTION 1 - INTRODUCTION

This Fishing Creek Flooding Assessment and Mitigation Study is the product of a comprehensive effort to identify flooding and wet weather issues within the Columbia County portion of the Fishing Creek Watershed and to investigate the mitigation options available from the site to watershed scale. The intent of this document is to present the findings of the study and provide a framework to identify potential mitigation projects to be implemented by the County and its Municipalities. Generally, the study was undertaken to develop recommendations for improved stormwater and flood management practices, to mitigate potential negative impacts by future land uses, and to improve conditions within County's portion of the Watershed. This section introduces some basic concepts relating the physical elements of stormwater and flood management, the hydrologic concepts, and the planning approach used throughout this study. Specific goals of this Study are discussed in detail in Section 2.

The Study was initiated by Columbia County to address problem areas throughout the Fishing Creek Watershed caused by intense rainfall, local and watershed-wide flooding events that occur as frequently as several times per year through less frequent large events such as tropical storms. Herbert, Rowland, and Grubic, Inc. (HRG) was selected to perform the study and identify feasible, actionable projects to assist in mitigating adverse impacts of wet weather and flooding events.

The study scope included field reconnaissance, technical analysis, flood hazard mitigation strategy development, public and municipal participation and outreach, and technical report development and presentation. Inherent to the project was developing an understanding of the desire and capacity of the County, its municipalities, residents, and landowners to implement solutions that target flood mitigation at the local level while mitigating flooding conditions at the watershed scale.

RAINFALL AND STORMWATER RUNOFF

Precipitation that falls on a natural landscape flows through a complex system of vegetation, soil, groundwater, surface waterways, and other elements as it moves through the hydrologic cycle. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, infiltration, and runoff. The natural system often sustains a dynamic equilibrium, where this hydrologic system evolves due to various ranges of flow, sediment movement, temperature, and other variables. Alterations to the natural landscape change the way the system responds to precipitation events. These changes often involve stream channel and floodplain encroachment, which results in increased stream velocities and negative environmental responses such as accelerated erosion, greater or more frequent flooding, increased pollution, and degradation of surface waters. Further, increases in impervious surfaces and limited land conservation techniques result in the stormwater runoff increases to both runoff quantity, or volume, and runoff rate. These two factors, land surface changes and stream channel modification, cause the natural system to change beyond its natural dynamic equilibrium.

Some level of stormwater runoff occurs as the ground surface becomes saturated. This occurs even in undisturbed watersheds. However, the volume and rate of runoff are substantially increased as earth disturbance and stream channel encroachment occur. Stormwater management is a general term for practices used to reduce the impacts of this accelerated stormwater runoff. Stormwater management practices such as detention ponds and infiltration areas are designed to mitigate the negative impacts of increased runoff.

As land surface disturbance has increased, so has the problem of managing the increased quantity of stormwater runoff. Individual land surface disturbance projects are frequently viewed as separate incidents, and not necessarily as an interconnected hydrologic and hydraulic system. This school of thought is exacerbated when the individual land development projects are scattered throughout a watershed (and in many different municipalities). However, it is has been

observed, and verified, that the cumulative nature of individual land surface changes dramatically influences flooding conditions. This cumulative effect of development in some areas has resulted in flooding of both small and large streams, with substantial financial property damage and risk to the public health and welfare. Therefore, given the distributed and cumulative nature of the land alteration process, a comprehensive (i.e., watershed-level) approach must be taken if a reasonable and practical management and implementation approach is to be successful.

Watersheds are an interconnected network in which changes to any portion of the watershed carry throughout the system. There are a variety of factors that influence how runoff from a particular site will affect the overall watershed. Many of the techniques for managing stormwater within a watershed are unique to each watershed. An effective flood mitigation study must be responsive to the existing characteristics of the watershed and recognize potential changing conditions. While land use regulation remains at the municipal level, the framework established within a watershed study enables municipalities to see the impact of land use management on the overall system, and hopefully spur coordination efforts with other stakeholders within the watershed.

WATERSHED HYDROLOGY

Under natural conditions, watershed hydrology is in dynamic equilibrium. That is, the watershed, its ground and surface water supplies, and resulting stream morphology and water quality evolve and change with the existing rainfall and runoff patterns. This natural state is displayed by stable channels with minimal erosion, relatively infrequent flooding, adequate groundwater recharge, adequate base flows, and relatively high water quality. When all of these conditions are present the streams support healthy, diverse and stable in-stream biological communities. The following is a brief discussion of the impacts of development on these steam characteristics:

- Channel Stability – In an undisturbed watershed, the channels of the stream network have reached an equilibrium over time to convey the runoff from its contributing area within the channel banks. Typically, the channel will be large enough to accommodate the runoff from a storm, the magnitude of which will occur approximately every 18-24 months. Disturbances, such as development and unmanaged agricultural uses, in the watershed disrupt this equilibrium. As land surface disturbance occurs, additional runoff reaches the streams more frequently. This results in the channel becoming instable as it attempts to resize itself. The resizing occurs through bed and bank erosion, altered flow patterns, and shifting sediment deposits.
- Flooding – When a watershed is disturbed, it results in increased localized flooding, and other associated problems. Overbank flows will occur more frequently until the channel reaches a new equilibrium. It is important to realize that this equilibrium may take many years to be attained once the new runoff patterns are in place. In watersheds with continuous land surface disturbance, a new equilibrium may not be reached. Additionally, floodplain encroachment and in-stream sediment deposits from channel erosion may exacerbate flooding.
- Groundwater Recharge – In an undisturbed watershed, runoff is minimal. Natural ground cover, undisturbed soils, and uneven terrain provide the most advantageous conditions for maximum infiltration to occur. When land surface disturbance occurs, these favorable conditions are diminished, or removed, causing more rainfall to become runoff that flows to receiving streams instead of being absorbed into the system. This causes less water to be retained in the watershed to replenish groundwater supplies.
- Base Flows – Loss of groundwater recharge, as described above, leads to insufficient groundwater available to replenish stream flow during dry weather. As a result, streams that may have an adequate base flow during dry weather under natural conditions may experience reduced flow, or become completely dry, during periods of low precipitation

in developed watersheds. Thermal degradation of the waterbody often accompanies the reduction of base flow originating from groundwater. The base flow is generally much cooler than surface water sources. The increase in water temperature can be detrimental to many ecological communities.

- Water Quality – Stormwater from disturbed and developed surfaces carries a wide variety of contaminants. Pesticides, herbicides, fertilizers, automotive fluids, hydrocarbons, sediment, detergents, bacteria, increased water temperatures, and other contaminants that are picked up on land surfaces are carried into streams by runoff. These contaminants affect the receiving streams in different ways, but they all have an adverse impact on the quality of the water in the stream.
- Stream Biology – Biological communities reflect the overall ecological health of a stream. The composition and density of organisms in aquatic communities responds proportionately to stressors placed on their habitat. Communities integrate the stresses over time and provide an ecological measure of fluctuating environmental conditions. The adverse impacts of improperly managed runoff and increased pollution are evident in the biological changes of impacted streams. When biological communities within a waterbody degrade the overall ecological integrity of the stream is also diminished.

It is important to understand that watershed hydrology, rainfall, stormwater runoff, and all of the above characteristics are interconnected. The implications of this concept are far reaching. How watersheds are managed has a direct impact on the water resources of the watershed. Any decision that affects land use and flood corridors has implications on stormwater management and flooding conditions and, in turn, impacts the quality of available water resources. The quality of water resources has economic consequence as well as an effect on the quality of life in the surrounding areas. This understanding is at the core of watershed based flooding and stormwater management approaches.

SECTION 2 - GOALS AND OBJECTIVES

This Study report was developed to present the findings of the flood mitigation and assessment study of the Fishing Creek Watershed within Columbia County. The principal purposes of this study were to identify flooding and wet weather problem areas within Fishing Creek Watershed in Columbia County, and to identify and assess proposed mitigation measures and projects for problem areas and the watershed area within the County. The study accomplished through efforts that included field reconnaissance, technical analysis, flood mitigation option development, public and municipal participation, education and outreach, and technical analysis presentation. Through the study process an understanding was developed of the desire and capacity of the County, its municipalities, residents, and landowners to implement solutions that target flood mitigation at the site scale while mitigating flooding conditions at the watershed scale.

The overall objective of this Study is to provide an assessment of problem areas and mitigation options and projects. The Study is intended to enable flood mitigation through the following goals:

- Identify flooding and weather problem areas within the entire Fishing Creek Watershed in Columbia County.
- Identify proposed mitigation measures and projects.
- Assess the impacts of proposed mitigation measures and projects.
- Ensure mitigation measures and projects are realistic, practical, and feasible.
- Document and communicate the Study methods and findings.

These goals provided the focus for the entire Study process. The initial part of the Study focused efforts on gathering the necessary data and developing strategies that address the goals. With the necessary data and tools developed, the later portion of the Study evaluated site and watershed specific information, incorporated in-depth technical analysis, and developed a comprehensive assessment and compilation of information to achieve these goals.

PUBLIC ENGAGEMENT AND COMMUNCIATION

Public participation by local stakeholders was an integral part of the Study. Coordination amongst various groups facilitates a more inclusive Study, that can better address the variety of issues experienced throughout the Watershed in the County. Several public meetings were facilitated throughout the development of this Study.

The purpose of the meetings was to provide access for municipal and resident input, voicing of concerns and questions, and to serve as a mechanism to ensure coordination and cooperation. The intent of the meetings was to help advise the Study team throughout the process, evaluate mitigation options, coordinate the Study with West End Flood Mitigation Study, and review the Study findings prior to completion. Table 2.1 is a summary of the meetings that were held throughout the Study process.

Table 2.1 Summary of Meetings

Meeting	Purpose of Meeting	Meeting Date
Public 1	Kick-off Meeting: Introduce the Flood Mitigation and Assessment Study process.	July 29, 2021
Public 2	Public/Municipal/Stakeholder Review: Provide opportunity to solicit feedback from municipalities on the Flood Mitigation and Assessment Study problem area identification process.	November 30, 2021

Meeting	Purpose of Meeting	Meeting Date
Legislator Meeting 1	Legislator Review Meeting: Present on the draft findings and strategies developed and assessed to mitigate flooding and wet weather issues in Fishing Creek Watershed with State and County officials.	February 16, 2021
Legislator Meeting 2	Legislator Review Meeting: Review high priority problem area mitigation projects to mitigate flooding and wet weather issues in Fishing Creek Watershed and discuss potential funding options/strategies.	March 4, 2022
Public 3	Final Public/Municipal/Stakeholder Review Meeting: present on the final findings and strategies developed and assessed to mitigate flooding in Fishing Creek Watershed.	March 31, 2022

SECTION 3 - FISHING CREEK WATERSHED DESCRIPTION

Fishing Creek Watershed in Columbia County is located in central Pennsylvania and is sourced in Sullivan and Luzerne Counties, with the main stem of Fishing Creek deriving from the East and West Branches of Fishing Creek in the northern part of Columbia County. From this point southward the creek picks up tributaries of varied sizes, finding its terminus at the Susquehanna River approximately 30 miles from the headwaters. The entire watershed has an area of approximately 384 square miles and is divided into 6 major watersheds. The watershed area within Columbia County is 227 square miles with 293 miles of waterways.

POLITICAL JURISDICTIONS

The Watershed is comprised of 18 municipalities. The political jurisdictions include 4 boroughs, one town, and 13 townships. In 2020, the municipalities that have land area falling within the Fishing Creek Watershed in Columbia County had an estimated population of 37,865, decreasing 5.4% from the 2010 census total of 39,824. The 18 municipalities and their respective populations in are as follows:

Table 3.1 Fishing Creek Watershed Municipalities

Townships	2020 Population	Area (mi^2)	Town/Boroughs	2020 Population	Area (mi^2)
Benton	1,323	19.94	Benton	823	0.61
Fishing Creek	1,523	28.73	Town of Bloomsburg	12,711	4.69
Greenwood	1,881	28.44	Stillwater	199	3.16
Hemlock	2,214	17.64	Orangeville	479	0.45
Jackson	622	18.43	Millville	976	0.99
Madison	1,564	34.26			
Montour	1,263	9.6			
Mt. Pleasant	1,498	16.91			
North Centre	2,036	15			
Orange	1,161	13.03			
Pine	1,011	29.49			
Scott	5,514	7.46			
Sugarloaf	887	26.3			

In addition to these political boundaries, most municipalities use a County Subdivision and Land Development Ordinance to regulate their land use (Sugarloaf, Pine, Greenwood, Benton, Mt. Pleasant, Orange, Orangeville, and Fishing Creek Townships and Stillwater, Benton, and Millville Boroughs) and the rest of the municipalities have their own Subdivision and Land Development Ordinance regulations (Town of Bloomsburg, and Jackson, Madison, Hemlock, Montour, Scott, and North Centre Townships). Section 4 explores this existing regulatory framework and its relationship to flooding and stormwater management.

LAND USE

GENERAL DEVELOPMENT PATTERNS

Fishing Creek Watershed within Columbia County is primarily rural in nature with over 85% of the land use either Agricultural or Rural. Bloomsburg, the Route 11, Route 42 and Route 487 corridors, and several Boroughs within the surrounding townships are primarily the commerce centers in the County. Table 3.2 reflects the proportion of current land uses. For the purposes of this Study, the existing land use as defined in the PASDA Land Use Dataset.

Table 3.2 Land Use in Fishing Creek Watershed

Land Use	Percentage of Total Land Use
Forested	48%
Agricultural	42%
Developed	7.9%
Low Vegetation	1.1%
Wetlands	0.9%
Water	0.2%

TRANSPORTATION

The major traffic routes in Fishing Creek Watershed in Columbia County include PA Routes 11, 44, 42, 487, 239, 254, 118, and Interstate 80. PA Route 11 runs through the southern portion of the County south of Montour Run in Montour Township and through the Town of Bloomsburg and continues to follow the Susquehanna River. PA Route 44 runs through the western part of Fishing Creek Watershed in Columbia County. PA Route 42 runs in a north-south direction through along Little Fishing Creek. PA Route 254 runs through the center of the Watershed and splits the Fishing Creek and Little Fishing Creek watersheds in an east-west direction (Figure 3.1). PA Route 239 runs through the northwestern portion of the Watershed through the Little Fishing Creek and East/West Branch Fishing Creek and mainstem Fishing Creek Watersheds (Figure 3.2). PA Route 118 runs through the northern portion of the Watershed through the Little Fishing Creek and East/West Branch Fishing Creek Watersheds (Figure 3.2). The major traffic route of Interstate 80 travels through the southern center portion of Columbia County, paralleling Fishing Creek to the south through portions of Hemlock Township, the Town of Bloomsburg, and Scott Township (Figure 3.3).

FARMLANDS

About 42 percent of the Fishing Creek Watershed in Columbia County is considered prime farmland. The majority of prime farmlands are located in the center and southern portion of the Watershed distributed through the Hemlock Creek, Little Fishing Creek, and Fishing Creek watersheds.

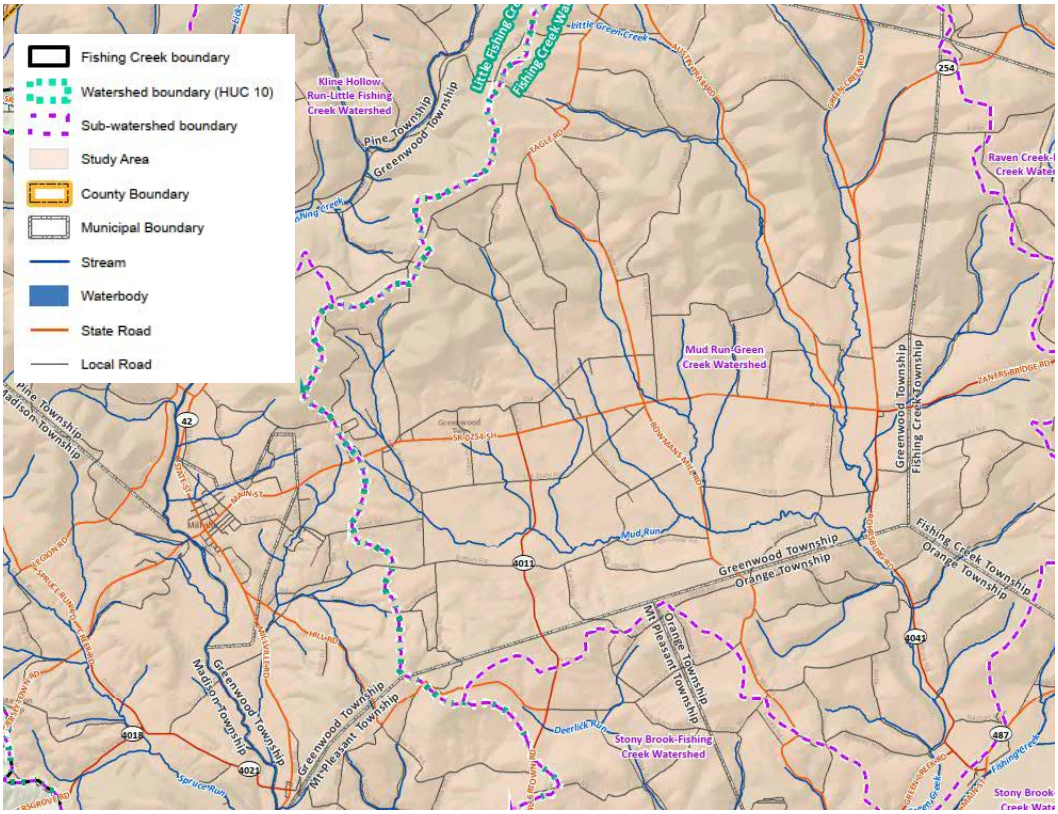

Figure 3.1 Major Roadways in the Central Portion of Fishing Creek Watershed

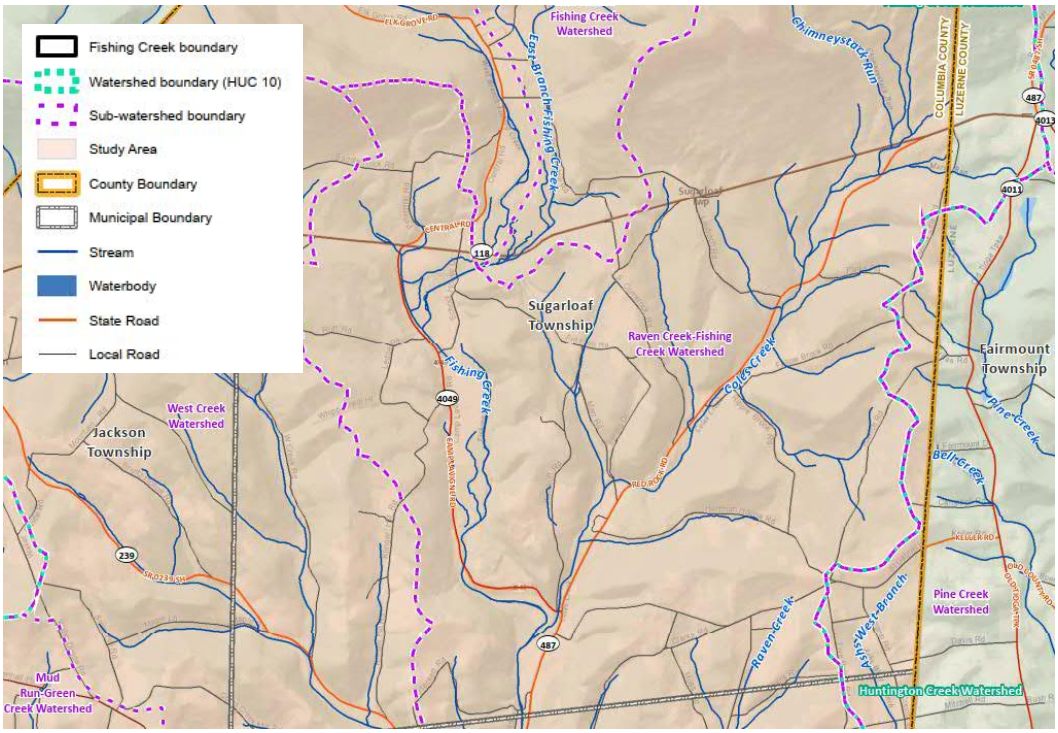

Figure 3.2 Major Roadways in Northern Portion of Fishing Creek Watershed

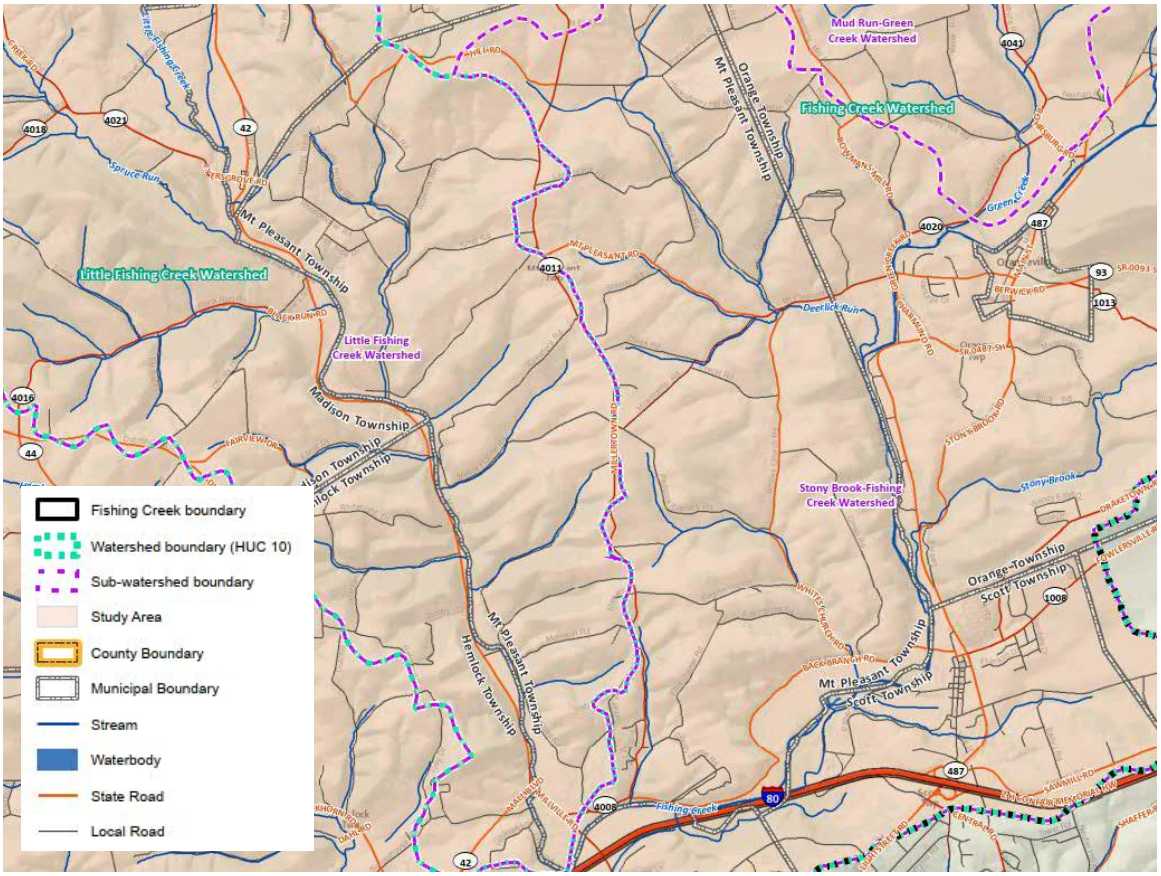

Figure 3.3 Major Roadways in Southern Portion of Fishing Creek Watershed

RAINFALL

Figures 3.4 and 3.5 show the rainfall statistics for the two closest locations with an extended record near Columbia County (Danville, PA from 1942 through 2010 and Williamsport, PA from 1945 through 2021). The average rainfall, shown in Figure 3.4 portrays the amount of precipitation throughout each year since 1942, although there can be significant variation in the annual rainfall total (between 27 and 70 inches). While this variation can have a significant impact on water supply and vegetative growth, it is the quantity of rain in a relatively short time period (1-hour, 6-hour, 24-hour, 48-hour) that impacts flooding conditions in Fishing Creek Watershed.

Figure 3.5 shows the annual maximum rainfall events recorded over the same time period graphed and the NOAA Atlas 14 values (Precipitation / Frequency Data) for the 2-year and 100-year storm events, derived using partial series data. The annual maximum rainfall for a station is constructed by extracting the highest precipitation amount for a particular duration in each successive year of record. A partial duration series is a listing of the period of record with the greatest observed precipitation depths for a given duration at a station, regardless of how many occurred in the same year. Thus, a partial data series accounts for various storms that may occur in a single year.

Historical focus on the annual maximum rainfall and the larger magnitude, low frequency storm events, as done in previous stormwater planning efforts throughout Pennsylvania, has lead to neglect of 1) the majority of storm events that are smaller than the annual maximum and their subsequent value to the landscape in terms of volume and water quality and 2) the fact that the inclusion of every storm may increase the 24-hour rainfall total typically used in design.

The majority of rainfall in Fishing Creek Watershed comes from storms of low magnitudes. Only 10% of the daily rainfall between 1942 and 2021 exceeded 0.85 inches, which is below any design standards currently being used in the County. It is important to acknowledge that many of these smaller rainfall events lead to larger runoff events as they may saturate the soils prior to a larger storm or occur within a short time period after a larger storm, overwhelming existing conveyance facilities.

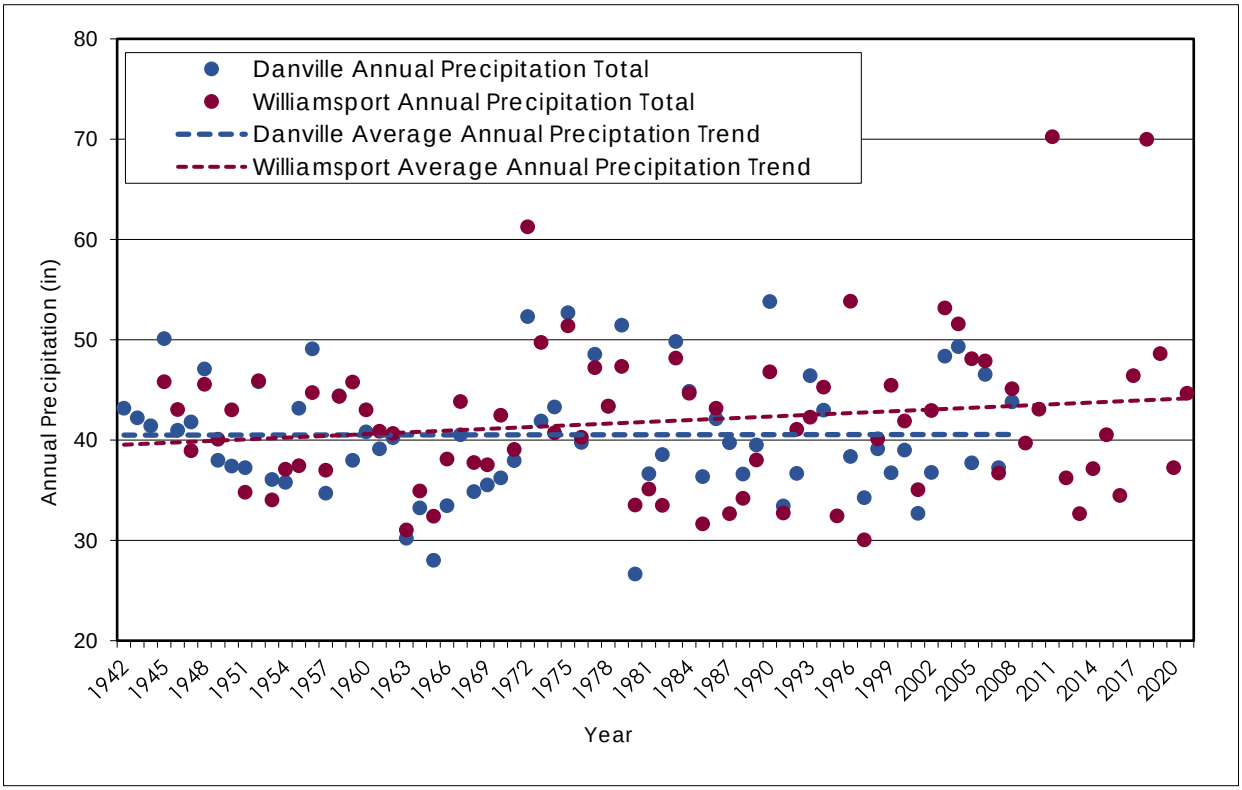

Figure 3.4 Annual Precipitation at Danville and Williamsport

For the gage data shown in Figure 3.4 and 3.5, the NOAA Atlas 24-hour, 2-year storm event total of 2.86 inches was exceeded 16 times in the most recent 30 years of data at Williamsport, PA. When analyzing only the annual maximum series, the NOAA Atlas 24-hour, 2-year storm was exceeded only 12 times. Thus, viewing only the annual maximum series may neglect significant historical rainfall events, particularly in years like 2006, 2010, 2011, or 2018 with several significant rain storms. The implication for flood control in Fishing Creek Watershed is that any changes to stormwater management regulations should incorporate the NOAA Atlas 14, partial duration data series to ensure the best available data is being used for design purposes.

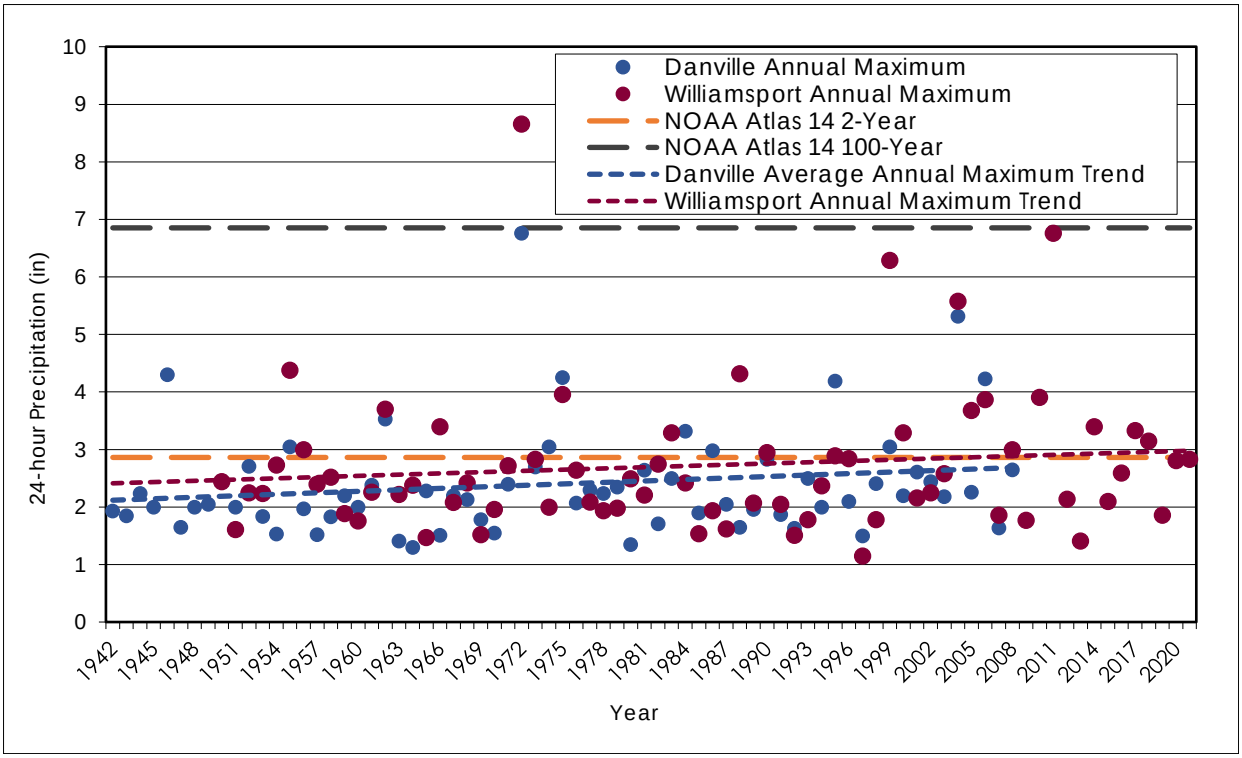

Figure 3.5 24-Hour Rainfall Statistics at Danville and Williamsport

GEOLOGY

Fishing Creek Watershed in Columbia County is primarily located in the Ridge and Valley Physiographic Province, with the extreme northern portion falling in the Appalachian Plateau. The Ridge and Valley Province is characterized by alternating series of long, narrow, and even-crested ridges and valleys. The ridge and valleys are oriented in a southwestern and southern direction with mountains as high as 2,400 feet down to 450 feet along the Susquehanna River. Some karst terrain exists in the extreme southern edge of the watershed along the Susquehanna River. The watershed begins from North Mountain in Sullivan and Luzerne Counties and the Knob Mountain diverts Huntington Creek west from Luzerne County into Fishing Creek in Columbia County on the southeastern portion of the Watershed.

Several bedrock formations are distributed across the Fishing Creek watershed, and some formations are concentrated in specific portions of the watershed. The upper portion of the Fishing Creek watershed in Sullivan, Luzerne, Lycoming, and Columbia County is generally comprised of Burgoon Sandstone and Huntley Mountain Formation along the upper sections, and Catskill Formation along the lower sections. The central portion of the Fishing Creek watershed in Lycoming, Columbia, and Luzerne County is generally comprised of Trimmers Rock Formation with a pocket of Hamilton Group in Columbia County. The lower portion of the Fishing Creek watershed in Montour, Columbia, and Luzerne County is comprised of many bedrock formations: Irish Valley, Sherman Creek, and Duncannon Member of Catskill Formation, Pocono Formation, and Catskill Formation, along with Trimmers Rock Formation, Hamilton Group, Keyser and Tonoloway Formations, Onondaga and Old Port Formations, Bloomsburg and Mifflintown Formations, Willis Creek Formation, and Clinton Group. Refer to Appendix A for a map of the geologic formations.

SLOPES

Fishing Creek Watershed in Columbia County is located within a moderately folded and faulted geologic region. As a result, much of the Watershed contains sizeable areas of steep slopes in the municipalities located near Lycoming and Sullivan Counties. Slopes with grades of 15% or greater are considered steep. If disturbed, these areas can yield heavy sediment loads on streams. Very steep slopes, with over 25% grade, produce heavy soil erosion and sediment loading. Slope values are broken into four categories and shown in Table 3.3 and the general land use and earth disturbance restrictions associated with each slope category.

For the hydrologic analysis, the Fishing Creek Watershed was divided into 232 subbasins and average land slopes were calculated for each subbasin. The maximum subbasin land slope was 45.5%, the minimum subbasin land slope was 2.7%, and the average subbasin land slope was 19.7%.

Table 3.3 Summary of Typical Slope Restrictions for Earth Disturbance and Land Use

Slope Classification	Slope Range	Slope Restrictions
Flat to Moderate	0-8%	Capable of all normal development for residential, commercial, and industrial uses; involves minimum amount of earth moving; suited to row crop agriculture, provided that terracing, contour planting, and other conservation practices are followed
Rolling Terrain and Moderate Slopes	8 - 15%	Generally suited only for residential development; site planning requires considerable skill; care is required in street layout to avoid long sustained gradients; drainage structures must be properly designed and installed to avoid erosion damage; generally suited to growing of perennial forage crops and pastures with occasional small grain plantings
Steep slopes	15 - 25%	Generally unsuited for most urban development; individual residences may be possible on large lot areas, uneconomical to provide improved streets and utilities; overly expensive to provide public services; foundation problems and erosion usually present; agricultural uses should be limited to pastures and tree farms
Severe and Precipitous Slopes	> 25%	No development of an intensive nature should be attempted; land not to be cultivated; permanent tree cover should be established & maintained; adaptable to open space uses (recreation, game farms, & watershed protection)

SOILS

The behavior of a soil's response to rainfall and infiltration is a critical input to the hydrologic cycle. The soils within Fishing Creek Watershed in Columbia County have variable drainage characteristics and various restrictions on their ability to drain, promote vegetative growth, and allow infiltration. They range from well drained with a low runoff potential, to moderately to poor drained with a high runoff potential.

Impediments to subsurface drainage in the Watershed include lithic and paralithic bedrock (i.e., solid and weather or broken layers of bedrock). Higher runoff rates and reduced infiltration capacity may exist in these soils.

An additional indicator of the ability of the soils in the Watershed to absorb rainfall is the hydrologic soil group assigned to each soil. This classification varies between "A" which has very low runoff potential and high permeability and "D" which typically has very high runoff potential and low permeability. Table 3.4 show a summary of the hydrologic soil groups for Fishing Creek Watershed in Columbia County. Some soils have variable runoff potential depending on whether or not they are drained or undrained. For example, agricultural field with tile drainage may decrease the runoff potential from hydrologic soil group D to hydrologic soil group A. Sixty-nine percent (69%) of the soils in Fishing Creek Watershed in Columbia County are hydrologic soil group A, B, or C indicating a moderate runoff potential (Refer to Appendix A for a map of soils).

Table 3.4 Hydrologic Soil Groups in Fishing Creek Watershed

Hydrologic Soil Group	Runoff Potential	Percent of Watershed
A	Low	9%
B	Low to Moderate	23%
C	Moderate to High	37%
D	High	31%

WATERSHEDS AND STUDY AREAS

For the purpose of this Study, Study Area watersheds were split into 4 sub-areas defined primarily by municipal boundaries. These 4 Study Areas are located in watersheds defined by the USGS Hydrologic Unit Code 12 (HUC12) watershed delineation. Fishing Creek Watershed within Columbia County contains at least a portion of 11 different HUC12 watersheds. This classification of the county's watersheds is summarized in the following Table 3.5. Appendix A contains maps of the Study Areas and additional maps reference the HUC12 watershed names.

Table 3.5 Summary of Fishing Creek Watersheds in Columbia County

Primary Watershed	Study Area Sub-watershed	USGS Hydrologic Unit Code 12 Watershed (HUC12)
Fishing Creek	Upper Fishing Creek	West Branch Fishing Creek - 020501070702
		East Branch Fishing Creek - 020501070701
		West Creek - 020501070703
		Raven Creek - 020501070704
		Pine Creek - 020501070503
	Middle Fishing Creek	Raven Creek - 020501070704
		Mud Run-Green Creek - 020501070705
		Huntington Creek-Fishing Creek - 020501070504
		Pine Creek - 020501070503
		Fishing Creek-Susquehanna River - 020501070707
	Little Fishing Creek	Kline Hollow Run-Little Fishing Creek - 020501070601
		Little Fishing Creek-Fishing Creek - 020501070602
	Hemlock Creek-Lower Fishing Creek	Hemlock Creek - 020501070706
		Little Fishing Creek-Fishing Creek - 020501070602
		Fishing Creek-Susquehanna River - 020501070707

UPPER FISHING CREEK STUDY AREA

The Upper Fishing Creek Study Area is located in the northern portion the County. The Upper Fishing Creek Study Area municipalities comprise an area of approximately 47 square miles, with portions of this area draining to Huntington Creek which contributes flow south of Orangeville to the main stem of Fishing Creek. Table 3.6 details the municipalities within the study area.

From the headwaters in the Sullivan County, the Upper Fishing Creek Study Area drains southwest towards Stillwater Borough. Its major tributaries include Coles Creek, East Branch Fishing Creek, West Branch Fishing Creek, and portions of Raven Creek.

Table 3.6 Upper Fishing Creek Study Area Municipalities

Study Area	Municipality
Upper Fishing Creek	Sugarloaf Township
	Benton Township
	Benton Borough

Major floods occurred in the Upper Fishing Creek Study Area during June 1972, January 1996, September 2011, and August 2018 rainfall/runoff events. Although flooding occurs throughout the area, the section from the confluence with the mainstem of Fishing Creek with West Creek (in Benton Borough) has historically received the most intense flooding since this is the largest population center in the Study Area and the land surface elevation is very near that of the contributing creeks.

MIDDLE FISHING CREEK

The Middle Fishing Creek Study Area is situated in the north-center portion of Columbia County. The Middle Fishing Creek Study Area municipalities comprise an area of 85 square miles, with portions of this area draining to Huntington Creek which contributes flow south of Orangeville to the main stem of Fishing Creek. Table 3.7 details the municipalities within the watershed.

The Middle Fishing Creek Study Area drains southwest towards Mt. Pleasant Township. Its major tributaries include Fishing Creek, Raven Creek, Huntington Creek, and Green Creek.

Table 3.7 Middle Fishing Creek Study Area Municipalities

Study Area	Municipality
Middle Fishing Creek	Fishing Creek Township
	Stillwater Borough
	Orange Township
	Orangeville Borough
	Greenwood Township
	North Centre Township

Similar to the Upper Fishing Creek Study area, major floods occurred in the Middle Fishing Creek Study Area during June 1972, January 1996, September 2011, and August 2018 rainfall/runoff events. Flooding occurs throughout the area from the confluence of Raven Creek with the mainstem of Fishing Creek (in Stillwater Borough) south through Orange Township receiving the most intense flooding issues since these areas have constrained creek channels and properties near the creek channel.

LITTLE FISHING CREEK

The Little Fishing Creek Study Area is located in the northwest portion of Columbia County. The Little Fishing Creek Study Area municipalities comprise an area of approximately 87 square miles, with portions of this area draining to West Creek which contributes flow near Benton Borough to the main stem of Fishing Creek. Table 3.8 details the municipalities within the watershed.

The Little Fishing Creek Study Area drains southwest towards Mt. Pleasant Township. Its major tributaries include several smaller runs including Spruce Run, West Branch Run, Shingle Run, Lick Run, Wolfhouse Run, and Devil Hole Run.

Table 3.8 Little Fishing Creek Study Area Municipalities

Study Area	Municipality
Little Fishing Creek	Jackson Township
	Pine Township
	Greenwood Township
	Millville Borough
	Madison Township

Flooding and wet weather issues occur throughout the Little Fishing Creek Study Area with the section from the Village of Iola (Greenwood Township) through Millville Borough receiving the most intense flooding issues since this is the largest population center in the Study Area and the areas have constrained creek channels and properties near the creek channel.

HEMLOCK CREEK-LOWER FISHING CREEK

The Hemlock Creek-Lower Fishing Creek Study Area is located in the central portion of Columbia County. The Hemlock Creek-Lower Fishing Creek Study Area municipalities comprise an area of approximately 39 square miles, with portions of this area draining to Little Fishing Creek . Table 3.9 details the municipalities within the watershed.

The Hemlock Creek-Lower Fishing Creek Study Area drains southwest towards the Susquehanna River. Its major tributaries include Little Fishing Creek, Hemlock Creek, Montour Run, and the mainstem of Fishing Creek.

Table 3.9 Hemlock Creek-Lower Fishing Creek Study Area Municipalities

Study Area	Municipality
Hemlock Creek-Lower Fishing Creek	Hemlock Township
	Mt. Pleasant Township
	Montour Township
	Scott Township
	Town of Bloomsburg

Major floods occurred in the Hemlock Creek-Lower Fishing Creek Study Area during June 1972, January 1996, September 2011, and August 2018 rainfall/runoff events. Most of these correspond to noted floods along the Susquehanna River, however Fishing Creek Watershed contributes to flooding conditions here as peak flows from Fishing Creek Watershed often occur prior to peak flows on the Susquehanna River when flooding events coincide. The Town of Bloomsburg is the most urbanized area within the Watershed and is mostly built out. The Town of Bloomsburg is partially protected by a system of levees that protects the Town from flooding from the Susquehanna River.

Floodplain Data

A flood occurs when the capacity of a stream channel to convey flow within its banks is exceeded and water flows out of the main channel onto and over adjacent land. This adjacent land is known as the floodplain. For convenience in communication and regulation, floods are characterized in terms of return periods, e.g., the 50-year flood event. In regulating floodplains, the standard is the 100-year floodplain, the flood that is defined as having a 1 percent chance of being equaled or exceeded during any given year. These floodplain maps, or Flood Insurance Rate Maps (FIRMs), are provided to the public (http://msc.fema.gov/) for floodplain management and insurance purposes. About 9.6% of the population within Fishing Creek Watershed in Columbia County lives in an area that is delineated under the 100-year floodplain, or High Hazard Area. Additionally, over 2,000 structures potentially lie within the high hazard area. Table 3.10 summarizes the municipal populations that live within 100-year floodplain (FEMA, 2019), these values are inclusive of areas outside of the Fishing Creek Watershed.

Table 3.10 Potential Impact Due to Flooding (FEMA, 2019)

Townships	% of Population in High Hazard Area	Structures in High Hazard Area	Town/ Boroughs	% of Population in High Hazard Area	Structures in High Hazard Area
Benton	9%	95	Benton	79%	375
Fishing Creek	6%	100	Bloomsburg	8%	560
Greenwood	11%	155	Stillwater	51%	80
Hemlock	10%	135	Orangeville	6%	20
Jackson	0%	<5*	Millville	6%	40
Madison	1%	30			
Montour	7%	80			
Mt. Pleasant	3%	45			
North Centre	2%	20			
Orange	9%	120			
Pine	5%	50			
Scott	12%	350			
Sugarloaf	12%	140			

*Values are approximate based on data available at time of analysis by FEMA.

In 2019, the Federal Emergency Management Agency (PEMA) completed a preliminary revision to the flood insurance risk map and provided County and municipal summaries of this information that provided cumulative paid losses for all major flood events since 1978. The study computed damages in dollars for total economic loss, building and content damage (FEMA, 2019). Table 3.11 summarizes the findings from this study.

Table 3.11 Building/Property Losses Due to Flooding (FEMA, 2019)

Townships	1978-2018 Losses ($)	Town/Boroughs	1978-2018 Losses ($)
Benton	$954,000	Benton	$1,600,000
Fishing Creek	$3,400,000	Bloomsburg*	$15,650,000
Greenwood	$286,000	Stillwater	$1,100,000
Hemlock	$5,500,000	Orangeville	$328,000
Jackson	$0	Millville	$4,000

Townships	1978-2018 Losses ($)	Town/Boroughs	1978-2018 Losses ($)
Madison	$17,000		
Montour	$1,200,000		
Mt. Pleasant	$1,000,000		
North Centre	$19,000		
Orange	$2,600,000		
Pine	$11,000		
Scott*	$3,200,000		
Sugarloaf	$213,000		

*Assumes half of losses based on Fishing Creek Flooding

DETAILED STUDIES

There are various levels of detail in floodplain mapping. Detailed studies (Zones AE and A1-A30 on the floodmaps) are conducted at locations where FEMA and communities have invested in engineering studies that define the base flood elevation and often distinguish sections of the floodplain between the floodway and flood fringe. See Figure 3.6 for a graphical representation of these terms. For a proposed development, most ordinances state that there shall be no increase in flood elevation anywhere within the floodway; the flood fringe is defined so that any development will not cumulatively raise that water surface elevation by more than a designated height (set at a maximum of 1'). Development within the flood fringe is usually allowed but most new construction is required to be designed for flooding (floodproofing, adequate ventilation, etc).

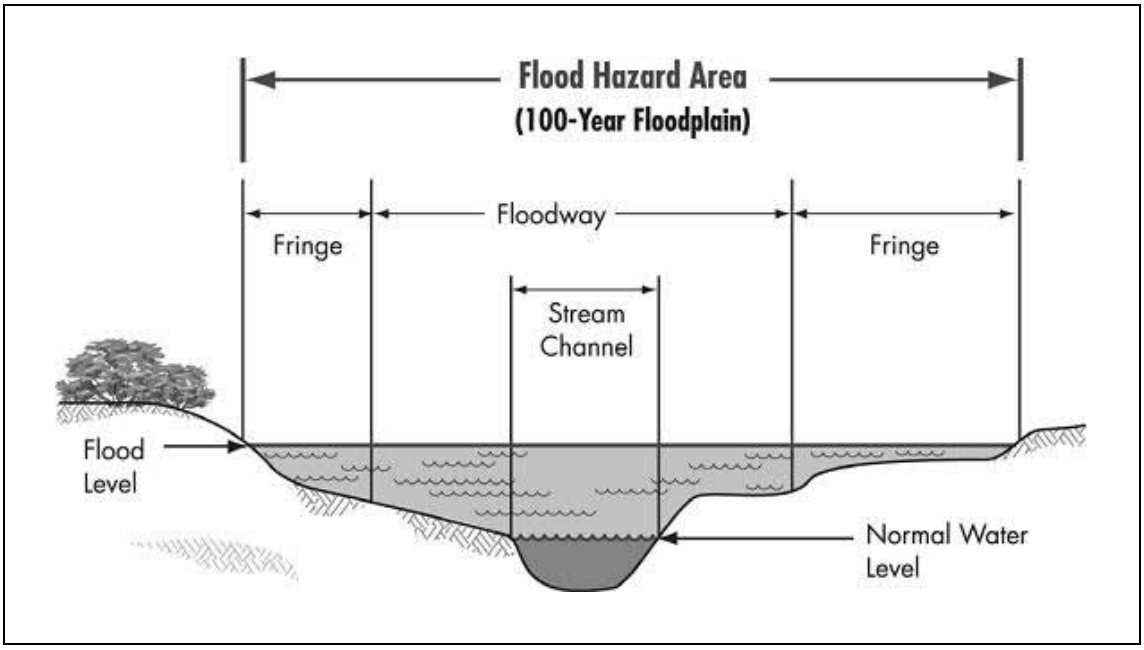

Figure 3.6 Floodplain Cross Section and Flood Fringe (NH Floodplain, 2019)

A review of the FIRMs revealed that several 100-year floodplains exist within Fishing Creek Watershed in Columbia County for the main streams. Detailed studies that clearly define the 100-year flood elevation and the floodway are provided in the locations indicated in the FIRM. Detailed studies have been performed along a short sections of Fishing Creek, Little Fishing Creek,

and Hemlock Creek. About 62% of the high hazard length of stream in Fishing Creek Watershed is delineated using detailed methods.

APPROXIMATE STUDIES AND NON-DELINEATED FLOODPLAINS

Approximate studies (Zone A on the DFIRM) delineate the flood hazard area, but are prepared using approximate methods that result in the delineation of a floodplain without providing base flood elevations or a distinction between floodway and flood fringe. If no detailed study information is available, some ordinances allow the base flood elevation to be determined based on the location of the proposed development relative to the approximated floodplain; at times, a municipality may find it necessary to have the developer pay for a detailed study at the location in question. There is no published engineering data or hydrology associated with approximate methods. About 38% of the high hazard length of stream in Fishing Creek Watershed is delineated using approximate methods.

One limitation of FIRMs and older Flood Insurance Rate Maps is the false sense of security provided to homeowners or developers who are technically not in the floodplain, but are still within an area that has a potential for flooding. Headwater streams, or smaller tributaries located in undeveloped areas, do not normally have FEMA delineated floodplains. This leaves these areas unregulated at the municipal level, and somewhat susceptible to uncontrolled development. Flood conditions, due to natural phenomenon as well as increased stormwater runoff generated by land development, are not restricted only to main channels and large tributaries. In fact, small streams and tributaries may be more susceptible to flooding from increased stormwater runoff due to their limited channel capacities.

Pennsylvania's Chapter 105 regulations partially address the problem of non-delineated floodplains. Chapter 105 regulations prohibit encroachments and obstructions, including structures, in the regulated floodway without first obtaining a state Water Obstruction and Encroachment permit. The floodway is the portion of the floodplain adjoining the stream required to carry the 100-year flood event with no more than a one (1) foot increase in the 100-year flood level due to encroachment in the floodplain outside of the floodway. Chapter 105 defines the floodway as the area identified as such by a detailed FEMA study or, where no FEMA study exists, as the area from the stream to 50-feet from the top of bank, absent evidence to the contrary. These regulations provide a measure of protection for areas not identified as floodplain by FEMA studies.

LEVEES AND OTHER FLOOD CONTROL STRUCTURES

As the administrator of the National Flood Insurance Program (NFIP), FEMA has a series of policies and guidelines concerning the protection of life and property behind levees. Periodically, FEMA updates the effective FIRMs as new hydrologic and hydraulic data become available and to reflect changes within the community. In the ongoing map update process, FEMA issued *Procedure Memorandum 43 (PM 43) – Guidelines for Identifying Provisionally Accredited Levees* (PALs). For communities with levees, PM 43 has potential to substantially impact the communities protected by levees. A PAL is a levee that has previously been accredited with providing base flood elevation plus required freeboard flood protection on an effective FIRM. After being designated as a PAL, levee owners will have up to 24 months to obtain and submit documentation that the levee will provide adequate protection against the base flood elevation plus required freeboard. If the levee cannot be certified as providing protection from the base flood elevation plus required freeboard, the areas currently being protected by the levees will be mapped and managed as if they were within the floodplain (i.e., in most cases, the residents and businesses currently being protected by the levees would be forced to purchase flood insurance in accordance with the NFIP).

There is one levee in the Fishing Creek Watershed located in Orange Township, Columbia County, recognized by FEMA in the county Flood Insurance Study (FEMA, 2020), but it is neither certified by the U.S. Army Corps of Engineers nor accredited by FEMA.

COMMUNITY RATING SYSTEM (CRS)

To reduce flood risk beyond what is accomplished through the minimum federal standards, the NFIP employs the Community Rating System to give credit to communities that reduce their community's risk through prudent floodplain management measures. Several of these measures coincide with the goals and objectives of flood mitigation measures: regulation of stormwater management, preservation of open space, and community outreach and education of the reduction of flood-related damages.

Flood insurance premiums can be reduced by as much as 45% for communities that obtain the highest rating. Currently, only the Town of Bloomsburg participates in the CRS within Fishing Creek Watershed. The Town currently maintains a CRS rating of 7 and receives a 15-percent discount on flood insurance premiums for properties within the Special Flood Hazard Area. Under Risk Rating 2.0: Equity in Action, a community's CRS discount applies to all CRS eligible NFIP policies in the community regardless of food zone.

SECTION 4 - REGULATIONS AND PLANNING STRATEGIES

Regulations and planning strategies can be an important tool in mitigating the impacts caused by stormwater and flooding. By looking at past and current regulations, and their outcomes, regulation and policy, recommendations can be made to provide a positive impact on stormwater and flooding related problems. Currently stormwater and floodplain regulations exist at a federal, state and can exist even at a local level. Generally, state and local regulations have the greatest impact on a community, as federal regulations often have a broader focus.

EXISTING FEDERAL REGULATIONS

As noted above, Federal regulations are generally board as they provide a national framework in which all other stormwater management regulations shall be developed.

CLEAN WATER ACT, SECTION 303 – Requires states to regulate point source pollution through the development of a Total Maximum Daily Load, to assure water quality and protect stream flora and fauna.

CLEAN WATER ACT, SECTION 404 – Regulations permitting of discharge of any dredged or fill material into United States waters. This includes the regulation of discharge into lakes, navigable streams and rivers, and wetlands.

CLEAN WATER ACT, SECTION 401/402 – Authorizes the Commonwealth to grant, deny, or condition Water Quality Certification for any licensed activity that may use result in a discharge to navigable waters. This also established the National Pollutant Discharge Elimination System (NPDES) that regulates earth disturbances activity of five (5) acres or more, or one (1) acre or more with a point source discharge.

RIVERS AND HARBORS ACT OF 1899, SECTION 10 – regulates activities that obstruct or alter any navigable waters of the United States.

FEDERAL EMERGENCY MANAGEMENT ACT – Requires any proposed structures within the floodplain boundaries of a stream cannot cause a significant rise (greater than one (1) foot) in the 100-year flood height of the stream.

EXISTING STATE REGULATIONS

Pennsylvania has developed a number of stormwater regulations that help the Commonwealth meet the federal standards and provide a statewide system for stormwater regulations. State regulations cover a variety of stormwater related topics, are more specific and include statewide standards for design criteria for state issued permits.

CHAPTER 92 – DISCHARGE ELIMINATION – regulates the permitting of point source discharges of pollution under the National Pollutant Discharge Elimination System (NPDES).

CHAPTER 93 – WATER QUALITY STANDARDS – Establishes the Water Use Protection classification (i.e. water quality standards) for all streams in the state, and stipulates anti-degradation criteria for all streams.

CHAPTER 96 – WATER QUALITY IMPLEMENTATION STANDARDS – Establishes the process for achieving and maintaining water quality standards for point source discharges of pollutants. In addition, this authorizes DEP to establish the Total Mass Daily Loads (TMDLs) and Water Quality Based Effluent Limitations (WQBELs) for all point source discharges to waters of the Commonwealth.

CHAPTER 102 – EROSION AND SEDIMENT CONTROL – requires anyone conducting and proposing earth disturbance activities to develop and maintain Best Management Practices (BMPs) to minimize the potential for erosion and sedimentation to manage post construction stormwater. The BMPs

shall be undertaken to protect, maintain, reclaim and restore water quality and designated uses of waters within the Commonwealth.

CHAPTER 105 – DAM SAFETY AND WATERWAY MANAGEMENT – regulates construction, operation and maintenance of dams and streams. It also regulates water obstructions and encroachments that are located in, along or projecting into a watercourse, floodway, wetland or body of water.

CHAPTER 106 – FLOODPLAIN MANAGEMENT – Manages the construction, operation and maintenance or structures located within the floodplain of a stream if owned by the State, a political subdivision, or a public utility.

EXISTING MUNICIPAL REGULATIONS

Throughout the state stormwater and floodplain regulations are typically enforced at a municipal level, however some municipalities will adopt the County's Subdivision and Land Development Ordinance (SALDO) which will include some stormwater and floodplain management regulations. Table 4.1 shows what zoning ordinances each municipality has. There are many municipalities within the study are that have adopted Columbia County's SALDO, and seven (7) that have their own (Columbia County, 2022).

Table 4.1 Municipal Regulation Summary (Columbia County, 2022)

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Sugarloaf Township	Within County SALDO	County SALDO	Yes	Within County SALDO
Jackson Township	No	Yes	Yes	No
Pine Township	Within County SALDO	County SALDO	Yes	Within County SALDO
Greenwood Township	Within County SALDO	County SALDO	Yes	Within County SALDO
Madison Township	Within Township SALDO	Yes	No	No
Millville Borough	Borough Ordinance & within County SALDO	County SALDO	Yes	Borough Ordinance, Regulations also in the County SALDO
Mt. Pleasant Township	Within County SALDO	County SALDO	Yes	Within Borough Zoning Ordinance, Regulations also in the County SALDO
Hemlock Township	Within Township SALDO	Yes	Yes	Within Township Zoning Ordinance
Montour Township	No	Yes	Yes	No

MUNICIPALITY	STORMWATER MANAGEMENT	SUBDIVISION & LAND DEVELOPMENT (SALDO)	ZONING	FLOODPLAIN MANAGEMENT
Scott Township	Within Township SALDO & Chapter 118	Yes	Yes	No
North Centre Township	Within Township SALDO	Yes	Yes	Within Township Zoning Ordinance
Town of Bloomsburg	Within SALDO	Yes	Yes	Yes
Orange Township	Within County SALDO	County SALDO	Yes	Township Ordinance
Orangeville Borough	Within County SALDO	County SALDO	No	Within County SALDO
Fishing Creek Township	Within County SALDO	County SALDO	No	Township Ordinance - Supersedes all other
Stillwater Borough	Within County SALDO	County SALDO	Yes	Within County SALDO
Benton Township	Within County SALDO	County SALDO	Yes	Within County SALDO
Benton Borough	Within County SALDO	County SALDO	Yes	Within County SALDO

RECOMMENDATIONS AND CONSIDERATIONS

As this study outlines several projects that would reduce the impacts of flooding, there are also a number of strategies that communities can take to decrease future impacts of stormwater and runoff through land use and zoning requirements. These efforts include municipal zoning, river corridor protection, and land use management and site design.

MUNICIPAL ZONING

Zoning is one of the most influential factors on the future of stormwater and flooding conditions within a community, as there is a direct correlation between runoff and land use, which is regulated through zoning. Developing, instituting, and adopting zoning or zoning amendments can be a difficult process, with potential political obstacles, financial related issues such as lack of staffing, and an increased level of enforcement that would be needed.

Despite these potential barriers, developing meaningful stormwater and floodplain management and land use zoning ordinances will directly impact future land use and development patterns, and are vital for successful stormwater management. However, the impacts of zoning regulations stretch beyond just stormwater and floodplain management, and any changes to zoning ordinances shall be developed with careful consideration to any and all potential effects of the changes.

Recommendations for Improved Municipal Zoning:

- Watershed Based Zoning – Master planning and zoning efforts that incorporate watershed specific regulations.
- Overlay Zoning – Overlay districts add an additional layer of regulations. These areas superimpose additional regulatory standards, permitted uses, or applies specific development criteria onto existing zoning regulations. An example of watershed related overlay districts maybe "impervious overlay zoning" in areas with documented stormwater problems to help set maximums for impervious area coverage. In some areas a riparian zoning overlay district could be an appropriate overlay district to help with water quality, floodplain management and stormwater management.
- Performance Zoning – requires a proposed development to meet certain desired levels of performance within a given area. This can be used to control traffic, noise, light requirements, and architectural styles, but can also help with watershed related performance zoning. This may include limits on stormwater quality and quantity and could be an option to help address impaired waterways.
- Large Lot Zoning – creates a district that can require development to occur at lower densities to help disperse impervious coverage. This can help mitigate stormwater runoff impacts related to increased impervious area.
- Infill Community Redevelopment – promotes the use of vacant or underutilized land within existing growth centers for increased development. This practice can limit the amount of new impervious area to a community by continuing to develop in areas where there is existing impervious area. This practice also helps to reduce negative impacts associated with sprawl and maximize the utilization of existing infrastructure.

RIVER CORRIDOR PROTECTION

River corridor protection is a broad term that includes a number of waterway management approaches for rivers, streams, creeks and other types of waterways. The concept behind corridor protection is to recognize the natural function of the waterway and to manage them to resolve conflicts between the natural system and land use. River corridors include the existing channel, the floodplain, and the adjacent riparian zone.

Floodplain Management

Floodplain management has a direct impact on mitigating flooding and wet weather conditions. Most stormwater management policy focuses on future development and reducing the likelihood of increased flooding, where most floodplain management focuses on preventative and corrective measures to reduce flood damage. Floodplain management policy serves to minimize the impacts of flooding events by reducing the conflicts related to land use and floodplains.

To develop effective floodplain management policy, it must include preventative provisions that restrict future development within the floodplains and corrective measures that help to reduce flood damage in identified problem areas.

Recommendations for floodplain management:

- Adopt and enforce the Pennsylvania Department of Community and Economic Development (DCED) Model Floodplain Ordinance. It is recommended that municipalities within the project area adopt the model ordinance as it will help to ensure that local ordinances address the minimum state and federal requirements and provide a consistent basis of floodplain management.
- Participate in the Community Rating System. The Community Rating System (CRS) provides credit to communities that reduce the risk of flood hazards. Through the implementation of the recommended projects and policies within this study, municipalities can help reduce flood insurance rates for residents that are located within the floodplain and outside of the Special Flood Hazard Area.

- Provide and Encourage Open Space Preservation in Floodplains. Open space preservation can help provide credits to future developments for reducing impervious area and in turn reducing stormwater runoff.
- Acquire and relocate flood-prone buildings from the floodplain. Within Columbia County, less than 1% of all properties have accounted for 49% of flood insurance claims since 1978 (FEMA, 2019). By removing properties and impervious area from the floodplains it can reduce the flooding and reduce the community's risk for flood damage. Most of the time it is more economical to remove properties than to install structural alternatives to protect the properties such as levees, diversion projects and dams.
- Implement a maintenance program for drainage systems. When infrastructure is designed and engineered it assumed that the infrastructure is at full function conveyance which means that when these areas get clogged or are not functioning properly this can cause increased flooding. It is important that municipalities implement a program for inspection and maintenance of channels, conveyance, and storage facilities.

River Corridor Planning

River corridor planning is the implementation of river (or stream) corridor management alternatives that consider all aspects of the river or stream by using river specific assessments that help to identify important features and potential areas of threat. This type of land use planning focuses on the impacts that land uses have on the river/stream system.

Recommendations for River Corridor Planning Include:

- Identify areas that could benefit from river corridor planning and initiate the planning process. The identification and planning of these areas can greatly reduce the economic impact that is caused by major flooding events. River corridor planning can be beneficial in areas that may see future development, areas with existing persistent flood damage, and areas with special value.
- Identify and project fluvial erosion hazard zones. Flooding can increase and occur more frequently as the channel changes from naturally occurring processes or human induced impacts. Geomorphic assessments can identify areas that are likely to experience channel changes through erosion. Through this process the identified areas can be used to help form overlay districts, areas that should have stream buffer requirements, or areas for additional protection.
- Review and incorporate river corridor planning resources into future changes in Fishing Creek Watershed planning and floodplain management, for example:
  - Vermont DEC River Management Program: https://dec.vermont.gov/watershed
  - FEMA River Corridor and Watershed Management: https://training.fema.gov/hiedu/docs/fmc/chapter%2014%20-%20river%20corridor%20and%20watershed%20mgmt.pdf

Riparian Zone Protection

The riparian zone is the area between the aquatic zone and adjacent uplands, which generally includes streambanks, floodplain, and any adjacent wetlands. Although similar and overlapping the river corridor, the riparian zone doesn't refer to a specified distance, where the riparian zone differs based on the geographic area.

There are two major benefits of riparian zones, flood protection and water quality functions. They provide flood protection by providing a temporary storage area that allows for the velocity of waters to be slowed and provide some amount of flooding reduction through infiltration. These zones also filter out pollutants and provides protection from streambank erosion.

Recommendations for Riparian Zone Protection include:

- Adopt and enforce the riparian buffer provision of the PA DEP Model Stormwater Management Ordinance. The Model Ordinance includes regulations that require the establishment of riparian buffers on all new development near watercourses. An exception is included for roadway maintenance activities and there is a waiver for linear projects. The model ordinance also includes requirements that are in accordance with the proposed changes to the statewide erosion and sedimentation plan.
- Adopt stream specific guidelines. In areas where there are numerous problems identified, and a riparian buffer is identified as a potential solution, the adoption of specific guidelines for a stream may be beneficial. One way to determine guidelines is through the preparation of a stream corridor study to help designate riparian zones within the study area, as these zones range from 75 feet to 1000 feet.
- Encourage voluntary establishment of riparian buffers. Regulatory approaches help to limit the future development within the riparian zone but have little to no effect on the existing land use that currently exists within riparian areas. There are incentive programs that help to provide technical and or financial assistance for landowners to establish riparian buffers.

LAND USE MANAGEMENT AND SITE DESIGN

Wetland Protection

Wetlands are essential to water quality protection, stormwater management, and provide ecological functions. Wetlands help to with storm flow modification, limit erosion, provide sediment and nutrient retention and provide groundwater replenishment. Wetlands also function as areas for flooding storage during wet weather events.

A recommendation related to wetlands protection would be:

- Protect special value wetlands. Since wetland provide a number of benefits, they have been protected by federal and state regulations, that protect them from development. However, under the existing regulations encroachment of wetlands is permitted for certain activities, therefore, municipalities should develop additional regulations to further protect wetlands.

Green Stormwater Infrastructure/Low Impact Development Design

Development can have impacts on stormwater and can cause increased flooding, which is a reason why green stormwater infrastructure, also known as low impact development, can help to limit the impacts development has on stormwater. Green stormwater infrastructure and low impact development design concepts strive to reduce the impervious surface area and minimize the natural area that is disturbed. These concepts also include decentralizing stormwater management facilities.

Limiting Impervious Cover

Studies show that when 10% of the land area within a watershed is impervious, biological indicators within the waterways begin to show degradation. Through the limitation of impervious cover, it can reduce the impact that development can have on the hydrologic cycle.

Concepts for reducing impervious coverage include:

- Road Widths – many roadways are assumed to have 12-foot travel lanes, and additional impervious coverage for sidewalks. If existing lanes are 12 feet, reducing them to 11 feet could decrease impervious coverage of the roadways by up to 8 percent. Adjustments in road widths may have impacts on certain municipal funding mechanisms (i.e. Liquid Fuels funds require minimum cartway widths of 16 feet).

- On-street parking – standardizing a maximum of 8-foot-wide parking and limiting street parking to one side of the road when feasible. Another option can be to require parking lanes to be constructed with pervious pavement or another type of impervious surface.
- Curb and Gutter Systems with Storm Sewers – ordinances could be modified to allow roadside swales, which provide additional opportunity for infiltration and can also provide filtration to help improve water quality.
- Parking Requirements and Dimensions – municipalities should consider reducing the number is parking spaces that are required, and the required stall size. Parking stall sizes requirements could be 8 feet wide by 18 feet long. Ordinances could also require minimums for green space within parking lots that should allow the runoff from the impervious area to flow over them so that water quality filtration and infiltration is enhanced.
- Total impervious coverage on a lot – limits should be established to limit the amount of impervious coverage on a single lot. Ordinances should also establish a minimum amount of green space that should be provided on commercial, institutional, and industrial developments. Furthermore, these green spaces shall be designed to help capture runoff from the impervious surfaces.

Limit Disturbance or Compaction of Topsoil

Topsoil provides a significant function when it comes to stormwater management. During wet weather events runoff does not occur until the topsoil becomes saturated and the holding capacity is exceeded. However, when soil is compacted, it can drastically limit the holding capacity. Therefore, municipalities should consider the following recommendations:

- Adopt ordinance language that discourages the common practice of removing topsoil the development sites during construction. The area of disturbance should be limited to the area that is necessary to complete the project.
- Adopt ordinance provisions that limit soil compaction where possible. Areas that are outside of the area of disturbance should still be protected from compaction by construction activities. These areas should be identified on side plans and protected by in-field measures.

SECTION 5 - PROBLEM AREAS

One of the stated goals of this Plan is to "identify problem areas in the entire Fishing Creek Watershed." The strategy for achieving this goal required the identification of the existing significant flooding and wet weather problem areas, and then an evaluation of the identified problem areas.

The first task was to identify the location and nature of existing flooding and wet weather problems within the Watershed, and where appropriate, gather field data to be used for further analysis of the problems. The geographic location data was used to map all of the problem areas and obstructions on a single map (Appendix A). Mapping the location of the sites in this manner enables you to identify isolated problems and determine which problems are part of more systemic problems. Systemic problems are often an indication that larger watershed problems exist, which may warrant watershed-wide strategies. This information was used when evaluating the individual problem area mitigation options and incorporated into watershed-wide strategies, where appropriate.

The second part of this task was to analyze individual problem areas and obstructions, determine potential solutions, and provide recommendations. All of the problem areas and obstructions were evaluated and potential solutions were developed. Where possible, the individual problem areas and obstructions were modeled to determine approximate capacities to be used for planning purposes. Then a preliminary prioritization assessment was conducted to give a watershed-wide overview of the severity of the existing problems. The priority assessment also provides general guidance on the relative order in which the problems should be addressed when considered by individual municipalities or at a watershed-wide level.

PROBLEM AREA IDENTIFICATION

Identification and review of existing information concerning the Watersheds flooding and wet weather issues within the project limits was conducted. Questionnaires were distributed to all of the municipalities in Fishing Creek Watershed within Columbia County. The questionnaire enabled the municipalities to report up to three (3) known problem areas within their municipality. Of the 18 municipalities with land area contributing to Fishing Creek Watershed in Columbia County, all 18 participated in the assessment process by returning completed questionnaires or providing indirect feedback through other contacts. The responses were reviewed and incorporated into the assessment of problem area mitigation options. Field reconnaissance was subsequently conducted to confirm problem area locations, assess existing conditions, identify problem area causes, and gather data to complete a planning level analysis.

Each reported problem area is listed by study area in Tables 5.1, 5.2, 5.3, and 5.4. A more detailed explanation of each site can be found in Appendix C – Problem Area Mitigation Summaries, which contains a summary of the data collected for each of the problem areas reported throughout the Watershed.

Table 5.1 Upper Fishing Creek Study Area Problem Areas

ID	Municipality	Location	Problem
UFC 1	Sugarloaf Township	Village of Central & Jamison City	Flooding from West Branch Fishing Creek, numerous log jams and debris buildup around Central Road Bridges
UFC 2	Sullivan County	Elk Grove	Flooding due to upstream impacts
UFC 3	Sugarloaf Township	Central Road	Flooding due to undersized culvert

ID	Municipality	Location	Problem
UFC 4	Sugarloaf Township	Market Street	Flooding caused by undersized bridge waterway opening and sediment build up under Market Street bridge
UFC 5	Sugarloaf Township	Central Road	Debris and Sediment building around Central Road bridge
UFC 6	Sugarloaf Township	School House Drive	Flooding caused by undersized bridge waterway opening and sediment build up under School House Drive bridge
UFC 7	Sugarloaf Township	Camp Lavigne Road	Sediment and Debris buildup in stream channel and along banks
UFC 8	Benton Borough	Benton Borough	Much of the borough is lower than the top of bank for Fishing Creek and much of the borough is located within the FEMA floodplain for Fishing Creek
UFC 9	Benton Borough/Township	Distillery Hill Road bridge	Debris and Sediment building around Distillery Hill Road bridge
UFC 10	Benton Township	Rohrsburg & Maple Grove Road	Flooding from Fishing Creek

Table 5.2 Middle Fishing Creek Study Area Problem Areas

ID	Municipality	Location	Problem
MFC 1 & 3	Stillwater Borough	Lower Raven Creek Road & Paperdale Road	Much of the borough is lower than the top of bank for Fishing Creek and much of the borough is located within the FEMA floodplain for Fishing Creek
MFC 2	Stillwater Borough	Paperdale & Buck Road	Flooding caused by undersized culverts and sediment/debris buildup
MFC 4	Fishing Creek Township	Ridge & Honeytown Road	Flooding caused by undersized culverts, lack of channel slope, and sediment/debris buildup
MFC 5	Fishing Creek Township	Zaner Bridge Road	Flooding caused by undersized bridge waterway opening and sediment build up under Zaner Bridge Road bridge
MFC 6	Fishing Creek Township	Winding & Harrison Road	Flooding caused by undersized culverts and sediment/debris buildup
MFC 7	Fishing Creek Township	Pealertown	Flooding from Fishing Creek
MFC 8	Fishing Creek Township	2870 SR 487	Severe erosion of streambanks
MFC 9	Orange Township	Moore's Grove	Flooding and heavy sedimentation along Fishing Creek
MFC 10	Orange Township	Rohrsburg & Neyhart Road	Flooding caused by lack of stormwater management infrastructure
MFC 11	Orange Township	Green Creek & Logging Road	Flooding caused by undersized culvert and sediment/debris buildup

ID	Municipality	Location	Problem
MFC 12	Orange Township	Green Creek Road	Flooding caused by undersized bridge waterway opening and sediment build up under Green Creek Road bridge
MFC 13	Orange Township	Evans Lane	Flooding due to constrained floodway and sediment/debris buildup
MFC 14 & 16	Orange Township	Mt. Pleasant Road	Properties located in low lying areas within the FEMA floodplain
MFC 15	Orange Township	Mt. Pleasant Road Bridge Stream Gauge	Stream gauge is exposed and at risk of damage from flooding and vandalism
MFC 17	Orange Township	Charmund Road & SR 487	Flooding caused by insufficient stormwater management infrastructure
MFC 18	Orange Township	Stony Brook Road & SR 487	Flooding caused by constrained stream channel and sediment/debris buildup at a small backyard structure
MFC 19	Orangeville Borough	Mt. Pleasant Road	Flooding caused by undersized culvert
MFC 20	Orangeville Borough	Broad and Mill Street	Flooding caused by undersized culverts and lack of stormwater management infrastructure
MFC 21	Greenwood Township	Rohrsburg Road	Flooding caused by undersized bridge waterway opening and sediment build up under Green Creek Road bridge

Table 5.3 Little Fishing Creek Study Area Problem Areas

ID	Municipality	Location	Problem
LFC1	Jackson Township	Pole Bridge Road	Flooding caused by undersized culvert
LFC2	Jackson Township	Pole Bridge Road and SR 239	Flooding caused by undersized culverts and sediment/debris buildup
LFC3	Jackson Township	Green Creek Road	Flooding caused by undersized culvert
LFC4	Pine Township	Peterman Road	Flooding caused by undersized culvert, poor stream alignment, and sediment/debris buildup
LFC 5	Greenwood Township	Mallard Road	Flooding caused by undersized culverts and sediment/debris buildup
LFC 6	Greenwood Township	Village of Iola	Flooding caused by undersized bridges, debris buildup, and constrained floodplain
LFC 7	Millville Borough	West Main Street Bridge	Flooding caused by undersized bridges, debris buildup, and constrained floodplain

Table 5.4 Hemlock Creek-Lower Fishing Creek Study Area Problem Areas

ID	Municipality	Location	Problem
HC 1	Mount Pleasant Township	Robbins Road bridge	Flooding caused by sediment build up under Robbins Road bridge
HC 2	Scott & Mount Pleasant Township	Back Branch road bridge	Significant scouring of bridge piers
HC 3	Mount Pleasant Township	Back Branch & Millertown Road	Flooding caused by constricted stream channel
HC 4	Mount Pleasant Township	Back Branch Road	Flooding caused by constricted stream channel
HC 5	Mount Pleasant Township	Millville & Millertown Road	Flooding due to property being located withing the FEMA regulatory floodplain (SFHA) for Fishing Creek
HC 6	Hemlock Township	Peppermill and Buckhorn Road	Flooding caused by undersized culvert, poor stream alignment, and sediment/debris buildup
HC 7	Hemlock Township	Orchard Drive	Flooding caused by undersized culverts and sediment/debris buildup
HC 8	Hemlock Township	Dahl Road	Flooding caused by undersized culvert
HC 9	Hemlock Township	Frosty Valley and Schoolhouse Road	Erosion along Hemlock Creek due to runoff from I-80
HC 10	Hemlock Township	Wanich Covered Bridge	Flooding caused by constrained stream channel from covered bridge
HC 11	Hemlock Township	Millville Road	Flooding caused by undersized bridge and proximity to FEMA floodplain
HC 12	Hemlock Township	Ridge Road and SR 42	Erosion and flooding driveway
HC 13	Hemlock & Montour Townships	Perry Avenue Bridge	Flooding caused by undersized bridge waterway opening and sediment build up under Perry Avenue bridge
HC 14/16	Hemlock Township & Town of Bloomsburg	Fernville	Flooding in the village of Fernville and West End of Bloomsburg
HC 15	Town of Bloomsburg	Hoffman Park	Erosion of the streambanks near walking trail
HC 17	Town of Bloomsburg	Boone's Dam	Dam is currently in a state where repairs may be required
HC 18	Scott Township	Lake Florence	Severe flooding occurs in this area
HC 19	Montour Township	Hock Road Bridge	Flooding caused by undersized bridge waterway opening

SECTION 6 – FLOODING AND WET WEATHER MITIGATION OPTIONS

After the problem areas were determined, mitigation measures needed to be proposed to reduce the risk of flooding and increase resiliency after flooding has occurred. The proposed mitigation measures and solutions fall into three categories: site mitigation options, nature based mitigation options, and watershed strategy options. Site mitigation options, both structural and nature based, are those that can be completed on individual problem areas, whereas watershed strategy options are those that can be implemented through county wide ordinances and inter-governmental/municipal cooperation to reduce the risk of flooding.

Site Mitigation Options

The site mitigation options considered include culvert replacements, bridge replacements, roadway reprofiling, stormwater infrastructure improvements, floodplain restorations, riparian forest buffer plantings, levees, sediment removal, stream realignments, property buyouts and/or property floodproofing.

Culvert replacements are proposed where existing culverts were determined to be undersized from field assessments and hydraulic modeling. Culvert replacements will increase the capacity of the culverts, allowing the water to move downstream instead of creating localized flooding and/or overtopping of roadways.

Bridge replacements are proposed where the existing hydraulic opening of the bridge was determined to be undersized from field assessments, known flooding history, and hydraulic assessments. Bridge replacements were also recommended based upon the current structural integrity of the bridge.

Roadway reprofiling involves the vertical adjustment of the roadway to raise it above the flood elevation. This option is usually paired with levees or culvert/bridge replacements to increase the hydraulic capacity of the openings.

Levees provide structural protection for residential areas that were constructed within floodplains. Levees can be compromised of many different materials, including earthen or MSE floodwalls. Levees are proposed for areas where no other solution is probable and large scale property buyouts and or floodproofing are not feasible.

Stormwater infrastructure improvements are proposed where a lack of infrastructure causes flooding. Stormwater infrastructure improvements would include upsizing existing inlets and cross pipes as well as installing new systems where current issues exist.

Property buyouts and floodproofing are proposed for properties with no other feasible option to reduce flood risk. Flood buyouts involve the local municipality working with a federal and or state agency to purchase the property at fair market value and demolish any existing structures. Floodproofing can either involve elevating a home out of the floodplain or adding materials to the home to increase the resiliency of the property. All buyouts and floodproofing eligibility will be determined by the agency issuing the grant and must be voluntary for each individual property owner.

Nature Based Mitigation Options

The nature based mitigation options considered included floodplain restorations, riparian forest buffer plantings, sediment removal, stream realignments, conservation measures and green stormwater infrastructure (also known as low impact development).

Floodplain restorations are proposed where legacy sediment and/or man placed fill has restricted the original floodplain and floodway. Removing legacy sediment and fill will allow for a wide flow path as well as slowing down the velocity of the flood flows. This will reduce erosion along the

stream banks. Floodplain restorations are generally paired with other proposed mitigation options to further mitigate flood levels.

Riparian forest buffers are proposed along streams within the watershed where meadows or farm fields immediately abut the stream corridor. Riparian forest buffers increase the amount of vegetation within the floodplain as well as the flood resiliency for erosion and decrease the velocity of flood flows.

Sediment removal involves the removal of legacy sediment that has been deposited from large storm events. Sediment removal is not a standalone mitigation measure and is only recommended in conjunction with other mitigation measures that will reduce sediment deposits in the future (i.e. floodplain reconnection, stream realignment, bridge/culvert replacements). Sediment removal when combined with another measure will provide the stream channel a more natural or effective cross section and reduce the risk of the sediment redepositing in the future.

Stream realignments are proposed where streams enter culverts and bridge openings at too sharp of an angle. Stream realignments will allow for increased capacity for existing culverts and bridge openings due to a decrease in overall flow length and losses due to sharp bends.

Green stormwater infrastructure, also known as low impact development practices, allows for more natural hydrologic functions to occur through stormwater management practices that allow for enhanced infiltration and evapotranspiration. These practices are useful at addressing site scale stormwater management issues and could be used through retrofit at large scales to decrease watershed flood flows. Some of the options identified in the Columbia County Countywide Action Plan fall into the green stormwater management option category (CCCD, 2021).

Watershed Strategy Options

The watershed strategy options considered include were land use management (including stormwater management ordinances or regulations), floodplain management, stormwater management regulations, and early warning system.

Land use management options would include modifications to enhance flood protection and increase stormwater management through county and municipal zoning ordinances, subdivision and land development ordinances, and conservation land use protections. Additional discussion of these options was included in Section 4.

Floodplain management options would include modifications to enhance flood protections through ordinances and planning efforts through direct floodplain management ordinance enactment or changes, river corridor planning and protection, and riparian zone protections. Additional discussion of these options was included in Section 4.

A flood early warning system is used to warn property owners of pending floods and flooding conditions and provide time for safe evacuation and relocation of moveable property to flood damage. This would be in addition or expansion of existing flood warning systems through enhancements in rainfall and stream flow monitoring to develop better, more accurate flood predictions.

SECTION 7 - TECHNICAL ANALYSIS

TECHNICAL APPROACH SUMMARY

To provide technical guidance for the Fishing Creek Watershed Flooding Assessment and Mitigation Study, a hydrologic model was prepared for the entire watershed and more detailed hydraulic models were developed for specific areas within the Watershed. The results from the hydrologic models increase the overall understanding of watershed response to rainfall and help guide mitigation efforts. Through the development and analysis of a hydrologic and hydraulic modeling tool, mitigation strategies can be identified and applied on a county-wide basis to evaluate longer term watershed changes while also addressing specific issues identified by the individual communities in the Watershed.

The hydrologic methodology used in the technical approach is the Natural Resource Conservation Service (NRCS) Rainfall-Runoff Method described in various NRCS publications (NRCS, 2008a). This method was chosen since it is the most common method used by designers in Pennsylvania and has widely available data (NRCS, 2008b). The calculations for this methodology were performed with HEC-HMS, the US Army Corps of Engineers' Hydrologic Modeling System.

The hydraulic modeling tools utilized included the conveyance component of HEC-HMS, the US Army Corps of Engineers River Analysis System (HEC-RAS), and Federal Highway Administration's HY-8 Culvert Hydraulic Analysis Program. HEC-RAS is the preferred tool for evaluations of open channel riverine hydraulics and HY-8 was utilized to evaluate individual culverts outside of the developed HEC-RAS model.

The hydrologic and hydraulic modeling approach in this study was to:

1. Establish a reasonable estimate of rainfall-runoff response under existing conditions,
2. Establish a reasonable estimate hydraulic conditions based on FEMA Flood Insurance Study results or observations,
3. Provide an examination of the impact of the individual flood mitigation concepts at various scales (site to watershed), and
4. Evaluate various combinations of recommended flood mitigation concepts based on problem area/project prioritization results.

Information from public meetings and discussions with various public officials has been incorporated to direct the focus of this modeling effort and to ensure the problem areas were assessed throughout the Fishing Creek Watershed in Columbia County.

HYDROLOGIC MODEL

BASELINE MODEL PARAMETERS

The Baseline HEC-HMS model utilized available GIS data to create a baseline model for future calibration and watershed-wide analysis. The model is comprised of subbasins, reaches, junctions, and meteorological data. These components are the basis for peak flow and runoff volume calculations.

SUBWATERSHED AREA

The subbasins are based on the Pennsylvania Small Watersheds GIS data from the Eastern Pennsylvania Coalition for Abandoned Mine Reclamation. This data was then modified to create 232 subbasins within the Fishing Creek Watershed by utilizing USGS topographic maps as a reference for subbasin delineations. All of the subbasins are less than 5.0 square miles, and since

the drainage area for the Fishing Creek Watershed is approximately 385 square miles, the average subbasin area is less than 2.0 square miles. The subbasins are named after their respective streams, and subbasins designated with a 'T' are tributary subbasins (e.g. SHLCR01 is designated as the most downstream subbasin for Hemlock Creek). The delineation of these subwatershed areas created points of interest at junctions where the subwatersheds were hydraulically connected in the HEC-HMS model. Maps of the Fishing Creek Watershed subareas and junction locations considered in this study are provided in Appendix B. Excerpts of the subarea map is shown in Figure 7.1 and the junction map is shown in Figure 7.2.

Each subbasin is defined by a SCS Curve Number and a SCS Unit Hydrograph. The curve number is used to calculate runoff volume for each subbasin, and the unit hydrograph is used to calculate how quickly the runoff volume travels across the subbasin. Together, the curve number and unit hydrograph are used to calculate the peak flow for each subbasin.

SOILS AND LAND USE

The SCS Curve Number for each subbasin is based on the 2019 Land Cover GIS data from the National Land Cover Database and the National Resources Conservation Service Soils GIS data from the United States Department of Agriculture. Curve number values are dependent on land cover and soil types, hence the intersection of these data sets is needed to calculate the curve number for each subbasin.

LAG TIME

The SCS Unit Hydrograph for each subbasin is based on the calculated lag time. The lag time is dependent on the curve number, flow length, and average land slope for each subbasin. The watershed lag method was utilized to calculate lag time, which applied the Mockus equation for the flow length calculation and the Chow equation for the average land slope calculation for each subbasin.

Lag time is the transform routine when using the NRCS Curve Number Runoff Method. Lag can be related to time of concentration using the empirical relation:

$$T_{Lag} = 0.6 * T_C$$

Lag time values for the subwatersheds were based on NRCS Lag Equation and altered as described in Appendix A:

$$T_{Lag} = L^{0.8} \frac{(S+1)^{0.7}}{1900\sqrt{Y}}$$

Where: T_{lag} = Lag time (hours)

L = Hydraulic length of watershed (feet)

Y = Average overland slope of watershed (percent)

S = Maximum retention in watershed as defined by: S = [(1000/CN) – 10]

CN = Curve Number (as defined by the NRCS Rainfall-Runoff Method)

For comparison purposes, a lag time was also calculated for each subwatershed using the TR-55 segmental method. Given the rural landscape of Columbia County, the best estimate for time of concentration calculation was provided by the NRCS lag equation.

INFILTRATION AND HYDROLOGIC LOSS ESTIMATES

Infiltration and all other hydrologic loss estimates (e.g., evapotranspiration, percolation, depression storage, etc.) were modeled using the standard initial abstraction in the NRCS Rainfall-Runoff Method (i.e., Ia = 0.2S) for the existing conditions and future conditions models.

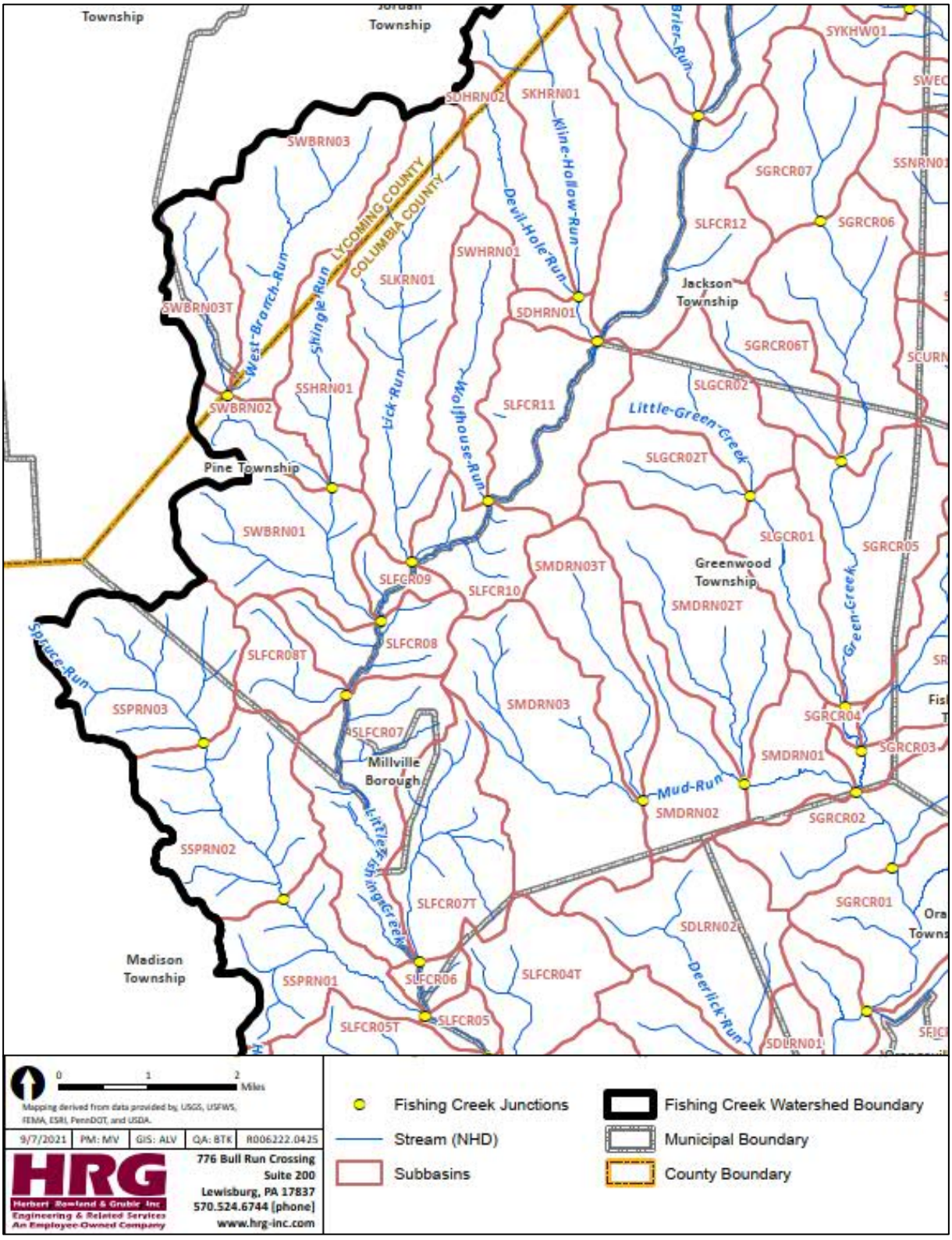

Figure 7.1 Fishing Creek Watershed Hydrologic Model Subbasin Example

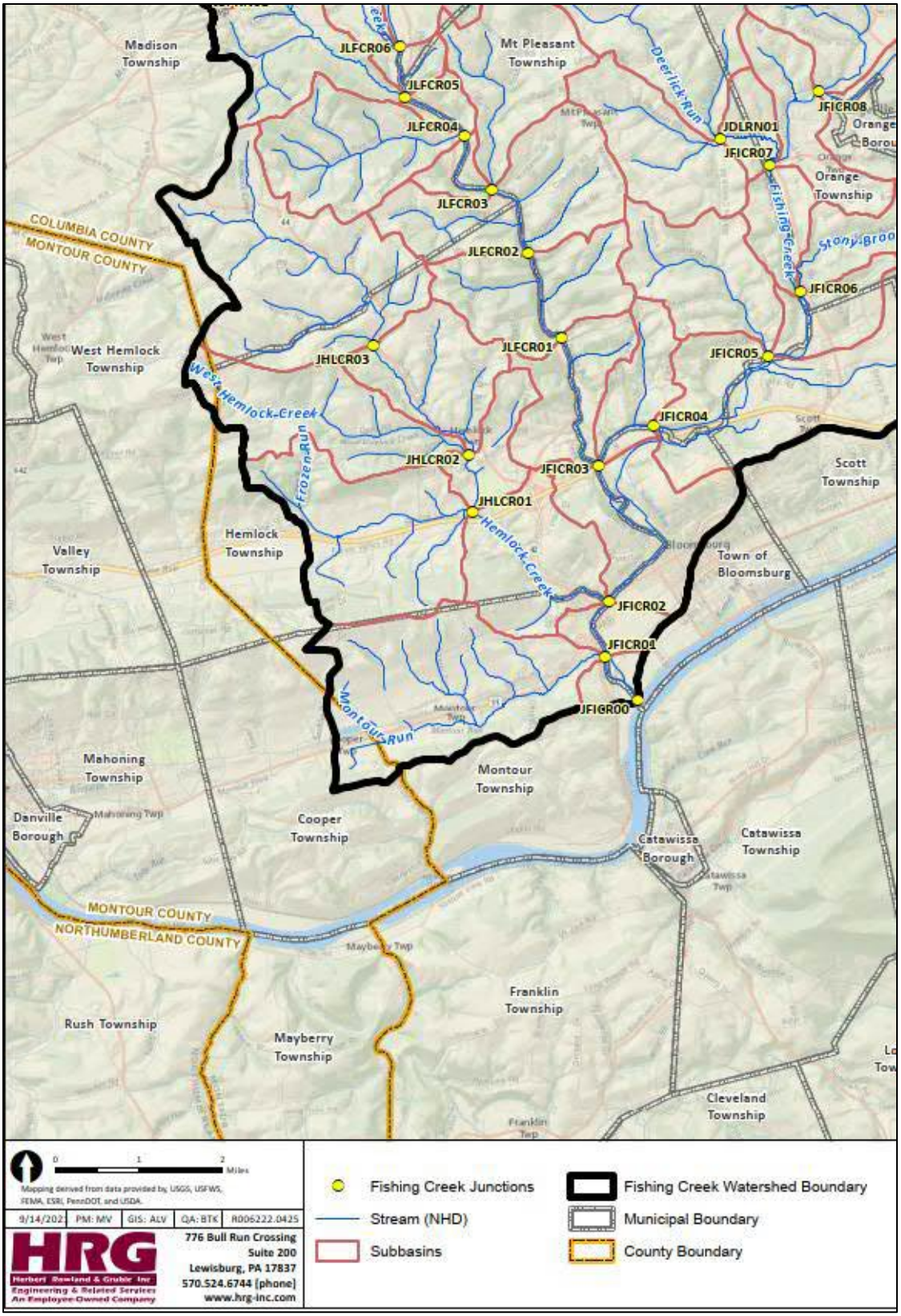

Figure 7.2 Fishing Creek Hydrologic Model Junctions Example

REACH LENGTHS, SLOPES, AND CROSS SECTION DIMENSIONS

The reaches are based on the National Hydrology Dataset Flowline GIS data from the United States Geological Survey. This data was then modified to create 131 reaches within the Fishing Creek Watershed by utilizing the previously completed subbasin delineations. The total length for all the reaches is approximately 182 miles and the average reach length is less than 1.5 miles. The reaches are named after their respective streams, which ultimately represent the major streams within the Fishing Creek Watershed (e.g. RHLCR01 is designated as the most downstream reach for Hemlock Creek).

Each reach is defined by the Muskingum-Cunge routing method. This method utilizes reach length, slope, cross sections, manning's n values, and index flows. Together, these parameters are used to calculate how quickly flow travels from the upstream portion of a reach to the downstream portion of a reach. The reach parameters do not have an impact on runoff volume calculations, but they do have an impact on peak flow timing and ultimately peak flow values. Figure 7.1 shows the dimensions as they are approximated.

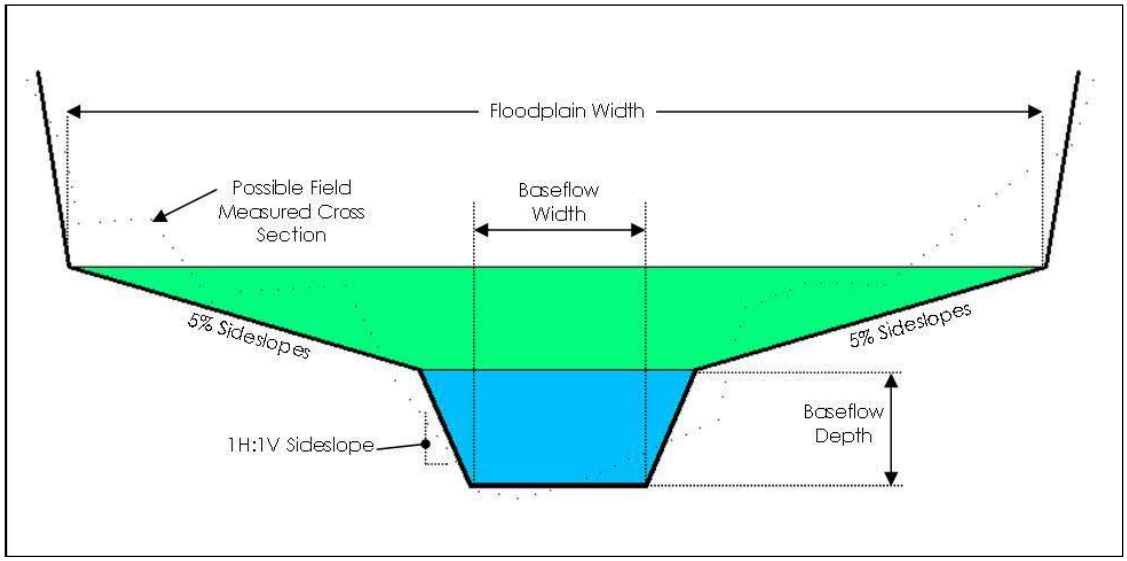

Figure 7.1 Cross Sections Used for Reaches in HEC-HMS Model

The slope for each reach is based on the Topographic Contours GIS data from the DCNR PAMAP Program. The upstream and downstream elevations for each reach was obtained from this data, and the reach slope was calculated by the difference in elevations over the calculated reach length. The slope for each reach is greatly dependent on the topography of the surrounding area, and the average reach slope for the Fishing Creek Watershed is less than 1.5%.

The cross section for each reach is based on the Nation Flood Hazard Layer GIS data from the Federal Emergency Management Agency, Topographic Contours GIS data from the DCNR PAMAP Program, and the Scientific Investigations Report 2018-5066 from the United States Geological Survey. Each reach is comprised of an eight-point cross section which generally outlines the channel and floodplain geometries. The channel geometry for each reach is determined by the bankfull linear regression equations presented in the 2018-5066 report, and the floodplain geometry is determined by FEMA data when available, or by contour data when FEMA data is not available. Overall, the floodplain benches are assumed to have a 5% cross slope, and the cross section geometry is assumed to be symmetrical. More detailed cross sections can be found in the HEC-RAS model.

The manning's n values for each reach are based on the Columbia, Luzerne, and Sullivan County Flood Insurance Studies from the Federal Emergency Management Agency. Each cross section

for each reach is comprised of three manning's n values: channel, left bank, and right bank. The channel manning's n values are approximated as the average channel manning's n value from the respective study for the respective stream on a watershed basis. The left and right manning's n values are approximated as the average overbank manning's n value from the respective study for the respective stream on a watershed basis. The average channel manning's n value for the entire Fishing Creek Watershed is approximately 0.045. The average overbank manning's n value for the entire Fishing Creek Watershed is 0.083. More detailed manning's n values can be found in the HEC-RAS model.

The index flows for each reach are based on the first iteration of model runs. Index flows are approximated to be half of the peak flow from the first iteration of model runs for each event along each reach. While index flows can affect peak flow calculations due to changes in computations, changes in index flows have a marginal effect on peak flows.

The junctions are based on the downstream and upstream points for each reach, and the junctions serve as hydraulic connections for the subbasins and reaches. There are 132 junctions throughout the Fishing Creek Watershed model, and the junctions are named after their respective streams (e.g. JHLCR01 is designated as the most downstream junction for Hemlock Creek).

The meteorological data is based on the SCS Type 2 Hypothetical Storm and the Point Precipitation Frequency Estimates from the National Oceanic and Atmospheric Administration Atlas 14, Volume 2, Version 3. The location for these estimates is near Benton Borough and Stillwater Borough along Fishing Creek. This location was chosen since it is the approximate centroid of the Fishing Creek watershed. Values for the 2, 10, 25, 50, 100, and 500-year 24-hour event were determined at this location and used for the entire watershed. As a reference, the 2-year 24-hour event is 2.87 inches and the 100-year 24-hour event is 6.92 inches.

The peak flow and runoff volume calculations are based on running the model over a 72-hour time period at 5-minute time intervals. The peak flows calculated by the baseline model are generally higher than the flows calculated by FEMA, which is expected. The baseline model utilized curve numbers, which is a conservative approach, and the FEMA reports utilized regression equations for their peak flow calculations within the Fishing Creek watershed.

CALIBRATED MODEL

The Calibrated HEC-HMS model utilized flow data from multiple sources to calibrate the Baseline HEC-HMS model. The main sources of calibration were from three stream gauges from the United States Geological Survey, and the Federal Emergency Management Agency Flood Insurance Studies for Columbia, Luzerne, and Sullivan Counties. These sources, along with additional analysis, provided a means to calibrate the baseline model.

The three stream gauges of interest were USGS 01539000 Fishing Creek near Bloomsburg (drainage area of 274 sq. mi.), USGS 01540000 Fishing Creek at Bloomsburg (drainage area of 355 sq. mi.), and USGS 01539500 Little Fishing Creek at Eyers Grove (drainage area of 56.5 sq. mi.). Unfortunately, USGS 01540000 and 01539500 did not have enough data to justify using them for calibration purposes since they each had approximately 20 years' worth of data from the early 1900s. Fortunately, USGS 01539000 has been in operation since the early 1900s and is still operating – making the stream gauge ideal for calibration purposes. Additionally, USGS 01539000 accounts for over 70% of the entire drainage area for the Fishing Creek watershed.

The FEMA FIS reports provide peak stream flows for multiple locations throughout the Fishing Creek Watershed for the 10, 50, 100, and 500-year event. These flows are generally based on regression equations and are the basis for water surface calculations for the FEMA Flood Insurance Rate Maps. USGS 01539000 is best represented by the FEMA flows provided for Fishing Creek with a drainage area of 292 sq. mi.. The peak stream flows provided by FEMA for this location are

approximately equal to the proportioned peak stream flows calculated by the Weibull Distribution Method for USGS 01539000. Therefore, the FEMA flows were considered sufficient for calibration purposes and the confluence of Fishing Creek with the Susquehanna River was chosen as the focal point for calibration.

Since FEMA flows were chosen as the main source of calibration, the 2-year and 25-year storm events did not have a formal basis for calibration since FEMA only calculated flows for the 10, 50, 100, and 500-year storm events. Therefore, the 2-year and 25-year flows had to be calibrated based on an interpolation and extrapolation process utilizing FEMA flows and the Weibull Distribution Method for the three stream gauges.

The calibration process generally used volume factors to modify curve numbers, which were approximately based on differences between flows from the baseline model and flows provided by FEMA on a drainage area basis. The volume factors were applied across the entire Fishing Creek watershed, and they are primarily dependent on the storm event (see Table 7.1). Generally, the baseline calculations for smaller storm events were closer to FEMA flows than larger events.

Table 7.1 Volume Factors by Event

Storm Event	Volume Factor
2-year	0.81
10-year	0.79
25-year	0.76
50-year	0.74
100-year	0.71
500-year	0.66

The results of the model indicate that the calibrated peak stream flows are generally greater than the FEMA peak stream flows provided in the FIS reports, which is expected. The FEMA flows generally utilized regression equations which are mainly dependent on drainage area characteristics. Whereas the HEC-HMS model considers the conveyance of runoff and joining of flows throughout the watershed, along with drainage area characteristics. Ultimately, the flows calculated for the calibrated model are conservative and should only be used as a reference for preliminary matters.

WATERSHED SCALE FLOOD MITIGATION OPTIONS EVALUATIONS

Agriculture to Meadow Model

The Agriculture to Meadow HEC-HMS model analyzed the effects of agriculture land use on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if agriculture land use areas were returned to a more natural state, and conversely, how much stream flows have increased due to the clearing of land for agriculture.

To complete this task, all of the agriculture land use within Columbia County was changed to a meadow land use. Curve numbers and lag times were updated for each subbasin, and index flows were updated for each reach. The updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that agriculture land use has a robust effect on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 41%. Granted, the scale of this reduction is due to 100% of the available agriculture land use being changed to meadow land use, which is not practical or realistic.

Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

Developed to Meadow Model

The Developed to Meadow HEC-HMS model analyzed the effects of developed land use on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if developed land use areas were returned to a more natural state, and conversely, how much stream flows have increased due to the clearing of land for development.

To complete this task, all of the developed land use within Columbia County was changed to a meadow land use. Curve numbers and lag times were updated for each subbasin, and index flows were updated for each reach. The updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that developed land use has a lesser effect than agriculture land use on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 5%. Granted, the scale of this reduction is due to 100% of the available developed land use being changed to meadow land use, which is not practical or realistic. Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

35 ft Riparian Buffers Model

The 35 ft Buffers HEC-HMS model analyzed the effects of riparian buffers on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if agriculture/barren land use areas within 35 ft of a surface water were returned to a more natural state, and conversely, how much stream flows have increased due to the clearing of land along stream corridors.

To complete this task, all of the agriculture/barren land use within the Restoration Opportunity Areas defined by the Columbia County 35 ft Buffers GIS data from the Chesapeake Conservancy was changed to a meadow land use. Curve numbers and lag times were updated for each subbasin, and manning's n values and index flows were updated for each reach. The updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that implementing 35 ft riparian buffers would have a negligible effect on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 0.4%. However, this reduction is due to 100% of the available agriculture/barren land use within 35 ft buffer restoration opportunity areas being changed to meadow land use, which is not practical or realistic. Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

100 ft Riparian Buffers Model

The 100 ft Riparian Buffers HEC-HMS model analyzed the effects of buffers on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if agriculture/barren land use areas within 100 ft of a surface water were returned to a more natural state, and conversely, how much stream flows have increased due to the clearing of land along stream corridors.

To complete this task, all of the agriculture/barren land use within the Restoration Opportunity Areas defined by the Columbia County 100 ft Riparian Buffers GIS data from the Chesapeake Conservancy was changed to a meadow land use. Curve numbers and lag times were updated for each subbasin, and manning's n values and index flows were updated for each reach. The

updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that implementing 100 ft riparian buffers would have a negligible effect on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 1%. However, this reduction is due to 100% of the available agriculture/barren land use within 100 ft buffer restoration opportunity areas being changed to meadow land use, which is not practical or realistic. Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

Wetland Restoration Model

The Wetland Restoration HEC-HMS model analyzed the effects of wetland restoration on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if restorable wetland areas were returned to a more natural state, and conversely, how much stream flows have increased due to the destruction of wetlands.

To complete this task, the total area of non-developed land use within the 100-year and 500-year floodplain areas defined by the Special Flood Hazard Layer GIS data from the Federal Emergency Management Agency, and within the Modeled Restorable Wetlands of Pennsylvania GIS data from the University of Vermont Spatial Analysis Laboratory, was multiplied by 1.0 ft to approximate the potential wetland storage volume for each subbasin within Columbia County. The calculated storage volumes were then used to reduce runoff volumes and ultimately modify curve numbers for each subbasin. Additionally, index flows were updated for each reach. The updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that restoring wetlands has a robust effect on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 47%. Granted, the scale of this reduction is due to 100% of the available restorable wetlands within the FEMA defined floodplain being restored, which is not practical or realistic. Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

Floodplain Reconnection Model

The Floodplain Reconnection HEC-HMS model analyzed the effects of floodplain reconnection on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if floodplain areas were reconnected to their streams, and conversely, how much stream flows have increased due to the disconnection of floodplains.

To complete this task, the total area of non-developed land use within the 100-year floodplain areas (excluding floodway) defined by the Special Flood Hazard Layer GIS data from the Federal Emergency Management Agency was multiplied by 1.0 ft to approximate the potential floodplain reconnection volume for each reach within Columbia County. The calculated volumes were then used to create ratios based on the total 100-year floodplain area (including floodway) for each reach, and these ratios were then used to lower the floodplain bench for each cross section of each reach. Additionally, index flows were updated for each reach. The updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that floodplain reconnection has a modest effect on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 8%. Granted, the scale of this reduction is due to 100% of the available non-developed floodplain areas being reconnected, which is not practical or realistic. Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

Countywide Action Plan Model

The Countywide Action Plan HEC-HMS model analyzed the effects of the Columbia County Countywide Action Plan on stream flows throughout the watershed. The intent of the model was to show how much stream flows would decrease if all of the Columbia County initiatives were implemented in the Columbia County portion of the Fishing Creek watershed.

Table 7.2 Countywide Action Plan Model Components

Watershed	Agriculture to Meadow (acres)	Developed to Meadow (acres)	Buffers – 100 feet wide (acre)
Bee Sellers Hollow	0	19	8
Coles Creek	0	93	2
Deerlick Run	645	95	24
Devil Hole Run	274	44	4
East Branch Raven Creek	0	59	9
Fishing Creek	0	0	138
Green Creek	1313	274	42
Hemlock Creek	1290	337	50
Little Fishing Creek	0	653	74
Little Green Creek	357	67	10
Little Pine Creek	0	55	11
Mud Run	1165	205	68
Raven Creek	0	105	30
Spruce Run	0	91	14
West Creek	0	162	30
York Hollow	137	33	5

To complete this task, components of the Countywide Action Plan were separated into categories that best fit previously completed models. Some of the proposed actions could be described by the previously completed models, while others could not. While several actions proposed wetland restoration and floodplain reconnection, these actions did not propose enough land area to include in the model. Therefore, only actions that best exemplified the Agriculture to Meadow, Developed to Meadow, or 100 ft Buffers model were used for the Countywide Action Plan model. The land areas proposed for these actions were then distributed on a watershed basis. This distribution of land area was dependent on watersheds that exemplified large differences in flows per previously completed models, and the assumption that only 25% of the available land area would be available for their respective changes (a table summarizing the area distribution is presented below). Once the distribution was completed, curve numbers and lag times were updated for each subbasin, and index flows were updated for each reach. The updated parameters were then analyzed in the model for various storm events, and the results were compared to the baseline and calibrated calculations.

The results of the model indicate that the Columbia County Countywide Action Plan would have a modest effect on stream flows throughout the watershed. For the 10-year event, the largest reduction in peak stream flow for a single junction was 8%. Considering the assumptions for the model, the scale of this reduction is considered practical and realistic. Overall, peak flow differences were more apparent for smaller storms events than for larger storm events.

WATERSHED MODELING DISCUSSION

The HEC-HMS models developed for the Fishing Creek Watershed indicate that the watershed is very large and that substantial improvements would be needed to decrease stream flows throughout the watershed.

While the models are based on current rainfall data, consideration should be given to future conditions when utilizing the flows calculated by these models or when making decisions related to flooding.

Based on data provided by Stream Gauge 01539000 from the United State Geological Survey, and data for the Williamsport Area from the National Oceanic and Atmospheric Administration, flooding occurrences have been increasing over the last 80 years, and based on current trendlines, may continue increasing. Annual mean flow, annual total precipitation, annual average temperature, and annual minimum temperature have all increased over the last 80 years. Additionally, seasonal total snowfall has decreased, and annual maximum temperature has remained relatively constant over the last 80 years. The results from this analysis indicate that peak stream flows may also be impacted by increases in temperature and precipitation, in addition to changes in land use.

Regardless, actions should be taken on a watershed-wide basis to help mitigate flooding occurrences. Modifications to agriculture and developed land uses, along with the reconnection of floodplains and restoration of wetlands, should all be considered to help decrease stream flows. Although riparian buffers may not substantially decrease stream flows, buffers along stream corridors would help control erosion and sedimentation while maintaining a healthy stream cross section and satisfying water quality needs. By implementing a multi-faceted approach throughout the Fishing Creek watershed, stream flows can be reduced, and flooding occurrences would decrease as a result.

HYDRAULIC MODEL

HEC-RAS ANALYSIS

The United States Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) program version 6.1 was used to calculate water surface elevations for the 2, 10, 25, 50, 100, and 500-year storms for various stream reaches within Columbia County (See Table 7.3). All USACE HEC-2 Water Surface Profiles (predecessor to HEC-RAS) and United States Geological Survey (USGS) Water Surface Profile (WSPRO) hydraulic models were received from FEMA and converted to a HEC-RAS model utilizing the HEC-2 User Manual dated September 1990, the HEC-RAS version 6.1 User Manual for reproducing HEC-2 results, and engineering judgment. All other stream reaches were developed in HEC-RAS utilizing publicly available data for topography and data received from Columbia County and PennDOT for any bridges.

Table 7.3 HEC-RAS Model Summary by Sub-Model Area

Stream Name	Downstream Limit	Upstream Limit	FEMA HEC-2 Available?
Fishing Creek	Confluence with Susquehanna River	Approximately 1,500 ft upstream of Fleckenstein Grove by Kee Equipment Services	Yes
Fishing Creek (Stillwater)	Southern Border of Stillwater Borough	Fishing Creek Veterinary Clinic	No
Fishing Creek (Benton)	Downstream of Sokol Quarries	Upstream of the Mill Race Golf Course Dam	Yes
West Branch Fishing Creek	South of Central Road Bridge by Steven Hill Road	Border of Sullivan County	No

Stream Name	Downstream Limit	Upstream Limit	FEMA HEC-2 Available?
Little Fishing Creek (Millville)	South of Boyer Bottom Road	North of PA 442	No
West Creek	Confluence with Fishing Creek	Upstream of 239	Yes
Hemlock Creek	Confluence with Fishing Creek	North of Interstate 80	Yes

Model Development

The hydraulic analysis in this study was completed using the USACE HEC-RAS version 6.1 program. For all models converted from HEC-2 to HEC-RAS, a 'duplicate model' was developed to reproduce the results published in the FEMA Flood Insurance Study (FIS) for Columbia County effective on August 19, 2008. Minor differences were noted between the results produced by both programs. The biggest differences were noted around the bridges and the dams. These differences can be attributed to the difference in the hydraulic computation of bridges. HEC-RAS can analyze the same geometric bridge input with several methods and utilizes four cross sections to compute energy losses due to the structure. HEC-2 required either the normal or special bridge routines to be chosen with each routine requiring different geometric input data. The special bridge routine uses a trapezoidal approximation of the bridge's hydraulic opening whereas HEC-RAS uses the bridge and cross-sectional geometry to determine the hydraulic opening. The HEC-2 special bridge routine computes pressure flow as if both the upstream and downstream sides of the bridge is fully submerged whereas HEC-RAS can compute pressure flow when only the upstream side or both sides of the bridge is fully submerged. The normal bridge routine computes low flow and high flow conditions using the energy equation. Since HEC-RAS has the option to also do this, the results were similar with small differences based on how piers are modeled. The Manning's "n" values used in HEC-2 were compared with aerial imagery and were found to be relatively consistent with the current land cover in Columbia County. As such, only the Manning "n" values for cross sections located near identified problem areas were refined. This process was chosen due to the significant length of stream analyzed and the strict time frame of the study. All Manning "n" values used were consistent with the Columbia County Flood Insurance Study (FIS).

All HEC-RAS models not developed from FEMA HEC-2 data were developed utilizing publicly available resources such as Light Detection and Ranging (LiDAR) topographic data and bridge data received from Colombia County and PennDOT. Manning's "n" values were selected based upon aerial imagery, The Hydraulic Reference Manual by the U.S. Army Corps of Engineer's Hydrologic Engineering Center and engineering judgment. Manning' "n" values ranged from 0.030-0.050 in the channel and 0.013-0.120 in the over bank areas.

The expansion and contraction coefficients were based on guidance from the HEC-RAS Hydraulic Reference Manual and engineering judgment. A 0.1 contraction coefficient and a 0.3 expansion coefficient were used at cross sections with gradual transitions. A 0.3 contraction and 0.5 expansion coefficient for the existing and proposed bridges were used.

A normal downstream boundary condition was used for all Study developed HEC-RAS models. All HEC-RAS models utilized Study developed flows except for Fishing Creek in Benton and West Creek. This is because Study developed flows were less than FEMA developed flows. Flow change locations were added at all junction locations from the HEC-HMS model (see Tables 7.4 through 7.9).

Table 7.4 Fishing Creek Watershed Study Developed Flow Rates by Location of Flow Changes

Cross Section Flow Change Location	2-Year (cfs)	10-Year (cfs)	25-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
At the Upstream Limits	7,362	18,197	30,627	35,634	45,729	81,544
At Moore's Grove	7,355	18,200	30,584	35,574	45,640	81,104
Upstream of Orangeville	8,497	20,436	34,009	39,531	50,659	90,108
At Fishing Creek Campground	8,643	20,673	34,330	39,897	51,102	90,720
Upstream of Kocher Park	8,620	20,703	34,267	39,790	51,012	90,351
Upstream of the Sediment Pond	8,638	20,740	34,279	39,786	50,961	90,000
Between Hoffman Park and the Sediment Pond	8,695	20,833	34,382	39,893	51,059	89,989
Upstream of Interstate 80 Bridge	10,293	24,243	39,968	46,539	59,713	105,721
At the Confluence with Hemlock Creek	10,334	24,370	39,922	46,357	59,132	103,472

Table 7.5 Fishing Creek – Benton Area Study Developed Flow Rates by Location of Flow Changes

Cross Section Flow Change Location	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
At the Upstream Limits	7,080	12,900	16,200	24,400
At the Confluence with West Creek	8,320	14,700	18,200	27,200
Upstream of Rohrsburg Road Bridge	8,510	15,100	18,600	27,400

Table 7.6 West Branch Creek – Sugarloaf Area Study Developed Flow Rates by Location of Flow Changes

Cross Section Flow Change Location	2-Year (cfs)	10-Year (cfs)	25-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
At the Upstream Limits	7,720	3,440	6,400	7,720	10,320	19,820

Table 7.7 Little Fishing Creek – Millville Area Study Developed Flow Rates by Location of Flow Changes

Cross Section Flow Change Location	2-Year (cfs)	10-Year (cfs)	25-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
At the Upstream Limits	1,799	4,449	7,389	8,746	11,134	18,842

Table 7.8 West Creek – Benton Area Study Developed Flow Rates by Location of Flow Changes

Cross Section Flow Change Location	10-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
At the Upstream Limits	2,450	4,790	6,170	9,720
At the Benton Area Rodeo Associates	2,630	5,130	6,610	10,300

Table 7.9 Hemlock Creek Study Developed Flow Rates by Location of Flow Changes

Cross Section Flow Change Location	2-Year (cfs)	10-Year (cfs)	25-Year (cfs)	50-Year (cfs)	100-Year (cfs)	500-Year (cfs)
At the Upstream Limits	777	2,168	3,720	4,396	5,669	9,911

Model Calibration

The Fishing Creek HEC-RAS model with Study developed flow was calibrated utilizing the stage-discharge curve from the USGS stream gauge located at the Mount Pleasant Road Bridge in Orangeville.

The Fishing Creek (Benton) model with FEMA flows matched well with photographic and video footage of the flash flooding event that occurred on July 25, 2018. No further calibration of the model was performed.

No other models were calibrated due to limited stream level monitoring data. For future studies, high water marks, anecdotal evidence from resident, along with video and photographic evidence of flooding resulting from Tropical Storm Lee and other well documented storms could be used to further refine developed HEC-RAS models.

Figure 7.1 shows a still shot of a video taken on July 25, 2018 which shows high water marks upstream of the Main Street Bridge in Benton Borough. Local rainfall data and the stage-discharge curve from the USGS stream gauge for this storm event closely corresponds to the 10-year return period storm event. The high water marks on the Main Street Bridge matches the results produced from the HEC-RAS modeling of the 10-year storm event for Fishing Creek (Benton) utilizing FEMA published flows.

Figure 7.1 July 25, 2018 storm event shows water within Fishing Creek (Benton) just below the bridge low chord. This still shot was taken from a video uploaded to YouTube by a local resident (Redneck News Benton).

Existing Conditions Analysis

The existing conditions plans were developed utilizing the calibrated geometry of Fishing Creek, the duplicate models of Fishing Creek (Benton), West Creek, and Hemlock Creek, and the HRG developed geometry for Fishing Creek (Stillwater), Little Fishing Creek (Millville), and West Branch Fishing Creek along with the flows referenced in Tables 7.4 through 7.9.

Proposed Conditions: Problem Area Analysis

A copy of the plans used in the Existing Conditions Analysis file were used to analyze each problem area when evaluated utilizing HEC-RAS. All problem areas were evaluated separately, this was done to produce the result as if no other projects were completed for each problem area.

Proposed-Conditions Agriculture to Meadow/Developed to Meadow analysis

For the proposed agriculture to meadow and developed to meadow HEC-RAS runs, a copy of the existing conditions for Fishing Creek, Fishing Creek (Benton), and Hemlock Creek, as referenced in the Existing-Conditions Analysis section, was used along with flows generated in the HEC-HMS Agriculture to Meadow and Developed to Meadow HEC-HMS model. See the Hydrology portion of this section for detailed discussion on the hydrological analysis and Appendix B for the results.

Proposed Conditions: Prioritized Problem Area Projects and CAP analysis

For the proposed County Wide Action Plan (CAP) HEC-RAS runs, new geometry files were developed for the high, high-medium, and high-medium-low priority problem areas as assessed through the prioritization of problem area solutions. These geometry files were created by first using a copy of the existing conditions for Fishing Creek, Fishing Creek (Benton), West Creek, and

Hemlock Creek, as referenced in the Existing-Conditions Analysis section, and then adding in the proposed conditions geometry data from the Proposed-Conditions Problem Area Analysis section. This process results in a maximum of three geometry files for each of the four stream corridors analyzed. Each of these geometries were then modeled utilizing the flows discussed in the Model Development section. Additionally, a final model run was done utilizing the high-medium-low geometry file and the CAP flow rates generated in the HEC-HMS CAP model, which is further discussed in the Hydrology portion of this section. This process results in multiple models which analyze the impacts of different level of project implementation throughout the four stream reaches. See Appendix D for the results.

HY-8 ANALYSIS

Model Development

When investigating problem areas where a HEC-RAS Model was not developed to perform an analysis, the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program was used to determine what year storm would cause the roadway to overtop at the specified problem area. Required input values to run the HY-8 application include channel width, roadway elevation, invert elevation, channel slope, pipe/culvert size, peak flow rates, etc. Input values for the existing conditions of each site were determined utilizing information gathered from site visits, aerial imagery, LiDAR, data received from Columbia County and PennDOT, and engineering judgement. Peak flow rates were determined using HRG determined flow values, which can be found in Appendix B. When HRG determined flow values were not available for a reach, the United States Geological Survey (USGS) StreamStats web application for estimating stream peak flow rates.

OPEN CHANNEL FLOOD MITIGATION OPTIONS EVALUATION RESULTS

PROPOSED CONDITIONS PROBLEM AREA RESULTS

Problem area solutions typically fell into three types of solutions: infrastructure improvements, floodplain restorations, and channel modifications. Infrastructure improvements consist of improving, constructing, or removing bridges, dams, culverts, levees, roadways, and implementing individual property improvements. Stream restorations are a type of flood mitigation best management practice (BMP) where the main goal is to increase the conveyance capacity of the floodplain to a more historical and natural condition. Channel modifications largely consist of maintenance activities such as debris management and accumulated sediment removal.

In general, implementation of problem area solutions result in localized improvements around the identified problem areas, but provide limited improvements to downstream or upstream locations. Problem areas located within minor tributaries to Fishing Creek had more implementable mitigation solutions whereas many problem areas located along or near the main branch of Fishing Creek contained little to no cost effective solution for mitigating flooding. This is attributed to two main issues found within the watershed. The first issue is the significant drainage area of Fishing Creek and the sheer volume of water that is conveyed through the channel and floodplain. The second issue is how the majority of infrastructure and the layout of the boroughs, such as Orangeville, Benton, and Stillwater, were built and designed. Throughout these communities, structures and buildings are constructed as close as 50 feet from the edge of the Fishing Creek banks. Additionally, these municipalities are located at an average elevation that is lower than the top elevation of the Fishing Creek banks. The problem with this is once peak flood elevations reach above the elevation of the banks, then the majority of the Town that is below this elevation is quickly flooded. Along with this, many of the major bridges that are located over Fishing Creek have a low chord elevation (bottom of the bridge deckway) that is higher than the average elevation of the Town. Additionally, these bridges are not designed to be able to handle large storm events through the bridge's hydraulic opening. Rather, bridges rely heavily on the

hydraulic capacity of the floodplain to convey flows past the bridge, which is where the Boroughs are situated (in the floodplains).

These existing problems create a significant challenge when looking for potential solutions to mitigate flooding. Improving the bridges provide minimal change in the quantity of property flooding because the Boroughs are already under water by the time flood elevation reaches the bridge deck. Increasing the available floodplain is also a challenge since the Boroughs and many populated areas in the Townships are essentially located within the only floodplain that is available to convey flow during these high storm events. One solution to this is to construct levees to protect the Boroughs. Although levees are technically feasible to construct, the design and construction of these levees are extremely costly and most municipalities located within Fishing Creek Watershed in Columbia County are not dense enough for the benefits of the levees to outweigh the significant construction costs, not including the environmental impact to the stream resource.

PROPOSED CONDITIONS: PRIORITIZATION AND CAP RESULTS

The hydraulic results for the prioritization runs were similar to the results on the individual problem areas as discussed in the section above. The implementation of problem areas results in located improvements, but water surface profiles and stream velocities converge shortly upstream and downstream of the improvements. Implementation of multiple improvements just provide more areas of localized improvements, but the reach wide profile generally remains the same. With the additional implementation of the CAP, there is a reduction of peak stream flows throughout the watershed.

SECTION 8 – BASIS OF COSTS

The assessment of Problem Area projects utilized cost estimation data for use in planning level screening, comparison of conceptual solutions, and prioritization of Problem Areas. The data was derived from recently evaluated construction cost data from publicly bid projects of similar scope and scale of those proposed in the Study.

Tabulated and unit costs used the analysis are updated frequently, considered appropriate and accurate for projects bid in 2022 and are relevant to the central Pennsylvania region. The cost opinions created are to be considered Level 4 cost estimates, as designated by The Association for the Advancement of Cost Engineering Recommended Practice No. 18R-97 (AACE, 2005), and actual costs are expected to fall within a range of 30% less to 50% more than the cost opinions given in Appendix C. This estimate class and accuracy is appropriate for planning level use.

Quantities were calculated using aerial imagery, LiDAR, and engineering judgment. The cost for the "Property Improvements" concepts were calculated using data from the FEMA Risk Mapping, Assessment and Planning Program. Levee and floodwall costs were developed and compared to West End Flood Mitigation Study cost for similar levee and/or floodwall systems.

It is noted that the costs provided are considered "construction costs", which means the raw cost of building conceptual solutions. The construction cost typically includes: general conditions, overhead and profit, mobilization, demobilization, contractor's bonds and insurance, and sub-contractor's markups.

The construction cost does not include non-construction costs. Non-construction costs would include engineering design, permitting, construction engineering, land acquisition, risk contingencies, and any associated financing costs. The costs provided in Appendix C do not include non-construction costs. A typical assumption for non-construction cost is 20% to 50% of the construction cost, depending on the scope, scale, and complexity of the given project.

SECTION 9 - PRIORITIZATION OF PROBLEM AREAS AND PROJECTS

Upon completion of the technical analysis of all the problem areas, an objective method was needed to assess the order in which the problem area and its proposed solutions should be implemented. An analysis like this is necessary to prioritize where available funding is most needed, while also most efficiently used. The chosen assessment system evaluates each problem area or obstruction independently of the others. This is more valuable than a ranking system which lists the problems in order because it helps determine the amount of resources that should be dedicated to addressing the existing problem areas and issues. However, as with any prioritization scheme, this assessment could not encompass all factors in the decision-making process and should be considered as a guide for future planning efforts.

A set of criteria were developed to determine the priority of each problem area. Criteria were modified from a stormwater prioritization assessment completed in Montour County Pennsylvania and were used to establish a system for prioritization (Montour, 2010). Table 9.1 provides a list of criteria that were used to assess each problem area and potential mitigation concept project. Each problem/project was assigned a rating between 1 and 10 for each of the five criteria. The five criteria were equally weighted to calculate a single relative rating between 1 and 10 for each problem.

Table 9.1 Problem Area/Project Prioritization Rating Criteria

Criteria	Description	Rating
Frequency of Existing Problem	How frequent was the problem area issue reported to occur?	1 to 10
Property and Public Impacts	Does the problem area impact individual properties or busy public spaces?	1 to 10
Problem Reduction	How well does the mitigation concept improve flooding/wet weather conditions?	1 to 10
Resiliency	How long will the proposed solution last and/or how frequent does it require maintenance?	1 to 10
Cost of Solution	Will the solution cost less than $250,000, more than $250,000 but less than $1 million, greater than $1 million to resolve?	1 to 10

Each of the problem areas and project concepts have been categorized in one of three categories based on their composite score: 1) Highest Priority Problem, 2) Medium Priority Problem, or 3) Lower Priority Problem. A composite rating between of 7 and 10 would classify a problem area or obstruction as a High Priority Problem. A composite rating between 4 and 6.9 would classify a problem area or obstruction as a Medium Problem, and a rating between 1 and 3.9 would be classified as a Lower Priority Problem. Because each problem was evaluated independetly, each municipality can use this assessment as the basis to develop their own problem area prioritization list.

Problem areas that were categorized as High Priority Problems, based upon the criteria provided in Table 9.1, have been analyzed in more detail. Figures 9.1 through 9.4, shown below, provide a list of the problem areas by the respective study area along with the priority rating. The data sheets in Appendix A for these problem areas include a more descriptive overview and a detailed recommended solution(s). Figure 9.5 shows the composite rating for all of the reported problem areas and obstructions throughout the entire Study area.

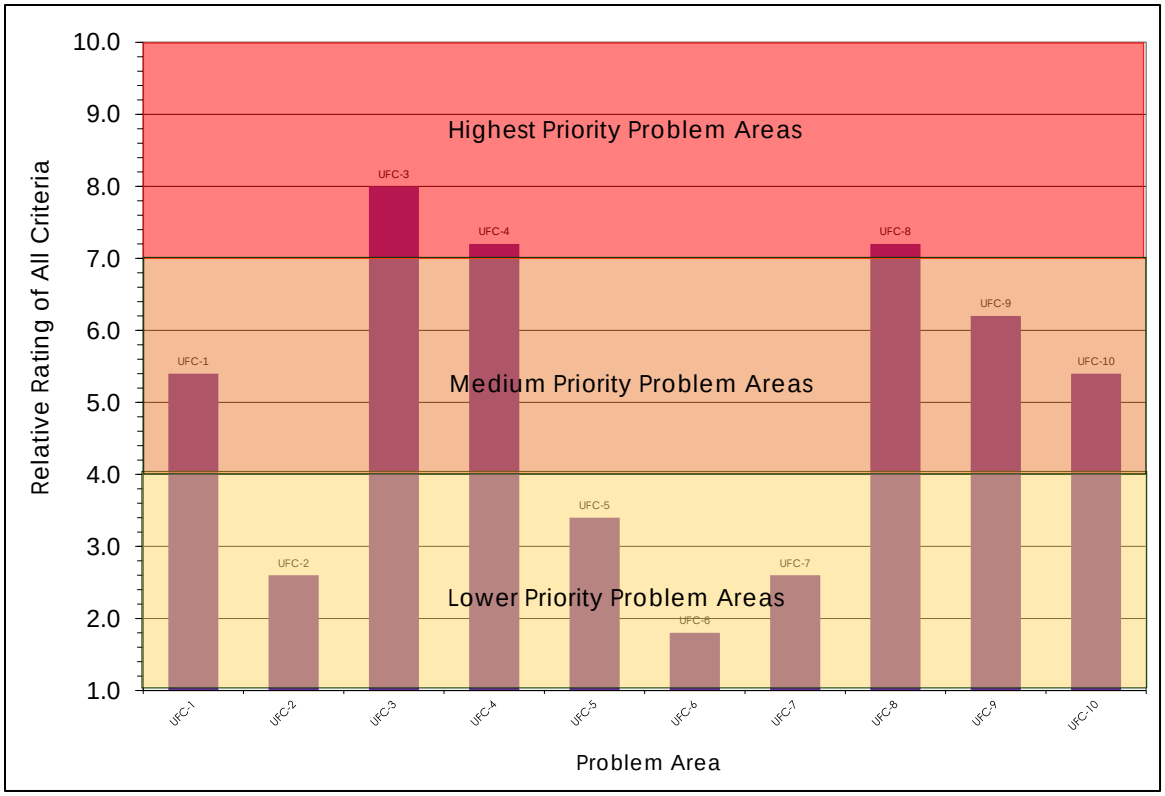

Figure 9.1 Upper Fishing Creek Study Area Relative Problem Area Prioritization Rating

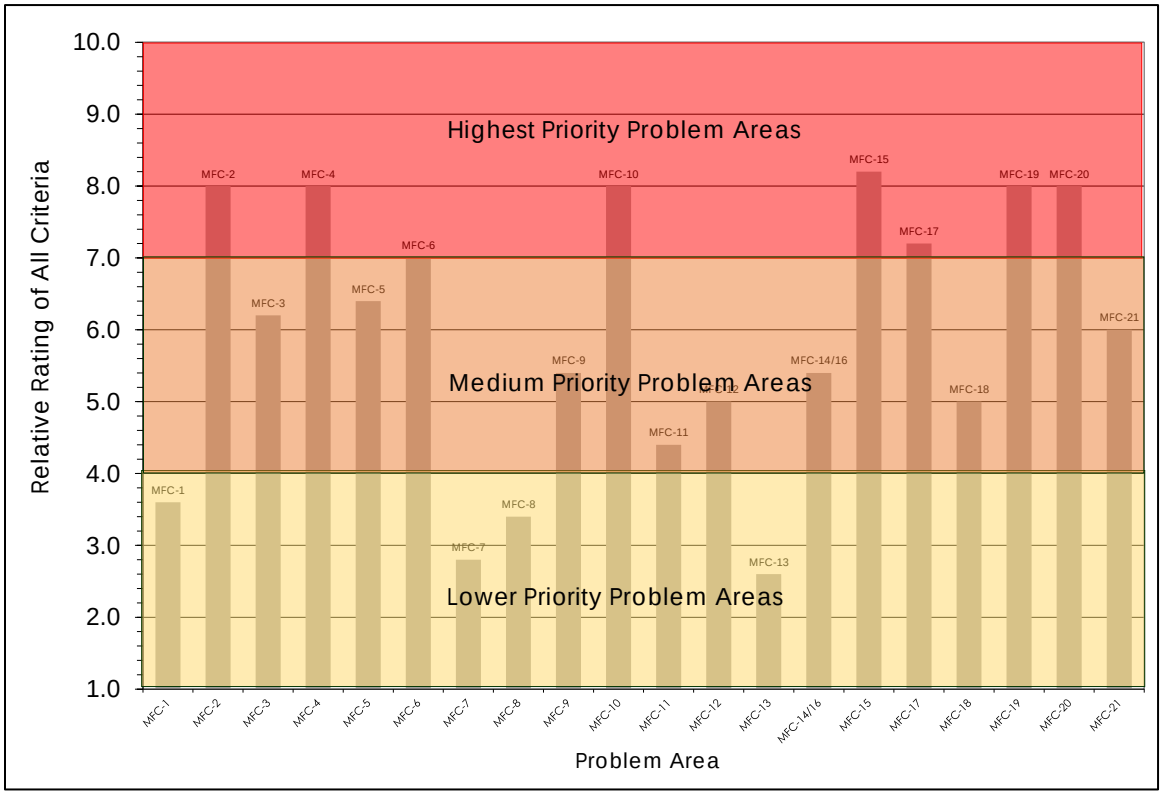

Figure 9.2 Middle Fishing Creek Study Area Relative Problem Area Prioritization Rating

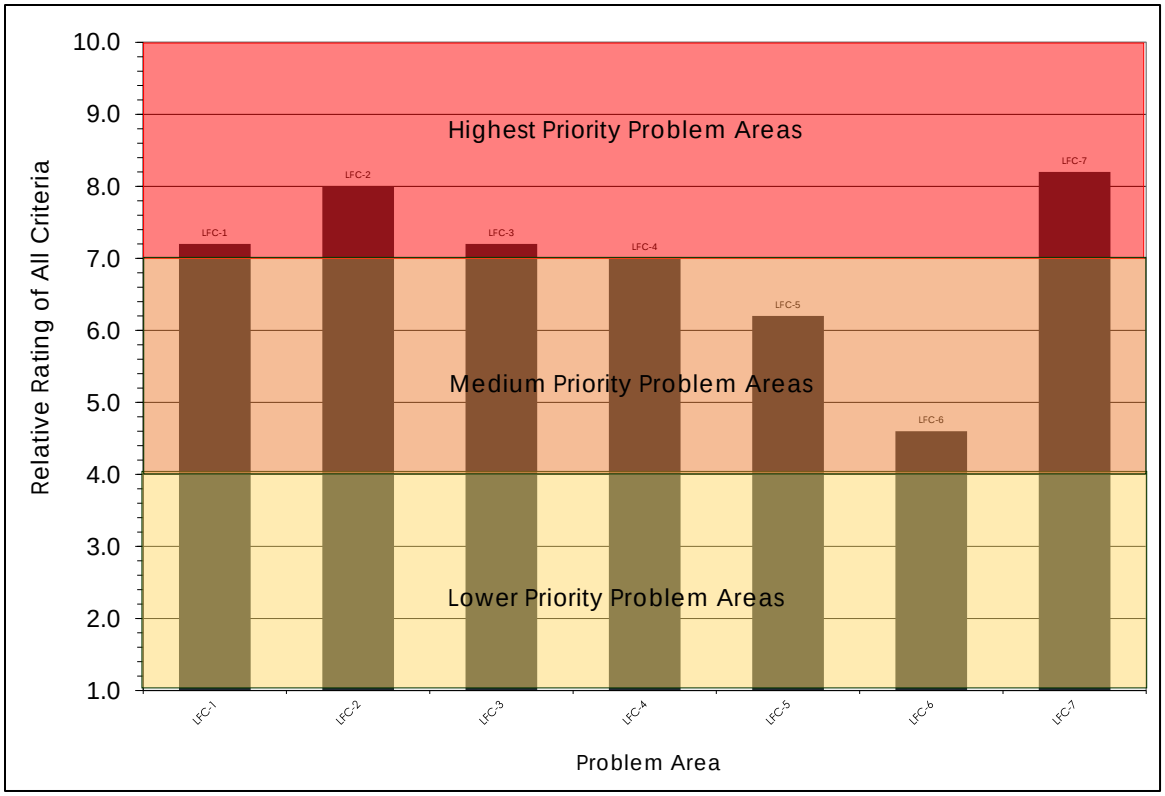

Figure 9.3 Little Fishing Creek Study Area Relative Problem Area Prioritization Rating

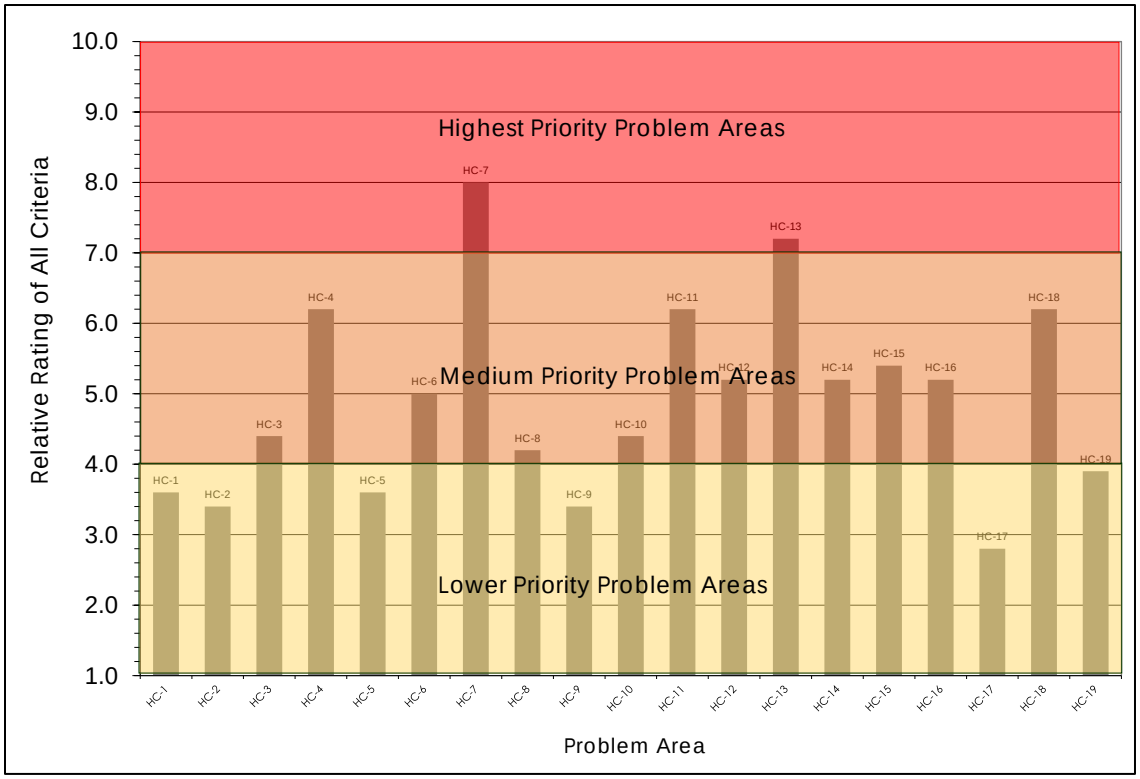

Figure 9.4 Hemlock Creek-Lower Fishing Creek Study Area Relative Problem Area Prioritization Rating

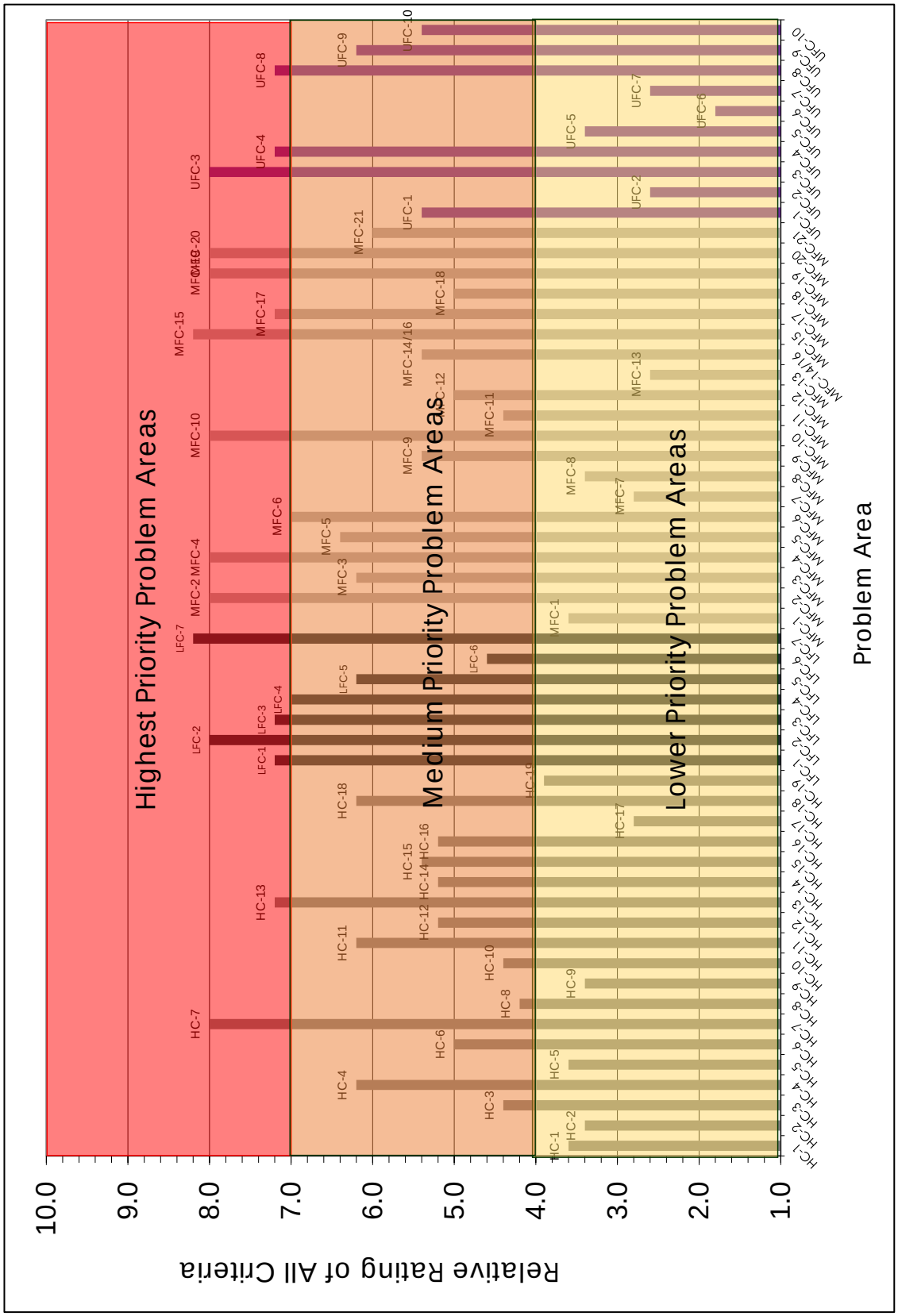

Figure 9.5 Fishing Creek Watershed Relative Problem Area Prioritization Rating

SUMMARY

The problem areas within Fishing Creek Watershed in Columbia County defined within this study varied spatially and in magnitude. The prioritization system presented in this section was developed to inform municipal officials about which projects may be most beneficial to address first. It attempts to provide a technically sound prioritization system that carefully considers input from the public officials and interest groups who participated in the study process. Thus, any County-wide or municipal capital improvement program may use the results to guide their next steps.

For the municipalities outside of the Bloomsburg-Orangeville-Stillwater-Benton corridor of the mainstem of Fishing Creek (Sugarloaf, Pine, Greenwood, Jackson, Millville, Madison), it may be most prudent to fix each problem individually since there is not yet an identified dense pattern of problem areas that are directly related to watershed initiatives. Appendix C provides conceptual solutions to each of these problem areas.

Hemlock Creek and small tributaries to mainstem Fishing Creek in the Hemlock Creek-Lower Fishing Creek Study Area have characteristics that indicate they are sensitive to development (e.g., several problem areas related to stream erosion) and they will have future development pressure. Thus, for Sugarloaf, Pine, Greenwood, Jackson, and Madison Townships and Millville Borough, solving individual problems now is a prudent approach; but reviewing and revising watershed and floodplain policies may help prevent creating systemic, regional problems that are currently being encountered by other municipalities.

Within the Hemlock Creek-Lower Fishing Creek, Middle Fishing Creek, and Upper Fishing Creek Study areas, there are two distinct types of problem areas: 1) shallow channels and large bedload movements and 2) floodplain encroachment. The mainstem Fishing Creek Watershed from Bloomsburg to Benton are impacted by development and agricultural land uses encroaching on the floodplain and stream channel. These areas have all identified problems in or near the creek and contribute flow downstream thus increasing the potential to exacerbate existing problems as the creek flow moves downstream towards Scott Township, Mt. Pleasant Township, the Town of Bloomsburg, Hemlock Township, and Montour Township. The mainstem of Fishing Creek from Benton to Bloomsburg has 23 of the Watershed's defined problem areas and 8 of them are designated as high priority problem areas. Appendix C has a more detailed description of each specific problem area along with potential solution concepts.

SECTION 10 - RECOMMENDATIONS AND EVALUATION OF PRIORITIZED PROJECTS AND STRATEGIES

The Fishing Creek Watershed Flood Mitigation Study is a comprehensive effort to identify flooding and wet weather issues within the Columbia County portion of the Fishing Creek Watershed and to investigate the mitigation options available from the site to watershed scale. This section summarizes prioritized problem areas and the associated conceptual projects, recommends areas and issues for further study, and summarizes the evaluation of prioritized options. The recommendations in this section are intended to provide public officials with the information to prioritize next steps for mitigating flooding conditions throughout Fishing Creek Watershed. An expanded detail of High Priority Problem Areas and associated Project information is provided in Table 10.6, at the end of this Section.

RECOMMENDED PROBLEM AREA PROJECTS AND STRATEGIES

The problem areas within Fishing Creek Watershed in Columbia County defined within this study are varied spatially and magnitude. The prioritization system presented in Section 9 was developed by the project team considering technical analysis and engineering judgment of the identified problem areas, with input from the public officials and interest groups who participated in this study process. Thus, any County-wide or municipal capital improvement program may use these results to guide their scheduling and pursuit of funding. It is recommended to address the Problem Areas that were categorized as High Priority Problems first, with the prioritization based upon the criteria provided in Section 9. The High Priority Problems are summarized in Table 10.1, with an expanded detail of High Priority Problem Areas and associated Project information is provided in Table 10.6, at the end of this Section. The summary sheets in Appendix C for the problem areas include a more descriptive overview and a more detailed recommended solution. Tables 10.2 and 10.3 provide a list of Medium Priority Problems and Low Priority Problems respectively. The problem areas in each table are sorted by the Study Area and Municipality.

It should be noted that attempting to solve each of these problem areas individually is only prudent where there is not an identified systemic, regional problem that may be the root cause of a specific problem. Appendix C provides conceptual solutions for each of these Problem Areas.

Table 10.1 High Priority Problem Areas

ID	Municipality	Location	Identified by Municipality /County	PennDOT Related
UFC 3	Sugarloaf Township	Central Road	No	Yes BR40867
UFC 4	Sugarloaf Township	Market Street	No	No
UFC 8/9	Benton Borough / Benton Township	Benton Borough / Distillery Hill Road bridge	Yes	Yes BR12543 BR12735
MFC 2	Stillwater Borough / Fishing Creek Township	Paperdale & Buck Road	No	Yes
MFC 4	Fishing Creek Township	Ridge & Honeytown Road	Yes	Yes
MFC 6	Fishing Creek Township	Winding & Harrison Road	Yes	Yes BR12631
MFC 10	Orange Township	Rohrsburg & Neyhart Road	Yes	Yes
MFC 15	Orange Township	Mt. Pleasant Road Bridge Stream Gauge	Yes	No
MFC 17	Orange Township	Charmund Road & SR 487	Yes	Yes

ID	Municipality	Location	Identified by Municipality /County	PennDOT Related
MFC 19	Orangeville Borough	Mt. Pleasant Road	Yes	Yes BR12744
MFC 20	Orangeville Borough	Broad and Mill Street	Yes	No
LFC1	Jackson Township	Pole Bridge Road	Yes	No
LFC2	Jackson Township	Pole Bridge Road and SR 239	Yes	Yes
LFC3	Jackson Township	Green Creek Road	Yes	No
LFC4	Pine Township	Peterman Road	No	No
LFC 7	Millville Borough	West Main Street Bridge	Yes	Yes BR12552
HC 7	Hemlock Township	Orchard Drive	Yes	No
HC 13	Hemlock Township / Montour Township	Perry Avenue Bridge	Yes	No

Table 10.2 Medium Priority Problem Areas

ID	Municipality	Location	Identified by Municipality /County	PennDOT Related
UFC 1	Sugarloaf Township	Central & Jamison City	Yes	No
UFC 10	Benton Township	Rohrsburg & Maple Grove Road	Yes	No
MFC 1 & 3	Stillwater Borough	Lower Raven Creek Road & Paperdale Road	Yes	Yes BR12654
MFC 5	Fishing Creek Township	Zaner Bridge Road	No	Yes BR12639
MFC 9	Orange Township	Moore's Grove	Yes	No
MFC 11	Orange Township	Green Creek & Logging Road	Yes	No
MFC 12	Orange Township	Green Creek Road	Yes	Yes BR12725
MFC 14 & 16	Orange Township	Mt. Pleasant Road	Yes	No
MFC 18	Orange Township	Stony Brook Road & SR 487	Yes	No
MFC 21	Greenwood Township	Rohrsburg Road	Yes	No
LFC 5	Greenwood Township	Mallard Road	Yes	No
LFC 6	Greenwood Township	Iola	Yes	Yes BR12728
HC 3	Mount Pleasant Township	Back Branch & Millertown Road	No	No
HC 4	Mount Pleasant Township	Back Branch Road	No	No
HC 6	Hemlock Township	Peppermill and Buckhorn Road	Yes	Yes
HC 8	Hemlock Township	Dahl Road	Yes	Yes BR12715
HC 10	Hemlock Township	Wanich Covered Bridge	Yes	No
HC 11	Hemlock Township	Millville Road	Yes	Yes BR45591
HC 12	Hemlock Township	Ridge Road and SR 42	Yes	No
HC 15	Town of Bloomsburg	Hoffman Park	Yes	Yes BR12713
HC 14/16	Hemlock Township / Town of Bloomsburg	Fernville	Yes	No
HC 18	Scott Township	Lake Florence	Yes	No

Table 10.3 Low Priority Problem Areas

ID	Municipality	Location	Identified by Municipality /County	PennDOT Related
UFC 2	Sullivan County	Elk Grove	No	No
UFC 5	Sugarloaf Township	Central Road	No	No
UFC 6	Sugarloaf Township	School House Drive	No	No
UFC 7	Sugarloaf Township	Camp Lavigne Road	No	No
MFC 7	Fishing Creek Township	Pealertown	No	No
MFC 8	Fishing Creek Township	2870 SR 487	Yes	No
MFC 13	Orange Township	Evans Lane	Yes	Yes BR12595
HC 1	Mount Pleasant Township	Robbins Road bridge	Yes	Yes BR12720
HC 2	Scott Township / Mount Pleasant Township	Back Branch Road bridge	Yes	Yes BR12711
HC 5	Mount Pleasant Township	Millville & Millertown Road	Yes	No
HC 9	Hemlock Township	Frosty Valley and Schoolhouse Road	Yes	No
HC 17	Town of Bloomsburg	Boone's Dam	Yes	No
HC 19	Montour Township	Hock Road Bridge	Yes	No

As discussed in Section 3, damage in the flood prone area of Fishing Creek Watershed in Columbia County accounts for substantial economic losses. Further, as discussed in Sections 4 and 6, adopting watershed and/or floodplain management principles and policies and following the related recommendations in the Study may help prevent creating new/future site, systemic, and/or regional problems, while potentially alleviating some of the flooding and wet weather conditions when implemented comprehensively. The following are recommendations for consideration of adjustments to watershed-based strategies (land use planning, land conservation, and flood corridor management):

- Implementation of Existing County/Municipal Plans and Efforts for Flood Mitigation through:
  - Prioritizing Columbia County's Countywide Action Plan projects to mitigate both water quality and flooding issues in Fishing Creek Watershed.
  - Considering enhancement, expansion of the Fishing Creek Watershed early warning system through further watershed monitoring.
- Improvements for Municipal Zoning through developing, instituting, and adopting zoning or zoning amendments such as:
  - Watershed Based Zoning, Overlay Zoning, Performance Zoning, Large Lot Zoning, and Infill Community Redevelopment.
- Improvements for River Corridor Protection:
  - Adopt and enforce floodplain ordinance throughout Watershed.
  - Wider municipal participation in FEMA's Community Rating System.
  - Provide and encourage open space preservation.
  - Floodproof or acquire/relocate flood prone buildings in floodplain.
  - Implement watershed-wide drainage system maintenance practices.
  - Review and incorporate River Corridor Planning Initiatives.
  - Identify, map and protect fluvial erosion hazard zones.
  - Adopt and enforce riparian buffers in land use ordinances.
  - Support and encourage voluntary implementation of riparian buffers.

- Improvements for Land Use through:
  - Implementation protections for existing special value wetlands and encourage expansion in areas where suitable.
  - Encouraging green stormwater infrastructure for stormwater management.
  - Limiting Impervious cover through ordinance modifications.
  - Limiting disturbance and compaction of topsoil through erosion and sediment control initiatives and support of the Countywide Action Plan.

RECOMMENDATIONS FOR FURTHER STUDY

The problem areas and issues identified as part of this Study resulted in the finding that the flooding and wet weather issues are watershed wide and vary in scope and scale. Due to the complexity of some issues and the scope limitations of this Study it is recommended that several problem areas and Fishing Creek Watershed flooding issues be evaluated further. Table 10.4 is a summary of the Problem Areas and issues recommended for further study.

Table 10.4 Fishing Creek Problem Areas and Issues to Consider for Further Study

ID(s) & Issues	Municipality	Summary of Further Study Considerations
UFC 1, 2, 3, & 5	Sugarloaf Township / Sullivan County	Direct coordination with Sullivan County on potential solutions and/or land use management strategies to alleviate/mitigate floodway encroachment and debris buildup in creek corridor. Further study and engagement with Sugarloaf Township and Sullivan County is recommended.
UFC 8 & 9	Benton Borough & Benton Township	Solutions identified as part of this Study were considered conceptual. Additional analysis of Benton area flooding conditions should be considered to identify cost effective, feasible, and community engaged solutions. Initial outreach and discussion with Benton Borough representatives indicated a desire to explore flood protection measures similar to those provided as part of the conceptual levee system evaluated and to further explore property mitigation measures such as flood buyouts and floodproofing. There is a desire to understand how variations of these approaches would effect various parts of the Borough and this requires additional investigation and analysis. Further study and engagement with the municipalities is recommended.
LFC 6 & 7	Greenwood Township & Millville Borough	Solutions identified as part of this Study were considered conceptual. Additional analysis of Millville Borough and Greenwood Township (lola) flooding conditions should be considered to identify cost effective, feasible, and community engaged solutions. Further study and engagement with municipalities is recommended.
MFC 1 & 3	Stillwater Borough	Solutions identified as part of this Study were considered conceptual. Additional analysis of Stillwater Borough flooding conditions should be considered to identify cost effective, feasible, and community engaged solutions. Further study and engagement with municipality is recommended.

ID(s) & Issues	Municipality	Summary of Further Study Considerations
MFC 9, 13, 14, & 16	Orange Township	Solutions identified as part of this Study were considered conceptual. Comprehensive analysis of Orange Township flooding conditions at these Problem Areas should be considered to identify cost effective, feasible, and community engaged solutions. Further study and engagement with municipality is recommended.
HC 3, 4, 15, & 18	Mount Pleasant Township, Scott Township, Town of Bloomsburg, & Hemlock Township	Solutions identified as part of this Study were considered conceptual. Comprehensive analysis of flooding conditions at these Problem Areas should be considered to identify cost effective, feasible, and community engaged solutions. Further study and engagement with municipalities is recommended.
HC 14/16	Hemlock Township & Town of Bloomsburg	The continuation of the West End Flood Mitigation Study is recommended to evaluate and assess potential mitigation measures.
CAP Integration	Watershed / County	The Columbia County Countywide Action Plan to achieve the requirements of the Chesapeake Bay TMDL presents a unique opportunity to implement projects that achieve water quality solutions while potentially impacting flood flows. This Study reviewed potential improvements to peak flows from the proposed projects, but further study and research on the impacts of agricultural conservation measures could be performed to provide additional justification and/or targeted implementation of Countywide Action Plan projects.
FEMA Floodplain	Watershed / County	The floodplain identified by FEMA Flood Impact Study analysis may misrepresent actual areas impacted by flooding conditions, impacting ability of residents/landowners to access flood insurance. Further evaluation of areas that are not part of a detailed FEMA FIS study area could assist municipalities/residents/landowners. Additionally, further understanding of the watershed flows could assist in moving properties out of the floodplain, thereby reducing the requirements for flood insurance.
Flood Corridor Protection	Watershed / County	The County's Municipalities do not have consistent floodplain management requirements: further evaluation and enactment of measures for floodplain protection areas could be considered based on the identification of Problem Areas in this Study.
Stormwater Management	Watershed / County	The County's Municipalities do not have consistent stormwater management requirements: further evaluation and enactment of measures for increased stormwater management and peak flow reductions could be considered.

ID(s) & Issues	Municipality	Summary of Further Study Considerations
Flood Warning System	Watershed / County	The Fishing Creek Watershed Flood Assessment and Mitigation Study and the West End Flood Mitigation Study both identified further monitoring and assessment of Fishing Creek Watershed streamflows as an enhancement to the Flood assessment. Additional rainfall and streamflow monitoring, even temporarily, within the watershed would enhance the understanding of the hydrologic and hydraulic functions of the watershed. Further monitoring and revision of tools developed from these studies is recommended to support the development of a flood warning system.

EVALUATION OF PRIORITIZED PROJECTS AND STRATEGIES

For an evaluation of the prioritized Problem Areas, the high, medium, and low priority problem areas were assessed in combination with the Countywide Action Plan (CAP) projects as discussed in Section 7. This assessment represents a comprehensive evaluation of flood mitigation concepts. If each combination of prioritized projects were implemented along with the CAP watershed strategies, peak flows could potentially be reduced, through increases in riparian buffers and wider adoption of cover crops and agricultural stormwater management. Appendix D provides detailed summary of the results. Table 10.5 provides a summary of the results of the evaluation of all problem area projects and watershed strategies at select locations in the watershed.

Table 10.5 Event Summary of All Priority Problem Area Projects with CAP Implementation

Event	Change in Water Surface Elevation in Channel	Change in Flow Rate
2 Year	Decrease on average < 3 inches Max Decrease >6 inches at Hoffman Park	Decrease on average 1-2% Max Decrease >20% at Hemlock Creek – Perry Ave. Bridge
10 Year	Decrease on average < 3 inches Max Decreases >6 inches at Hoffman Park, Millville, and Benton Borough (with dam removal)	Decrease on average 1% Max Decrease >20% at Hemlock Creek – Perry Ave. Bridge
100 Year	Decrease on average < 3 inches Max Decreases >12 inches at Hoffman Park, Millville, Stillwater (with covered bridge removal), and Benton Borough (with dam removal)	Decrease on average <1% Max Decrease >20% at Hemlock Creek – Perry Ave. Bridge

Implementation of the recommended Study projects to address Problem Areas is likely a several year or decade long process. These results are summarized to provide a summary of the potential flood mitigation measures at the full watershed scale. The majority of Problem Areas identified are best addressed through site specific mitigation that protect or enhance site or area's ability to deal with flooding conditions. Further, the evaluation of CAP related projects is considered conservative and likely understates the benefits of implementing CAP related projects such as cover crops, riparian buffers, and invasive species management. Additional study and evaluation of the flood reduction benefits of these land conservation measures could provide further justification to promote and target their implementation in Fishing Creek Watershed.

Table 10.6 Fishing Creek Watershed Flood Study High Priority Projects Summary

Project Name	Project Scope/Improvement(s)	Projected Construction Cost (unless otherwise noted)	Impacts	Municipality	State/County Identifier
UFC-3: Elk Grove Area Flooding	Culvert and Bridge Replacement	$1.4 to 2.6 million	20+ properties, 450 vehicles per day	Sugarloaf Twp.	SR4049 & PA BR 40867
UFC-4: Jamison City Road Flooding	Bridge Replacement, Floodplain Improvements	$2 to 3.5 million	15 properties, 450 vehicles per day	Sugarloaf Twp.	County Bridge #157
UFC-8: Benton Area Flooding	Detailed Flood Study Flood Protection and/or Dam Removal	$500,000 (study) $2 to 50 million (flood mitigation measures)	150 +/- properties including Benton Area Schools, 5,300 vehicles per day	Benton Twp. & Benton Boro.	PA BR 12735, PA BR 12543, Benton BR3
MFC-2: Paperdale Road Flooding	Culvert Replacement, Stream Stabilization	$50,000 to 100,000	3 properties, 50 vehicles per day	Fishing Creek Twp.	
MFC-4: Honeytown Road Flooding	Culvert Replacements, Riparian Buffer, and Stream Stabilization	$100,000 to 200,000	4 properties, 350 vehicles per day	Fishing Creek Twp.	SR1025 (Honeytown Rd) at Ridge Rd.
MFC-10: Neyhart Road Flooding	Culvert Replacement	$70,000 to 130,000	3 properties, 1,500 vehicles per day	Orange Twp.	SR4041 (Rohrsburg Rd.) at Neyhart Rd.
MFC-17: Charmund Rd./SR0487 Flooding	Culvert Installation or Replacement, Fill Removal	$800,000 to 1.6 million	4 properties, 6,000 vehicles per day	Orange Twp.	SR0487 at Charmund Rd.
MFC-19: Orangeville-Mt Pleasant Rd. Flooding	Culvert Replacement, Riparian Buffer	$150,000 to 280,000	4 properties, 700 vehicles per day	Orangeville Boro.	PA BR 12744
MFC-20: Orangeville-Broad St. Flooding	Culvert Replacement, Riparian Buffer	$140,000 to 270,000	2 properties, 6,000 vehicles per day	Orangeville Boro.	Adjacent to SR0487
LFC-1: Pole Bridge Rd.	Culvert Replacement	$70,000 to 120,000	2 properties, 50 vehicles per day	Orangeville Boro.	
LFC-2: Orchard Road Culvert	Culvert Replacement, Road Reprofiling	$180,000 to 320,000	3 properties, 500 vehicles per day	Jackson Twp.	SR0239 & Pole Bridge Rd
LFC-3: Green Creek Road Flooding	Culvert Replacement	$30,000 to 60,000	2 properties, 100 vehicles per day	Jackson Twp.	
LFC-4: Peterman Road Flooding	Culvert Replacement, Road Reprofiling, Road Reprofiling	$196,000 to 390,000	2 properties, 50 vehicles per day	Jackson Twp.	
LFC-7: Main Street Bridge	Bridge Replacement, Floodplain improvements	$2.4 to 4.45 million	5 properties, 2,900 vehicles per day	Pine Twp.	PA BR 12552
HC-6: Peppermill Road Flooding	Culvert Replacement, Riparian Buffer	$300,000 to 600,000	2 properties, 1,000 vehicles per day	Hemlock Twp.	SR4012 (Peppermill Road) at SR0044
HC-7: Orchard Drive Flooding	Culvert Replacement, Riparian Buffer	$100,000 to 200,000	2 properties, 800 vehicles per day	Hemlock Twp.	
HC-13: Perry Avenue Bridge	Bridge Removal or Replacement, Floodplain Improvements	$1.3 to 2.5 million	County building, 3 properties, 450 vehicles per day	Hemlock Twp. & Montour Twp.	PA BR 23856
HC-15: Hoffman Park Erosion/Flooding	Stream Stabilization, Floodplain Reconnection, Bridge Replacement	$400,000 to 9.3 million	Public park, 3+ properties, up to 5,300 vehicles	Town of Bloomsburg & Mt. Pleasant Township	PA BR 12713
Chesapeake Bay TMDL Countywide Action Plan (CAP) Implementation	Agricultural Best Management Practices, Stream Restoration, Stream Buffers	$50+/- million	Agricultural areas are watershed-wide; CAP projects improve stormwater management locally and provide cumulative benefits to downstream properties	Watershed-wide	
USGS Stream Gauge Maintenance	Continue USGS gauges, supplement with additional gauges downstream (Railroad St.) and on Little Fishing Creek (Millville)	$35,000 (gauge installation); $10,000 to 30,000 (gauge maintenance annually)	~2,000+/- structures in high hazard areas within watershed Flood warning reduces losses by up to 30%; USGS gauges support that through improved watershed hydrology/hydraulic understanding	Orange Twp. (existing); Town of Bloomsburg and Millville Boro. (potential new sites)	

SECTION 11 - REFERENCES

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APPENDIX A – WATERSHED TECHNICAL DATA AND MAPS

An overview of the process that was used to complete the watershed description is presented in Section 3 – Watershed Description of this report. The following technical data and maps are included here to supplement the general information provided in that section.

SUMMARY MAPS AND TECHNICAL DATA

MUNICIPALITY MAPS

Benton Borough

Benton Township

Town of Bloomsburg

Fishing Creek Township

Greenwood Township

Hemlock Township

Jackson Township

Madison Township

Millville Borough

Montour Township

Mount Pleasant Township

North Centre Township

Orange Township

Orangeville Borough

Pine Township

Scott Township

Stillwater Borough

Sugarloaf Township

TECHNICAL DATA MAPS

Aerial

Major Roadways

Geology

Soils

Hillshade (Slopes)

Land Use

FEMA Floodplains

Fishing Creek Flood Study

Benton Borough
Columbia County, PA

Fishing Creek boundary
Watershed boundary (HUC 10)
Sub-watershed boundary
Study Area
Municipal Boundary
Stream

Fishing Creek Watershed
West Creek Watershed
Raven Creek-Fishing Creek Watershed

RAINBOW-HILL-RD
WEST-CREEK-RD
MENDENHALL-LN
GREEN-ACRES-RD
SR-0239-SH
SHICKSHINNY-HW
NORTH-ST
EVERETT-ST
WARNER-AV
MCHENRY-AV
FIFTH-ST
MARKET-ST
KELSEY-JOHNSON-RD
DISTILLERY-HILL-RD
MCHENRY-HILL-RD
COLLEY-ST
PARK-ST
MAIN-ST
MILL-ST
HILL-ST
THIRD-ST
SUNNY-HILLSIDE-RD
CEMETERY-HILL-RD
West Creek
Fishing Creek
Airport Rd
Mendenhall Ln
Green Acres Rd
North St
Cox St
Everett St
Warner St
Church St
Main St
Masters St
Park St
Market St
3rd St
Beaver St
Colley St
Smith St
Benton Manor Dr
Hiscock St
Hill St
Mill St
Benton Cemetery
Cemetery Hill Rd
Benton
Twp
239
487

0 1,300 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Benton Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Town of Bloomsburg
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Fishing Creek Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 6,000 8,000 Feet

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Fishing Creek Flood Study

Greenwood Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 6,000 8,000 Feet

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Fishing Creek Flood Study

Hemlock Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

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Fishing Creek Flood Study

Jackson Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

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Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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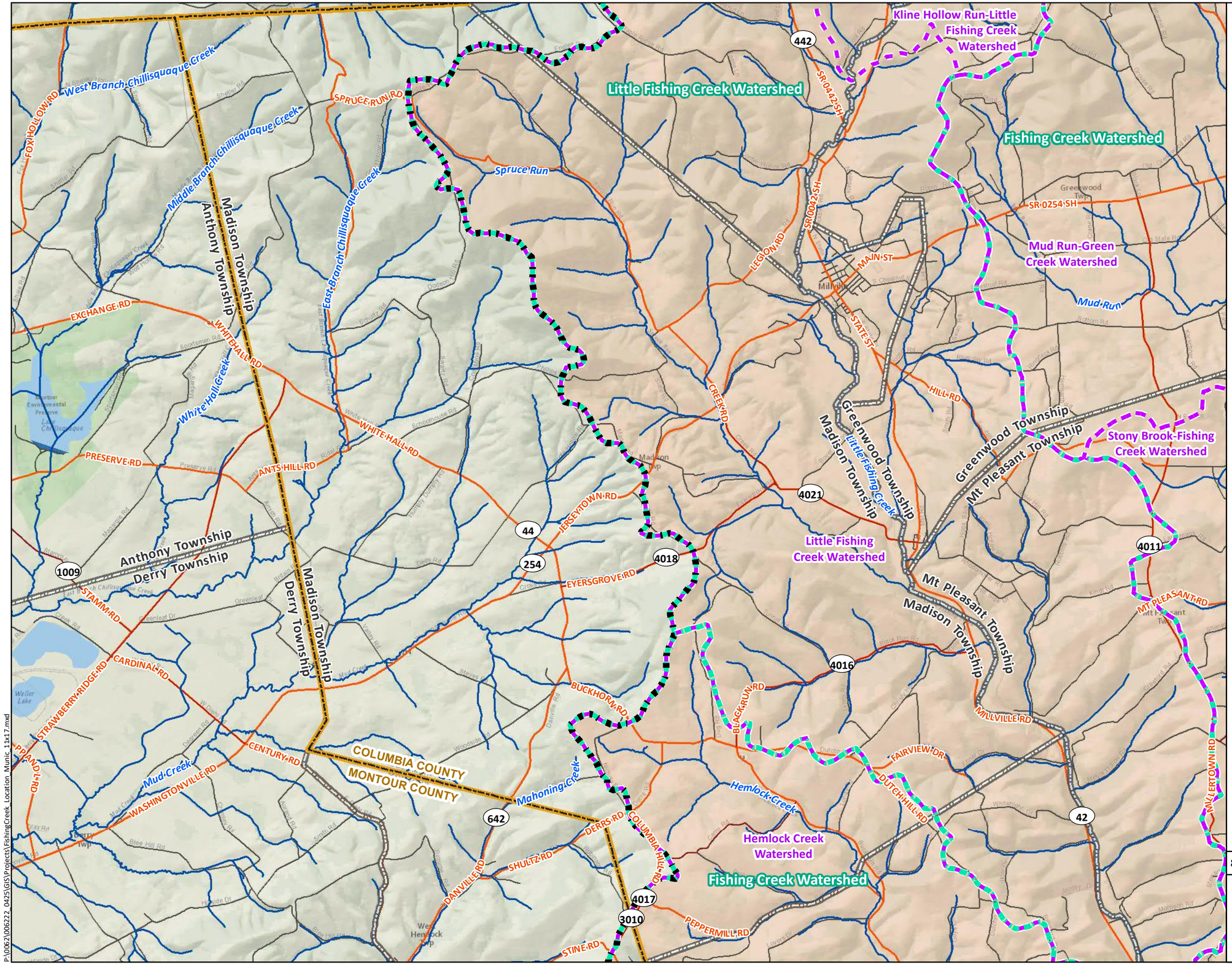

Fishing Creek Flood Study

Madison Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 6,000 8,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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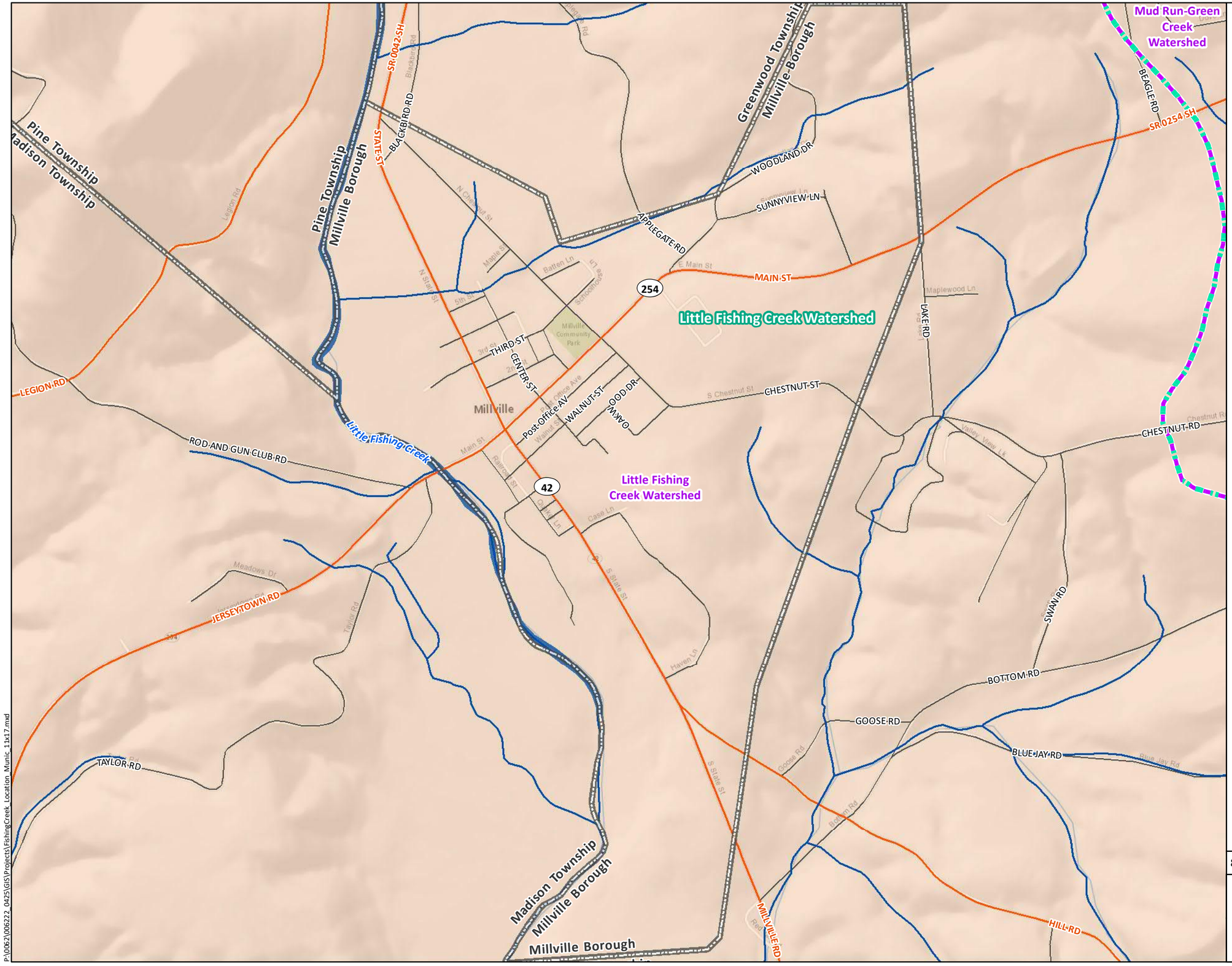

Fishing Creek Flood Study

Millville Borough
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

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Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Montour Township
Columbia County, PA

Hemlock Creek Watershed

Hemlock Township

Montour Township

Fishing Creek Watershed

Stony Brook-Fishing Creek Watershed

COLUMBIA COUNTY

MONTOUR COUNTY

Cooper Township

Montour Township

Hemlock Creek

Fishing Creek

Montour Run

Sechler Run

Susquehanna River

RIDGE RD

VALLEY RD

QUARRY DR

MONTOUR BL

BLOOM RD

GROVANIA DR

LEGION RD

SUSQUE VIEW RD

RIVER DR

COUNTY LINE DR

RIDGE DR

MT ZION DR

NUMIDIA DR

PERRY AV

MALL BLVD

DRINKER ST

MAIN ST

RUPERT DR

11

42

2006

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Mt Pleasant Township
Columbia County, PA

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 6,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

8/10/2021	PM: MJV	GIS: ALV	QA: BTK	R006225.0425

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Fishing Creek Flood Study

North Centre Township
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

8/10/2021	PM: MJV	GIS: ALV	QA: BTK	R006225.0425

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Fishing Creek Flood Study

Orange Township
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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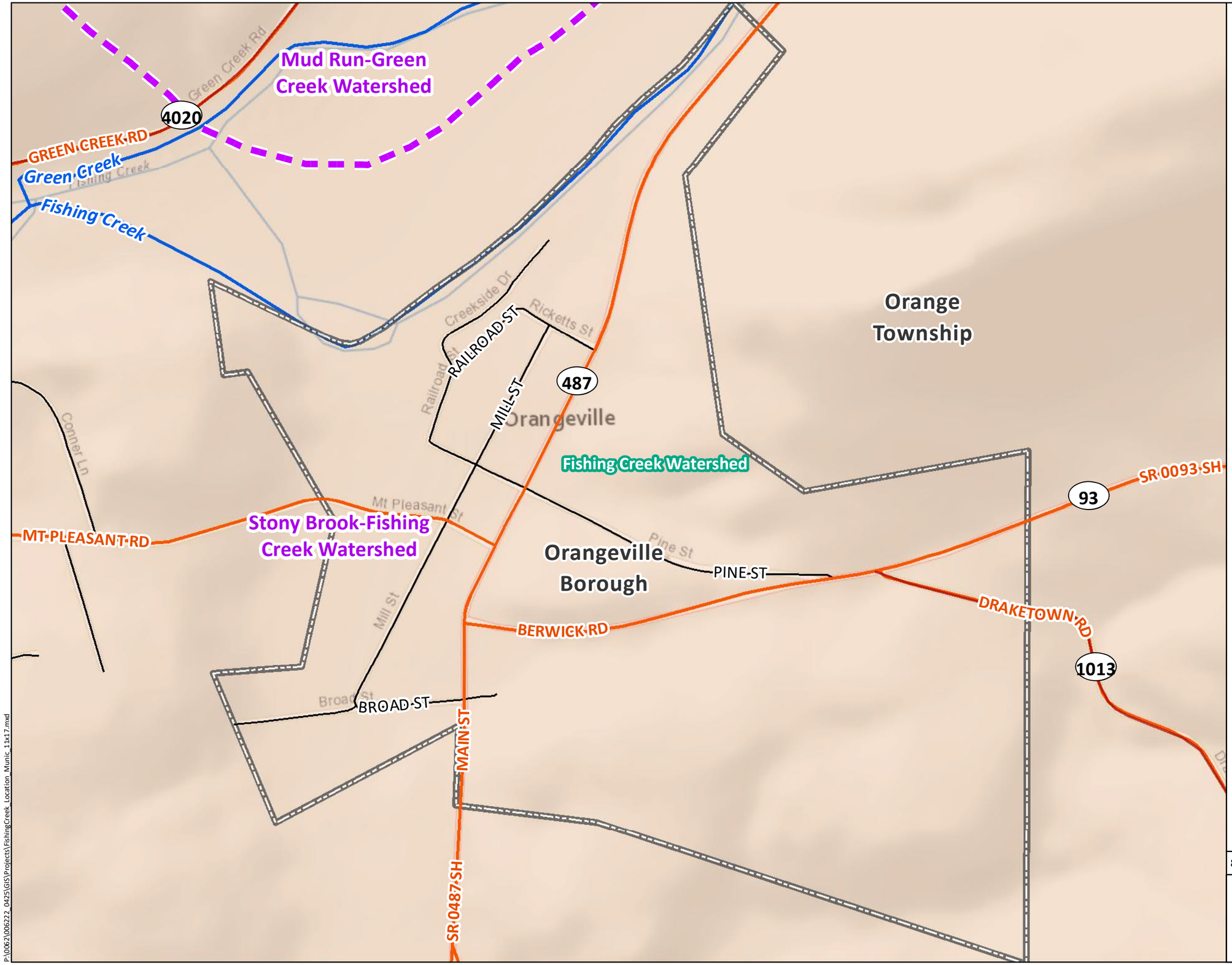
Fishing Creek Flood Study

Orangeville Borough
Columbia County, PA



- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- Municipal Boundary
- Stream

0 1,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Pine Township
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 6,000 8,000 10,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Scott Township
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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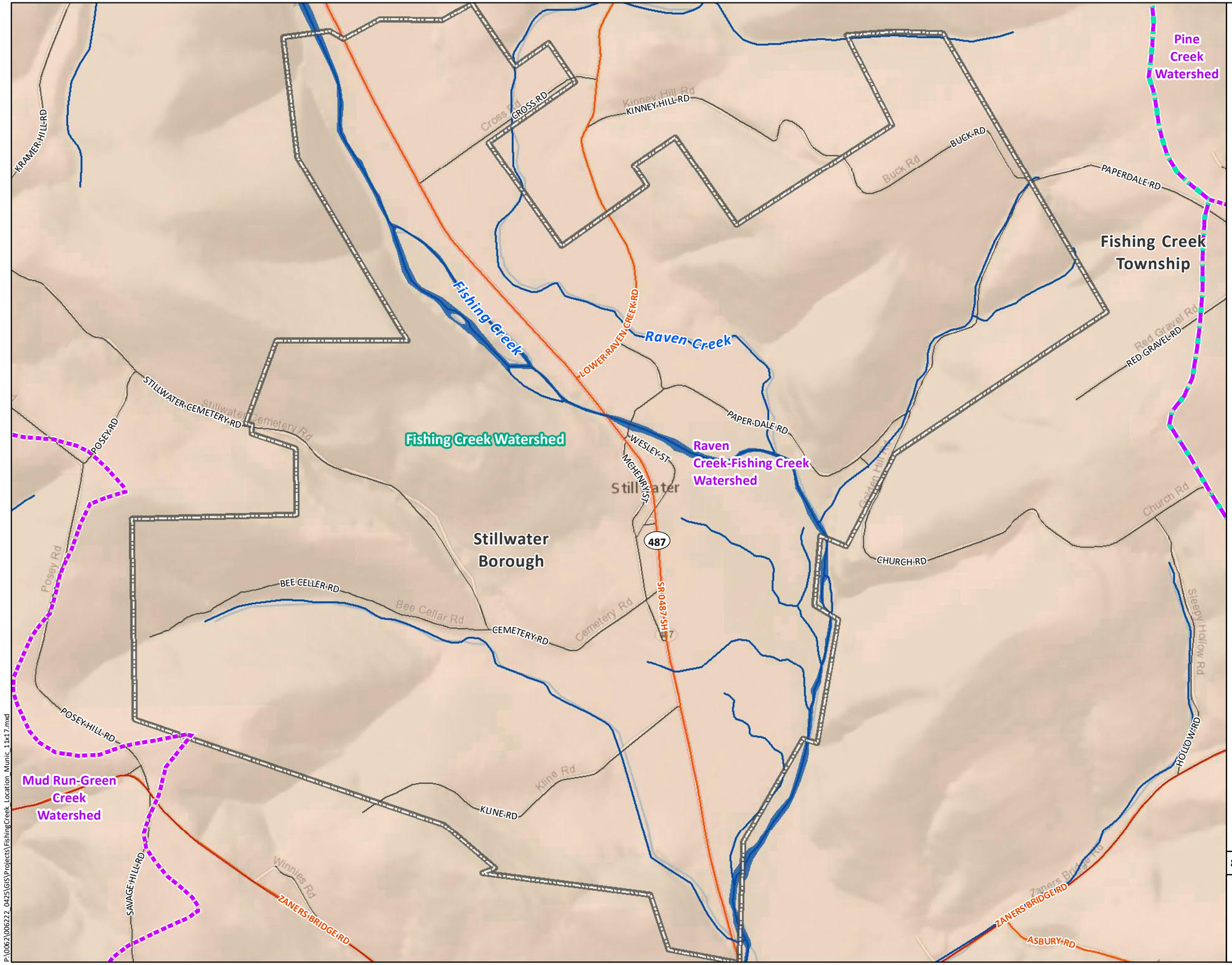

Fishing Creek Flood Study

Stillwater Borough
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study

Sugarloaf Township
Columbia County, PA

- Sub-watershed boundary
- Watershed boundary (HUC 10)
- Fishing Creek boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- State Road
- Local Road

0 2,000 4,000 6,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Fishing Creek Flood Study
Location
Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- Freeway or Other Major Road
- Other Major Road
- Secondary Road
- Important Local Road

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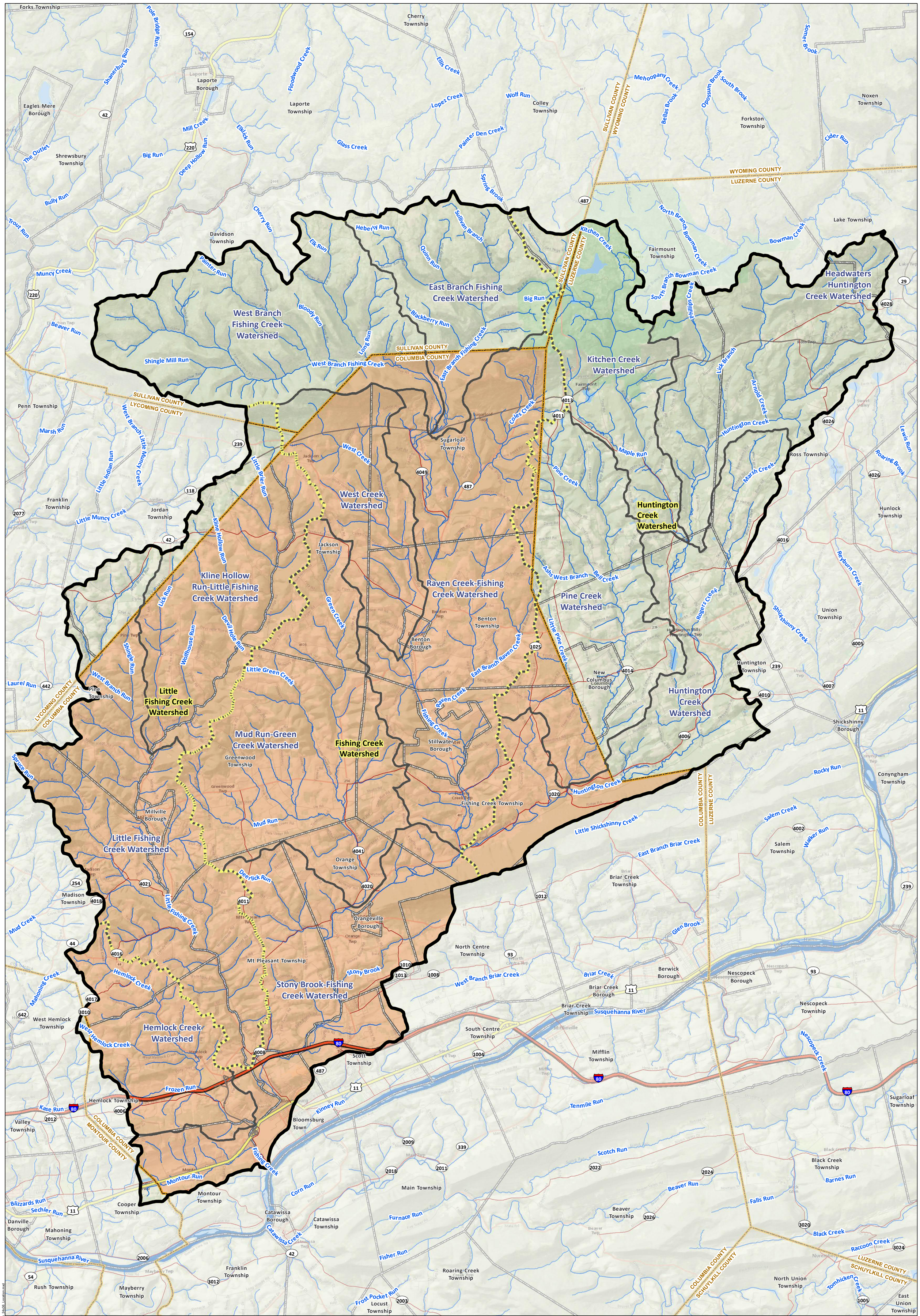

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- Freeway or Other Major Road
- Other Major Road
- Secondary Road
- Important Local Road

Fishing Creek Flood Study
Location
Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

Bedrock Geology

- Bloomsburg and Mifflintown Formations, undivided
- Buddys Run Member of Catskill Formation
- Burgoon Sandstone
- Catskill Formation
- Clinton Group
- Duncannon Member of Catskill Formation
- Hamilton Group
- Huntley Mountain Formation
- Irish Valley Member of Catskill Formation
- Keyser and Tonoloway Formations, undivided
- Llewellyn Formation
- Mauch Chunk Formation
- Onondaga and Old Port Formations, undivided
- Pocono Formation
- Pottsville Formation
- Sherman Creek Member of Catskill Formation
- Spechty Kopf Formation
- Trimmers Rock Formation
- Wills Creek Formation

Forks Township
Colley Township
Forkston Township
Noxen Township
Davidson Township
Fairmount Township
Lake Township
Penn Township
Franklin Township
Jordan Township
Jackson Township
Sugarloaf Township
Benton Township
Benton Borough
Kline Hollow Run-Little Fishing Creek Watershed
West Branch Fishing Creek Watershed
East Branch Fishing Creek Watershed
West Creek Watershed
Kitchen Creek Watershed
Huntington Creek Watershed
Raven Creek-Fishing Creek Watershed
Pine Creek Watershed
Little Fishing Creek Watershed
Mud Run-Green Creek Watershed
Fishing Creek Watershed
Stony Brook-Fishing Creek Watershed
Hemlock Creek Watershed
Headwaters Huntington Creek Watershed
Millville Borough
Greenwood Township
Orange Township
Orangeville Borough
Mt Pleasant Township
Madison Township
Pine Township
Hemlock Township
Valley Township
West Hemlock Township
Mahoning Township
Cooper Township
Montour Township
Danville Borough
Rush Township
Mayberry Township
Franklin Township
Catawissa Borough
Catawissa Township
Scott Township
Bloomsburg Town
Stillwater Borough
Fishing Creek Township
New Columbus Borough
Huntington Township
Ross Township
Shickshinny Borough
Hunlock Township
Conyngham Township
Salem Township
Briar Creek Township
Briar Creek Borough
North Centre Township
South Centre Township
Berwick Borough
Nescopeck Borough
Nescopeck Township
Union Township
Hollenback Township
Mifflin Township
Main Township
Beaver Township
Roaring Creek Township
North Union Township
Black Creek Township
Sugarloaf Township
East Union Township
Locust Township
Susquehanna River
Wyoming County
Luzerne County
Sullivan County
Lycoming County
Columbia County
Montour County
Northumberland County
Schuylkill County

0 1 2 Miles

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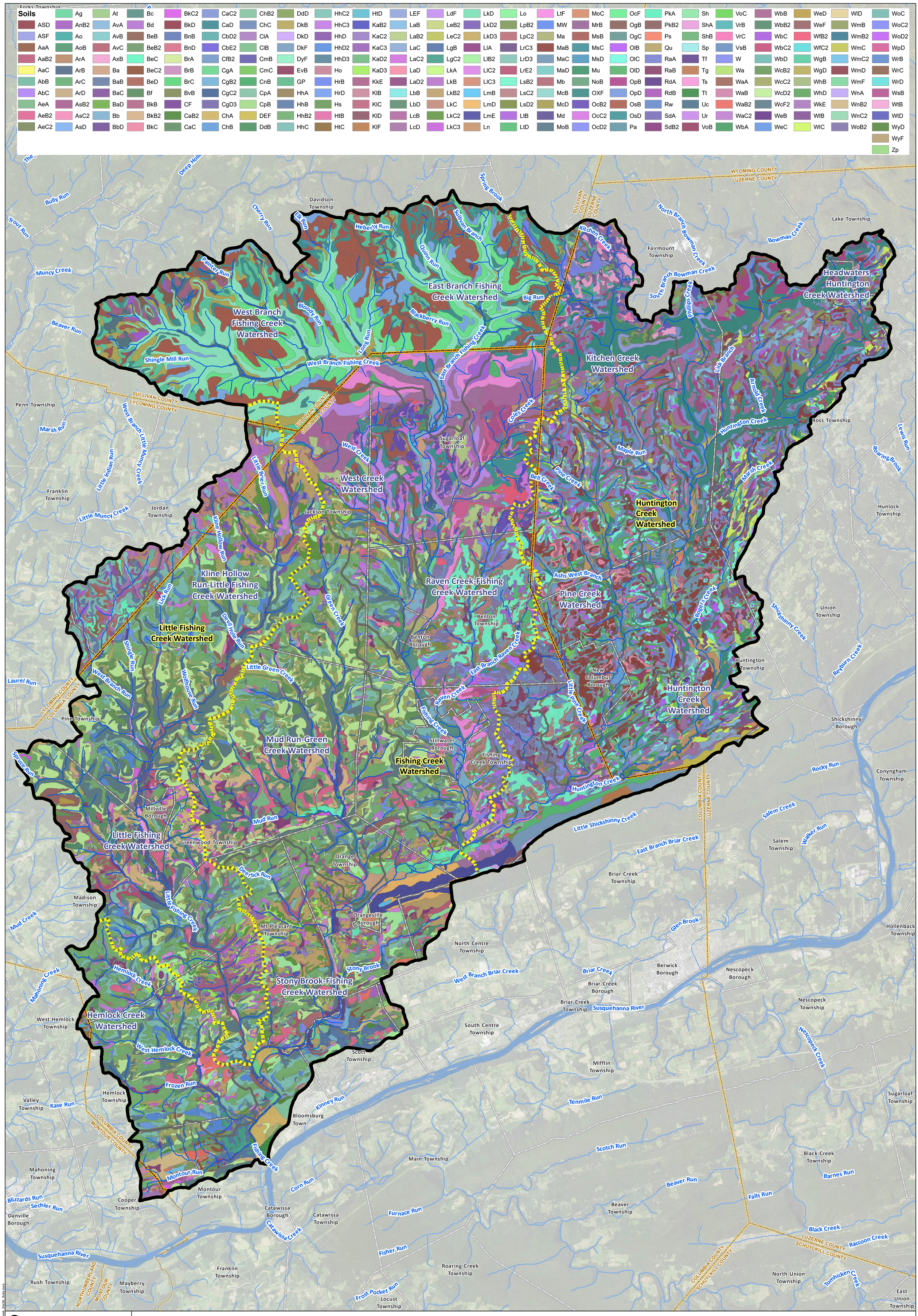
- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary (HUC 12)
- Municipal Boundary
- County Boundary
- Stream
- Waterbody

Fishing Creek Flood Study
Geology
Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

Soils

ASD, AaA, AaB2, AaC, AbB, AbC, AeA, AeB2, AeC2, ASF, AnB2, Ao, AoB, ArA, ArB, ArC, ArD, AsB2, AsC2, AsD, Ag, AvA, AvB, AvC, AxB, Ba, BaB, BaC, BaD, Bb, BbD, At, Bc, Bd, BeB, BeB2, BeC, BeC2, BeD, Bf, BkB, BkB2, BkC, BkC2, BkD, BnB, BnD, BrA, BrB, BrC, BvB, CF, CaB2, CaC, CaC2, CaD, CbD2, CbE2, CfB2, CgA, CgB2, CgC2, CgD3, ChA, ChB, ChB2, ChC, ClA, ClB, CmB, CmC, CnB, CpA, CpB, DEF, DdB, DdD, DkB, DkD, DkF, DyF, EvB, GP, HhA, HhB, HhB2, HhC, HhC2, HhC3, HhD, HhD2, HhD3, Ho, Hs, HrB, HrD, HtB, HtC, HtD, KaB2, KaC2, KaC3, KaD2, KaD3, KkE, KlB, KlC, KlD, KlF, LEF, LaB, LaB2, LaC, LaC2, LaD, LaD2, LbB, LbD, LcB, LcD, LdF, LeB2, LeC2, LgB, LgC2, LkA, LkB, LkB2, LkC, LkC2, LkC3, LkD, LkD2, LkD3, LlA, LlB2, LlC2, LlC3, LmB, LmD, LmE, Ln, Lo, LpB2, LpC2, LrC3, LrD3, LrE2, LsB2, LsC2, LsD2, LtB, LtD, LtF, MW, Ma, MaB, MaC, MaD, Mb, Md, MoB, MoC, MrB, MsB, MsC, MsD, Mu, NoB, OXF, OcB2, OcC2, OcD2, OcF, OgB, OgC, OlB, OlC, OlD, OpB, OpD, OsB, OsD, Pa, PkA, PkB2, Ps, Qu, RaA, RaB, RdA, RdB, Rw, SdA, SdB2, Sh, ShA, ShB, Sp, Tf, Tg, Ts, Tt, Uc, Ur, VoB, VoC, VrB, VrC, VsB, W, Wa, WaA, WaB, WaB2, WaC2, WbA, WbB, WbB2, WbC, WbC2, WbD, WcB2, WcC2, WcD2, WcF2, WeB, WeC, WeD, WeF, WfB2, WfC2, WgB, WgD, WhB, WhD, WlB, WlC, WlD, WmB, WmB2, WmC, WmC2, WmD, WmF, WnA, WnB2, WnC2, WoB2, WoC, WoC2, WoD2, WpD, WrB, WrC, WrD, WsB, WtB, WtD, WyD, WyF, Zp



0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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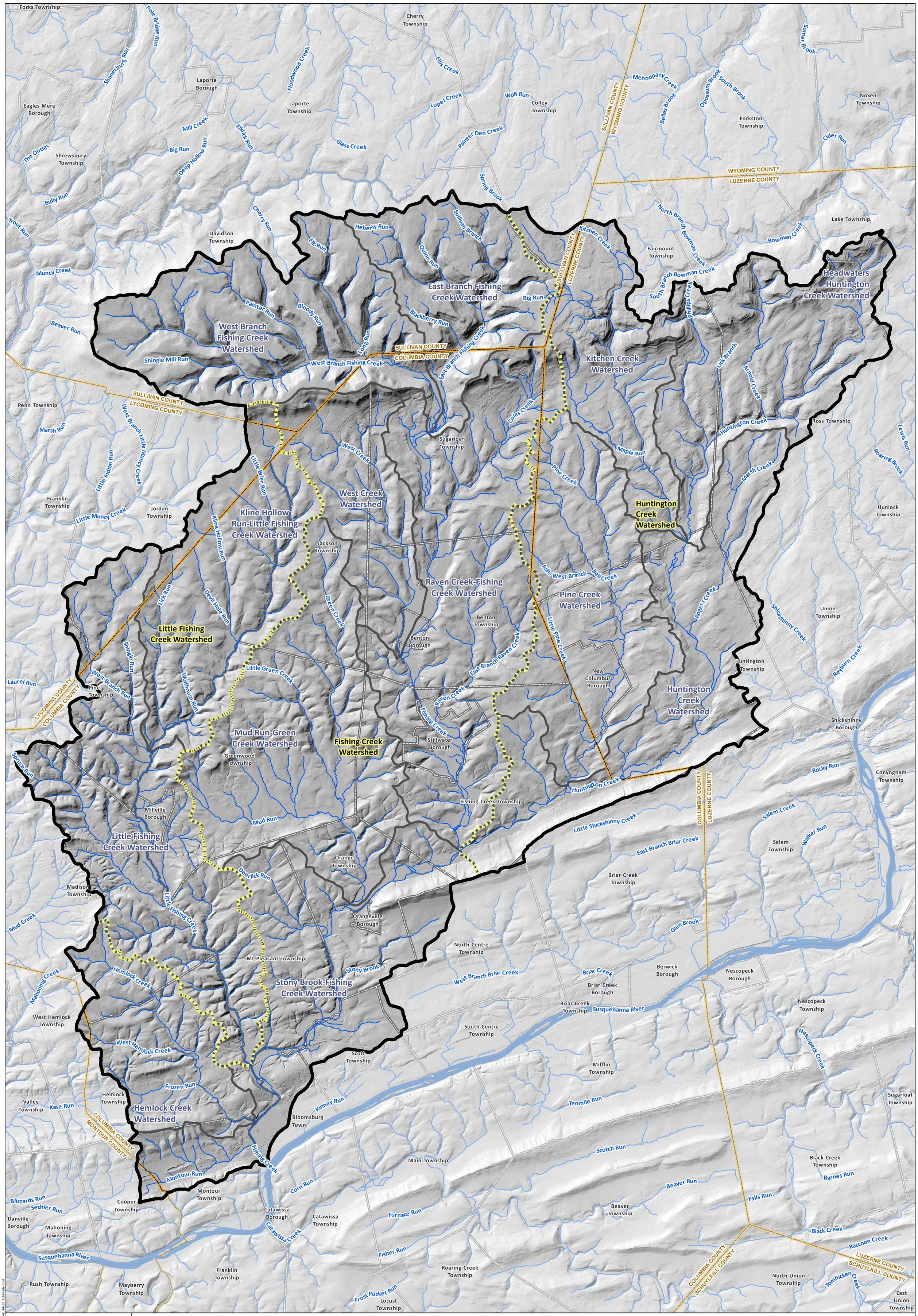
- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary (HUC 12)
- Municipal Boundary
- County Boundary
- Stream
- Waterbody

Fishing Creek Flood Study

Soils

Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania



0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Municipal Boundary
- County Boundary
- Stream
- Waterbody

Fishing Creek Flood Study
Hillshade
Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

Fishing Creek Flood Study
Land Use
Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Land Cover

- Woody Wetlands
- Shrub/Scrub
- Open Water
- Mixed Forest
- Herbaceuous
- Hay/Pasture
- Evergreen Forest
- Emergent Herbaceuous Wetlands
- Developed, Open Space
- Developed, Medium Intensity
- Developed, Low Intensity
- Developed, High Intensity
- Deciduous Forest
- Cultivated Crops
- Barren Land

- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary (HUC 12)
- County Boundary
- Municipal Boundary
- Stream
- Waterbody

Fishing Creek Flood Study
FEMA Flood Zones
Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Fishing Creek boundary
- Watershed boundary (HUC 10)
- Sub-watershed boundary
- Study Area
- County Boundary
- Municipal Boundary
- Stream
- Waterbody
- 100-Year Flood Zone

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APPENDIX B – MODEL CALCULATIONS AND INVESTIGATIVE RESULTS

An overview of the process that was used to complete the hydrologic modeling in preparation of this Study is presented in Section 6 – Technical Analysis of this report. The following technical data is included here to supplement the general information provided in that section.

HYDROLOGIC MODEL PARAMETER DATA

SOILS, LAND USE, AND CURVE NUMBERS

The determination of curve numbers is a function of soil type and land use. The hydrologic soil groups were defined by NRCS (2008). The 2019 NLCD was simplified to provide an estimate of curve numbers using the scheme shown in Table A.1.

The curve numbers presented in the above tables represent "average" antecedent runoff condition (i.e. ARC = 2). In a significant hydrologic event, runoff is often influenced by external factors such as extremely dry antecedent runoff conditions (ARC=1) or wet antecedent runoff conditions (ARC=3). The antecedent runoff conditions of the above curve numbers were altered during the calibration process so that model results are within a reasonable range of other hydrologic estimates.

Table A.1 Curve Number Determination

GIS Value	NLCD (2019) Description	NRCS (1986) Description	A	B	C	D
11	Open Water	Water	98	98	98	98
21	Developed, Open Space	Open space - Good Condition	39	61	74	80
22	Developed, Low Intensity	Residential - 1 acre	51	68	79	84
23	Developed, Medium Intensity	Residential - 1/2 acre	54	70	80	85
24	Developed, High Intensity	Commercial and Business	89	92	94	95
31	Barren Land (Rock/Sand/Clay)	Newly graded areas	77	86	91	94
41	Deciduous Forest	Woods - Good Condition	30	55	70	77
42	Evergreen Forest	Woods - Good Condition	30	55	70	77
43	Mixed Forest	Woods - Good Condition	30	55	70	77
52	Shrub/Scrub	Brush - Good Condition	30	48	65	73
71	Grassland/Herbaceous	Meadow - Good Condition	30	58	71	78
81	Pasture/Hay	Pasture - Good Condition	39	61	74	80
82	Cultivated Crops	Contoured Row Crops - Good Condition	65	75	82	86
90	Woody Wetlands	Woods - Good Condition	30	55	70	77
95	Emergent Herbaceous Wetlands	Water	98	98	98	98
101	Agricultural	Pasture - Good Condition	39	61	74	80
102	Commercial	Commercial and Business	89	92	94	95
103	Forested	Woods - Good Condition	30	55	70	77
104	Industrial	Industrial	81	88	91	93
105	Medical/Institutional	Industrial	81	88	91	93
106	Public Semi Public	Open space - Good Condition	39	61	74	80
107	Residential	Average of all TR-55 Residential	58	73	82	86
108	Transportation	Paved surfaces	98	98	98	98

GIS Value	NLCD (2019) Description	NRCS (1986) Description	A	B	C	D
109	Village Center	Residential 1/8 acre or less (town houses)	77	85	90	92
201	Water	Water	98	98	98	98

Model Calibration

Three parameters were modified to develop a calibrated hydrologic model: the curve number, the time of concentration, and the Manning's coefficient used in the Muskingum-Cunge routing method.

The antecedent runoff condition was altered for each storm event so that each subbasin and calibration point was within an acceptable range of a target flow. The equation used to modify antecedent runoff condition (Maryland Hydrology Panel, 2006):

For ARC≤2:

$$CN_x = \frac{[10 + 5.8(x - 2)]CN_2}{10 + 0.058(x - 2)CN_2}$$

For ARC>2:

$$CN_x = \frac{[10 + 13(x - 2)]CN_2}{10 + 0.013(x - 2)CN_2}$$

Thus a unique ARC and resulting curve number was calculated for each subbasin for each storm event. The same ARC was applied in both existing and proposed conditions.

Additionally, lag times were calculated using both TR-55 and the NRCS lag equation. The initial model runs used the results from the NRCS lag equation. A factor between 0 and 2 was applied to the initial value to obtain a calibrated time of concentration value. The same time of concentration was applied to all existing condition storms. The proposed land use time of concentration was calculated using the NRCS lag equation with future land curve numbers and it was subsequently adjusted by the same factor used in existing conditions.

Finally the Manning's n value for channels and overbank areas was modified to obtain realistic flow values. The respective ranges for the channel and overbank areas were 0.02-0.07 and 0.03-0.2.

MODELING RESULTS

A summary of the hydrologic modeling results has been provided by the respective junctions in the maps in this appendix.

SUMMARY MODEL OUPUT

HYDROLOGIC MODEL DATA SUMMARY AND OUTPUT

Hydrologic Subbasin Map

Hydrologic Junction Map

35 Foot Riparian Buffer Investigative Model Results

100 Foot Riparian Buffer Investigative Model Results

Agriculture as Meadow Investigative Model Results

Developed as Meadow Investigative Model Results

Floodplain Reconnection Investigative Model Results

Wetland Restoration Investigative Model Results

HYDRAULIC MODEL DATA SUMMARY AND OUTPUT

Agriculture as Meadow Investigative Model Results:

- Benton Area
- Lower Fishing Creek
- Hemlock Creek

Developed as Meadow Investigative Model Results:

- Benton Area
- Lower Fishing Creek
- Hemlock Creek

Fishing Creek Subbasins

Columbia, Luzerne, Lycoming and Sullivan Counties
Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Fishing Creek Junctions
- Stream (NHD)
- Subbasins
- Fishing Creek Watershed Boundary
- Municipal Boundary
- County Boundary

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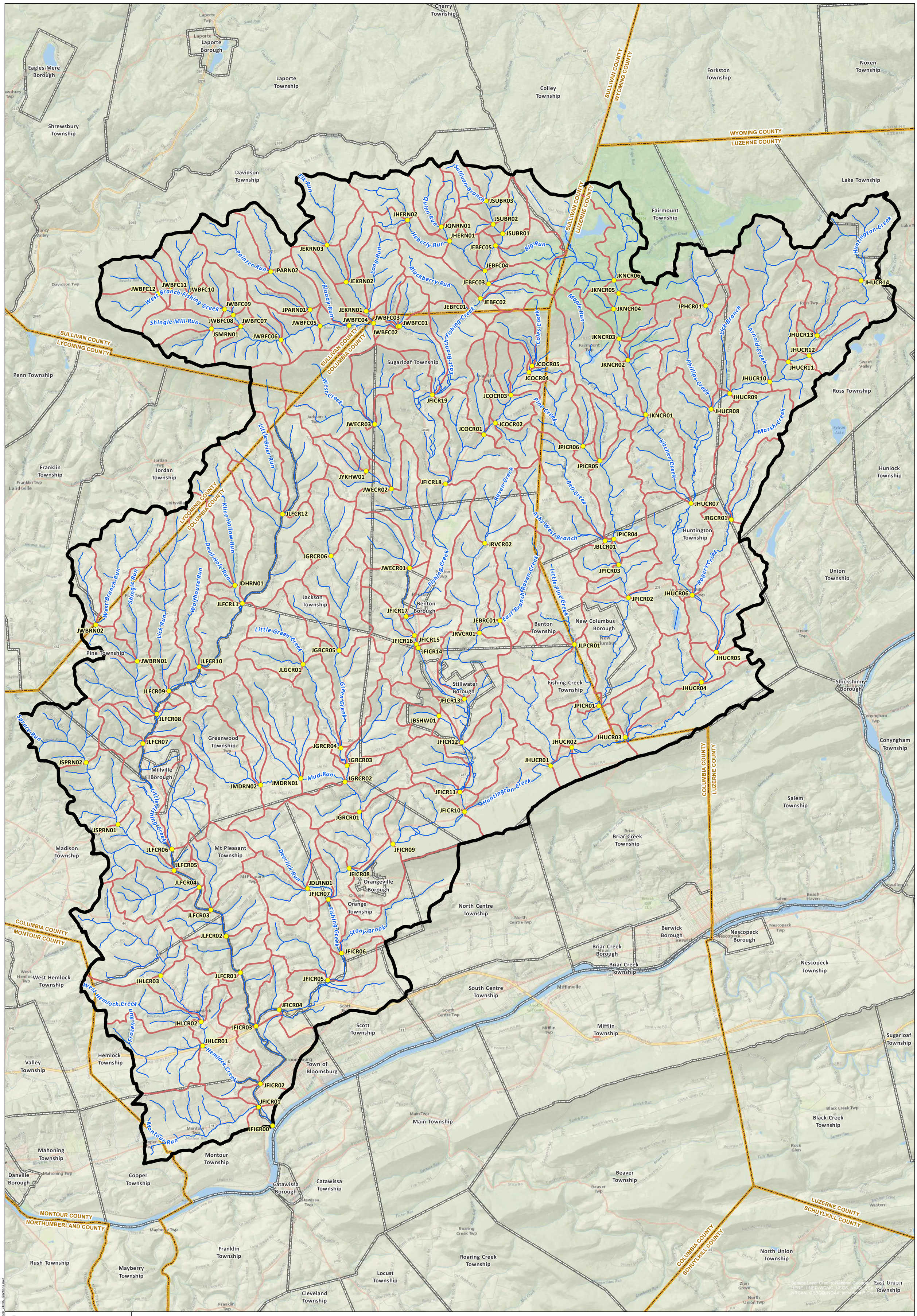

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Fishing Creek Junctions
- Stream (NHD)
- Subbasins
- Fishing Creek Watershed Boundary
- Municipal Boundary
- County Boundary

Fishing Creek Junctions

Columbia, Luzerne, Lycoming and Sullivan Counties Pennsylvania

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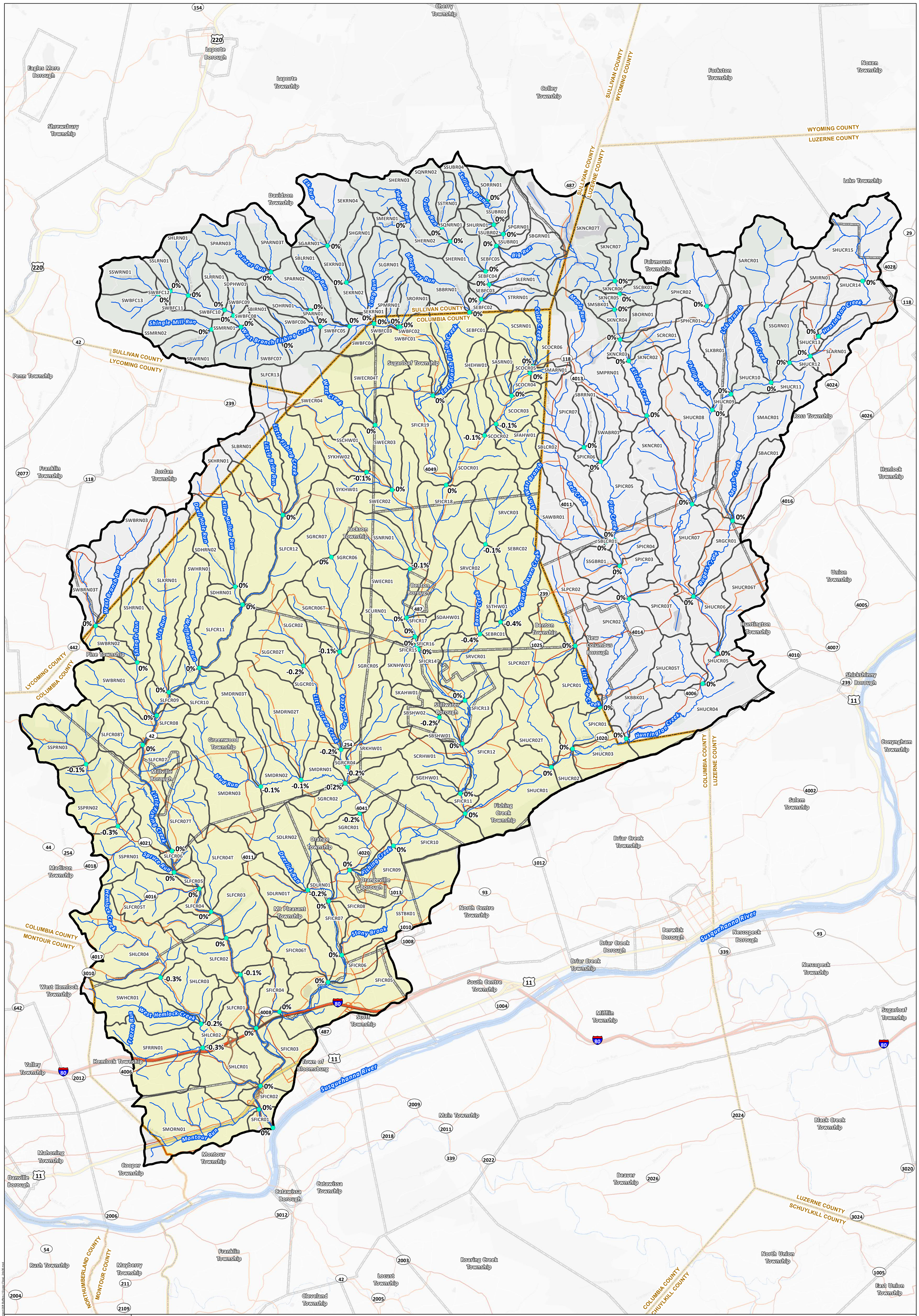

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- 35ft buffers
- Stream (NHD)
- Fishing Creek Watershed Boundary
- Study Area
- Subbasins
- Municipal Boundary
- County Boundary

35ft Buffers (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

100ft Buffers (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/7/2022	PM: MV	GIS: ALV	QA: BTK	R006222.0425

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- 100ft buffers
- Stream (NHD)
- Fishing Creek Watershed Boundary
- Study Area
- Subbasins
- Municipal Boundary
- County Boundary

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Agriculture to Meadow (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Agriculture Use
- Stream (NHD)
- Fishing Creek Watershed Boundary
- Study Area
- Subbasins
- Municipal Boundary
- County Boundary

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Developed to Meadow (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Developed Use
- Stream (NHD)
- Fishing Creek Watershed Boundary
- Study Area
- Subbasins
- Municipal Boundary
- County Boundary

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Floodplain Reconnection (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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- Floodplain Reconnection
- Floodplain Percentage
- Stream (NHD)
- Fishing Creek Watershed Boundary
- Study Area
- Municipal Boundary
- County Boundary

Wetland Restoration (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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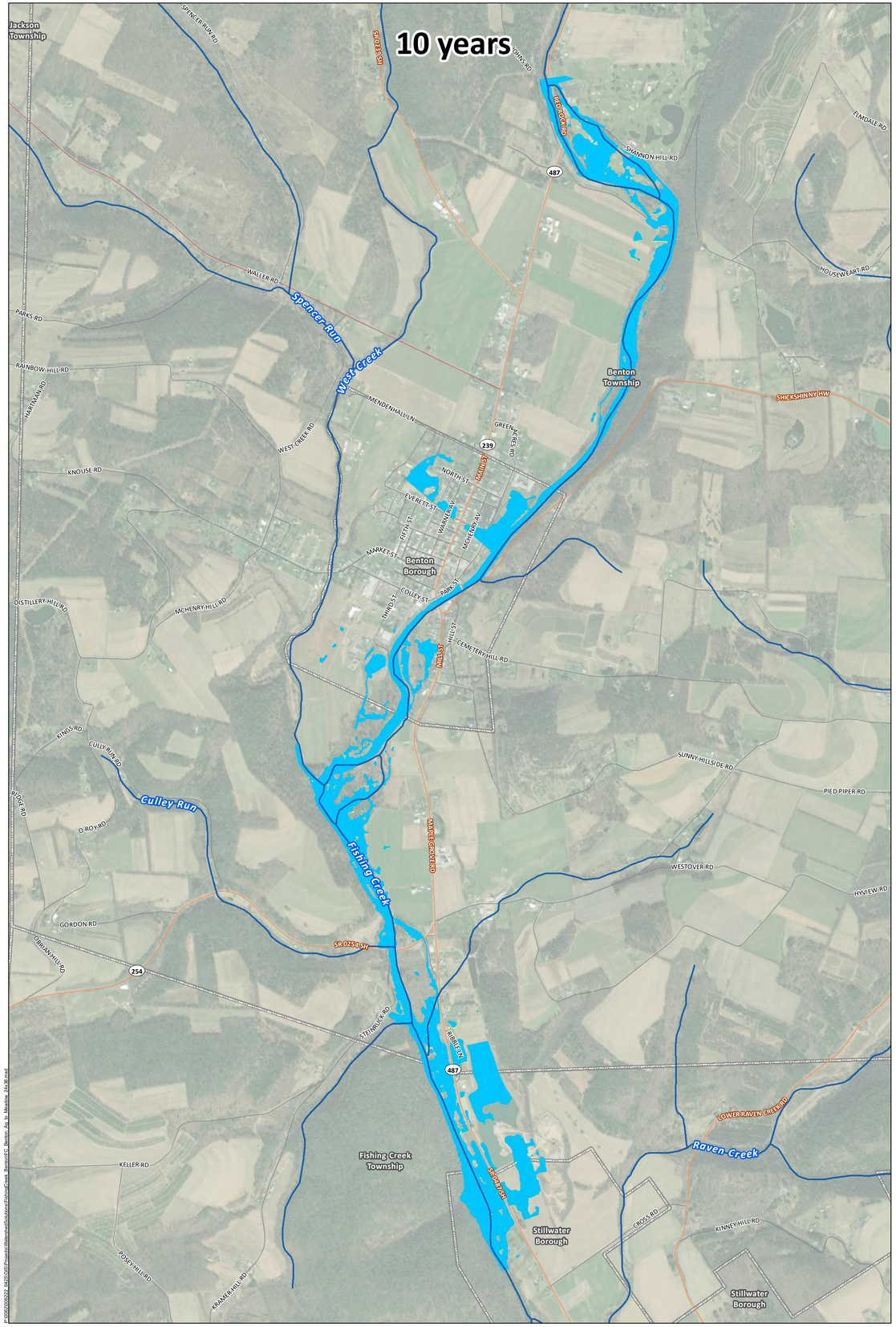
- Wetland Restoration
- Stream (NHD)
- Fishing Creek Watershed Boundary
- Study Area
- Subbasins
- Municipal Boundary
- County Boundary



Fishing Creek- Benton Agriculture to Meadow

Columbia County, Pennsylvania

1,000 0 1,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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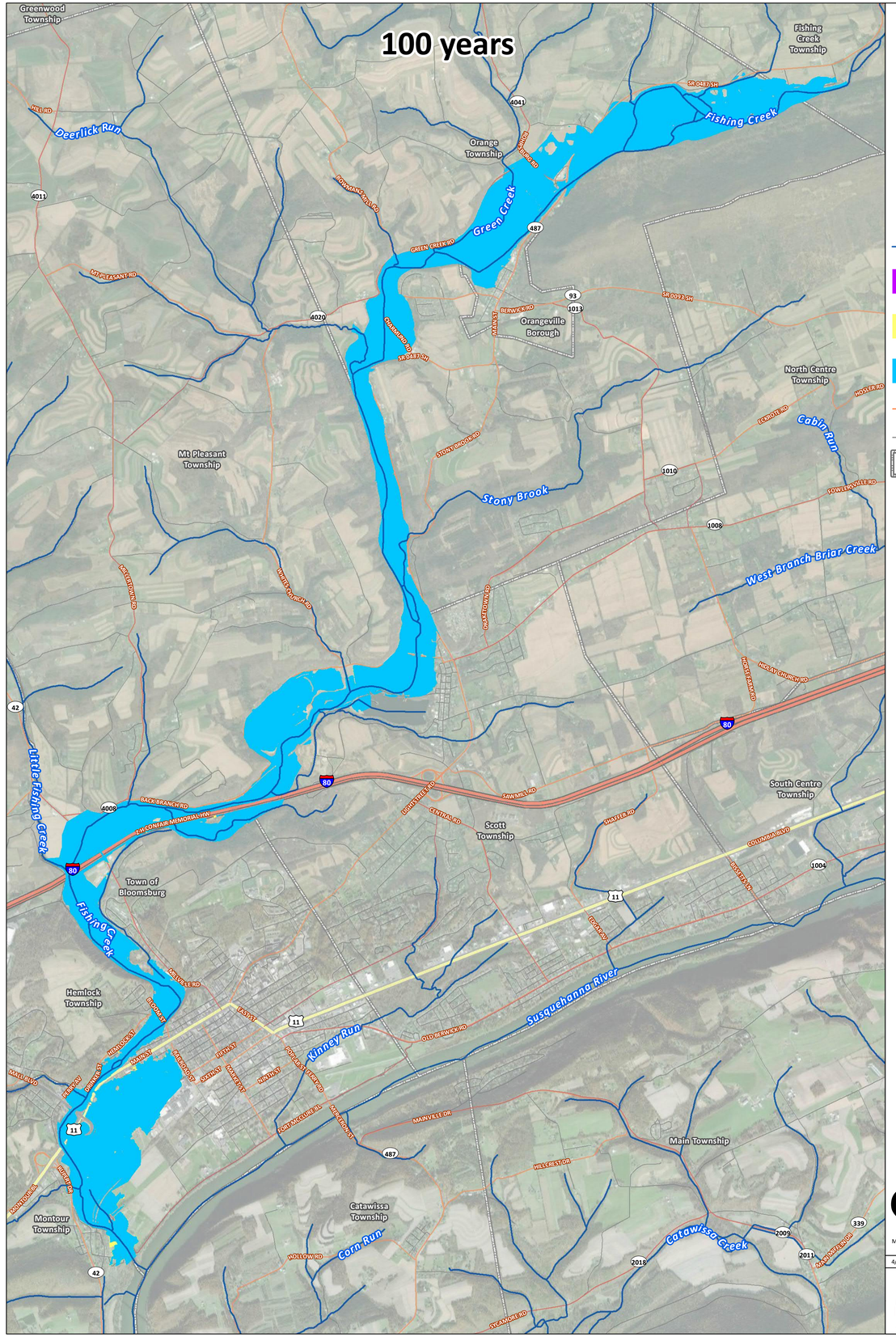

Fishing Creek Agriculture to Meadow

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

1,100 0 1,100 2,200 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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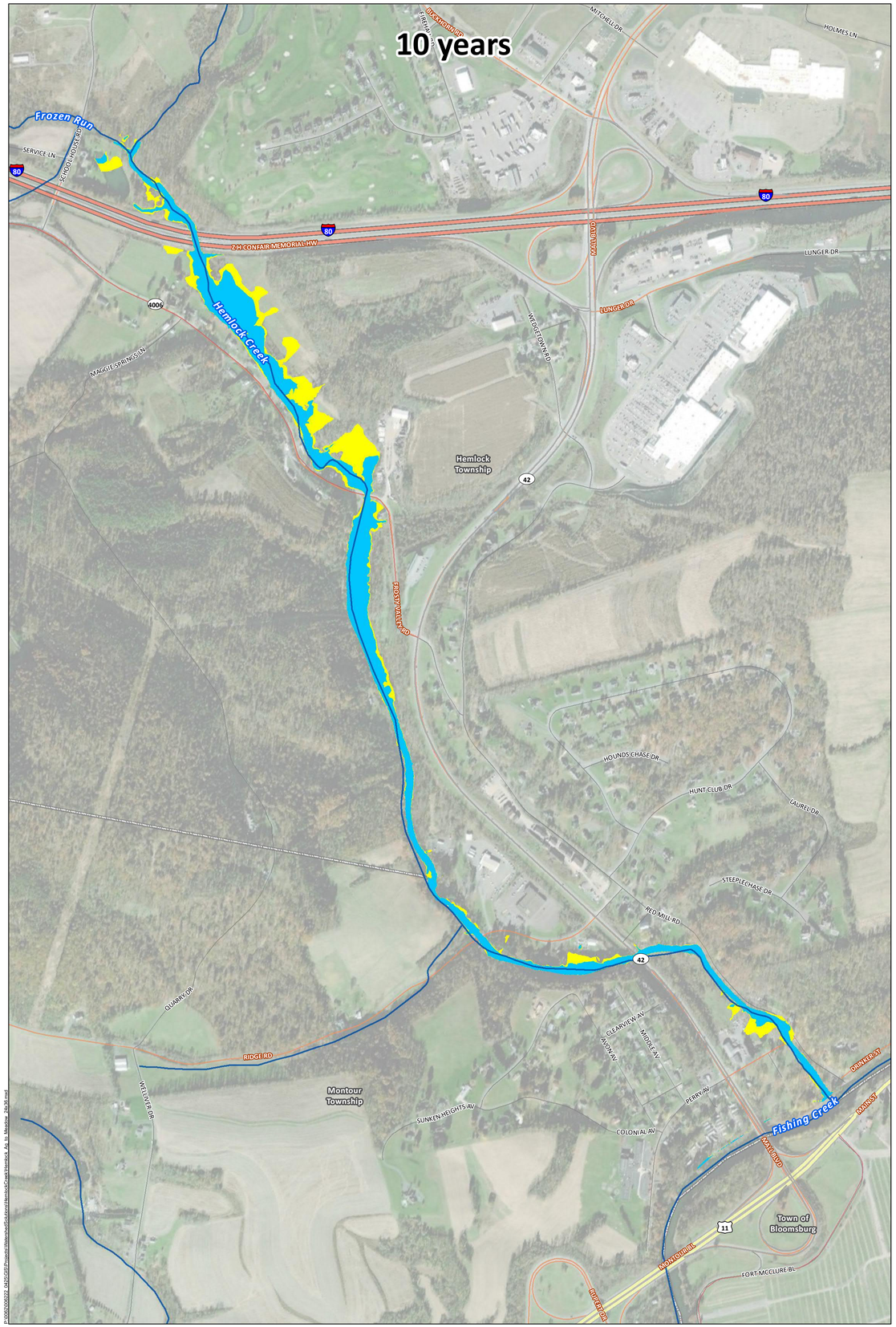

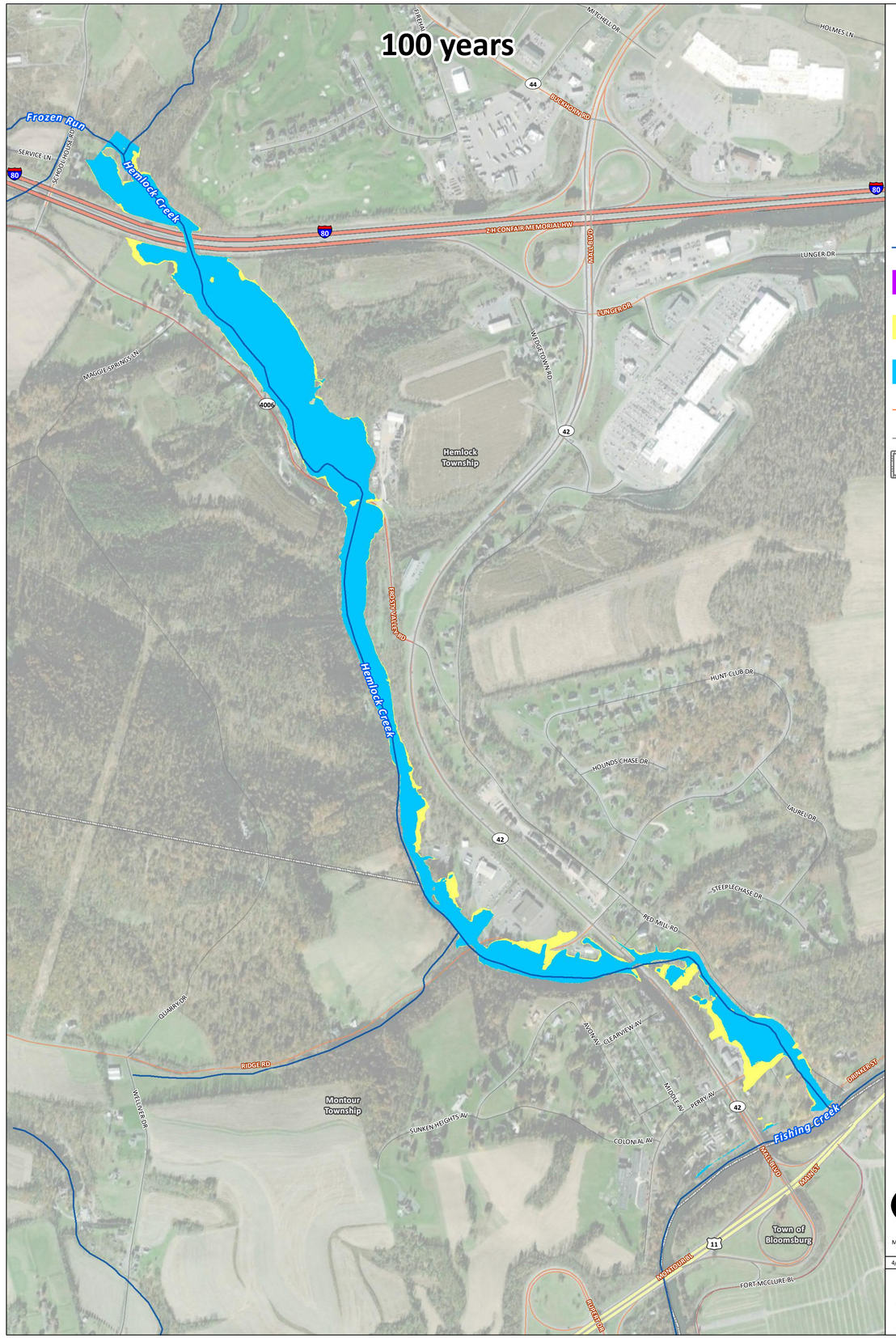

Hemlock Creek Agriculture to Meadow

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

500 0 500 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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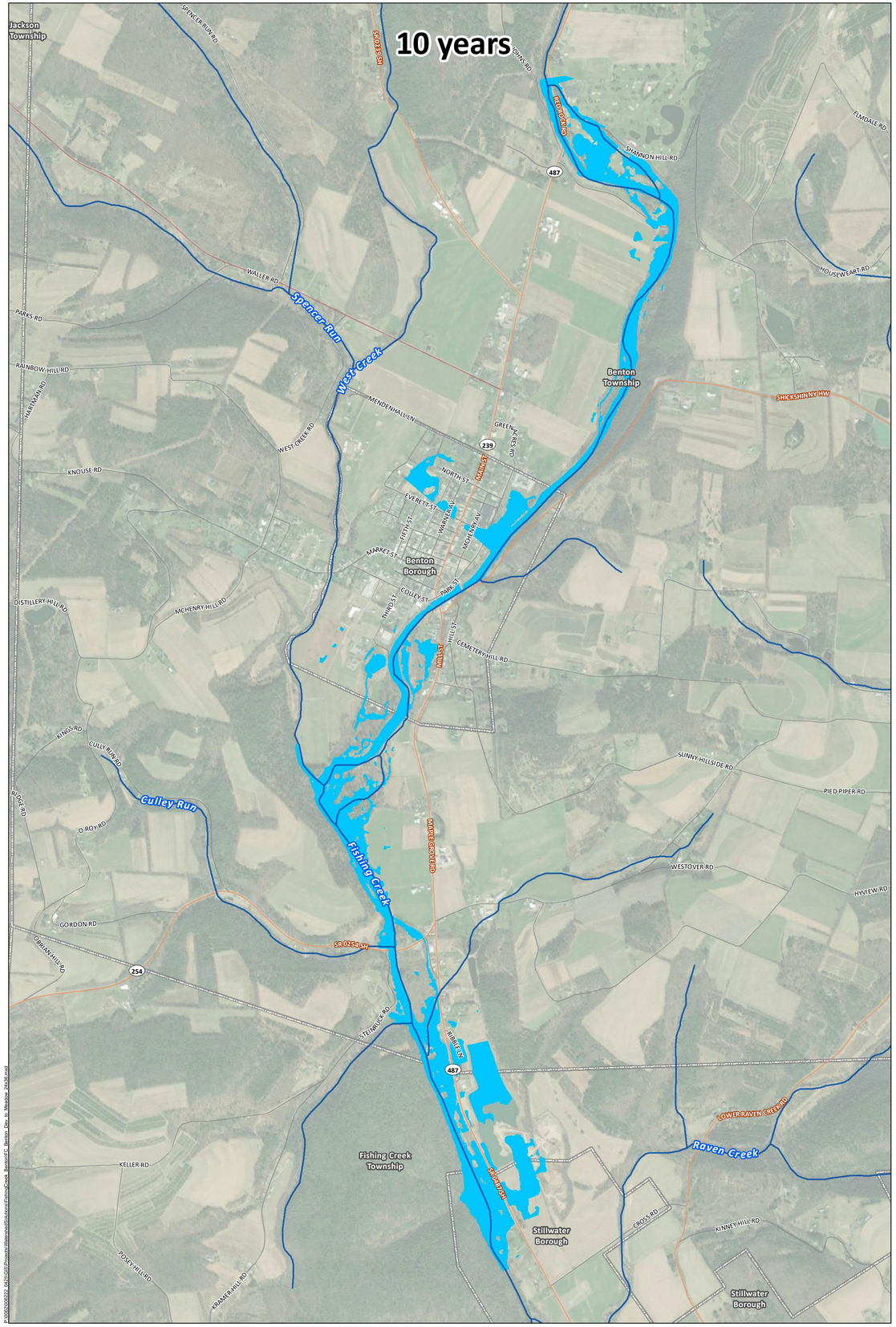

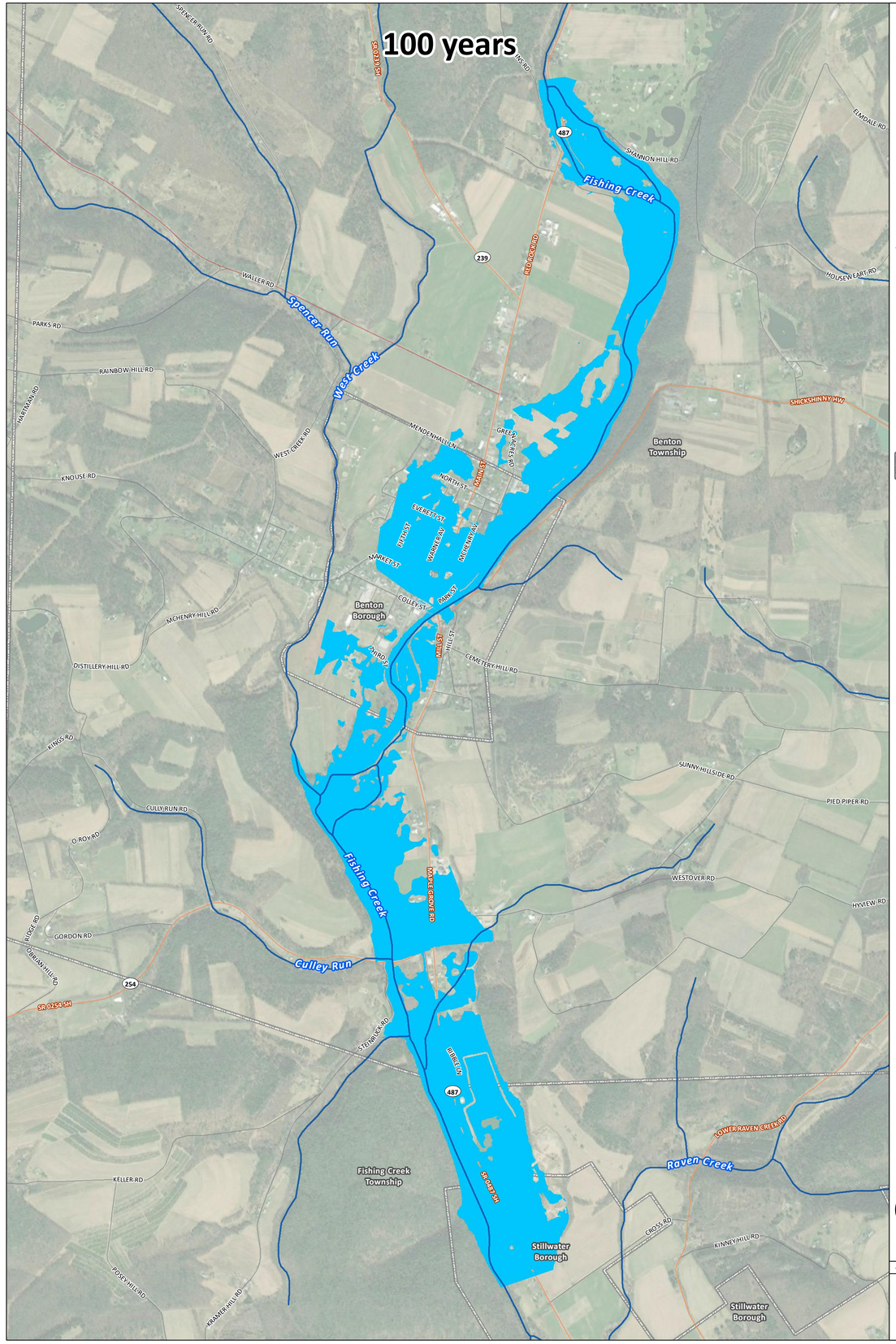

Fishing Creek- Benton Developed to Meadow

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area- Increase
- High Hazard Flood Area- Decrease
- High Hazard Flood Area- No Change
- State Road
- Local Road
- Municipal Boundary

1,000 0 1,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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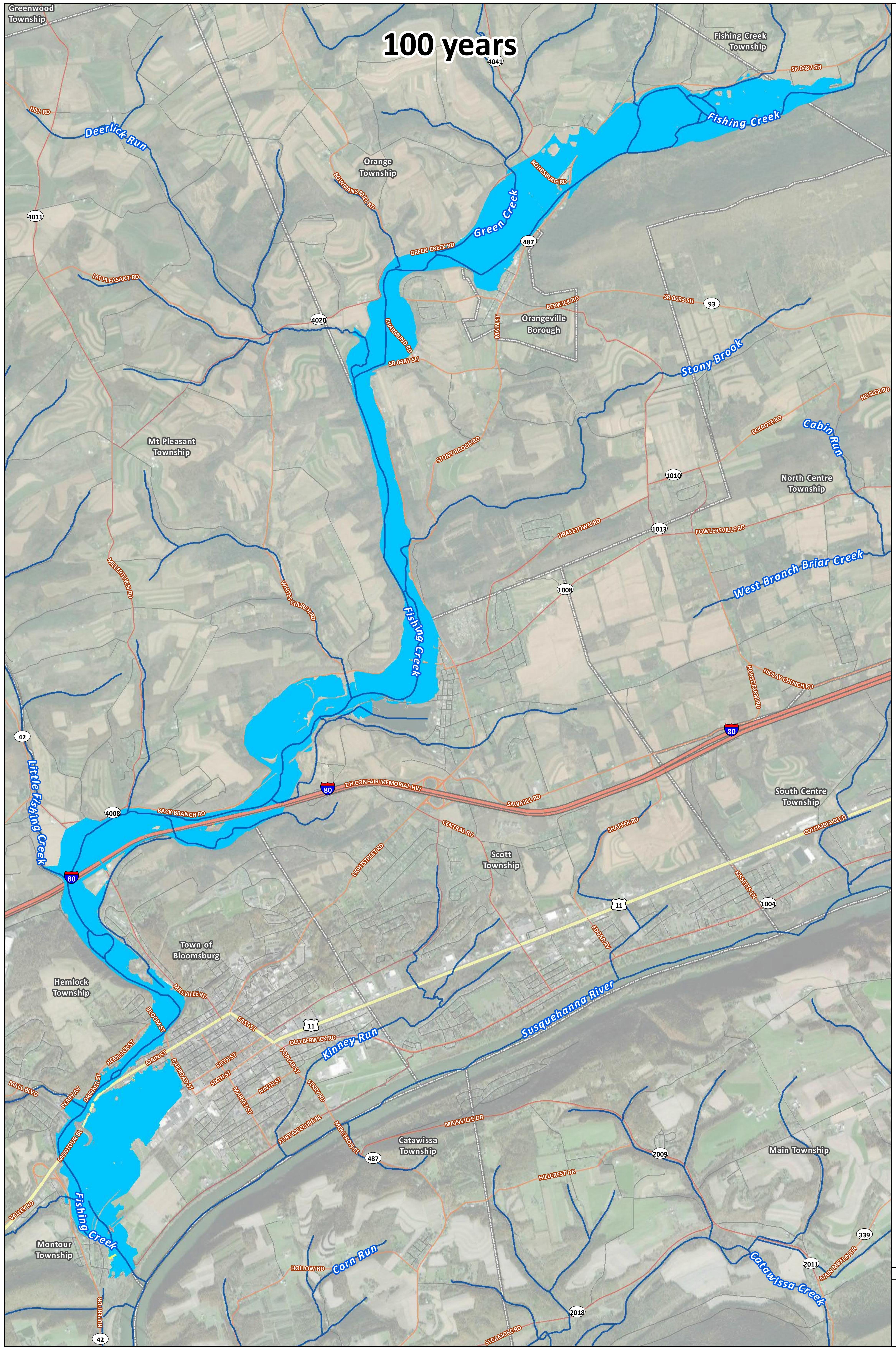

Fishing Creek
Developed to Meadow

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

1,100 0 1,100 2,200 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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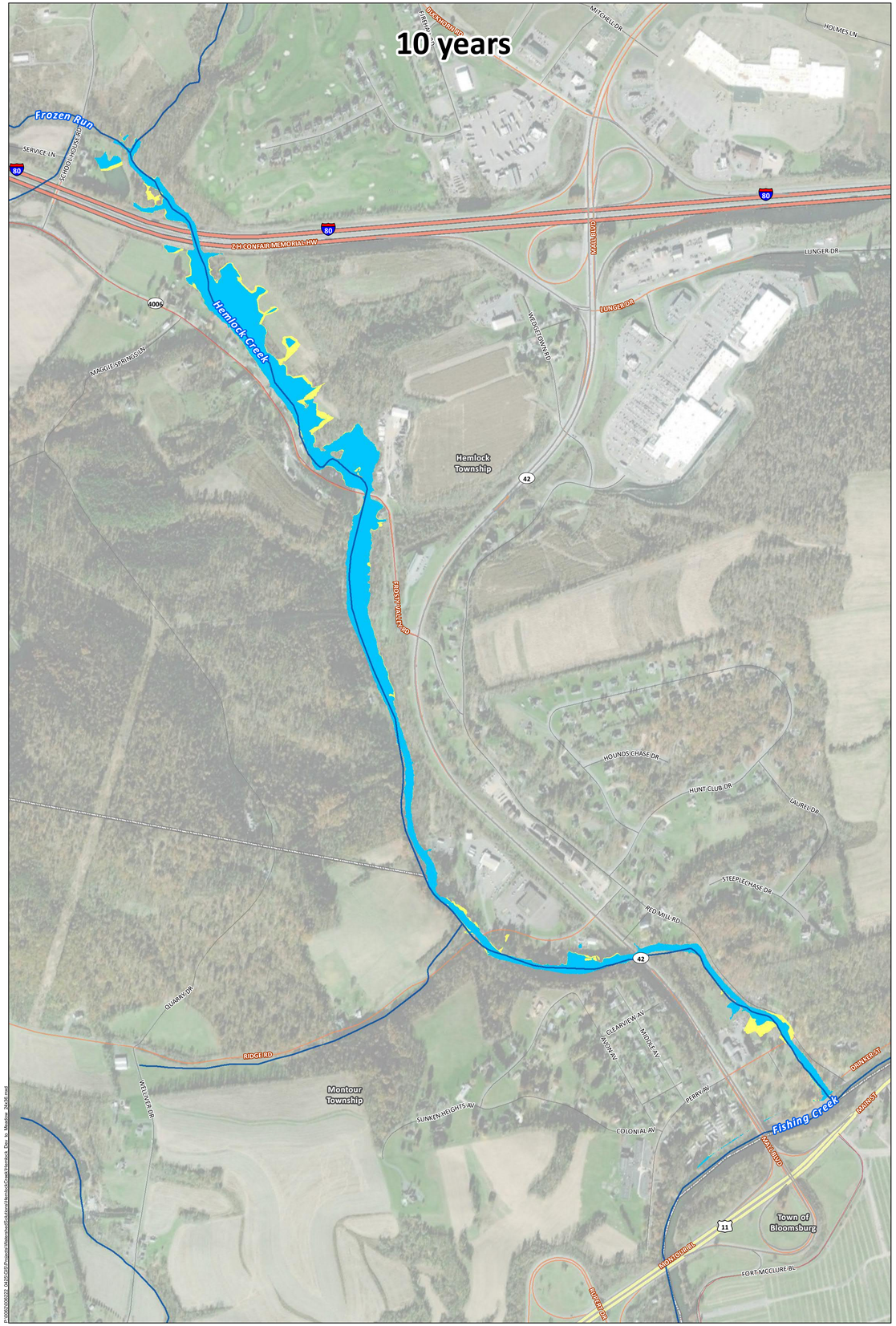

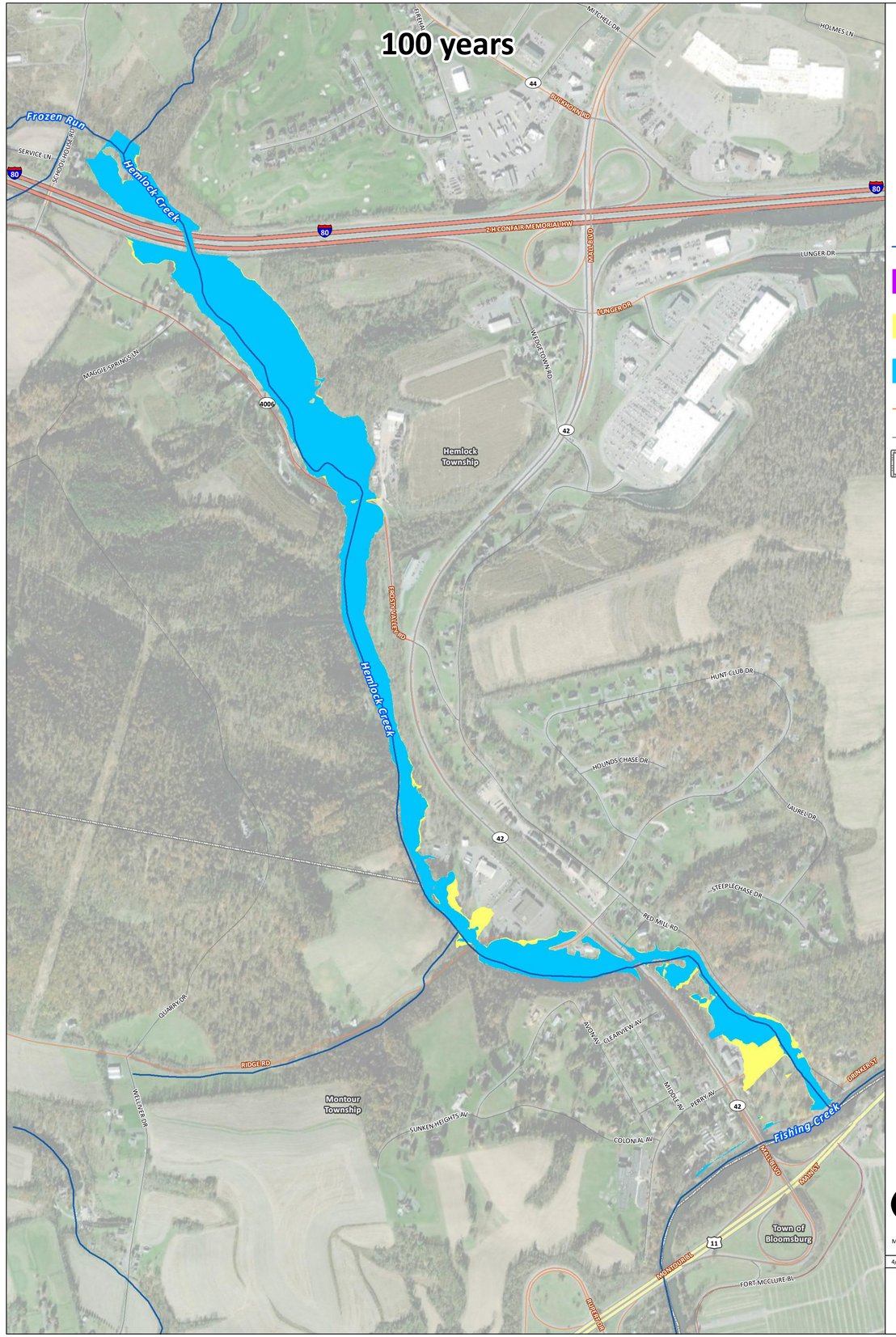

Hemlock Creek Developed to Meadow

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

500 0 500 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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APPENDIX C – STUDY AREAS AND PROBLEM AREA MITIGATION SUMMARIES

An overview of the process that was used to complete the problem area analysis is presented in Section 5 – Problem Area Identification of this report. An overview of the process that was used to complete the problem area prioritization is presented in Section 9 – Prioritization of Problem Areas/Projects of this report. Study Areas were defined in Section 3. The following technical data and maps are included here to supplement the general information provided in those sections.

SUMMARY MAPS AND TECHNICAL DATA

STUDY AREA MAPS

Fishing Creek Watershed Flooding Assessment and Mitigation Study Areas

Upper Fishing Creek Study Area

Middle Fishing Creek Study Area

Little Fishing Creek Study Area

Hemlock Creek-Lower Fishing Creek Study Area

PROBLEM AREA SUMMARIES

Upper Fishing Creek Study Area Problem Areas

ID	Municipality	Location
UFC 1	Sugarloaf Township	Village of Central & Jamison City
UFC 2	Sullivan County	Elk Grove
UFC 3	Sugarloaf Township	Central Road
UFC 4	Sugarloaf Township	Market Street
UFC 5	Sugarloaf Township	Central Road
UFC 6	Sugarloaf Township	School House Drive
UFC 7	Sugarloaf Township	Camp Lavigne Road
UFC 8	Benton Borough	Benton Borough
UFC 9	Benton Borough/Township	Distillery Hill Road bridge
UFC 10	Benton Township	Rohrsburg & Maple Grove Road

Middle Fishing Creek Study Area Problem Areas

ID	Municipality	Location
MFC 1 & 3	Stillwater Borough	Lower Raven Creek Road & Paperdale Road
MFC 2	Stillwater Borough	Paperdale & Buck Road
MFC 4	Fishing Creek Township	Ridge & Honeytown Road
MFC 5	Fishing Creek Township	Zaner Bridge Road
MFC 6	Fishing Creek Township	Winding & Harrison Road
MFC 7	Fishing Creek Township	Pealertown
MFC 8	Fishing Creek Township	2870 SR 487
MFC 9	Orange Township	Moore's Grove
MFC 10	Orange Township	Rohrsburg & Neyhart Road
MFC 11	Orange Township	Green Creek & Logging Road
MFC 12	Orange Township	Green Creek Road
MFC 13	Orange Township	Evans Lane
MFC 14 & 16	Orange Township	Mt. Pleasant Road
MFC 15	Orange Township	Mt. Pleasant Road Bridge Stream Gauge

ID	Municipality	Location
MFC 17	Orange Township	Charmund Road & SR 487
MFC 18	Orange Township	Stony Brook Road & SR 487
MFC 19	Orangeville Borough	Mt. Pleasant Road
MFC 20	Orangeville Borough	Broad and Mill Street
MFC 21	Greenwood Township	Rohrsburg Road

Little Fishing Creek Study Area Problem Areas

ID	Municipality	Location
LFC1	Jackson Township	Pole Bridge Road
LFC2	Jackson Township	Pole Bridge Road and SR 239
LFC3	Jackson Township	Green Creek Road
LFC4	Pine Township	Peterman Road
LFC 5	Greenwood Township	Mallard Road
LFC 6	Greenwood Township	Village of Iola
LFC 7	Millville Borough	West Main Street Bridge

Hemlock Creek-Lower Fishing Creek Study Area Problem Areas

ID	Municipality	Location
HC 1	Mount Pleasant Township	Robbins Road bridge
HC 2	Scott & Mount Pleasant Township	Back Branch road bridge
HC 3	Mount Pleasant Township	Back Branch & Millertown Road
HC 4	Mount Pleasant Township	Back Branch Road
HC 5	Mount Pleasant Township	Millville & Millertown Road
HC 6	Hemlock Township	Peppermill and Buckhorn Road
HC 7	Hemlock Township	Orchard Drive
HC 8	Hemlock Township	Dahl Road
HC 9	Hemlock Township	Frosty Valley and Schoolhouse Road
HC 10	Hemlock Township	Wanich Covered Bridge
HC 11	Hemlock Township	Millville Road
HC 12	Hemlock Township	Ridge Road and SR 42
HC 13	Hemlock & Montour Townships	Perry Avenue Bridge
HC 14/16	Hemlock Township & Town of Bloomsburg	Fernville
HC 15	Town of Bloomsburg	Hoffman Park
HC 17	Town of Bloomsburg	Boone's Dam
HC 18	Scott Township	Lake Florence
HC 19	Montour Township	Hock Road Bridge

Fishing Creek Watershed Study Areas
Columbia County, Pennsylvania

Problem Type

- Flooding from waterbody
- Flooding due to lack of SWM
- Flooding due to undersized/damaged infrastructure
- Erosion/Sedimentation

- Fishing Creek Watershed Boundary
- Municipal Boundary
- County Boundary
- Stream (NHD)
- Upper Fishing Creek Municipalities
- Middle Fishing Creek Municipalities
- Little Fishing Creek Municipalities
- Hemlock Creek - Lower Fishing Creek Municipalities

Greenwood Township boundary shown reflects boundary between Middle Fishing Creek and Little Fishing Creek Watersheds

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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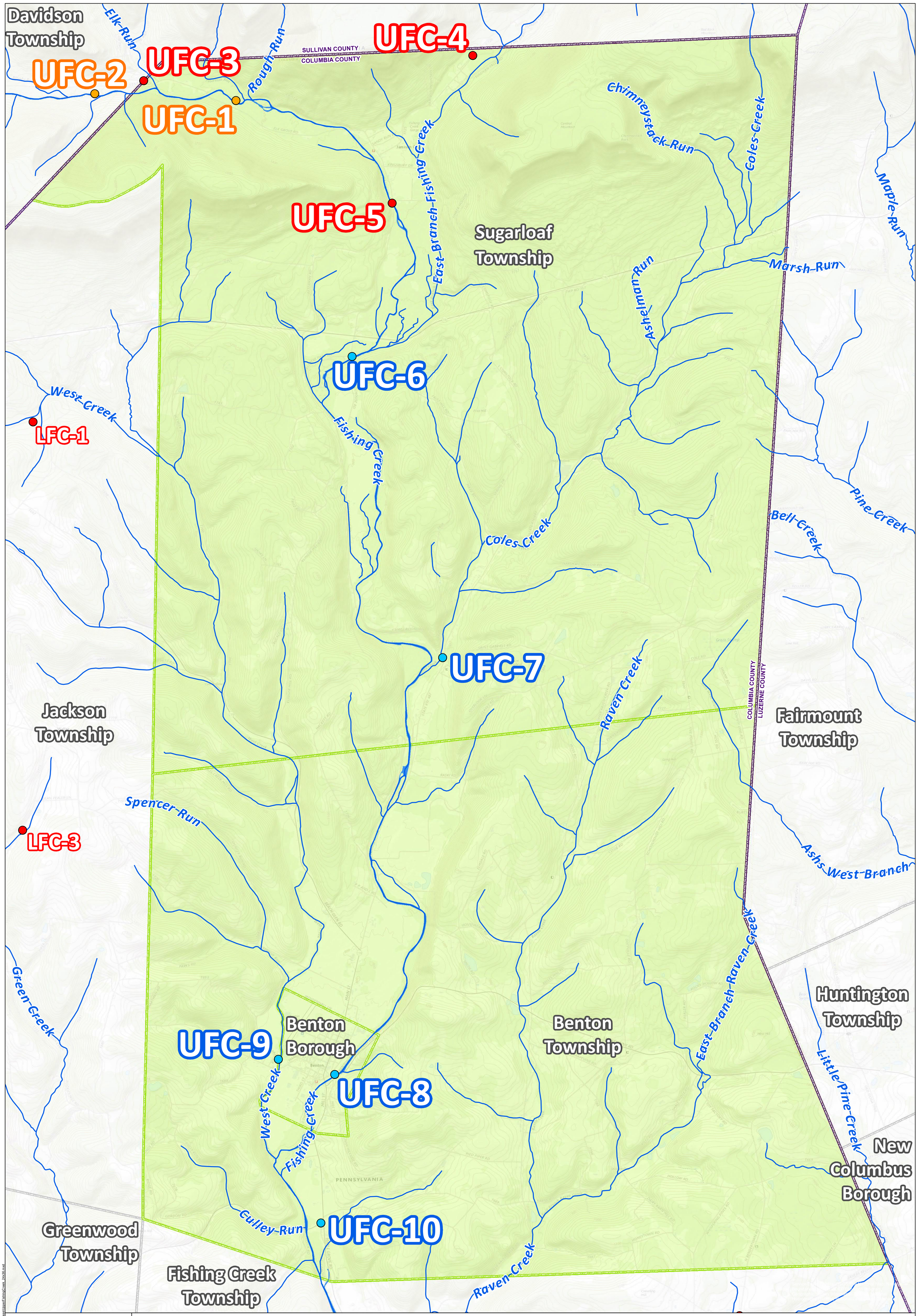
Davidson Township
Elk Run
UFC-2
UFC-3
UFC-4
Rough Run
SULLIVAN COUNTY
COLUMBIA COUNTY
UFC-1
UFC-5
East Branch Fishing Creek
Chimneystack Run
Coles Creek
Maple Run
Sugarloaf Township
Marsh Run
Ashelman Run
UFC-6
West Creek
LFC-1
Fishing Creek
Coles Creek
Pine Creek
Bell Creek
UFC-7
Raven Creek
Jackson Township
Fairmount Township
COLUMBIA COUNTY
LUZERNE COUNTY
LFC-3
Spencer Run
Ashs West Branch
Green Creek
Benton Borough
Benton Township
UFC-9
West Creek
Fishing Creek
UFC-8
East Branch Raven Creek
Little Pine Creek
New Columbus Borough
PENNSYLVANIA
Culley Run
UFC-10
Greenwood Township
Fishing Creek Township
Raven Creek
0
1,600
3,200
Feet
Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.
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GIS: ALV
QA: IU
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P:\006\006222_0425\GIS\Projects\ProblemAreas\UpperFishingCreek_24x36.mxd
Problem Type
Flooding from waterbody
Flooding due to lack of SWM
Flooding due to undersized/damaged infrastructure
Erosion/Sedimentation
Municipal Boundary
County Boundary
Upper Fishing Creek Municipalities
Stream (NHD)
Upper Fishing Creek Watershed
Study Area
Columbia County
Pennsylvania

Middle Fishing Creek Watershed Study Area
Columbia County
Pennsylvania
Problem Type
Flooding from waterbody
Flooding due to lack of SWM
Flooding due to undersized/ damaged infrastructure
Erosion/Sedimentation
Municipal Boundary
County Boundary
Middle Fishing Creek Municipalities
Stream (NHD)
Greenwood Township boundary shown reflects boundary between Middle Fishing Creek and Little Fishing Creek Watersheds
0
0.5
1
Miles
Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.
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GIS: ALV
QA: IU
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Pine Township
Jackson Township
Benton Borough
Benton Township
New Columbus Borough
Huntington Township
Greenwood Township
Stillwater Borough
Fishing Creek Township
Orange Township
Briar Creek Township
Madison Township
Mt Pleasant Township
North Centre Township
Berwick Borough
Briar Creek Borough
Hemlock Township
Scott Township
South Centre Township
Mifflin Township
LUZERNE COUNTY
COLUMBIA COUNTY
Little Fishing Creek
Wolfhouse Run
Little Green Creek
Green Creek
Culley Run
Fishing Creek
Raven Creek
East Branch Raven Creek
Little Pine Creek
Pine Creek
Kingsbury Brook
Huntington Creek
Mud Run
Deerlick Run
Stony Brook
Susquehanna River
UFC-8
UFC-9
UFC-10
LFC-5
MFC-1
MFC-2
MFC-3
MFC-4
MFC-5
MFC-6
MFC-7
MFC-8
MFC-9
MFC-10
MFC-11
MFC-12
MFC-13
MFC-14
MFC-15
MFC-16
MFC-17
MFC-18
MFC-19
MFC-20
MFC-21
HC-1
HC-2
HC-10

Penn Township
Davidson Township
Sugarloaf Township
Franklin Township
Jordan Township
Moreland Township
Jackson Township
Pine Township
Greenwood Township
Millville Borough
Anthony Township
Madison Township
Mt Pleasant Township
Orange Township
Fishing Creek Township
Derry Township
West Hemlock Township
Hemlock Township
Scott Township

SULLIVAN COUNTY
LYCOMING COUNTY
SULLIVAN COUNTY
COLUMBIA COUNTY
LYCOMING COUNTY
COLUMBIA COUNTY
COLUMBIA COUNTY
MONTOUR COUNTY

LFC-1
LFC-2
LFC-3
LFC-4
LFC-5
LFC-6
LFC-7
HC-1
HC-2
HC-4
HC-6
HC-10
HC-18
MFC-10
MFC-11
MFC-12
MFC-13
MFC-15
MFC-16
MFC-17
MFC-18
MFC-19
MFC-20
MFC-21

Little Brier Run
West Creek
Kline Hollow Run
Little Fishing Creek
Green Creek
West Branch Run
Shingle Run
Lick Run
Wolfhouse Run
Devil Hole Run
Little Green Creek
Spruce Run
Mud Run
Deer Lick Run
Hemlock Creek
Stony Brook
Fishing Creek

0 0.5 1 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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Problem Type
- Flooding from waterbody
- Flooding due to lack of SWM
- Flooding due to undersized/damaged infrastructure
- Erosion/Sedimentation

- Municipal Boundary
- County Boundary
- Little Fishing Creek Municipalities
- Stream (NHD)

Greenwood Township boundary shown reflects boundary between Middle Fishing Creek and Little Fishing Creek Watersheds

Little Fishing Creek Watershed Study Area
Columbia County
Pennsylvania

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Pine Township
Stillwater Borough
Millville Borough
Fishing Creek Township
Greenwood Township
Madison Township
Mt Pleasant Township
Orange Township
North Centre Township
South Centre Township
Scott Township
Hemlock Township
Town of Bloomsburg
West Hemlock Township
Montour Township
Main Township
Catawissa Borough
Catawissa Township
Mahoning Township
Rush Township
Mayberry Township
Franklin Township
Roaring Creek Township
Locust Township
Cooper Township

LFC-6
LFC-7
MFC-21
MFC-8
MFC-9
MFC-10
MFC-11
MFC-12
MFC-13
MFC-14
MFC-15
MFC-16
MFC-17
MFC-18
MFC-19
MFC-20
HC-1
HC-2
HC-3
HC-4
HC-5
HC-6
HC-7
HC-8
HC-9
HC-10
HC-11
HC-12
HC-13
HC-14
HC-15
HC-16
HC-17
HC-18
HC-19

Spruce Run
Little Fishing Creek
Mud Run
Green Creek
Deer Lick Run
Hemlock Creek
West Hemlock Creek
Fishing Creek
Stony Brook
Frozen Run
Montour Run
Susquehanna River
COLUMBIA COUNTY
MONTOUR COUNTY

0 0.5 1 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

3/23/2022	PM: MV	GIS: ALV	QA: IU	R006222.0425

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
An Employee-Owned Company
776 Bull Run Crossing
Suite 200
Lewisburg, PA 17837
570.524.6744 [phone]
www.hrg-inc.com

Problem Type
- Flooding from waterbody
- Flooding due to lack of SWM
- Flooding due to undersized/damaged infrastructure
- Erosion/Sedimentation

- Stream (NHD)
- Municipal Boundary
- County Boundary
- Hemlock Creek - Lower Fishing Creek Municipalities

Hemlock Creek-Lower Fishing Creek Study Area
Columbia County
Pennsylvania

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Flooding and Debris Issues around Central, Jamison City (UFC-1)

Sugarloaf Township

General Information

Affected Land Ownership:	Public
Responsible Entity:	Columbia County / Sugarloaf Township
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	50+
Watershed:	West Branch Fishing Creek
Priority Level:	Medium
Project Type:	Debris Management
Permit Required:	N/A

Problem Area Descriptive Location

The problem area is located along West Branch Fishing Creek within Central, Jamison City.

Latitude: 41.296756
Longitude: -76.373070

Estimated Construction Cost

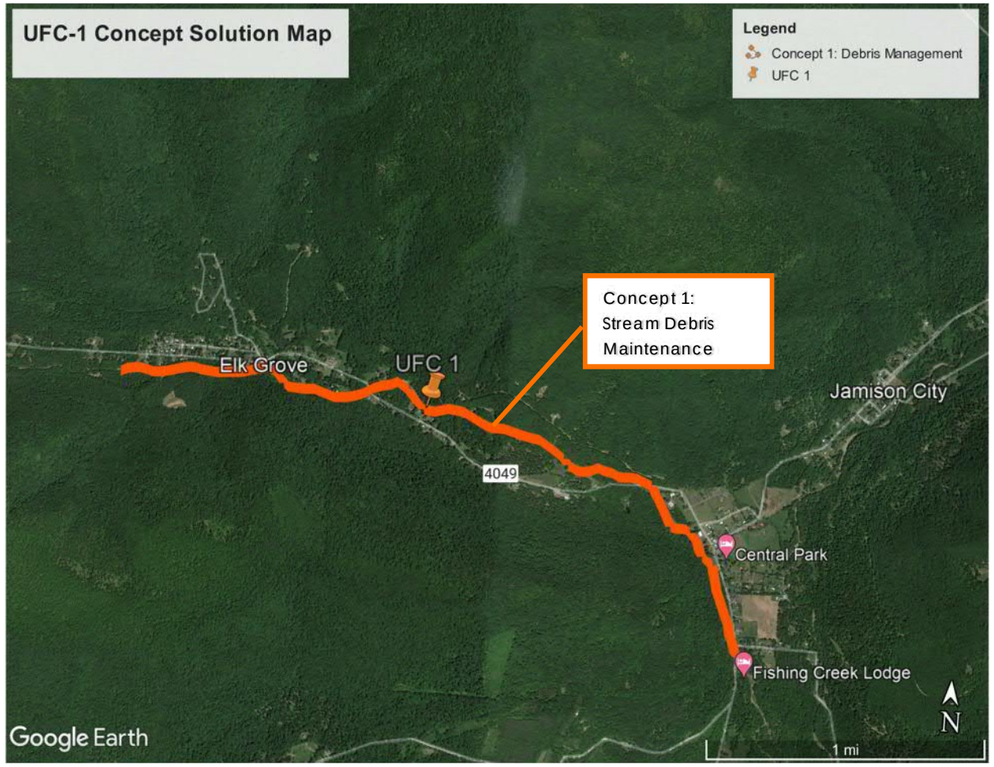
Concept 1: $0-$100,000+ (Stream Maintenance)
Concept 2: $1.5+ Million (Property Improvements)

Concept Impacts

Concept 1: 15,000 Linear Feet of Stream Maintenance
Concept 3: 50+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	Low = Few High = Many
Frequency of Existing Problem	5	Low = Infrequent High = More Frequent
Flood Level Reduction	1	Low = Infrequent High = More Frequent
Resiliency	1	Low = More Maintenance High = Long-Lasting
Construction Cost	10	Low = Significant Cost ($$$) High = Less Cost ($)
Priority Score Total =	Medium (5.4)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding and heavy debris along and within this section of West Branch Fishing Creek has been identified. Upon further investigations of the site, numerous log jams were noted around the Central Road bridges.

Problem Area Photo

Concept Solutions

Concept 1: Vegetation/debris management along West Branch Fishing Creek. Continual maintenance of the creek corridor would reduce the amount of sediment/trees that end up within the channel and bridges. This concept is recommended to be implemented and would ensure that the hydraulic structures and stream channel are functioning at their maximum capacity. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Elk Grove Flooding (UFC-2)

Sullivan County

General Information

Ownership:	Public/Private
Problem Type:	Flooding
Responsible Entity:	Columbia County
Impacted Properties Anticipated:	N/A
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	TBD
Permit Required:	N/A

Problem Area Descriptive Location

The problem area is at the Village of Elk Grove in Sullivan County

Latitude: 41.304828
Longitude: -76.415494

Estimated Construction Cost

Concept 1: TBD

Concept Impacts

Concept 1: TBD

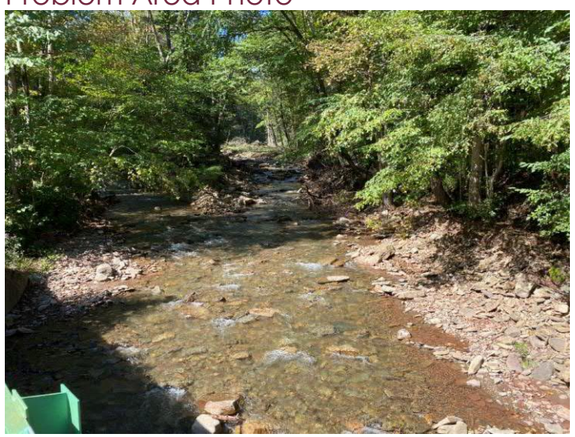
Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (2.6)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

Problem Area Issue

The village of Elk Grove experiences flooding from Fishing Creek during large rainfall events. Elk Grove is located in Sullivan County and has seen benefit from some downstream projects performed in Colombia County, however, no projects on Fishing Creek have been performed across the municipal boundary.

Problem Area Photo



Concept Solutions

Concept 1: Coordination between Sullivan County and Columbia County is encouraged. Municipalities only have the authority to work within their boundaries. Possible projects could include floodplain restorations, streambank stabilizations, and general creek corridor maintenance. By collaborating on projects for funding and construction the counties could perform more projects in this area that would be beneficial to both counties and their residents.

Central Road Flooding (UFC-3)

Sugarloaf Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / State Highway Agency
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	50+
Watershed:	Upper Fishing Creek
Priority Level:	High (8.0)
Project Type:	Culvert Replacement / Bridge Replacement
Permit Required:	TBD

Problem Area Descriptive Location

The problem area is located upstream from an existing culvert which crosses under Central Road and eventually discharges into Fishing Creek.

Latitude: 41.306211
Longitude: -76.408186

Estimated Construction Cost

Concept 1: $30,000-60,000 (Dual Pipe Culvert)
Concept 2: $70,000-130,000 (Concrete Box Culvert)
Concept 3: $1.3-$2.4 Million (Bridge Replacement)
Concept 4: $1.5 Million+ (Property Improvements)

Concept Impacts

Concept 1: 30 Linear Feet of Culvert Replacement
Concept 2: 30 Linear Feet of Culvert Replacement
Concept 3: 90’ Length x 34’ Width of Bridge Replacement
Concept 4: N/A

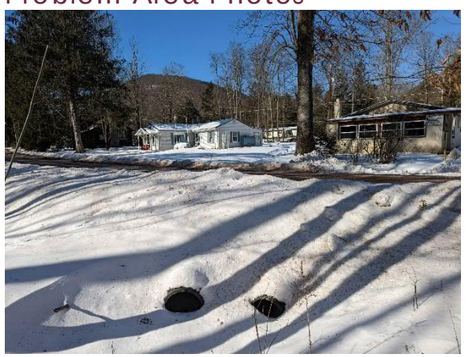
Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

Problem Area Issue

Flooding along this drainage swale section upstream of a Central Road culvert has been identified. Upon further investigation, the culvert is undersized for the culvert’s drainage area.

Problem Area Photos



Concept Solutions

Concept 1: Replace the existing 15” HPDE pipe culvert with a 36” HPDE dual pipe culvert. Utilizing the Federal Highway Administration’s (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 2-year storm event. The proposed dual pipe culvert can convey the 100-year storm without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area and surrounding properties.

Concept 2: Replace the existing 15” HPDE pipe culvert with a 6’ span and 2.5’ rise concrete box culvert. Utilizing the Federal Highway Administration’s (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 2-year storm event. The proposed concrete box culvert can convey the 200-year storm without overtopping the roadway. This concept will help to mitigate flooding issues within the location of the culvert and surrounding properties.

Concept 3: Replacement of the Central Road bridge and remove the retaining wall from the flooding area. The existing bridge was constructed in 2000 and is in good condition as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding caused by the obstruction. Preliminary hydraulic analysis results show that increasing the height of the waterway opening by 6 inches allows the existing bridge to pass the 500-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is not recommended to mitigate flooding issues within the problem area.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Jamison City Road Flooding (UFC-4)

Sugarloaf Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	1-3
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	Sediment Removal/Bridge Replacement
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located on the Market Street bridge which crosses Each Branch Fishing Creek and along the East Branch Fishing Creek corridor upstream of the bridge crossing.

Latitude: 41.306053
Longitude: -76.359941

Problem Area Issue

Flooding along this section of East Branch Fishing Creek and obstruction of the Market Street bridge has been identified. Upon further investigations on the site, approximately three feet of streambed material has been deposited on the right side (looking downstream) of the bridge and extends to approximately the center of the bridge. Heavy sediment deposition can be seen upstream of the bridge.

Problem Area Photo

Estimated Construction Cost

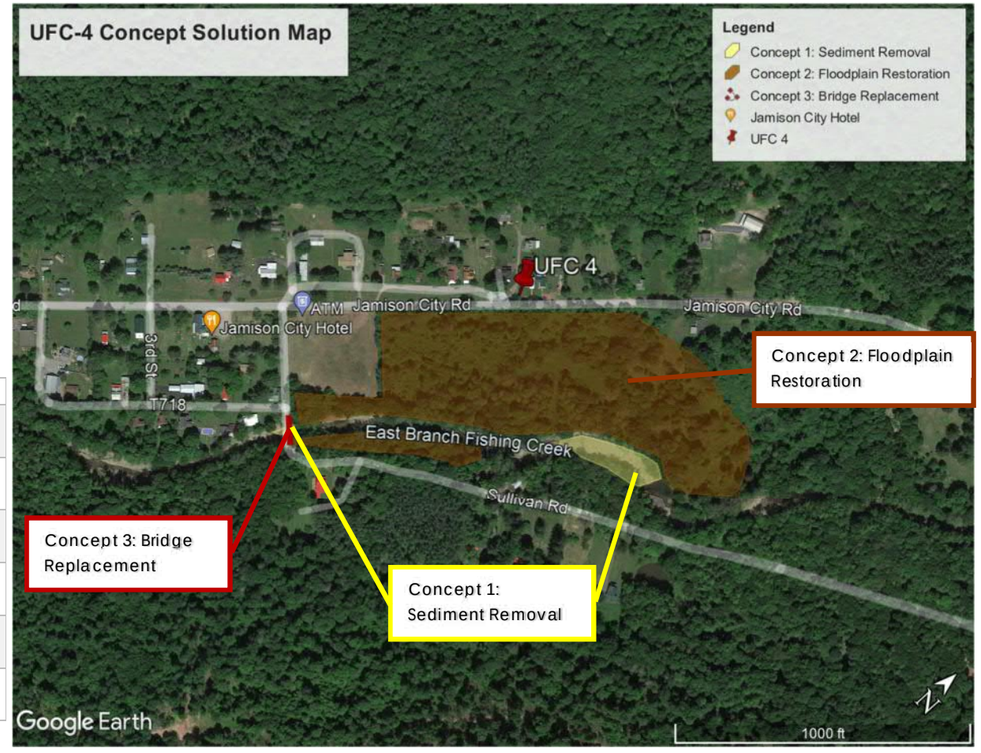
Concept 1: $420,000-530,000 (Sediment Removal)
Concept 2: $1.2-$2.3 Million (Floodplain Restoration)
Concept 3: $0.6-$1.1 Million (Bridge Replacement)
Concept 4: $90,000+ (Property Improvements)

Concept Impacts

Concept 1: 70' Length x 18' Width of Sediment Removal Underneath Bridge and 370' Length x 73' Width of Sediment Removal Upstream of Bridge
Concept 2: 650' Length x 70' Width x 3' Depth of Floodplain Restoration
Concept 3: 70' Length x 20.3' Width of Bridge Replacement
Concept 4: 1-3+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Concept Solutions

Concept 1: Remove deposited sediment from under the Market Street bridge and within the upstream channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing unobstructed bridge is sized sufficiently to convey the 200-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced and is only able to convey the 100-year design storm with no available freeboard before it overtops the roadway. The removal of the deposited sediment would provide a cost efficient and highly effective solution in reducing high flow flooding caused by the bridge. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Restore the floodplain upstream of the bridge by removing approximately 60,000 cubic yards of sediment. The project is located on the border of Sullivan County and could be further extended from interested neighboring governments. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor. This concept is not recommended to mitigate flooding issues within the problem area.

Concept 3: Replacement of the Market Street bridge. The existing bridge was constructed in 1977 and is in poor conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that extension of the bridge length by 10 feet and increasing the height of the waterway opening by 6 inches allows the existing bridge to almost pass the 500-year design storm without overtopping the roadway (passes 5,560 cfs of the 5,660 cfs). The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is not recommended to mitigate flooding issues within the problem area, however, it is recommended for replacement due to the bridge being in poor conditions. This bridge is currently under design or constructed as per Columbia County's bridge replacement priorities.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Central Road/Stevens Hill Road Flooding (UFC-5)

Sugarloaf Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Sugarloaf Township
Impacted Properties Anticipated:	3
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	Debris removal/maintenance
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located on the Central Road Bridge near the intersection with Stevens Hill Road.

Latitude: 41.292047
Longitude: -76.371533

Estimated Construction Cost

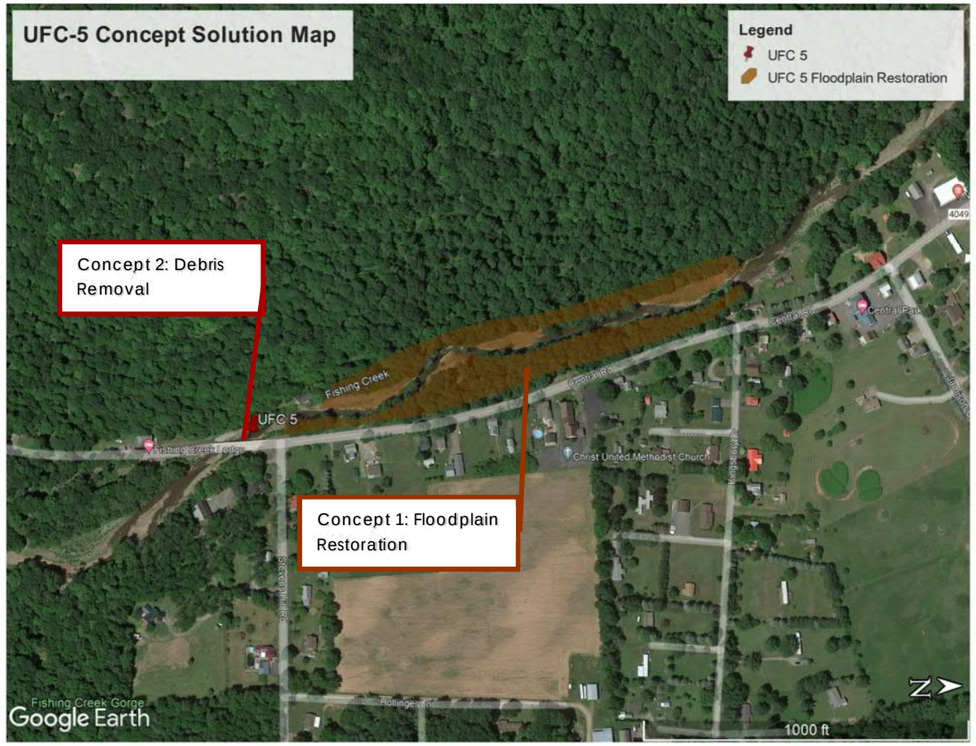
Concept 1: $500,000-$900,000 (Floodplain Restoration)
Concept 2: $10,000-20,000 (Debris Removal around Bridge Piers)

Concept Impacts

Concept 1: 2800' Length x 100' Width x 3' Depth of Floodplain Restoration
Concept 2: N/A

Project Prioritization

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Infrequent 10 = More Frequent
Resiliency	1	1 = More Maintenance 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.4)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along this section of Fishing Creek and obstruction of the bridge has been identified. Flooding occurs in this area during large rainfall events.

Problem Area Photo

Concept Solutions

Concept 1: Restore the floodplain upstream of the bridge by removing approximately 31,000 cubic yards of sediment upstream of the bridge on both the east and west sides of the channel. Small scale stream restorations such as this typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the creek corridor. This concept is not recommended to mitigate flooding issues within the problem area.

Concept 2: Removal of debris from around the bridge piers. Removing debris from the piers will open up the waterway under the bridge and prevent additional buildup of debris during large rainfall events. This is a continual maintenance activity that should be performed after large rainfall events or when significant debris buildup is noted on the bridge pier. This concept is recommended to mitigate flooding issues within the problem area.

School House Drive Bridge (UFC-6)

Sugarloaf Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	8+
Watershed:	Upper Fishing Creek
Priority Level:	Low (1.8)
Project Type:	Debris removal/maintenance
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located on the School House Drive (County Bridge #154) bridge which crosses Fishing Creek near the intersection of School House Drive and Grassmere Park Road.

Latitude: 41.27492
Longitude: -76.37784

Estimated Construction Cost

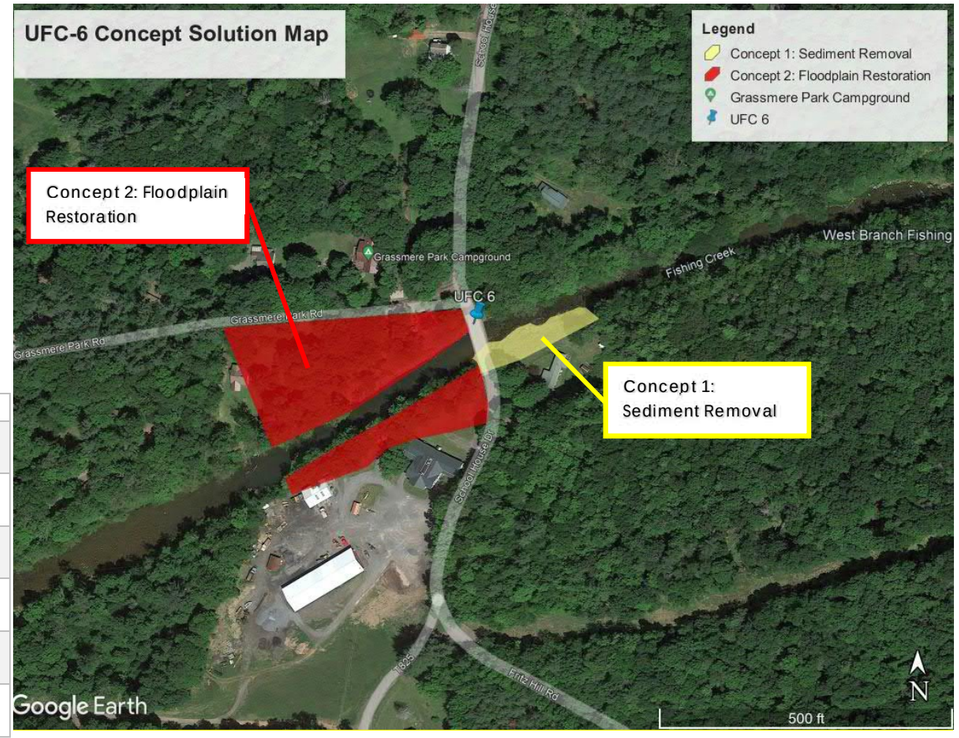
Concept 1: $90,000-$160,000 (Sediment Removal)
Concept 2: $400,000-$500,000 (Floodplain Restoration)
Concept 3: $240,000+ (Property Improvements)

Concept Impacts

Concept 1: 250' Length x 50' Width x 2' Depth of Sediment Removal
Concept 2: 450' Length x 300' Width x 3' Depth of Floodplain Restoration
Concept 3: 8+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Infrequent 10 = More Frequent
Resiliency	1	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (1.8)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

There is sediment and debris buildup along the south bank of Fishing Creek upstream and underneath the School House Drive Bridge. During large storm events this build up constricts the waterway and collects additional debris being carried downstream by the high flows.

Concept Solutions

Concept 1: Remove deposited sediment from under the School House Drive bridge and within the upstream channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and HRG for estimating stream peak flow rates, the existing unobstructed bridge is sized sufficiently to convey the 100-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced; however, it is still able to convey the 200-year design storm with available freeboard. The removal of the deposited sediment is a cost efficient solution; however, it will most likely have little impact on the surrounding area. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Restore the floodplain downstream of the bridge by removing approximately 10,000 cubic yards of sediment. Stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor upstream. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Camp Lavigne Road Bridge (UFC-7)

Sugarloaf Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Infrastructure
Responsible Entity:	Benton Township
Impacted Properties Anticipated:	2
Watershed:	Little Fishing Creek
Priority Level:	Low
Project Type:	Vegetation/ Debris Management
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at the Camp Lavigne Road Bridge near the intersection with Red Rock Road and the confluence of Cole's Creek and Fishing Creek.

Latitude: 41.241405
Longitude: -76.365120

Estimated Construction Cost

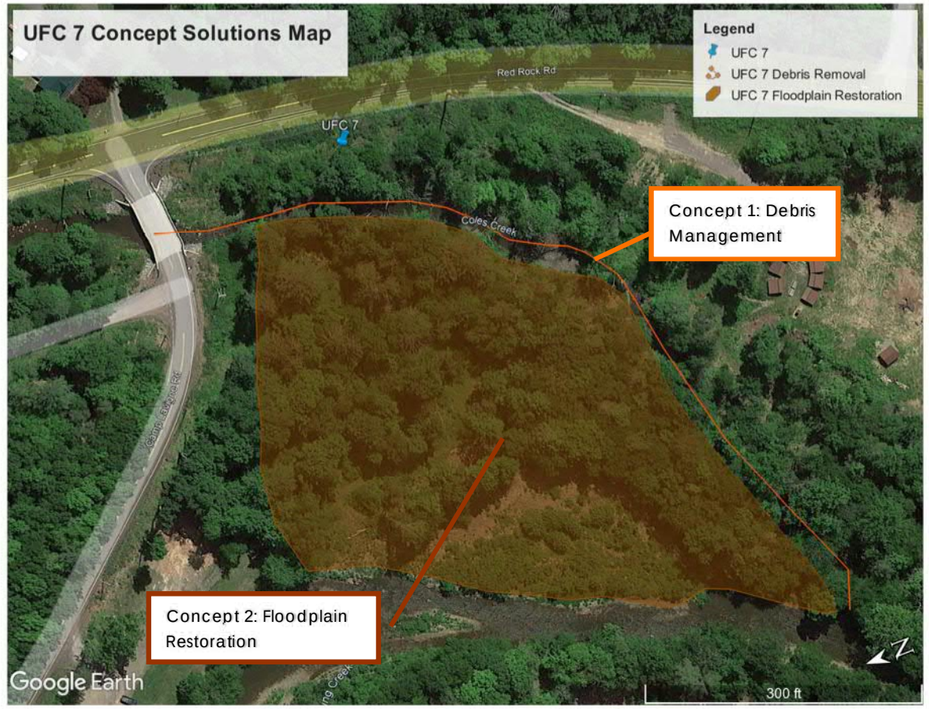
Concept 1: $0-$100,000 per year (Debris Management)
Concept 2: $0.7-$1.3 Million (Floodplain Restoration)

Concept Impacts

Concept 1: 1000 Linear Feet of Debris Management
Concept 2: 475' Length x 380' Width x 3' Depth of Floodplain Restoration

Assessment and Analysis of Solutions

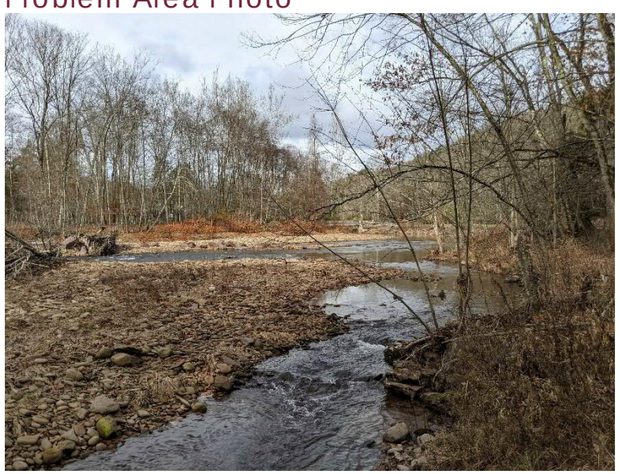
Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	1	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (2.6)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Possible flooding location. Streambanks are heavily lined with Japanese Knotweed and there is debris built up in the stream channel.

Problem Area Photo



Concept Solutions

Concept 1: Vegetation/debris management along Cole's Creek. Continual maintenance of the creek corridor would reduce the amount of sediment/trees that end up within the channel and bridges. This concept is recommended to be implemented and would ensure that the hydraulic structures and stream channel are functioning at their maximum capacity, as well as remove the invasive Japanese Knotweed from the streambanks.

Concept 2: Restore the floodplain upstream of the bridge by removing approximately 21,000 cubic yards of sediment. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor.

Benton Borough Flooding (UFC-8)

Benton Borough

General Information

Ownership:	Public/Private
Problem Type:	Flooding
Impacted Properties Anticipated:	100+
Watershed:	West Creek/Fishing Creek
Priority Level:	High
Project Type:	Dam Removal/ Levee/Roadway Re-profiling
Permit Required:	PADEP JPA/Chapter 106/LOMR

Problem Area Descriptive Location

The problem area is located throughout Benton Borough.

Latitude: 41.195967
Longitude: -76.384425

Estimated Construction Cost

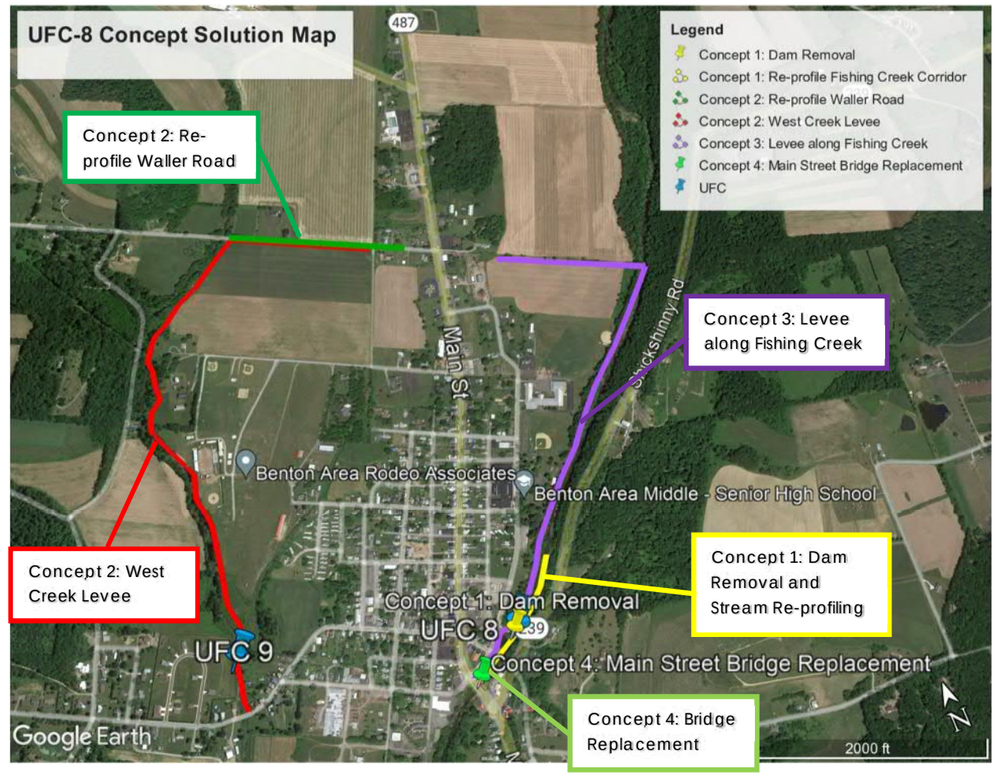
Concept 1: $0.7-$1.3 Million (Dam Removal and Stream Re-profiling)
Concept 2: $12-$22 Million (Levee)
Concept 3: $11.5-$21.5 Million (Roadway Re-profiling and Levee)
Concept 4: $2.0-$3.8 Million (Bridge Replacement)
Concept 5: $3 Million+ (Property Improvements)

Concept Impacts

Concept 1: 1,300' Linear Feet of Dam Removal and Stream Re-Profiling
Concept 2: 1,500' Length of Roadway Re-profiling and 1 Mile Length of Levee
Concept 3: 1 Mile Length of Levee
Concept 4: 130' Length x 45' Width of Bridge Replacement
Concept 5: 100+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding within Benton Borough from Fishing Creek and West Creek has been identified. Upon further investigations of the problem area, the majority of Benton Borough is located within a detailed FEMA floodplain affected by both Fishing Creek and West Creek. Additionally, Benton Borough is relatively flat and located approximately 3 feet below the top of Fishing Creek's banks. Any flooding event that causes overtopping of Fishing Creek's banks will cause the majority of Benton Borough to be inundated.

Problem Area Photo

Concept Solutions

Concept 1A: Remove the Benton Borough dam, re-profile the Fishing Creek corridor. This concept would remove the significant obstruction to flow caused by the Benton Borough dam. Significant buildup of steambed material behind the dam was noticed during site visits to the site. Re-profiling of the creek corridor would restore the historical capacity of the creek improving the conveyance capacity and reducing flood elevations. Preliminary analysis indicates a reduction in flood elevation by approximately 1-foot during the 100-year storm event. This concept would remove 50 or more structures out of the floodplain caused by Fishing Creek.

Concept 1B: This concept is the same as Concept 1A with the addition of relocating the existing berm from the Benton Borough dam to the northern baseball field. The existing berm would be relocated approximately 50 feet to the west. The additional flood mitigation provided by the relocation of the berm is de-minimis,

Concept 2: Re-profile 1,500 linear feet of Waller Road and construct approximately 1 mile long levee along West Creek that extends from Distillery Road to Waller Road. The levee height ranges from 5 feet to 10 feet tall. Preliminary analysis indicate the levee would mitigate flooding from West Creek within Benton Borough up to the 500-year storm design storm event with 2-feet of freeboard below the levee. Implementation of this concept would require more in-depth structural, geotechnical, cost/benefit analysis, and detailed risk analysis/management to determine if this concept is desirable. Implementation of just this concept would not eliminate flooding in Benton due to flood waters from Fishing Creek also impacting Benton Borough.

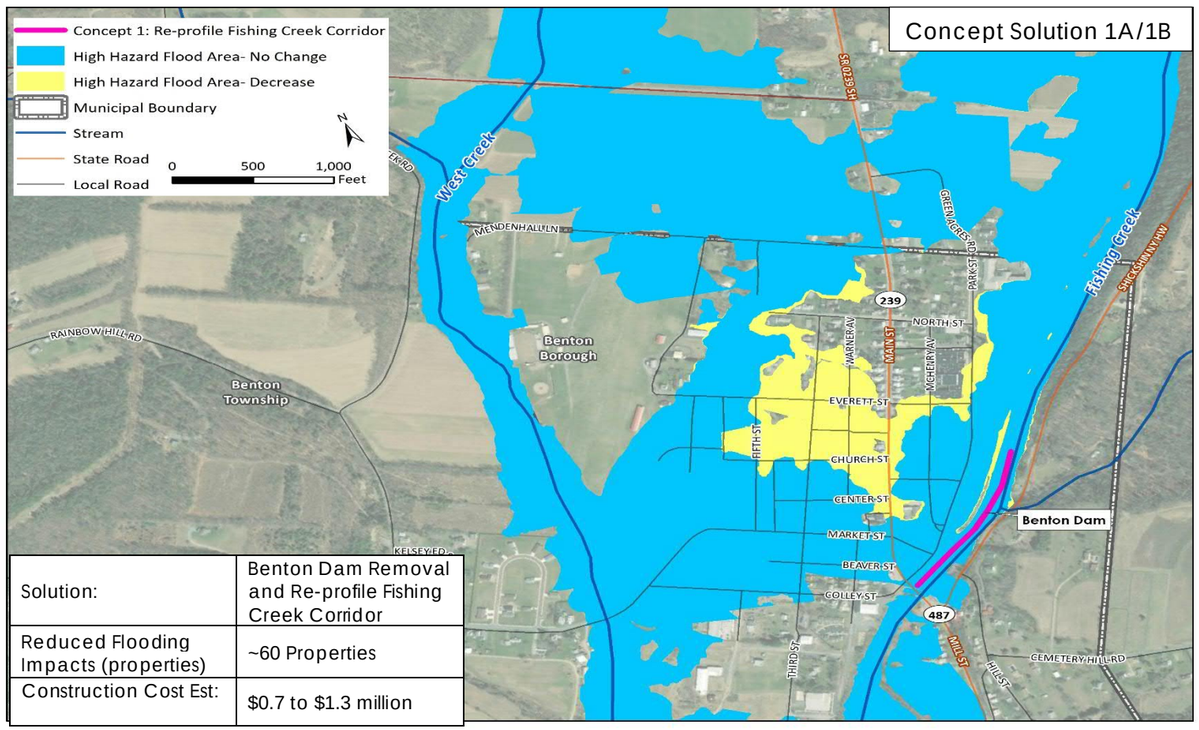
Concept 3: Construct an approximately 1 mile long levee along Fishing Creek that extends from Main Street to Waller Road. The levee height ranges from 2 feet to 10 feet tall. Preliminary analysis indicate the levee would mitigate flooding from Fishing Creek within Benton Borough up to the 500-year storm design storm event with 2-feet of freeboard below the levee. Implementation of this concept would require more in-depth structural, geotechnical, cost/benefit analysis and detailed risk analysis/management to determine if this concept is feasible and necessary. Implementation of just this concept would not eliminate flooding in Benton due to flood waters from West Creek also impacting Benton Borough.

Concept 4: Replace the Main Street Bridge. The existing bridge was constructed in 1926 and is in fair condition as assessed by PennDOT. Due to the location of the bridge and its proximity to buildings and major roadways throughout Benton Borough, there are no improvements to the bridge that would provide any significant increase to the hydraulic capacity of the structure. Therefore, this concept is not recommended to be implemented for flood mitigation.

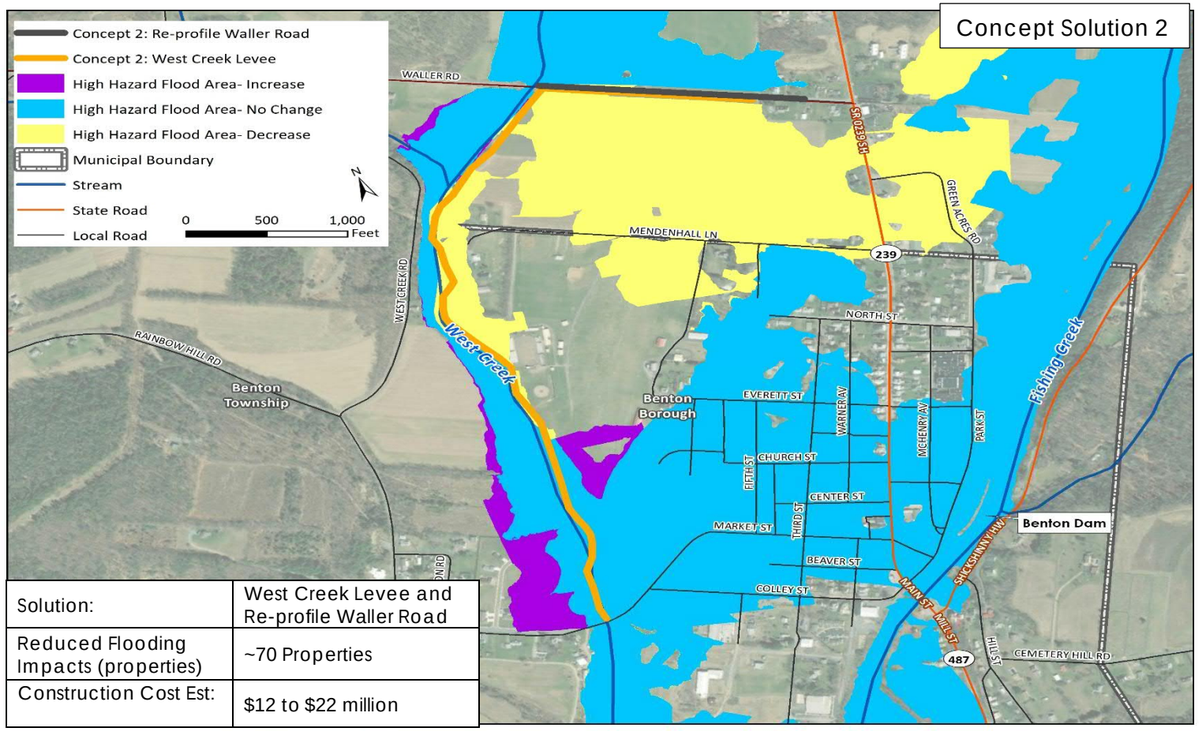
Concept 5: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program. Since the majority of Benton Borough is flood prone, this concept is not recommended to be implemented for flood mitigation.

Benton Borough Flooding (UFC-8)

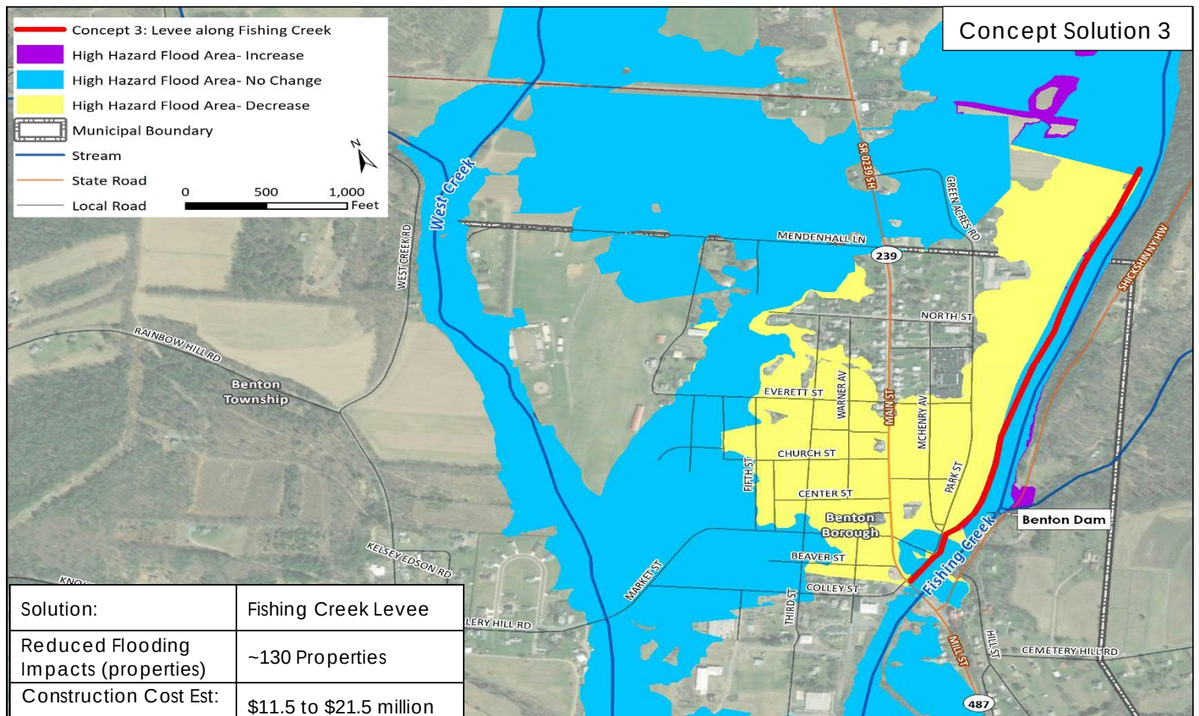
Benton Borough



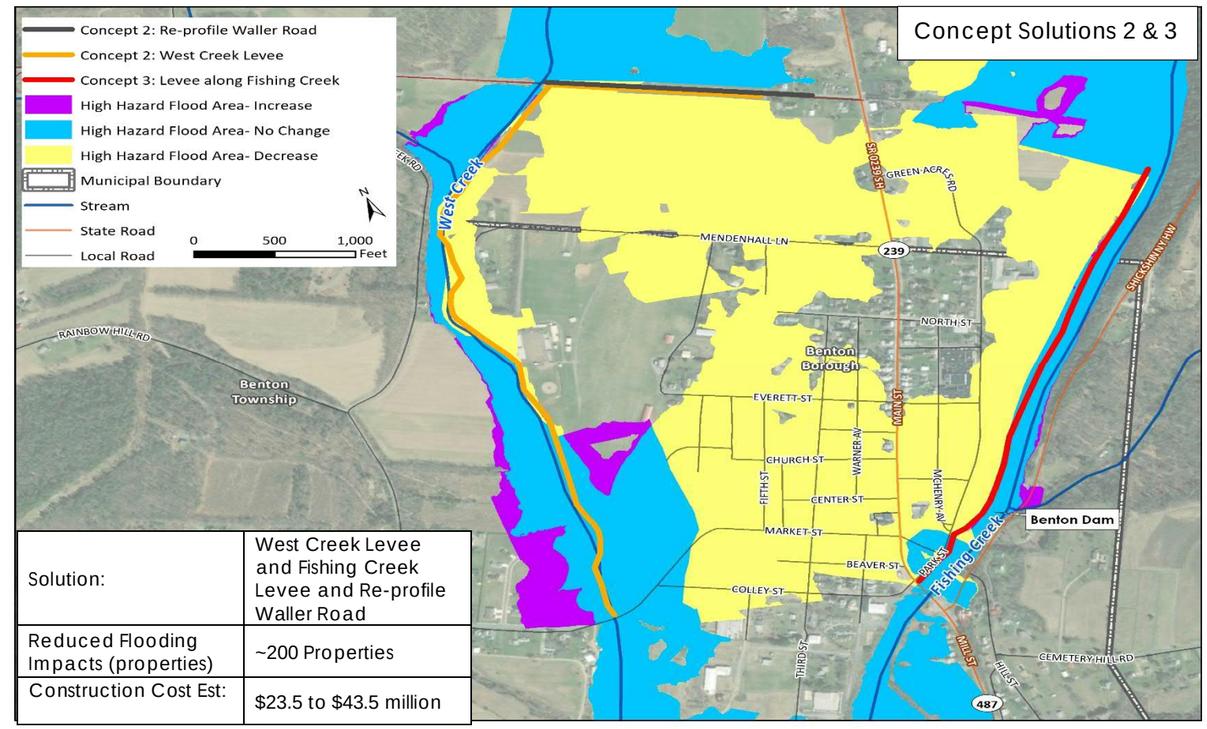
Solution:	Benton Dam Removal and Re-profile Fishing Creek Corridor
Reduced Flooding Impacts (properties)	~60 Properties
Construction Cost Est:	$0.7 to $1.3 million



Solution:	West Creek Levee and Re-profile Waller Road
Reduced Flooding Impacts (properties)	~70 Properties
Construction Cost Est:	$12 to $22 million



Solution:	Fishing Creek Levee
Reduced Flooding Impacts (properties)	~130 Properties
Construction Cost Est:	$11.5 to $21.5 million



Solution:	West Creek Levee and Fishing Creek Levee and Re-profile Waller Road
Reduced Flooding Impacts (properties)	~200 Properties
Construction Cost Est:	$23.5 to $43.5 million

Distillery Hill Road Flooding (UFC-9)

Benton Borough/Benton Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency
Problem Type:	Flooding
Impacted Properties Anticipated:	10+
Watershed:	West Creek
Priority Level:	Medium
Project Type:	Bridge Replacement/ Sediment Removal
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located on the Distillery Hill Road bridge which crosses West Creek at the border of Benton Township and Benton Borough.

Latitude: 41.195263
Longitude: -76.390594

Estimated Construction Cost

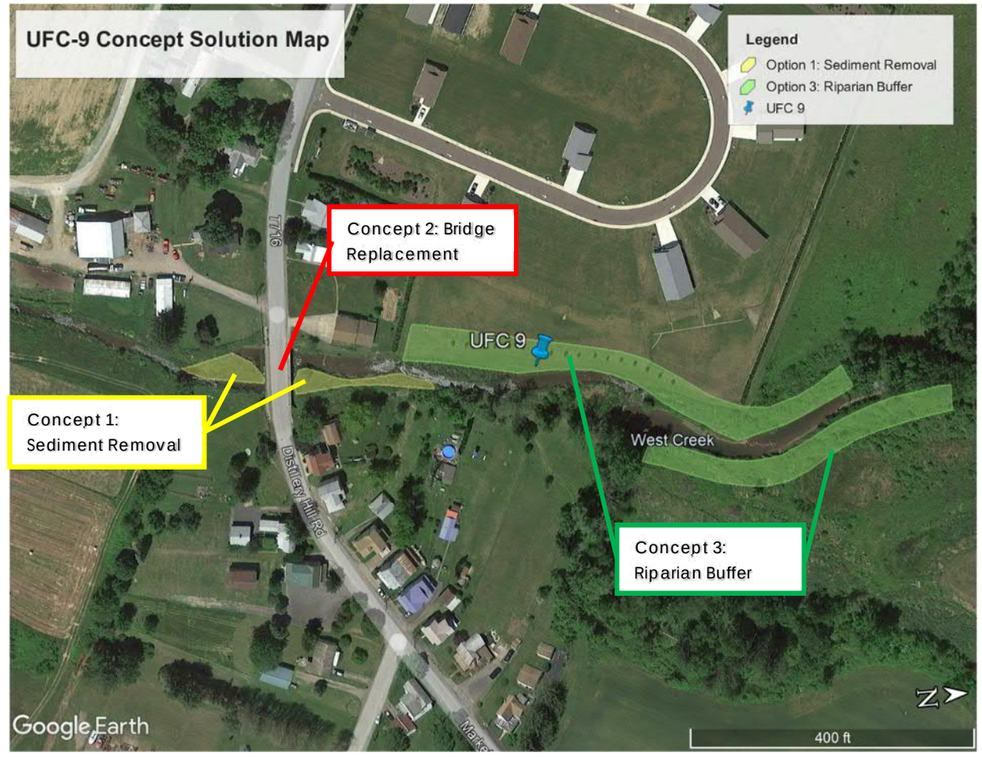
Concept 1: $60,000-$110,000 (Sediment Removal)
Concept 2: $1.2-$2.2 Million (Bridge Replacement and Sediment Removal)
Concept 3: $20,000-$40,000 (Riparian Buffer)
Concept 4: $300,000+ (Property Improvements)

Concept Impacts

Concept 1: 325' Length x 22' Width of Sediment Removal
Concept 2: 325' Length x 22' Width of Sediment Removal and 81' Length x 36' Width of Bridge Replacement
Concept 3: 1,250 Linear Feet of Riparian Buffer
Concept 4: 10+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (6.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding along this section of West Creek has been identified. Upon further investigations on the site, approximately three feet of streambed material has been deposited on the upstream left side (looking downstream) and on the downstream right side (looking downstream) of the bridge. The amount of sediment deposited extends to the pier of the bridge and from 100-200 feet upstream and downstream of the bridge.

Problem Area Photo

Concept Solutions

Concept 1: Remove deposited sediment from under Distillery Hill Road bridge and within the upstream channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and FEMA developed peak flow rates, the existing unobstructed bridge is able to adequately convey the 50-year design storm peak flow rates. With the existing sediment deposition, the capacity of the bridge is even further reduced increasing the velocity through the bridge section. The removal of the deposited sediment would provide a cost efficient solution in restoring normal flow conditions through the bridge. This concept would result in short term improvements but would not be effective in long term resiliency. Therefore, this concept is not recommended to mitigate flooding issues within the problem area.

Concept 2: Concept 2 is the same as Concept 1 with the addition of the replacement of the Distillery Hill Road bridge. The existing bridge is a state owner steel I beam bridge constructed in 1951 and is in fair conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that removal of the existing pier and reducing the bridge deck thickness to 30 inches showed minimal changes in flooding frequency and is still unable to pass the 100-year design storm peak flows. In addition to the above noted improvements, if the bridge was raised by 1-foot, there would be sufficient hydraulic area to convey the 100-year design storm. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. Improvement to the bridge will result in better hydraulic capacity and reduce bridge deck overtopping. Flooding of the roadway and properties to the east of West Creek and the property located at 8 Distillery Hill Road to the west of West Creek will still occur since these are low lying areas and/or located within the proposed flood elevation. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: A 35' wide Riparian Buffer along the banks of West Creek. A riparian buffer would help to protect the Creek banks and reduce stream bank erosion and sediment deposition. There will be a de-minimis impact to flooding as a result of this concept. This concept is recommended to reduce streambank erosion and improve resiliency of the bridge.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program. The buyout of properties to the east of West Creek along Distillery Hill Road would allow the roadway to be re-profiled and raised; minimizing the amount of roadway flooding. This alternative was not analyzed as it would be contingent upon the buyout at least 10 properties to be deemed feasible.

Intersection of Rohrsburg Road and Maple Grove Road Flooding (UFC-10)

Benton Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency
Problem Type:	Flooding
Impacted Properties Anticipated:	25+
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Property Buyout/Relocation
Permit Required:	N/A

Problem Area Descriptive Location

The problem area is located along Rohrsburg Road and Maple Grove Road.

Latitude: 41.177851
Longitude: -76.384211

Estimated Construction Cost

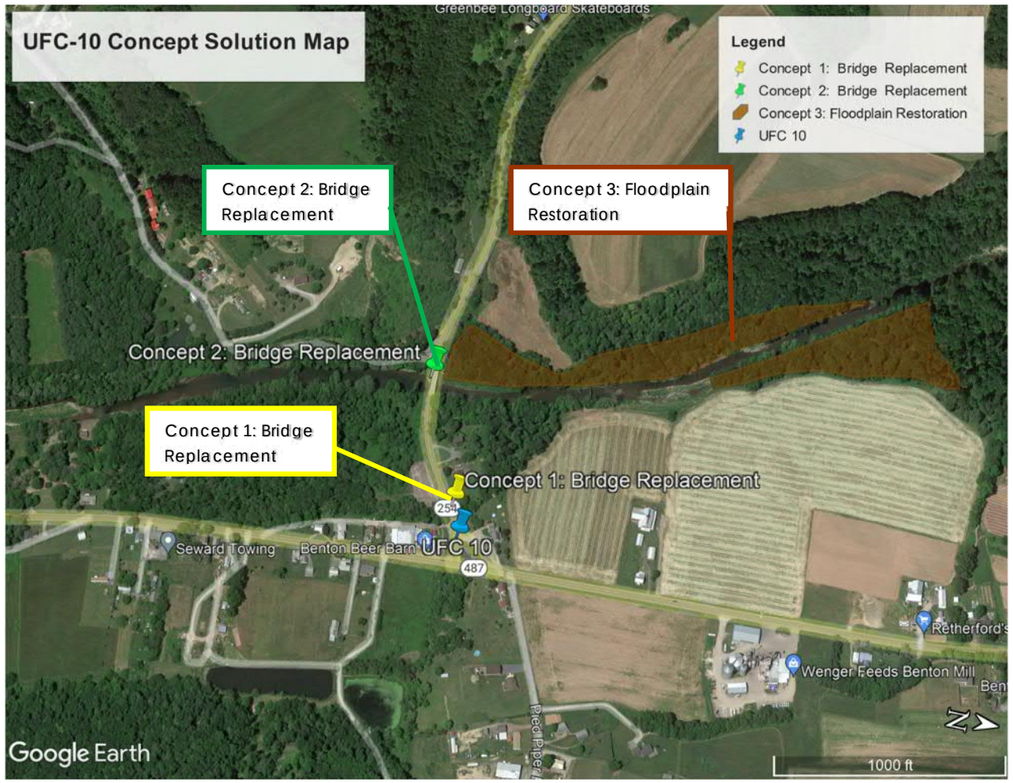
Concept 1: $300,000-$600,000 (Bridge Replacement)
Concept 2: $1.2-$2.3 Million (Bridge Replacement)
Concept 3: $500,000-$900,000 (Floodplain Restoration)
Concept 4: $750,000+ (Property Improvements)

Concept Impacts

Concept 1: 26' Length x 21' Width of Bridge Replacement
Concept 2: 118' Length x 29' Width of Bridge Replacement
Concept 3: 2,825' Length x 150' Width x 3' Depth of Floodplain Restoration
Concept 4: 25+ Properties

Project Prioritization

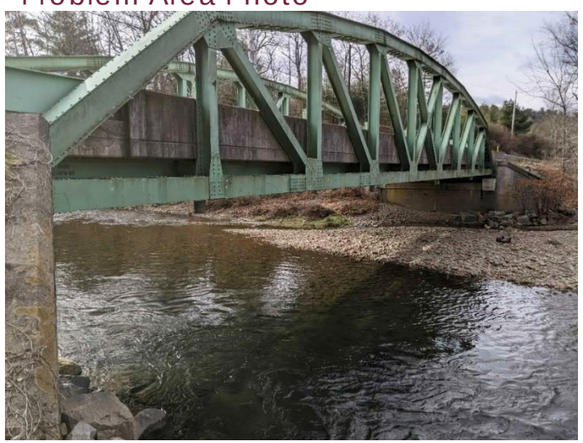
Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding along this section of Fishing Creek has been identified. Upon further investigations on the site, two bridges are located on Rohrsburg Road west of Maple Grove Road. The first bridge is located on Fishing Creek next to Steinruck Road. The second is located northeast of Benton Beer Barn. The area between the first bridge and Maple Grove Road is located at a low spot.

Problem Area Photo



Concept Solutions

Concept 1: Replacement of the Rohrsburg Road bridge located northeast of Benton Beer Barn. The existing bridge is a state owned concrete slab bridge constructed in 1923 and is in poor conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing bridge is adequately sized and able to convey the 500-year design storm peak flow rates. Redesign and reconstruction of this bridge will result in minimal flood mitigation due to the flood elevation of Fishing Creek being significantly higher. This bridge is recommended to be replace due to its poor conditions. This concept is not recommended to mitigate flooding issues due to the insignificant impacts of the proposed bridge replacement.

Concept 2: Replacement of the Rohrsburg Road bridge located next to Steinruck Road. The existing bridge is a state owned steel truss bridge constructed in 1923 and is in fair conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates, the existing bridge is able to convey the 50-year design storm peak flow rates. Redesign and reconstruction of this bridge will result in minimal flood mitigation due to the flood elevation of Fishing Creek being significantly higher than the properties located on Maple Grove Road. This concept is not recommended to mitigate flooding issues due to the insignificant impacts of the proposed bridge replacement.

Concept 3: Restore the floodplain upstream of the bridge by removing approximately 15,000 cubic yards of sediment. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor. This concept is not recommended to mitigate flooding issues, but is recommended for watershed-wide resiliency.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program. The buildings along Rohrsburg Road and Maple Grove Road would need raised by 4-8 feet to be located above the 100-year flood zone. Raising of the buildings out of the flood zone would significantly reduce any damages to the properties. Property buyouts/raising the buildings out of the floodplain are the only reasonable/implementable solutions that will mitigate the impacts of flooding for the affected properties.

Stillwater Borough Flooding (MFC-1& 3)

Stillwater Borough

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / State Highway Agency / Private Owner
Problem Type:	Flooding
Impacted Properties Anticipated:	50+
Watershed:	Fishing Creek and Raven Creek
Priority Level:	Low
Project Type:	Bridge Replacement
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is flooding in Stillwater Borough caused by Fishing Creek and Raven Creek.

Latitude: 41.151182
Longitude: -76.366251

Problem Area Issue

Flooding along this section of Fishing Creek and Raven Creek has been identified. After further investigation, it appears that most of Stillwater Borough is located at a lower elevation that the top of banks of Fishing Creek and the deck of the covered bridge and the PA 487 bridge. Additionally, it appears that the Paperdale Road and Lower Raven Creek Road bridges are significantly undersized.

Problem Area Photo

Estimated Construction Cost

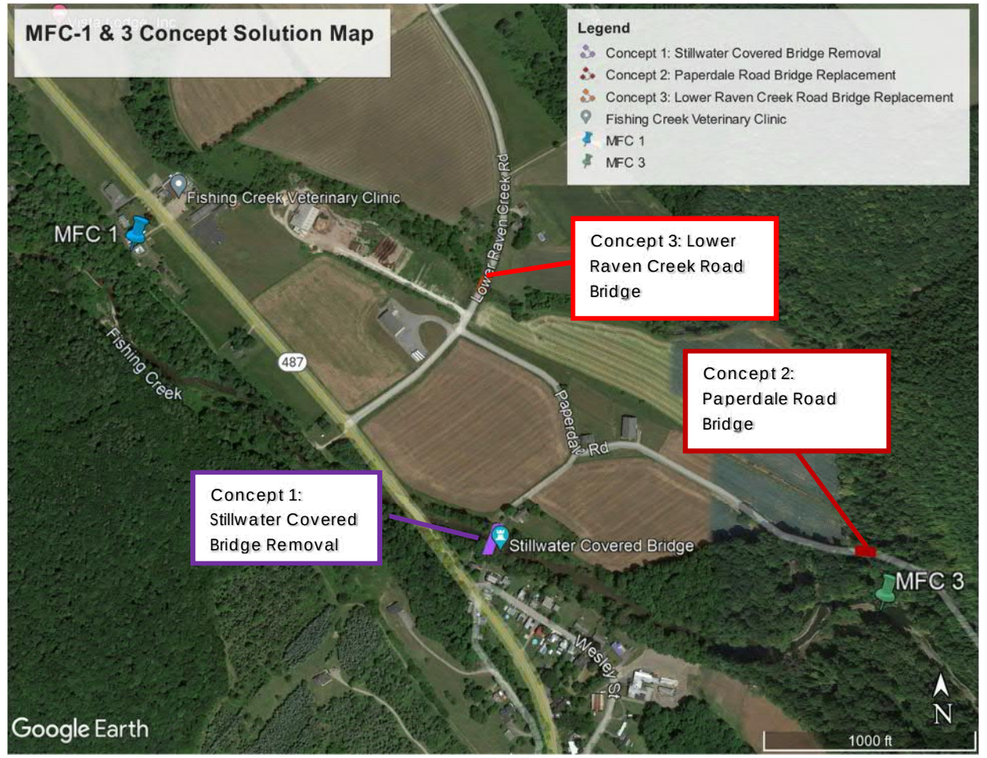
Concept 1: $140,000-$260,000 (Covered Bridge Removal)
Concept 2: $0.6 - 1.2 Million (Paperdale Road Bridge)
Concept 3: $1.3 - 2.5 Million (Lower Raven Creek Road Bridge)
Concept 4: $1.5+ Million

Concept Impacts

Concept 1: 160' Length x 20' Width of Covered Bridge Removal
Concept 2: 93' Length x 18' Width of Bridge Replacement
Concept 3: 104' Length x 36' Width of Bridge Replacement
Concept 4: 50+ Properties

Project Prioritization

Category	Score (MFC-1/3)	Scale
Property or Public Impacts	10 / 10	1 = Few 10 = Many
Frequency of Existing Problem	1 / 10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1 / 5	1 = Minimal 10 = Significant
Resiliency	5 / 5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1 / 1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	MFC-1: Low (3.6) MFC-3: Med (6.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Concept Solutions

Each concept solution listed below, excluding property buyouts/improvements, is analyzed utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates.

Concept 1: Remove the Stillwater Covered Bridge. The existing covered bridge is a significant encroachment to the hydraulic capacity of the Fishing Creek corridor. Preliminary hydrologic and hydraulic analysis indicate that the bridge is able to hydraulically convey the 25-year design storm event through the Fishing Creek channel. Removal of the bridge would result in an approximate decrease of 2 to 3 feet in water surface elevation during the 100-year design storm event. This decrease occurs directly upstream of where the existing covered bridge is and extend to approximately 1,000 feet upstream. There is no impact downstream from the covered bridge. Although this concept would provide a significant reduction in water surface elevation, a reduction in the quantity of impacted properties would not occur due to the elevation of the properties compared to the Fishing Creek banks and the bridge deck. This concept is recommended to be implemented for flood mitigation.

Concept 2: Replace the Paperdale Road Bridge. The existing bridge is a pre-stressed concrete box beam County owned bridge constructed in 1959 and is in poor condition as assessed by Pennsylvania Department of Transportation (PennDOT). The existing bridge is able to convey the 25-year design storm event without surcharging the bridge deck, however, significant conveyance in the right overbank (Along Paperdale Road) is utilized during this storm event meaning that the structure is not hydraulically designed to convey high flow conditions through the bridge structure without flooding the roadway. Preliminary hydrologic and hydraulic analysis shows that increasing the span by 50 feet would allow the 100-year design storm event to pass through the bridge without surcharging the bridge deck. Flooding in the right overbank would still continue meaning that Paperdale Road would continue to be flooding during extreme storm events. This proposed concept would help to reduce the occurrence of this flooding. The bridge is currently under design or construction as per Columbia County's bridge replacement priorities. This concept is recommended to be implemented for flood mitigation.

Concept 3: Replace the Lower Raven Creek Road Bridge. The existing bridge is a pre-stressed concrete box beam State owned bridge constructed in 1944 and is in good condition as assessed by Pennsylvania Department of Transportation (PennDOT). The existing bridge is able to convey the 2-year design storm event without surcharging the bridge deck. Preliminary hydrologic and hydraulic analysis shows that increasing the span by 50 feet would allow the 10-year design storm event to pass through the bridge without surcharging the bridge deck. All higher storm events see a decrease in water surface elevation 500-feet upstream of the bridge by approximately 1-foot. This concept is recommended to be implemented for flood mitigation.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program. Properties within Stillwater Borough would need to be raised 2-5 feet to get out of the floodplain. The Fishing Creek Veterinary Clinic is located approximately 3-4 feet below the 100-year floodplain and the properties located across from the Veterinary Clinic are located approximately 4-5 feet below the 100-year floodplain.

Paperdale Road (MFC-2)

Stillwater Borough

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Stillwater Borough
Impacted Properties Anticipated:	3
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	Vegetation/ Debris Management
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at the culvert crossing Buck Road near the intersection of Buck Road and Paperdale Road.

Latitude: 41.153447
Longitude: -76.353133

Estimated Construction Cost

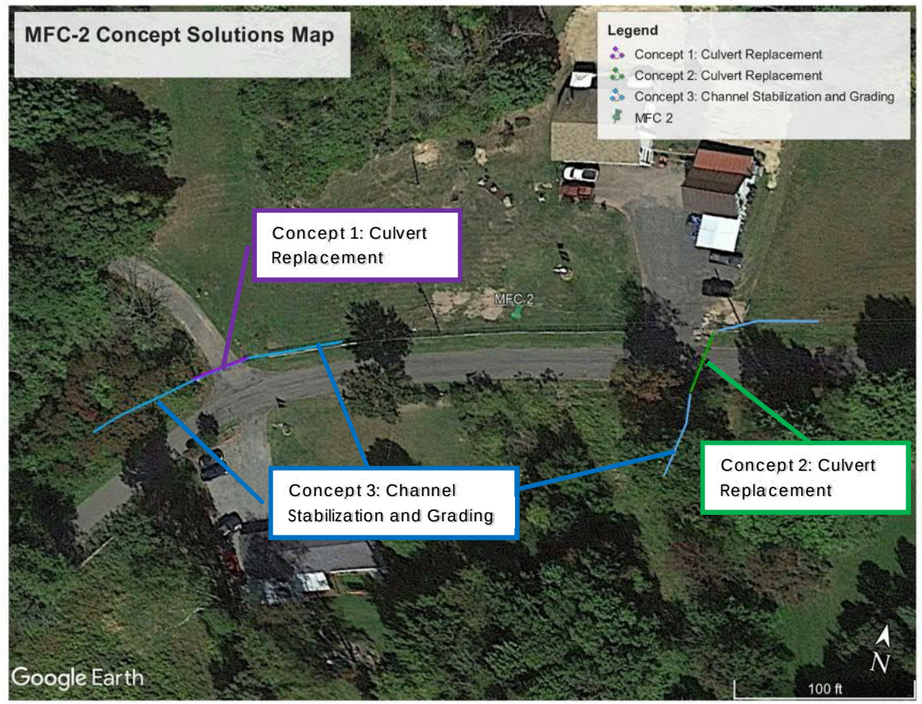
Concept 1: $30,000-$60,000 (Culvert Replacement)
Concept 2: $30,000-$60,000 (Culvert Replacement)
Concept 3: $40,000-$80,000 (Channel Stabilization and Grading)

Concept Impacts

Concept 1: 45 Linear Feet of Culvert Replacement
Concept 2: 100 Linear Feet of Culvert Replacement
Concept 3: 120 Linear Feet of Channel Stabilization and Grading

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

The existing culvert carrying the UNT to Fishing Creek under Buck Road and Paperdale Road are undersized. This results in backup of runoff during storm events that can overtop the channel and run onto Buck Road and Paperdale Road, which was confirmed by analysis done by Coleman Engineering in November 2020. Additionally, as discovered by The Crossroads Group LLC during their site investigation in April 2021, approximately 50' of the downstream channel has significant sedimental buildup. This sediment buildup also reduces the flows that the channel and culvert are able to properly convey during storm events.

Problem Area Photo

Concept Solutions

Concept 1: Remove and replace the existing 18" HPDE culvert with an Aluminum Spiral Ribbed Pipe (ASPR) culvert. By replacing the existing culvert with a 40" x 31" ASPR Arch culvert the water way opening can be increased significantly and while still maintaining the required pipe cover. Utilizing, the existing culvert is sized sufficiently to convey the 2-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 40" x 31" ASPR pipe is sized sufficiently to convey the 25-year design peak flow rates without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Based on analysis performed by Coleman Engineering, using the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, replacing the existing 18" culvert under Paperdale Road with a 35" x 24" Aluminum Spiral Ribbed Pipe (ASPR) culvert will allow the culvert to pass the 25-year storm without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: Stabilizing the channel both upstream and downstream of the channels will reduce the erosion that is caused by flows coming from the pipe crossings, as well as, reducing the amount of sediment and debris that would otherwise end up collecting at the downstream end of the channels. Regrading will remove the excess sediment buildup along the channel and add slope to any existing flat areas that are allowing sediment to collect. This concept is recommended as a potential additional step to Concepts 1 & 2.

Honeytown Road Flooding (MFC-4)

Fishing Creek Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Fishing Creek Township
Impacted Properties Anticipated:	4
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	Culvert Replacements
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

Latitude: 41.166592
Longitude: -76.32275

The problem area is located at the intersection of Ridge Road and Honeytown Road

Estimated Construction Cost

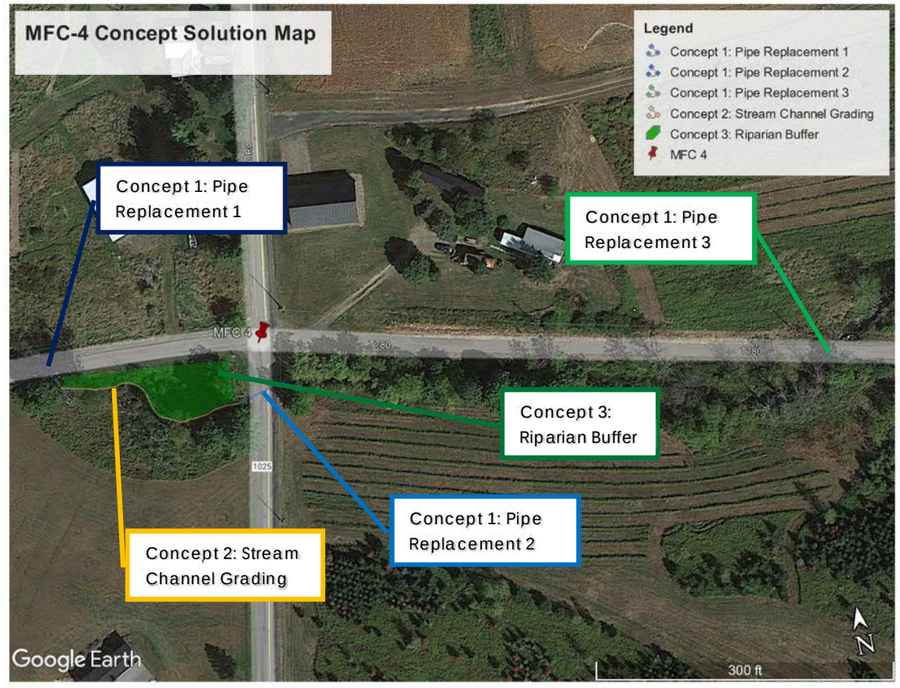
Concept 1: $90,000-$170,000 (Culvert Replacement)
Concept 2: $14,000-$27,000 (Stream Grading)
Concept 3: $3,000-6,000 (Riparian Buffer)

Concept Impacts

Concept 1:180 Linear Feet of Culvert Replacement
Concept 2: 205 Linear Feet of Stream Grading
Concept 3: 0.2 Acres of Riparian Buffer

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1= Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

During high rainfall events the intersection of Ridge Road and Honeytown Road experiences flooding. There are several undersized culverts located within proximity to the intersection. The existing channel has very little slope and does not provide positive drainage downstream. This is results in water collecting in the areas between the culverts and adding to the flooding.

Problem Area Photo

Concept Solutions

Concept 1: Remove and replace the existing culverts with an Aluminum Spiral Ribbed Pipe (ASPR) culvert. By replacing the existing culvert with an 81" x 59" ASPR Arch culvert will allow the water way opening to be increased significantly and while still maintaining the required pipe cover. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culverts are sized sufficiently to convey the 2-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 81" x 59" ASPR pipe is sized sufficiently to convey the 10-year design peak flow rates without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: The existing channel will be regraded and profiled to promote positive drainage downstream. Adding additional slope to the channel will help to prevent water from ponding and reduce the chances of flooding. This concept is recommended as an additional measure to Concept 1.

Concept 3: A 35' wide Riparian Buffer along the banks of the stream channel. A riparian buffer would help to protect the Creek banks and reduce stream bank erosion and sediment deposition. There will be a de-minimis impact to flooding as a result of this concept. This concept is recommended as an additional measure to Concept 1.

Zaner Bridge Road Flooding (MFC-5)

Fishing Creek Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / State Highway Agency
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	1-3
Watershed:	Middle Fishing Creek
Priority Level:	Medium (6.4)
Project Type:	Bridge Replacement/ Sediment Removal
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area is located on the Zaner Bridge Road bridge which crosses Fishing Creek and along the Fishing Creek corridor upstream of the bridge crossing.

Latitude: 41.12955
Longitude: -76.36017

Estimated Construction Cost

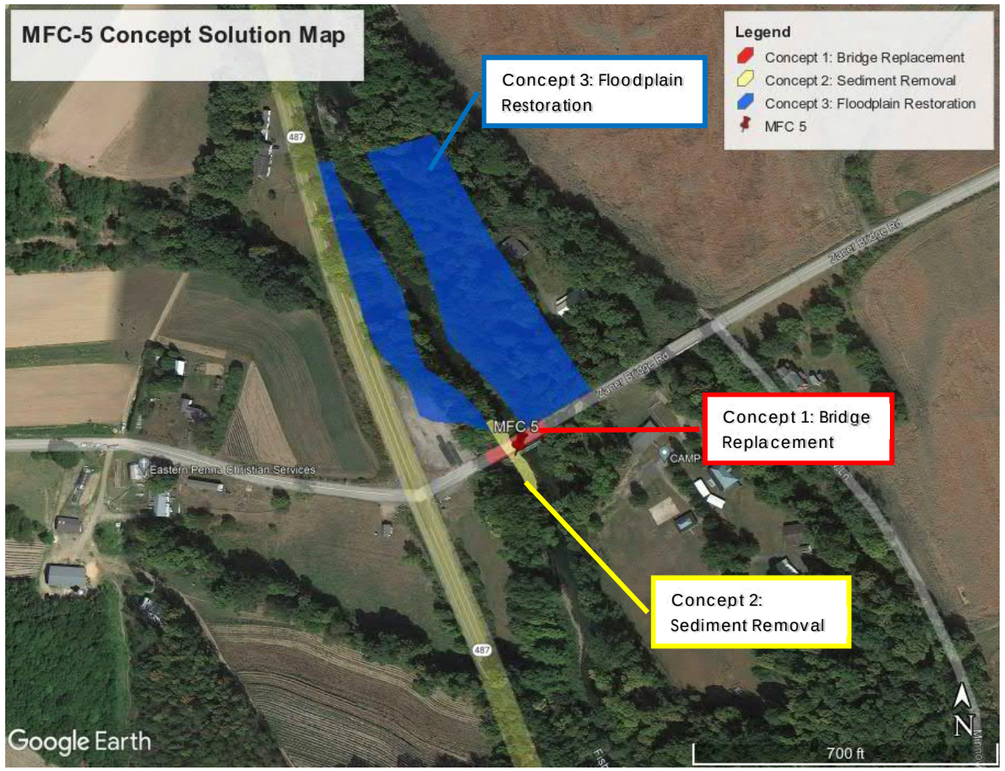
Concept 1: $1.1-$2.0 Million (Bridge Replacement)
Concept 2: $70,000-130,000 (Sediment Removal)
Concept 3: $400,000-800,000 (Floodplain Restoration)
Concept 4: $90,000+

Concept Impacts

Concept 1: 121' Length x 25' Width of Bridge Replacement
Concept 2: 200' Length x 20' Width of Sediment Removal
Concept 3: 700' Length x 200' Width x 3' Depth of Floodplain Restoration
Concept 4: 1-3 Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Infrequent 10 = More Frequent
Resiliency	10	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (6.4)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along this section of Fishing Creek and obstruction of the Zaner Bridge Road bridge have been identified. Upon further investigations on the site, approximately three feet of streambed material has been deposited on the right side (looking downstream) of the bridge and extends to approximately 100 feet downstream of the bridge. Sediment deposition can be seen upstream of the bridge.

Problem Area Photo

Concept Solutions

Concept 1: Replacement of the Zaner Bridge Road bridge. The existing bridge was constructed in 1947 and is in fair condition as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that extension of the bridge length by 10 feet and increasing the height of the waterway opening by 2 feet allows the existing bridge to pass the 500-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Remove deposited sediment from under the Zaner Bridge Road bridge and within the channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing unobstructed bridge is sized sufficiently to convey the 200-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced and is only able to convey the 100-year design storm with no available freeboard before it overtops the roadway. The removal of the deposited sediment would provide a cost efficient and highly effective solution in reducing high flow flooding caused by the bridge. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: Restore the floodplain upstream of the bridge by removing approximately 20,000 cubic yards of sediment. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor. This concept is not recommended to mitigate flooding issues within the problem area.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Winding Road Culvert (MFC-6)

Fishing Creek Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / State Highway Agency
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	3
Watershed:	Middle Fishing Creek
Priority Level:	High (7.0)
Project Type:	Culvert Replacement
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area is located near the intersection of Winding Road and Harrison Road.

Latitude: 41.10776
Longitude: -76.36128

Estimated Construction Cost

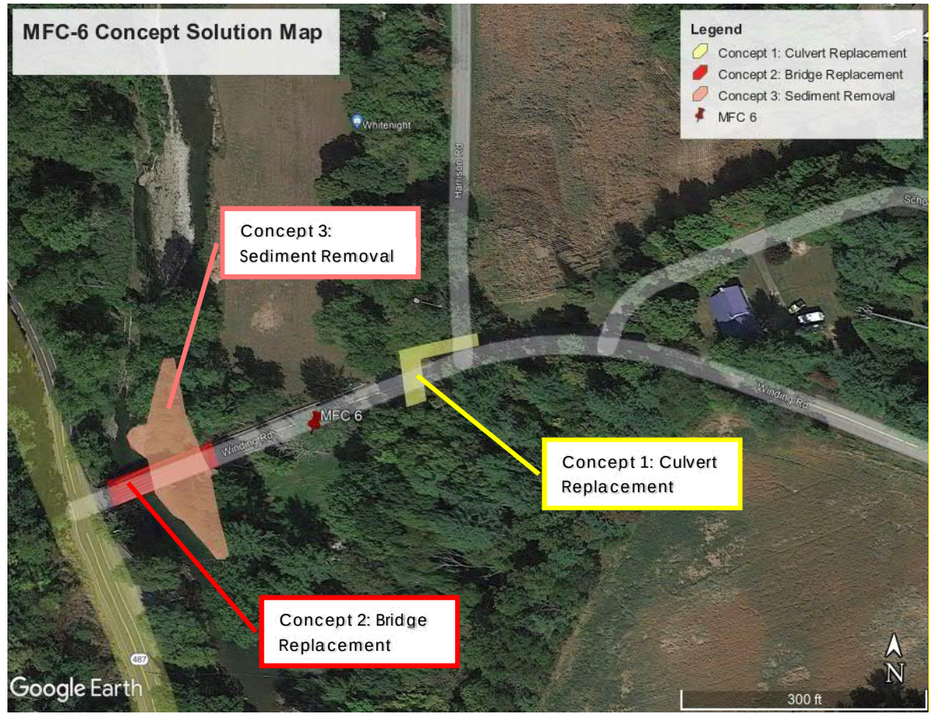
Concept 1: $40,000-$70,000 (Culvert Replacement)
Concept 2: $1.4-$2.7 Million (Bridge Replacement)
Concept 3: $80,000-$160,000 (Sediment Removal)

Concept Impacts

Concept 1: 100 Linear Feet of Culvert Replacement
Concept 2: 148’ Length x 28’ Width of Bridge Replacement
Concept 3: 150’ Length x 60’ Width x 3’ Depth of Sediment Removal

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

There is a 24” pipe crossing Winding Road and 18” pipe crossing Harrison Road. Preliminary site investigation showed debris buildup at the inflow of the pipe crossing Winding Road and roadside erosion indicating that these structures may be undersized.

Problem Area Photo

Concept Solutions

Concept 1: Remove and replace the existing 24” pipe crossing with a 36” HDPE pipe and 18” pipe crossing with a 24” HPDE pipe. By replacing the existing culvert with a 36” HPDE pipe the water way opening can be increased significantly and while still maintaining the required pipe cover. Utilizing the Federal Highway Administration’s (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culvert is sized sufficiently to convey the 5-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 36” HPDE pipe is sized sufficiently to convey the 50-year design peak flow rates without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Replacement of the Winding Road bridge. The existing bridge was constructed in 1955 and is in fair condition as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that extension of the bridge length by 20 feet and increasing the height of the waterway opening by 1.75 feet allows the existing bridge to pass the 500-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is not recommended to mitigate flooding issues within the problem area, however, it is recommended due to the bridge being in fair condition.

Concept 3: Remove deposited sediment from under the Winding Road bridge and within the channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration’s (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing unobstructed bridge is sized sufficiently to convey the 200-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced and is only able to convey the 100-year design storm with no available freeboard before it overtops the roadway. The removal of the deposited sediment would provide a cost efficient and highly effective solution in reducing high flow flooding caused by the bridge. This concept is recommended to mitigate flooding issues within the problem area.

Pealertown Flooding (MFC-7)

Fishing Creek Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Fishing Creek Township
Impacted Properties Anticipated:	1-2
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	Floodplain Reconnection
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area Fish Creek Corridor near Pealertown.

Latitude: 41.116997
Longitude: -76.361361

Estimated Construction Cost

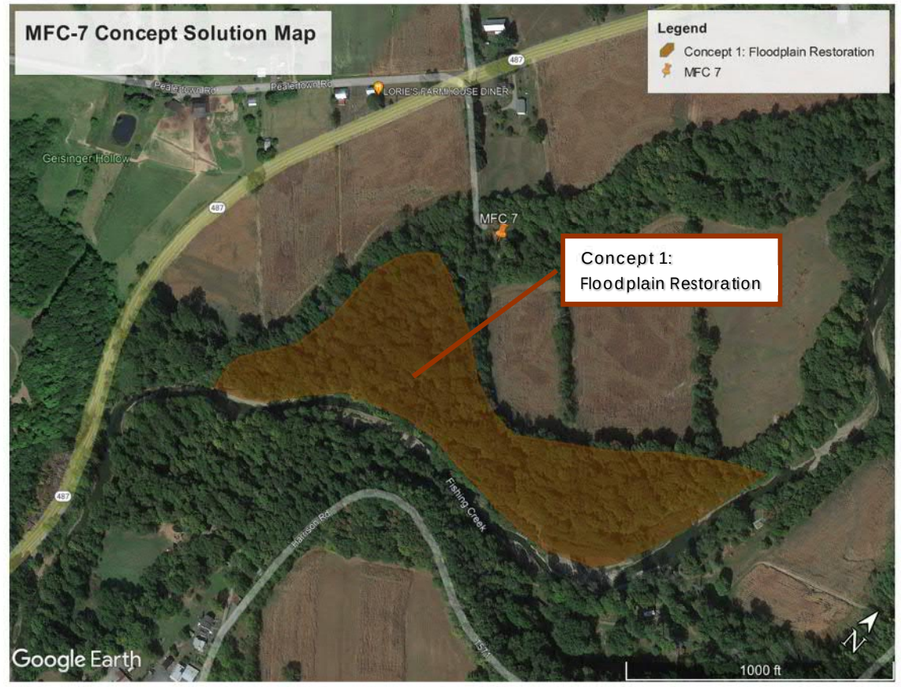
Concept 1: $5.5-$10.2 Million (Floodplain Restoration
Concept 2: $40,000-$80,000+

Concept Impacts

Concept 1:4,300' Length x 350' Width x 3' Depth of Floodplain Restoration
Concept 2: 1-2 properties

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Infrequent 10 = More Frequent
Resiliency	1	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (2.8)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

During large rainfall events flooding from Fishing Creek reach the property at 3118 SR 487 and risk potential property damage.

Concept Solutions

Concept 1: Restore the floodplain upstream of the bridge by removing approximately 167,000 cubic yards of sediment. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around this property and within the Creek corridor. Due to the high cost of this project and the minimal effect it will have on flooding in the area this solution is not recommended.

Concept 2: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

2870 SR 487 (MFC-8)

Fishing Creek Township

General Information

Affected Land Ownership:	Public
Responsible Entity:	Columbia County
Problem Type:	Erosion/Flooding / Fishing Creek Township
Responsible Entity:	Fishing Creek Township
Impacted Properties Anticipated:	2
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	Floodplain Reconnection/ Streambank Stabilization
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located at 2870 SR 487 along the banks of Fishing Creek.

Latitude: 41.101919
Longitude: -76.366172

Estimated Construction Cost

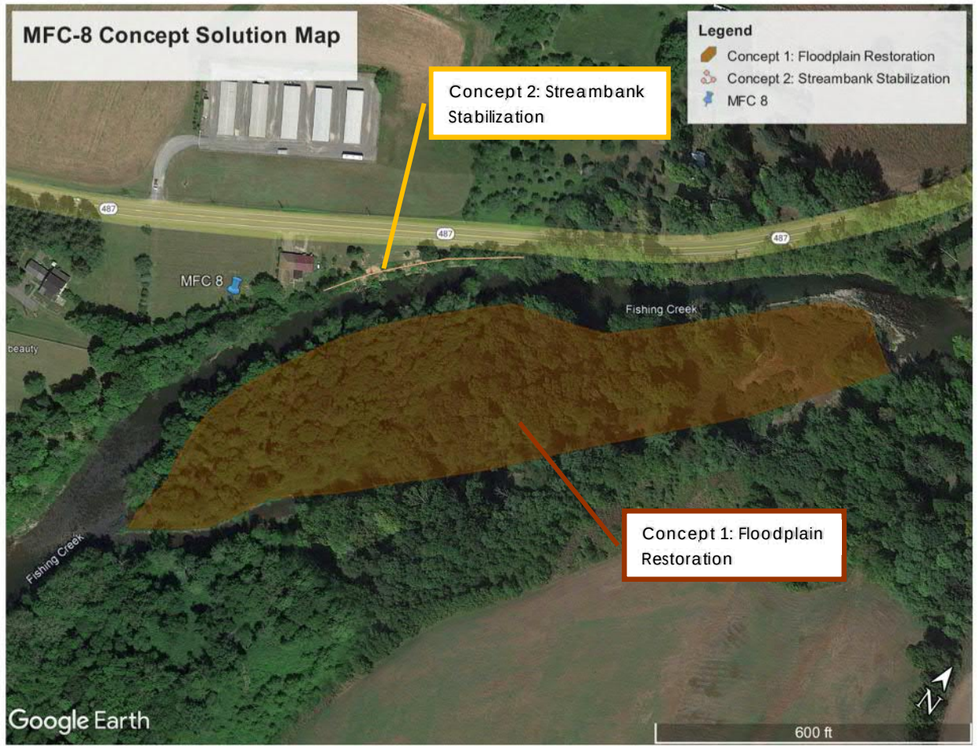
Concept 1: $0.7-$1.4 Million (Floodplain Restoration)
Concept 2: $300,000-$500,000 (Streambank Stabilization)

Concept Impacts

Concept 1: 1,400' Length x 230' Width x 3' Depth of Floodplain Restoration
Concept 2: 390 Linear Feet of Streambank Stabilization

Project Prioritization

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Continual erosion of the Fishing Creek banks have been identified at the project site. There is concern that continued erosion of the stream banks will compromise the SR 487 and make it unsafe for the public to use, as well as, potential damage to nearby structures.

Problem Area Photo

Concept Solutions

Concept 1: Restore the floodplain across from the property by removing approximately 36,000 cubic yards of sediment. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor.

Concept 2: Stabilize 390 feet of stream bank. This concept would reinforce the banks along Fishing Creek and reduce the rate of stream bank erosion protecting the trail and prolonging its use. This concept is recommended to reduce the rate of streambank erosion and to avoid any potential conflicts with any structures on the property and SR 487.

Moore's Grove Road Flooding (MFC-9)

Orange Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / Orange Township / Private Owner
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	40+
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Streambank Stabilization & Property Buyout/Relocation
Permit Required:	PADEP JPA

Problem Area Descriptive Location

Latitude: 41.096742
Longitude: -76.378636

The problem area is located along the Fishing Creek corridor from Fleckenstein Grove to east of Fishing Creek Transportation.

Problem Area Issue

Flooding and heavy sedimentation along this section of Fishing Creek has been identified by three separate survey responses. Heavy sedimentation was observed directly downstream from the maintenance channel located south of Diggers Diversion Bar. The high deposition of sediment is likely caused by the minimal buffering along the maintenance channel and the surrounding agricultural land draining to it. Flooding from Fishing Creek is attributed to the large flow during large storm events and the constriction of the floodplain from State Route 487 and the steep slopes on the southern side of Fishing Creek.

Problem Area Photo

Estimated Construction Cost

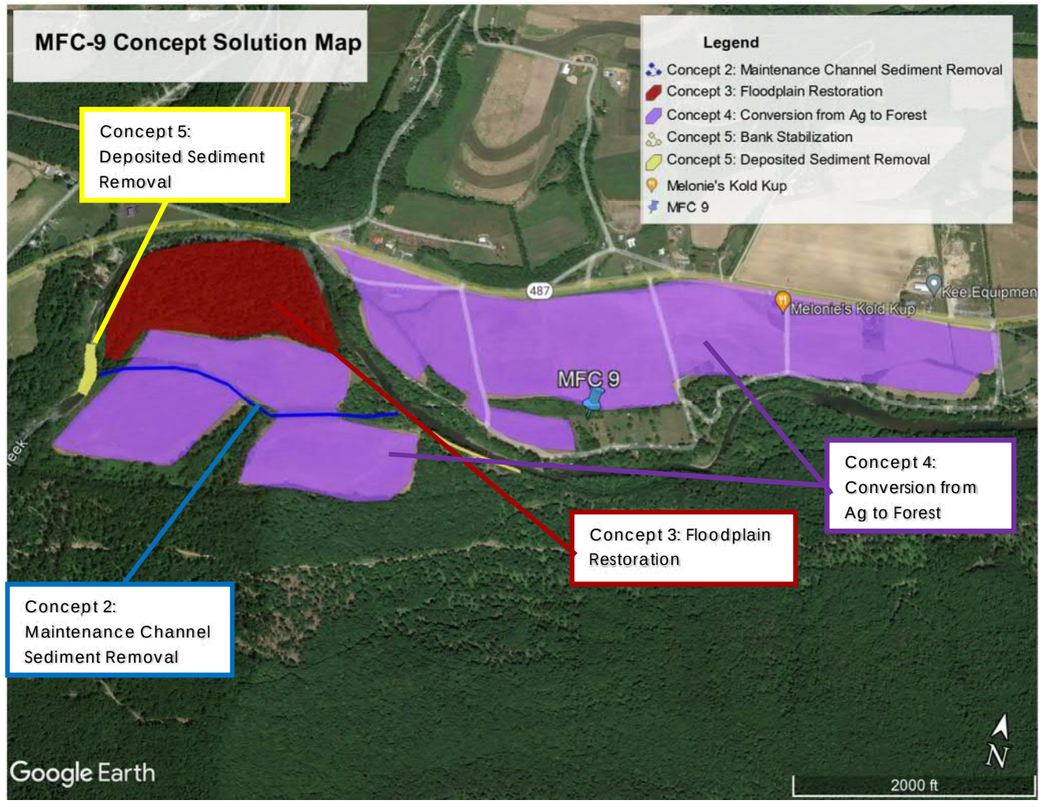
Concept 1: $1.2 Million+ (Property Improvements)
Concept 2: $400,000-$800,000 (Maintenance Channel Sediment Removal)
Concept 3: $3.6-$6.7 Million (Floodplain Restoration)
Concept 4: $3.4-$6.4 Million (Riparian Buffer)
Concept 5: $1.0-$1.8 Million (Streambank Stabilization and Sediment Removal)

Concept Impacts

Concept 1: 40+ Properties
Concept 2: 2,700' Linear Feet of Maintenance Channel Sediment Removal
Concept 3: 3,000' Length x 475' Width x 3' Depth of Floodplain Restoration
Concept 4: 160 Acres of Buffer Plantings
Concept 5: 1,000 Linear Feet of Bank Stabilization and 400' Length x 120' Width of Sediment Removal

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	1	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Concept Solutions

Concept 1: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program. Property buyouts/raising the buildings out of the floodplain are the only reasonable/implementable solutions that will mitigate the impacts of flooding for the affected properties. This concept is recommended to mitigate property flooding.

Concept 2: Dredge maintenance channel by 2 feet, remove stone blocking the upstream side, and stabilize banks with a 35 Foot wide buffer. Construction of this concept would result in 6,700 cubic yards of material from the maintenance channel and planting of 5 acres of riparian buffer. Results from the HEC-RAS run showed negligible changes in water surface elevation during all storm events (0" to < 3") and a slight increase in velocities (0% to 6%) on the left overbank attributed to the increase in conveyance capacity. This concept is not recommended to mitigate flooding issues due to the insignificant impacts of the proposed maintenance channel improvements.

Concept 3: Floodplain restoration southwest of Diggers Diversion Bar. This option would consist of regrading the forested area southwest of Diggers Diversion Bar which would improve the conveyance capacity of Fishing Creek's left overbank. Construction of this concept would result in 50,000 cubic yards of material removed from the Fishing Creek Floodplain and planting of 33 acres of riparian buffer. Negligible changes in velocity and water surface elevation were observed upstream and downstream of the floodplain restoration. Through the floodplain restoration project area, a more noticeable decrease was seen. A decrease in water surface elevation was observed throughout all storm events ranging from 1" to 6" throughout and variable increase and decreases in velocities in both the left and right overbanks. This concept is not recommended to mitigate flooding issues due to the insignificant impacts of the proposed floodplain restoration compared to the significant costs.

Concept 4: Conversion from agricultural land use to forest by planting of 160 acres of riparian buffer. Results from the HEC-RAS run showed an increase in water surface elevation during all storm events from 6" to 2'. Throughout the new forested land, a decrease in velocity was observed in the left overbank by 30% to 60% and a decrease in velocity in the right overbanks by 40% to 84%. The constricted areas saw a slight increase in velocity by 2% to 15%. This concept is not recommended to mitigate flooding issues due to the high costs and unlikelihood of the County to procure the properties.

Concept 5: Stabilize 1,000 feet of stream bank and remove 2,500 cubic yards of deposited sediment from Fishing Creek. This option would result in negligible changes to large storm events but would restore historical low flow conditions and protect properties along Fishing Creek by reinforcing the banks and reducing the rate of stream bank erosion. This concept is not recommended to mitigate flooding issues but is recommended to protect the property located on the left overbank.

Rohrsburg Road Culvert (MFC-10)

Orange Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding
Impacted Properties Anticipated:	3
Watershed:	Middle Fishing Creek
Priority Level:	High (8.0)
Project Type:	Culvert Installation
Permit Required:	TBD

Problem Area Descriptive Location

The problem area is located near the intersection of Rohrsburg Road and Neyhart Road.

Latitude: 41.09579
Longitude: -76.41053

Estimated Construction Cost

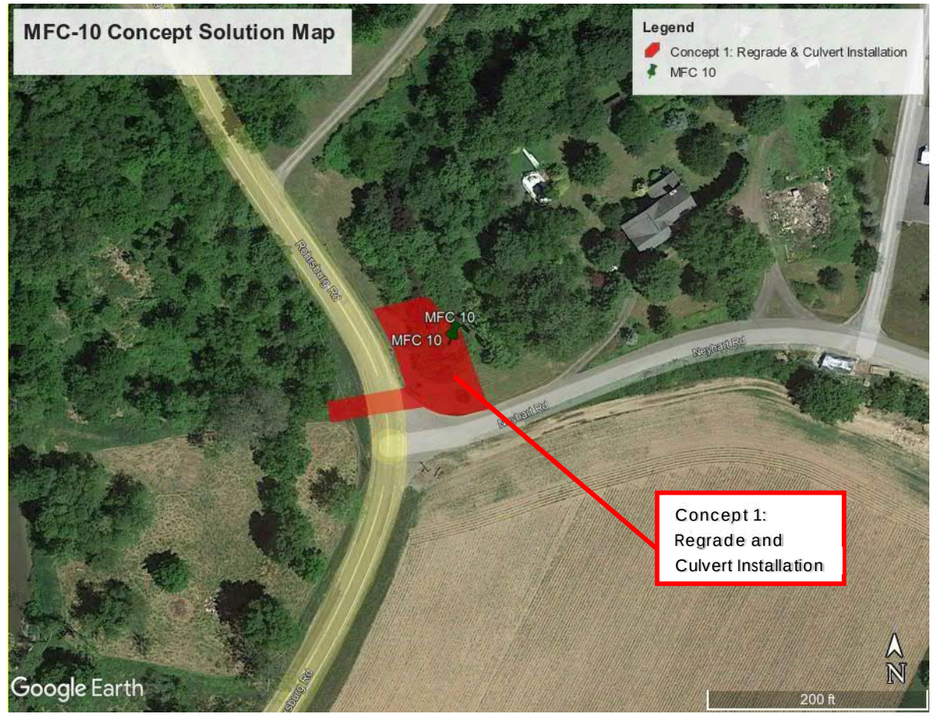
Concept 1: $70,000-$130,000 (regrading and Culvert Installation)

Concept Impacts

Concept 1: 100 Linear Feet of Regrading and Culvert Installation

Assessment and Analysis of Solutions

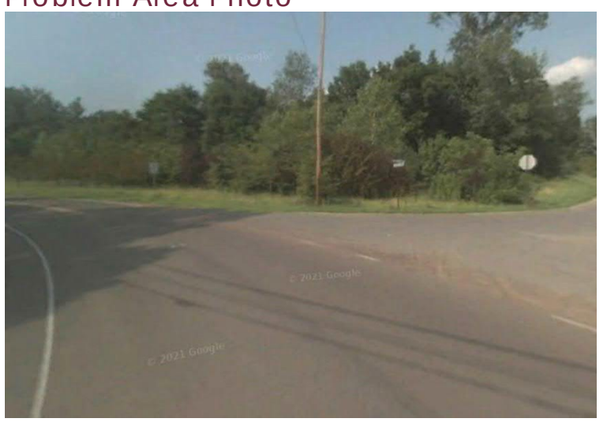
Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

There is currently no cross piping at the intersection of Rohrsburg Road and Neyhart Road to allow stormwater runoff from the east to discharge to the west towards Green Creek. Preliminary investigation showed ponding at the intersection and eventual overtopping during more severe storms.

Problem Area Photo



Concept Solutions

Concept 1: Regrade the existing area northeast of Rohrsburg and Neyhart Road intersection westward towards Green Creek and install a dual 24" HPDE pipe culvert. By installing a culvert crossing, the existing low point which ponds water along the northeast portion of the intersection will now drain towards Green Creek. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the dual 24" pipe is sized sufficiently to convey the 10-year design peak flow rates without overtopping the roadway. There is no feasible solution to mitigate flooding in this area from more severe storms, such as tropical storm conditions, but this concept is recommended to mitigate some flooding issues within the problem area.

Green Creek Road Flooding (MFC-11)

Orange Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / Orange Township / Private Owner
Problem Type:	Flooding
Impacted Properties Anticipated:	3
Watershed:	Green Creek
Priority Level:	Medium
Project Type:	Floodgate/Floodplain Restoration
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area is located on the agricultural property north of the intersection of Green Creek Road and Logging Road.

Latitude: 41.093212
Longitude: -76.411996

Estimated Construction Cost

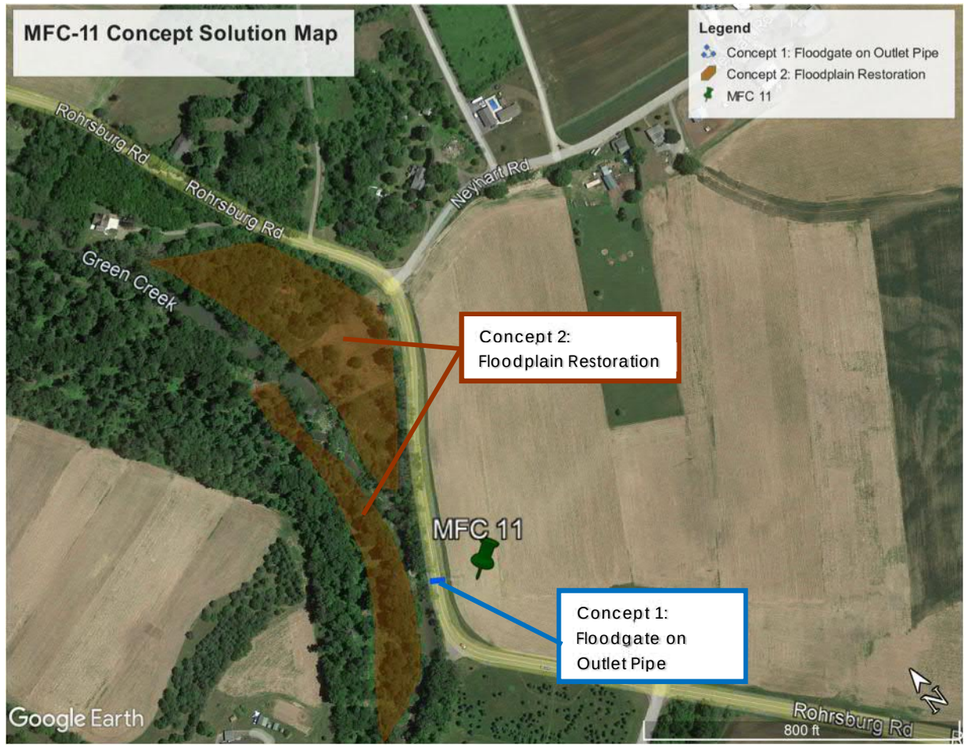
Concept 1: $2,000-$4,000 (Floodgate Installation)
Concept 2: $0.5-$1.0 Million (Floodplain Restoration)

Concept Impacts

Concept 1: 1 Floodgate on outlet Pipe
Concept 2: 2,000' Length x 120' Width x 3' Depth of Floodplain Restoration

Project Prioritization

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (4.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding within the agricultural property from Green Creek has been identified. Upon further investigations on the site, an existing outlet pipe, located on the southwestern corner of the property, carries drainage from the field to Green Creek. During typical storm events, the flood waters from Green Creek cause the outlet pipe to backup and pond on the property.

Problem Area Photo

Concept Solutions

Concept 1: Place a floodgate on the existing outlet pipe to reduce the amount of water impounded onto the farm property. A floodgate would allow water to drain from the farm to Fishing Creek during low storm events but would close and reduce the amount of water backing up through the pipe and ponding on the property during higher storm events. Once flood water elevations overtop Logging Road, the property would still be inundated by water. This concept is recommended for implementation to reduce the occurrence of flooding on the property.

Concept 2: Restore the floodplain along Rohsrsburg Road from the intersection of Green Creek Road to upstream of Rohrsburg Road and Neyhart Road (MFC-10). Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion within the creek corridor. This concept is not recommended to mitigate flooding issues within the problem area but is recommended for watershed wide improvements.

Green Creek Road Flooding (MFC-12)

Orange Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County / State Highway Agency
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	3+
Watershed:	Green Creek
Priority Level:	Medium (5.0)
Project Type:	Bridge Replacement/ Sediment Removal
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located near the Green Creek Road bridge which crosses Green Creek and along the Green Creek corridor upstream of the bridge crossing.

Latitude: 41.09159
Longitude: -76.41474

Estimated Construction Cost

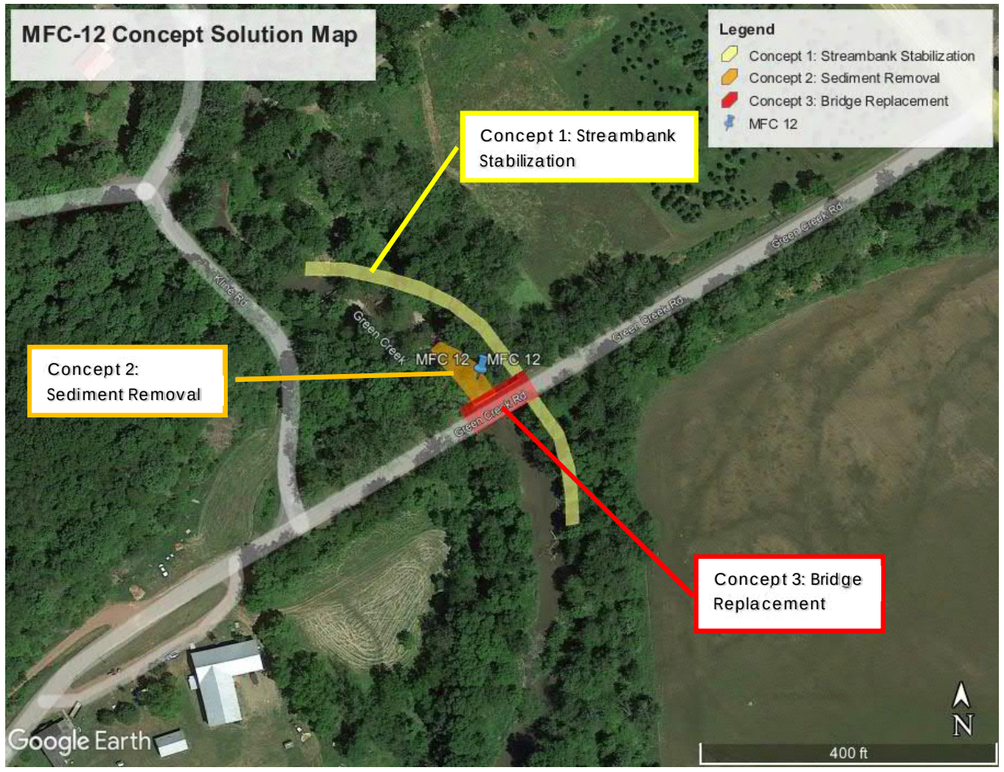
Concept 1: $400,000-$700,000 (Streambank Stabilization)
Concept 2: $50,000-$90,000 (Sediment Removal)
Concept 3: $1.3-$2.4 Million (Bridge Replacement
Concept 4: $90,000+

Concept Impacts

Concept 1: 500' Linear Feet of Streambank Stabilization
Concept 2: 100' Length x 35' Width x 3' Depth of Sediment Removal
Concept 3: 106' Length x 34' Width of Bridge Replacement
Concept 4: 3+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along this section of Green Creek and obstruction of the Green Creek Road bridge has been identified. Upon further investigations on the site, approximately three feet of streambed material and debris has been deposited at the upstream of the bridge and extends to approximately 100 feet upstream of the bridge.

Problem Area Photo

Concept Solutions

Concept 1: Stabilize 500 feet of streambank along the east bank. This will have little impact on the water surface elevations for larger storms. However, it will reduce the amount of sediment that gets removed from the bank and deposited downstream. This project is not recommended for flood mitigation, but is recommended to reduce downstream sediment buildup and land lose/safety concerns for the nearby property.

Concept 2: Remove deposited sediment from under the Green Creek Road bridge and within the channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing unobstructed bridge is sized sufficiently to convey the 200-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced and is only able to convey the 100-year design storm with no available freeboard before it overtops the roadway. The removal of the deposited sediment would provide a cost efficient and highly effective solution in reducing high flow flooding caused by the bridge. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: Replacement of the Green Creek Road bridge. The existing bridge was constructed in 1961 and is in fair condition as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that extension of the bridge length by 20 feet and increasing the height of the waterway opening by 1.5 feet allows the existing bridge to pass the 500-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is recommended to mitigate flooding issues within the problem area.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Evans Lane Flooding (MFC-13)

Orange Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Orange Township
Impacted Properties Anticipated:	1-7
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	Structure Removal/Streambank Stabilization
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located at the Evans Lane area in Orange Township

Latitude: 41.087722
Longitude: -76.4085

Estimated Construction Cost

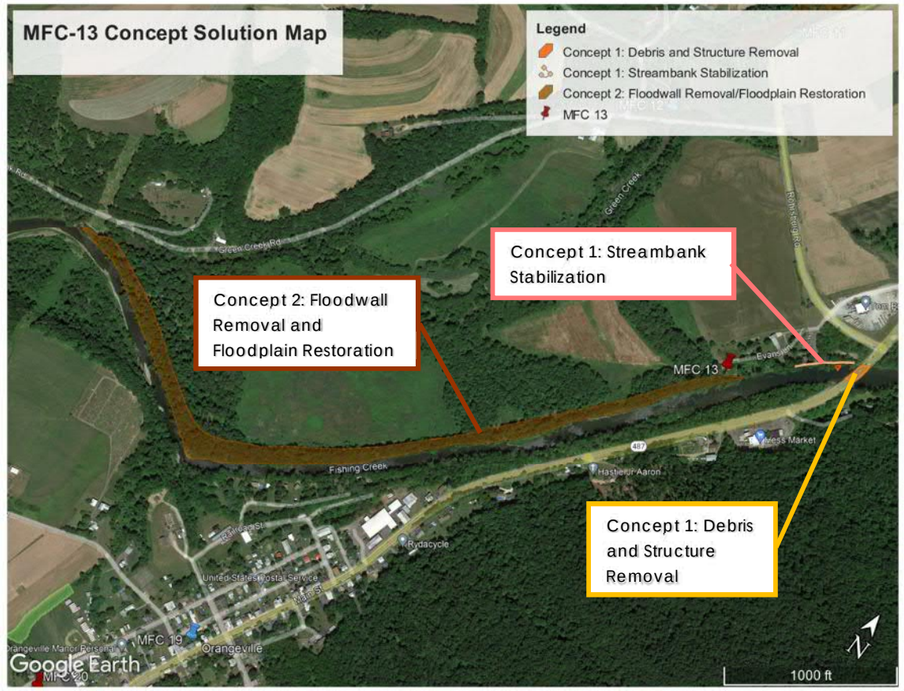
Concept 1: $500,000-$950,000 (Streambank Stabilization)
Concept 2: $4.5 Million-$5.5Million (Floodplain Restoration and Floodwall Removal)
Concept 3: $30,000-$220,000+ (Property Improvements)

Concept Impacts

Concept 1: 415 Linear Feet of Streambank Stabilization
Concept 2: 5,450' Length x 100' Width x 3' Depth of floodplain Restoration and Floodwall Removal
Concept 3: 1-7 Properties

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	Low = Few High = Many
Frequency of Existing Problem	5	Low = Infrequent High = More Frequent
Flood Level Reduction	1	Low = Infrequent High = More Frequent
Resiliency	1	Low = More Maintenance, High = Long-Lasting
Construction Cost	1	Low = Significant Cost ($$$) High = Less Cost ($)
Priority Score Total =	Low (2.6)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

The properties along Evans Lane experience flooding several times per year. There is significant erosion on the west bank leading up the bridge. There are also remnants of old bridge structures located in the stream channel, as well as a concrete and earthen floodwall running along the west bank of the channel.

Problem Area Photo

Concept Solutions

Concept 1: Removal of the old concrete bridge structures and debris and streambank stabilization. Removing the structures would restore the channel to natural flow conditions and add additional area to the waterway opening. Additionally, removal of some the larger debris that is in the channel will also work to restore natural flow conditions. Debris removal is a continual maintenance activity that should be performed after large rainfall events or when significant debris buildup is noted in the creek channel. Once the structures have been removed from the channel stabilize 415 feet of streambank along the west bank in the area that will be used to access the creek for the structure removal. The bank stabilization will have little impact on the water surface elevations for larger storms. However, it will reduce the amount of sediment that gets removed from the bank and deposited downstream. The bank stabilization will also protect the nearby property located on the west bank. This structure removal is recommended to mitigate flooding issues within the problem area and the streambank stabilization is recommended to reduce downstream sediment buildup and land loss/safety concerns for the nearby property.

Concept 2: Removal of the floodwall downstream from the Evans Lane area to the confluence with Green Creek. The existing floodwall is constraining the flows of Fishing Creek and not allowing water to access the floodway during large rainfall events. By removing the floodwall and restoring the floodplain in this area could slightly reduce the water surface elevation at the Evans Lane Area.

Concept 3: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Charmund Road Flooding (MFC-14 and MFC-16)

Orange Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding
Impacted Properties Anticipated:	25+
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Property Buyout/Relocation
Permit Required:	N/A

Problem Area Descriptive Location

The problem area is located at the Mount Pleasant Road bridge and along Charmund Road south of the bridge.

Latitude: 41.078265
Longitude: -76.431216

Estimated Construction Cost

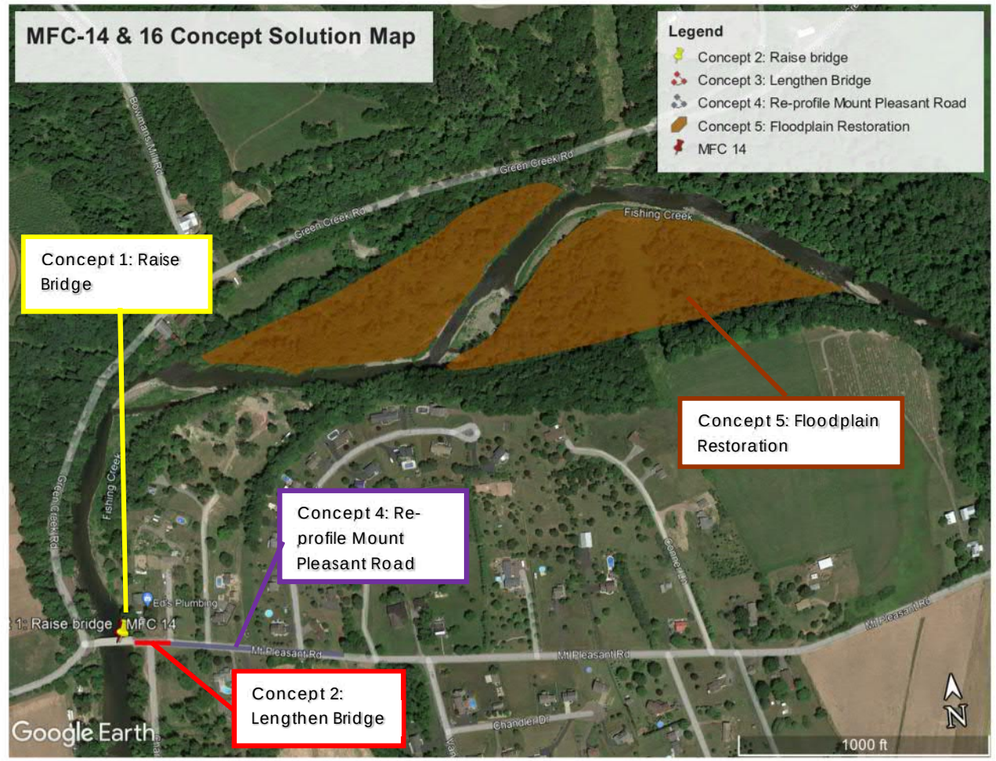
Concept 1: $750,000+ (Property Improvements)
Concept 2: $1.7-$3.2 Million (Bridge Replacement)
Concept 3: $5.0-9.3 Million (Bridge Replacement)
Concept 4: $500,000-$900,000 (Roadway Re-profiling)
Concept 5: $1.9-$3.5 Million (Floodplain Restoration)

Concept Impacts

Concept 1: 25+ Properties
Concept 2: 153' Length x 32.3' Width of Bridge Replacement
Concept 3: 353' Length x 32.3' Width of Bridge Replacement
Concept 4: 800 Linear Feet of Roadway Re-profiling
Concept 5: 3,300' Length x 250' Width x 3' Depth of Floodplain Restoration

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding along this section of Fishing Creek has been identified. Upon further investigations on the site, the properties located northeast of Mount Pleasant Road and the properties located along Charmund Road and Noman's Grove are located in a low lying area adjacent to the Fishing Creek corridor resulting in frequent flooding.

Problem Area Photo

Concept Solutions

Each concept solution listed below, excluding property buyouts/improvements, is analyzed utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates. The existing Mount Pleasant Road bridge is an existing three span pre-stressed concrete adjacent box beam bridge reconstructed in 1989 and is in fair conditions as assessed by Pennsylvania Department of Transportation (PennDOT). The existing bridge is able to convey the 100-year design storm event without surcharging the bridge deck, however, significant conveyance in the left overbank (along Mount Pleasant Road) is utilized during this storm event meaning that the structure is not hydraulically designed to convey high flow conditions through the bridge structure without flooding the properties east of the bridge.

Concept 1: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program. The buildings located along the edge of the floodplain could be raised 1-2 feet to get out of the floodplain whereas properties located close to the creek/floodway fringe would need to be raised 5-10 feet to get out of the floodplain. Raising of the buildings out of the flood zone would significantly reduce any damages to the properties. This concept is recommended to mitigate property flooding within the problem area.

Concept 2: Raise the Mount Pleasant Road bridge deck by two feet and reconstruct 200 feet on the eastern approach. This solutions would improve the hydraulic capacity of the bridge, but would not reduce any flooding experienced each of the bridge and south along Charmund Road due to the left overbank still being utilized during high flow events.

Concept 3: Extend Mount Pleasant Road bridge150 feet to the east, realign Charmund Road, and reconstruct the eastern approach. This solution would double the length of the bridge resulting in a significant increase to the hydraulic capacity of the bridge. Preliminary hydraulic analysis shows that most design storm events saw a decrease in water surface elevation by 1 foot except for the 100-year design storm which saw in increase in water surface elevation by three feet. This is because there is because the hydraulic opening of the bridge is sufficiently sized to carry the smaller storm events, but it still unable to convey the 100-year event through the bridge opening. Since the bridge deck is expanded, a larger amount the left overbank is obstructed resulting in a net decrease in available conveyance during the 100-year event. This concept would be extremely costly and would require property buyouts to achieve with undesirable improvements.

Concept 4: Re-profile Mount Pleasant Road to raise it out of the floodplain. This concept would result in a significant decrease in left overbank conveyance resulting in an increase in water surface elevation such that high flow events still overtop the roadway. This concept would require fill to be placed in the floodway and would result in no improvements to flooding.

Concept 5: Restore the floodplain north of Mount Pleasant Road. Restoration of the floodplain upstream of the bridge resulting in a decrease in water surface elevation by approximately 2" throughout all storm events. This would help to mitigate some of the flooding issues experienced but would not eliminate flooding experience.

USGS Stream Gauge at Mount Pleasant Road Bridge (MFC-15)

Orange Township

General Information

Affected Land Ownership:	Public
Responsible Entity:	Columbia County
Problem Type:	Flooding
Impacted Properties Anticipated:	N/A
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	USGS Stream Gauge Reconstruction/Maintenance
Permit Required:	TBD

Problem Area Descriptive Location

The USGS stream gauge is located to the southwest of the Mount Pleasant Road Bridge adjacent to Charmund Road.

Latitude: 41.078199
Longitude: -76.431683

Estimated Construction Cost

Concept 1: $20,000-$80,000 (USGS Stream Gauge Replacement)
Concept 2: $10,000-$30-000 per year (USGS Stream Gauge Maintenance)

Concept Impacts

Concept 1: N/A
Concept 2: N/A

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10

Problem Area Issue

The USGS stream gauge on the Mount Pleasant Road bridge is the last USGS stream gauge for Fishing Creek and is utilized for decision making by local governments and the County.

Problem Area Photo

Concept Solutions

Concept 1: When the Mount Pleasant Bridge is replaced, reconstruct the USGS stream gauge to be better protected from damage and vandalism. A secured concrete structure could be constructed to house the stream gauge. This solution would require coordination with USGS.

Concept 2: Continue regular maintenance of the USGS stream gauge as recommended by USGS.

State Route 487 & Charmund Road (MFC-17)

Orange Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	3
Watershed:	Middle Fishing Creek
Priority Level:	High (7.2)
Project Type:	Culvert Replacement
Permit Required:	HOP

Problem Area Descriptive Location

The problem area is located near Charmund Road across from Route 487.

Latitude: 41.07112
Longitude: -76.42666

Estimated Construction Cost

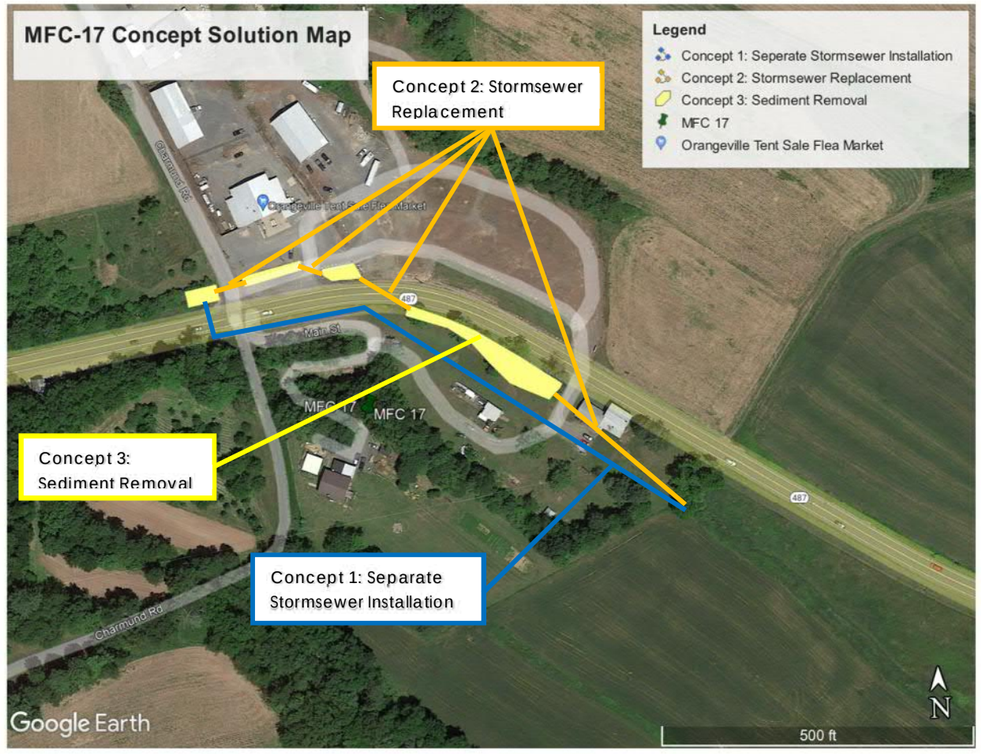
Concept 1: $0.8-1.5 million (Separate Stormsewer Installation)
Concept 2: $400,000-$500,000 (Stormsewer Replacement)
Concept 3: $30,000-$60,000 (Sediment Removal)

Concept Impacts

Concept 1: 900 Linear Feet of Separate Stormsewer Installation
Concept 2: 200 Linear Feet of Stormsewer Replacement
Concept 3: 450' Length x 20' Width x 1' Depth of Sediment Removal

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	10	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

There is a 24" reinforced concrete pipe currently collecting a large area of stormwater runoff from the adjacent agricultural fields. Preliminary site investigation showed the pipe is undersized and the current overland runoff into this pipe excessively floods the downstream tributary crossing State Route 487.

Problem Area Photo

Concept Solutions

Concept 1: Remove the existing 24" RCP that conveys overland flow underneath the property south of SR 487 and install a separate stormsewer conveyance facility which includes a 5.5'x3' concrete box culvert. By removing the existing pipe which bottlenecks stormwater runoff conveyance, the existing streamflow will be conveyed efficiently across SR 487 while the separate storm sewer system can capture overland flow and convey it across SR 487 further downstream. Using Manning's Formula for Uniform Pipe flow at full flow and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing 24" RCP is sized sufficiently to convey the 1-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 5.5'x3' concrete box culvert is sized sufficiently to convey the 50-year design peak flow rates without overtopping the roadway. A detailed survey, stormsewer analysis and downstream analysis will also be required for this concept. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Remove and replace the existing 24" RCP with a dual 24" HDPE pipe, existing 6'x3' concrete arch crossing with an 8'x3' concrete box culvert, existing 8'x3' concrete box culvert with a 9'x3' concrete box culvert, and existing 6'x2.5' ASRP with a 9'x3' concrete box culvert. By replacing the existing pipes and culvert, the water way opening can be increased significantly and while still maintaining the required pipe cover. Using Manning's Formula for Uniform Pipe flow at full flow and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing 24" RCP is sized sufficiently to convey the 1-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the dual 24" HPDE pipe is sized sufficiently to convey the 50-year design peak flow rates without overtopping the roadway. This concept is not recommended to mitigate flooding issues within the problem area, as the large amount of overland flow from upstream agricultural fields will continue to combine with the existing tributary conveyance, as well as sedimentation discharge into the existing open channels. A detailed survey, stormsewer analysis and downstream analysis will also be required for this concept.

Concept 3: Remove deposited sediment from the open channel areas. The removal of the deposited sediment will restore the hydraulic capacity of the pipes and culverts and restore normal flow conditions in the upstream channel. The removal of the deposited sediment would provide a cost efficient and highly effective solution in reducing high flow flooding caused by the bridge. This concept is not recommended to mitigate flooding issues within the problem area in the long-term.

Stony Brook Road Flooding (MFC-18)

Orange Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Private Owner
Impacted Properties Anticipated:	1
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Floodplain Reconnection
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located near the intersection of SR 487 and Stony Brook Road.

Latitude: 41.052228
Longitude: -76.428392

Estimated Construction Cost

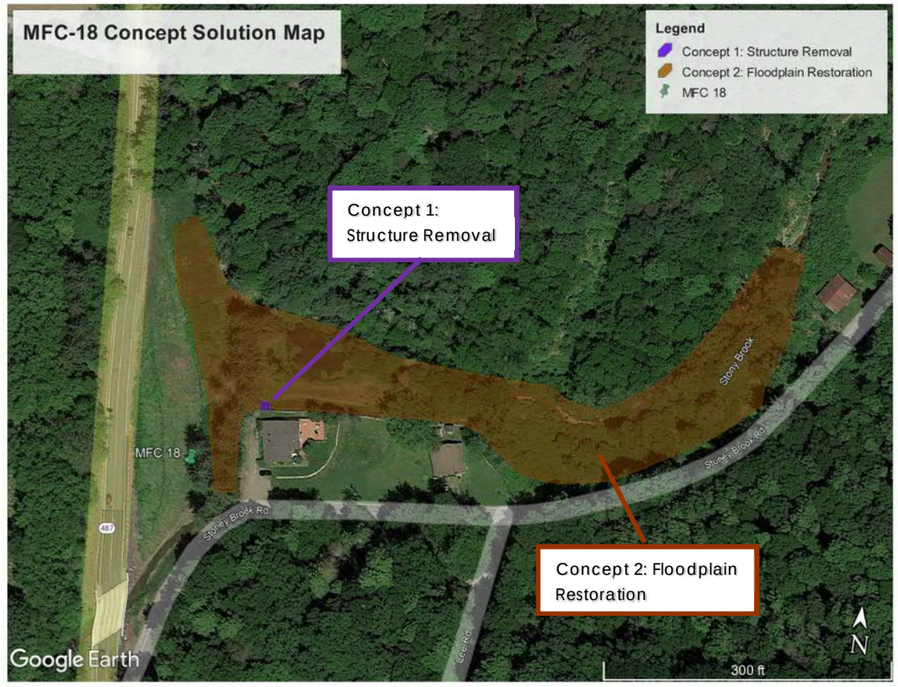
Concept 1: $5,000-$20,000 (Structure Removal)
Concept 2: $300,000-$600,000 (Floodplain Restoration)

Concept Impacts

Concept 1:12’ Length x 10’ Width of Structure Removal
Concept 2: 850’ Length x 110’ Width x 3’ Depth of Floodplain Restoration

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

There is an existing small bridge/structure crossing Stoney Brook near its confluence with Fishing Creek. As can be seen in the photo below this structure collects a large amount of debris from Stony Brook, especially during larger rainfall events. During these large rainfall events this build up causes the creek to back up causing upstream flooding.

Problem Area Photo

Concept Solutions

Concept 1: Remove the structure crossing Stony Brook and remove all of the built-up debris. Removal of the built but debris will allow the stream channel to return back to its natural flow conditions. In order to prevent debris, build up in the future the small structure crossing the stream should also be removed. This solution is recommended as it is a low cost solution that will likely correct much of the flooding issues in this area.

Concept 2: Restore the floodplain upstream of the bridge by removing approximately 10,400 cubic yards of sediment. Small scale stream restorations typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor. Due to the high cost of this project and the minimal effect it will have on flooding in the area this solution is not recommended.

Orangeville Flooding (MFC-19)

Orangeville Borough

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	4+
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	Culvert Replacement/ Riparian Buffer
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located along a culvert that crosses Mt. Pleasant Road which traverses a tributary of East Branch Fishing Creek and along an UNT of East Branch Fishing Creek corridor downstream of the culvert crossing.

Latitude: 41.078233
Longitude: -76.414675

Estimated Construction Cost

Concept 1: $110,000-$200,000 (Culvert) $40,000-$80,000 (Buffer)
Concept 2: $120,000+ (Property Improvements)

Concept Impacts

Concept 1: 35 Linear Feet of Culvert Replacement, 0.95 Acres of Riparian Buffer
Concept 2: 4+ Properties

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

Problem Area Issue

Flooding along this section tributary of East Branch Fishing Creek and Mt. Pleasant Road culvert has been identified. Upon further investigation, the culvert is undersized for the culvert's drainage area. Additionally, the upstream tributary area lacks proper riparian buffer from surrounding properties.

Problem Area Photo

Concept Solutions

Concept 1: Replace the existing culvert with a 10' span and 4' rise concrete box culvert and provide riparian buffer plantings along the upstream portion of the channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 25-year storm event. The proposed concrete box culvert is able to convey the 100-year storm without overtopping the roadway. The proposed riparian buffer planting will stabilize banks, filter sediment, increase infiltration, and reduce flood damage within the surrounding area. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Broad Street (MFC-20)

Orangeville Borough

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Orangeville Borough
Impacted Properties Anticipated:	2
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	Culvert Replacements
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at the intersection of Broad Street and Mill Street.

Latitude: 41.075220
Longitude: -76.417793

Estimated Construction Cost

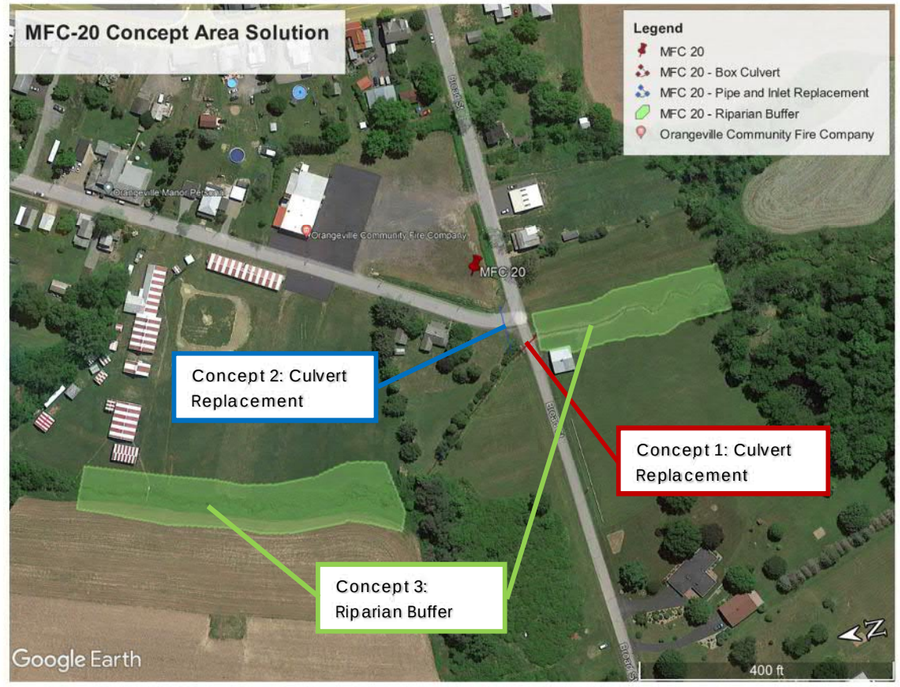
Concept 1: $100,000-$190,000 (Culvert Replacement)
Concept 2: $30,000-$60,000 (Culvert Replacement)
Concept 3: $10,000-$20,000 (Riparian Buffer)

Concept Impacts

Concept 1: 35 Linear Feet of Culvert Replacement
Concept 2: 85 Linear Feet of Culvert Replacement
Concept 3: 0.6 Acres of Riparian Buffer

Assessment and Analysis of Solutions

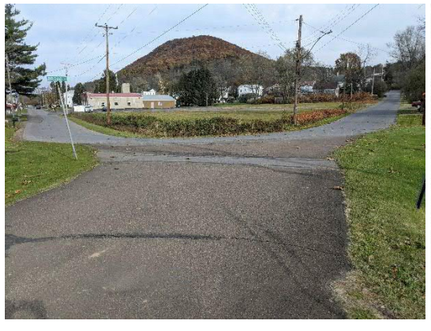
Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10= More Frequent
Resiliency	10	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Intersection floods during high rainfall storm events. The culvert that passes underneath Mill Street appears to be undersized. Also, the culvert inlet is lower than the culvert outlet, causing the water to only discharge when enough head pressure exists. Additionally, the roadway at the intersection is also profiled in away that creates a low area opposite of the drainage way and creates ponding.

Problem Area Photo



Concept Solutions

Concept 1: Remove and replace the existing culvert with a concrete box culvert. By replacing the existing culvert with a 3' x 10' concrete box culvert will allow the water way opening to be increased significantly and while still maintaining the required pipe cover. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culverts are sized sufficiently to convey the 2-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 3' x 10' concrete box culvert is sized sufficiently to convey the 25-year design peak flow rates without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Install an inlet and larger pipe under Mill Street. Currently this area is receiving runoff flowing down Broad and Mill Streets. The water collects in the low area in the NE corner of the intersection and the existing pipe is not sized large enough to convey flows. Installing an inlet in the low area and piping the water under Mill Street to the drainage way will prevent ponding in the street from occurring in this area. This concept is recommended to mitigate the flooding at this intersection.

Concept 3: A 35' wide Riparian Buffer along the banks of the stream channel. A riparian buffer would help to protect the Creek banks and reduce stream bank erosion and sediment deposition. There will be a de-minimis impact to flooding as a result of this concept.

Rohrsburg Flooding (MFC-21)

Greenwood Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	PennDOT
Problem Type:	Flooding/Sedimentation
Impacted Properties Anticipated:	3
Watershed:	Green Creek/Little Green Creek
Priority Level:	Medium
Project Type:	Bridge Replacement
Project Impact:	3900 SF of Bridge Deck
Permit Required:	PADEP GP-11 & PennDOT HOP

Problem Area Descriptive Location

The problem area is located at a bridge that traverses Little Green Creek west of 1933 SR 254 as well as a bridge that traverses Green Creek east of 1933 SR 254.

Latitude: 41.13605
Longitude: -76.428456

Estimated Construction Cost

Concept 1: $20,000 - $40,000 (Sediment Removal)
Concept 2: $400,000 – $800,000 (Bridge Replacement)

Concept Impacts

Concept 1: 125’ Length x 30’ Width x 2’ Depth of Sediment Removal
Concept 2: 83’ Length x 45’ Width of Bridge Replacement

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequency
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (6.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

Problem Area Issue

Flooding along this section of Little Green Creek and Green Creek and sedimentation along the bridge that traverses Green Creek has been identified. Upon further investigations on the site, streambed material has been deposited on the right side (looking downstream) of the bridge and extends to approximately the center of the bridge. Sediment deposition can be seen upstream of the bridge.

Problem Area Photo

Concept Solutions

Concept 1: Remove deposited sediment from under the Greek Creek bridge and within the upstream channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration’s (FHWA) HY-8 Culvert Hydraulic Analysis Program and HRG developed flows, the existing unobstructed bridge is sized sufficiently to convey the 100-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced; however, it is still able to convey the 100-year design storm with available freeboard. The removal of the deposited sediment is a cost efficient solution, however it will most likely have little to no effect on the surrounding area.

Concept 2: Replacement of the Rohrsburg Road bridge. The existing bridge was constructed in 1919 and is in fair conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding caused by the obstruction. With the existing bridge, the roadway overtops during the 25-year storm. Preliminary hydraulic analysis results show that extending the bridge to a length of 130 feet and removing sediment within the waterway crossing to increase the height of the waterway opening by 1 foot allows the proposed bridge to pass the 100-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is recommended to mitigate flooding issues within the problem area.

Pole Bridge Road Flooding (LFC-1)

Jackson Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Jackson Township
Problem Type:	Flooding
Impacted Properties Anticipated:	2+
Watershed:	Little Fishing Creek
Priority Level:	Medium
Project Type:	Culvert Replacement
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located along two culverts that cross Pole Bridge Road which traverse tributaries of West Creek.

Latitude: 41.269672
Longitude: -76.429081

Estimated Construction Cost

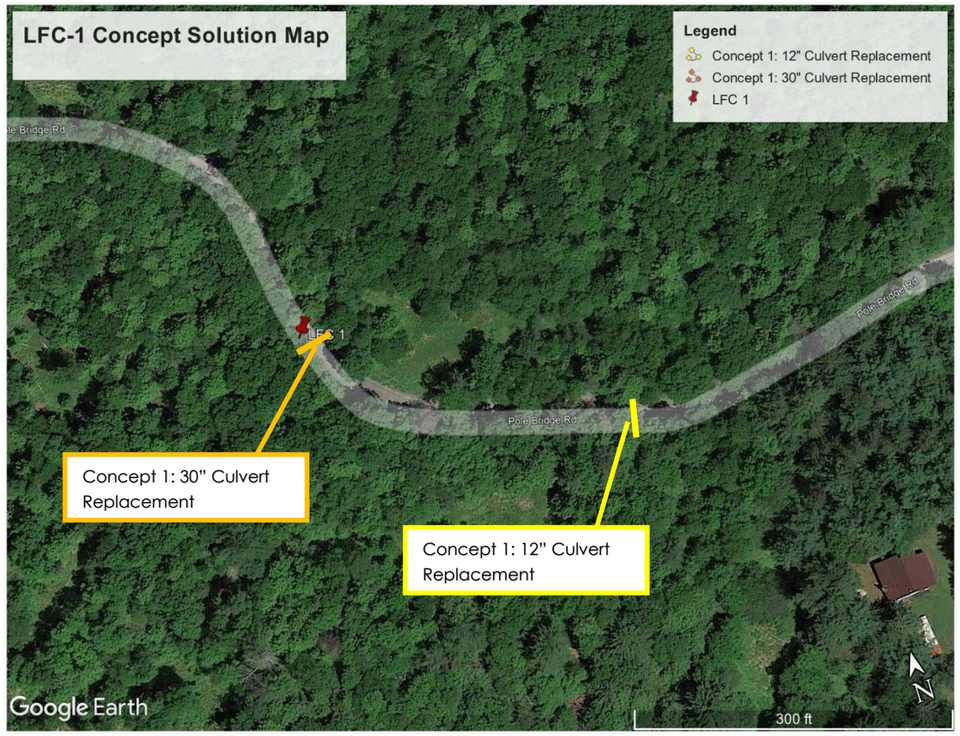
Concept 1: $70,000 – 120,000 (Culvert)

Concept Impacts

Concept 1: 50 Linear Feet of Culvert Replacement

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along these tributary sections of West Creek and Pole Bridge Road culverts have been identified. Upon further investigation, the culverts are undersized for the drainage areas.

Problem Area Photo

Concept Solutions

Concept 1: Replace the existing 30" culvert with a 54" rise and 88" span concrete pipe arch. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 1-year storm event. The proposed concrete pipe arch is able to convey the 5-year storm without overtopping the roadway. Additionally, Concept 1 includes the replacement of an existing 12" culvert with a 26.62" rise and 43.75" span concrete pipe arch. The proposed concrete pipe arch is able to convey the 5-year storm without overtopping the roadway. This concept will help to mitigate flooding issues within the problem area during more frequent storm events.

Pole Bridge Road Culvert (LFC-2)

Jackson Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Jackson Township
Impacted Properties Anticipated:	3
Watershed:	Little Fishing Creek
Priority Level:	High
Project Type:	Culvert Replacement
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located near the intersection of Pole Bridge Road and State Route 239.

Latitude: 41.266722
Longitude: -76.437442

Estimated Construction Cost

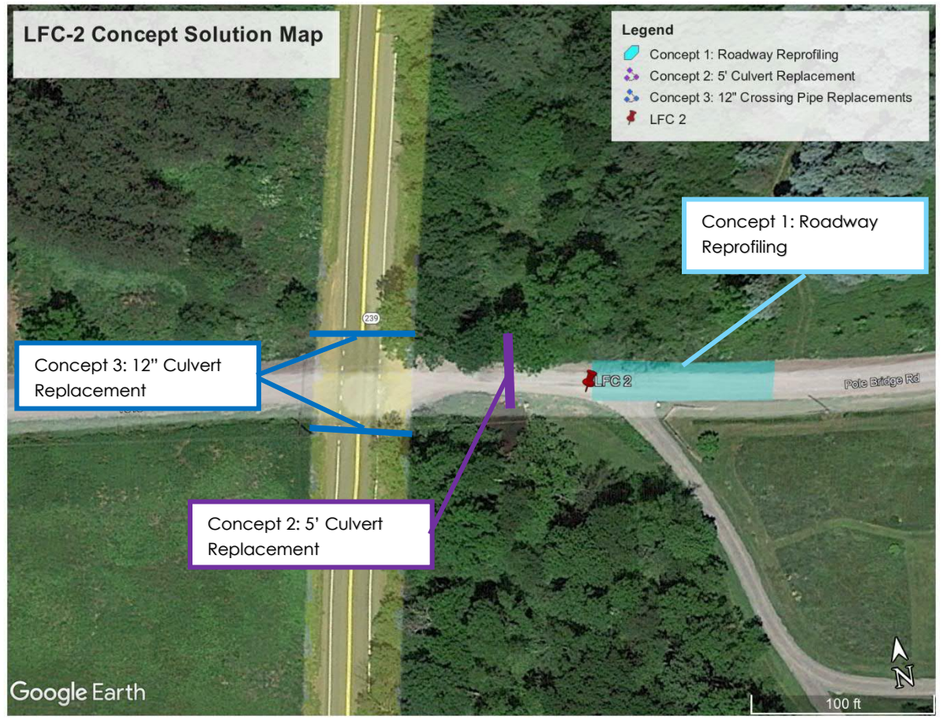
Concept 1: $100,000-$180,000 (Roadway Reprofiling)
Concept 2: $50,000-$80,000 (5' Culvert Replacement)
Concept 3: $30,000-$60,000 (12" Culvert Replacement)

Concept Impacts

Concept 1: 100' Length x 23' Width of Roadway Reprofiling
Concept 2: 30 Linear Feet of Culvert Replacement
Concept 3: 110 Linear Feet of Cross Pipe Replacement

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	Low = Few High = Many
Frequency of Existing Problem	10	Low = Infrequent High = More Frequent
Flood Level Reduction	10	Low = Infrequent High = More Frequent
Resiliency	5	Low = More Maintenance, High = Long-Lasting
Construction Cost	10	Low = Significant Cost ($$$) High = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

There are two 12" pipes crossing SR 239 and a 5' culvert carrying UNT to Little Fishing Creek across Pole Bridge Road. Preliminary site investigation showed debris buildup at the outflows of the pipes crossing SR 239 and roadside erosion indicating that these structures may be undersized.

Problem Area Photo

Concept Solutions

Concept 1: Approximately 160' east of the intersection it appears that there is a sag vertical curve in Pole Barn Road. Reprofiling the road to remove this sag will prevent high flows from overtopping the roadway at this location and encourage flow through the culvert. Reprofiling the roadway to bring the roadway up one foot would allow enough cover for a 103" x 71" ASPR pipe to be used. This increase in roadway elevation and pipe size allows the culvert to pass the 100-year design storm without overtopping the roadway.

Concept 2: Remove and replace the existing 5' culvert with an Aluminum Spiral Ribbed Pipe (ASPR) culvert. By replacing the existing culvert with an 81" x 59" ASPR Arch culvert the water way opening can be increased significantly and while still maintaining the required pipe cover. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culvert is sized sufficiently to convey the 2-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 81" x 59" ASPR pipe is sized sufficiently to convey the 10-year design peak flow rates without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: Upsizing the pipes crossing SR 239 will allow for higher flows to be conveyed to the UNT. This will reduce the likelihood of ponding occurring on the west side of SR 239 and eventually overtopping SR 239 during larger storm events. The increased flows will also result in less debris build up occurring where the pipe flows meet the UNT.

Green Creek Road Flooding (LFC-3)

Jackson Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Jackson Township
Problem Type:	Flooding, Erosion, Sedimentation
Impacted Properties Anticipated:	2+
Watershed:	Green Creek
Priority Level:	High
Project Type:	Culvert Replacement
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at a culvert that crosses Green Creek Road which traverses a tributary of Green Creek.

Latitude: 41.222378
Longitude: -76.427911

Estimated Construction Cost

Concept 1: $30,000 - $60,000 (Culvert)

Concept Impacts

Concept 1: 25 Linear Feet of Culvert Replacement

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

Problem Area Issue

Flooding along this section of Green Creek Road has been identified. Upon further investigation, the culvert is undersized for the drainage area.

Problem Area Photo

Concept Solutions

Concept 1: Replace the existing 24" culvert with a 45" rise and 73" span concrete pipe arch. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 2-year storm event. The proposed concrete pipe arch is able to convey the 25-year storm without overtopping the roadway. This concept will help to mitigate flooding issues within the problem area during more frequent storm events.

Peterman Road (LFC-4)

Pine Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Pine Township
Impacted Properties Anticipated:	2
Watershed:	Little Fishing Creek
Priority Level:	High
Project Type:	Culvert Replacement
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area is located near the intersection of Peterman Road and Kessler Hollow Road.

Latitude: 41.24675
Longitude: -76.471781

Problem Area Issue

A 5' culvert carries a UNT of Little Fishing Creek under Peterman Road. The upstream of the culvert the stream channel makes several tight bends and turns that are collecting debris. The main creek channel flow is not aligned with the inlet of the culvert which is creating a

Problem Area Photo

Estimated Construction Cost

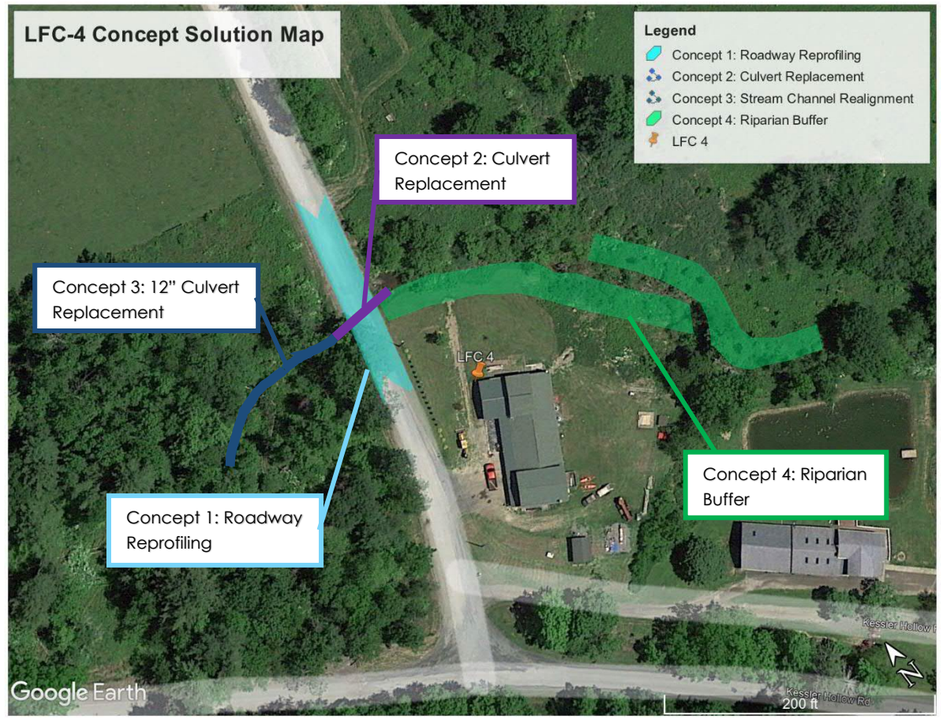
Concept 1: $150,000-$280,000 (Roadway Reprofiling)
Concept 2: $50,000-$100,000 (Culvert Replacement)
Concept 3: $40,000-$80,000 (Stream Channel Realignment)
Concept 4: $6,000-$12,000 (Riparian Buffer)

Concept Impacts

Concept 1: 165' Length x 28' Width of Roadway Reprofiling, 58 Linear Feet of Culvert Replacement
Concept 2: 58 Linear Feet of Culvert Replacement
Concept 3: 130 Linear Feet of Stream Channel Realignment
Concept 4: 0.25 Acres of Riparian Buffer

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Concept Solutions

Concept 1: Approximately 240' north of the intersection it appears that there is a sag vertical curve in Peterman Road. Reprofiling the road to remove this sag will prevent high flows from overtopping the roadway at this location and encourage flow through the culvert. Reprofiling the roadway to bring the roadway up one foot would allow enough cover for a 103" x 71" ASPR pipe to be used. This increase in roadway elevation and pipe size allows the culvert to pass the 100-year design storm without overtopping the roadway.

Concept 2: Remove and replace the existing 5' culvert with an Aluminum Spiral Ribbed Pipe (ASRP) culvert that is properly aligned with the stream channel. By replacing the existing culvert with an 81" x 59" ASPR Arch culvert the water way opening can be increased significantly and while still maintaining the required pipe cover. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culvert is sized sufficiently to convey the 10-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the 81" x 59" ASPR pipe is sized sufficiently to convey the 25-year design peak flow rates without overtopping the roadway. Additionally, once the culvert is properly aligned with the stream channel the existing issue of flows backing up at the culvert inlet with be significantly reduced.

Concept 3: Realigning the stream channel to match the alignment of the existing culvert would prevent the flow back up that is currently occurring at the pipe inlet. Removing some of very tight bends in the stream channel would improve the flow, as well as remove areas that are likely to collect sediment and debris build up in channel.

Concept 4: A 35' wide Riparian Buffer along the banks of the stream channel. A riparian buffer would help to protect the Creek banks and reduce stream bank erosion and sediment deposition. There will be a de-minimis impact to flooding as a result of this concept.

Mallard Road Erosion (LFC-5)

Greenwood Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Sugarloaf Township
Impacted Properties Anticipated:	2
Watershed:	Little Fishing Creek
Priority Level:	Medium
Project Type:	Culvert Replacement
Project Impact:	250 LF of channel/swale
Permit Requirement:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located near the intersection of Mallard Road and Sereno Hollow Road.

Lat: 41.162941
Long: -76.503875

Problem Area Issue

Flooding near the intersection of Mallard Road and Sereno Hollow Road along Little Fishing Creek. The dwelling at this intersection is located in a low area with an 18" concrete pipe conveying water from the property under Mallard Road to a swale that discharges to Little Fishing Creek. Erosion in the swale indicates that stabilization is needed and that the culvert may be undersized.

Problem Area Photo

Estimated Construction Cost

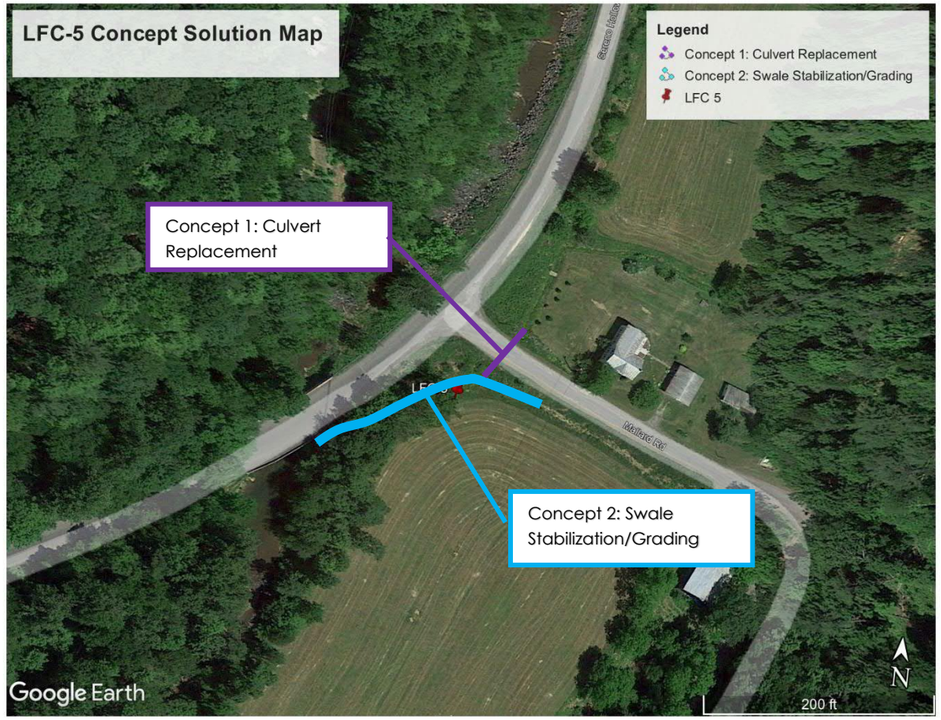
Concept 1: $30,000-$50,000 (Culvert Replacement)
Concept 2: $40,000-$70,000 (Swale Stabilization/Grading)

Concept Impacts

Concept 1: 66 Linear Feet of Culvert Replacement
Concept 2: 240 Linear Feet of Swale Stabilization

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (2.6)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Concept Solutions

Concept 1: Remove and replace the existing concrete culvert with an upsized HDPE pipe. By replacing the existing culvert with an 40" HDPE pipe the water way opening can be increased significantly and while still maintaining the required pipe cover. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) StreamStats application for estimating stream peak flow rates, the existing culvert is sized sufficiently to convey the 2-year design storm peak flow rates without overtopping the roadway. Using the same methods of analysis, the HDPE pipe is sized sufficiently to convey the 100-year design peak flow rates without overtopping the roadway. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Stabilizing the swale will reduce the erosion that is caused by flows coming from the pipe crossing, as well as, reducing the amount of sediment and debris that would otherwise end up getting washed into Little Fishing Creek. Regrading will ensure that the swale has enough slope to properly convey flows to Little Fishing Creek without any ponding occurring. This concept is recommended as a potential additional step to Concept 1.

Flooding Around Iola (LFC-6)

Greenwood Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency / Columbia County / Greenwood Township / Millville Borough
Problem Type:	Flooding/Infrastructure
Impacted Properties Anticipated:	20+
Watershed:	Little Fishing Creek
Priority Level:	Medium
Project Type:	Bridge Replacement/Stream Maintenance
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located along the Little Fishing Creek Corridor around Iola.

Latitude: 41.134211
Longitude: -76.534090

Estimated Construction Cost

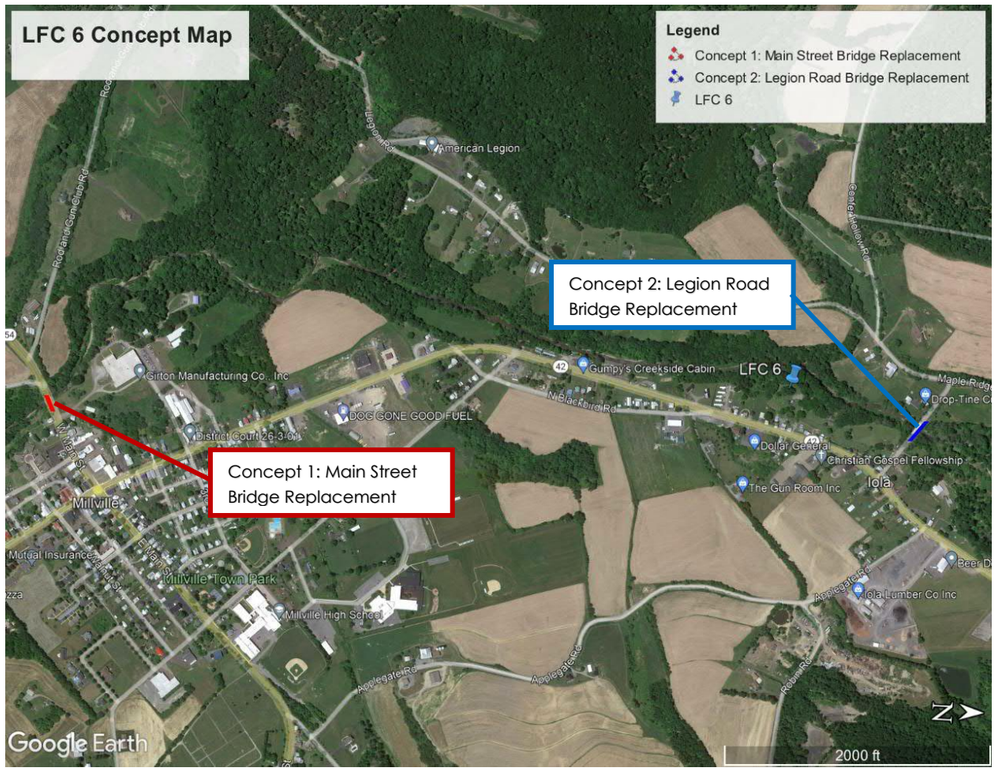
Concept 1: See LFC 7 (Main Street Bridge Replacement)
Concept 2: $1.5 -$2.75 Million (Legion Road Bridge Replacement)
Concept 3: $0-$100,000+ per year (Vegetation/Debris Management)
Concept 4: $600,000+ (Property Improvements)

Concept Impacts

Concept 1: See LFC 7
Concept 2: 144' Length x 30' Width of Bridge Replacement
Concept 3: 10,000 Linear Feet of Stream Maintenance
Concept 4: 1-5 Properties

Project Prioritization

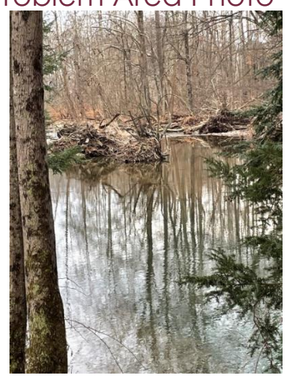
Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (4.6)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding along this section of Little Fishing Creek has been identified. Upon further investigations on the site, flooding appears to be caused by the undersized bridges on Legion and Main Street and the constriction of the floodplain by properties located along the Little Fishing Creek corridor. Heavy debris was noted along the creek corridor. This debris could wash into the creek during large storm and create a significant obstruction and worsen flooding in Iola.

Problem Area Photo



Concept Solutions

Concept 1: Replace the West Main Street bridge. See LFC-7 for more information.

Concept 2: Replace the Legion Road bridge. The existing bridge is a state owned steel girder bridge constructed in 1941 and is in fair conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). The existing bridge is able to convey the 10-year design peak flow rates through the hydraulic opening and the 100-year design speak flow rates without surcharging the bridge deck. Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that raising the bridge deck by two feet, reducing the bridge deck thickness to 30 inches, and widening the bridge by 25 feet on each approach allows the bridge the convey the 100-year design peak flow rates through the hydraulic opening and the 500-year design storm without surcharging the bridge deck. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. Improvement to the bridge will result in better hydraulic capacity and reduce bridge deck overtopping. Flooding of the Main Street roadway would be reduced from the 100-year event to the 500-year event with approximately 2-5 less properties being located within the HRG delineated floodplain. This concept is recommended to mitigate flooding issues within the problem area.

Concept 3: Vegetation/debris management along Little Fishing Creek. Continual maintenance of the creek corridor would reduce the amount of sediment/trees that end up within the channel and bridges. This concept is recommended to be implemented and would ensure that the hydraulic structures and stream channel are functioning at their maximum capacity.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Main Street (PA 254) Bridge (LFC-7)

Millville Borough

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency / Columbia County / Millville Borough
Problem Type:	Flooding/Infrastructure
Impacted Properties Anticipated:	20+
Watershed:	Little Fishing Creek
Priority Level:	High
Project Type:	Bridge Replacement/ Floodplain Reconnection
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located on the West Main Street bridge which crosses Little Fishing Creek in Millville Borough.

Latitude: 41.119308
Longitude: -76.532713

Estimated Construction Cost

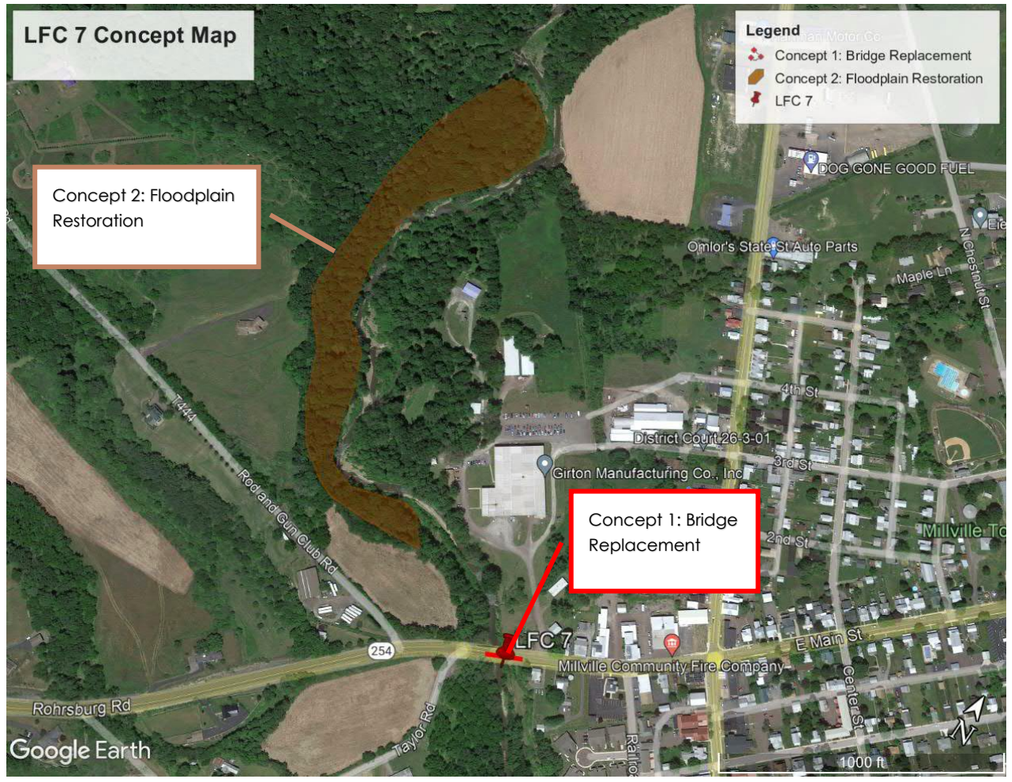
Concept 1: $1.5-$2.7 Million (Bridge Replacement)
Concept 2: $0.9 -$1.7 Million (Floodplain Restoration)
Concept 3: $600,000+ (Property Improvements)

Concept Impacts

Concept 1: 125' Length x 33' Width of Bridge Replacement
Concept 2: 3,500' Length x 275' Width x 3' Depth of Floodplain Restoration
Concept 3: 20+ Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Flooding along this section of Little Fishing Creek has been identified. Upon further investigations on the site, flooding appears to be caused by the undersized bridge and the constriction of the floodplain by properties located along the Little Fishing Creek corridor. It is also noted that a significant portion of the right side (looking downstream) stream channel is silted in and no flow during normal conditions passes through this side of the bridge.

Problem Area Photo

Concept Solutions

Concept 1: Replace the West Main Street bridge. The existing bridge is a state owned concrete T beam bridge constructed in 1930 and is in fair conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). The existing bridge is able to convey the 2-year design peak flow rates through the hydraulic opening and the 10-year design speak flow rates without surcharging the bridge deck. Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that removal of the existing pier, raising the bridge deck by two feet and reducing the bridge deck thickness to 30 inches allows the bridge the convey the 25-year design peak flow rates through the hydraulic opening. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. Improvement to the bridge will result in better hydraulic capacity and reduce bridge deck overtopping. Flooding of the Main Street roadway would be reduced from the 25-year event to the 50-year event with no changes to the affected properties. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Restore the floodplain within the right overbanks of Little Fishing Creek directly west of Millville. This option would consist of regrading the forested area which would improve the conveyance capacity of the right overbank. Construction of this concept would result in 40,000 cubic yards of material removed from the Little Fishing Creek Floodplain. A slight reduction in velocity (<0.5 fps) and water surface elevations (<2") were observed throughout the restored reach and no change upstream of downstream of restoration. This concept is not recommended to mitigate flooding issues, but is recommended for watershed-wide resiliency.

Concept 3: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Robbins Road Bridge (HC-1)

Mount Pleasant Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Mount Pleasant Township
Impacted Properties Anticipated:	2
Watershed:	Little Fishing Creek
Priority Level:	Low
Project Type:	Sediment Removal
Project Impact:	150 LF of Stream
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

Latitude: 41.066111
Longitude: -76.498764

The problem area is located on the Robbins Road bridge which crosses Little Fishing Creek near the intersection of Robbins Road and State Route 42.

Estimated Construction Cost

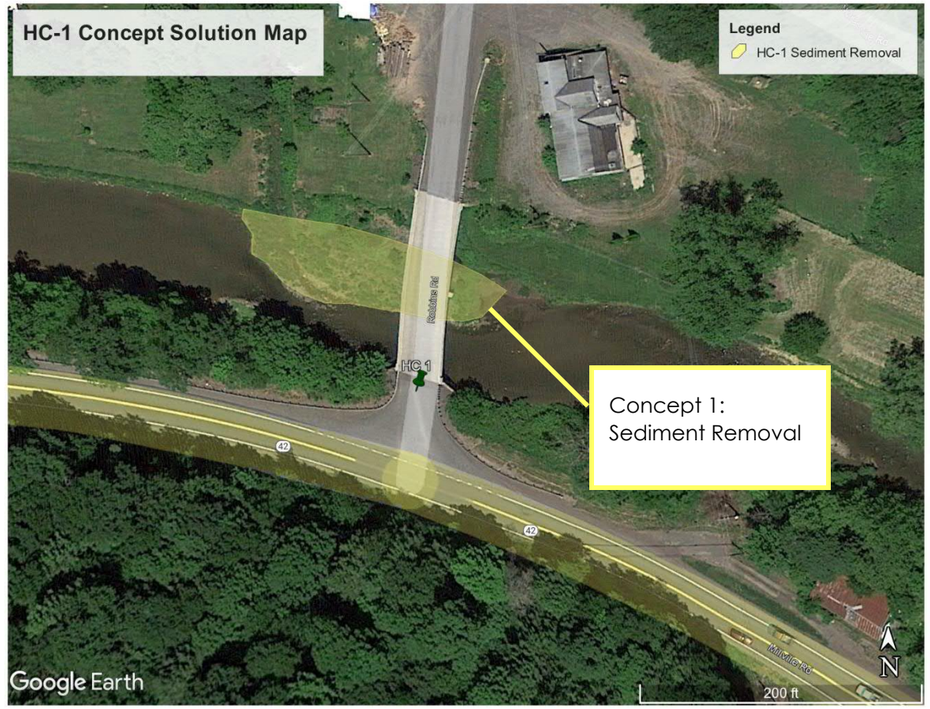
Concept 1: $70,000-$140,000 (Sediment Removal)
Concept 2: $60,000+ (Property Improvements)

Concept Impacts

Concept 1: 150' Length x 50' Width x 2' Depth of Sediment Removal
Concept 2: 1-2 Properties

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Infrequent 10 = More Frequent
Resiliency	1	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.6)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

There is sediment and debris buildup along the north bank of Little Fishing Creek upstream and underneath the Robbins Road Bridge. During large storm events this build up constricts the waterway and collects additional debris being carried downstream by the high flows.

Problem Area Photo

Concept Solutions

Concept 1: Remove deposited sediment from under the Robbins Road bridge and within the upstream channel. The removal of the deposited sediment will restore the hydraulic capacity of the bridge and restore normal flow conditions in the upstream channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and HRG for estimating stream peak flow rates, the existing unobstructed bridge is sized sufficiently to convey the 500-year design storm peak flow rates without overtopping the roadway. With the sediment deposition, the capacity of the bridge is reduced; however, it is still able to convey the 100-year design storm with available freeboard. The removal of the deposited sediment is a cost-effective solution; however, it will most likely have little impact on the surrounding area. This concept is recommended to restore natural flow conditions to the stream channel.

Concept 2: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Back Branch Road Bridge Scour (HC-2)

Scott Township / Mount Pleasant Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency / Columbia County / Private Owner
Problem Type:	Erosion/ Flooding / Infrastructure
Impacted Properties Anticipated:	2
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Pier Protection / Floodplain Reconnection
Permit Required:	PADEP GP-11/JPA

Problem Area Descriptive Location

The problem area is located on the Back Branch Road bridge which crosses Fishing Creek.

Latitude: 41.040558
Longitude: -76.427219

Estimated Construction Cost

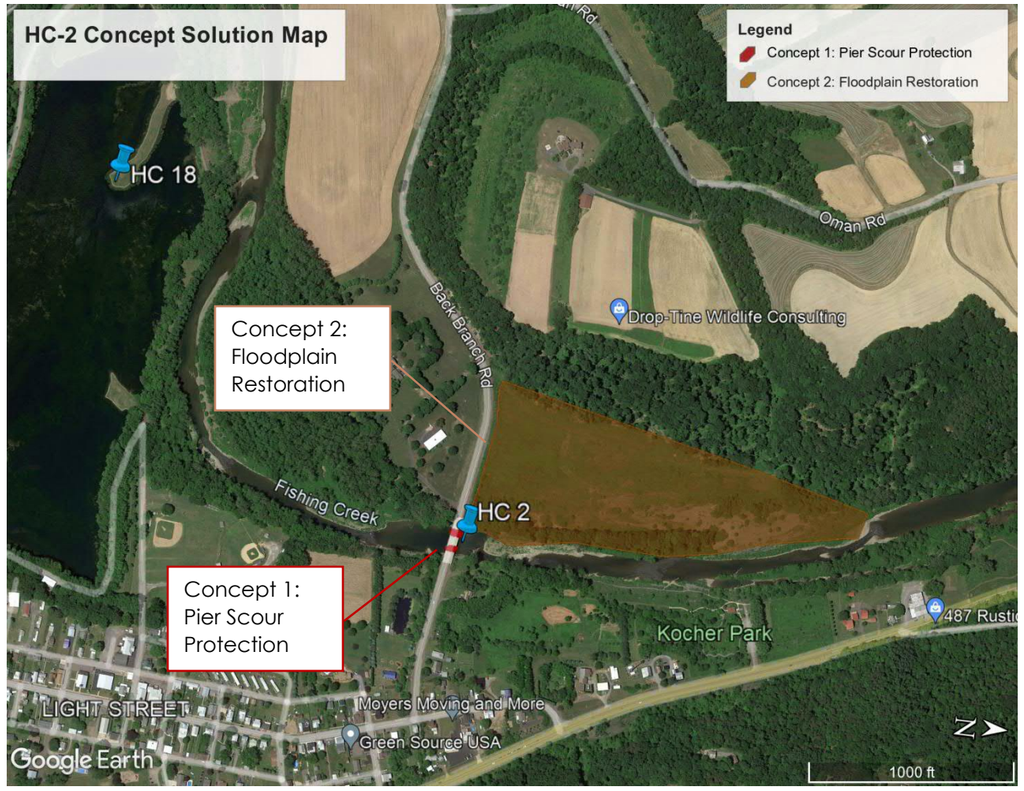
Concept 1: $350,000-$650,000 (Pier Scour Protection)
Concept 2: $0.7-$1.3 Million (Floodplain Restoration)
Concept 3: See HC-18 (Downstream Improvements)

Concept Impacts

Concept 1: Scour Protection for 2 Piers
Concept 2: 2,000' Length x 50' Width x 1' Depth of Floodplain Restoration
Concept 3: See HC-18

Project Prioritization

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Significant scour around the piers of the Back Branch Road bridge were identified by the County.

Problem Area Photo

Concept Solutions

Concept 1: Reconstruct the scour protection around the two piers with R-8 riprap choked with R-5 riprap and sealed with grout. Reconstruction of the riprap armoring around the piers would reduce scour around the piers and improve the expected life of the structure. This concept is recommended for implementation to reduce scour around the existing piers.

Concept 2: Restore the floodplain upstream of the bridge by removing approximately 100,000 cubic yards of sediment. Small scale floodplain reconnections typically result in minimal change to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease in velocity can reduce the rate of streambank erosion and scour/ sediment deposition around the bridge and within the Creek corridor. This concept is not recommended to mitigate scour due to the significant costs compared to Concept 2.

Concept 3: Floodplain improvements downstream of the bridge. Please see the Problem Area Solution Table for problem area HC 18 for more information.

Back Branch Road Flooding (HC-3)

Mount Pleasant Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency / Columbia County / Mount Pleasant Township
Impacted Properties Anticipated:	4
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Floodplain Restoration / Road Closure
Permit Required:	PADEP JPA

Problem Area Descriptive Location

Latitude: 41.025316
Longitude: -76.455463

The problem are is located along Back Branch Rroad from Millertown Road to Whites Church Road.

Problem Area Issue

Frequent Flooding along Back Branch Road has been identified. The Fishing Creek corridor along this segment of Back Branch Road is significantly constricted by both Back Branch Road and I-80 with minimal areas for floodplain access.

Problem Area Photo

Estimated Construction Cost

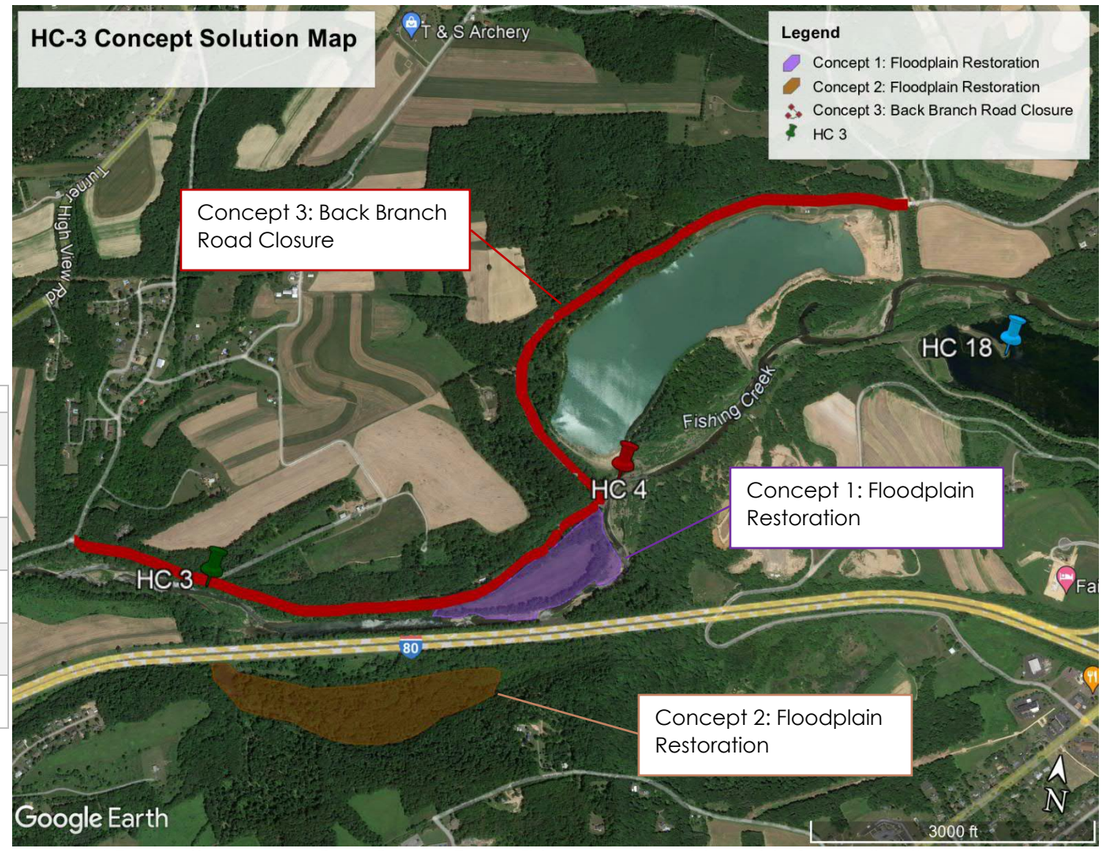
Concept 1: $1-$2 Million (Floodplain Restoration)
Concept 2: $1-$2 Million (Floodplain Restoration)
Concept 3: $150,000-$900,000 (Back Branch Road Closure)

Concept Impacts

Concept 1: 1,000' Length x 100' Width x 1.5' Depth of Floodplain Restoration
Concept 2: 3,000' Length x 475' Width x 1' Depth of Floodplain Reconnection
Concept 3: 2.4 Miles of Road Closure

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (4.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Concept Solutions

Concept 1: Floodplain reconnection on the right overbank of Fishing Creek along Back Branch Road. This concept would consist of regrading the open area southwest of the sediment pond which would improve the conveyance capacity of Fishing Creek's right overbank. Construction of this concept would result in 50,000 cubic yards of material removed from the Fishing Creek Floodplain. Negligible changes in velocity and water surface elevation were observed upstream and downstream of the floodplain reconnection. Through the floodplain restoration project area, a more noticeable decrease was seen. A decrease in water surface elevation was observed throughout all storm events ranging from 1" to 3" throughout and variable increase and decreases in velocities in both the left and right overbanks. This concept is not recommended to mitigate flooding issues due to the insignificant impacts of the proposed floodplain restoration compared to the significant costs.

Concept 2: Improve culvert under I-80 and improve the floodplain capacity to the south of the highway. This solution would allow normal flow conditions to function as it currently does, however, during high flow conditions backwater from Fishing Creek along Back Branch Road would flow under I-80 and into the large storage area behind it. Increasing the culvert size would increase the capacity of the pipe allowing for a larger rate of backwater from Fishing Creek to access this portion of the floodplain. This solution requires in depth hydrologic and hydraulic analyses which are out of the scope of this flood study. The quantification of improvements made by the concept is currently unknown and thereby cannot be recommended without further analysis and investigations.

Concept 3: Close Back Branch Road from Millertown Road to Whites Church Road. The portion of Back Branch Road from White Church Road to the sediment pond would be designated as 'no through traffic' and be open to local traffic only. Approximately 4 properties would need to be removed. This concept would eliminate hazardous conditions along Back Branch Road by no longer allowing it to be a viable travel route. Instead, traffic wanting to traverse from Millerstown Road to Back Branch Road at the intersection of Whites Church Road would head northbound on Thomas Road to Millertown Road then to Whites Church Road where it leads to Back Branch Road. This would increase the travel time from Millerstown Road to the intersection of Back Branch Road and Whites Church Road from 4 minutes to 9 minutes without any traffic. Back Branch Road is a state route with an average daily traffic (ADT) of 950. This concept is unlikely to be a viable project due to the significant volume of daily traffic and that the roadway is a state route. If this concept were to be implemented, closure of the roadway would also allow for future floodplain improvements projects to reduce the rate of streambank erosion within this section of Fishing Creek.

Fishing Creek Corridor Improvements by the Back Branch Road Sedimentation Pond (HC-4)

Mount Pleasant Township

General Information

Affected Property Ownership:	Public/Private
Responsible Entity:	Private Owner / Columbia County / Mount Pleasant Township
Problem Type:	Flooding
Impacted Properties Anticipated:	1
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Floodplain Reconnection/Stream Realignment
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area is located along the Fishing Creek corridor adjacent to the sediment pond located along Back Branch Road.

Latitude: 41.034422
Longitude: -76.446508

Estimated Construction Cost

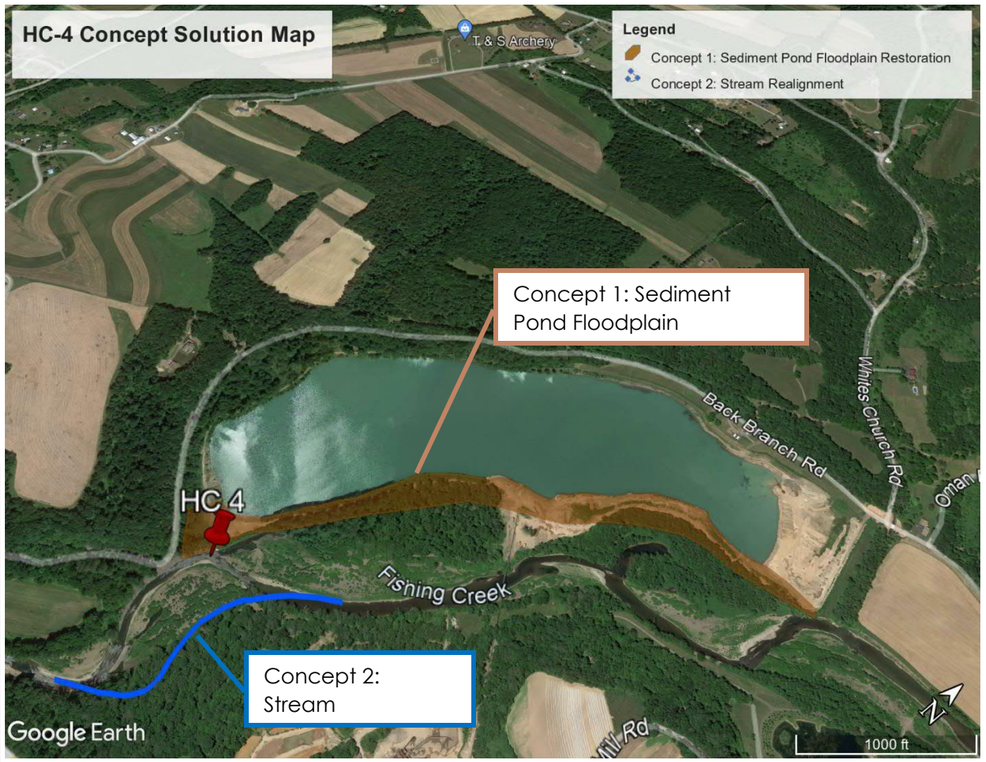
Concept 1: $5.2-$9.6 Million (Sediment Pond Floodplain Restoration)
Concept 2: $0.8-$1.6 Million (Stream Realignment)

Concept Impacts

Concept 1: 4,000' Length x 180' Width x 10' Depth of Floodplain Restoration
Concept 2: 2,000 Linear Feet of Stream Realignment

Project Prioritization

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (6.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

The Fishing Creek corridor has been severely constricted by quarry activities along Back Branch Road. The old sand and gravel quarry has since been turned into a sedimentation pond that retains water all year round. Additionally the large embankments constructed for the sediment pond severely constrict the Fishing Creek corridor reducing the capacity of the floodplain during flooding conditions.

Problem Area Photo

Concept Solutions

Concept 1: Connecting the Fishing Creek floodplain to the sediment pond. In this concept, the sediment pond would continue to function as it currently does, however, approximately 10 feet of the 20 feet tall embankment would be removed to allow the Fishing Creek floodplain to overflow and utilize the available storage capacity in the sediment pond during high flow conditions. Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates, the proposed project would result in a decrease in water surface elevation by 1-8 feet throughout connected floodplain sections for various analyzed storm events. The smaller storm events (2, 10 and 25-year) saw the largest decrease in water surface elevation (1-8 feet) whereas the 100 and 500-year storms saw a de-minimis change in water surface elevation. A small decrease in water surface elevation is seen upstream from the proposed improvements, however, these improvements become de-minimis further upstream around the center of Lake Florence. Directly downstream from the sediment pond, the proposed water surface elevation converges with the existing, meaning no further improvements are seen farther than the sediment pond. Although this project would result in significant improvements to the Fishing Creek floodplain, it is noted that the sediment pond is privately owned and actively used for local quarry activities. This concept would not be feasible until the quarry is closed. Negotiations with the property owner would be required before this project could be completed. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Realign Fishing Creek corridor away from Back Branch Road. The existing stream channel meanders towards Back Branch Road just before the roadway turns westerly around the sediment pond. This location has required heavy armoring to reduce the amount of bank erosion. It is expected that erosion will continue to occur and reduce the roadway embankment until it is no longer safe. Realigning the stream away from Back Branch Road would help to mitigate the rate of erosion around this bend. This concept would not provide any mitigation to flooding, but would reduce active erosion on the existing Back Branch Road embankment.

Steve Shannon Tire & Auto Center Flooding (HC-5)

Mt. Pleasant Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Mt. Pleasant Township
Problem Type:	Runoff, Flooding, Stream Velocity
Impacted Properties Anticipated:	1-5
Watershed:	Little Fishing Creek
Priority Level:	Low
Project Type:	Property Buyout
Permit Required:	N/A

Problem Area Descriptive Location

The problem area is located along the rear of Steve Shannon Tire and Auto Centers' property along Little Fishing Creek.

Latitude: 41.024375
Longitude: -76.476492

Estimated Construction Cost

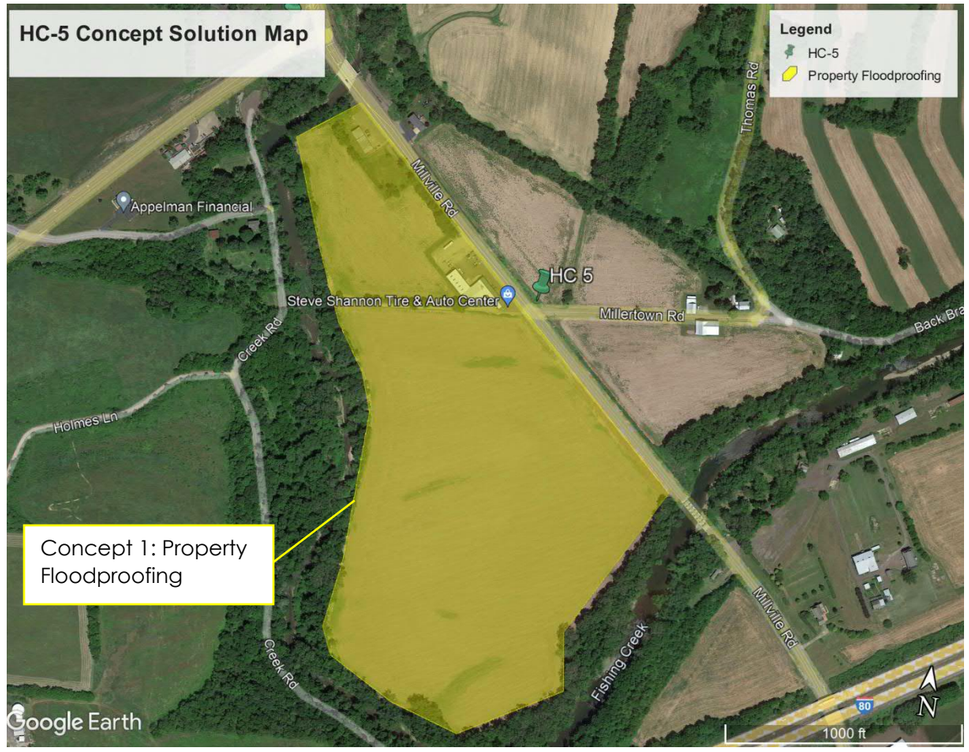
Concept 1: $30,000 - $150,0000+ (Property Floodproofing)

Concept Impacts

Concept 1: 1-5 Properties

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	1	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.6)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along this section of Little Fishing Creek has been identified. Upon further investigation, the subject property lies within the floodplain of Fishing Creek. Flooding is bound to occur. Only possible solutions are a property buyout or watershed wide flood remediation.

Concept Solutions

Concept 1: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Peppermill Road and Buckhorn Road Flooding (HC-6)

Hemlock Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Columbia County
Problem Type:	Flooding, Erosion, Sedimentation
Impacted Properties Anticipated:	2+
Watershed:	Hemlock Creek
Priority Level:	Medium
Project Type:	Culvert Replacement and Stream Enhancements
Permit Required:	PADEP GP-11, JPA

Problem Area Descriptive Location

The problem area is located along a culvert that crosses Peppermill Road at the intersection of Buckhorn Road, which traverses Hemlock Creek.

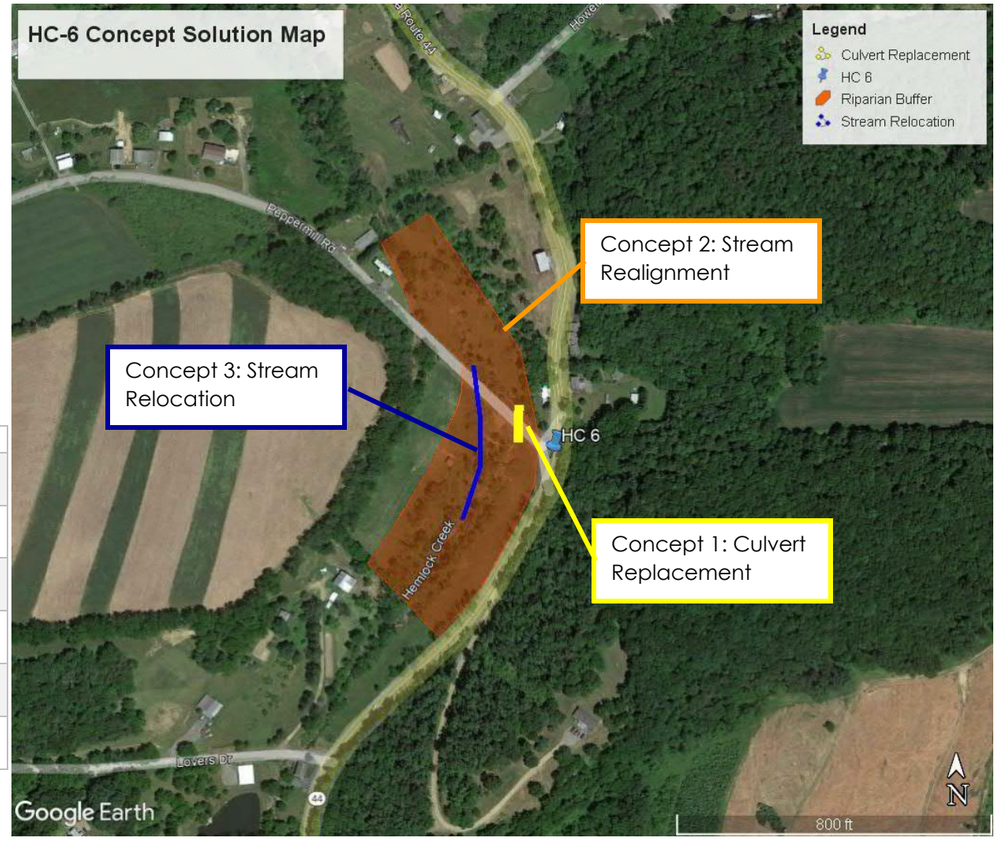
Latitude: 41.043711
Longitude: -76.523886

Estimated Construction Cost

Concept 1: $200,000 - $400,000 (Culvert)
Concept 2: $100,000 - $200,000 (Riparian Buffer)
Concept 3: $200,000 - $300,000 (Stream Realignment)

Concept Impacts

Concept 1: 60 Linear Feet of Culvert Replacement
Concept 2: 6.3 Acres of Riparian Buffer
Concept 3: 600 Linear Feet of Stream Realignment



Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	5	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.0)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

Problem Area Issue

Flooding along this section of a tributary of Hemlock Creek has been identified. Upon further investigation, the culvert is undersized for the culvert's drainage area. Additionally, the stream's natural drainage path appears to be realigned and lacks proper riparian buffer.

Problem Area Photo

Concept Solutions

Concept 1: Replace the existing 20' span by 4' rise concrete box culvert with a 45' span and 4' rise concrete box culvert. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 25-year storm event. The proposed concrete box culvert is able to convey the 100-year storm without overtopping the roadway. This concept will help to mitigate flooding issues within the location of the culvert and surrounding properties.

Concept 2: Riparian Buffer Plantings will stabilize banks, filter sediment, increase filtration, and reduce flood damage within the surrounding area. This solution may be paired with Concept 1 and Concept 3 to enhance flood mitigation practices.

Concept 3: Realign Hemlock Creek away from Peppermill Road to allow for a more natural floodplain. The floodplain of Peppermill Road should also be enhanced by Concept 2: Riparian Buffer Plantings. By realigning Hemlock Creek to its' natural floodplain, the floodplain will act as a natural buffer during flood events and should mitigate the frequency of flooding within the surrounding area's infrastructure. During realignment, in-stream structure may be introduced to reduce stream velocity and shear stress. Additionally, in-stream structures may enhance stream quality and improve aquatic life. Stream realignment will also require Concept 1's solution for the stream crosses Peppermill Road.

Orchard Drive Flooding (HC-7)

Hemlock Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Hemlock Township
Impacted Properties Anticipated:	2
Watershed:	Hemlock Creek
Priority Level:	High
Project Type:	Culvert Replacement
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located near the intersection of Dahl Road and Orchard Drive.

Latitude: 41.023317
Longitude: -76.510989

Estimated Construction Cost

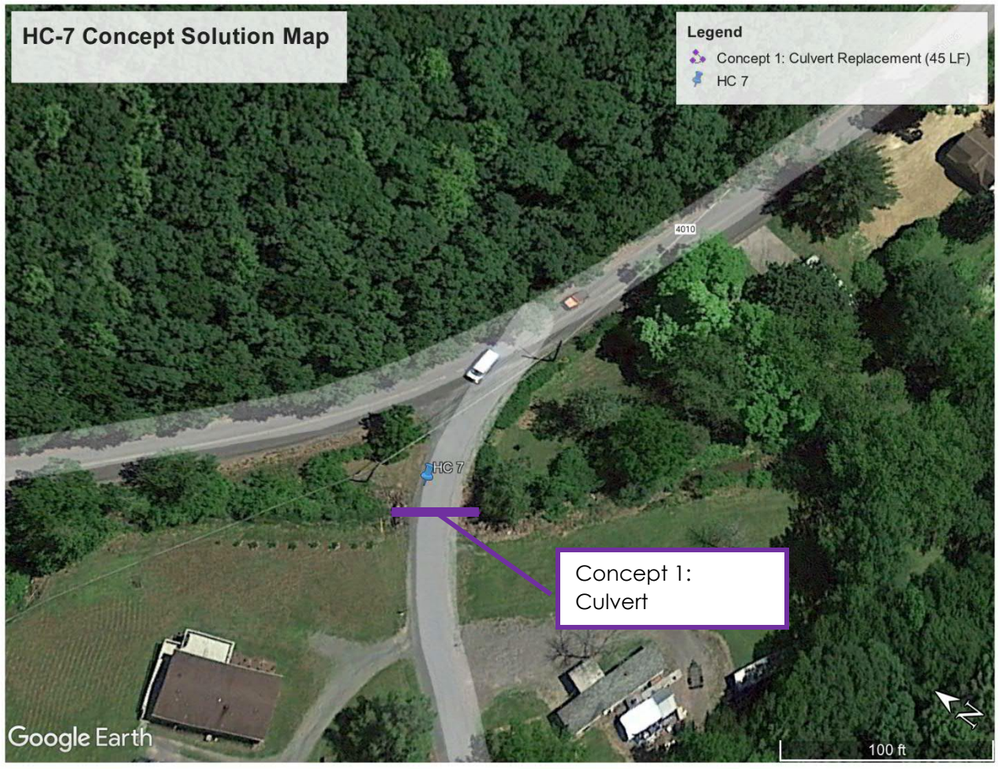
Concept 1: $100,000-$200,000 (Culvert Replacement
Concept 2: $60,000+ (Property Improvements)

Concept Impacts

Concept 1: 41 Linear Feet of Culvert Replacement
Concept 2: 1-2 Properties

Project Prioritization

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (8.0)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

The existing culvert under T483 (Orchard Drive) gets blocked with vegetation. Previously a large culvert was replaced with two smaller diameter culverts. The property owner on Northwest corner said he often clears vegetation, and it has flooded several times over the last 20 years he has been there because he could not remove the vegetation himself. At that time the creek floods and goes into his basement. One time it has taken out the road. There is bank erosion along Dahl Road and the creek is cutting into the bank.

Concept Solutions

Concept 1: Replace the two existing 5' culverts with a 20' span and 5' rise concrete box culvert and provide riparian buffer plantings along the upstream portion of the channel. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing culverts overtop the roadway during the 10-year storm event. The proposed concrete box culvert is able to convey the 100-year storm without overtopping the roadway. The additional space added to the waterway opening will also reduce the amount of debris that gets caught on upstream side of the culvert. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Dahl Road Flooding (HC-8)

Hemlock Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	PennDOT
Problem Type:	Flooding, Erosion, Sedimentation
Impacted Properties Anticipated:	4+
Watershed:	Hemlock Creek
Priority Level:	Medium
Project Type:	Culvert Replacement and Stream Enhancements
Permit Required:	PADEP GP-11, JPA

Problem Area Descriptive Location

The problem area is located along a culvert that crosses Dahl Road at the intersection of PA Route 44, which traverses Hemlock Creek.

Latitude: 41.022581
Longitude: -76.504581

Estimated Construction Cost

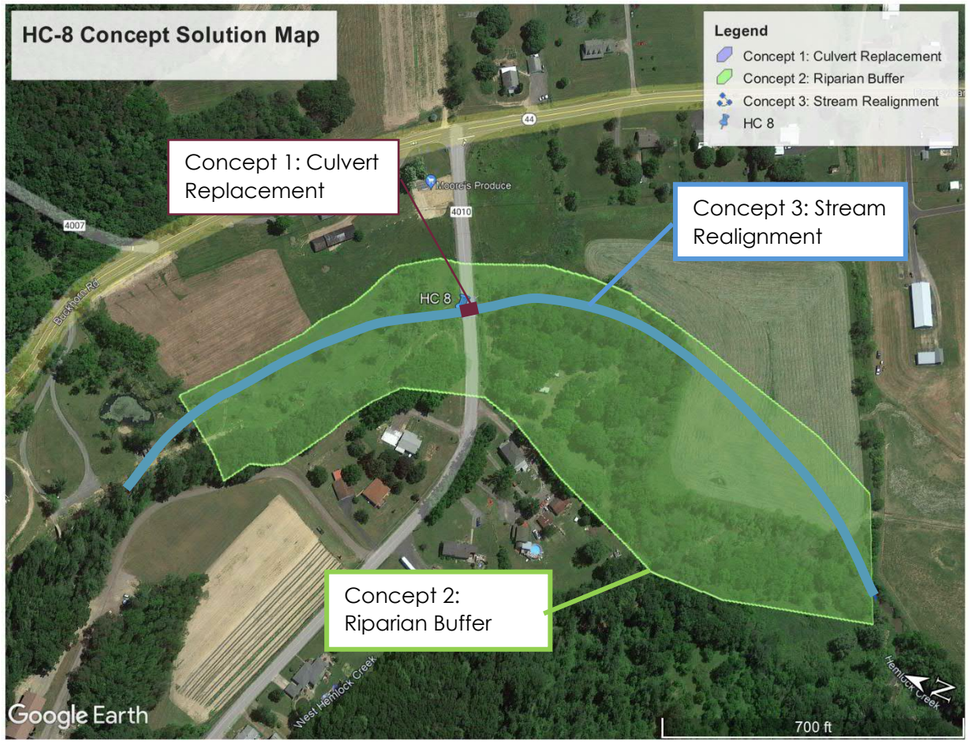
Concept 1: $300,000 - $500,000 (Culvert)
Concept 2: $300,000 - $500,000 (Riparian Buffer)
Concept 3: $500,000 - $900,000 (Stream Realignment)

Concept Impacts

Concept 1: 35 Linear Feet of Culvert Replacement
Concept 2: 12 Acres of Riparian Buffer
Concept 3: 1,150 Linear Feet of Stream Realignment

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (4.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along this section of Dahl Road has been identified. Upon further investigation, the culvert is undersized for the culvert's drainage area. Additionally, the stream's natural floodplain is in proximity to neighboring properties.

Problem Area Photo

Concept Solutions

Concept 1: Replace the existing 40' span by 5' rise concrete box culvert with a 70' span and 5' rise concrete box culvert. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing culvert overtops the roadway during the 25-year storm event. The proposed concrete box culvert is able to convey the 100-year storm without overtopping the roadway. This concept will help to mitigate flooding issues within the location of the culvert and surrounding properties.

Concept 2: Riparian Buffer Plantings will stabilize banks, filter sediment, increase filtration, and reduce flood damage within the surrounding area. This solution may be paired with Concept 1 and Concept 3 to enhance flood mitigation practices.

Concept 3: Realign Hemlock Creek away from Dahl Road and nearby residences to allow for a more natural floodplain. The floodplain of Dahl Road should also be enhanced by Concept 2: Riparian Buffer Plantings. By realigning Hemlock Creek to its' natural floodplain, the floodplain will act as a natural buffer during flood events and should mitigate the frequency of flooding within the surrounding development. During realignment, in-stream structures may be introduced to reduce stream velocity and shear stress. Additionally, in-stream structures may enhance stream quality and improve aquatic life. Stream realignment will also require Concept 1's solution for the stream crosses Dahl Road.

Frosty Valley Road (HC-9)

Hemlock Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	PennDOT
Problem Type:	Erosion, Sedimentation
Impacted Properties Anticipated:	1+
Watershed:	Hemlock Creek
Priority Level:	Low
Project Type:	Stream Bank Protection, Storm Sewer Infrastructure
Permit Required:	HOP, GP-3

Problem Area Descriptive Location

The problem area is located along an unnamed tributary to Hemlock Creek around the intersection of Frosty Valley Road and Schoolhouse Rd, and I-80.

Latitude: 41.006992
Longitude: -76.499925

Estimated Construction Cost

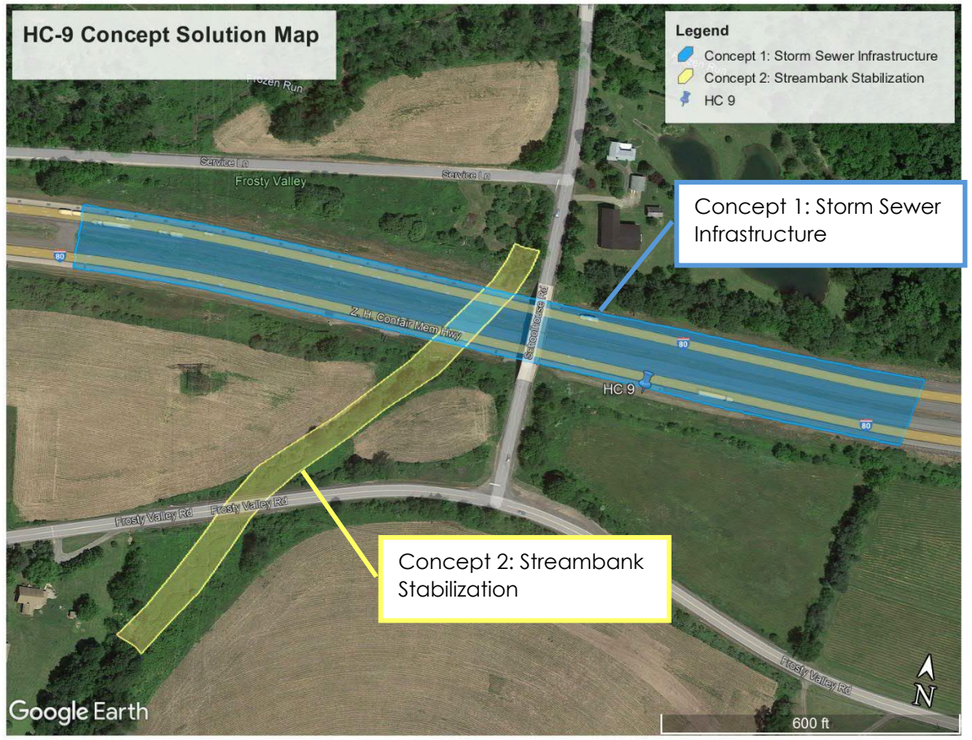
Concept 1: N/A (PennDOT Storm Sewer Infrastructure)
Concept 2: $70,000 - $130,000 (Stream Bank Protection)

Concept Impacts

Concept 1: N/A
Concept 2: 100 Linear Feet of Streambank Stabilization

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.4)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Erosion along Hemlock Creek caused by runoff from I-80 has been identified.

Problem Area Photo

Concept Solutions

Concept 1: Coordinate with PennDOT for highway drainage improvements. At the location of HC-9, Interstate I-80 lacks the proper drainage infrastructure to mitigate flooding along Hemlock Creek. The culvert along I-80 may need to be up-sized, additional inlets and storm sewers can be installed, and additional stormwater BMPs may constructed within the PennDOT right-of-way.

Concept 2: Provide streambank protection along Hemlock Creek where the drainage system from I-80 discharges into the stream. The stream may be lined with rip-rap or vegetative plantings. Streambank protection can be combined with Concept 1 to mitigate erosion along Hemlock Creek.

Wanich Covered Bridge (HC-10)

Hemlock Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding, Stream Velocity, Erosion
Responsible Entity:	Columbia County
Impacted Properties Anticipated:	1
Watershed:	Little Fishing Creek
Priority Level:	Medium
Project Type:	Bridge Raising
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at the Wanich Covered Bridge crossing Little Fishing Creek near the intersection with Thomas Road

Latitude: 41.039914
Longitude: -76.483219

Problem Area Issue

Flooding along this section of Little Fishing Creek.

Problem Area Photo

Estimated Construction Cost

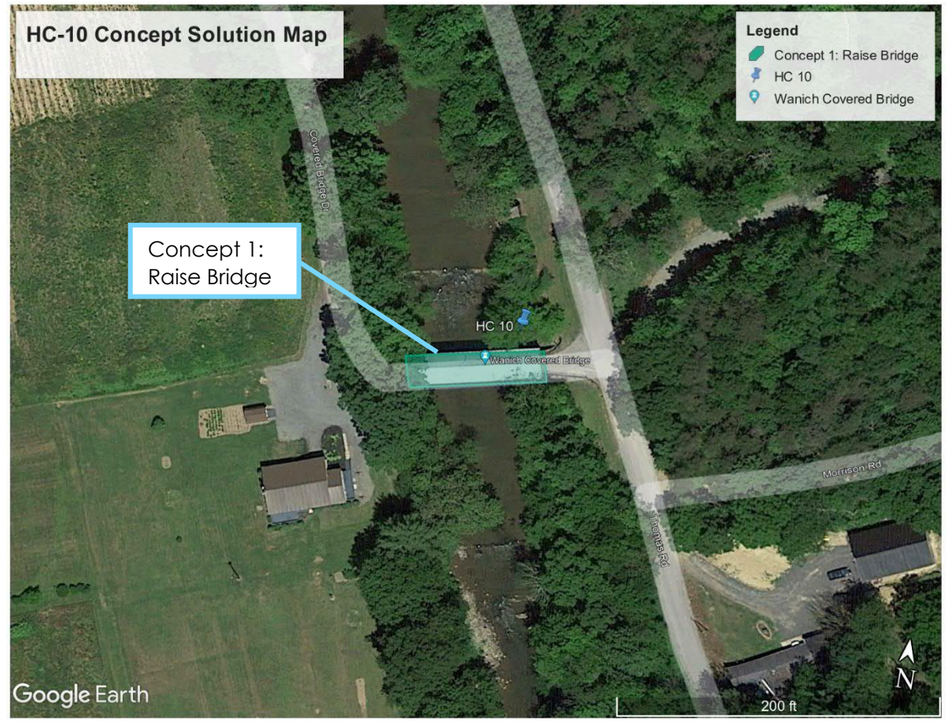
Concept 1: $150,000-$900,000 (Raise Bridge)
Concept 2: $20,000-40,000+ (Property Improvements)

Concept Impacts

Concept 1: 82' Length X 14' Width of Bridge Deck Replacement
Concept 2: 1 Property

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	10	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (4.4)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Concept Solutions

Concept 1: Raise the bridge by one foot. PennDOT classifies the bridge as being in fair/satisfactory condition. The existing bridge is 82 feet in length and 14 feet wide. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing bridge overtops the roadway during the 50-year storm event. If the bridge is raised by one foot the bridge will be able to pass the 100-year storm without overtopping the roadway. This solution is not recommended due to the this being a historical covered bridge and the solution having a minor improvement on the existing condition of the bridge.

Concept 2: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Millville Road Flooding (HC-11)

Hemlock Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	PennDOT/Hemlock Township
Problem Type:	Flooding, Stream Velocity, Erosion
Impacted Properties Anticipated:	2+
Watershed:	Little Fishing Creek
Priority Level:	Medium
Project Type:	Bridge Replacement, Floodplain Reconnection
Permit Required:	PADEP GP-11, JPA

Problem Area Descriptive Location

The problem area is located at a bridge crossing along Millville Rd just south of the intersection with PA Route 42.

Latitude: 41.027189
Longitude: -76.480897

Estimated Construction Cost

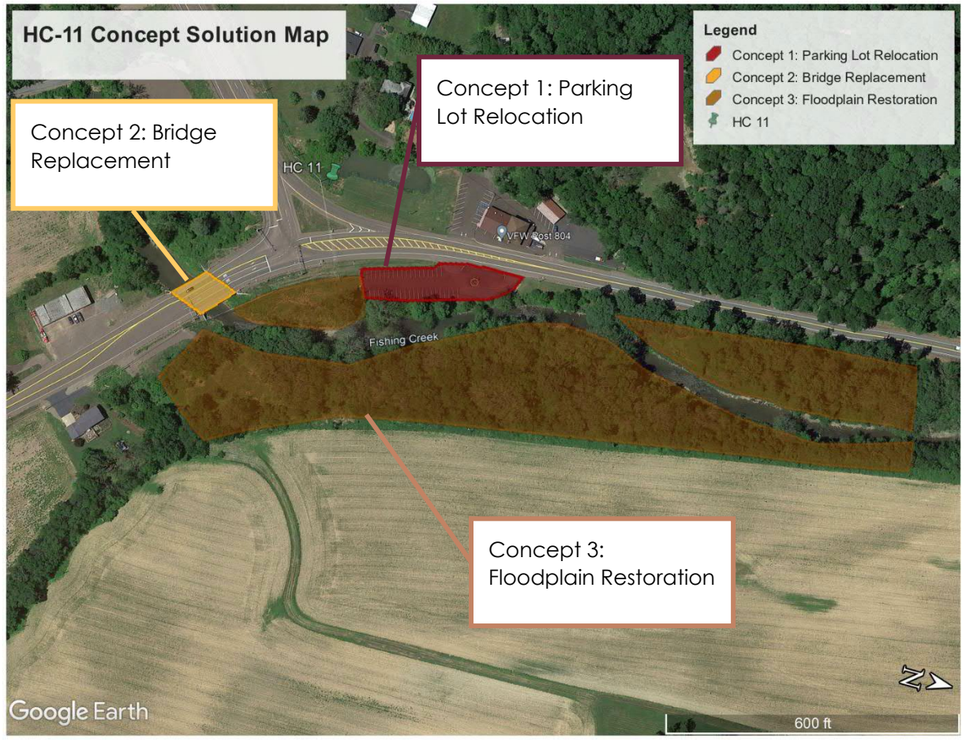
Concept 1: $.1 - $.2 Million (Parking Lot Relocation)
Concept 2: $2.2 - $4 Million (Bridge Replacement)
Concept 3: $1– 1.9 Million (Floodplain Restoration)

Concept Impacts

Concept 1: 2,400 SY of Parking Lot Replacement
Concept 2: 85' Length x 70' Width of Bridge Replacement
Concept 3: 4,000 Length x 140' Width x 3' Depth of Floodplain Restoration

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	10	1= Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (6.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

Flooding along this section of Millville Road has been identified. Upon further investigation, the bridge is undersized for the bridge's drainage area. Additionally, the stream's natural floodplain is in proximity to neighboring properties.

Problem Area Photo

Concept Solutions

Concept 1: Relocate the existing parking lot along Little Fishing Creek. The existing parking lot abuts the streambank and is within the floodway and floodplain of Little Fishing Creek. The parking lot shall be relocated to the west, away from Little Fishing Creek, outside of the floodplain. Relocation of the parking lot will lessen the frequency of flooding of the parking lot.

Concept 2: PennDOT bridge 45591 is a pre-stressed precast concrete adjacent box beam bridge built in 2009. PennDOT classifies the bridge as being in good condition. The existing bridge is 85 feet in length and 70 feet wide. Utilizing the Federal Highway Administration's (FHWA) HY-8 Culvert Hydraulic Analysis Program and the United States Geological Survey (USGS) Streamstats application for estimating stream peak flow rates, the existing bridge overtops the roadway during the 25-year storm event. If the bridge is expanded by 60 feet to a span of 130 feet, the bridge will then be able to pass the 100-year storm without overtopping the roadway. Coordination with PennDOT is required. This solution is recommended to reduce flooding.

Concept 3: Restore the floodplain upstream of the bridge by removing approximately 50,000 cubic yards of sediment. Small scale stream restorations typically result in minimal ahnge to local stream flow volume and water surface elevation but can result in a significant decrease in streamline velocities. This decrease can reduce the rate of streambank erosion and sediment deposition around the bridge and within the Creek corridor. This concept is not recommend to mitigate flooding issues, but is recommend for watershed-wide resiliency.

Ridge Road Flooding (HC-12)

Hemlock Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	State Highway Agency / Columbia County / Private Owners
Problem Type:	Flooding/Erosion
Impacted Properties Anticipated:	2
Watershed:	Hemlock Creek
Priority Level:	Medium
Project Type:	Bridge Replacement/ Driveway Relocation/ Streambank Stabilization
Permit Required:	GP-11/GP-3

Problem Area Descriptive Location

The problem area is located at the bridge on Ridge Road approximately 1,000 feet to the southwest of the intersection of Ridge Road and PA 42.

Latitude: 40.995761
Longitude: -76.486125

Problem Area Issue

During large rainfall events flows from Hemlock Creek overtops Ridge Road and floods out the properties located next to the roadway. Upon further investigation, active streambank erosion along the upstream left overbank was observed. Additionally, the driveway to the private lot located to the west of the Bloomsburg Auto Auction was washed out and evidence of frequent ponding was observed.

Problem Area Photo

Estimated Construction Cost

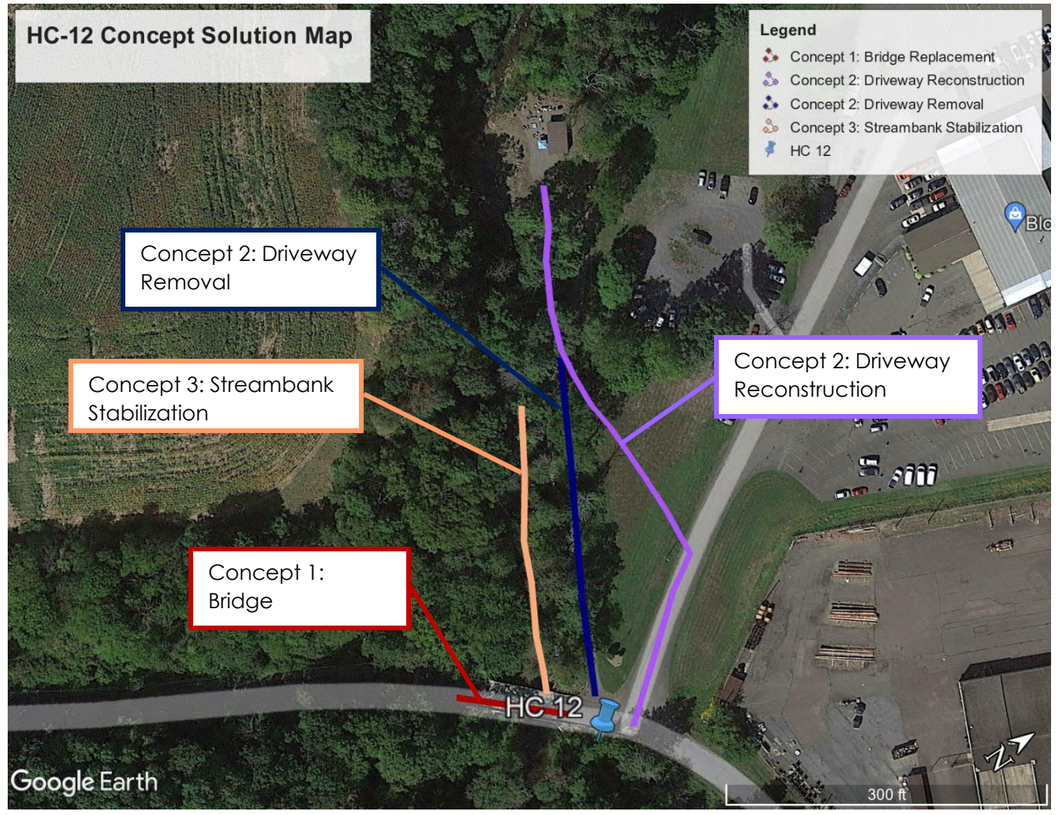
Concept 1: $0.9 - $1.7 Million (Bridge Replacement)
Concept 2: $63,000 - $120,000 (Driveway Reconstruction & Removal)
Concept 3: $0.2-$0.4 Million (Streambank Stabilization)

Concept Impacts

Concept 1: 85' Length x 28' Width of Bridge Replacement
Concept 2: 740 SY of Driveway Reconstruction
Concept 3: 275' Linear Feet of Streambank Stabilization

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Concept Solutions

Concept 1: Replacement of the Ridge Road bridge. The existing bridge is a state owned bridge constructed in 1957 and is in good conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could improve the capacity of the bridge and reduce flooding cause by the obstruction. Preliminary hydraulic analysis results show that the existing hydraulic opening is sufficient to past the 10-year design storm without overtopping the roadway. Extension of the bridge length by 25 feet and increasing the height of the waterway opening by 6 inches allows the proposed bridge to pass the 25-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Reconstruction and pavement of the existing driveway to the private lot and the Bloomsburg Auto Auction. This concept would combine the existing two driveways into a single shared access. The connection of the driveways would remove one ingress/egress point from Ridge Road and would shift the access point to the private lot away Hemlock Creek. The proposed driveway located off of the shared access would be paved. This concept would reduce the frequency/severity of driveway flooding and reduce the amount of washout by improving the driveway from gravel to bituminous pavement. This concept would require agreements between the two property owners prior to implementation. This concept is recommended to be implemented by the private owner to improve lot access.

Concept 3: Stabilize 275 feet of stream bank along the upstream left overbank of Hemlock Creek. This option would result in a de-minimis change to flooding but would protect the property along Hemlock Creek by reinforcing the banks and reducing the rate of stream bank erosion. This concept is not recommended to mitigate flooding issues but is recommended to protect the property located on the left overbank.

Perry Avenue Bridge (HC-13)

Hemlock Township & Montour Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding
Responsible Entity:	Hemlock Township/Montour Township/Columbia County
Impacted Properties Anticipated:	3
Watershed:	Fishing Creek
Priority Level:	High
Project Type:	Bridge Removal/Replacement
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at the Perry Avenue Bridge over Hemlock Creek near the intersection with Red Mill Road.

Latitude: 40.996008
Longitude: -76.475983

Estimated Construction Cost

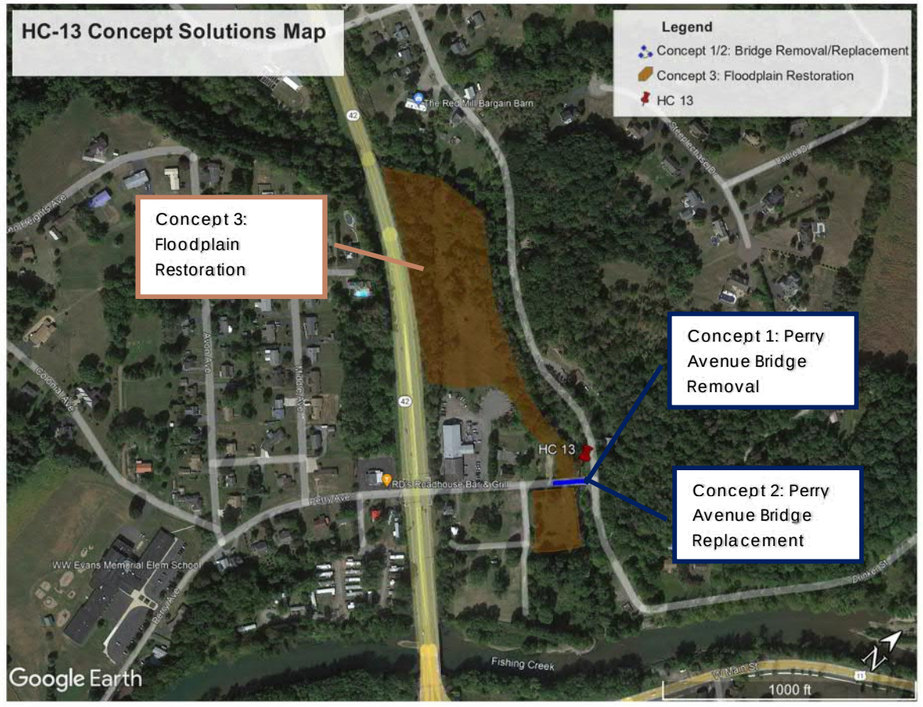
Concept 1: $40,000-$80,000 (Perry Avenue Bridge Removal)
Concept 2: $0.6-$1.2 Million (Perry Avenue Bridge Replacement)
Concept 3: $0.6-$1.2 Million (Floodplain Restoration)
Concept 4: $90,000+ (Property Improvements)

Concept Impacts

Concept 1: 60' Length x 22' Width of Bridge Removal
Concept 2: 140' Length x 22' Width of Bridge Replacement
Concept 3: 150' Length x 150' Width x 3' Depth of Floodplain Restoration
Concept 4: 1-3 Properties

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	10	1 = Few 10 = Many
Frequency of Existing Problem	5	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Infrequent 10 = More Frequent
Resiliency	10	1 = More Maintenance, 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	High (7.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10



Problem Area Issue

The existing bridge on Perry Avenue is significantly undersized having a waterway opening approximately 1/4 the area of the bridges upstream. During rainfall events this causes the stream to back up and overtop Perry Avenue with standing water reaching all of the way up to the County building located near the intersection with SR 42.

Problem Area Photo

Concept Solutions

Concept 1: Removal of the Perry Avenue bridge. The existing bridge was constructed in 1926 and is in fair/poor conditions as assessed by the Pennsylvania Department of Transportation (PennDOT. The existing structure is able to pass enough flows to prevent the 10-year design storm from overtopping Perry Avenue. Preliminary hydraulic analysis results show that removal the existing bridge would restore hydraulic capacity of the existing stream channel and reduce the 100-year water surface elevation by approximately 5 feet within the proximity of the old bridge. This would bring the 100-year water surface elevation to approximately the same elevation as the top of the existing bridge. This is our recommended solution to improve the conditions at this problem area.

Concept 2: Replacement of the Perry Avenue bridge. The existing bridge was constructed in 1926 and is in fair/poor conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding caused by the obstruction. The existing structure is able to pass enough flows to prevent the 10-year design storm from overtopping Perry Avenue. Preliminary hydraulic analysis results show that replacing the existing bridge with a single span bridge with twice the span of the existing bridge, expanding the channel, and removing built-up sediment in the existing channel would create a waterway opening that is similar to that of the upstream bridges and would allow the bridge to pass the 25-year design storm without overtopping Perry Avenue. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. If the removal of the bridge is not a viable solution for Responsible Entities, then this would be the next recommended solution to improve conditions at this problem area.

Concept 3: Floodplain restoration upstream and downstream Perry Avenue. This solution would very slightly drop the water surface elevation during large storm events. This concept is not recommended to mitigate flooding issues, however, this concept is recommended to reduce flow velocities and reduce streambank erosions which will in turn increase the resiliency of the bridge.

Concept 4: Individual property owners affected by significant flooding could seek out mitigation options that include: property improvements consisting of floodproofing, elevating, or relocating structures out of the floodway/floodplain or determining if their property is eligible to be bought out through a flood buyout program.

Fernville / West End Flooding (HC-14 & 16)

Hemlock Township and Town of Bloomsburg

General Information

Ownership:	Public/Private
Problem Type:	Flooding
Impacted Properties Anticipated:	200+
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	TBD
Permit Required:	TBD

Problem Area Descriptive Location

The problem area is the village of Fernville in the Hemlock Township and the West End area of the Town of Bloomsburg west and north of Railroad Street bridge and along the Fishing Creek stream channel corridor.

HC-14: Fernville
Latitude: 41.004494
Longitude: -76.463603

HC-16: Railroad Street Bridge
Latitude: 41.002142
Longitude: -76.462914

Estimated Construction Cost

Concept 1: Refer to West End Study

Concept Impacts

Concept 1: Refer to West End Study

Assessment and Analysis of Solutions

Category	Score	Scale
Property or Public Impacts	10	Low = Few High = Many
Frequency of Existing Problem	5	Low = Infrequent High = More Frequent
Flood Level Reduction	5	Low = Infrequent High = More Frequent
Resiliency	5	Low = More Maintenance, High = Long-Lasting
Construction Cost	1	Low = Significant Cost ($$$) High = Less Cost ($)
Priority Score Total =	Medium (5.2)	Low = 1-3.9, Medium = 4.0-6.9, High = 7.0-10

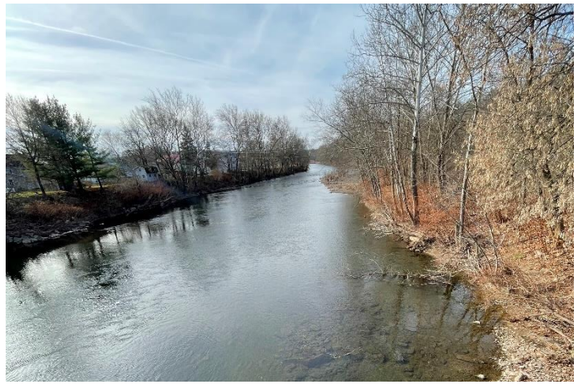
Problem Area Issue

During large rainfall events flows from Fishing Creek begin to inundate areas of Fernville and West End of Bloomsburg. Railroad Street is the last access point out of Fernville after Creek Road and Drinker Street flood. When this occurs access in and out of Fernville for residents, emergency vehicles, etc. is shutdown. Areas of the West End of Bloomsburg flood during similar events areas near the Bloomsburg Fairgrounds and residential properties are impacted.

Concept Solutions

Concept 1: This problem area is being evaluated as part of their West End Flood Study. The West End Flood Mitigation Study is in being completed. Preliminary findings can be found via Columbia County and SEDA-COG resources. The following hyperlink provides a summary of the study to date: https://seda-cog.org/wp-content/uploads/West-End-Flood-Study-Final-Public-Meeting-Presentation-Mar-10-2022.pdf

Problem Area Photos



Hoffman Park Trail Erosion (HC-15)

Town of Bloomsburg

General Information

Affected Land Ownership:	Public
Responsible Entity:	State Highway Agency / Columbia County
Problem Type:	Erosion/Flooding
Impacted Properties Anticipated:	2
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Bridge Replacement/ Floodplain Reconnection/ Streambank Stabilization
Permit Required:	PADEP GP-11/GP-3/JPA

Problem Area Descriptive Location

The problem area is located at Hoffman Park east of the Millville Road crossing of Fishing Creek.

Latitude: 41.022832
Longitude: -76.472899

Estimated Construction Cost

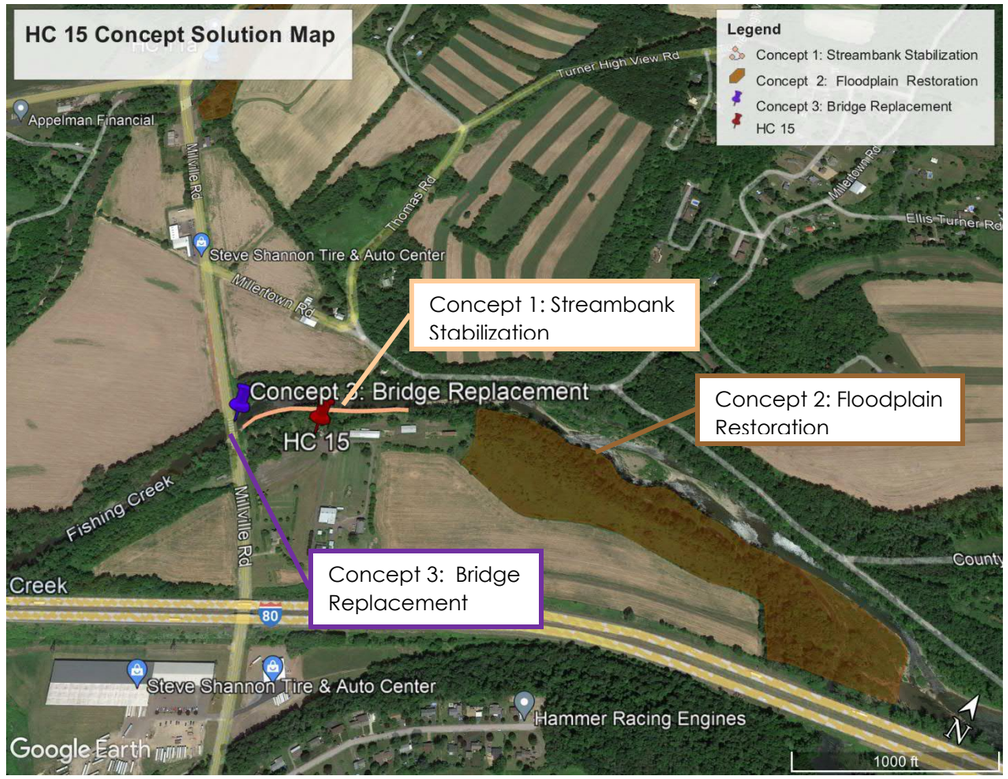
Concept 1: $0.4-$0.8 Million (Streambank Stabilization)
Concept 2: $2.3-$4.2 Million (Floodplain Restoration)
Concept 3: $2.3-$4.3 Million (Bridge Replacement)
Concept 4: See HC-3

Concept Impacts

Concept 1: 1,000 Linear Feet of Streambank Stabilization
Concept 2: 2,500' Length x 375' Width x 3' Depth of Floodplain Restoration
Concept 3: 300' Length x 24' Width of Bridge Replacement
Concept 4: See HC-3

Project Prioritization

Category	Score	Scale
Property or Public Impacts	1	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Minimal 10 = Significant
Resiliency	10	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (5.4)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Continual erosion of the Fishing Creek banks have been identified at the project site. There is concern that continued erosion of the stream banks will compromise the existing trail through Hoffman Park and make it unsafe for the public to use.

Problem Area Photo

Concept Solutions

Concept 1: Stabilize 1,000 feet of stream bank. This concept would reinforce the banks along Fishing Creek and reduce the rate of stream bank erosion protecting the trail and prolonging its use. This concept is recommended to reduce the rate of streambank erosion and to prolong the use of the walking trail at Hoffer Park.

Concept 2: Floodplain reconnection within the left overbanks of Fishing Creek directly east of Hoffman Park. This option would consist of regrading the forested area which would improve the conveyance capacity of Fishing Creek's left overbank. Construction of this concept would result in 100,000 cubic yards of material removed from the Fishing Creek Floodplain. A reduction in velocity and water surface were observed throughout the restored reach and approximately 3,000 feet upstream of the improvements. No improvements were observed downstream from the floodplain reconnection. Velocities were reduced by approximately one foot per second (fps) throughout all storm events within the sections of observed changes and water surface elevations were reduced by 0-8 inches for all storm events within the sections of observed changes. This concept is not recommended to mitigate flooding issues, but is recommended for watershed-wide resiliency.

Concept 3: Replacement of Millville Road Bridge. The existing bridge is a state owned steel truss bridge constructed in 1930 and is in fair conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates, the existing bridge is able to convey the 2-year design storm peak flow rates through the hydraulic opening and able to convey the 10-year design storm peak flow rates without surcharging the bridge deck. In this concept, the bridge deck is raised by two feet and the roadway approaches are reconstructed. The proposed structure would be able to convey the 10-year design storm peak flows through the hydraulic opening and able to convey the 25-year design storm peak flow rates without surcharging the bridge deck. It is noted that Millville Road would still flood due to it being located at a lower elevation than the bridge deck. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area. This concept is recommended to mitigate flooding issues within the problem area.

Concept 4: Improvements upstream of the park. Please see the Problem Area Solution Table for problem area HC 3 for more information.

Boone's Dam (HC-17)

Town of Bloomsburg

General Information

Affected Land Ownership:	Public
Responsible Entity:	Columbia County
Problem Type:	Erosion/Flooding
Responsible Entity:	Town of Bloomsburg
Impacted Properties Anticipated:	2
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	Dam removal
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

The problem area is located at Boone's Dam on Fishing Creek.

Latitude: 40.985769
Longitude: -76.474494

Estimated Construction Cost

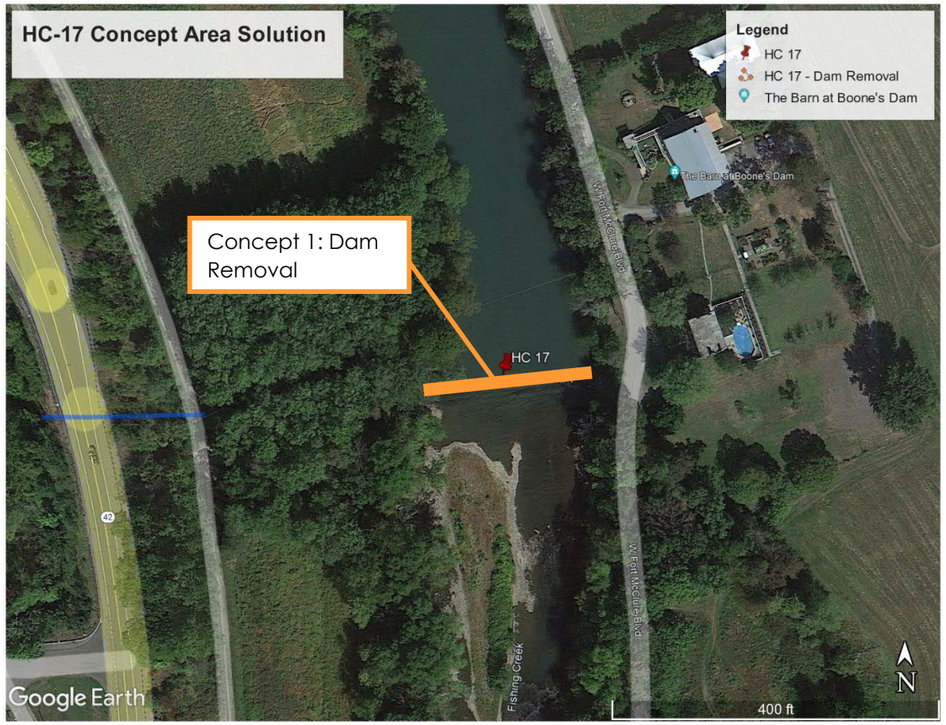
Concept 1: $175,000-$325,000 (Dam Removal)
Concept 2: $0.5-$1 Million (Dam Repair)

Concept Impacts

Concept 1: 250 feet of Dam Removal
Concept 2: 250 feet of Dam Replacement

Project Prioritization

Category	Score	Scale
Property or Public Impacts	1	1= Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	1	1 = Infrequent 10 = More Frequent
Resiliency	1	1 = More Maintenance 10 = Long-Lasting
Construction Cost	10	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (2.8)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Boone's Dam is currently in a state where future repairs are likely to be required.

Problem Area Photo

Concept Solutions

Concept 1: Removal of Boone's Dam. Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flows, preliminary H&H analysis indicates that the removal of the dam would have a di-minimus impact on the water surface elevation during all rainfall events. This is most likely caused by the backwater effect from the Susquehanna River. The backwater effect causes Boones Dam to be highly submerged during all rainfall events resulting in the hydraulics over the dam being governed by gravity rather than the flows over the dam. This solution is not recommend for flood mitigation, however, it is recommended due to the detrimental impacts that low head dams are known to have on stream ecosystems.

Concept 2: Repair Boone's Dam as necessary. This would require detailed structural and geotechnical analysis. This concept is not recommended due to the detrimental environmental impacts that low head dams have on stream ecosystems.

Fishing Creek Corridor Improvements by Lake Florence (HC-18)

Scott Township

General Information

Affected Land Ownership:	Public/Private
Responsible Entity:	Private Owner / Columbia County / Scott Township
Problem Type:	Flooding
Impacted Properties Anticipated:	2
Watershed:	Fishing Creek
Priority Level:	Medium
Project Type:	Floodplain Reconnection
Permit Required:	PADEP JPA

Problem Area Descriptive Location

The problem area is located along the Fishing Creek corridor adjacent to Lake Florence.

Latitude: 41.034944
Longitude: -76.431437

Estimated Construction Cost

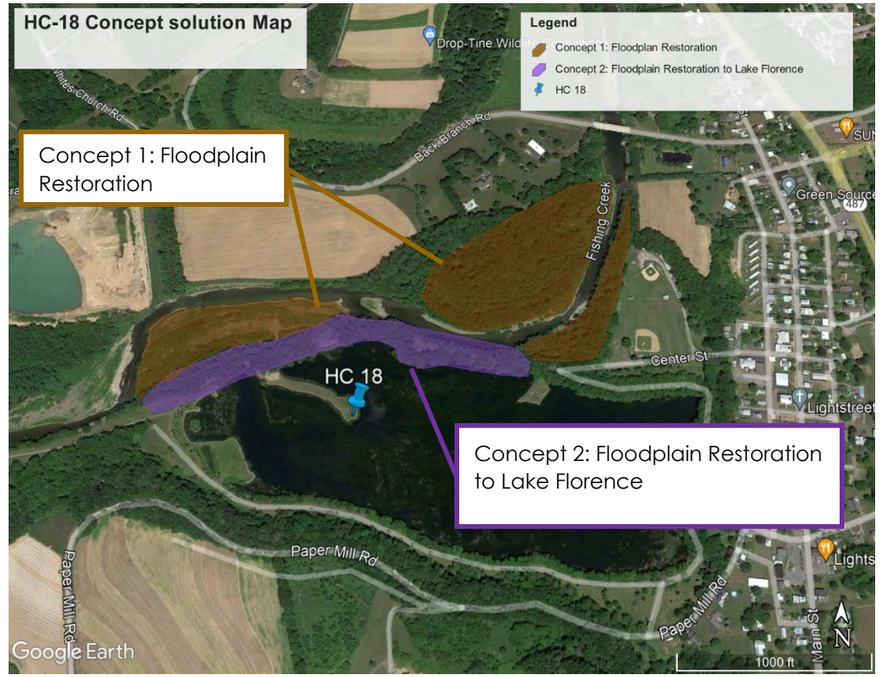
Concept 1: $3.3-$6.1Million (Floodplain Restoration)
Concept $2.5-$4.6 Million (Floodplain Restoration to Lake Florence)

Concept Impacts

Concept 1: 1,200' Length x 130' Width x 3' Depth of Floodplain Restoration
Concept 2: 2,500' Length x 300' Width x 3' Depth of Floodplain Restoration

Project Prioritization

Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	10	1 = Infrequent 10 = More Frequent
Flood Level Reduction	10	1 = Minimal 10 = Significant
Resiliency	5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Medium (6.2)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

Fishing Creek is known to cause severe flooding within the problem area and further downstream. Lake Florence and the surrounding properties have been identified as potential floodplain reconnection areas to help alleviate downstream flooding.

Problem Area Photo

Concept Solutions

Concept 1: Floodplain reconnection within the overbanks along Fishing Creek. Three distinct location of floodplain reconnection are proposed within this concept. The locations are on the left (28,000 CY) and right (100,000 CY) overbanks directly downstream from the Back Branch Road Bridge and on the left overbank downstream from Lake Florence (30,000 CY). This concept would result in approximately 158,000 CY of sediment being permanently removed from the Fishing Creek Floodplain. Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates, the proposed project would result in a 1-2 inch decrease in water surface elevation for all storm durations throughout the restored floodplain sections and a de-minimis change upstream and downstream of the restored sections. A decrease in velocity by approximately 5%-10% is also seen throughout the restored sections and no change upstream and downstream. The locations of the proposed floodplain reconnection sections are located on private land and negotiations with the property owner would be required before this project could be completed. This concept is recommended to mitigate flooding issues within the problem area.

Concept 2: Connecting the Fishing Creek floodplain to Lake Florence. In this concept, Lake Florence would continue to remain a lake, however, 12 feet of the 23 feet tall embankment would be removed to allow the Fishing Creek floodplain to overflow and utilize the available storage capacity in Lake Florence during high flow conditions. Utilizing the Army Corp of Engineers (USACE) Hydrologic Engineering Center River Analysis System (HEC-RAS) and HRG developed peak flow rates, the proposed project would result in a decrease in water surface elevation by 1-8 feet throughout connected floodplain sections for various analyzed storm events. The 100-year storm event saw the largest decrease in water surface elevation (6-8 feet) whereas the smaller and larger storm saw a significantly smaller decrease (1-6 feet). A small decrease in water surface elevation is seen upstream from the proposed improvements, however, these improvements become de-minimis further upstream from the Back Branch Road bridge. Approximately 600 feet downstream from Lake Florence, the proposed water surface elevation converges with the existing meaning no further improvements are seen farther than 600 feet downstream. Although this project would result in a significant improvements to the Fishing Creek floodplain, it is noted that Lake Florence is privately owned and negotiations with the property owner would be required before this project could be completed. This concept is recommended to mitigate flooding issues within the problem area.

Hock Road Bridge (HC-19)

Montour Township

General Information

Ownership:	Public/Private
Problem Type:	Flooding/Sedimentation
Responsible Entity:	Columbia County/PennDOT
Impacted Properties Anticipated:	4
Watershed:	Fishing Creek
Priority Level:	Low
Project Type:	Bridge Replacement
Project Impact:	865 SF of Bridge Deck
Permit Required:	PADEP GP-11

Problem Area Descriptive Location

Latitude: 40.996758
Longitude: -76.475478

The problem area is located on the Market Street bridge which crosses Each Branch Fishing Creek and along the East Branch Fishing Creek corridor upstream of the bridge crossing.

Estimated Construction Cost

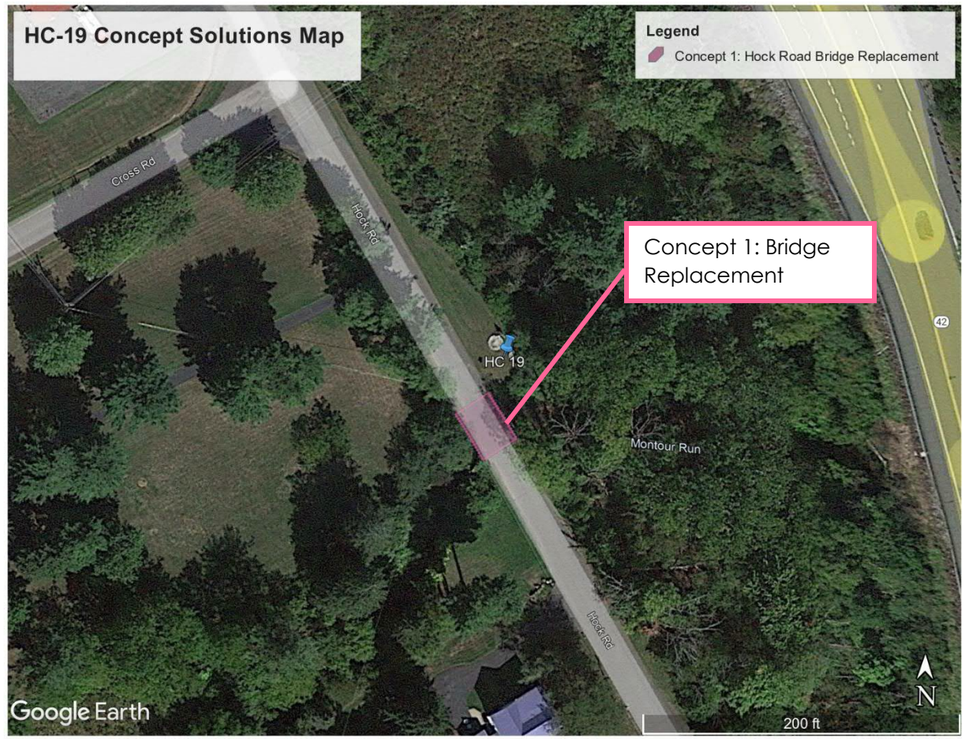
Concept 1: $400,000-$800,000 (Hock Road Bridge Replacement)

Concept Impacts

Concept 1: 34' Length X 24' Width of Bridge Replacement

Assessment and Analysis of Solutions

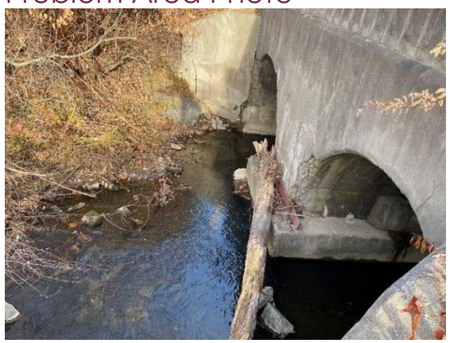
Category	Score	Scale
Property or Public Impacts	5	1 = Few 10 = Many
Frequency of Existing Problem	1	1 = Infrequent 10 = More Frequent
Flood Level Reduction	5	1 = Infrequent 10 = More Frequent
Resiliency	7.5	1 = More Maintenance 10 = Long-Lasting
Construction Cost	1	1 = Significant Cost ($$$) 10 = Less Cost ($)
Priority Score Total =	Low (3.9)	Low = 1-3.9, Medium = 4.0-6.9 High = 7.0-10



Problem Area Issue

The existing Hock Road bridge crossing Montour Run consist of two large arched culverts separated by a large pier in the middle that is not aligned with the stream channel. During large storm events this structure constricts the waterway and debris being carried downstream by the high flows gets caught on the pier which can further constrict the waterway.

Problem Area Photo



Concept Solutions

Concept 1: Replacement of the Hock Street bridge. The existing bridge was constructed in 1927 and is in poor/serious conditions as assessed by the Pennsylvania Department of Transportation (PennDOT). Reconstruction and redesign of the bridge could further to improve the capacity of the bridge and reduce flooding caused by the obstruction. With the existing bridge, the roadway overtops during the 100-year storm. Preliminary hydraulic analysis results show that removing the existing bridge and replacing it with a single span bridge would allow the proposed bridge to pass the 500-year design storm without overtopping the roadway. The feasibility of these improvements would require further investigations and more detailed evaluations of the structural and traffic related elements of the problem area.

APPENDIX D – PRIORITIZED PROBLEM AREAS AND WATERSHED SOLUTIONS MODEL RESULTS

SUMMARY MODEL OUPUT

HYDROLOGIC MODEL RESULT MAPS

Columbia County Countywide Action Plan Model Results

HYDRAULIC MODEL RESULT MAPS

Countywide Action Plan Model Results:

- Benton Area
- Stillwater Area
- Millville Area
- Middle/Lower Fishing Creek
- Hemlock Creek

All Projects with Countywide Action Plan Model Results:

- Benton Area
- Stillwater Area
- Millville Area
- Middle/Lower Fishing Creek
- Hemlock Creek

Countywide Action Plan (10-year Flow)
Fishing Creek Watershed Study
Columbia County, Pennsylvania

Countywide Action Plan
Stream (NHD)
Fishing Creek Watershed Boundary
Study Area
Subbasins
Municipal Boundary
County Boundary

0 1 2 Miles

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/7/2022	PM: MV	GIS: ALV	QA: BTK	R006222.0425

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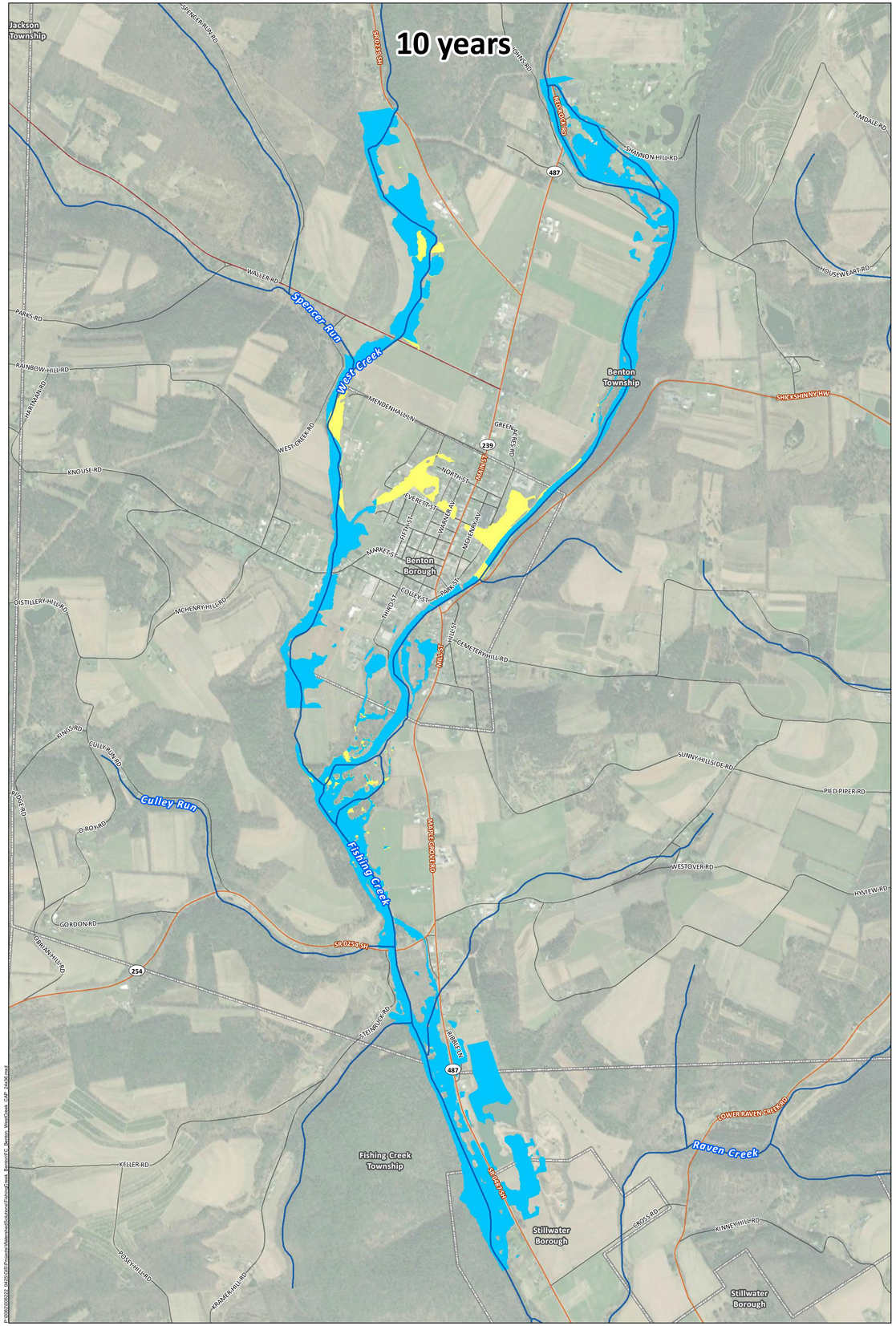

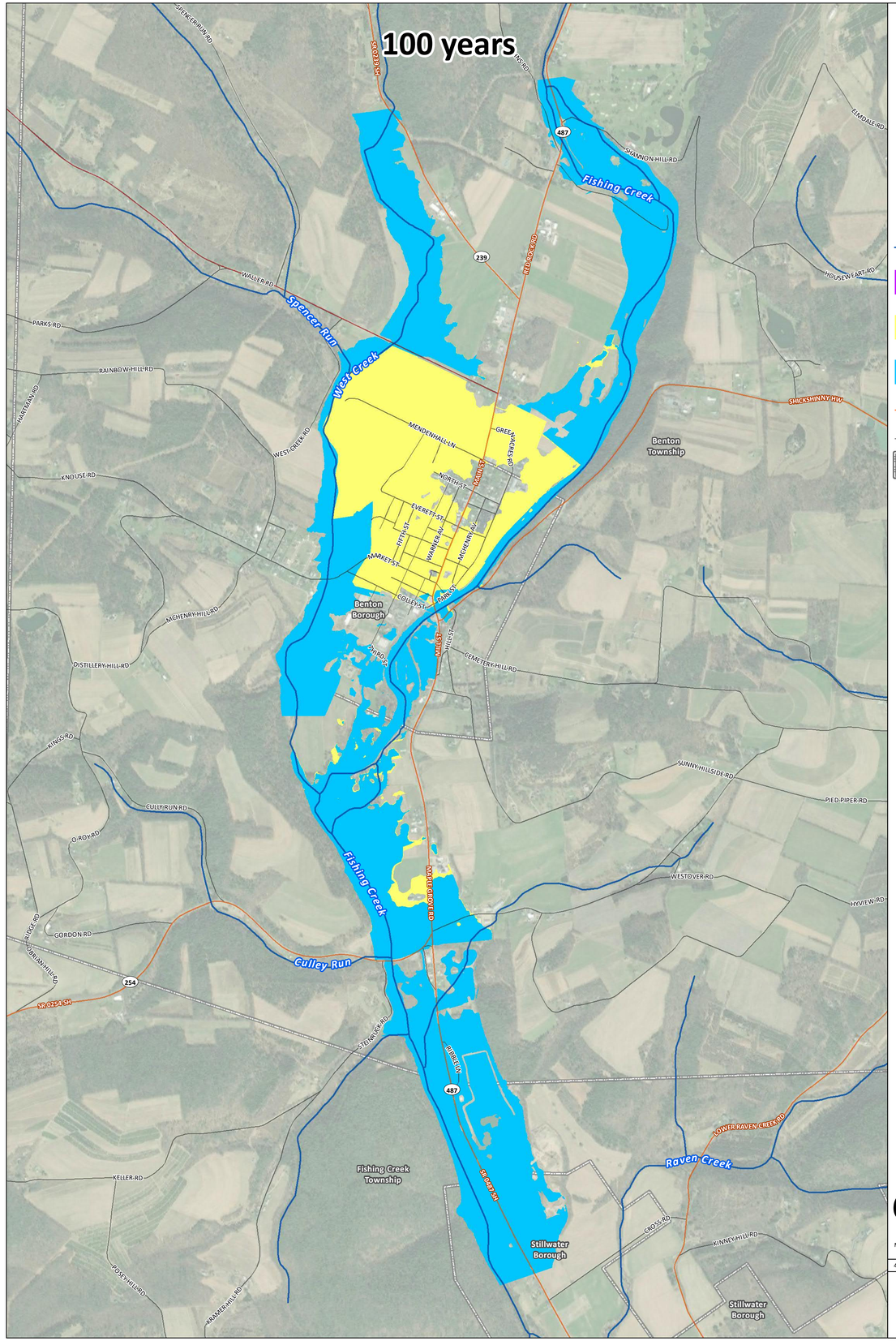

Fishing Creek- Benton CAP Run

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area- Increase
- High Hazard Flood Area- Decrease
- High Hazard Flood Area- No Change
- State Road
- Local Road
- Municipal Boundary

1,000 0 1,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/19/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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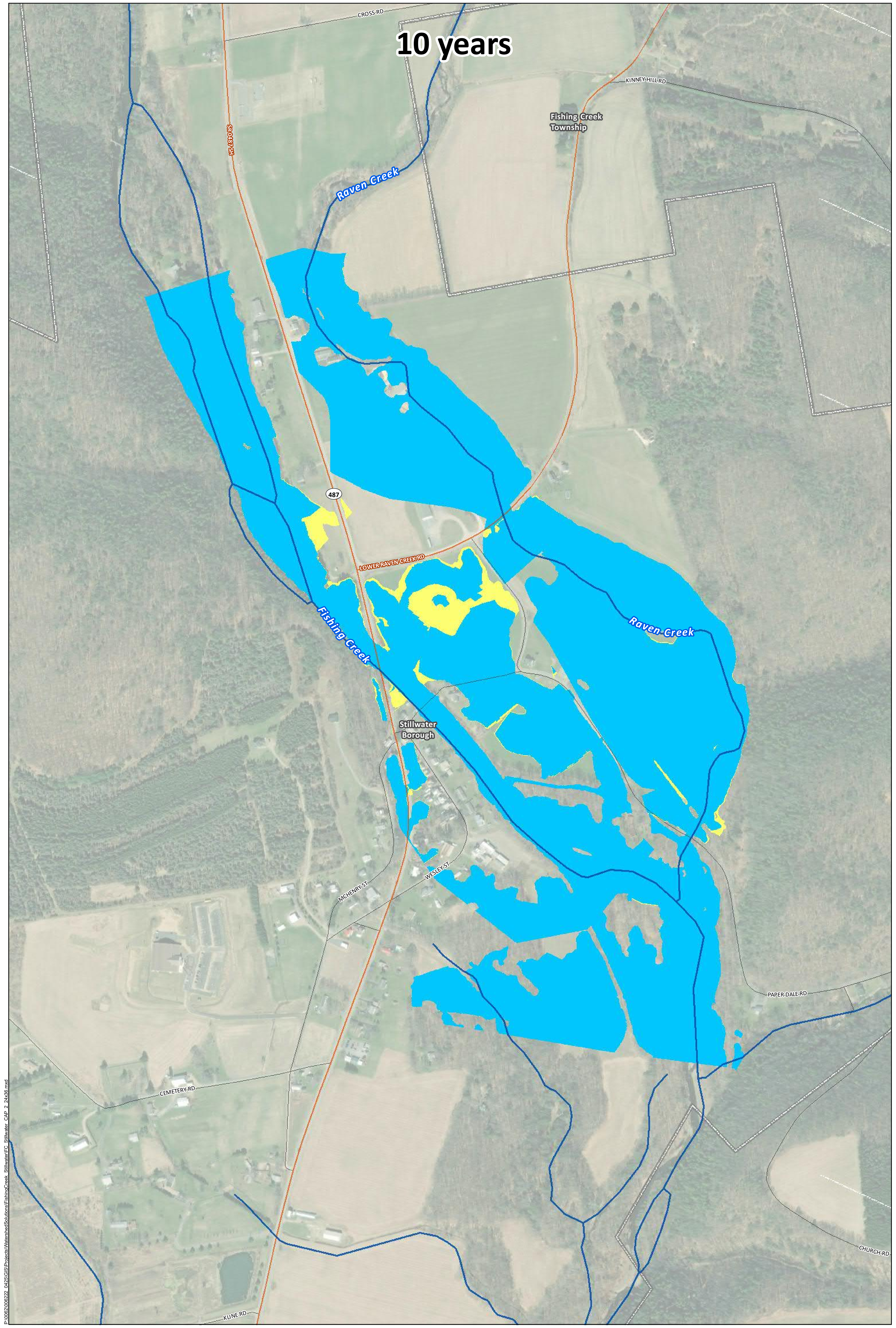

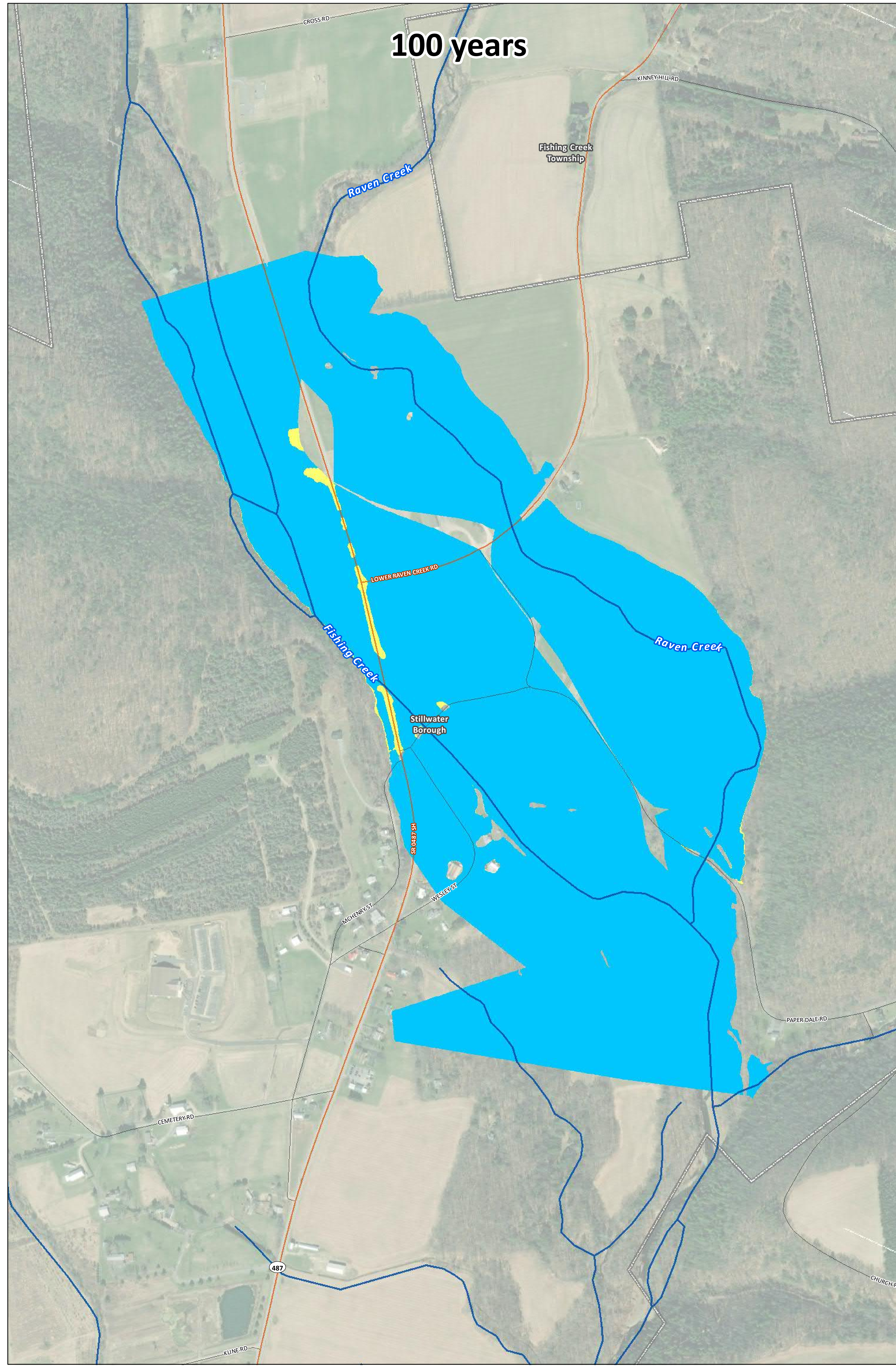

Fishing Creek- Stillwater CAP Runs

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

350 0 350 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/18/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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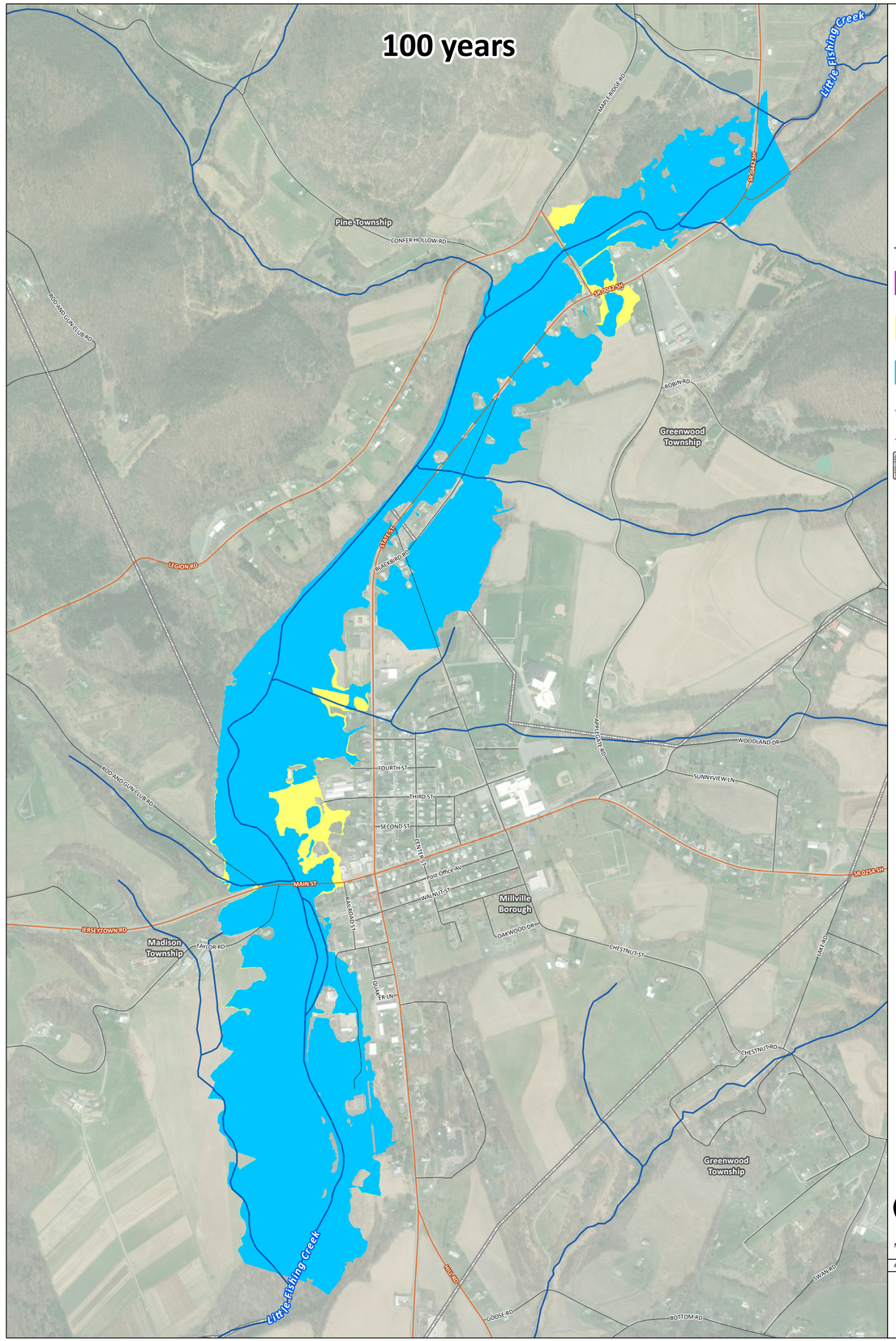
10 years

100 years



Little Fishing Creek-Millville CAP Runs

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

550 0 550 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/19/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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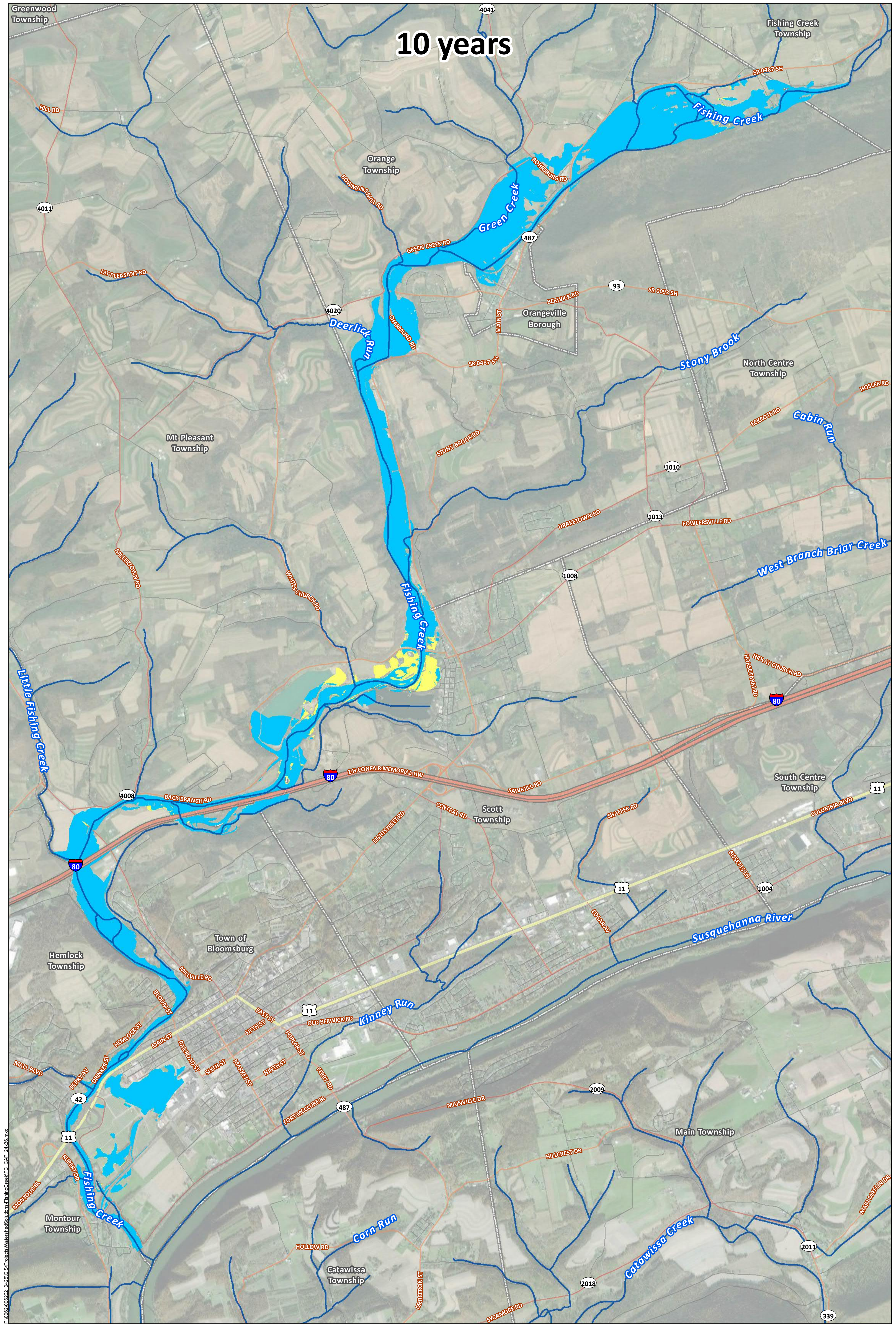

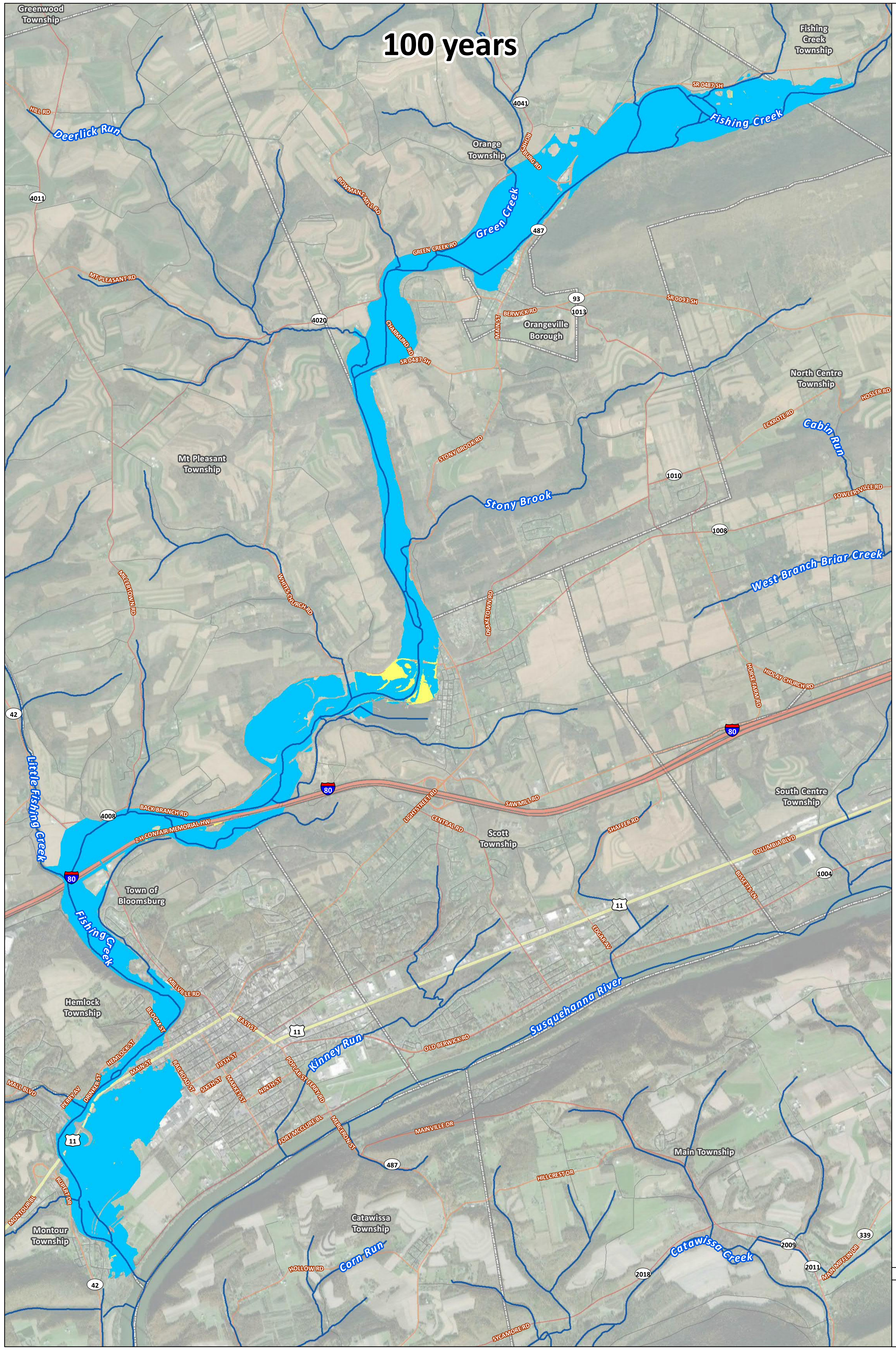

Fishing Creek
CAP Run

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

1,100 0 1,100 2,200 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/18/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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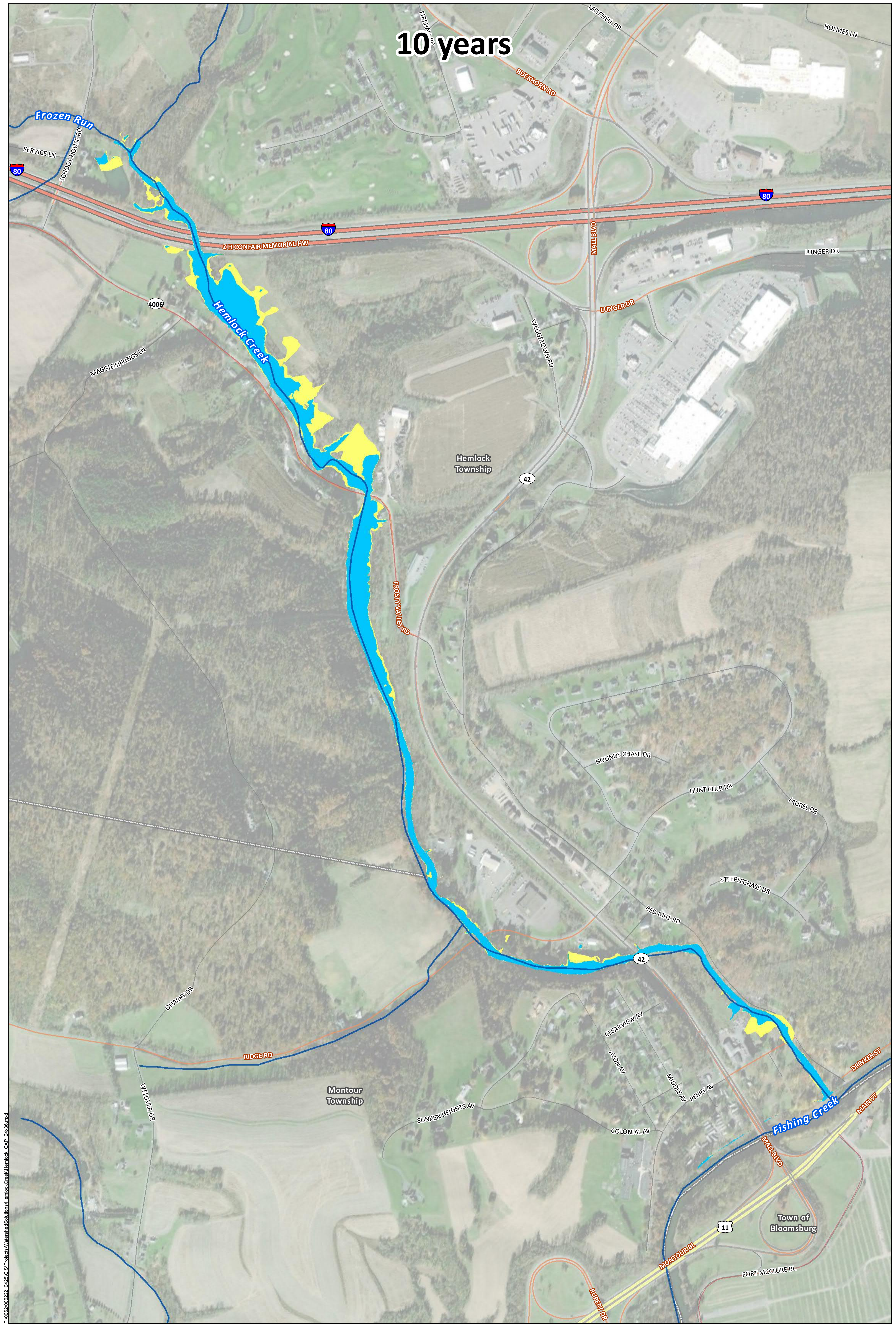

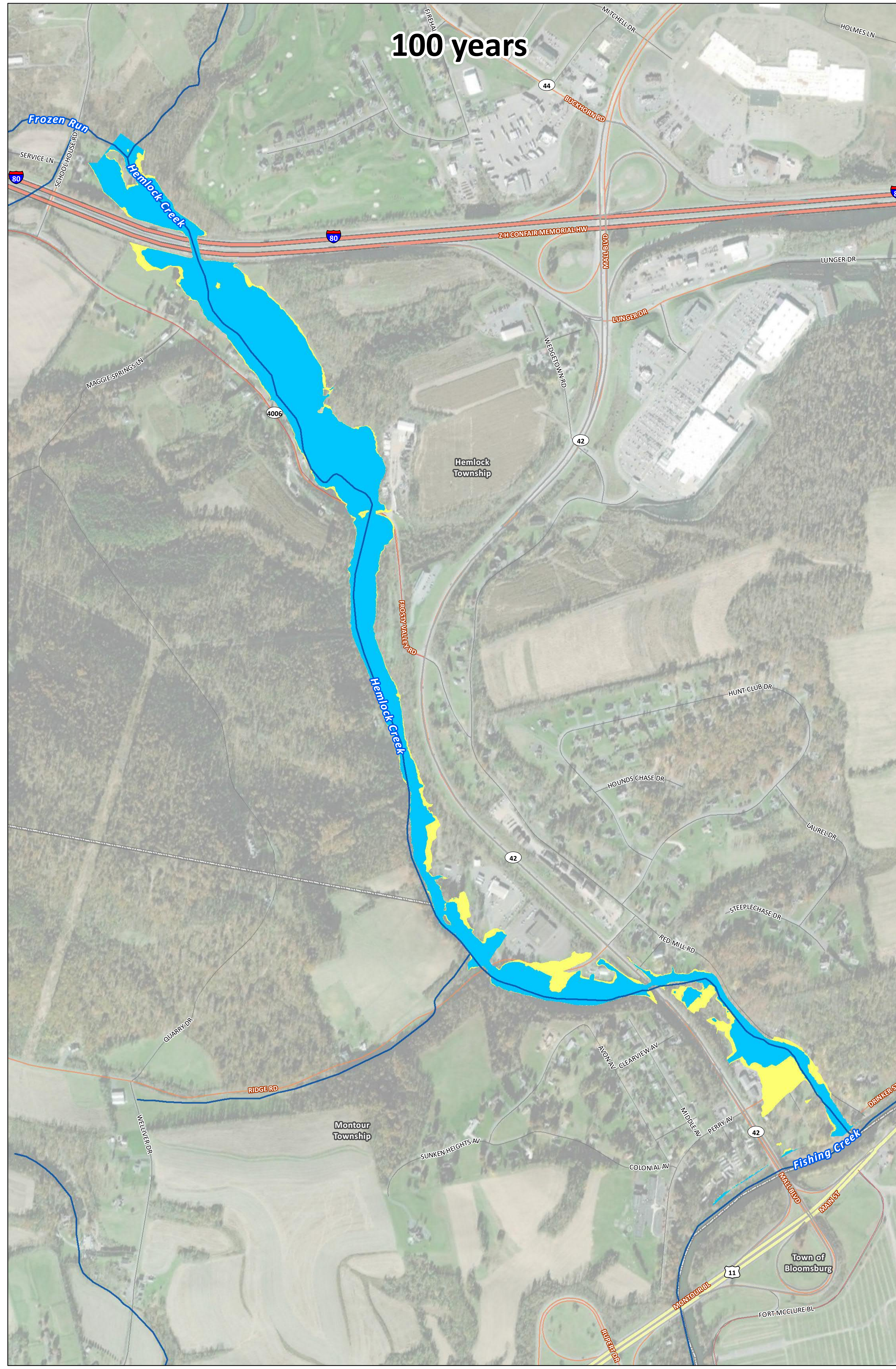

Hemlock Creek
CAP Run

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

500 0 500 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/19/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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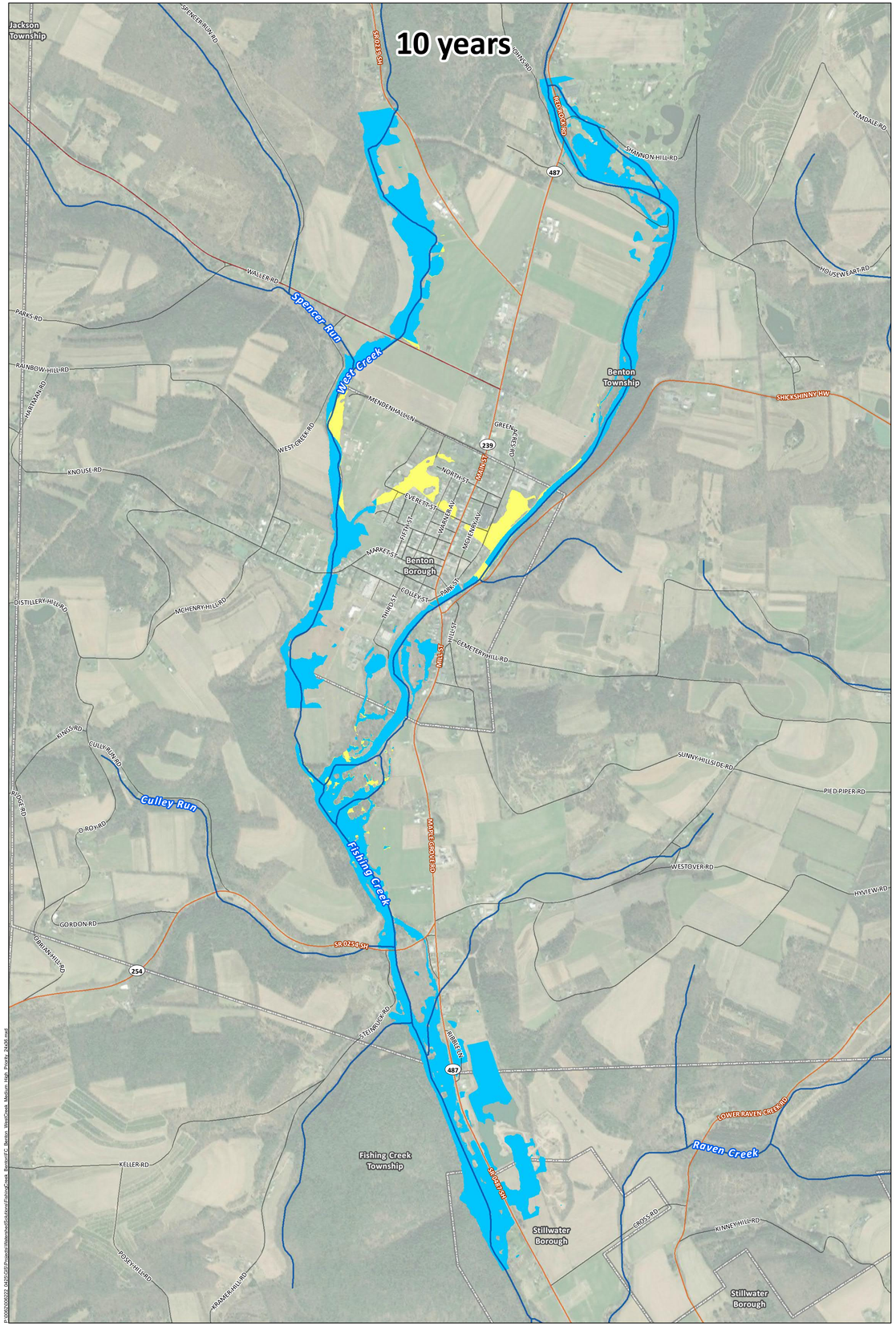

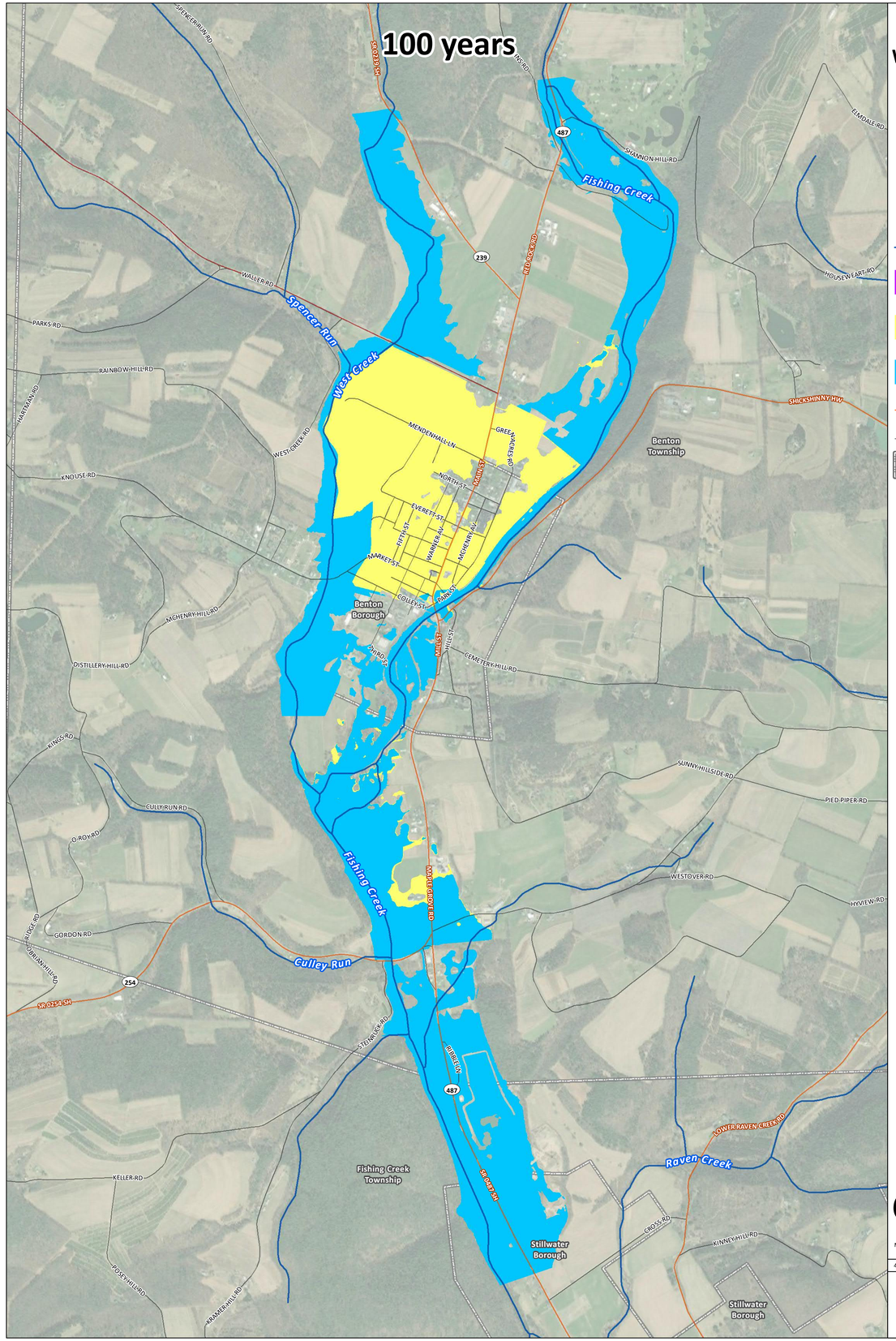

Benton Borough
West Creek & Fishing Creek
Medium-High Priority

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

1,000 0 1,000 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/20/2022	PM: MV	GIS: AIV	QA: JH	R006222.0425

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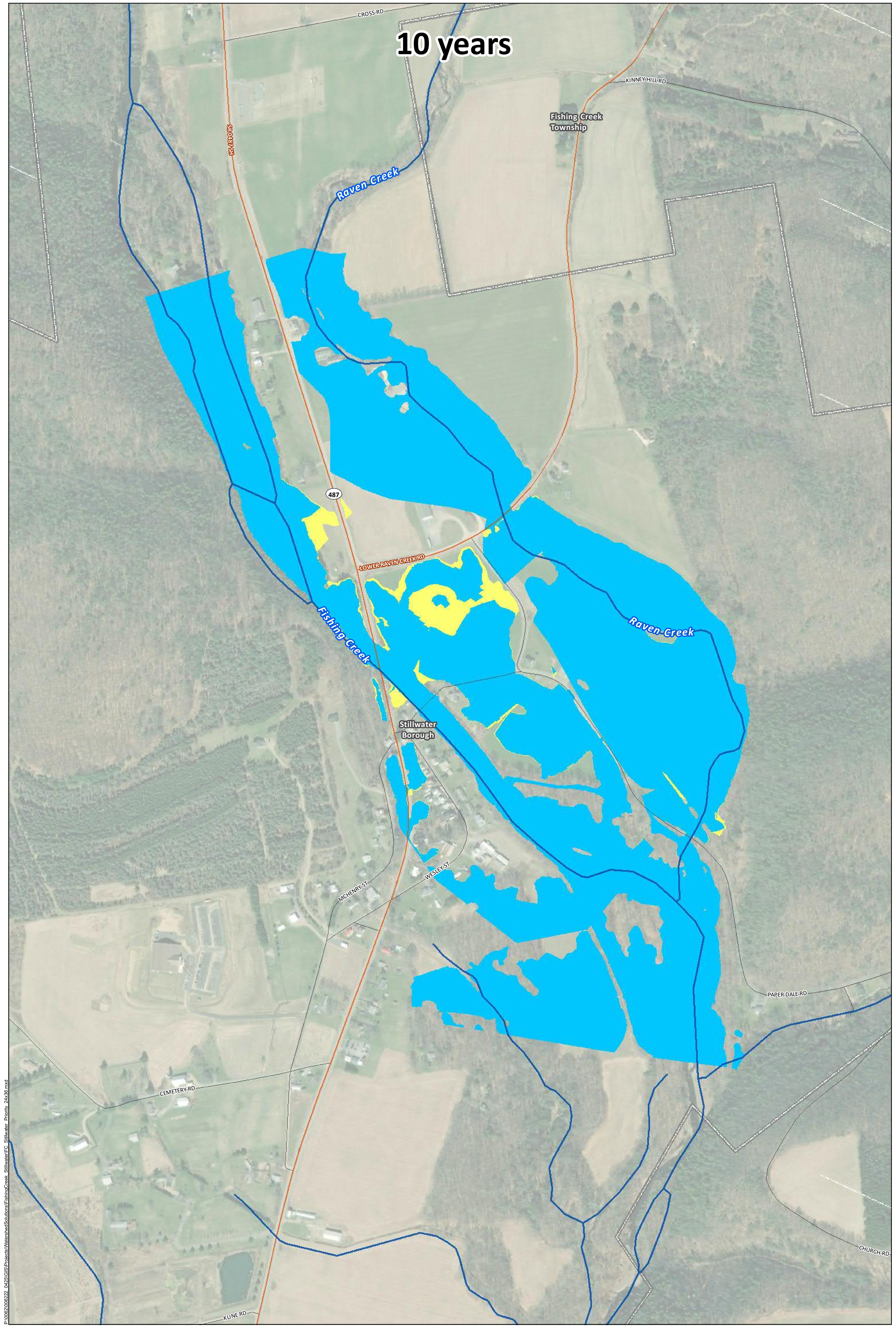
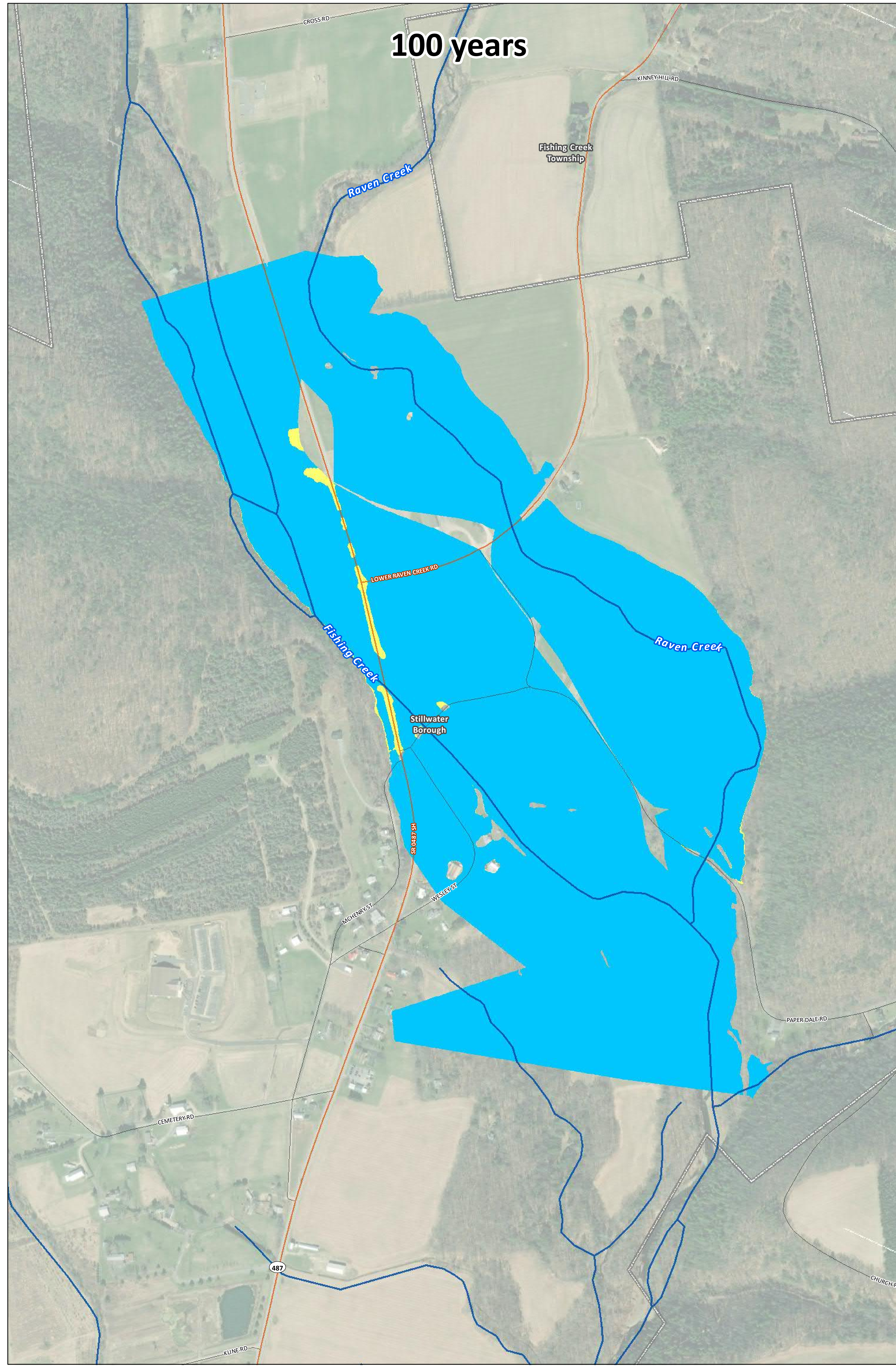
Fishing Creek- Stillwater Low Priority

Columbia County, Pennsylvania





- Stream
- High Hazard Flood Area- Increase
- High Hazard Flood Area- Decrease
- High Hazard Flood Area- No Change
- State Road
- Local Road
- Municipal Boundary

350 0 350 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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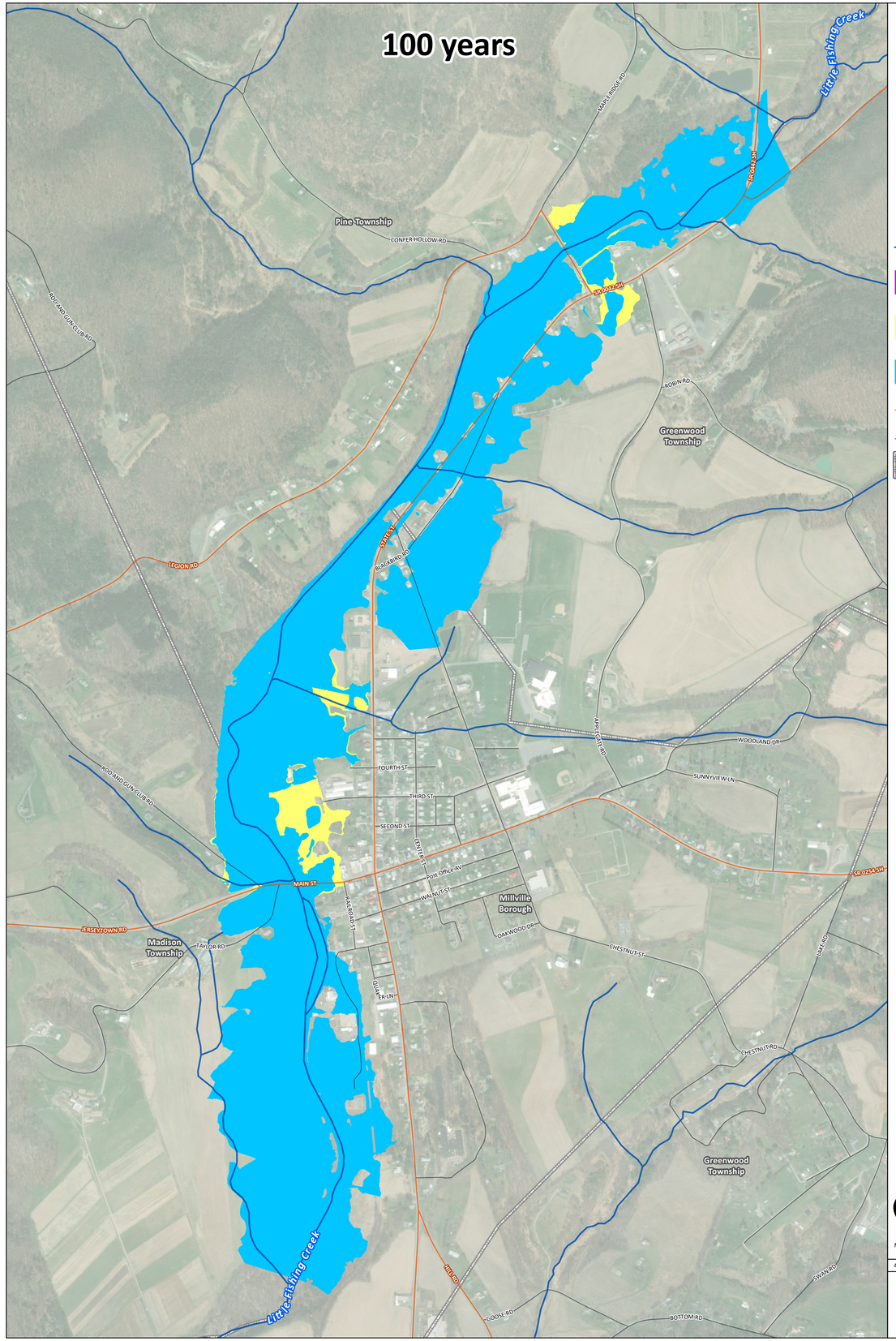

Little Fishing Creek-Millville Medium-High Priority

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

550 0 550 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/19/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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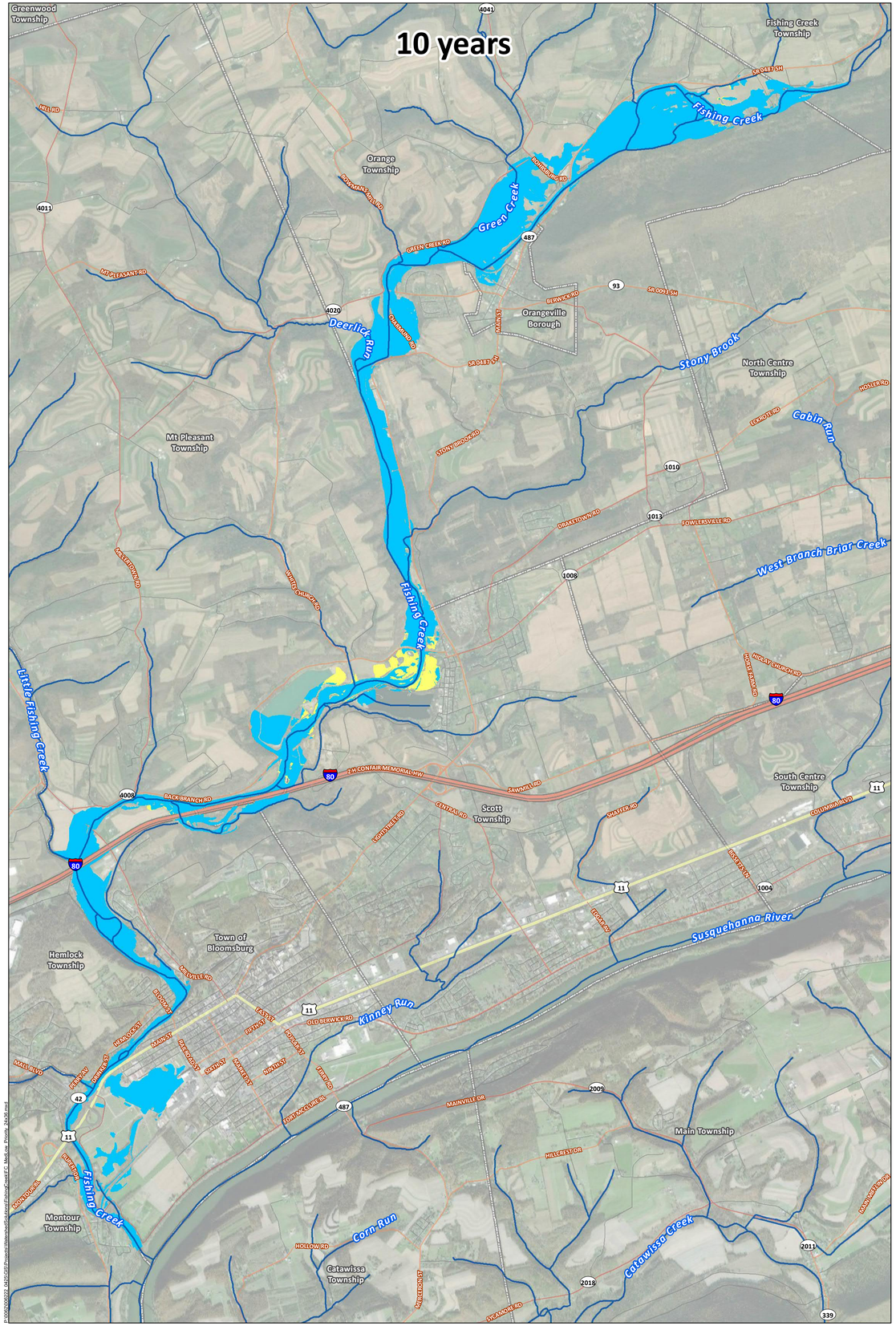

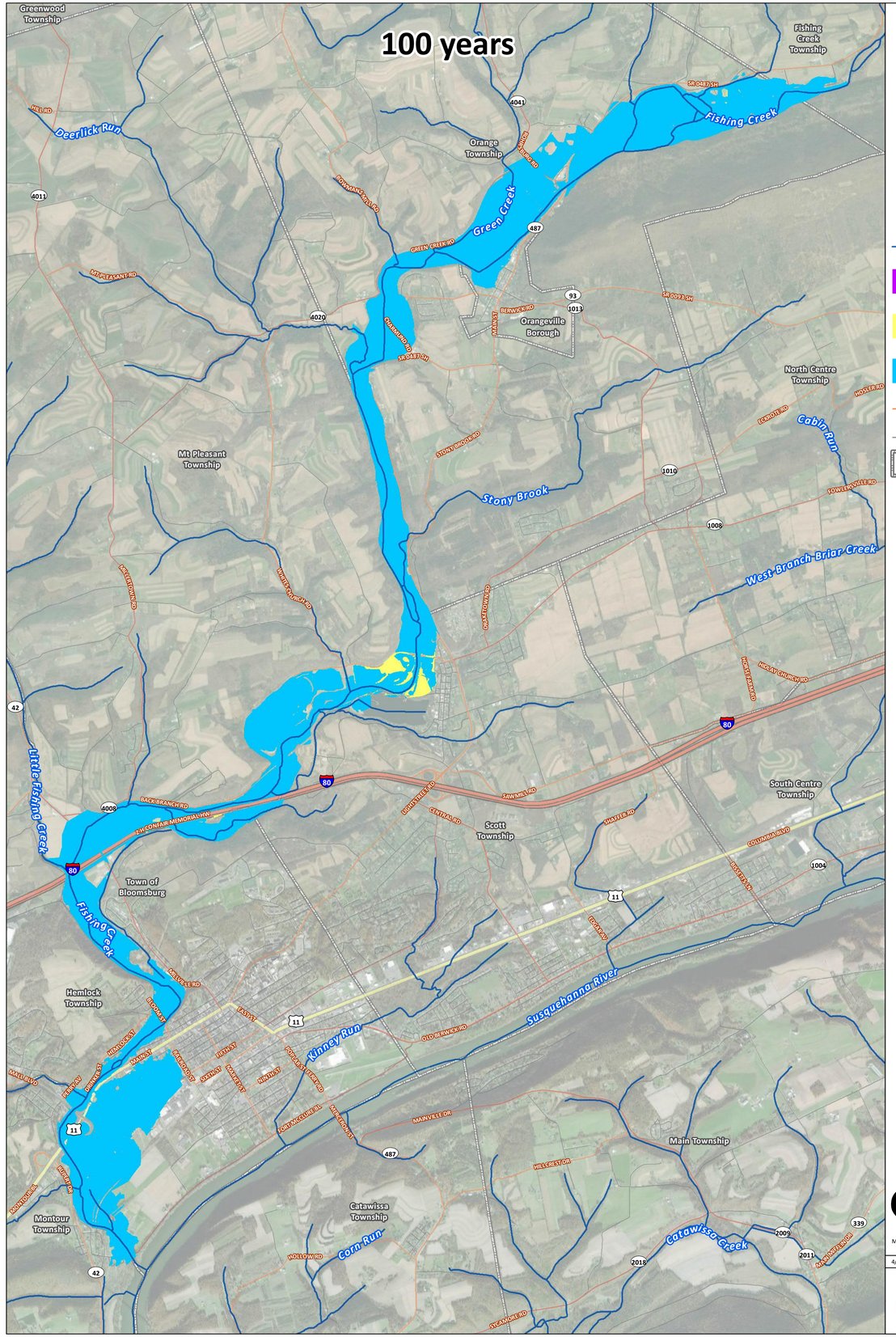

Fishing Creek Medium-Low Priority

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

1,100 0 1,100 2,200 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

4/18/2022	PM: MV	GIS: ALV	QA: JH	R006222.0425

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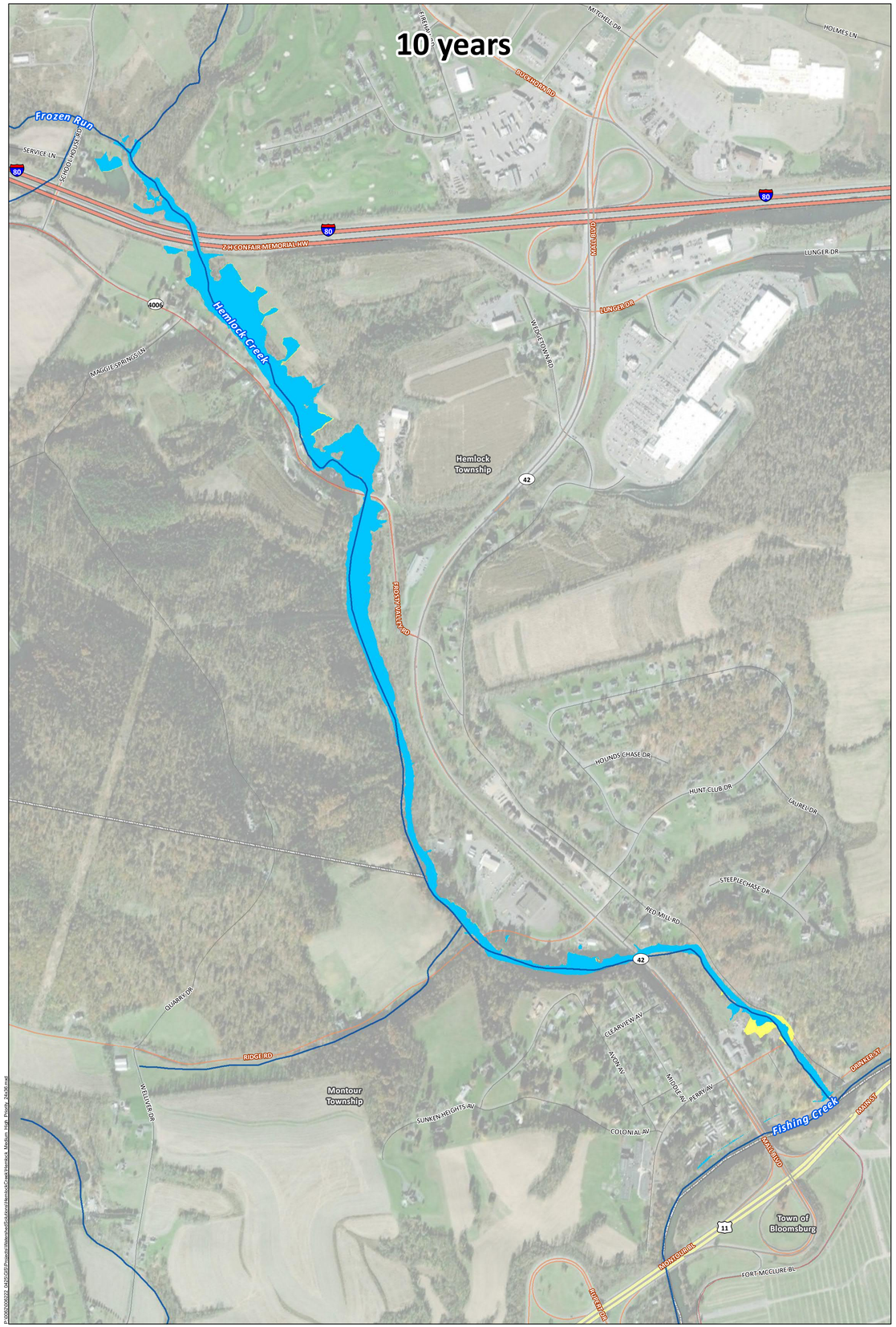

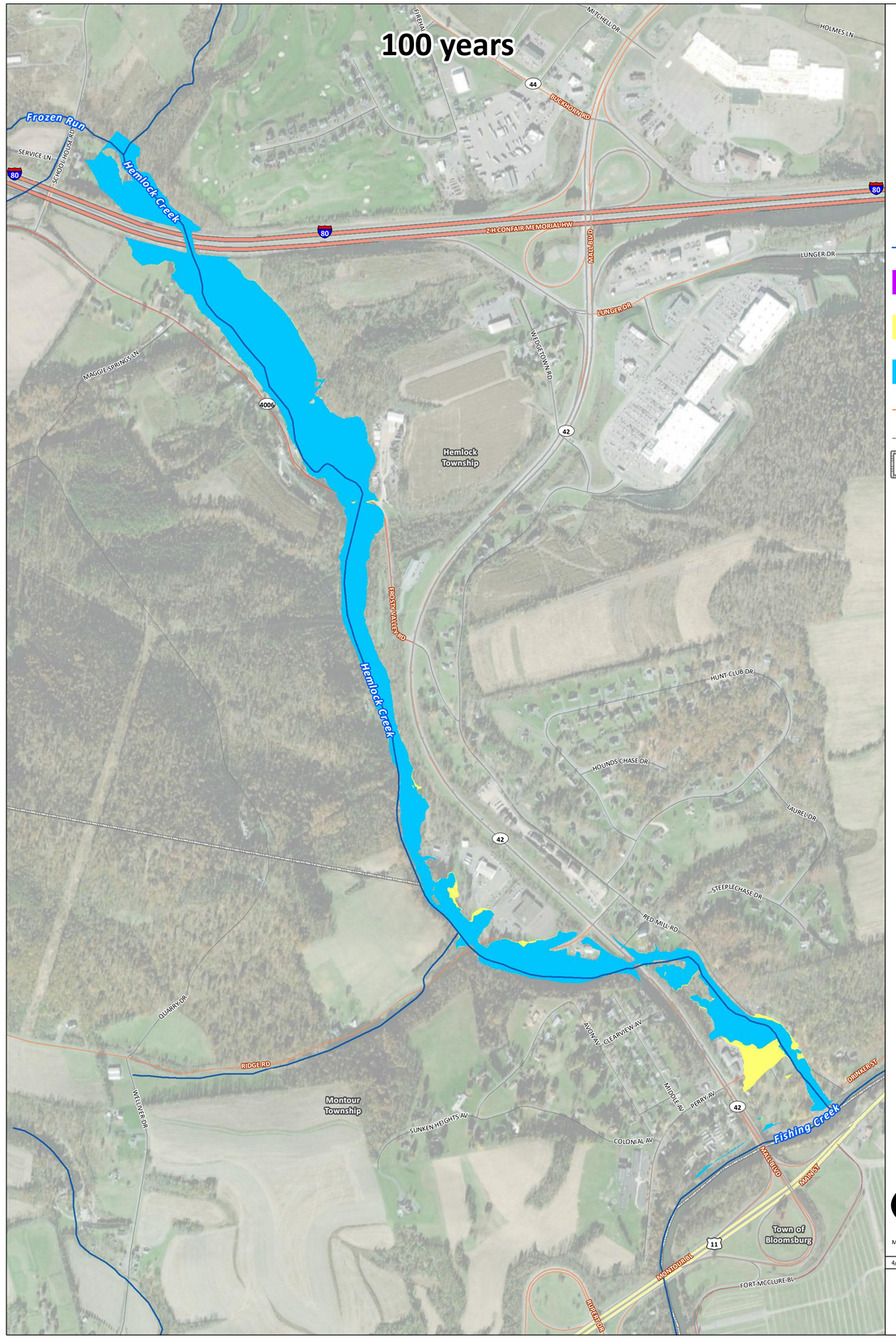

Hemlock Creek Medium-High Priority

Columbia County, Pennsylvania

- Stream
- High Hazard Flood Area-Increase
- High Hazard Flood Area-Decrease
- High Hazard Flood Area-No Change
- State Road
- Local Road
- Municipal Boundary

500 0 500 Feet

Mapping derived from data provided by, USGS, USFWS, FEMA, ESRI, PennDOT, and USDA.

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APPENDIX E – FINAL PUBLIC MEETING DOCUMENTS

Public participation by local stakeholders was an integral part of the Study. Several public meetings were facilitated throughout the development of this Study. The following documents are included here to provide a summary of the final public meeting to discuss the findings of the study.

FINAL MEETING DOCUMENTS

Fishing Creek Watershed Flooding Assessment and Mitigation Study Final Meeting Presentation

Fishing Creek Watershed Flooding Assessment and Mitigation Study High Priority Projects Summary

Fishing Creek Watershed Flooding Assessment and Mitigation Study Overview Poster

Fishing Creek Watershed Flooding Assessment and Mitigation Study Solutions Summary Poster

Upper Fishing Creek Study Area Problem Area Summary Poster

Middle Fishing Creek Study Area Problem Area Summary Poster

Little Fishing Creek Study Area Problem Area Summary Poster

Hemlock Creek-Lower Fishing Creek Study Area Problem Area Summary Poster

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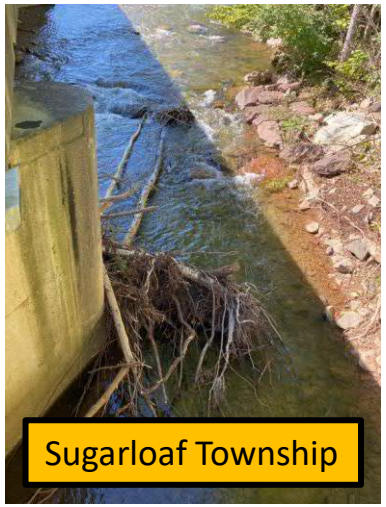
SEDA COG

Columbia County Resiliency Office

Fishing Creek Watershed Flooding Assessment and Mitigation Study


Orange Township


Sugarloaf Township


Greenwood Township

PA pennsylvania
DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

This project has been financed by grants from the Commonwealth of Pennsylvania, Commonwealth Financing Authority and the Department of Community and Economic Development.

March 31, 2022

Agenda

- *Project Team*
- *Watershed Study Area Outline & Goals*
- *Draft Findings:*
  - *Problem Area Identification*
  - Study Areas/Subwatersheds
  - Proposed Mitigation Measures
- *Next Steps*
- *Break to Open House for Comments/Questions*

Project Team

Eric Stahley
Resiliency Officer

Teri Provost, CFM
Director, Flood Resiliency

Geralee Zeigler
Flood Resiliency Program Analyst

Erin Threet, PE
Assistant Vice President
Client Manager

Matt Vanaskie, PE
Project Manager
Water Resources Engineer

Scott Smith, PE
Project Engineer
Site Investigation/Assessment Lead

Isaac Underhill, EIT
Project Engineer
Technical Analysis

Kaitlin Mills
Project Planner
Ordinance Review

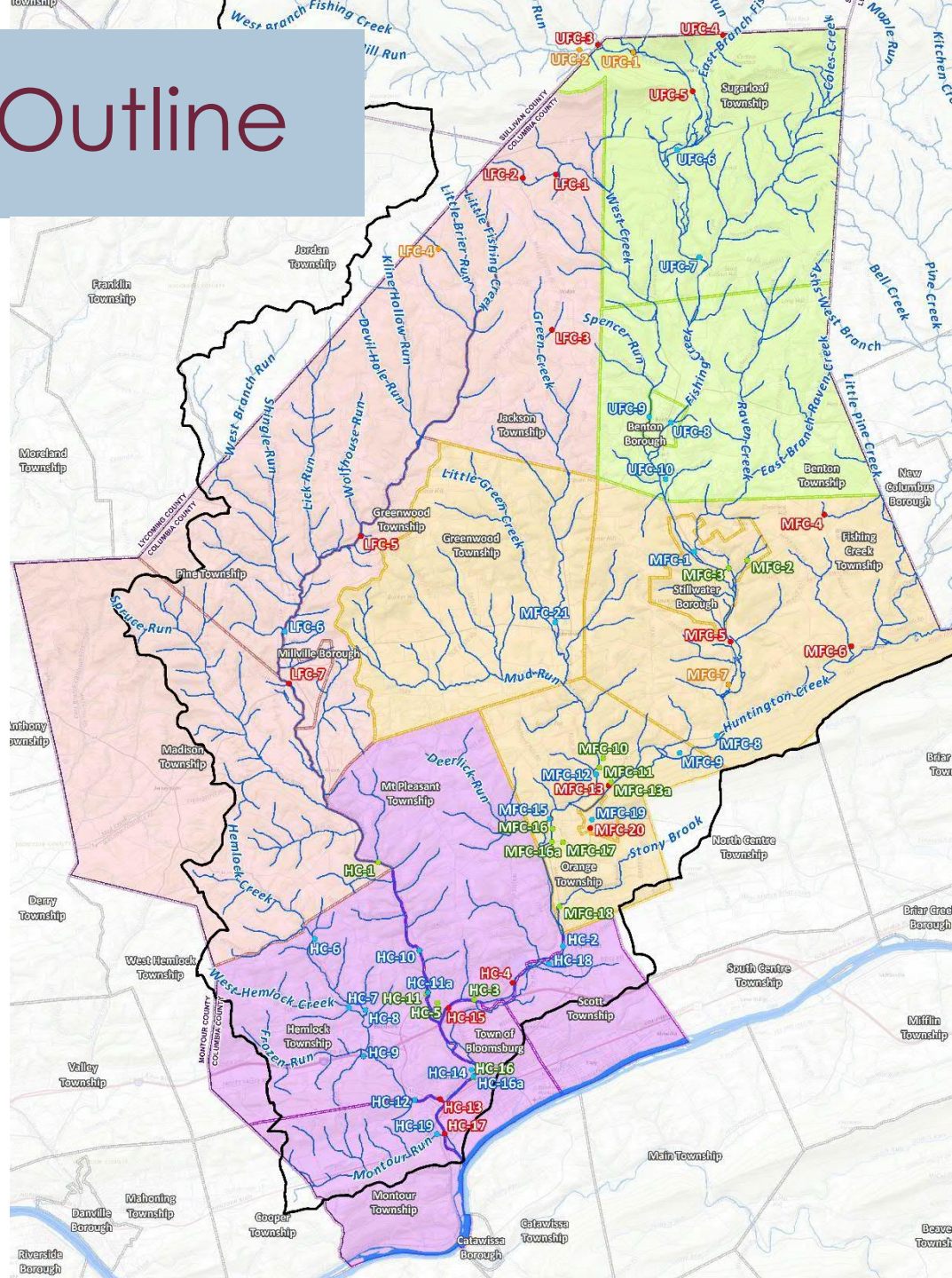
David Pyle
Project Engineer
Site Investigations

Coordination with West End Flood Study Project Team (Borton-Lawson)

Watershed Study Area Outline

- *Fishing Creek Watershed in Columbia County*
- *18 Municipalities*
- *227 Square Mile Area*
  - *1.6x area of Philadelphia*
  - *3.9x area of Pittsburgh*
  - *52x area of Bloomsburg*
- *293 Miles of Waterway*
  - *5% (10) of covered bridges in PA*
- *Land Use & Form*
  - *Primarily forest & agriculture*
  - *Fill impacts floodway/floodplain*
- *Substantial Past/Potential Losses*:*
  - *$37 million paid losses* 1978-2018*
  - *$152+ million projected 40-year losses**

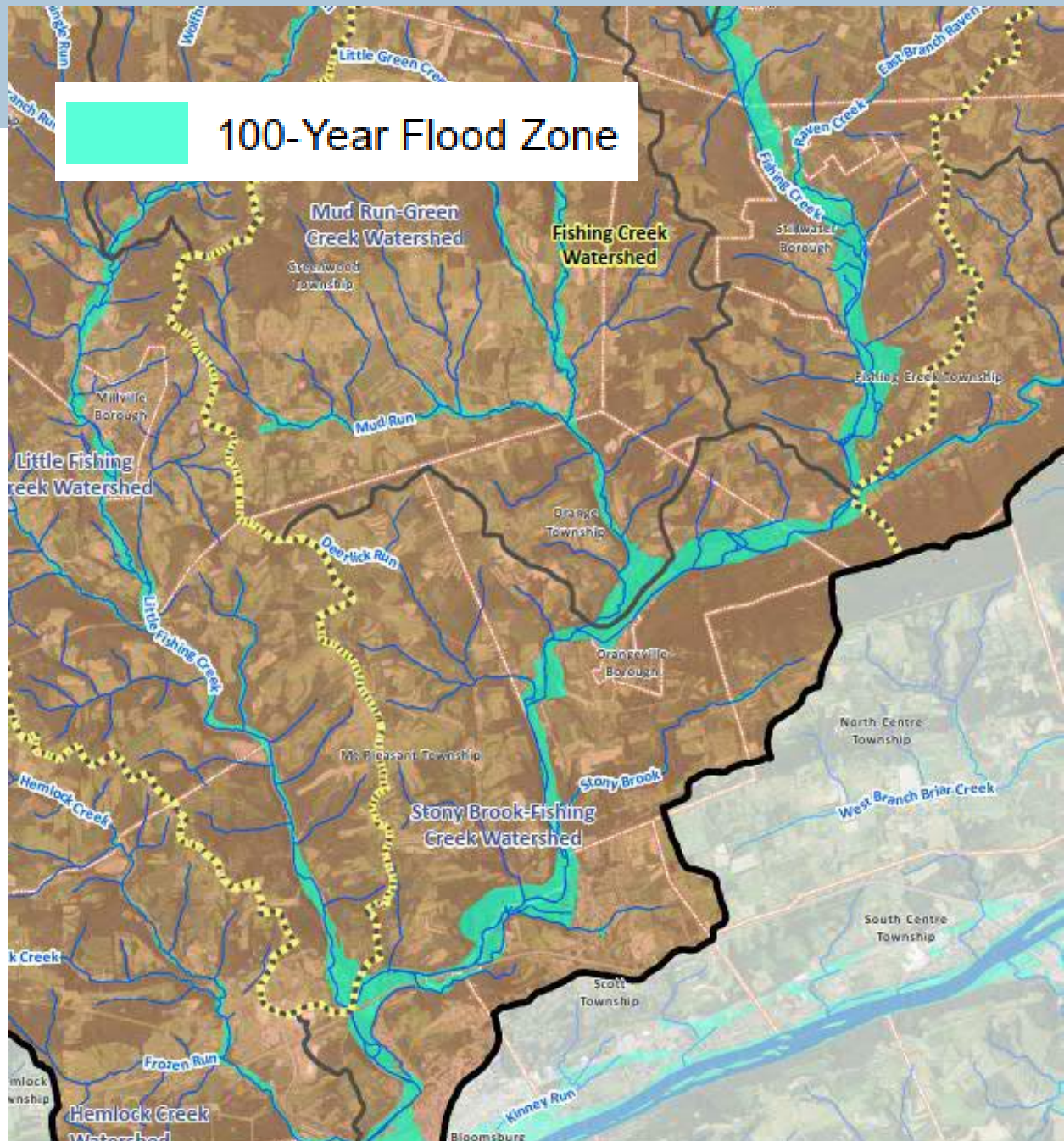
* Does not include infrastructure damages



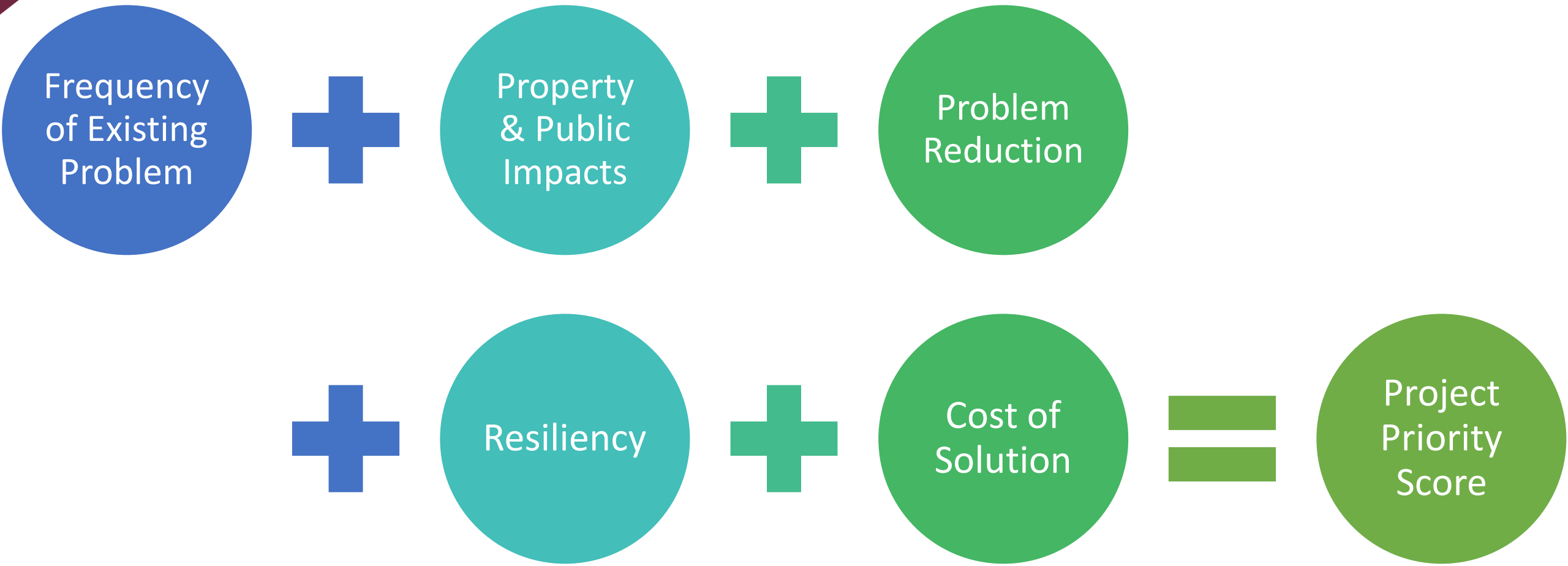
Goals of the Study

1. Identification of Flooding **Problem Areas** within the Fishing Creek Watershed

2. Identification & Assessment of Proposed **Mitigation Measures** and Projects



Flood Mitigation Problem Area/Project Prioritization

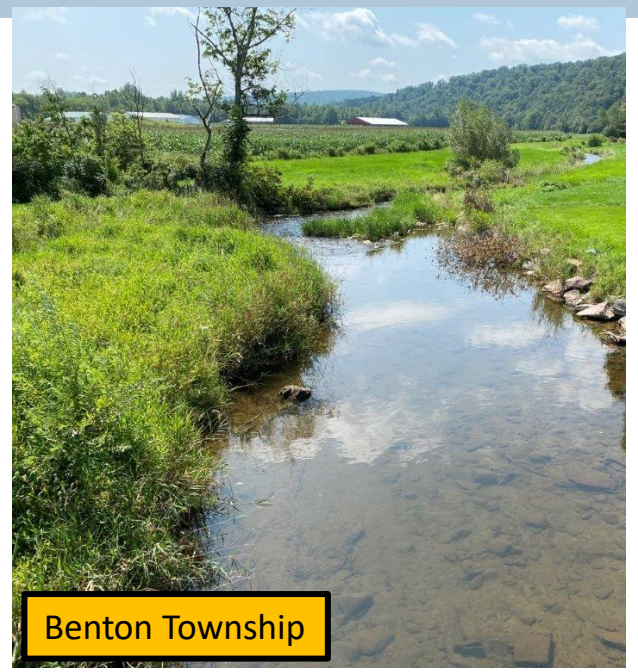


FINDINGS AND MITIGATION OPTIONS


Town of Bloomsburg

Greenwood Township

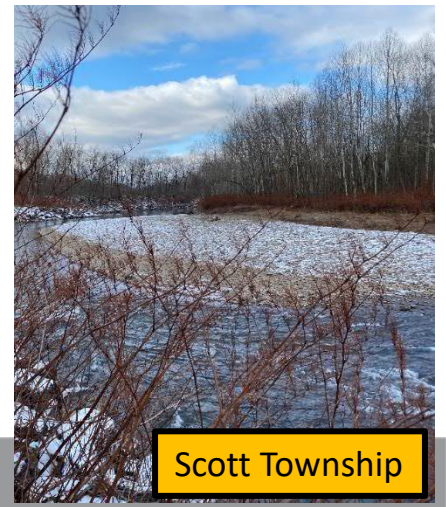

Hemlock Township


Benton Township


Montour Township


Jackson Township


Sugarloaf Township


Scott Township

Problem Area Identification

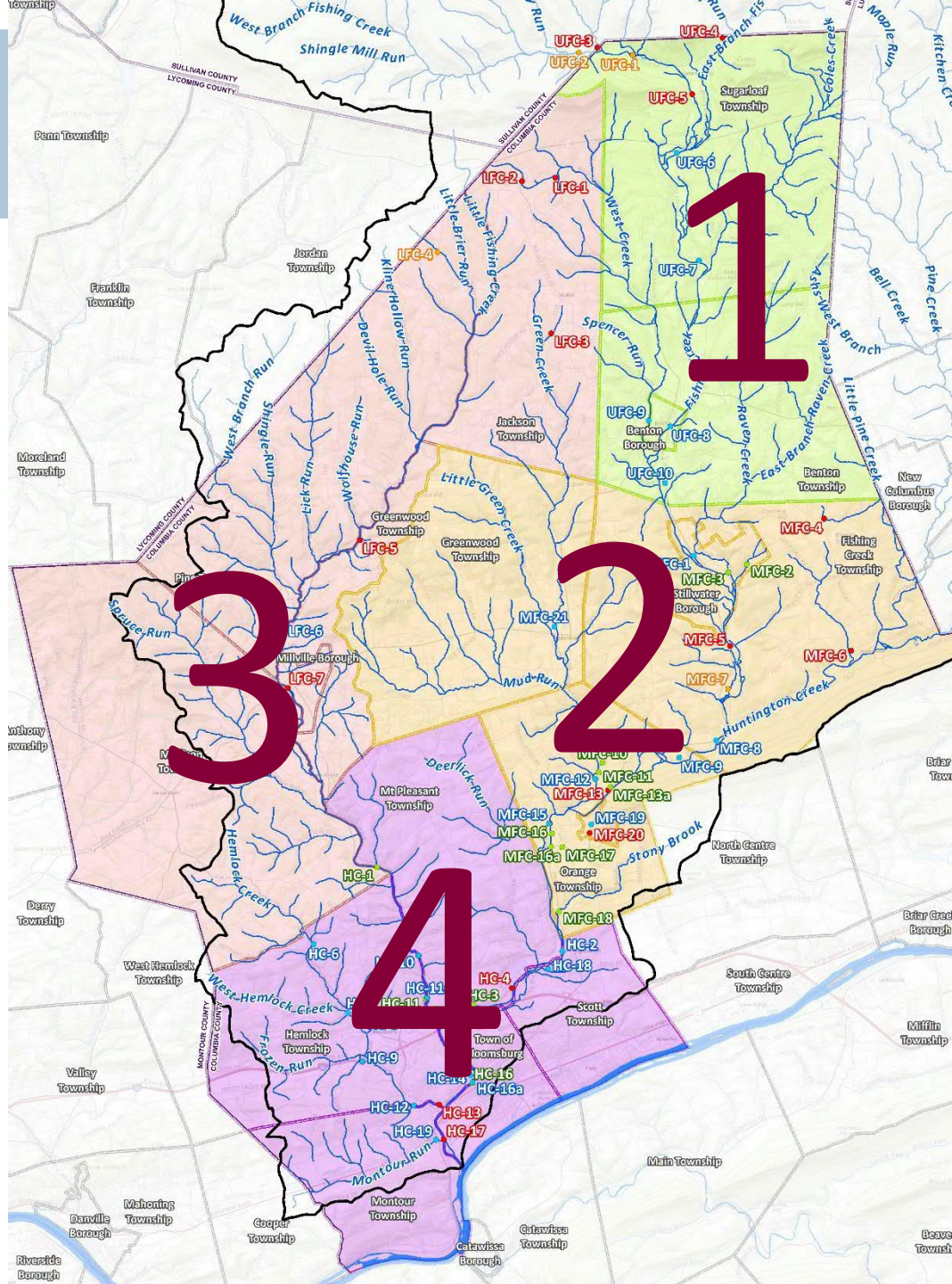
- Sought Input for Up to 3 Problem Areas Per Municipality
- Received Input from All 18 Municipalities
- 75 Problem Area/Site Responses
- 57 Problem Areas/Sites After Review/Consolidation
- Flooding/Wet Weather Issues are Watershed Wide

Study Areas

Four Study Areas

> By Subwatershed:
  - 1: Upper Fishing Creek
  - 2: Middle Fishing Creek
  - 3: Little Fishing Creek
  - 4: Hemlock Creek-Lower Fishing Creek

> 3-5 Municipalities per Area



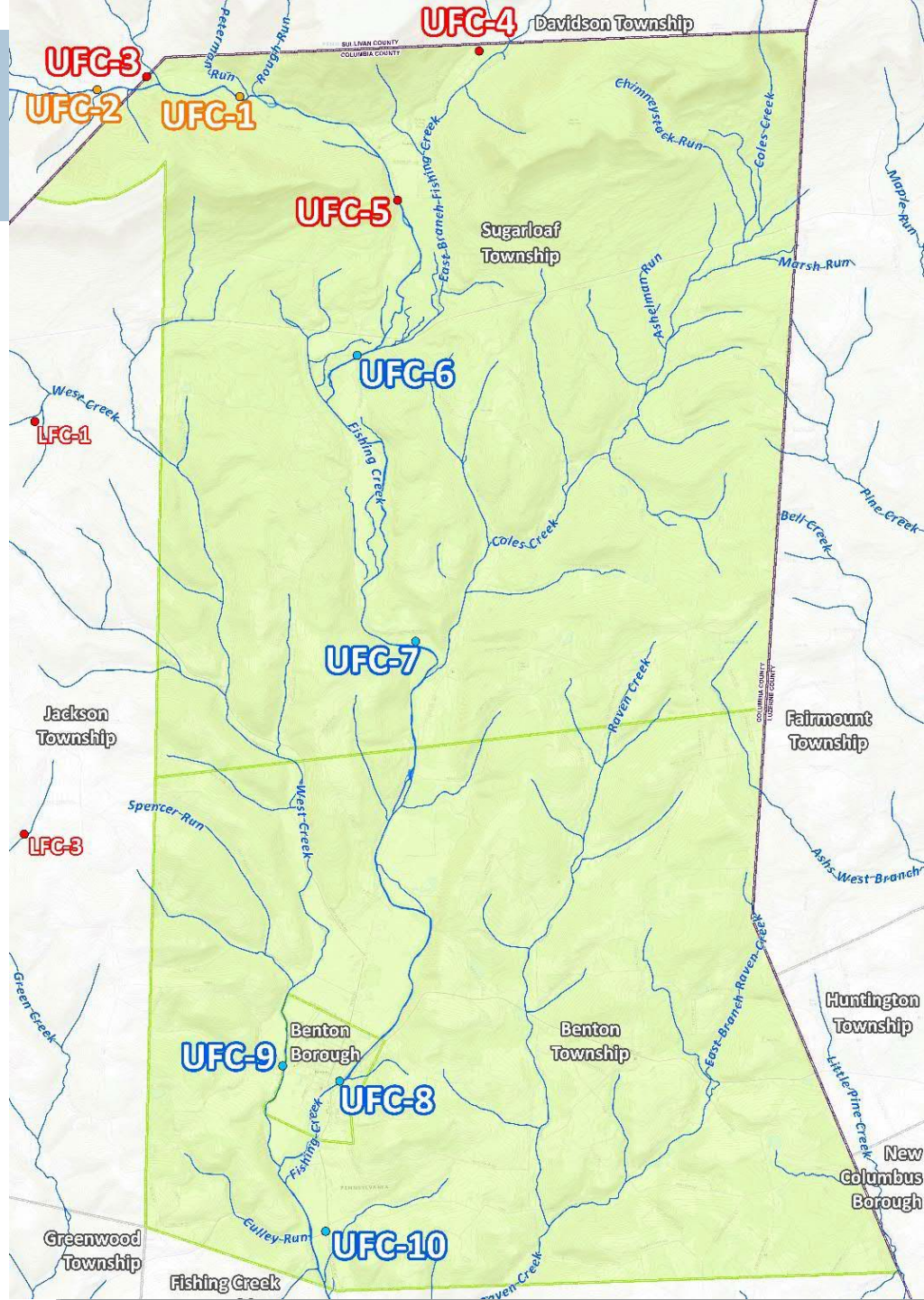
Upper Fishing Creek

Summary

> 10 Problem Areas

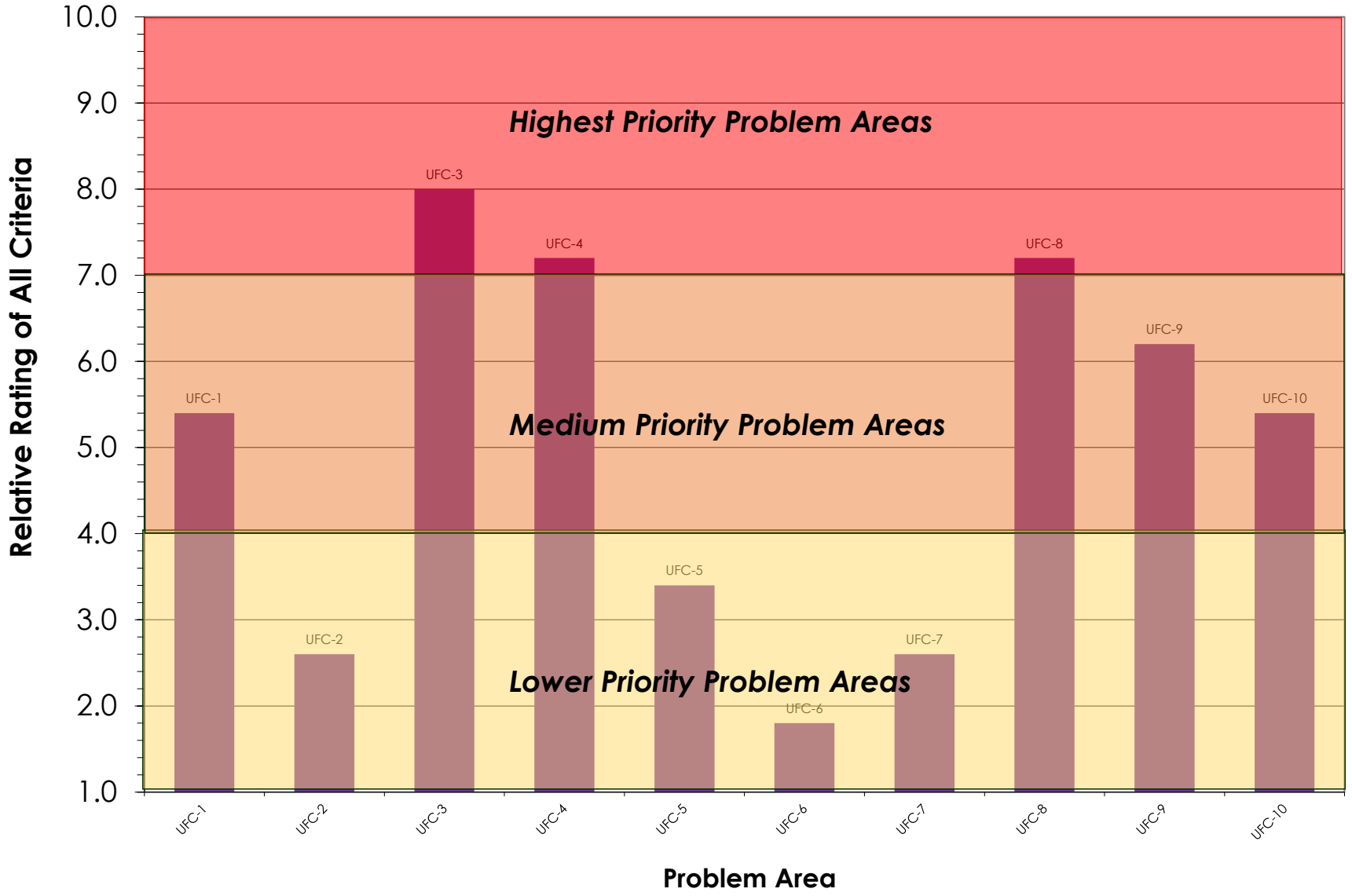
> Typical Issues
  - debris/logjams
  - overbank flooding
  - properties along channel (floodway)

> Estimated Construction Cost:
  - $35 to 61 million to implement proposed mitigation measures
  - $24 to 44 million to implement high priority (priority score >7) mitigation measures (3)



Upper Fishing Creek

Problem Area Prioritization

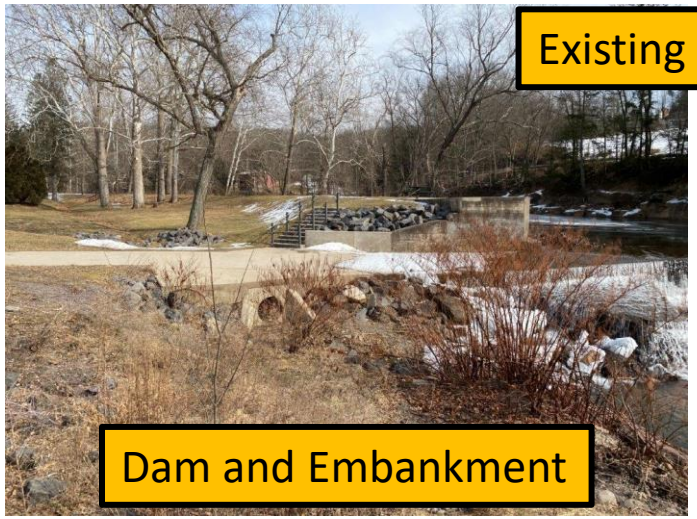


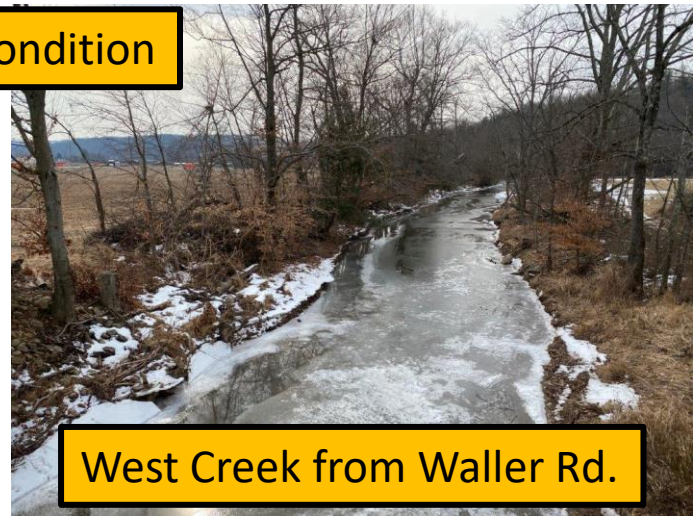
Upper Fishing Creek

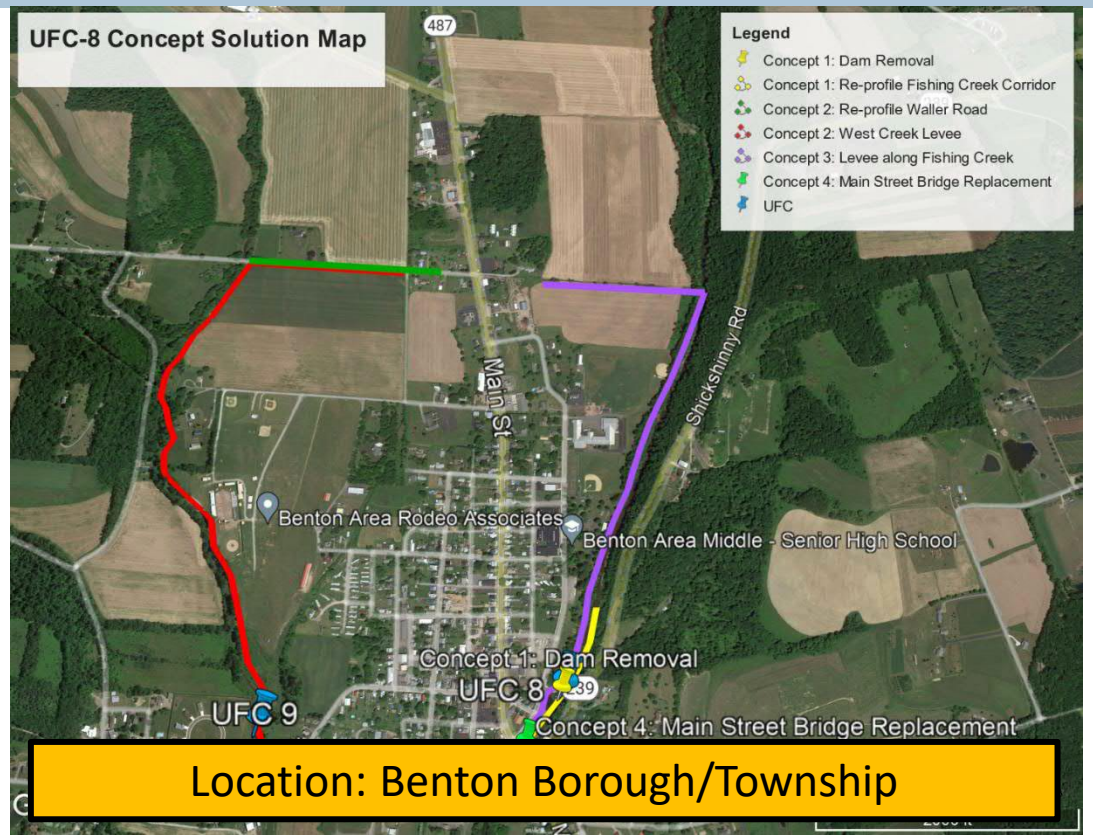
Benton Area Flooding

Priority Project Summary: UFC-8

- Issue: Constricted Channel
- Solution: Levee/Floodwall, Dam Removal, Road Re-profiling, Voluntary Property Floodproofing
- Estimated Construction Cost: $2.0 to 45 million
- Priority Score: 7.2



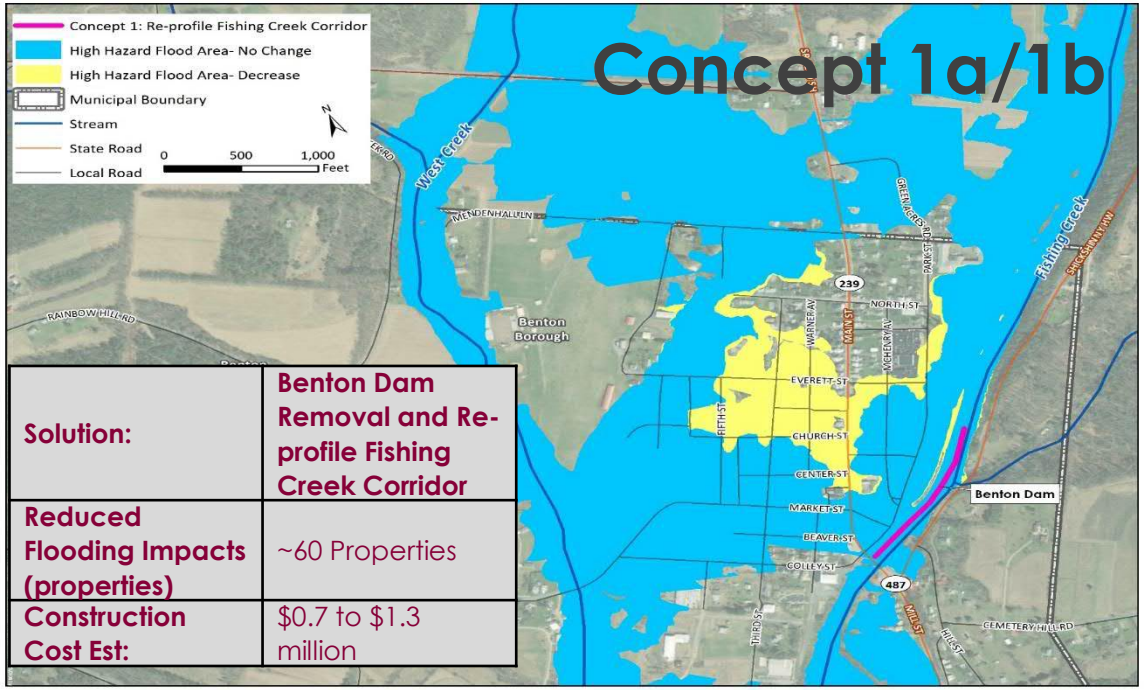




Benefits:

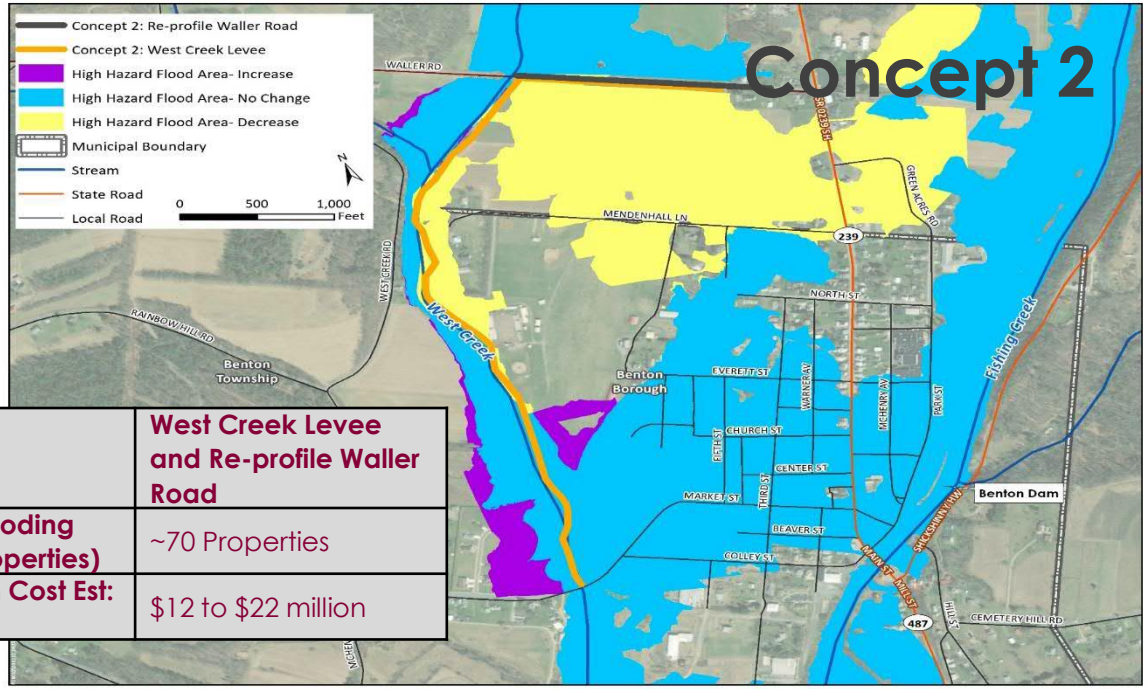
- Reduced Local Flooding
- Reduced Stream Velocity
- Up to 200+ Properties and Benton Area Schools Directly Impacted
- Up to 5,000 Vehicles Per Day

Concept 1a/1b



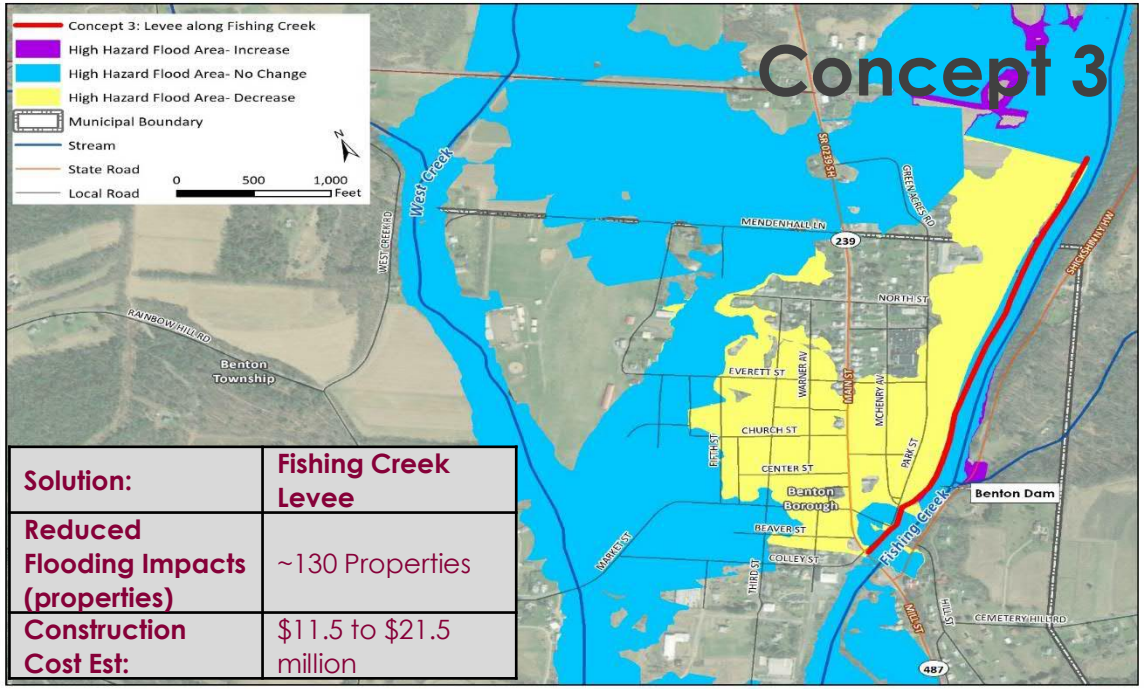
Solution:	Benton Dam Removal and Re-profile Fishing Creek Corridor
Reduced Flooding Impacts (properties)	~60 Properties
Construction Cost Est:	$0.7 to $1.3 million

Concept 2



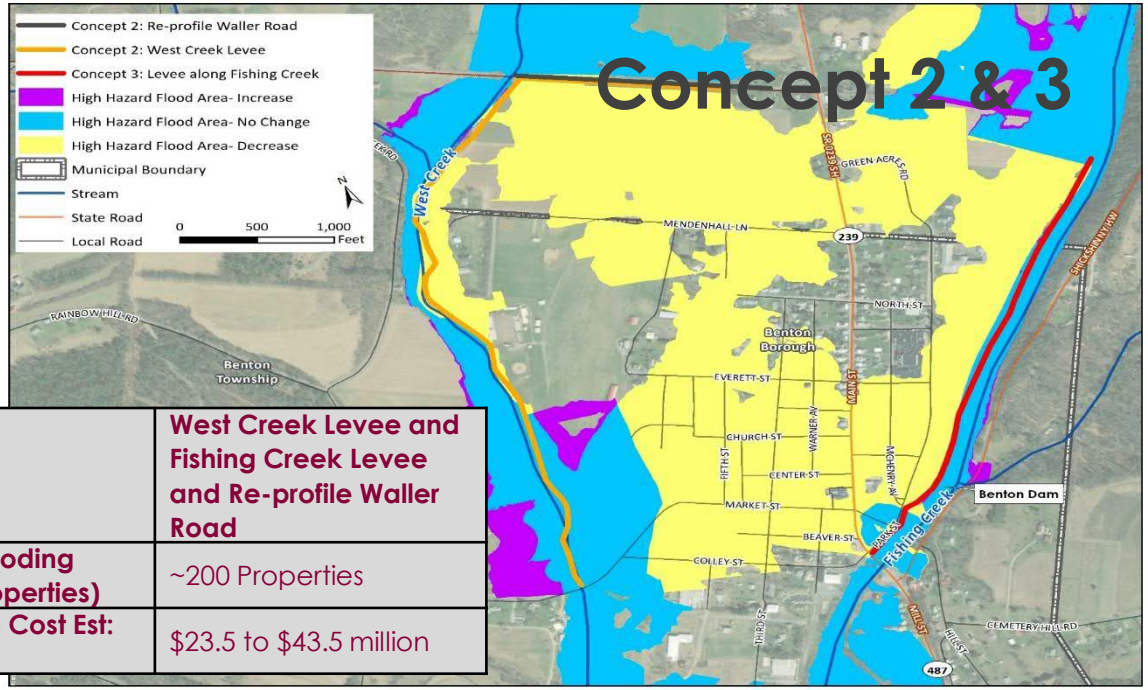
Solution:	West Creek Levee and Re-profile Waller Road
Reduced Flooding Impacts (properties)	~70 Properties
Construction Cost Est:	$12 to $22 million

Concept 3



Solution:	Fishing Creek Levee
Reduced Flooding Impacts (properties)	~130 Properties
Construction Cost Est:	$11.5 to $21.5 million

Concept 2 & 3



Solution:	West Creek Levee and Fishing Creek Levee and Re-profile Waller Road
Reduced Flooding Impacts (properties)	~200 Properties
Construction Cost Est:	$23.5 to $43.5 million

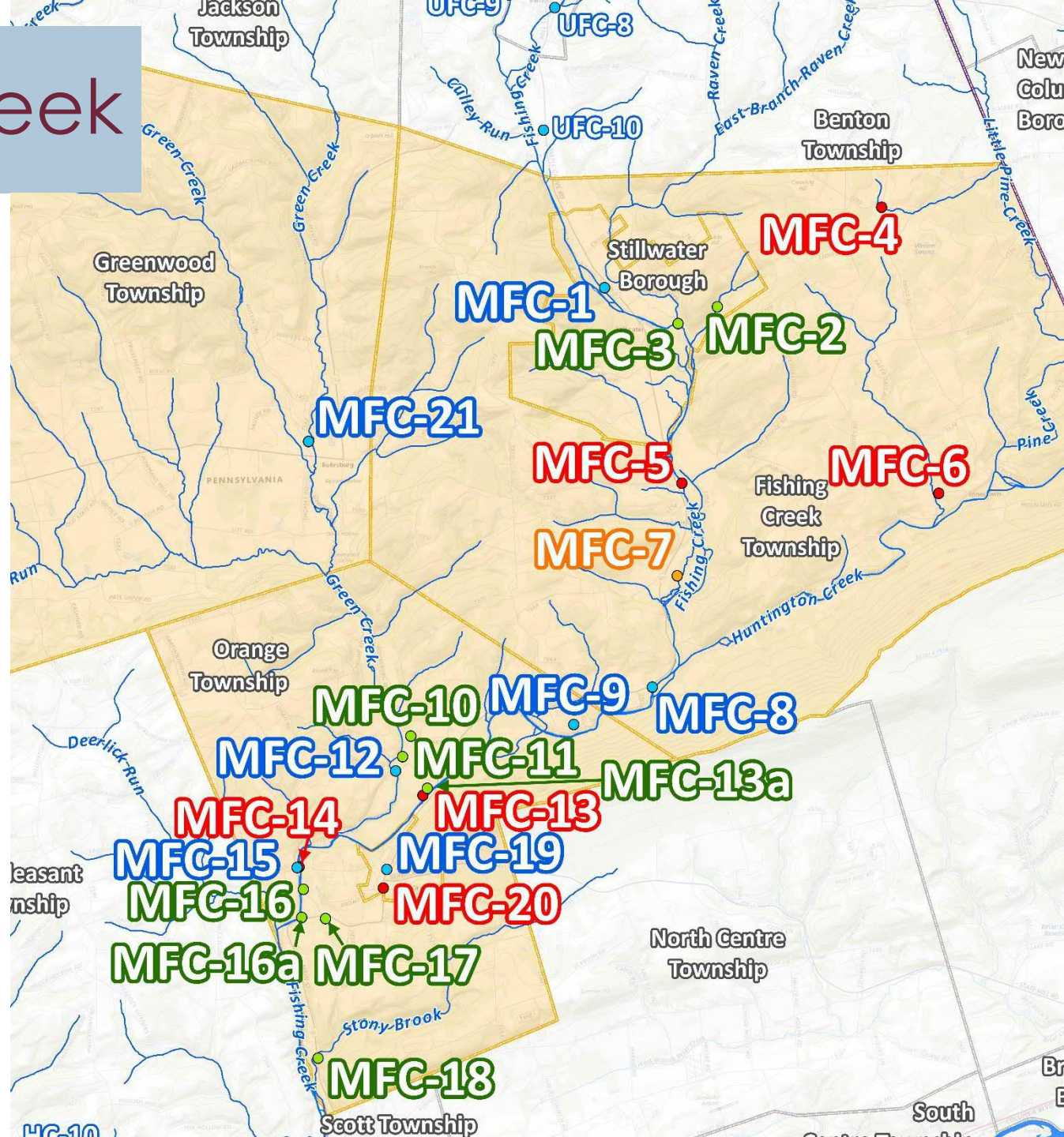
Middle Fishing Creek

Summary

> 21 Problem Areas

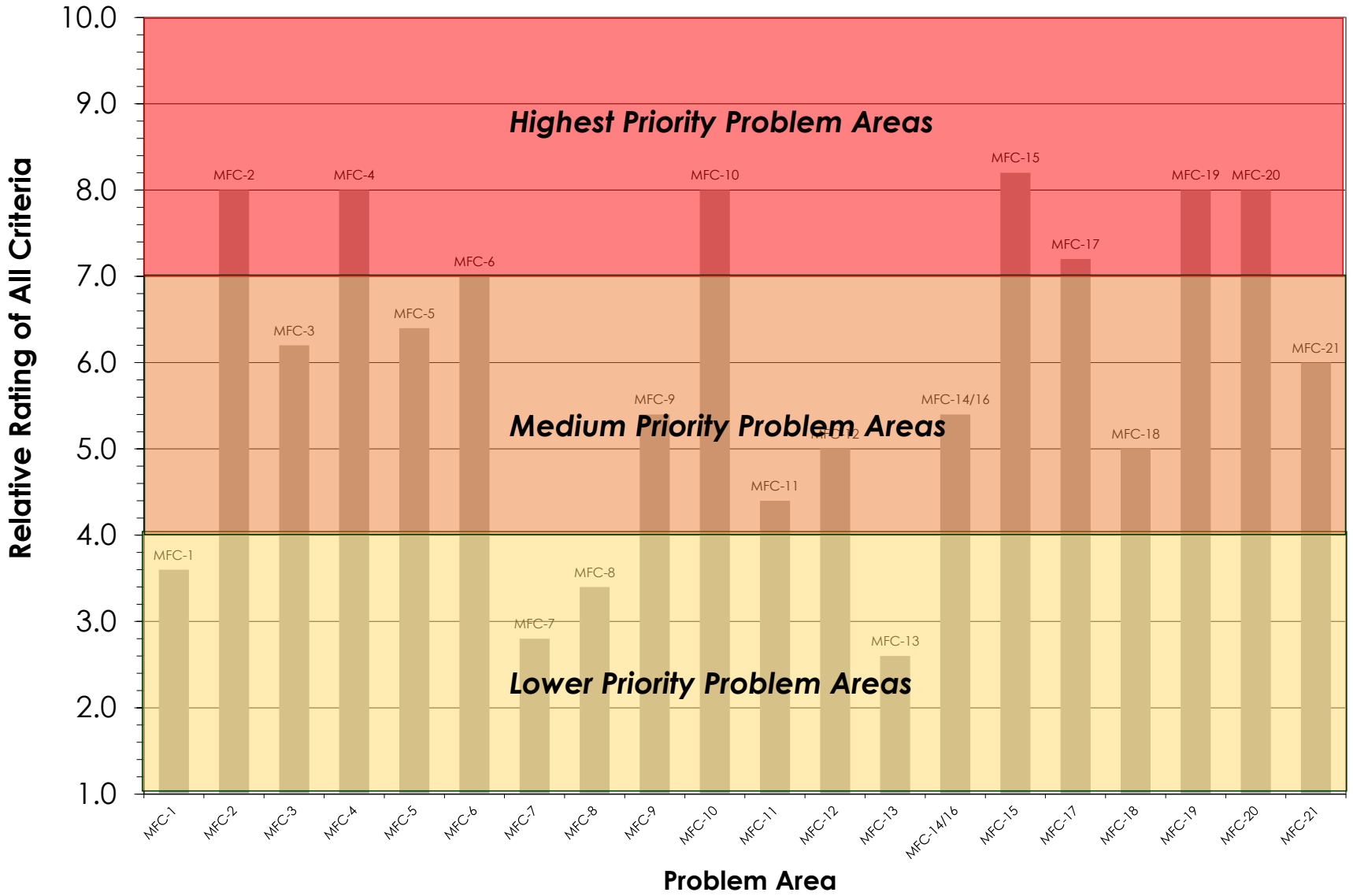
> Typical Issues:
  - Undersized bridges/culverts
  - Overbank flooding
  - Properties along channel (floodway)

> Estimated Construction Cost:
  - $40 to 71 million to implement proposed mitigation measures
  - $3.0 to 5.6 million to implement high priority (priority score >7) proposed mitigation measures (8)



Middle Fishing Creek

Problem Area Prioritization



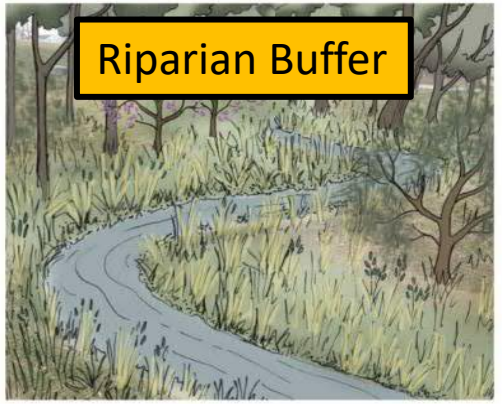
Middle Fishing Creek
Orangeville-Mt. Pleasant Flooding

Priority Project Summary: MFC-19

- Issue: Constricted Upstream Channel and Culvert
- Solution: Culvert Replacement, Riparian Buffer
- Estimated Construction Cost $150,000 to $280,000
- Priority Score: 8.0

Benefits:

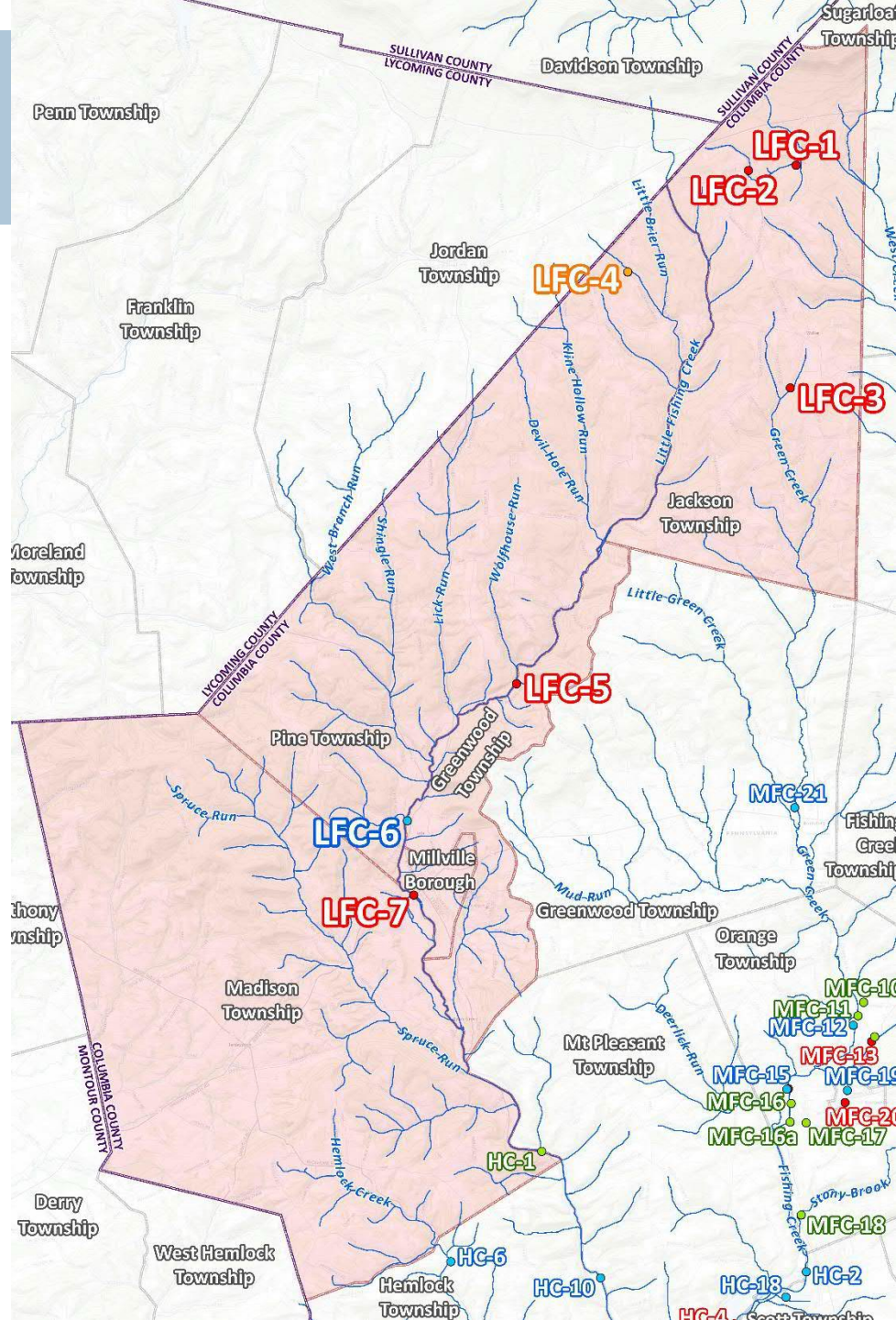
- Reduced Roadway Flooding
- Culvert Capacity Increased
- Reduced Erosion
- Approximately 4 Properties Directly Impacted



Little Fishing Creek

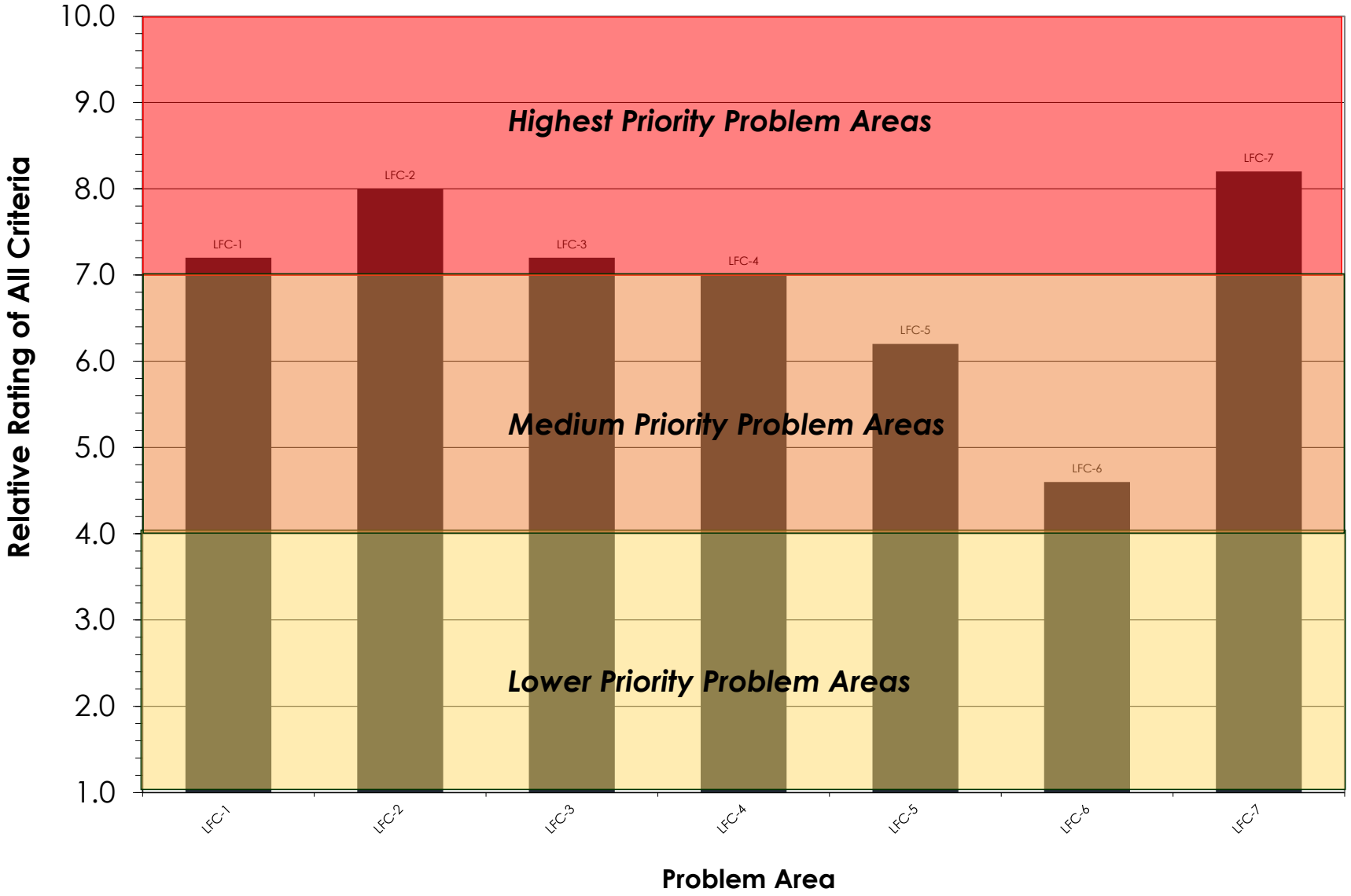
Summary

- 7 Problem Areas
- Typical Issues:
  - undersized bridges/culverts
- Estimated Construction Cost:
  - $5.8 to 10.2 million to implement proposed mitigation measures
  - $2.7 to 5.1 million to implement high priority (priority score >7) proposed mitigation measures (4)



Little Fishing Creek

Problem Area Prioritization



Little Fishing Creek

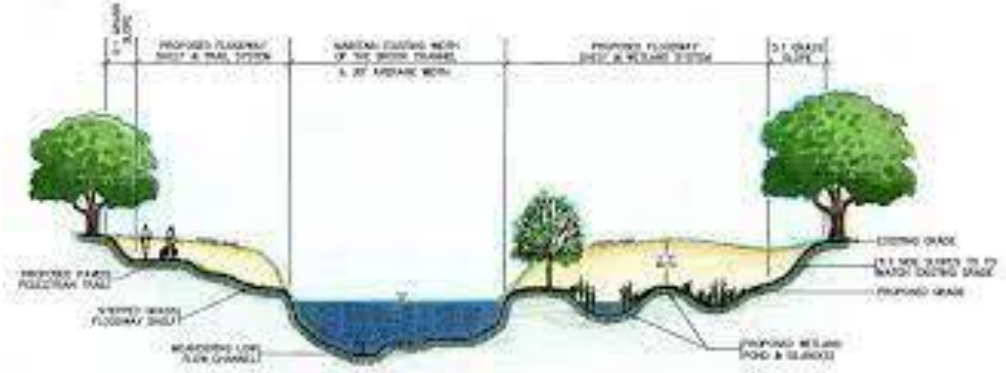
Main Street Bridge

Priority Project Summary: LFC-7

- Issue: Undersized Bridge Opening, Constricted Channel/Floodway
- Solution: Bridge Replacement, Floodplain Reconnection
- Estimated Construction Cost: $2.4 to 4.5 million
- Priority Score: 8.2

Benefits:

- Reduced Roadway Flooding
- Bridge Capacity Increased
- Reduced Stream Velocity
- Bridge Average Daily Traffic 2,900 Vehicles



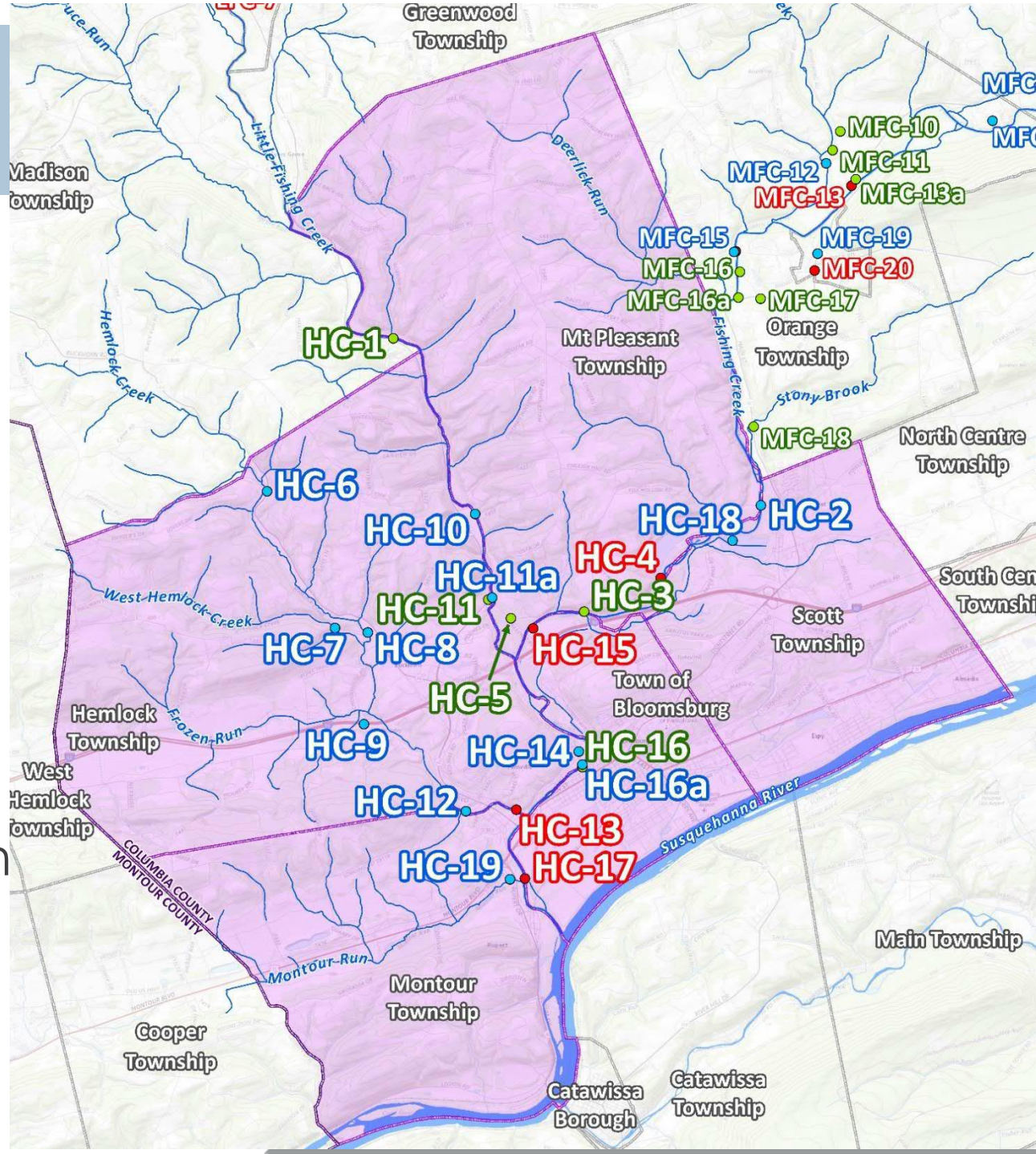
Hemlock Creek-Lower Fishing Creek

Summary

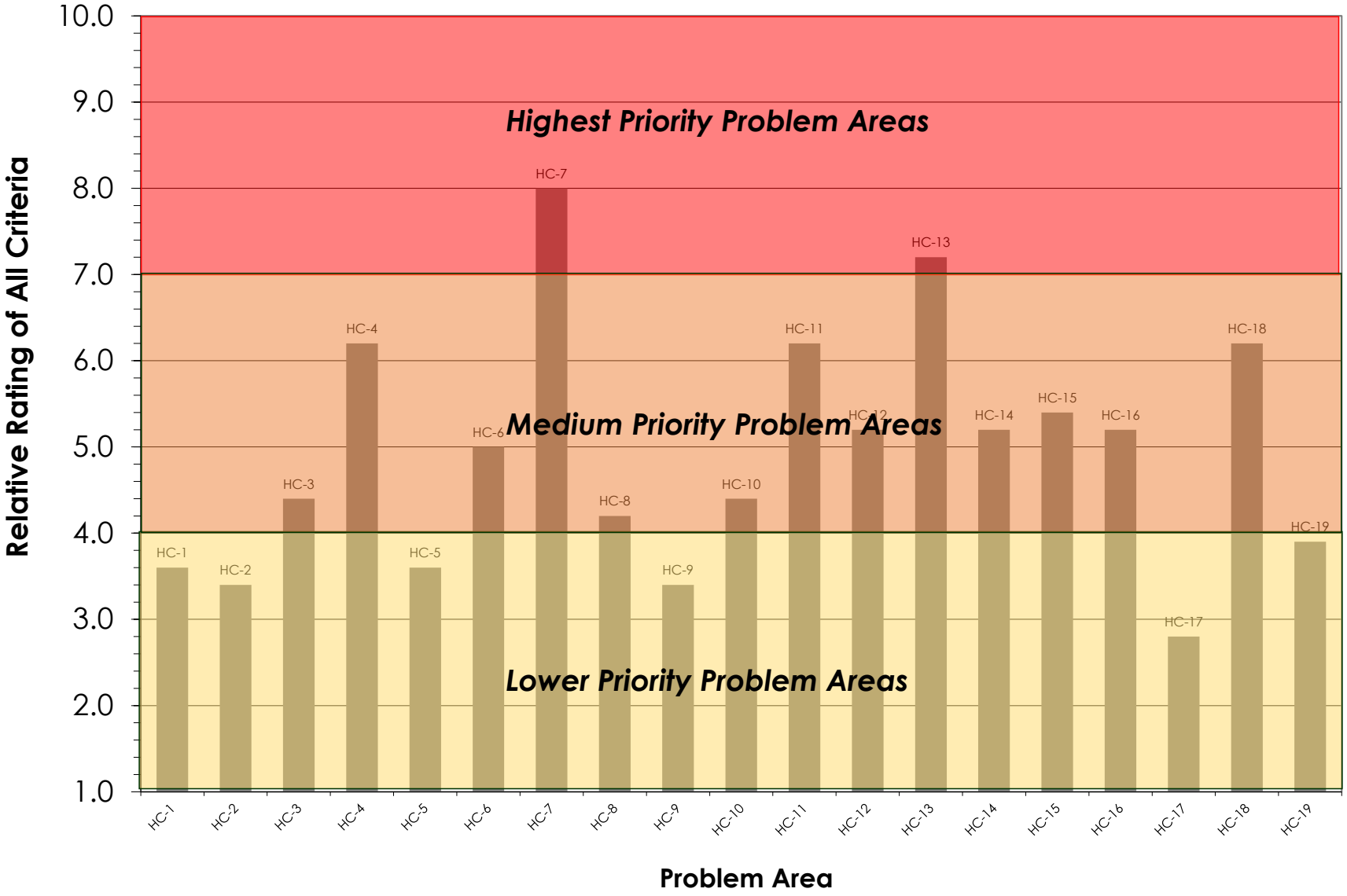
> 19 Problem Areas

> Typical Issue:
- undersized bridges/culverts
- constricted channel/floodplain

> Estimated Construction Cost:
- $31 to 57 million to implement proposed mitigation measures
- $1.4 to 2.5 million to implement high priority (priority score >7) mitigation measures (2, not including West End)



Hemlock Creek-Lower Fishing Creek Problem Area Prioritization

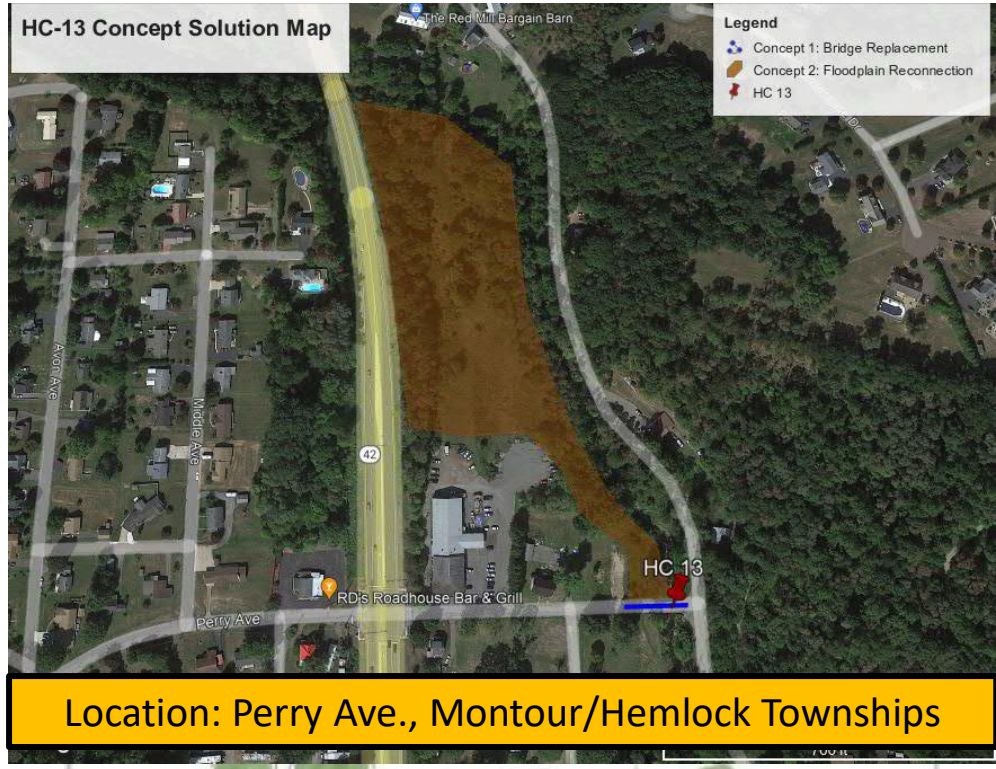


Hemlock Creek-Lower Fishing Creek

Perry Avenue Bridge

Priority Project Summary: HC-13

- Issue: Undersized Bridge Opening, Constricted Channel/Floodway
- Solution: Bridge Replacement, Floodplain Reconnection
- Estimated Construction Cost $1.3 to 2.5 Million
- Replacement Identified by PennDOT
- Priority Score: 7.0



Location: Perry Ave., Montour/Hemlock Townships

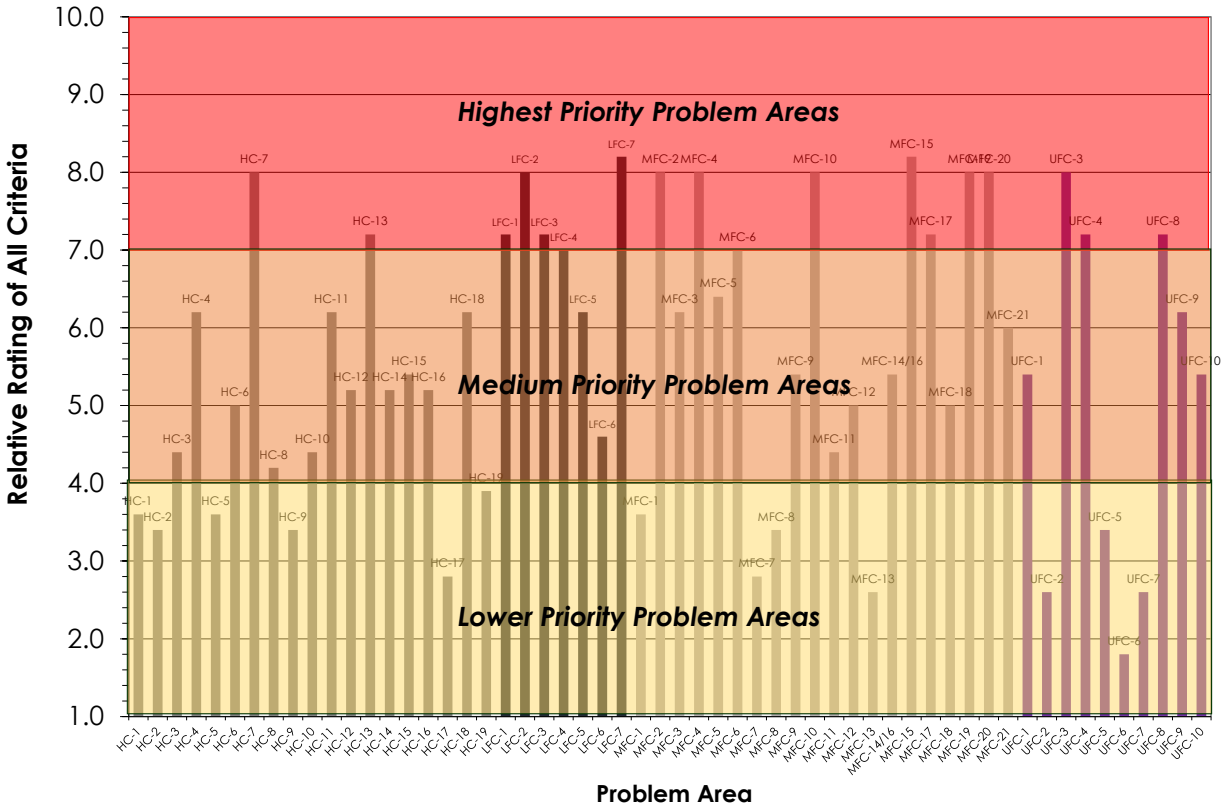
Benefits:

- Reduced Roadway Flooding
- Bridge Capacity Increased
- Reduced Stream Velocity
- Bridge Average Daily Traffic 450 Vehicles

Next Steps: Mitigation Measure Projects

Next Steps

- County and Municipal Partnering
- Identification of Funding Sources



Projects Address Issues For:

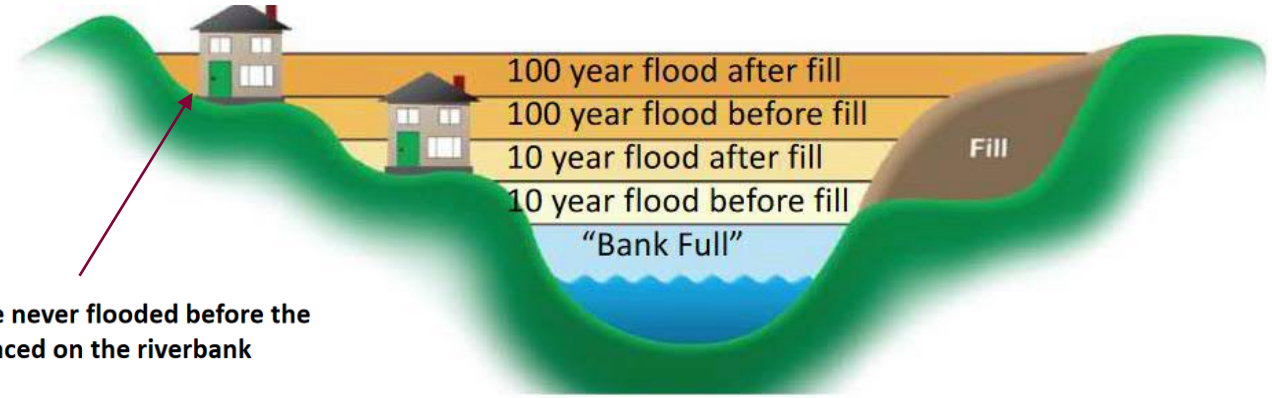
Implementation

- Target "Low Hanging" and Prioritized Mitigation Measures to Scope Projects
- Active Flood Protection/Prevention at Problem Area Sites
- Long Term Watershed Scale Impacts of Problem Area Mitigation Measures
  - Approx. 1-10% Peak Flow Reduction for 2-year Storm
  - Approx. 0-5% Peak Flow Reduction for 100-year Storm

Next Steps: Preventative Mitigation Strategies

Land Planning and Floodplain Management

- Implement Countywide Action Plan → Small Scale Impacts
- Flood Control/Floodplain Requirements → Prevent New Risks
- Flood Warning System → Prepare Residents
- Revisions to Timbering and E&S Controls → Prevent Debris
- Creek Corridor Buffer Requirement → Allow Natural Functions
- Cumulative Benefits Over Time



This house never flooded before the fill was placed on the riverbank

The Effects of Fill on a Floodplain

Countywide Action Plan Overview
Columbia County

Plan Highlights

The Columbia County Countywide Action Plan (CAP) is a roadmap to reduce pollution in county waters. Our 2025 targets are to:

- Reduce annual nitrogen pollution by 1,327,000 pounds
- Reduce phosphorus pollution by 38,000 pounds.

We will hit our targets by helping landowners install Best Management Practices (BMPs). The county is currently on track to reduce nitrogen by ~338,000 lbs and phosphorous by ~176,000 lbs, so we have more work to do. As an added benefit, the proposed BMPs will significantly lower the amount of sediment in local waters (22% of county streams have high sediment levels).

We intend for the Columbia CAP to serve as a long-term blueprint for local clean water efforts beyond the 2025 target date. It's a living document that summarizes approaches and tracks implementation efforts for local clean water activities. The plan is aspirational, but realistic. We will update the document each year, and report on our progress to local leaders and the Pennsylvania Department of Environmental Protection (PADEP). Each report will summarize progress towards long-term goals and any revisions we need to make to reach our goals.

Break to Open House for Comments and Questions…

Final Report will be Made Available

Study Website:

https://seda-cog.org/departments/flood-resiliency/columbia-county-flood-mitigation-studies

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Fishing Creek Watershed Columbia County Flood Study

High Priority Projects

Project Name	Project Scope/Improvement(s)	Projected Construction Cost (unless otherwise noted)	Impacts	Municipality	State/County Identifier
UFC-3: Elk Grove Area Flooding	Culvert and Bridge Replacement	$1.4 to 2.6 million	20+ properties, 450 vehicles per day	Sugarloaf Twp.	SR4049 & PA BR 40867
UFC-4: Jamison City Road Flooding	Bridge Replacement, Floodplain Improvements	$2 to 3.5 million	15 properties, 450 vehicles per day	Sugarloaf Twp.	County Bridge #157
UFC-8: Benton Area Flooding	Detailed Flood Study Flood Protection and/or Dam Removal	$500,000 (study) $2 to 50 million (flood mitigation measures)	150 +/- properties including Benton Area Schools, 5,300 vehicles per day	Benton Twp. & Benton Boro.	PA BR 12735, PA BR 12543, Benton BR3
MFC-2: Paperdale Road Flooding	Culvert Replacement, Stream Stabilization	$50,000 to 100,000	3 properties, 50 vehicles per day	Fishing Creek Twp.	
MFC-4: Honeytown Road Flooding	Culvert Replacements, Riparian Buffer, and Stream Stabilization	$100,000 to 200,000	4 properties, 350 vehicles per day	Fishing Creek Twp.	SR1025 (Honeytown Rd) at Ridge Rd.
MFC-10: Neyhart Road Flooding	Culvert Replacement	$70,000 to 130,000	3 properties, 1,500 vehicles per day	Orange Twp.	SR4041 (Rohrsburg Rd.) at Neyhart Rd.
MFC-17: Charmund Rd./SR0487 Flooding	Culvert Installation or Replacement, Fill Removal	$800,000 to 1.6 million	4 properties, 6,000 vehicles per day	Orange Twp.	SR0487 at Charmund Rd.
MFC-19: Orangeville-Mt Pleasant Rd. Flooding	Culvert Replacement, Riparian Buffer	$150,000 to 280,000	4 properties, 700 vehicles per day	Orangeville Boro.	PA BR 12744
MFC-20: Orangeville-Broad St. Flooding	Culvert Replacement, Riparian Buffer	$140,000 to 270,000	2 properties, 6,000 vehicles per day	Orangeville Boro.	Adjacent to SR0487
LFC-1: Pole Bridge Rd.	Culvert Replacement	$70,000 to 120,000	2 properties, 50 vehicles per day	Orangeville Boro.	
LFC-2: Orchard Road Culvert	Culvert Replacement, Road Reprofiling	$180,000 to 320,000	3 properties, 500 vehicles per day	Jackson Twp.	SR0239 & Pole Bridge Rd
LFC-3: Green Creek Road Flooding	Culvert Replacement	$30,000 to 60,000	2 properties, 100 vehicles per day	Jackson Twp.	
LFC-4: Peterman Road Flooding	Culvert Replacement, Road Reprofiling, Road Reprofiling	$196,000 to 390,000	2 properties, 50 vehicles per day	Jackson Twp.	
LFC-7: Main Street Bridge	Bridge Replacement, Floodplain improvements	$2.4 to 4.45 million	5 properties, 2,900 vehicles per day	Pine Twp.	PA BR 12552
HC-6: Peppermill Road Flooding	Culvert Replacement, Riparian Buffer	$300,000 to 600,000	2 properties, 1,000 vehicles per day	Hemlock Twp.	SR4012 (Peppermill Road) at SR0044
HC-7: Orchard Drive Flooding	Culvert Replacement, Riparian Buffer	$100,000 to 200,000	2 properties, 800 vehicles per day	Hemlock Twp.	
HC-13: Perry Avenue Bridge	Bridge Replacement, Floodplain Improvements	$1.3 to 2.5 million	County building, 3 properties, 450 vehicles per day	Hemlock Twp. & Montour Twp.	PA BR 23856
HC-15: Hoffman Park Erosion/Flooding	Stream Stabilization, Floodplain Reconnection, Bridge Replacement	$400,000 to 9.3 million	Public park, 3+ properties, up to 5,300 vehicles	Town of Bloomsburg & Mt. Pleasant Township	PA BR 12713
Chesapeake Bay TMDL Countywide Action Plan (CAP) Implementation	Agricultural Best Management Practices, Stream Restoration, Stream Buffers	$50+/- million	Agricultural areas are watershed-wide; CAP projects improve stormwater management locally and provide cumulative benefits to downstream properties	Watershed-wide	
USGS Stream Gauge Maintenance	Continue USGS gauges, supplement with additional gauges downstream (Railroad St.) and on Little Fishing Creek (Millville)	$35,000 (gauge installation); $10,000 to 30,000 (gauge maintenance annually)	~2,000+/- structures in high hazard areas within watershed Flood warning reduces losses by up to 30%; USGS gauges support that through improved watershed hydrology/hydraulic understanding	Orange Twp. (existing); Town of Bloomsburg and Millville Boro. (potential new sites)	

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COUNTY OF COLUMBIA 1813

Columbia County Resiliency Office

SEDA COG

FISHING CREEK FLOOD MITIGATION STUDY

PROJECT OVERVIEW

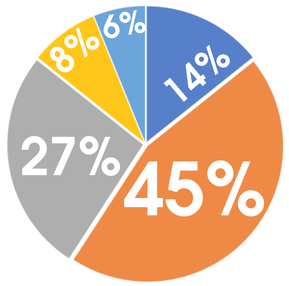
The Flood Mitigation Study is being developed to assist the County in understanding flooding issues in the Fishing Creek Watershed and identify mitigation strategies while considering effectiveness, feasibility, resiliency, and cost of those strategies and solutions.

GOALS OF THE STUDY

IDENTIFICATION OF FLOODING PROBLEMS

One of the key goals of the study is to identify what flooding means for the Fishing Creek Watershed, specifically in Columbia County. This includes identifying:

1. where does flooding occur?
2. when does flooding happen?
3. why does flooding happen?



45% of noted problem areas experience flooding more than once a year

89% of municipalities stated they have flooding issues

88% of identified problem areas attributed stormwater volume is the cause of the flooding

IDENTIFICATION OF POTENTIAL SOLUTIONS

Identifying the potential solutions means determining what strategies and projects will help to mitigate the impacts of flooding in the watershed. Solutions are broken into four types, property solutions, non-structural solutions, structural solutions, and nature based. Ultimately we are working to answer the question: what is effective at mitigating or protecting against flooding?

Solutions are broken into four types, property solutions, non-structural solutions, structural solutions, and nature based.

STRATEGY BASED SOLUTIONS

- Limited Floodplain Development
- Stormwater Management Plans
- Early Warning System
- Protection of Conservation Areas

NATURE BASED SOLUTIONS

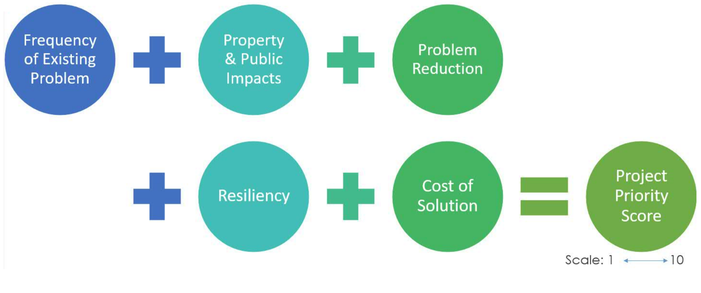
- Open Spaces
- Natural Drainage Systems
- Green Infrastructure
- Streamside Riparian Buffers

STRUCTURAL SOLUTIONS

- Flood Control Structures
- Removal of Structures from Floodplains
- Improved Stormwater Drainage Systems
- Elevating Roads & Bridges

ASSESSMENT & ANALYSIS OF SOLUTIONS

The assessment and analysis of solutions will help to identify the risk, feasibility and the economic considerations for potential solutions. Solutions are broken into four types, property solutions, strategies (non-structural solutions), structural solutions, and nature based.



STRATEGIES: LAND USE / FLOODPLAIN MANAGEMENT & NOTIFICATION SYSTEMS

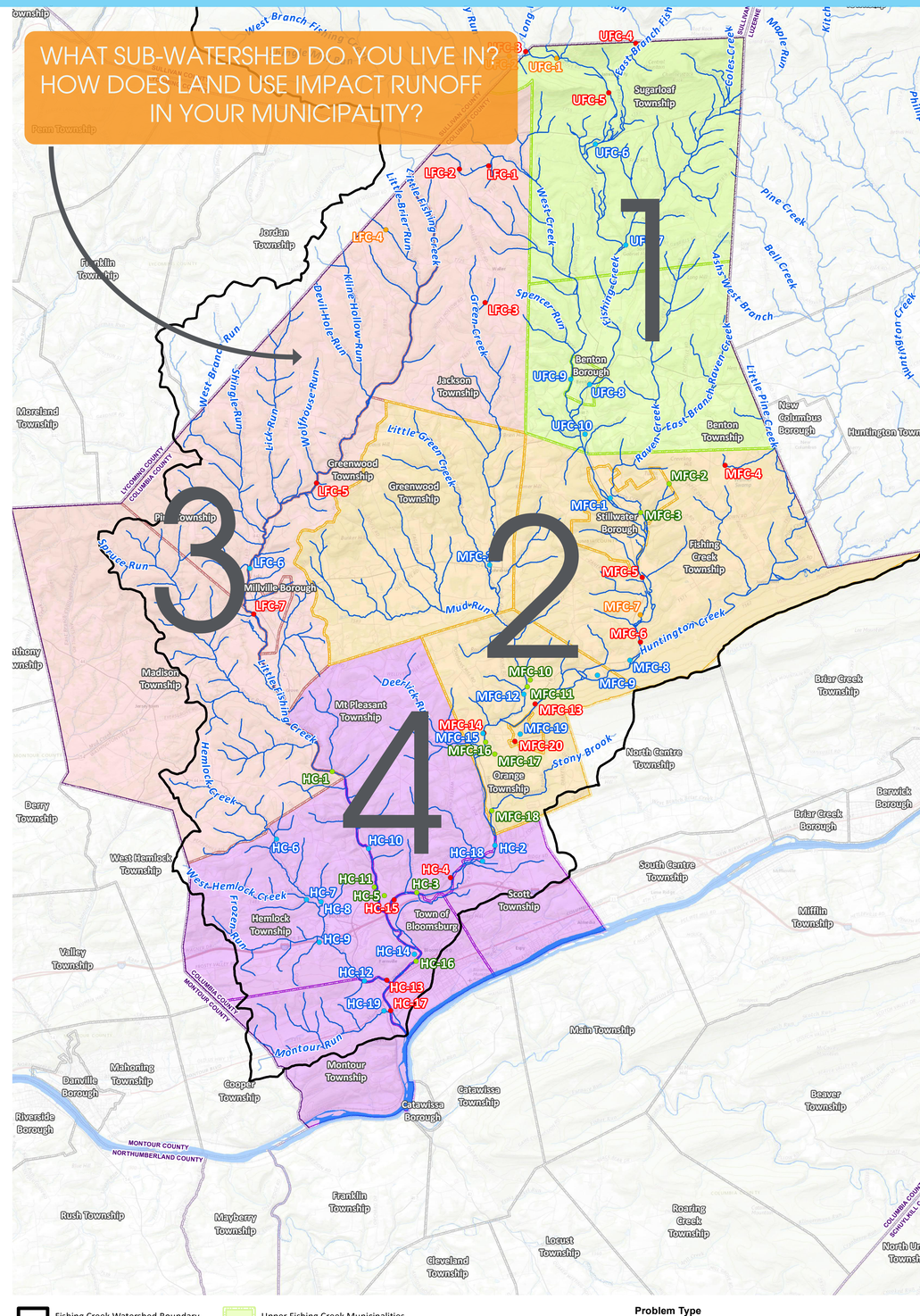
Flood Mitigation Smaller Events	Performance Larger Events	Resiliency	Feasibilty	Cost
HIGH	MEDIUM	MEDIUM	HIGH	LOW

NATURE BASED SOLUTIONS

Flood Mitigation Smaller Events	Performance Larger Events	Resiliency	Feasibilty	Cost
HIGH	LOW	HIGH	MEDIUM	MEDIUM

STRUCTURAL SOLUTIONS

Flood Mitigation Smaller Events	Performance Larger Events	Resiliency	Feasibilty	Cost
HIGH	HIGH	MEDIUM	LOW	HIGH

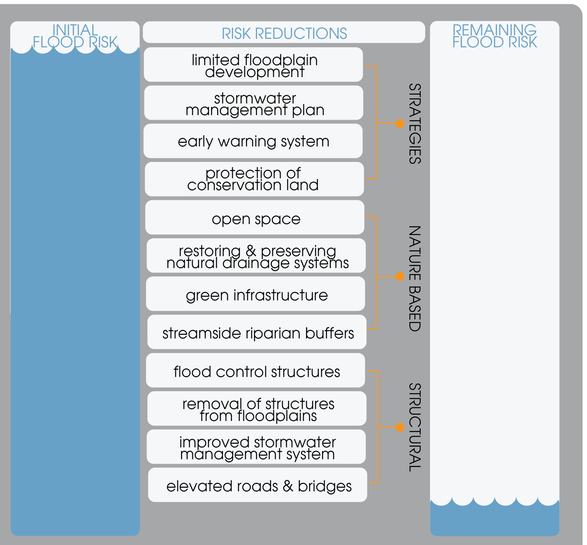


This project has been financed by grants from the Commonwealth of Pennsylvania, Commonwealth Financing Authority and the Department of Community and Economic Development.

FISHING CREEK FLOOD MITIGATION STUDY

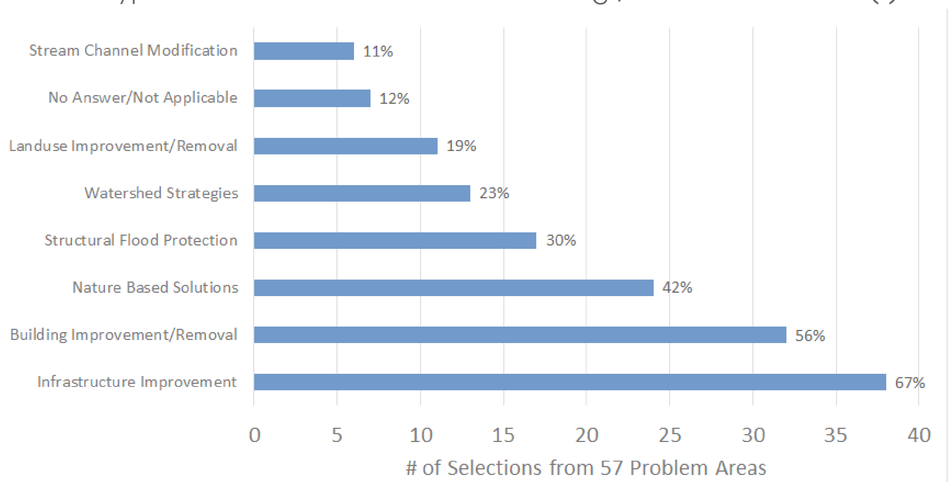
POTENTIAL STRATEGIES & SOLUTIONS

Flooding risks are never able to be fully removed from an area, however through using a combination of solutions, the risk of flooding can be greatly decreased. Solutions come in a number of shapes and sizes and rage from individual solutions, local planning and regulations, structural improvements and nature based infrastructure.



SOLUTIONS TO FLOODING & WET WEATHER ISSUES

What types of solutions can address flooding / wet weather issue(s)?



PROPERTY SOLUTIONS

The goals of this study is to focus larger community based solutions however below are solutions for individuals:

1 Elevate Home
2. Reduce Runoff
3. Sump Pump Installation
4. Move Home
5. Raise Building Systems

What can you do?

In your own backyard you can be a part of a county-wide initiative to steward and restore our vital natural resources and habitats, reduce impacts of stormwater, flooding, and erosion, and improve our drinking water quality and other watershed resources.

Learn more at: columbiaccd.org/betterbackyards.html

STRATEGY BASED SOLUTIONS

Limited Floodplain Development helps to limit the impervious area and buildings that could be flooded.

Stormwater Management Plans create municipal standards to reduce the impact of runoff stormwater.

Early Warning System measures for potentially dangerous flooding conditions and sends alerts to the communities.

Protection of Conservation Areas though zoning and policy to protect natural landscapes and promote healthy habitats.

NATURE BASED SOLUTIONS

Open Spaces such as parks and preserves help reduce flooding due to limited impervious surface.

Restoring and Preserving Natural Drainage Systems such as wetlands allow water to be stored and reduced flooding.

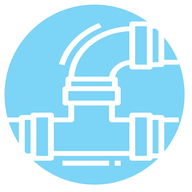
Green Infrastructure such as rain gardens allow for runoff to be captured and infiltrated reducing flooding.

Streamside Riparian Buffers help to hold stream banks in place, improve the habitat, and provide cleaner water.

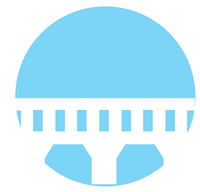
STRUCTURAL BASED SOLUTIONS

Flood Control Structures such as levees and other physical barriers that help prevent areas from flooding.

Removal of Structures from Floodplains helps to remove flooding risk, and can improve water infiltration.



Improved Stormwater Drainage Systems, when upgraded systems are more effective at managing stormwater.



Elevating Roads and Bridges help to drain water, reduced flooding and allow for greater infiltration.

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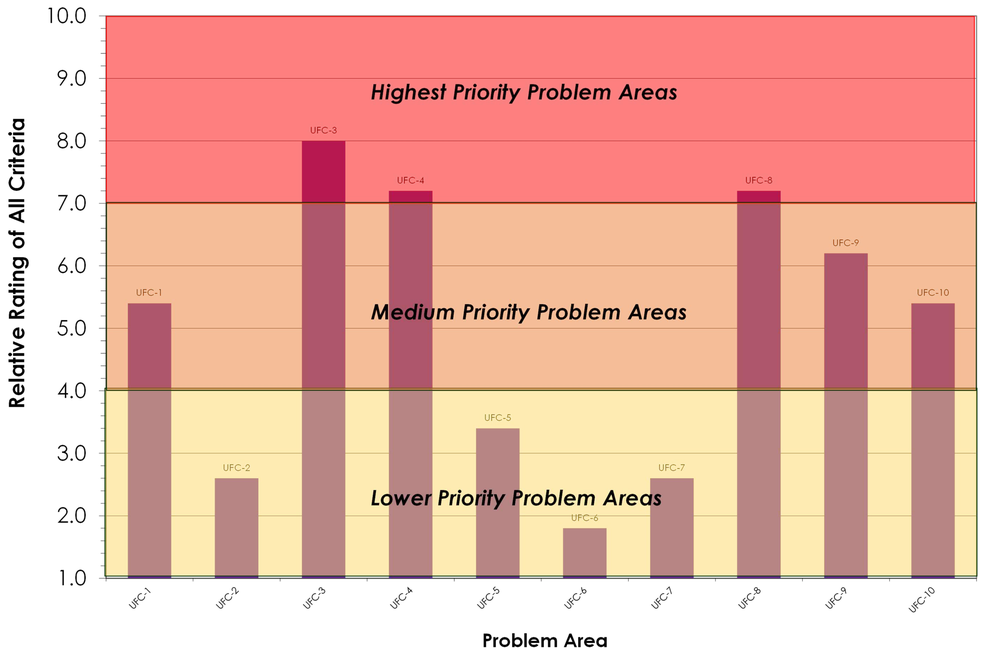
FISHING CREEK FLOOD MITIGATION STUDY

UPPER FISHING CREEK STUDY AREA



REGULAR FLOODING IN THE UPPER FISHING CREEK STUDY AREA RESULTS IN:

351+ DIRECTLY IMPACTED PROPERTIES

5,300+ AVERAGE DAILY TRIPS PREVENTED

AVERAGE LIKELYHOOD OF A PROBLEM IN A YEAR

25% / EVERY 2-5 YEARS

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Engineering & Related Services
AN EMPLOYEE-OWNED COMPANY

pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

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1 UFC-1:FLOODING & DEBRIS ISSUES AROUND CENTRAL, JAMISON CITY

Problems: Flooding/Sedimentation
Mitigation Concepts: Debris Management

2 UFC-2 : ELK GROVE FLOODING

Problems: Flooding
Mitigation Concepts: Coordination with Sullivan County on timbering and erosion controls.

3 UFC-3 : CENTRAL ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement / Bridge Replacement

4 UFC-4 : JAMISON CITY ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Sediment Removal/Bridge Replacement

5 UFC-5 : CENTRAL ROAD/STEVENS HILL ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Debris removal/ maintenance

6 UFC-6 : SCHOOL HOUSE DRIVE BRIDGE

Problems: Flooding/Sedimentation
Mitigation Concepts:Debris removal/maintenance

7 UFC-7 : CAMP LAVIGNE ROAD BRIDGE

Problems: Flooding/Infrastructure
Mitigation Concepts:Vegetation/ Debris Management

8 UFC- 8 : BENTON BOROUGH FLOODING

Problems: Flooding
Mitigation Concepts: Dam Removal/ Levee/Roadway Reprofiling

9 UFC-9 : DISTILLERY HILL ROAD FLOODING

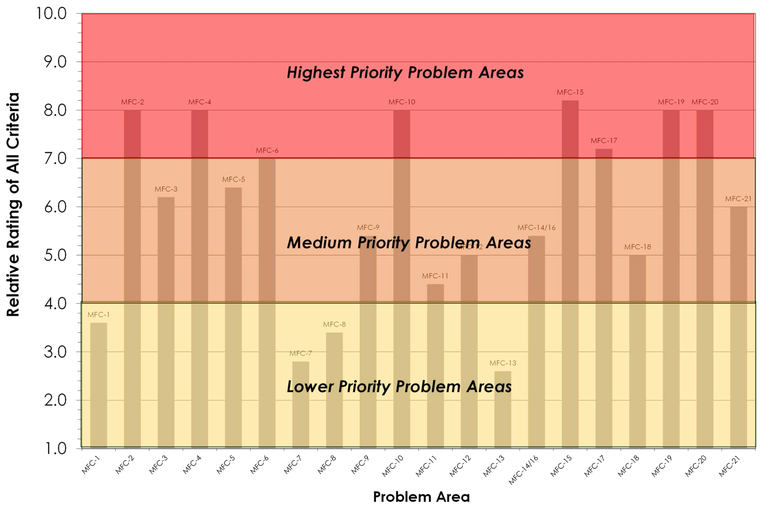
Problems: Flooding
Mitigation Concepts: Bridge Replacement/ Sediment Removal

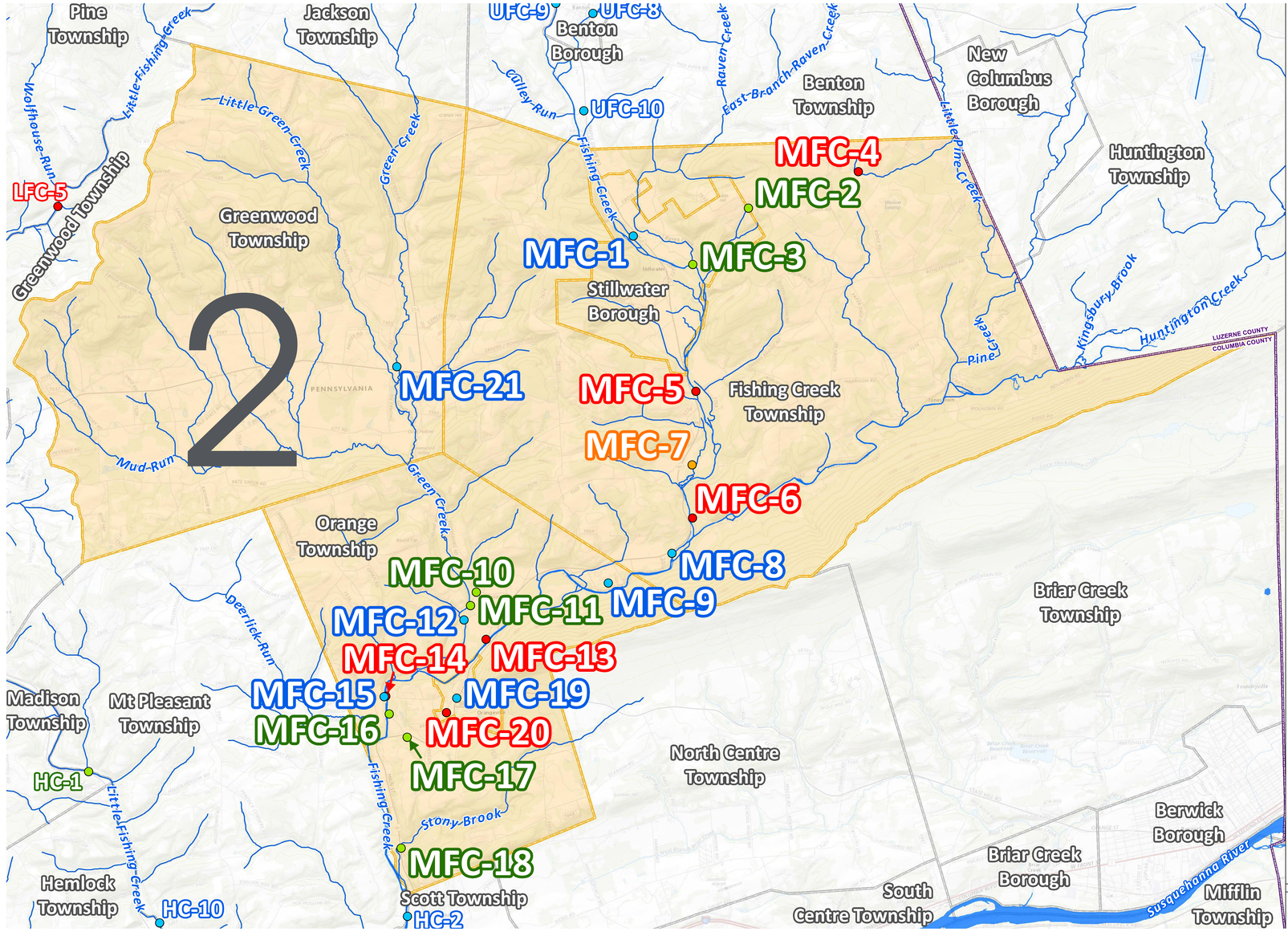
10 UFC-10 : INTERSECTION OF ROHRSBURG ROAD & MAPLE GROVE ROAD FLOODING

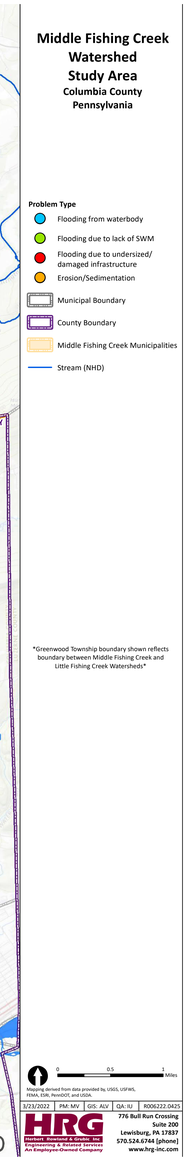
Problems: Flooding
Mitigation Concepts: Property Buyout/Relocation

FISHING CREEK FLOOD MITIGATION STUDY

MIDDLE FISHING CREEK STUDY AREA







REGULAR FLOODING IN THE MIDDLE FISHING CREEK STUDY AREA RESULTS IN:

211+ DIRECTLY IMPACTED PROPERTIES

6,000+ AVERAGE DAILY TRIPS PREVENTED

AVERAGE LIKELYHOOD OF A PROBLEM IN A YEAR

50% / EVERY 2 YEARS

pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

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1 & 3 MFC-1 & MFC3 : STILLWATER BOROUGH FLOODING

Problems: Flooding
Mitigation Concepts: Bridge Replacement

2 MFC-2 : PAPERDALE ROAD

Problems: Flooding/Sedimentation
Mitigation Concepts: Vegetation/ Debris Management

4 MFC-4 : HONEYTOWN ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacements

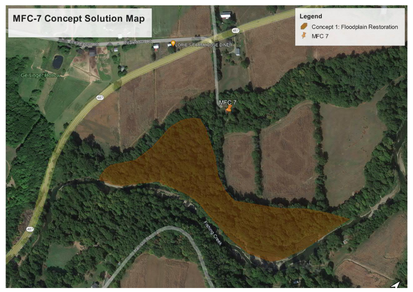
5 MFC-5 :ZANER BRIDGE ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Bridge Replacement/ Sediment Removal

6 MFC-6 : WINDING ROAD CULVERT

Problems: Flooding/Sedimentation
Mitigation Concepts:Culvert Replacement

7 MFC-7 : PEALERTOWN FLOODING



Problems: Flooding/Sedimentation
Mitigation Concepts: Floodplain Reconnection

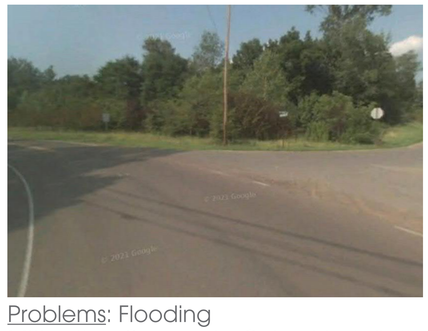
8 MFC-8 : 2870 SR 487

Problems: Erosion/Flooding
Mitigation Concepts: Floodplain Reconnection/ Streambank Stabilization

9 MFC-9 : MOORE'S GROVE ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Streambank Stabilization & Property Buyout/Relocation

10 MFC-10 : ROHRSBURG ROAD CULVERT

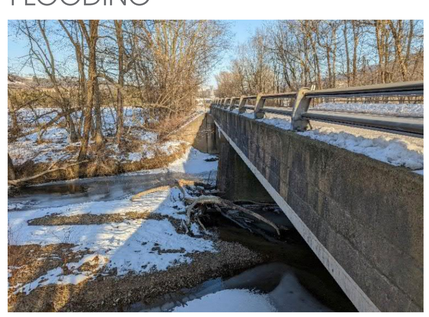


Problems: Flooding
Mitigation Concepts: Culvert Installation

11 MFC-11 : GREEN CREEK ROAD FLOODING

Problems: Flooding
Mitigation Concepts: Floodgate/Floodplain Restoration

12 MFC-12 : GREEN CREEK ROAD FLOODING



Problemss: Flooding/Sedimentation
Mitigation Concepts:Bridge Replacement/ Sediment Removal

13 MFC-13 : EVANS LANE FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Structure Removal/ Streambank Stabilization

14 &16 MFC-14 & 16:CHARMUND ROAD FLOODING

Problems: Flooding
Mitigation Concepts: Property Buyout/ Relocation

15 MFC-15 : USGS STREAM GAUGE AT MOUNT PLEASANT ROAD BRIDGE

Problems: Flooding
Mitigation Concepts: USGS Stream Gauge Reconstruction/Maintenance

17 MFC-17 : STATE ROUTE 487 & CHARMUND ROAD

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement

18 MFC-18 : STONY BROOK ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Floodplain Reconnection

19 MFC-19 : ORANGEVILLE FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement/ Riparian Buffer

20 MFC-20 : BROAD STREET

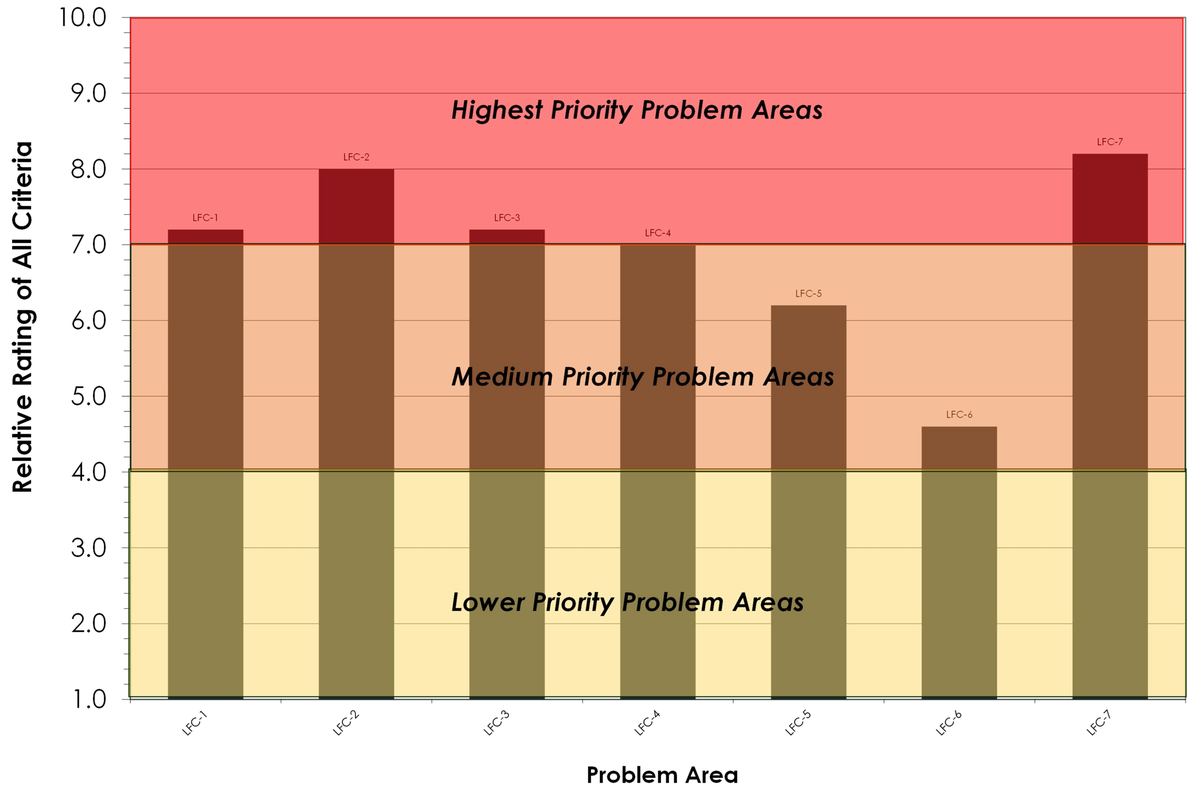
Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacements

21 MFC-21 : ROHRSBURG FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Bridge Replacement

FISHING CREEK FLOOD MITIGATION STUDY

LITTLE FISHING CREEK STUDY AREA



REGULAR FLOODING IN THE LITTLE FISHING CREEK STUDY AREA RESULTS IN:

51+ DIRECTLY IMPACTED PROPERTIES

5,200+ AVERAGE DAILY TRIPS PREVENTED

AVERAGE LIKELYHOOD OF A PROBLEM IN A YEAR

30% / EVERY 2-5 YEARS

1 LFC-1: POLE BRIDGE ROAD FLOODING

Problems: Flooding
Mitigation Concepts: Culvert Replacement

2 LFC-2 :POLE BRIDGE ROAD CULVERT

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement

3 LFC-3 :GREEN CREEK ROAD FLOODING

Problems: Flooding, Erosion, Sedimentation
Mitigation Concepts: Culvert Replacement

4 LFC-4 : PETERMAN ROAD

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement

5 LFC-5 : MALLARD ROAD EROSION

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement

6 LFC-6 : FLOODING AROUND IOLA

Problems: Flooding/Infrastructure
Mitigation Concepts:Bridge Replacement/ Stream Maintenance

7 LFC-7 : MAIN STREET (PA 254) BRIDGE

Problems: Flooding/Infrastructure
Mitigation Concepts: Bridge Replacement/ Floodplain Reconnection

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FISHING CREEK FLOOD MITIGATION STUDY

HEMLOCK CREEK-LOWER FISHING CREEK STUDY AREA

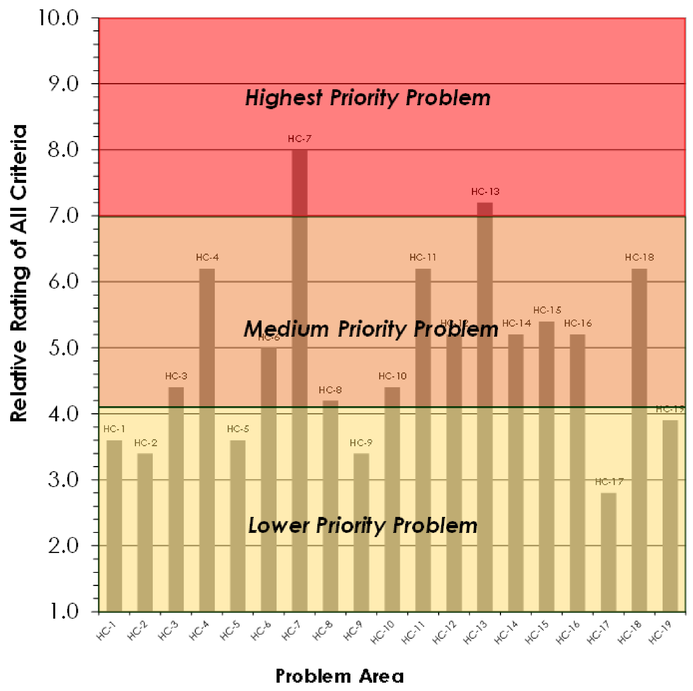
REGULAR FLOODING IN THE HEMLOCK CREEK - LOWER FISHING CREEK STUDY AREA RESULTS IN:

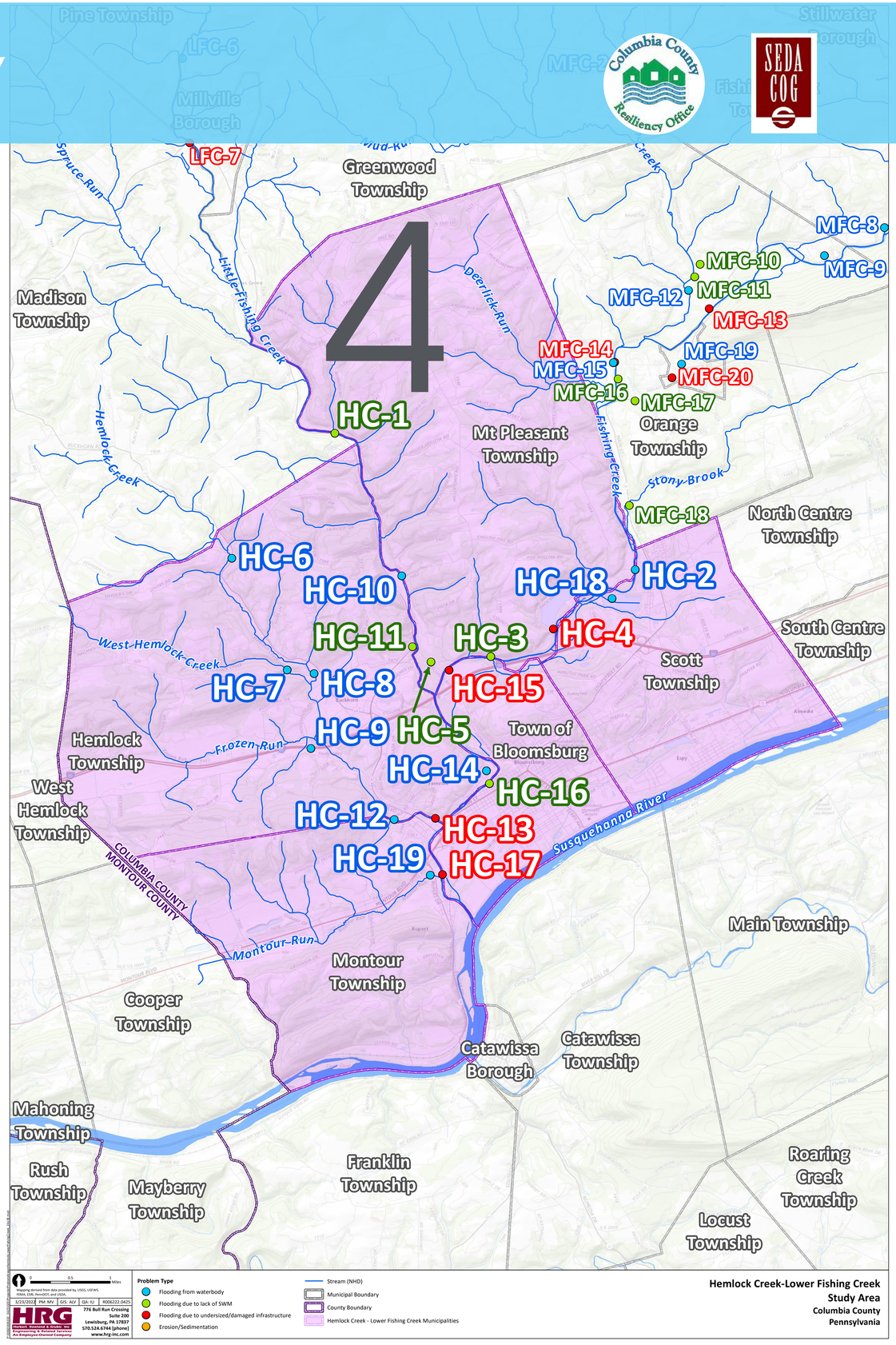
361+
DIRECTLY IMPACTED PROPERTIES

10,000+
AVERAGE DAILY TRIPS PREVENTED

AVERAGE LIKELYHOOD OF A PROBLEM IN A YEAR

15%
/ EVERY 5-10 YEARS





1 HC-1: ROBBINS ROAD BRIDGE

Problems: Sediment and Debris Buildup
Mitigation Concepts: Sediment Removal

2 HC-2 : BACK BRANCH ROAD BRIDGE SCOUR

Problems: Erosion/ Flooding / Infrastructure
Mitigation Concepts: Pier Scour Protection / Floodplain Reconenction

3 HC-3 : BACK BRANCH ROAD FLOODING

Problems: Frequent Flooding
Mitigation Concepts: Floodplain Restoration / Road Closure

4 HC-4 : BACK BRANCH ROAD SEDIMENTATION POND

Problems: Flooding
Mitigation Concepts: Floodplain Reconnection/ Stream Realignment

pennsylvania DEPARTMENT OF COMMUNITY & ECONOMIC DEVELOPMENT

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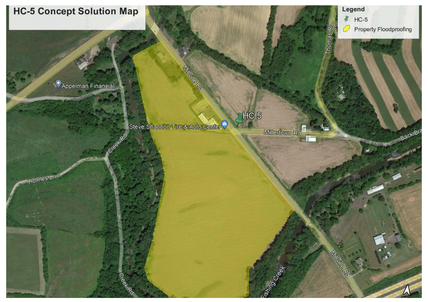
5 HC-5 : STEVE SHANNON TIRE & AUTO CENTER FLOODING



Problems: Runoff, Flooding, Stream Velocity
Mitigation Concepts: Property Floodproofing

6 HC-6 : PEPPERMILL ROAD & BUCKHORN ROAD FLOODING

Problems: Flooding, Erosion, Sedimentation
Mitigation Concepts:Culvert Replacement and Stream Enhancements

7 HC-7 : DAHL ROAD FLOODING

Problems: Flooding/Sedimentation
Mitigation Concepts: Culvert Replacement

8 HC- 8 : ORCHARD DRIVE FLOODING

Problems: Flooding, Erosion, Sedimentation
Mitigation Concepts: Culvert Replacement and Stream Enhancements

9 HC-9 : FROSTY VALLEY ROAD

Problems: Erosion, Sedimentation
Mitigation Concepts: Stream Bank Protection, Storm Sewer Infrastructure

10 HC-10 : WANICH COVERED BRIDGE

Problems: Flooding, Stream Velocity, Erosion
Mitigation Concepts: Bridge Raising

11 HC-11 : MILLVILLE ROAD FLOODING

Problems: Flooding, Stream Velocity, Erosion
Mitigation Concepts: Bridge Replacement, Floodplain Reconnection

12 HC-12 : RIDGE ROAD FLOODING

Problemss: Flooding/Erosion
Mitigation Concepts: Bridge Replacement/ Driveway Relocation/ Streambank Stabilization

13 HC-13 : PERRY AVENUE BRIDGE

Problems: Flooding
Mitigation Concepts: Bridge Replacement

14 HC-14 : FERNVILLE FLOODING

Problems: Flooding
Mitigation Concepts: Property Floodproofing, Emergency Access Road

15 HC-15 : HOFFMAN PARK TRAIL EROSION

Problems: Erosion/Flooding
Mitigation Concepts: Bridge Replacement/ Floodplain Reconnection/ Streambank Stabilization

16 HC-16 : RAILROAD ST FLOODING

Problems: Flooding
Mitigation Concepts: Levee system, Property Floodproofing

17 HC-17 : BOONE'S DAM

Problems: Erosion/Flooding
Mitigation Concepts: Dam Removal

18 HC-18 : BY LAKE FLORENCE

Problems: Flooding
Mitigation Concepts: Floodplain Reconnection

19 HC-19 : HOCK ROAD BRIDGE

Problems: Flooding/Sedimentation
Mitigation Concepts: Bridge Replcamenet

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