BOROUGH OF LEWISBURG PENNSYLVANIA

LEWISBURG FLOOD MITIGATION STUDY

Borough of Lewisburg, Union County, PA

June 2023

LEWISBURG FLOOD MITIGATION STUDY

Lewisburg Borough

55 South Fifth Street, Lewisburg, PA 17837

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SECTION 1 - EXECUTIVE SUMMARY

The Borough of Lewisburg launched a Flood Mitigation Study in 2022 to improve the Borough's ability to withstand a flooding event, regardless of the size of the flood event. The Borough was devastated 50 years ago by the Hurricane Agnes flood, and since that time it has made significant strides in improvements to the community's flood resiliency. Projects have included removal of flood prone properties in the floodplain, reconnection of floodplains and open spaces, widening bridges and culverts, and restricting development in the floodplain. This progress is significant; however, more mitigation efforts are needed to ensure the community can quickly recover from the next significant flood event, similar to Hurricane Agnes. To aid the Borough, the Flood Mitigation Study was a recommendation of the Borough's Early Intervention Plan adopted in 2019 to limit the exposure to a significant flooding event while maintaining the Borough's charming attributes prized by residents and visitors alike. The Borough has provided funding for this study, along with a grant from the Strategic Management Planning Program of the Department of Community and Economic Development (DCED) in the Commonwealth of Pennsylvania.

The goals of this study included:

1. Identifying Borough-wide impacts based on severity of flooding.
2. Developing flood mitigation tools for preparedness and recovery.
3. Take bigger steps towards becoming a Flood Resilient Community.
4. Planning and developing concepts for a demonstration of green infrastructure opportunities within the Borough's infrastructure.

The project team was assigned to perform the study and identify actionable steps and recommendations towards achieving flood resiliency and mitigating adverse impacts from flooding events. The study scope consisted of a detailed technical analysis including field reconnaissance, topographic survey, and conceptual flood hazard mitigation project development. In addition to the technical analysis, public and municipal participation was incorporated including education and outreach opportunities, and development of Borough flood preparation tools. Fundamental to the project was developing an understanding of the desire and capacity of the Borough, its residents, and landowners to implement solutions that target flood mitigation at the local level while mitigating flooding conditions throughout the Borough. All of this was summarized in this technical report and will be presented to the Borough.

After public outreach and field reconnaissance, flood mitigation strategies and solutions were identified with the goal of minimizing flooding impacts throughout the community, including both limiting property damages and limiting any reduction in economic activity within the Borough. Mitigation options evaluated include property floodproofing, structure elevations, bridge replacements, and modifications to the floodplains. Additionally, the study included development of Borough tools for future use in preparing for flooding events:

- Flood Resilient Community Toolbox
- Operational Action and Recovery Plan
- Revenue Impact Analysis
- Ordinance Review
- Limestone/Bull Run Hydrologic and Hydraulic Study
- Green Infrastructure Demonstration Project

1.1 - SUMMARY OF FINDINGS

The study's findings will support the Borough's development and implementation of initiatives to improve the community's flood resiliency. The highlights of these include:

- Update Borough ordinances to provide incentives for residents and businesses to improve flood resiliency of their buildings and properties.

- Further evaluations of flood mitigation projects in Limestone/Bull Run Watershed.
- Coordinating with Borough residents and business owners to develop flood preparation/recovery plans.
- Continuing flooding resiliency education and engagement through expanded methods.
- Identifying financial resources within and external to the Borough that can be applied to flood mitigation efforts.
- Utilizing, maintaining, and updating Borough flood preparation tools.

SECTION 2 - INTRODUCTION

2.1 - STUDY AREA

The Borough of Lewisburg (Borough) is located within the floodplains of the West Branch Susquehanna River, Buffalo Creek and Limestone/Bull Run. It is bordered by East Buffalo and Kelly Townships and is the most densely populated portion of Union County. It also serves as the County Seat for the government of Union County. The population as of 2021 was estimated to be 5,232 and is the location of Bucknell University.

The floodplains of the river, creek, and run cover approximately one third of the Borough's land area (Figure 1.1) with over 500 properties located within the current, regulatory floodplain. Further, the Borough is essentially built-out with most developable area occupied by homes, businesses, and institutions.

The West Branch Susquehanna River forms the eastern border of Lewisburg, with flows moving north to south. The river's contributory area to Lewisburg is 6,847 square miles (USGS, 2023). The United States Geological Survey (USGS) operates a flow and stage monitoring gage at the eastern abutment of the Market Street Bridge. Major floods (exceeding the Base Flood Elevation, BFE) have occurred at Lewisburg from the West Branch Susquehanna River in 1889, 1936, and 1972.

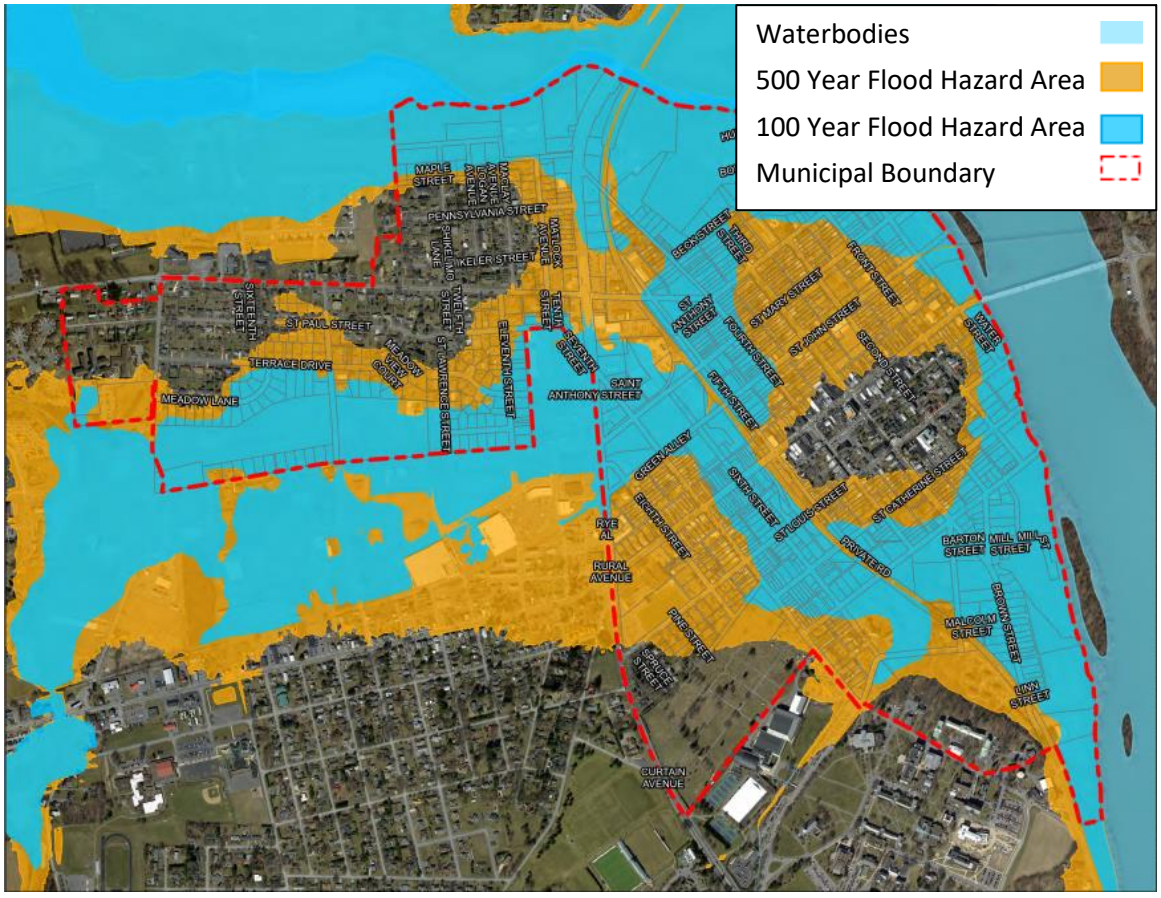

FIGURE 1.1 – Borough Area and Floodplain Extents

Buffalo Creek flows into the West Branch Susquehanna River along the western bank and forms the northern boundary of Lewisburg Borough, separating the Borough from Kelly Township. Buffalo Creek watershed's contributory area is 135 square miles (UCCD, 2008).

Limestone/Bull Run flows into the West Branch Susquehanna River along the western bank at the southeastern corner of Lewisburg. Limestone/Bull Run forms part of the upper southwestern boundary of Lewisburg Borough between the Borough and East Buffalo Township. Miller Run flows into Limestone/Bull Run in Lewisburg near St. George Street between South Fourth and South Fifth Streets and drains most of the area comprising the portion of Bucknell University's campus located in East Buffalo Township. Limestone/Bull Run watershed's contributory area is 8.41 square miles (USGS, 2023). Major floods have occurred at Lewisburg from the Limestone/Bull Run watershed in 1972 and 1999.

2.2 - FLOODING AND RAINFALL HISTORY

The Borough has recorded historic flooding dating back to 1889. Flooding primarily occurs from the backwater of the West Branch Susquehanna River through the Buffalo Creek and Limestone/Bull Run floodways. Limestone/Bull Run has created flooding conditions from significant, localized intense rainfall events. In 1972, the Borough experienced a devastating flood event due to Tropical Storm Agnes, that caused the river to rise 35 feet above the river bed elevation, and resulted in over 1,500 impacted structures, and 4 deaths in the Borough. Estimated impact area from the 1972 Hurricane Agnes event is shown in Figure 2.2.

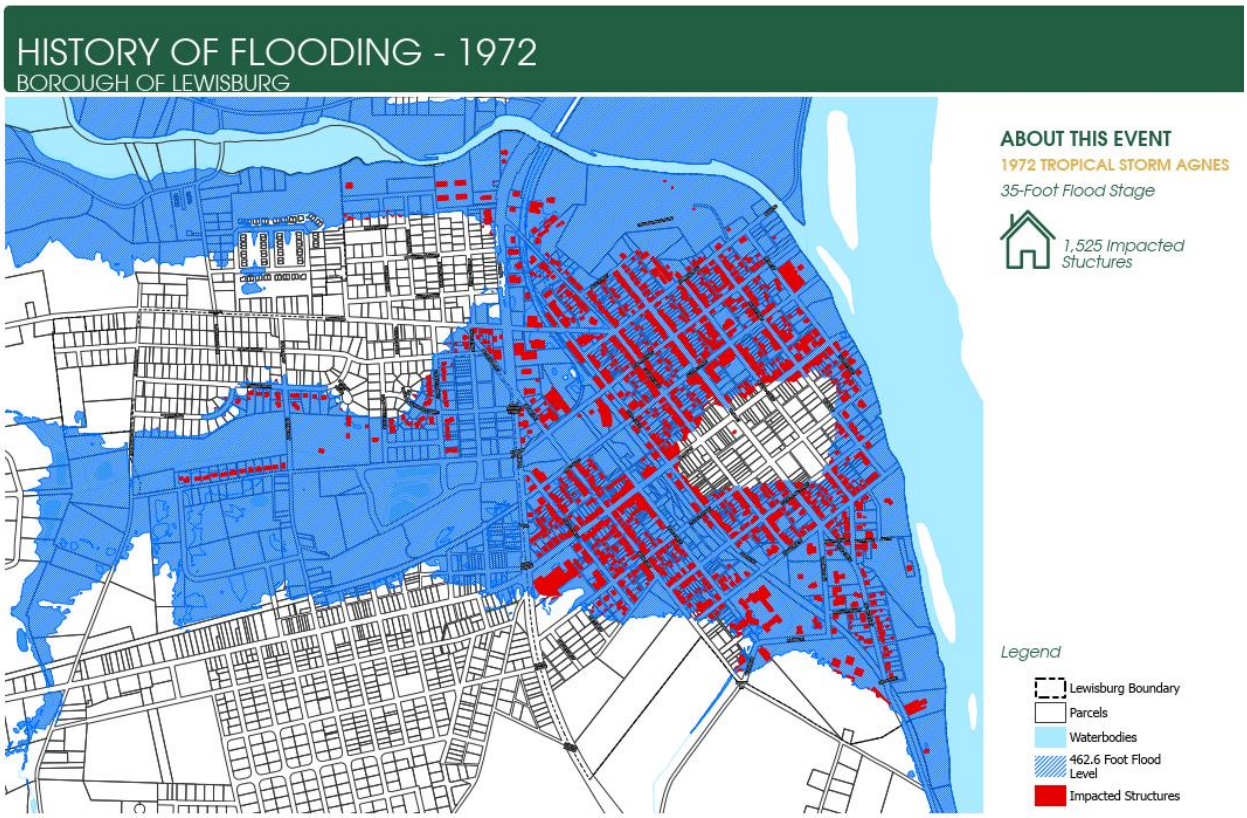

Figure 2.2 1972 Estimated Flood Extents and Impacts

In 2011, another severely damaging flood event occurred due to Tropical Storm Lee, resulting in over 100 impacted structures and over $760,000 in insurance claims made in 2011 dollars (or just over $1 million in 2023 dollars) Although an event of this nature hasn't occurred since then, and fortunately, no other deaths have resulted from flooding, the Borough continues to experience smaller flood events, which still have damaging effects on the community. A significant local event in September 1999 caused damage to 82 properties in the Borough and a large portion of Bucknell University within the Limestone/Bull Run Floodplain. Table 2.1 summarizes the significant floods to impact Lewisburg since 1889.

Table 2.1 Significant Floods in Lewisburg Borough

West Branch Susquehanna River			
Year	**Month Day**	**River Crest (ft)**	**Storm**
1889	June 1	29.8	
1894	May 21	28.5	
1936	March 19	32.1	
1946	May 29	28.43	
1948	April 15	20.07	
1950	November 26	26.05	
1960	April 15	21	
1961	February 27	21.17	
1964	March 11	26.16	
1972	June 24	34.23	Hurricane Agnes
1975	September	27.62	Hurricane Eloise
1979	March 6	23.44	
1982	February	20	
1984	February 15	24.26	
1993	April 2	21.3	
1996	January 20	25.94	
2004	September 19	26.01	Hurricane Ivan
2010	December 2	20.9	
2011	March 15	20.78	
2011	April 29	20.13	
2011	September 9	25.91	Tropical Storm Lee
Limestone/Bull/Miller Run			
Year	**Month Day**	**River Crest (ft)**	**Storm**
1972	June 22	Bull Run	Hurricane Agnes
1999	September 7	Bull Run/Miller Run	Hurricane Dennis

A review of significant West Branch Susquehanna River events indicates these events typically occur during the tropical storm season or during snow melt events in late winter and early spring (Figure 1.2). With state-wide rainfall data indicating a greater frequency of high-intensity rainfall events over the last 20 years (see Figure 2.4 and links to studies) and the occurrence of large tropical storm events in Pennsylvania. Understanding the potential for future events, the Borough desires to continue nearly 50 years of improving flood resiliency and minimizing the impacts from and ensuring preparedness for any future flooding events.

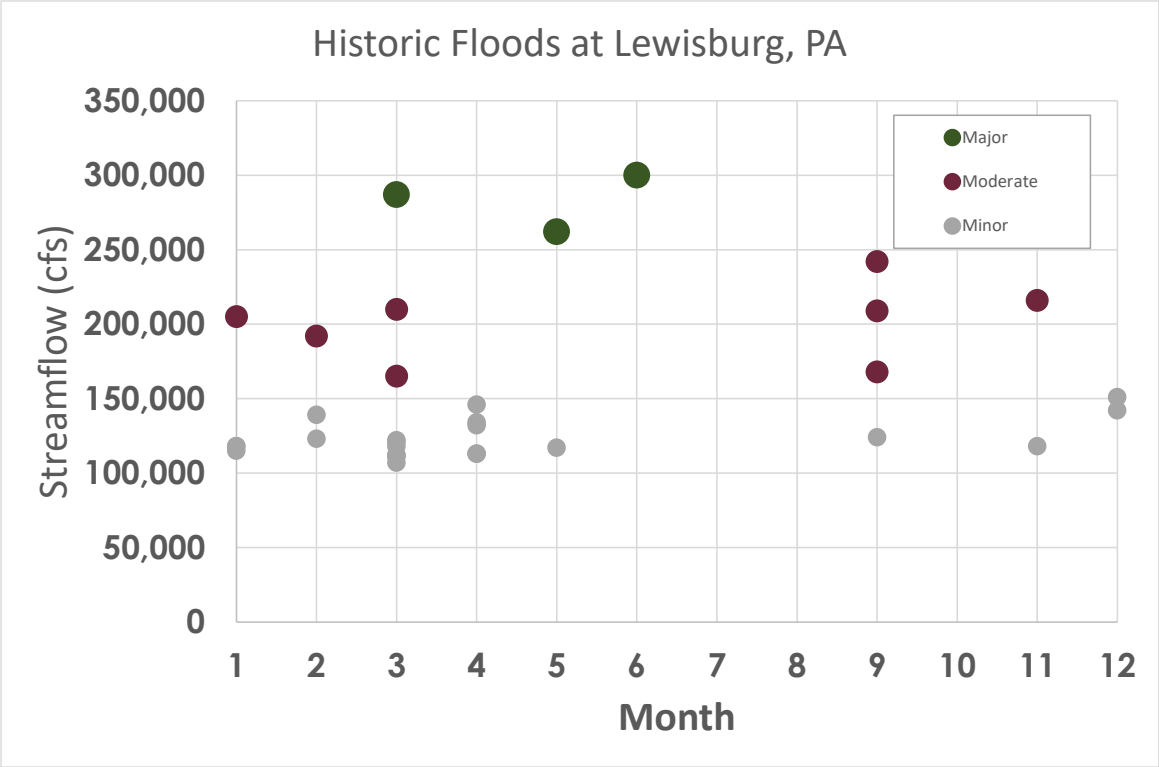

Figure 2.2 Historic Floods at Lewisburg by Month

Figures 2.3 and 2.4 show the rainfall statistics for the two closest locations with an extended record near Lewisburg (Danville, PA from 1942 through 2010 and Williamsport, PA from 1945 through 2021). The average rainfall, shown in Figure 2.3 portrays the amount of precipitation throughout each year since 1942. It is notable that 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, 12-hour) that impacts flooding conditions from Buffalo Creek and Limestone/Bull Run in Lewisburg, while significant longer time period events create flooding conditions from the West Branch Susquehanna River (12-hour, 24-hour)

Figure 2.4 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.

The majority of rainfall in Lewisburg and surrounding areas (including the contributory area of the West Branch Susquehanna River) comes from storms of low magnitudes. Only 10% of the daily rainfall between 1942 and 2021 exceeded 0.85 inches. For the gage data shown in Figure 2.4, 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 rainstorms.

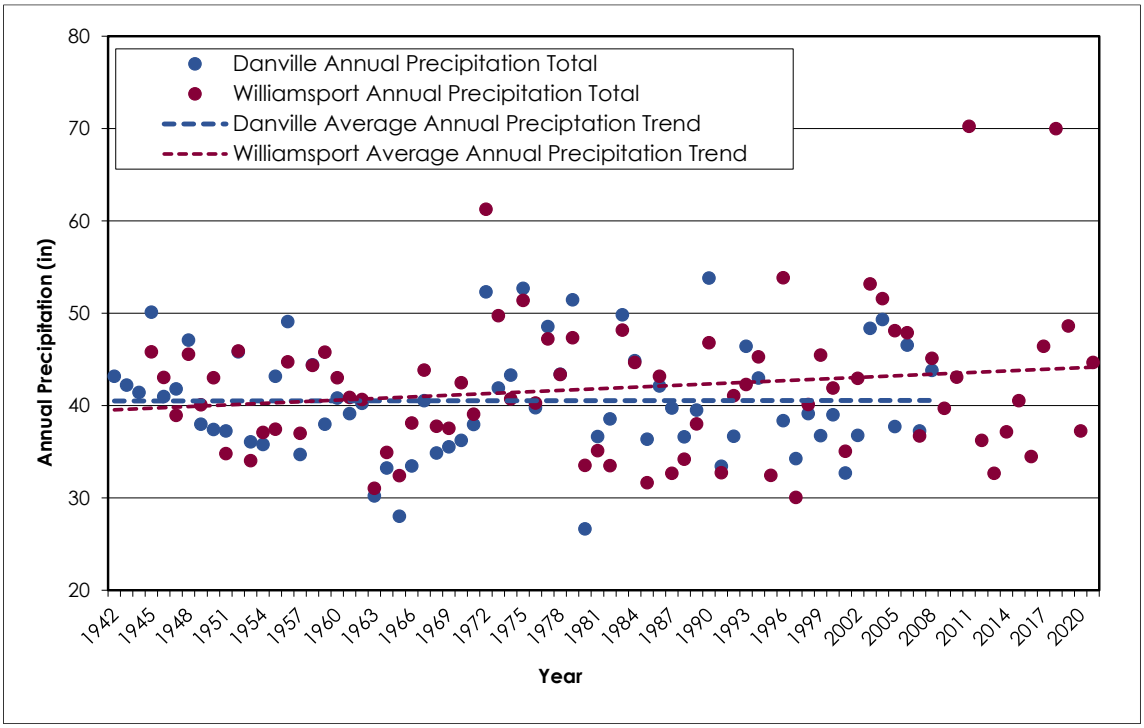

Figure 2.3 Annual Precipitation at Danville and Williamsport

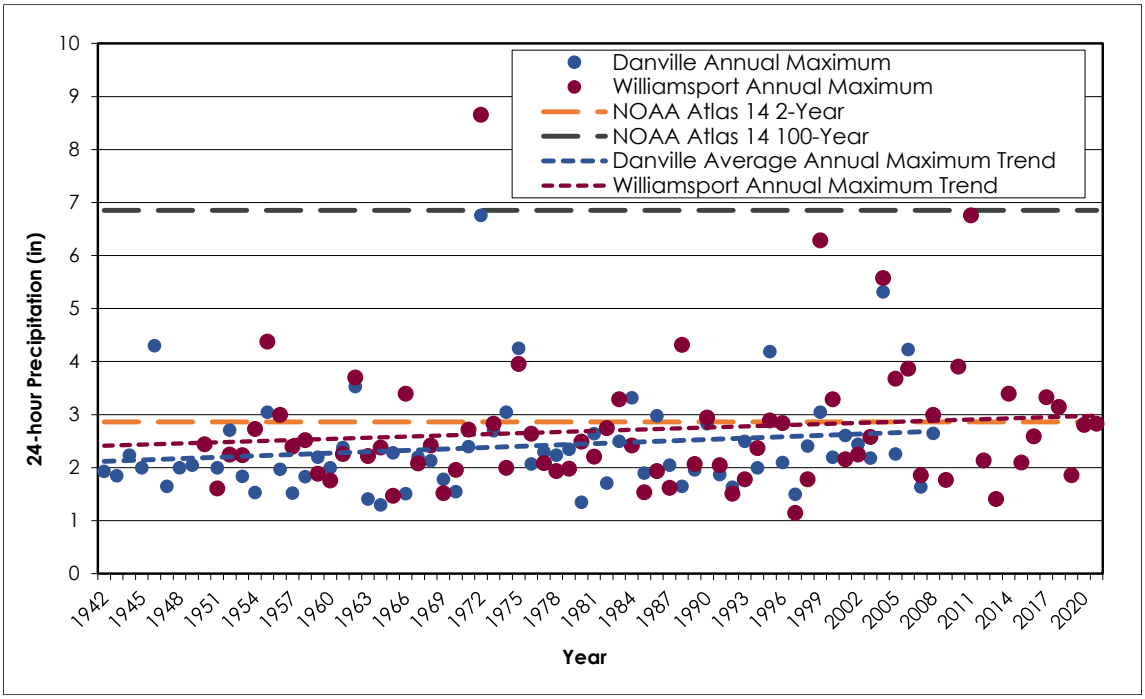

Figure 2.4 24-Hour Rainfall Statistics at Danville and Williamsport

2.3 - EXISTING FLOODING AND STORMWATER INFRASTRUCTURE

Lewisburg Borough has a mix of areas that are drained by storm sewers and undrained areas. At least Forty-three (43) discharge points exist along the banks of the three waterbodies within the Borough. These are a mixture of storm drains on bridges/culverts and larger collection stormwater collection systems that drain several street intersections/blocks and/or parking lots. Larger outfalls that drain the significant portions of the Borough could benefit from backflow prevention devices to prevent backwater during high flows from backing up into low areas within the Borough. One such outfall is planned to be replaced with a backflow prevention mechanism adjacent to the Buffalo Valley Rail Trail west of Fifth Street.

The Borough has also implemented a floodplain restoration project in Hufnagle Park south of St. Louis Street and intends to expand floodplain restoration efforts up and downstream from this area within the next few years.

2.4 - GOALS

The purpose of the Lewisburg Flood Mitigation Study (Study) is to identify approaches towards improving the Borough's ability to withstand events described in Table 2.1. This includes identifying means to minimize damages and recover quickly, and steps towards becoming a flood resilient community. The Borough desires to achieve flood resiliency. As it relates to flooding and natural disasters, the Federal Emergency Management Agency (FEMA) defines resilience as:

> "Resilience is the capacity of individuals, communities, businesses, institutions, and governments to adapt to changing conditions and to prepare for, withstand, and rapidly recover from disruptions to everyday life, such as hazard events."

The Borough has taken many steps towards flood mitigation and flood event resiliency, as demonstrated through their many projects, including the Hufnagle Park Floodplain Restoration Project, the 6th Street Property Buyouts and Demolitions Project, and bridge/culvert removals and enlargement projects. However, as identified through this study, there is still much work remaining in order for the Borough to reduce flood impacts and achieve resiliency.

This Study has been funded by the Borough and a Strategic Management Planning Program Grant from the Commonwealth of Pennsylvania's Department of Community and Economic Development (DCED). It is the product of a comprehensive study of flood related issues and deficiencies throughout the Borough. The study included a review of previous efforts to improve flooding within the Borough, evaluation of current conditions within the Borough, future risk predictions, identification of flood mitigation options available within a subset of areas throughout the Borough (specifically the North Fourth Street/North Fifth Street neighborhood and the Limestone/Bull Run Floodplain area between Route 15 and Buffalo Creek Railroad Bridge below Hufnagle Park, and an understanding of the Borough's and public's awareness and preparedness for damaging flood events. The intent of this document is to summarize the study process, provide an educational toolbox for residents and commercial property owners to learn the planning steps to achieve flood resiliency, provide flood mitigation options within select areas, provide tools for the Borough in order to prepare for, withstand, and recover from flooding events, provide a framework for identification and implementation of potential flood mitigation solutions by the Borough, and present the findings of the study.

The goals of this study included:

1. Identifying Borough-wide impacts based on severity of flooding.
2. Developing flood mitigation tools for preparedness and recovery
3. Steps towards becoming a Flood Resilient Community
4. Planning and developing concepts for a Green Infrastructure Demonstration Project within the Borough

2.5 - SCOPE OF STUDY

The scope of the Study was to develop tools and provide direction to the Borough on next steps towards flood event resiliency. The full Study scope included:

- Inventory existing data and previous studies;
- Complete surveys of residents, property owners and businesses First Floor Elevations (FFE's);
- Perform building/property elevation surveys;
- Identify and evaluate conceptual mitigation solutions for select areas and properties, including the area known as North Fourth/North Fifth Street Neighborhood and select Commercial/Industrial Businesses located in the floodplain;
- Develop a Borough Flood Event Operational Action and Recovery Plan;
- Develop a tax Revenue Impact Analysis;
- Review existing Ordinances and provide summary of potential revisions for flood resilience improvement(s);
- Develop a Flood Resilient Community Toolbox, that is an expansion of educational and informational tools for flood preparation, action, and recovery;
- Conduct Public Meetings;
- Complete a hydrologic and hydraulic study of Limestone/Bull Run in a select area;
- Select and develop a Green Infrastructure Demonstration Project;
- Develop a Final Report summarizing the process and identifying priority steps to achieve resiliency.

SECTION 3 - PUBLIC ENGAGEMENT

3.1 - PUBLIC MEETINGS

Public participation was an integral part of the Study. Coordination amongst various groups facilitates a more inclusive Study, that can better address the variety of flood-related issues experienced throughout the Borough and improve residents' understanding of the risks presented by flooding in their communities. Several public meetings and engagements were facilitated throughout the development of this Study.

The purpose of the meetings and surveys was to provide residents, business owners and other stakeholders the opportunity to voice concerns and ask questions, and to educate them on the various options for preparing for and recovering from flood events. The intent of the meetings was to help advise the Study team throughout the process, assess the community's perception and preparedness for flood events, evaluate mitigation options, review the Study findings prior to completion, and develop a toolbox of public education and outreach material for use by the Borough- (See Appendix B for Toolbox: Public education and outreach material developed through this study). Table 3.1 below is a summary of the meetings that were held throughout the study.

Table 3.1: Public Meetings held throughout the Study

Meeting	Date & Location	Summary
#1 Kickoff Meeting	November 3, 2022 Lewisburg Downtown Partnership Office	Held to inform the public of what the scope and goals of the study were and generate more interest in the eye of the public. Held to discuss historical impacts of flooding and improvements made since the last notable flood event. The public had the chance for questions and answers to gain better insight of the overall process and purpose of the study. The public was also given the opportunity to voice their thoughts through an advertised online survey ahead of the meeting. The purpose of the survey was to assess the public's general preparedness and ability to react as well as educating them on recovery planning needs. Comments and questions received provided the Study team additional awareness of public concerns. The Lewisburg Downtown Partnership Office graciously hosted the space for this public meeting.
#2 Town Hall Meeting	February 22, 2023 Lewisburg Hotel	Held as a Town Hall format, in which the status of the project was shared and meeting attendees had the opportunity to engage one-on-one with the Study team (Consultants & Borough Staff) on the following topics: 1. Flood Mitigation Study Overview 2. Flood Risk Awareness: What is Your Property Risk? 3. Resources for Preparation, Action, and Recovery 4. Green Infrastructure Feedback received at this meeting were reviewed and taken into consideration ahead of finalizing the study. The Lewisburg Hotel graciously hosted the space for this public meeting.
#3 Final Meeting	June 8, 2023 Lewisburg Downtown Partnership Office	Held to provide the public of an overview of the entire study and recommendations, and to highlight the materials related to becoming a more flood resilient community.

3.2 - RESIDENT AND BUSINESS OWNER SURVEYS

At the onset of the study, Borough residents and business owners were surveyed through questionnaires to understand impacts flooding has had on them, to identify any actions taken on by them to potentially mitigate future impacts, and to gauge interest in flood planning investments.

Lewisburg Borough posted a link to the online survey ("Lewisburg Borough Flooding Survey") onto their website that was accessible by all local constituents. (See Appendix A for survey questionnaire that was shared online) The survey was published in October 2022 and was left open until the end of the year. Announcements of the survey were made at Public Meeting #1 and were also posted on the Borough website and communicated through local media. A separate survey was made available for homeowners and business owners respectively. A total of 52 responses were received from local homeowners and renters. Another 12 responses were received from local business owners. The survey ultimately served as an alternate route for the public to share their experiences, thoughts, and concerns with the Borough without having to attend an in-person meeting. Conducting this survey electronically also made data collection and analyzation simpler. The questions were aimed at collecting information of residents and property owners within or adjacent to the local floodplains. Demographics, high risk areas, and overall preparedness were corelated graphically to easily identify trends and correlations of the data received.

The survey consisted of 26 different questions and were simple enough for the participant to complete in under 10 minutes. There were also placeholders for upfront information about the participant and any open comments they may have at the end. Questions 1-5 aimed to identify the risk associated with properties throughout the Borough. Questions 6-11 dealt with general preparedness for flooding such as asking about insurance policies or organizations that were available and seeing how many people were utilizing them. Questions 12-19 dealt mostly with informing the public about retrofitting policies and strategies and how much interest was available with retrofitting properties. Questions 20-25 dealt with identifying the higher risk and repetitive loss properties. These sets of questions and responses were used to identify targets for future recommendations based on the perceived overall value and risk associated with the property and the willingness of the owner to cooperate in resiliency projects. The final question was used to generate interest in attending Public Meeting #1 pertaining to the issue of flooding in the community.

The survey results obtained here helped form a clearer understanding of the study area in general. Figure 3.1 shows examples of survey results for a few important questions. While a majority of the respondents believe they are somewhat or well prepared for a future flood event and a majority consider flooding a serious or extreme challenge to the community, only 2% have a plan for when a flooding event occurs.

The responses to this survey were compared to a similar survey Lewisburg had sent out in 2017 conducted by SEDA-COG. Each survey's respective data could be graphed and compared against each other. Some metrics jumped out because of the drastic changes seen over the 5-year gap between surveys. While the respective data sets are unique and consist of different respondents, it is useful to understand the potential changes in community flooding awareness and preparedness. For example:

- A large change in the types of properties within the study area were identified. In 2017, the majority of properties were residential homes, but the overall area was mixed with businesses. Since then, the gap between property types has expanded greatly. There was a large increase in the number of responses that confirmed addresses as residential homes compared to a large decrease in those that responded with a business address.
- In both 2017 and 2022, survey responders were mostly unaware whether or not they lived within the floodplain

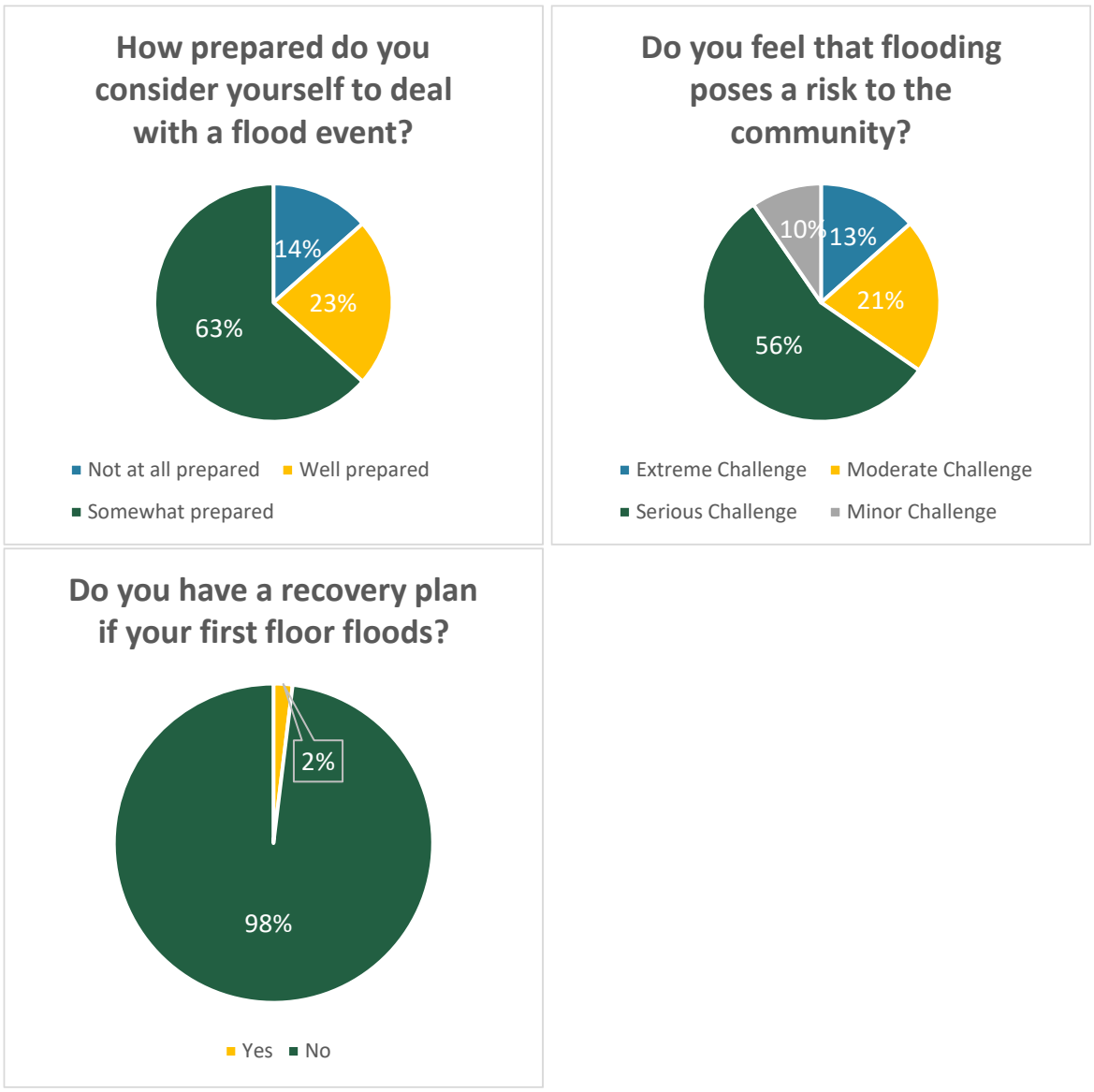

Figure 3.1: Example 2023 Survey Questionnaire Results

The business owners that were polled in a similar alternate survey had the majority responding that they were at least somewhat to well prepared for flood events. The following was learned through the survey results:

- One (1) out of eleven (11) respondents indicated they have received a FEMA Elevation Certificate and six (6) have obtained some form of flood insurance.
- Businesses seemed extremely split on if or how to modify their property within the floodplain. Most, however, shifted towards no changes, while the other majority response was unsure of what would work best and wanted to have further conversations about it. This answer is especially interesting given that nine (9) out of the eleven (11) businesses claimed their structure has been impacted by flooding in the past.
- Even with the most recent flooding events in 1999 and 2011, 90% of business owners surveyed state they do not want to relocate their current business.
- The majority of businesses categorized riverine flooding in the Borough as a moderate challenge that faces their community.

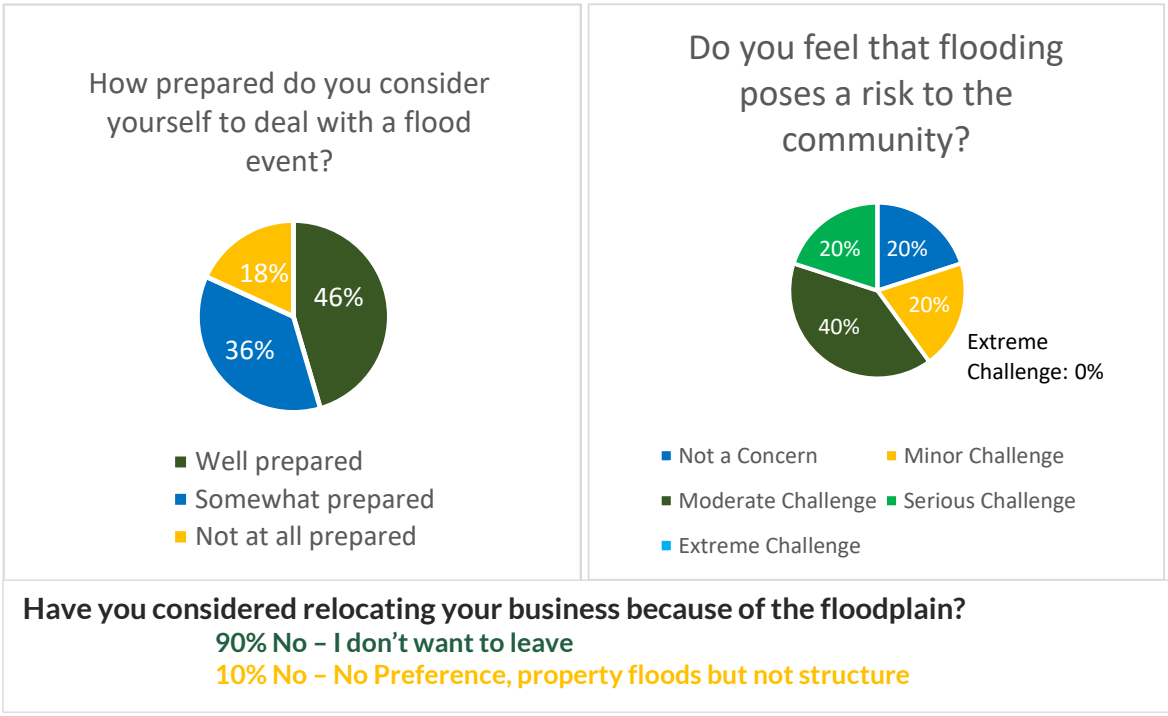

Figure 3.2 – Business Owner Survey Result Highlights

3.3 - COMMUNITY FLOODING STORIES AND EXPERIENCES

A community web portal to document flooding experiences was created and shared at the Town Hall meeting for the later part of the study. Padlet.com was utilized as an engagement tool to gather personal flooding experiences and stories to provide insight of long-term residents to newer or temporary residents. The survey was promoted using online and social media postings as well as through hard-copy flyers that were available at the Town Hall and Final Meeting. Documentation of these stories are provided in Appendix A.

3.4 - SUMMARY OF STAKEHOLDER FINDINGS

The Borough's residents, business owners and government officials alike recognize flooding to be a major challenge. Based on the survey results, there seems to be opportunity to address a few of the counter-intuitive results.

- Many of the participants seem confused on which type of flood insurance preparation steps, and financial aid may be needed or available to them. Developing and providing educational materials related to these topics could help resolve any uncertainties they may have.
- As stated earlier, many of the participants were not certain where their properties are located with respect to the 100 and 500-yr floodplains. To improve resiliency, it is critical for those properties that lie within these floodplains be well informed. With a better understanding of the financial aid available and knowledge of the current floodplain mapping, residents and business owners may be able to make more confident decisions on what actions to take for preparedness, recovery, and resiliency.

- A few of the survey participants indicated that they already have insurance; however, that insurance may not specifically cover flooding. Some participants indicated that flood insurance may not be necessary since the chances of another severely damaging flood event is very low. Some property owners would rather not add flood insurance as an additional expenditure, choosing to take on the risk of flood recovery costs on their own. It is noted, the Study recommends working with property owners to develop flood preparation/recovery plans and supporting property floodproofing improvements.
- The business owners surveyed indicated they have much at stake with their business investments. Most of them own the properties which house their businesses. The majority of surveyed business owners have FEMA Elevation Certifications, a great sign indicating they are aware how their first-floor elevation compared to the river flood stage. This provides them an understanding of which flood events will impact their property and should better prepare them in predicting the damages their business could be exposed to in the event of flooding. Messaging of flood insurance benefits to business owners could emphasize that flood insurance can protect their structures and help maintain their ability to provide goods and services to the Borough, essentially reducing their losses. Additionally, businesses surveyed in the floodplain were found to employ a total of 49 part-time and 108 full time employees. Businesses serve an essential role in the community of Lewisburg, and it is important that these businesses can prepare for and recover quickly from a flood event so their business can continue to serve the community quickly following a flood event.

3.5 - SUMMARY OF FINDINGS

While there is a diverse range of constituents in the Borough, with many lifelong residents who have experienced several serious flood events and likely just as many that have yet to experience flooding conditions. Residents and business owners that were engaged as part of this Study agree that flooding is at least a serious challenge that faces the community frequently. One of the most useful things the Borough can continue to expand on is a public outreach and education campaign related to the need for flood preparedness and recovery awareness and planning. In general, there were a few survey participants that indicated they were not aware of their personal responsibilities and options available to them in the event of flooding. Keeping updated maps of the floodplain and sharing them often can continue to foster the public awareness and keep the conversation going to become more resilient against flooding with each passing year.

3.6 - RECOMMENDED ACTION ITEMS

The following is a summary of recommended action items related to Public Engagement:

- Seek funding to work with individual businesses to create flooding preparation/recovery plans.
- Continue public education and outreach through various means: social media, public events/presentations, Borough website, and Borough mailings to name a few.
- Integrate Flood Resilient Community Toolbox into Borough website and Borough events (Discussed further in Section 4).
- Implement floodplain restoration projects in Hufnagle Park/Danny Green Field and the proposed green infrastructure demonstration (Discussed further in Section 9).
- Perform a feasibility study of neighborhood wide green infrastructure implementation (Discussed further in Section 9).

SECTION 4 - FLOOD RESILIENT COMMUNITY TOOLBOX SUMMARY

Flooding is the most common natural disaster in Pennsylvania and Lewisburg is located at the junction of three distinct waterbodies that can flood from various runoff events (such as flash floods, snowmelt, and tropical storms) and varied timescales (hours to days). Further, Lewisburg Borough has a high number of new or temporary residents, and many have never experienced a flooding event.

Community awareness and education is considered one of the most important flood mitigation measures. Many government planning agencies recognize that flood protection and modification measures cannot protect communities from the various types of flood events. With that understanding, the Borough identified a need to improve upon and expand educational materials to be made available and provided to residents and property owners. These concerns were also expressed by Borough residents at the Flood Mitigation Study Town Hall Meeting. Noted comments include:

Do you have any specific concerns as it relates to flooding (individually or as a community)?

"Residents' lack of awareness, students' lack of awareness"

What do you think the Borough should be doing to prepare the community for a flooding event?

"Nurture public awareness and communications"

"Create and distribute evacuation maps"

"Continue educating the public"

To address these concerns, materials were prepared as part of the ***Flood Resilient Community Toolbox***, and included creation and identification of materials to help residents and property owners understand their flood hazard risk, what to do to minimize their risk, how to prepare for a flood, what to do during a flood, and how to recover from a flood. This section provides a Toolbox Guide and highlights some of the ***Flood Resilient Community Toolbox*** materials, with further information provided in Appendix B and available on the Borough's website.

4.1 - RECOMMENDED ACTION ITEMS

The following is a summary of recommended action items related to the Flood Resilient Community Toolbox:

- Seek funding to work with individual businesses to create flooding preparation/recovery plans.
- Continue public education and outreach through various means: social media, public events, Borough website, and Borough mailings to name a few.
- Integrate Flood Resilient Community Toolbox into Borough website and Borough events. Define a Floodplain Overlay District that extends beyond the 100-year floodplain developed by FEMA (See Section 8 for further details).

LEWISBURG'S FLOOD RESILIENT COMMUNITY TOOLBOX GUIDE

PURPOSE

This toolbox guide was developed to assist Lewisburg property owners and residents in becoming resilient to flooding events. It will help to:

- Understand your risk to flooding events
- Learn how to prepare your property, family, and community for flooding
- Determine what you should do following a flood event

Additional materials are available in Appendix B of the Lewisburg Flood Mitigation Study and through the resources provided in Section 5 of this Flood Resilient Community Toolbox Guide.

Market St. 1972

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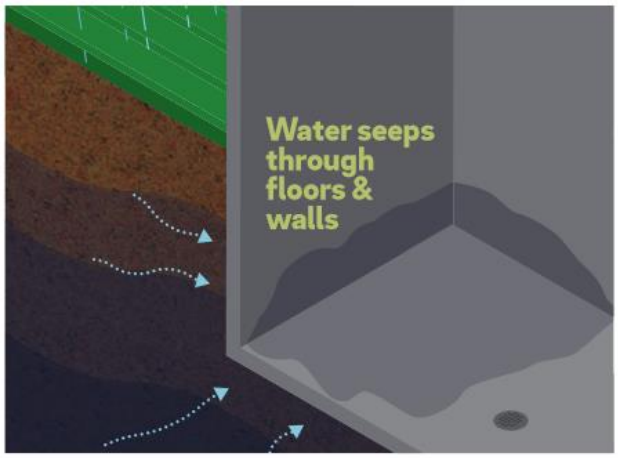
1. KNOW YOUR RISK

Flooding impacts in Lewisburg take different forms depending on where a property is located and the source of the floodwaters. Sources or types of flooding that impact Lewisburg include:

Riverine Flooding: occurs from local streams and rivers overtopping their banks during or after short, intense rainfall events or long periods of wet weather (like tropical storms or hurricane remnants). Lewisburg sees both of these types of events, as summarized in Section 1 of the Flood Mitigation Study.

Overland or Street Runoff (Pluvial) Flooding: occurs when excessive water runs over the land surface (ground and streets). In areas that are close to streams or rivers this flooding could occur due the inability of storm sewers to drain due to highwater. Lewisburg also has areas that lack storm sewers, which can contribute to this type of flooding.

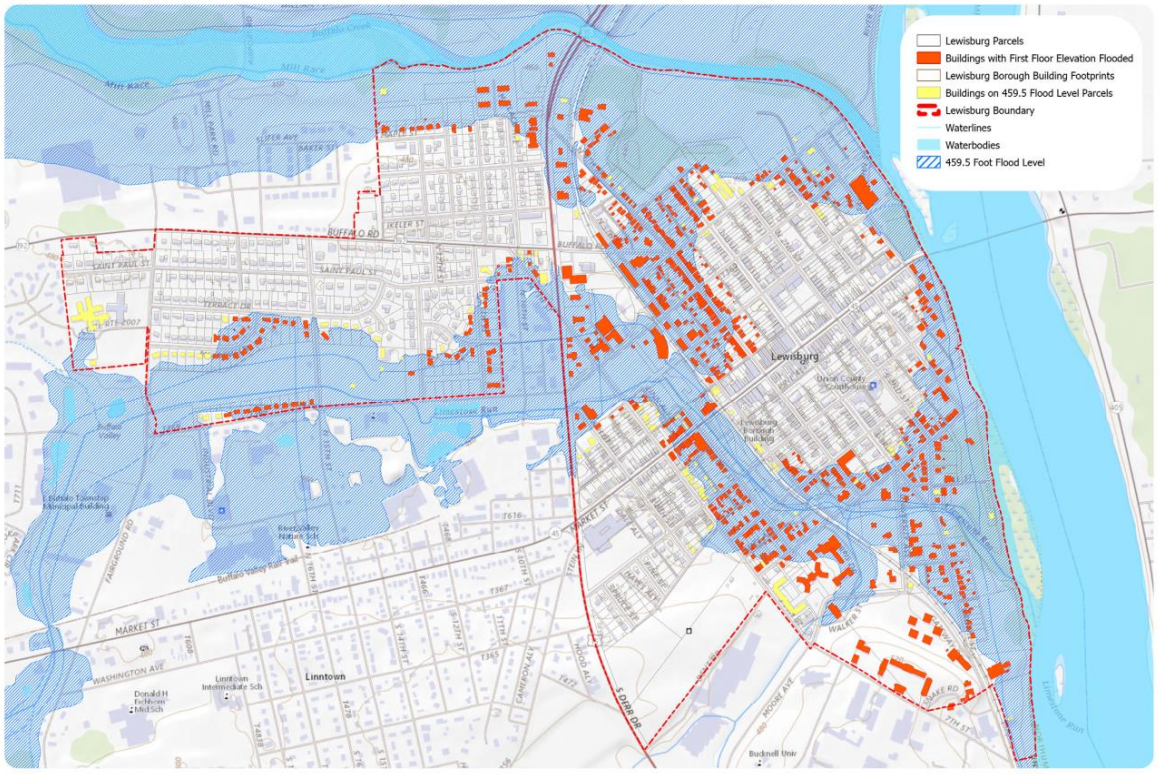


Groundwater Flooding: when the ground and subsurface becomes saturated groundwater can enter homes and buildings through the floors and walls in basements.

The most significant risk in the Borough is from Riverine flooding, both in the wide area it affects and the potential impacts it can cause. The Flood Risk Handout figure on page 17 is an example handout identifying the areas impacted by base flood event (100-year event).

FLOOD RISK

The Federal Emergency Management Agency (FEMA) develops and manages floodplain maps that help you determine what flood zone your home or business is in, and your corresponding risk level. This map also identifies if your property's first floor or basement / property would flood during base flood elevation flooding event.



IF YOUR HOME'S RISK IS ELEVATED FOR FLOODING YOU SHOULD TAKE ACTION!

Actions to consider based on your flood risk: red = first floor, yellow = basement/property

PREPARE THE INSIDE OF YOUR HOME OR BUSINESS

- PREPARE A LIST OF BELONGINGS
- GET FLOOD INSURANCE
- STORE VALUABLES
- ELEVATE UTILITIES
- FLOODPROOF BASEMENTS
- INSTALL FLOOD VENTS
- USE FLOOD RESISTANT INSULATION & DRYWALL
- REPLACE CARPETING WITH TILES

PREPARE THE OUTSIDE OF YOUR HOME OR BUSINESS

- ELEVATE YOUR HOME
- SECURE YARD ITEMS
- SEAL CRACKS AND GAPS
- DIRECT WATER AWAY FROM STRUCTURES
- ANCHOR FUEL TANKS
- FLOODPROOF WALLS

https://www.fema.gov/flood-maps/national-flood-hazard-layer

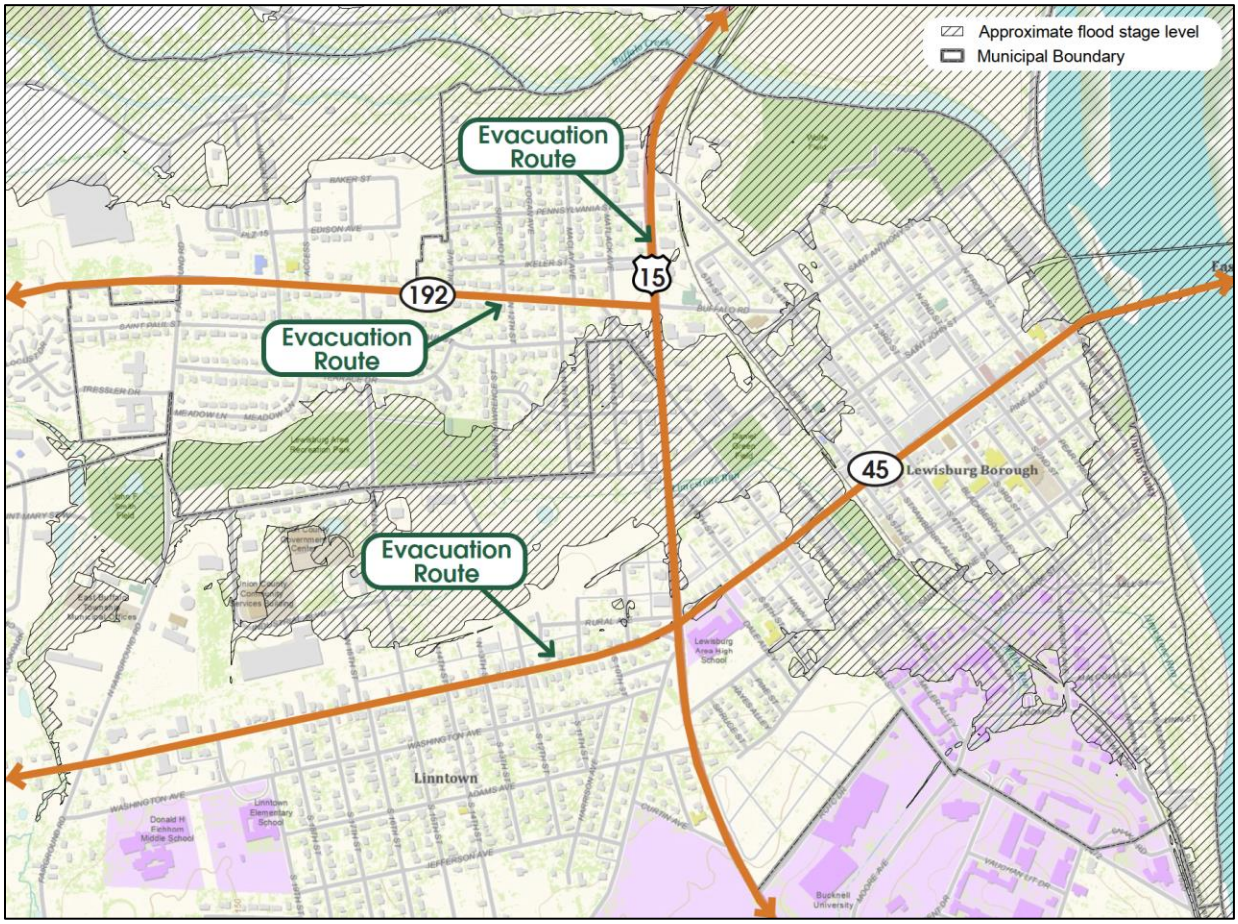
2. BECOMING A FLOOD RESILIENT COMMUNITY BEFORE, DURING, AND AFTER

All Lewisburg residents should be ready for flooding events as the impacts are Borough-wide and affect everyone's daily routines. Part of Becoming a Flood Resilient Community is knowing what to do before, during, and after a flood event.

Before a Flood

For additional information review – Preparation resources available on page 25 of this Guide and Appendix B of the Lewisburg Flood Mitigation Study.

Step 1: Understand Your Risk by reviewing and understanding flood maps to determine what flood zone you are in and what flood zone designation signifies, as well as understanding safe pathways and evacuation routes around known flooding problem areas.



Step 2: Prepare the Inside of Your House

Step 3: Prepare the Outside of Your House

Sign up for CodeRED Emergency Notifications from Lewisburg Borough – Many Lewisburg Evacuation Routes become flooded, therefore getting out early is critical.

CodeRED®

Borough of Lewisburg
Emergency Notification
Sign-up at www.Lewisburgborough.org
Or Text "LewisburgPA" to 99411
Or for assistance call 570-523-3614 x314

During a Flood

Take Protective Measures

Evacuate if Directed To

Stay Out of And Away from the Water

Seek Higher Ground if Trapped in a Building

Stay Connected to Emergency Broadcasts

South 6th Street 2011

After a Flood

For additional information review - Recovery resources available on page 27 of this Guide and Appendix B of the Lewisburg Flood Mitigation Study.

Pay Attention to Lewisburg, County, State and Federal Authorities

Take Personal Protective Measures when Dealing with Flood Damaged Materials

Be Aware of the Risk of Electrocution – Do Not Touch Equipment While Standing in Water

Stay Out of the Water – Avoid Wading and Driving Through Floodwaters

Assess and Document Damage, Contact Insurance Providers, and Track Costs

Review and follow the County and Borough Debris Removal Procedures

3. LEWISBURG'S FLOOD RESILIENT STRATEGY

The Borough was devastated 50 years ago by the Hurricane Agnes flood and since that time it has made significant strides in improvements to the community's flood resiliency. Projects have included removal of flood prone properties in the floodplain, reconnection of floodplains and open spaces, widening bridges and culverts, and restricting development in the floodplain.

The 'Flood Mitigation Study' and the 'Becoming Flood Resilient' resources were a recommendation of the Borough's Early Intervention Plan adopted in 2019 to limit the Borough's exposure to a significant flooding event. The goals of the study included:

1. Identifying Borough-wide impacts based on severity of flooding
2. Developing flood mitigation tools for preparedness and recovery
3. Steps towards becoming a Flood Resilient Community
4. Planning and developing concepts for a demonstration Green Infrastructure Project within the Borough

Findings of the Study will guide the Borough's future Flood Resilient Strategy: to implement a set of prioritized initiatives while allocating resources to improve upon the community's flood resiliency. Preliminary initiatives of the strategy include:

- Updating Ordinances to improve flood resiliency.
- Further evaluations of flood mitigation projects in Limestone/Bull Run Watershed.
- Coordinate with Borough residents and business owners to develop flood prep/recovery plans.
- Continue flooding resiliency education and engagement through expanded methods.
- Identify external and/or dedicate Borough financial resources to flood mitigation efforts.
- Utilize, maintain, and update Borough flood preparation tools.

4. LEWISBURG'S FLOODPLAIN

Flooding occurs when rivers and creeks overflow their banks and submerge land that is normally dry. Flooding in Lewisburg occurs when excessive rain or snowmelt runoff overwhelms rivers and creeks and water overflows the banks and into adjacent land and areas known as the floodplains.

Lewisburg's Floodplain – The Federal Emergency Management Agency (FEMA) has defined the Special Flood Hazard Areas (SFHA) in Lewisburg that are adjacent to the West Branch Susquehanna River, Buffalo Creek, and Limestone/Bull Run. There are various definitions for these areas as defined by FEMA.

Special Flood Hazard Areas

Floodway: The channel of a river or stream and the parts of the floodplain adjoining the channel that are reasonably required to efficiently carry and discharge the floodwater or flood flow of a river or stream.

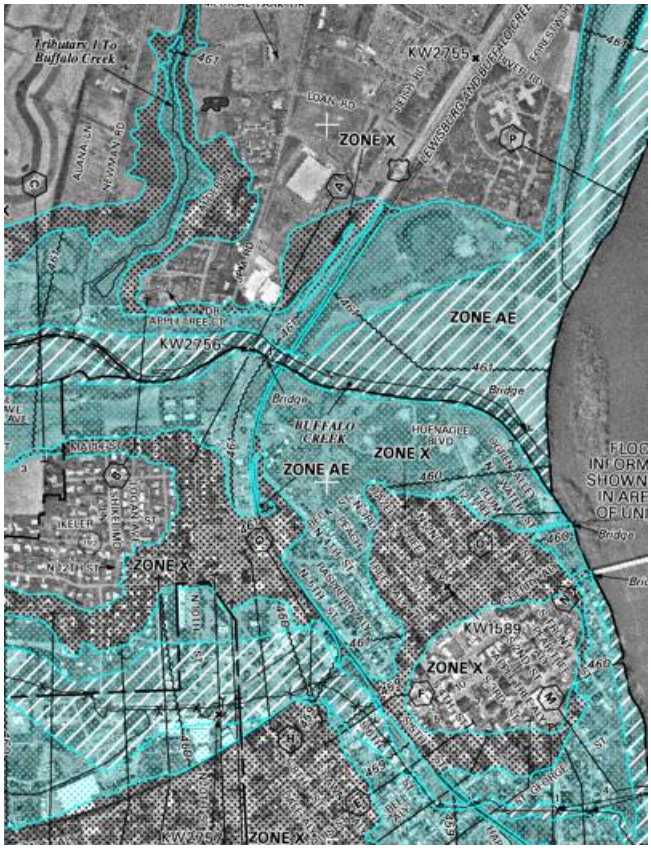
Zone AE: These are high-potential Special Flood Hazard Areas (SFHA) for One-Percent Floods that are subject to rising waters and are usually near a body of water. FEMA has determined the Base Flood Elevation for these zones and they are included on Flood Insurance Rate Maps. https://www.floodsmart.gov/all-about-flood-maps

Zone A: These are high-potential Special Flood Hazard Areas (SFHA) for One-Percent Floods that are subject to rising waters and are usually near a body of water. There are no base flood elevations or depths available within these zones.

Zone X Shaded: Has a moderate flood risk and is traditionally called the 500-year floodplain, meaning the area has a 0.02 percent chance of such a flood happening each year.

Flood Maps

To identify a community's flood risk, FEMA conducts a Flood Insurance Study. The study includes statistical data for river flow, hydrologic and hydraulic analyses, rainfall and topographic surveys. FEMA uses this data to create the flood hazard maps that outline a community's different flood risk areas.



To create a FEMA map (firmette) for your property: http://msc.fema.gov/portal

Floodsmart.gov FAQs: https://www.floodsmart.gov

Lewisburg Borough Flood Information: https://www.lewisburgborough.org/zoning/flood-information/

5. MORE INFORMATION

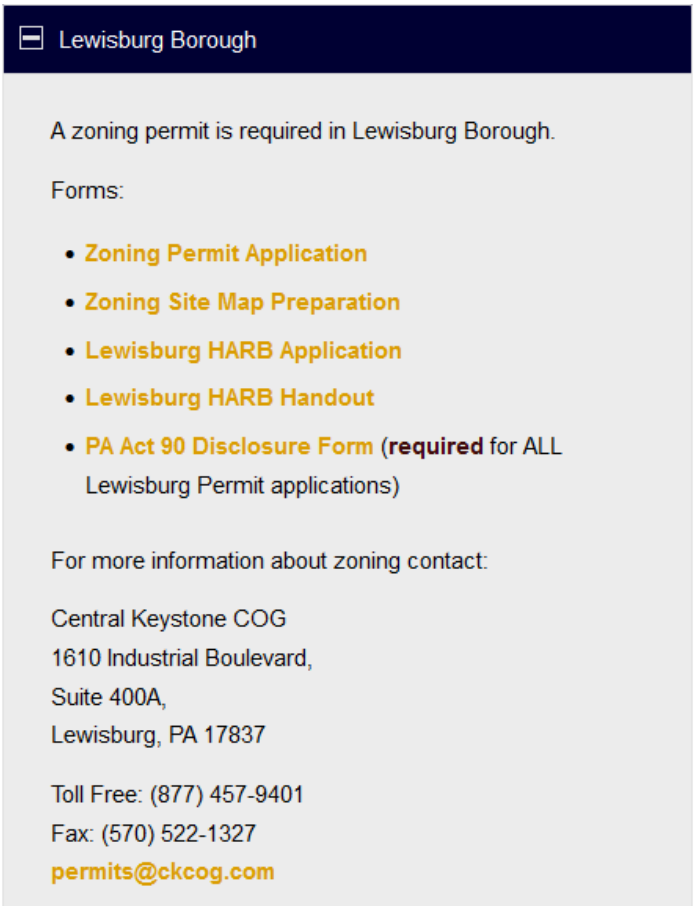
Lewisburg has prepared this toolbox for residents and business owners to become aware of the resources available to become a more flood resilient community. Everyone should be aware that the Borough is susceptible to flooding throughout the year and in any location. This section provides some additional information to become more resilient to flooding conditions.

Build Responsibly

- Make sure you get a permit from the CK-COG before you build: https://www.ckcog.com
- Use contractors who are familiar with the regulations regarding building in flood-prone areas.
- Reference current Borough Permits, Codes, and Zoning requirements: https://www.lewisburgborough.org/zoning/permits-codes-zoning/

Flooding, Erosion or Drainage Concerns?

- On-site visits and technical assistance are provided to residents who are experiencing problems in areas of flooding and drainage, or for those who want recommendations on how to retrofit an existing property.
- Funding or other financial assistance may be available for elevation and other mitigation activities for flooded properties.
- Direct inquires to the Lewisburg Borough Zoning Officer.



Lewisburg Borough

A zoning permit is required in Lewisburg Borough.

Forms:

- Zoning Permit Application
- Zoning Site Map Preparation
- Lewisburg HARB Application
- Lewisburg HARB Handout
- PA Act 90 Disclosure Form (**required** for ALL Lewisburg Permit applications)

For more information about zoning contact:

Central Keystone COG
1610 Industrial Boulevard,
Suite 400A,
Lewisburg, PA 17837

Toll Free: (877) 457-9401
Fax: (570) 522-1327
permits@ckcog.com

Preparation: What to Do Before a Flood Occurs

FLOOD PREPARATION

Being prepared for potential flooding can reduce fear, anxiety, and losses that accompany flooding events. Communities, families, and individuals can reduce the impact of flood events by preparing the inside and outside of their home or business. Below discusses ways to prepare your home for flooding events.

PREPARE THE INSIDE OF YOUR HOUSE

PREPARE A LIST OF BELONGINGS
Documenting all your belongings will help with the insurance claims process. Consider taking photos of high value items or doing a video walkthrough of your home to document its contents.

GET FLOOD INSURANCE
Most homeowners' insurance policies don't cover flood damage. Protect your investment by purchasing flood insurance for your home and contents, even if you do not live in the flood plain.

STORE VALUABLES
Store valuables and waterproof documents in waterproof or water-resistant containers above the BFE (preferably on an upper floor). Make copies and store them online or off-site.

ELEVATE UTILITIES
Elevate or floodproof mechanical units, furnaces, water heaters, electrical systems, and other utilities on masonry, concrete, or pressure-treated lumber at least 18 inches above the BFE.

REPLACE CARPETING WITH TILES
Tiles are more flood-resistant than carpet. Using tile or other food-resistant materials in areas below the BFE can help reduce water damage.

FLOODPROOF BASEMENTS
If you have a basement, minimize damage by floodproofing your basement and sealing walls with waterproofing compounds. Consider installing a sump pump.

INSTALL FLOOD VENTS
Install food vents in foundation walls, garages, and other enclosed areas to allow water to flow through, drain out, and lower the risk of structural damage.

USE FLOOD RESISTANT INSULATION AND DRYWALL
Flood-resistant insulation and drywall will help minimize damage and can be easily cleaned and sanitized.

Preparation: What to Do Before a Flood Occurs

PREPARE THE OUTSIDE OF YOUR HOUSE

ELEVATE YOUR HOME
While it is an investment, elevating your home prepares your property against foods and lowers food insurance premiums. When a home is properly elevated, the lowest floor should be above the BFE. Areas below the BFE can be used for parking, storage, or access to the house.

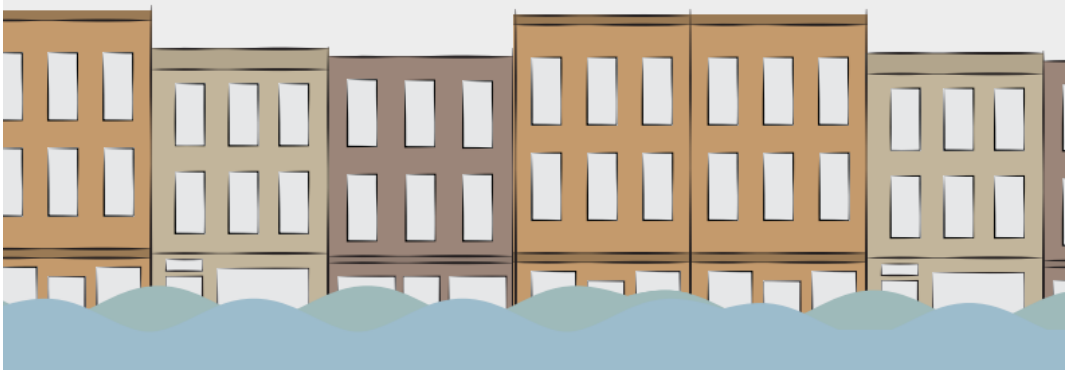
SECURE YARD ITEMS
Unsecure items can be swept away or damaged by floodwaters. They can also be swept into your home, causing damage. Secure items in your yard by anchoring them or attaching them to more substantial structures.

SEAL CRACKS AND GAPS
Check caulking around windows and doors to make it is not cracked, broken, or missing. Fill any holes or gaps around pipes and wires that enter your building.

DIRECT WATER AWAY FROM STRUCTURES
If you have a single-family home, make sure your yard slopes away from buildings on your property and that water has a place to drain. Clear your gutters, assess drainage issues, or collect water in rain barrels.

ANCHOR FUEL TANKS
Anchor any fuel tanks to the pad to prevent them from tipping over or floating in a food. Spilled fuel could become a fire hazard. Make sure vents and fill-line openings are above the BFE. Note: This may require permission from your fuel provider.

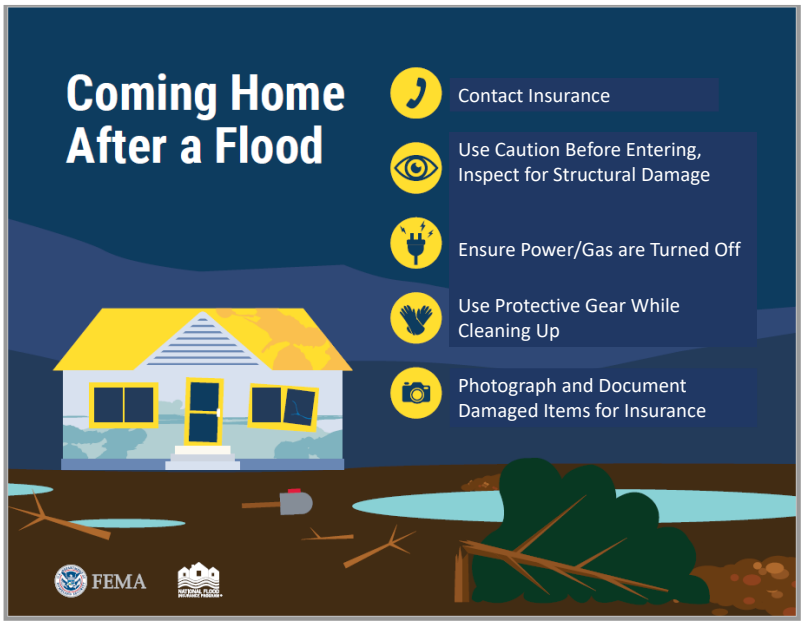
FLOODPROOF WALLS
Add water-resistant exterior sheathing on walls and seal them to prevent shallow flooding from damaging your home. Cover openings below the BFE and seal all exterior openings around pumping and equipment.



Recover: What to Do After a Flood Occurs

Reentering Your Flooded Home

- Try to return to your home during the daytime so that you do not have to use any lights. Use battery-powered flashlights and lanterns, rather than candles, gas lanterns, or torches.
- Caution! Flood water may contain trash, harmful materials, and contaminants.
- If you have standing water in your home and can turn off the main power from a dry location, then go ahead and turn off the power, even if it delays cleaning. If you must enter standing water to access the main power switch, then call an electrician to turn it off. **NEVER turn power on or off yourself or use an electric tool or appliance while standing in water.**



- Have an electrician check the house's electrical system before turning the power on again.
- If you smell gas or suspect a leak, turn off the main gas valve, open all windows, and leave your house immediately. Notify the gas company or the police or fire departments, and do not turn on the lights or do anything that could cause a spark. Do not return until you are told it is safe to do so.
- If the house has been closed up for several days, enter briefly to open doors and windows to let the house air out for a while (at least 30 minutes) before you stay for any length of time.
- If your home has been flooded and has been closed up for several days, assume it has mold.
- Listen for information from your local officials on how to safely use water to drink, cook, or clean.
- Wash hands with soap and water to help prevent germs.

Safe Water, Medicines, Foods, and Kitchen Items

- Floodwater can contaminate your drinking water. Some contaminants from surface water get into the groundwater and affect municipal water systems that use groundwater.
- Follow guidance from the Pennsylvania American Water Compay on whether your water is safe to drink.
- Do not use water you suspect or have been told is contaminated to wash dishes, brush your teeth, wash and prepare food, wash your hands, make ice, or make baby formula. Safe water for drinking, cooking, and personal hygiene includes bottled, boiled, or treated water.
- Discard all medicines and foods in contact with floodwater. Throw out all perishable foods that have been out of refrigeration for more than six hours. Do not refreeze frozen foods that have been thawed.
- All cooking and eating utensils, food preparation surfaces, counters and work surfaces that were touched or splashed by floodwater should be washed with soap and water and wiped with a diluted bleach solution.

Use Generators and Electrical Equipment Safely

- Talk to your utility company about using electrical equipment, including power generators. Be aware that it is against the law and a violation of electrical codes to connect generators to your home's electrical circuits without the approved, automatic-interrupt devices. If a generator is on line when electrical service is restored, it can become a major fire hazard. In addition, the improper connection of a generator to your home's electrical circuits may endanger line workers helping to restore power in your area.
- All electrical equipment and appliances must be completely dry before returning them to service. Have a certified electrician check these items if there is any question.
- Never use a generator, pressure washer, or any gasoline-powered engine inside your home, basement, or garage or less than 20 feet from any window, door, or vent.

This information has been adapted from several publicly available resources. For additional flood recovery information please review the following:
https://www.ready.pa.gov/AfterAnEmergency/Recover%20And%20Rebuild/Documents/After%20the%20Disaster.pdf

https://www.epa.gov/flooded-homes

https://www.cdc.gov/disasters/floods/after.html

Dry Out Your Home to Prevent Mold

- Use fans, air conditioning units, and dehumidifiers for drying, and if weather permits, open windows and doors of the house to aid in the drying-out process.
- If you have electricity and an electrician has determined that it's safe to turn it on, use a "wet-dry" shop vacuum (or the vacuum function of a carpet steam cleaner), an electric-powered water transfer pump, or sump pump to remove standing water. If you are operating equipment in wet areas, be sure to wear rubber boots.
- Have your home heating, ventilating, and air-conditioning (HVAC) system checked and cleaned by a maintenance or service professional who is experienced in mold cleanup before you turn it on. If the HVAC system was flooded with water, turning on the mold-contaminated HVAC will spread mold throughout the house. Professional cleaning will kill the mold and prevent later mold growth.
- Prevent water outdoors from reentering your home. For example, rainwater from gutters or the roof should drain away from the house; the ground around the house should slope away from the house to keep basements and crawl spaces dry.
- Ensure that crawl spaces in basements have proper drainage to limit water seepage. Ventilate to allow the area to dry out.

Clean up Safely

- For cleanup, wear rubber boots and plastic gloves.
- Throw away items that cannot be disinfected, like wall coverings, cloth, rugs, and drywall.
- Clean walls, hard floors, and other surfaces with soap and water. Use a mixture of 1 cup bleach and 1 gallon water to disinfect.
- Take steps to protect yourself and your loved ones during your cleanup after a flood. Follow our cleanup tips and monitor your radio or television for up-to-date emergency information.

SECTION 5 - PROPERTY IMPACTS AND MITIGATION OPTIONS

5.1 - OVERVIEW

Flood risk mitigation is aimed at reducing the impact of floods. There are two main categories of flood risk mitigation options: structural and nonstructural alternatives. The goal of these measures is to reduce the damages and risks associated with floods. By adopting these measures, communities can better prepare for and respond to flood events, mitigating the potential harm caused by such disasters.

Structural options refer to the physical modifications made to reduce the risk of flooding. These measures can include the construction of levees, dams, flood walls, and other engineering structures aimed at controlling or diverting water flow.

Nonstructural alternatives are measures that focus on reducing the exposure and vulnerability of communities to flood risks. These may include policies such as land-use planning, zoning regulations, early warning systems, and community education and outreach programs.

Structural Options:

- **Levees / Floodwall**
  A structure built along a watercourse that contains floodwaters and prevents them from inundating the adjacent area.

- **Benched Floodplain**
  The creation of a flat or gently sloping area within the floodplain of a watercourse that acts a buffer between the watercourse and nearby structures or infrastructure. The additional space allows floodwater to spread out and slow down.

- **Stream Modification**
  An intentional alteration a natural stream. Examples include channelization, damming, dredging straightening, and widening. Typically, the intent of stream modification is to increase the capacity of the stream so it can more effectively convey flood waters.

- **Emergency Access Roads**
  Construction of emergency access road that will allow transport between areas isolated by floodwaters and dry land outside of the floodplain.

Nonstructural Options:

- **Acquisition/demolition**
  Acquisition/demolition is the complete removal of a structure and all ancillary structures within a flood risk area. The land is then deed restricted to prevent future development.

- **Elevation**
  This option raises an existing structure 1.5 feet above base flood elevation.

- **Relocation**
  Physical transport of high-risk structures to a location outside the floodplain. Structure must be separated from its foundation. Building must be sturdy enough to handle travel. Relocation requires coordination with local governments and the Department of Transportation.

- **Reconstruction**
  Demolition of an existing structure and construction of a structure compliant with floodplain ordinances.

- **Wet Floodproofing**
  Waterproofing all utilities and materials so that no water damage is incurred on the structure. Water will enter the structure, but its contents and materials are "unaffected".

- **Dry Floodproofing**
  Waterproofing the entire structure so no water breaches. Not NFIP recognized for reduction of rates.

- **Floodproofing Wastewater/Utility Systems**
  Protect and secure utilities (electrical power, water supply, wastewater, telecommunication, transportation) by elevating Base Flood Elevation, placing in a sealed enclosure, applying waterproof sealant or coverings, and/or establish backups or redundancies. These measures will aid the continued operation of essential infrastructure in emergencies and immediately after.

- **Flood Warning System**
  A combination of physical infrastructure such as stream and rain gauges, hydrologic modelling software, and communications planning that can predict flooding events, determine the amount of response time available, and distributes a warning to the public. This system can be integrated with the Borough's mass emergency notification system, CodeRED, that distributes messages directly to stakeholders. The system can also be integrated with the proposed emergency siren system.

- **Land Use Ordinance Alterations**
  Review of stormwater and floodplain ordinances and implementation of updates that prevent flood damage through development requirements. See Section 8 for additional information and review of land use ordinance modifications.

- **Temporary Protective Measures**
  More affordable and low impact on existing structures than permanent measures. Useful in relatively shallow floods of limited duration. Temporary measures require time and labor to set up, so they can be ineffective in situations with little warning. These systems are not infallible. Seepage is highly likely, and these methods should be implemented in conjunction with a sump pumps and generators. It is important to always have all temporary measures on hand so that implementation can be swift. Planning is also a key element in these practices. These systems must operate autonomously in the event of an evacuation.
  - Sandbags
  - Water filled temporary dam/ water bladder
  - Floodgate (seals off doorways/entrances/windows)
  - Waterproof fabric and sandbags

- **Basement Filling**
  Applicable to homes with a basement below grade. Typically requires relocation or waterproofing of utilities. Fill material should be compacted to the same elevation as the existing grade on the exterior of the structure. Additional fill should be added to maintain this relationship as consolidation lower the elevation of the fill. Limited by the amount of space to allow equipment to important compact fill. If the floor of the basement is impervious, the floor should either be broken up or hole should be drilled to allow water to infiltrate. A pumping system should be installed to drain the space if necessary.

- **Raise Utilities**
  The elevation of electrical equipment, water supply components, or communication systems 1.5 feet above the base flood elevation.

5.2 - STRUCTURAL ALTERNATIVES CONSIDERED

North 4th/North 5th Neighborhood

BECK STREET FLOODWALL

The Beck Street Floodwall alignment would begin on Beck Street between North 4th Street and Peach Tree Alley, then run down Hazel Tree Alley for approximately 80 feet (Figure 5.1). The floodwall would be approximately 530 linear feet in length. This alignment would allow the floodwall to connect the 462-foot elevation mark on each end of the alignment.

Figure 5.1: Beck Street Floodwall Alignment

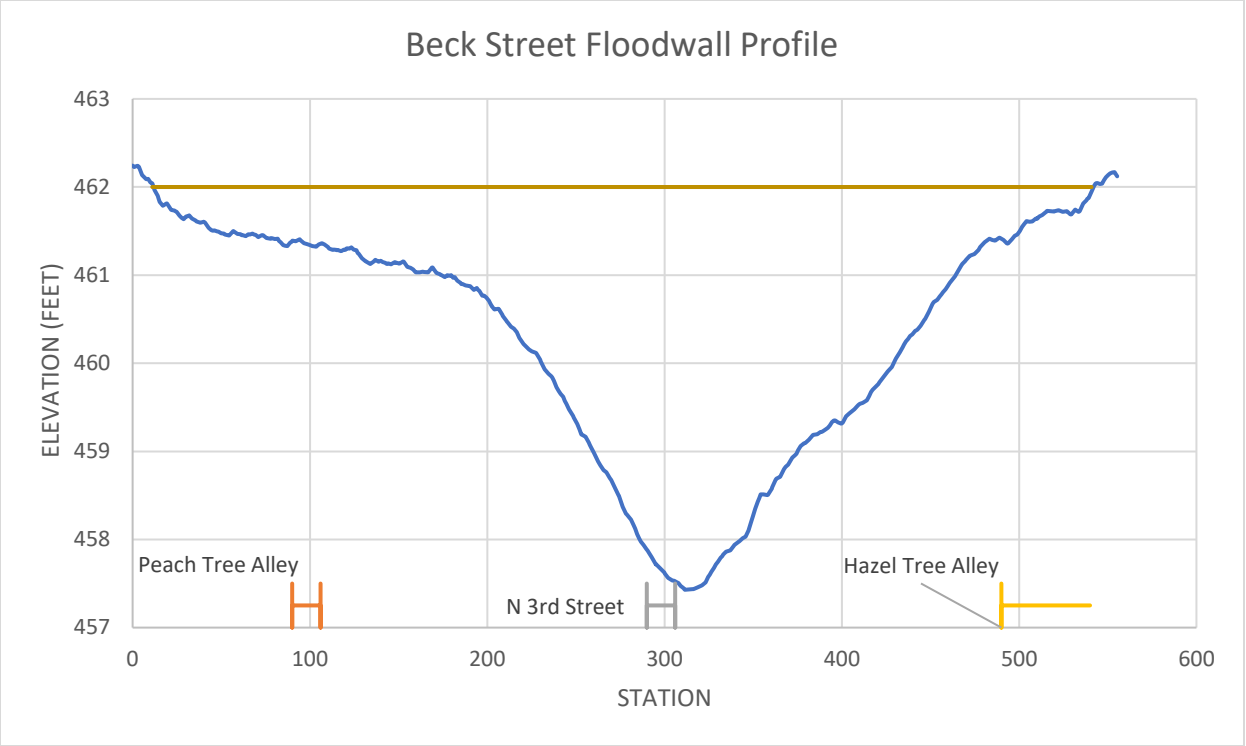


Figure 5.2: Beck Street Floodwall Profile

RAILROAD/NORTH 5TH FLOODWALL

The Railroad/North 5th Floodwall alignment begins at Market Street and ends at Buffalo Road and is located between the Railroad and North 5th Street and spans approximately 1,700 linear feet.

Analysis of the local topography and the available FEMA flood maps, it was determined that a floodwall in this region would not be practical in protecting the North 4th/ North 5th neighborhood. It appears that North 4th/ North 5th neighborhood is primarily impacted by Buffalo Creek and the West Branch Susquehanna River. The Railroad berm has an approximate minimum elevation of 460 feet, on the section north of St. John Street. The FEMA National Flood Hazard Layer (NFHL) shows that the elevations of Limestone/Bull Run do not overtop the Railroad during the 100-year event. These conditions were also observed in the results of hydrologic and hydraulic analysis of Limestone/Bull Run (see Section 9). The FEMA NFHL displayed that the flood elevations to the east of the Railroad and caused by Buffalo Creek/ West Branch Susquehanna River were greater than the Railroad elevations. Because Buffalo Creek/West Branch Susquehanna River is the primary contributor to flooding in the North 4th/ North 5th neighborhood, it would not be practical to install a floodwall with intent of mitigating Limestone/Bull Run induced inundation.

Figure 5.3: Railroad Centerline Alignment

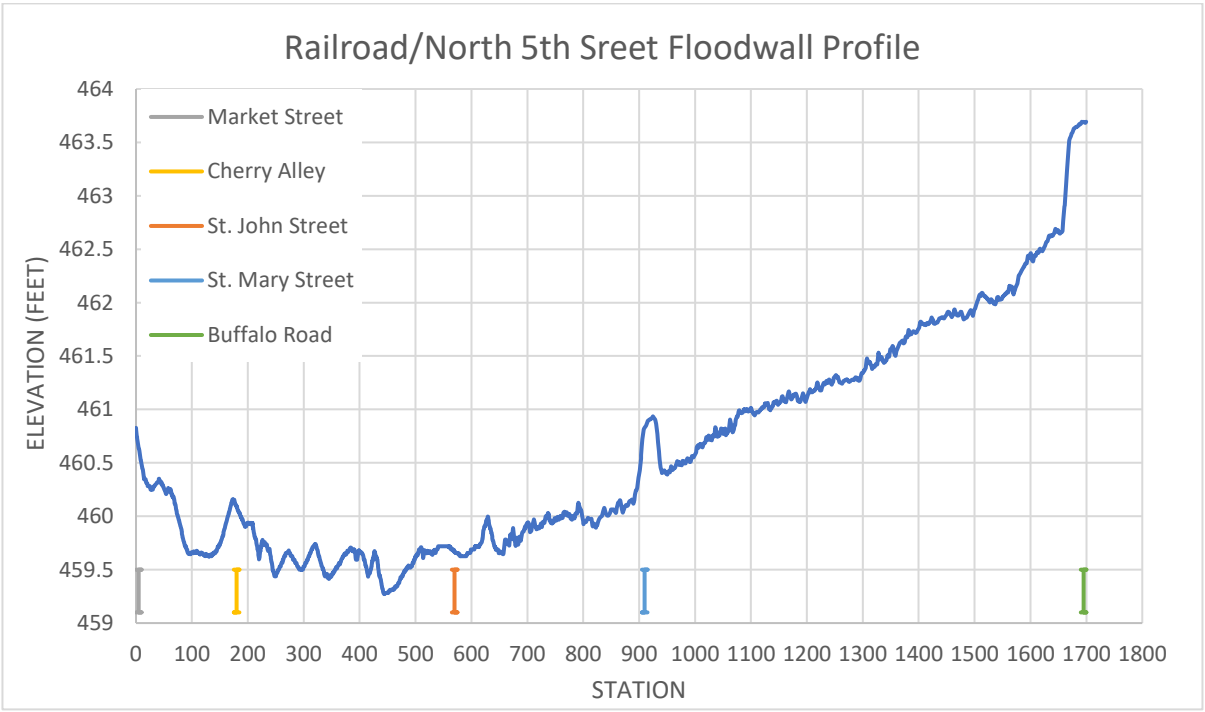


Figure 5.4: Railroad Centerline Profile

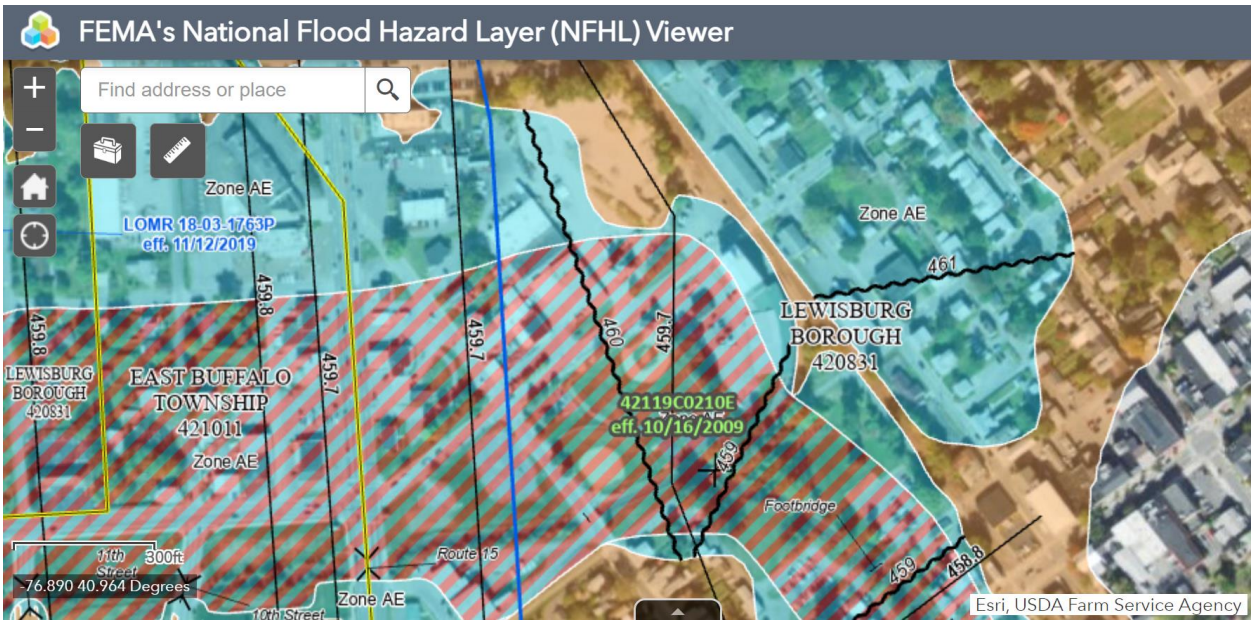


Figure 5.5: Limestone/ Bull Run FEMA National Flood Hazard Layer

5.3 - APPLICABLE MITIGATION OPTIONS

Mitigation options are recommended to be dealt with in stages that are tailored to each property's first floor elevation (FFE) compared to a given storm event's floodplain. The conditions of the 100-year flood event was used in for this analysis. Given this event the properties located within the floodplain of Lewisburg were summarized into five separate groups based on their elevation in relation to the flood water elevation. During a 100-year flood event, the flood waters are predicted to reach elevations of 459 to 460.5 feet above sea level, depending on the location in the Borough. This was then compared to a mix of surveyed and estimated FFE's and the following groups of properties were summarized:

- Dry Basements,
- Wet Basements,
- 0-1 feet of water above the FFE,
- greater than 1 feet and less than 4 feet of flood water above the FFE, and
- any properties with over 4 feet of water above the FFE.

Basements were predicted to be wet or dry based on whether the flood elevation comes within 5 feet of the FFE as water has been reported in many Borough basements during wet weather events.

The properties in the wet basement category can be improved with utility relocations and removing all valuables from the basement given flooding forecasted, install sump pumps or foundation vents. The properties in the 0-1 feet above the FFE category can adopt measures from the previous group as well as looking to more involved measures such as the use of sandbags of floodgates near entry ways like doors and windows, move carpets or low-lying valuables, raise electrical outlets above the 1 feet mark to prevent major electrical damages. The greater than 1 feet but less than 4 feet group will require the most rigorous flood proofing. Options such as filling in basements, raising the building on stilts, or regrading the property to effectively raise the FFE at least 1.5 feet above the BFE can reduce flood damages. Properties predicted to have over 4 feet of flooding on the FFE can be classified as high risk with potential for repetitive loss: these properties could be classified as potential targets for buyouts or property elevations for the Borough. With any properties acquired by the Borough, the area should be used as open green space to buffer flood waters from still active properties. The 100-year flood event was examined due to its likeliness of occurring

any given year being considerably higher than a 500-year event and it encompasses other historical flooding Lewisburg has experienced such as Tropical Storm Lee. This same process can be done for various flood events and accurate predictions on the flood damage a property may receive can be made.

Lewisburg Borough Mitigation Opportunities

A total of 887 properties have the potential to be impacted by the 500-year flood event in the Borough of Lewisburg. These properties were assessed for their flood vulnerability by utilizing surveyed FFE's, topography, and the FEMA 100-year flood elevations. A summary of the results is provided in Figure 5.6.

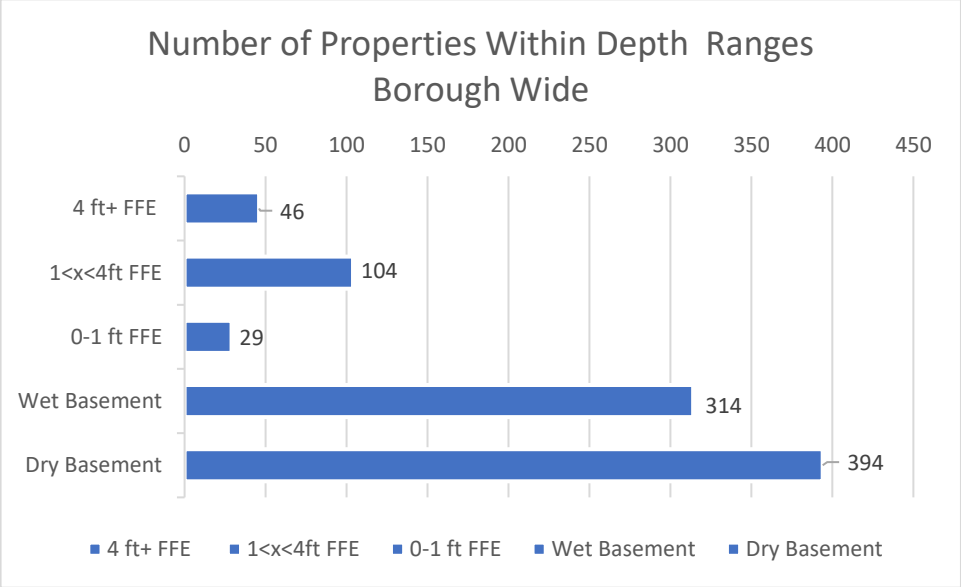


Figure 5.6: Distribution of 100-year Inundation Depths in the Borough

Viable Mitigation Alternatives:

Figure 5.6 shows that more than half of the structures within the Borough are impacted by the 100-year flood, with 20 percent experiencing flooding above the FFE. Below are some general alternatives the Borough can enact to further mitigate damages caused by flooding in the Borough.

- Ordinance Alterations
- Flood Warning System
- Dry Floodproofing of the North Water Street LAJSA Pump Station

North 4th / North 5th Mitigation Opportunities

One hundred and forty eight (148) properties in the North 4th/ North 5th Street neighborhood were assessed for their flood vulnerability by utilizing surveyed FFE's, topography, and the FEMA 100-year flood elevations. A summary of the results is provided in Figure 5.7.

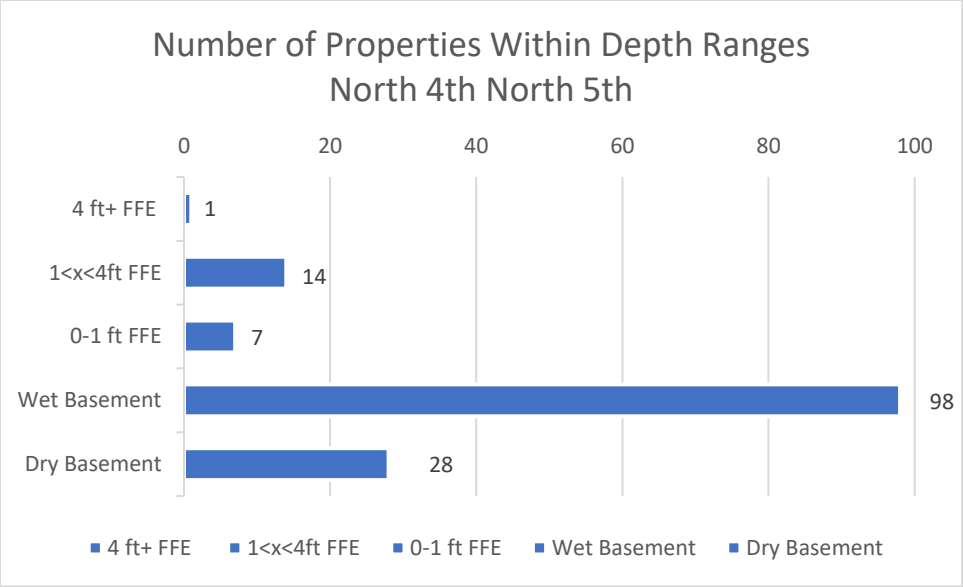


Figure 5.7: Distribution of 100-year Inundation Depths in the North 4th/ North 5th Neighborhood

Viable Mitigation Alternatives:

Figure 5.7 shows that the majority of properties impacted by the 100-year flood in the North 4th/North 5 neighborhood are only experiencing water in the basement. No properties in this neighborhood are inundated above four feet; therefore, buyouts are not applicable. Below are some alternatives that can be implemented to further mitigate damages caused by flooding in the North 4th/North 5th neighborhood.

- Raise Utilities Above Base Flood Elevation
- Voluntary Elevations
- Voluntary Basement Filling
- Construct Floodwall along Beck Street

Commercial Properties

Nine (9) commercial properties in Lewisburg Borough neighborhood were assessed for their flood vulnerability by utilizing surveyed FFE's, topography, and the FEMA 100-year flood elevations. A summary of the results is provided in Figure 5.8.

Viable Mitigation Alternatives:

All of the commercial properties considered in this analysis are impacted by the 100-year flood, with the vast majority experiencing inundation depth above 1-foot. Below are some alternatives that can be implemented to further mitigate damages caused by flooding for the commercial properties of the Borough.

- Raise Utilities above BFE
- Voluntary Property Buyouts
- Voluntary Elevations
- Wet Floodproofing
- Reconstruction

- Temporary Flood Protection Measures

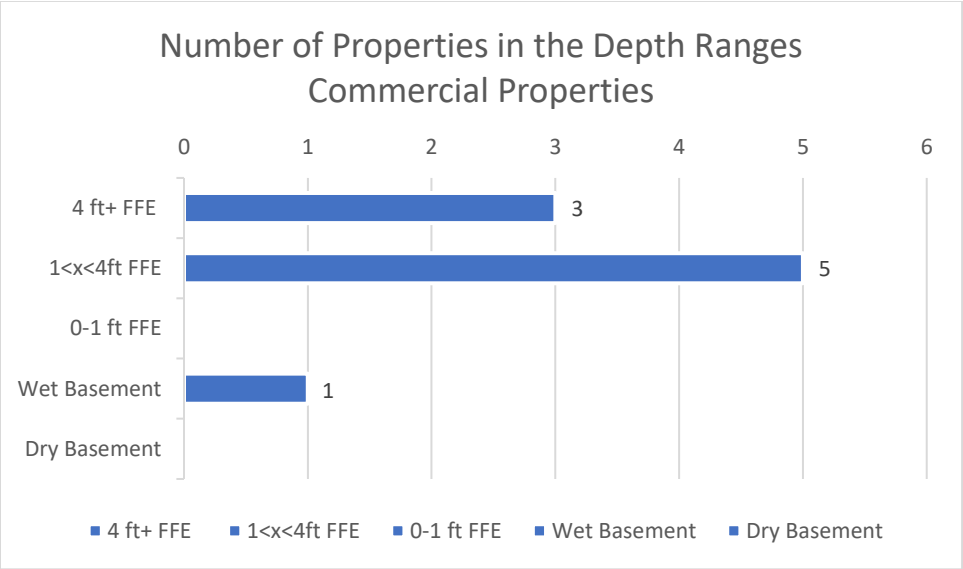


Figure 5.8: Distribution of 100-year Inundation Depths for Commercial Properties

Inflatable Flood Wall

An inflatable floodwall was considered as a mitigation option that could protect multiple commercial structures simultaneously. The inflatable floodwall was determined to not be a viable option due to several constraints. Due to the depth of flows and the extent of inundation, the size and length of the inflatable floodwall required would be difficult to deploy in a short period of time. There are also concerns that the inflatable floodwall is susceptible to punctures from debris flowing in flood water. Failure of one of these floodwalls could prove more destructive than the flood itself.

5.4 – BASIS OF COSTS

Elevations and individual property floodproofing mitigation projects have many variables that have a direct impact on the cost of the project, such as the type and size of the building's existing foundation, the condition of the foundation, the required height for the elevation/floodproofing, and the size and finished detail of the re-built structure. Due to the number of factors that impact cost for these types of projects, each home would need to be evaluated on a case-by-case to determine if it would qualify for the FEMA Pre-Calculated Benefit to justify FEMA funding.

Structural mitigation options, such as floodwalls, require additional planning and design efforts to determine specific project cost estimates. However, planning level cost estimates can be derived from reference projects of similar or related scope. Bloomsburg's levee and floodwall system is one of the local examples of such a reference. The recent West End Flood Mitigation Study (Columbia County, 2022) estimated the total capital cost (inclusive of construction, design, permitting and related project cost) of a flood wall/levee system at around $4,000 per linear foot of wall/levee length.

The cost opinions created are to be considered Level 5 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 50% less to 100% more than the cost opinions given. This estimate class and accuracy is appropriate for planning level use.

5.5 - BENEFIT-COST ANALYSIS

The FEMA Benefit-Cost Analysis (BCA) Tool was used to determine the cost effectiveness of each proposed mitigation option.

Acquisition

FEMA provides funding for acquisition/demolition projects that meet specific criteria, and property owners can voluntarily participate in this program. To qualify for FEMA funding, the structure must be located in the Floodplain SFHA or be classified as Repetitive Loss or Severe Repetitive Loss if located outside of the SFHA.

For acquisitions, a Pre-Calculated Benefit of $323,000 per structure is defined by FEMA. If the total cost of the acquisition/demolition project is less than $323,000, it qualifies for FEMA funding without the need for a Benefit-Cost Analysis (BCA). However, if the project cost is estimated to be greater than $323,000, a BCR calculation must be performed using FEMA's BCA Tool, and the resulting BCR must be greater than 1 to qualify.

Elevation and Reconstruction

FEMA provides funding for elevation and reconstruction projects that meet specific criteria, and property owners can voluntarily participate in this program. To qualify for FEMA funding, the structure must be located in the Floodplain SFHA or be classified as Repetitive Loss or Severe Repetitive Loss if located outside of the SFHA, and the resulting structure must be 1.5 feet above the Base Flood Elevation

For elevations and reconstructions, a Pre-Calculated Benefit of $205,000 per structure is defined by FEMA. If the total cost of the Elevation/reconstruction project is less than $205,000, it qualifies for FEMA funding without the need for a Benefit-Cost Analysis (BCA). However, if the project cost is estimated to be greater than $205,000, a BCR calculation must be performed using FEMA's BCA Tool, and the resulting BCR must be greater than 1 to qualify.

Due to the variability in the physical characteristics of each property, the cost of these elevations/ reconstruction would have to be calculated for each individual property.

Structural Alternatives

A FEMA BCA was developed for a range of flood depths above the first-floor elevation to cover the range of flood depth categories:

- 0-1 feet above of water above the FFE,
- greater than 1 feet and less than 4 feet above of flood water above the FFE,
- and any properties with over 4 feet of water above the FFE.

The resulting benefits per property and flood depth is summarized in Table 5.1. Residential structures were assumed to be 1,000 square-feet and non-residential structures were assumed to be 3,000 square feet, and Lewisburg Borough and William Cameron buildings were assumed to be 5,000 square feet.

Table 5.1: Floodproofing Alternative Benefits

Depth	Benefit per Residential Property	Benefit per Non-Residential Property*
4 feet+ above FFE	$43,500	$82,000
1<x<4 feet above FFE	$24,000	$22,000
0-1 feet above FFE	$18,000	$8,000

*Use dependent – average of various non-residential uses shown.

The following data was utilized in the FEMA BCA Tool to determine the benefit cost results:

- Assume the project is a "Floodproofing" mitigation alternative
- Assume the only benefits associated with the project are from the residential structures
- Residential properties have a 1,000 square-foot footprint area
- Commercial properties have a 2,000 square-foot footprint area
- Beck Street conceptual project capital cost of approximately $2.1 million
- Floodwall useful life = 30 years
- Standard FEMA BCA assumptions including:
  - Residential Building Replacement Value (BRV) = $100
  - Commercial Building Replacement Value (BRV) = $100
- The following elevations were input to determine damages at different depths.

With this information a benefit cost analysis could be developed for the Beck Street Mitigation concept. Table 5.2 summarizes the benefit-cost determination for this mitigation option.

Table 5.2: Beck Street Benefit-Cost Ratio Determination

Depth	Number of Residential Properties	Number of Non-Residential Properties*	Benefit
0-1 feet above FFE	7	0	$128,000
1<x<4 above feet FFE	8	6	$455,000
4 feet+ above FFE	0	1	$85,000
		Total Benefits	$668,000
	Cost Per Linear Foot	**Linear Foot**	**Total Cost**
	$4,000	530	$2,120,000
		Benefit Cost Ratio (BCR)	0.32

*Includes Lewisburg Borough and William Cameron Fire Buildings

A Benefit-Cost Ratio (BCR) must be greater than one to be considered cost effective by FEMA. Due to the low BCR of 0.32, the Beck Street Floodwall conceptual project cannot be considered economically viable.

There are additional variables that could be evaluated in this Benefit-Cost Analysis, resulting in a more accurate analysis. Further design of floodwall would give greater insight on the cost of engineering, permitting and other associated cost. Higher values for BRV can be utilized if justification is provided. There are more benefits that could be considered such as damages to roadways and utilities. A detailed analysis of the unique impacts on individual structures would also provide a more accurate summary of the benefits of the floodwall.

Temporary Flood Protection Measures

Due to the variability in the physical characteristics of each property and the types and costs of temporary flood protection measures, the cost of the temporary flood protection measures would have to be calculated for each individual property and type of temporary protection measure.

5.6 - RECOMMENDED ACTION ITEMS

The following is a summary of recommended action items related to the Flood Resilient Community Toolbox:

- Seek funding to work with individual businesses to create flooding preparation/recovery plans.
- Continue public education and outreach through various means: social media, public events, Borough website, and Borough mailings to name a few.
- Conduct further studies on potential projects (i.e. Beck Street floodwall, floodplain restoration) and update benefit-cost analysis tool with potential project and property details.
- Evaluate and implement partnerships with adjacent municipalities to update ordinances and institute flood mitigation solutions in the Limestone/Bull Run watershed.
- Evaluate the retrofitting of existing watershed stormwater management basins.
- Evaluate creating a dedicated flood mitigation revenue stream.

SECTION 6 - FLOOD EVENT OPERATIONAL ACTION AND RECOVERY PLAN SUMMARY

Lewisburg identified a need to prepare a guide for the community in the event of significant flooding event. The intent is to provide steps to assist Borough staff and other support services during the chaotic period before, during, and after a flood event. This summary provides an overview of this plan, known as the Flood Event Operational Action and Recovery Plan (OARP). The full Plan has been distributed to the relevant organizations and individuals who have a role in implementing and administering it during a flooding event.

6.1 - PURPOSE AND SCOPE

The Operational Action and Recovery Plan (OARP) is a comprehensive document aimed at minimizing the potential damage caused by floods in waterways and nearby areas. The Plan outlines various emergency actions to be taken by public officials and emergency personnel, as well as response actions to be undertaken in the event of a potential or imminent flood. The primary purpose is to safeguard the lives of Borough citizens, reduce property damage, and to foster a more resilient community. The Plan defines effective methodologies for waterway surveillance, prompt notification of local emergency management agencies, citizen warning and evacuation response. The Plan is designed to ensure that all stakeholders are aware of their roles and responsibilities during an emergency and to facilitate coordinated efforts for an effective response.

6.2 - SITUATION

This section of the plan identifies the situations of concern for the Borough, this includes a summary of flood risk sources, known problem areas. This section also identifies assets and resources available to be prepared in the event of a significant flooding event. The following is a highlight of this information.

The Borough of Lewisburg in Pennsylvania is located within the floodplains of three watercourses (West Branch Susquehanna River, Buffalo Creek and Limestone/Bull Run), and has suffered significant flood damage in the past. Floodplains make up one third of the Borough's land area, and about 530 structures are at risk during a Base Flood Event (commonly known as the 100-year flood event). Most of the Borough's equipment and facilities are located within the approximate flood stage level of the West Branch Susquehanna River, putting assets at risk. The downtown area is isolated during a flood and no flood recovery resources are housed there to aid potentially stranded individuals. The Borough is also vulnerable to non-riverine flash flooding on Buffalo Creek and Limestone/Bull Run caused by heavy rains in the Buffalo Valley. A variety of projects such as stream improvements, repetitive loss property buyouts, increased floodplain regulation and bridge/culvert widening have been implemented to reduce the effects of flooding in the Borough. The Borough is continuing to implement similar projects to create a more resilient community.

6.3 - CONCEPT OF OPERATIONS

This section details the procedures for surveillance, early warning, warning, and evacuation notification during flooding. The incorporation of the Borough's emergency notification system, Code Red, to the Plan is discussed. The Plan defines the responsibilities of the Public Works Department and the emergency management officials in responding to flood emergencies. It also includes guidelines for termination of surveillance and notifications and the incident management structure that will be implemented in the event of flooding.

6.4 - RESPONSIBILITIES AND DUTIES

This section outlines the responsibilities and duties of various agencies and organizations during a flood event in the Borough area. The responsibilities of these organization generally include the following. The Public Works Department is responsible for river surveillance and monitoring and initiating early warning notification to the Union County PSAP/911. The Lewisburg Borough Emergency Management Coordinator (EMC) coordinates evacuation, damage reporting, media notifications, advisories to local organizations. The Union County PSAP/911 is responsible for notifying various agencies, including the Union County EMA, William Cameron Engine Co. and the Buffalo Valley Regional Police. The County EMA (in coordination with the Borough EMC) is responsible for contacting various personnel and agencies, including the National Weather Service and the American Red Cross. The William Cameron Engine Co. is responsible for citizen notification and route alerting. The Buffalo Valley Regional Police is responsible for traffic control and securing evacuated areas. EMS provides evacuation transportation assistance, assists fire and police departments, and provides EMS support to any mass care center. Voluntary Organizations Active in Disasters (VOAD) maintains the reception center, and PennDOT provides services, signs, barricades, and guidance on roads and bridges. Emergency Support Functions (ESFs), vital operations to be conducted or maintained during disasters, are defined in this section. The responsibility of the coordinating agency, primary, agency, and support agency are similarly defined.

6.5 - ADMINISTRATION AND LOGISTICS

This section outlines guidelines for administration and logistics during a flood emergency situation. Entities responsible for filling out situation reports and damage reports are specified.

6.6 - RECOVERY ACTIVITIES

This section outlines the recovery activities after the flooding event has peaked and recovery procedures can commence. The Emergency Management Coordinator will prepare a report for financial aid from Union County, PEMA, and FEMA based on damage reports. Recycling dumpsters in Wolfe Park should be relocated to minimize transportation distance, and municipal parking lots should be used for storage during emergency conditions. Solid waste collection should continue as scheduled in unimpacted areas, and at least one truck and dumpster should be allocated for the "Downtown Island" and emergency management staff. Public parks should be cleared and appurtenances secured to prevent debris from causing property damage. The Union County Debris Management Plan is also a key resource in managing debris cleanup after a significant flood event.

6.7 - BACK MATTER AND APPENDICES

The back matter of the document includes Authority and References sections, Definitions of terms used in the document, and an Exercise and Training section. The Authority section lists the sources of authority for emergency management, including FEMA's National Incident Management System and the Emergency Management Services Code. The References section provides sources of flood information, mapping, hazard mitigation, and emergency operations Plans. The Definitions section provides explanations for key terms used in the Plan. The Exercise and Training section discusses how the Plan will be exercised and maintained, and the Plan Maintenance and Distribution section outlines the responsibilities of Borough staff, partnering agencies, and the Borough Emergency Management Coordinator for maintaining and reviewing the OARP. Appendices include maps, traffic control concept, telephone roster, media announcement template, and notices for known flooded areas.

SECTION 7 - REVENUE IMPACT ANALYSIS SUMMARY

The Revenue Impact Analysis was a limited evaluation of the Borough's financial revenues and expenditures to provide scenario planning for short- and long-term revenue implications based on the severity of flooding impacts to Borough properties. The analysis focused only on the Borough's General Fund which is its primary Fund associated with Borough operations. The analysis did not exam other Borough Tax Funds, Fee for Service Funds, or Project Specific Funds. The results will assist the Borough to determine reasonable investments and reserve funding based on the findings of this Study to prepare for and recover from flood events.

Evaluation of Lewisburg's General Fund budget revealed the Borough's operations are comparable to many other similarly sized municipalities across the Commonwealth. With this data, projections for future Borough revenues and expenditures were made assuming low to moderate increases for various categories in both (generally limited to a maximum increase of 3% per year). Combining the financial projections with estimated properties impacted by given flood elevations/river stage data an estimate of General Fund tax revenue impacts was developed. This analysis can be visualized using Figure 7.1.

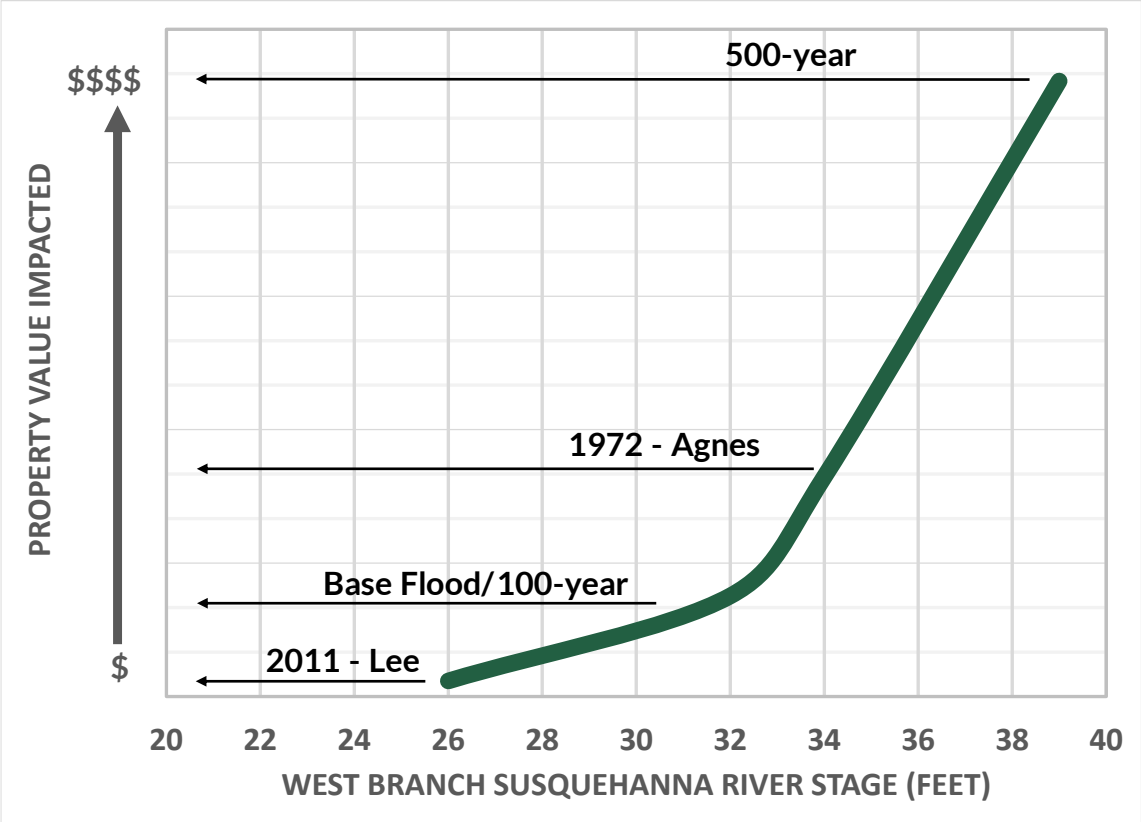


Figure 7.1 Revenue Impact Analysis Example

As part of this review, consideration was given towards developing a revenue stream to fund flood mitigation efforts, with potential implementation through the use of short-term municipal tax relief awards for residential properties willing to implement flood proofing measures or potential larger capital investment in flood mitigation measures.

7.1 - SUMMARY OF FINDINGS

In the range of scenarios evaluated for the Borough, there is the potential for significant impacts to the Borough's General Fund tax revenue, potentially impacting the Borough's ability to provide basic services and impacting property owners that are able to maintain their residence after a significant flooding event. Therefore, it is prudent for the Borough to consider options to limit tax revenue loss potential. In brief, the cost of doing nothing far outweighs the cost of being proactive using planning and mitigation measures.

As is illustrated in findings in Table 3 of Appendix C, the financial loss if properties considered a substantial loss were not rebuilt elsewhere in the Borough the impact is over $180,000 in General Fund property tax revenue for an event equivalent to the 1972 Agnes flood and the assessed value of the property that could potentially be impacted is almost 25% of the total taxable assessed property value in the Borough as a whole. The study further evaluates the effect that a flood at varying levels will have on the total assessed value of the Borough should the affected parcels choose not to rebuild as a result of the devastation. Additional impacts to earned income tax revenue were estimated on the order of $100,000 with an event equivalent to the base flood event.

Reinvesting tax dollars in resiliency measures is a wise investment that will yield a positive return on investment. Funding a grant program to help residents implement flood protection measures or setting aside an annual investment for capital projects for additional flood protection are two ways this could be implemented.

Based upon our analysis, we recommend that the Borough consider starting to accumulate between $250,000 to $750,000 in General Fund Tax operating reserve funds for the recommended 3-12 months after a flooding event, in addition to ample revenues to handle up to twelve months in revenue loss if flooding events with river stages of greater than 32 feet are reached.

Ensuring that the Borough has ample reserve funds available to cover a period of decreased real estate and earned income tax revenue should be viewed as being prudent and good stewards of taxpayer dollars. Reinvesting tax dollars in resiliency measures is a wise investment that will yield a positive return on investment. Refer to Appendix C for the full revenue impact analysis report.

7.2 - RECOMMENDED ACTION ITEMS

The following is a summary of recommended action items related to the Revenue Impact Analysis:

- Evaluate creating a dedicated flood mitigation program revenue stream.
- Consider working with Partner Organizations to develop a revolving loan program to assist in implementing individual property owner flood mitigation projects and programs.
- Update the Revenue Impact Analysis every 5 years to understand impacts to current Borough financial status.

SECTION 8 - ORDINANCE REVIEW

Regulations are an important tool to help mitigate the impacts of stormwater and flooding. Stormwater and floodplain regulations exist at federal, state and local levels. Generally, state and local regulations have the greatest impact on a community, as federal regulations often have a broader focus. Many municipalities throughout Pennsylvania enforce stormwater and floodplain regulations through their Zoning Ordinance, Subdivision and Land Development Ordinance (SALDO), and sometimes separate Floodplain and or Stormwater Management Ordinances. The Borough has a Zoning Ordinance, SALDO, and Stormwater Ordinance. The Borough adopted a new Stormwater Ordinance in November 2022, which has been revised to include a 16-24% increase in design rainfall values, which is a pro-active approach to addressing potential increases in future rainfall intensities. The Borough's floodplain regulations currently reside in the zoning ordinance. Below is an overview of the Federal, State and the Borough's existing regulations related to flooding and stormwater, a review of the Borough's Ordinances, and some recommendations to consider.

8.1 - OVERVIEW OF FEDERAL, STATE, AND LOCAL REGULATIONS

As noted, federal regulations are generally broad 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 (TMDL), to assure water quality and protect stream flora and fauna.

CLEAN WATER ACT, SECTION 404 – Regulations related to 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 result in a discharge to navigable waters. This also established the National Pollutant Discharge Elimination System (NPDES) that regulates earth disturbances activities 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. In general, proposed structures cannot cause a significant rise greater than one (1) foot to the 100-year flood elevation of the stream.

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 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 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 of structures located within the floodplain of a stream if owned by the State, a political subdivision, or a public utility.

Local regulations related to stormwater management and flooding are found in the Zoning Ordinance, SALDO, and sometimes separate Floodplain and or Stormwater Management Ordinances. Below is a brief description about each type of ordinance.

ZONING ORDINANCE – A zoning ordinance regulates how property can be used based on their geographic area and land use type. It can regulate lot sizes, placement, density, architectural style, and height, among other items.

SUBDIVISION AND LAND DEVELOPMENT ORDINANCE (SALDO) – A SALDO is a type of zoning ordinance that regulates the division and development of privately owned property.

FLOODPLAIN MANAGEMENT ORDINANCE – A floodplain management ordinance regulates land management and use based on flood hazard information, to the extent they are known. These regulations are typically mandated by the state onto the local municipality in order to obtain federal disaster relief funding and/or participation in the National Flood Insurance Program.

STORMWATER MANAGEMENT ORDINANCE – the purpose of this ordinance is to protect, maintain and enhance the public health, safety and general welfare by establishing minimum requirements and procedures that control the adverse impacts associated with increased stormwater runoff.

8.2 - BOROUGH ORDINANCE REVIEW

As part of the Lewisburg Borough Flood Study, the project team reviewed the existing zoning ordinance regulations related to stormwater management components (i.e. impervious coverage, floodplain protection, etc.) and floodplain management, along with emerging best practices and items the Borough

requested to be examined in more detail. Through this analysis, recommendations related to flooding and stormwater management for Borough consideration have been developed in order to improve the flood resiliency of structures in future storm events. The sections below summarize topics that were reviewed and recommendations for Borough.

Converting Single-family Dwellings to Multi-family Dwellings within the Floodway

Addition of residential living quarters within the floodway increases the number of dwelling units and people at risk. The conversion of a structure from a single-family dwelling unit to a multi-family dwelling unit requires an application and approval by the Borough Council using the conditional use process established by the Pennsylvania Municipalities Planning Code. In addition, it would require a new occupancy permit since the number of dwelling units would change. The development or conversion of a property is regulated by the Zoning Ordinance and SALDO if extensive infrastructure and land development improvements are necessary. The Borough already has regulations and an approval process in place for conversions of dwellings. However, no Borough regulation exists currently that limits conversions that add dwelling units within existing structures located in the floodway. Since living within the floodway is inherently dangerous to both the resident and emergency personnel who may be needed to rescue those residents; the expansion of the number of dwelling units in existing residential structures should be prohibited unless the entire structure and living unit conforms with the floodplain ordinance regardless of historic designation (i.e. no exemptions shall be granted for historic buildings).

Regulation of Non-Historic Structures within the Floodplain

The Borough regulations related to substantial renovations, alterations, remodeling or reconstruction of non-historic properties were reviewed. Renovations, alternations, remodeling or reconstruction are considered property improvements, which result in an increased property value, subsequently increasing the potential cost of flood-related damage. To address this issue, many zoning regulations, including that of the Borough, regulate renovations, alterations, remodeling or reconstruction within the floodplain. The Borough only requires properties improved over 50% of the property value to meet all of the requirements regarding floodproofing. However, a drawback of this regulatory approach is when properties do not exceed 50% of the property value, those owners are only required to meet the regulations of the Floodplain Management Section of the Ordinance “to the greatest extent possible”, which is open to interpretation. These regulations should include stronger language to establish the expectations and absolute minimum resiliency improvements to be required.

Regulation of Historical Structures within the Floodplain

In the case of historic properties and structures within the Borough, those that are listed on the National Register of Historic Places or a State Inventory of Historic Places are eligible for exemption from ‘substantial improvements’ compliance of the floodplain management section of the Zoning Ordinance. In the Borough’s historic district, most structures as designated “contributing” and therefore, considered exempt from the floodplain ordinance. However, the Borough’s zoning ordinance still requires that property owners’ complete improvements to the greatest extent possible, without impacting their historic designation. These regulations should include stronger language to establish the expectations and absolute minimum resiliency improvements to be required on the interior of historic structures not impacting the exterior.

Floodplain Designation / Overlay

Floodplain designations are developed by the Federal Emergency Management Agency (FEMA) and their 100-year floodplains are often used by municipalities to help regulate properties within their jurisdiction. However, when using FEMA's 100-year floodplain designations, there are some limitations, they include:

- Runoff from properties outside the designated floodplain may still severely impact those within the designated floodplain. If stormwater is not managed and addressed on one's property, it may runoff and negatively impact downstream properties, namely in the scenario of extreme rainfall events that create pluvial flooding events. Pluvial flooding events occur when stormwater drainage systems are overwhelmed as well as when flash flood events occur during an intense, high velocity rain falling within a short amount of time. Therefore, even if you are not within the floodplain, what you do on your property can impact others greatly.
- A common misconception by property owners located outside the floodplain, is that if their property lies outside the floodplain, it will not flood, however, this is not true. Increases in development and impervious cover within the watershed, coupled with higher intensity storm events observed and trending in recent decades, along with other variables, are resulting in increased incidents of properties flooding outside the floodplain.

Freeboard Requirements

Freeboard is an additional amount of height above a flood elevation used as a factor of safety in determining the level at which a structure's lowest floor must be elevated or floodproofed to in accordance with floodplain management regulations. The Borough's current zoning ordinance requires the lowest floor (including basement) of any new or substantially improved residential structures within any Floodway or Flood Fringe area to be at least 1.5-feet above the 100-yr flood elevation. For non-residential structures, a similar requirement for the lowest floor elevation is to be at least 1.5-feet above the 100-yr flood elevation within the Floodway or Flood Fringe area, or be designed and constructed so that the space enclosed by such structure shall remain either completely or essentially dry during any flood up to that height. It is recommended that the Borough consider revising this minimum height to 2-feet to allow for current protection from events greater than the 100-yr event as well being prepared for potential future increases to the 100-yr rainfall event which results in a higher 100-yr flood elevation.

Recommendations Specific to Noted Borough Ordinances

- One of the best tools is education. It is important to educate the community on the importance of floodproofing and flood preparedness. It is also important to make sure that those outside the floodplain still understand both their risk and impact. Providing educational material and resources, such as toolbox material developed for this study, for people to gain knowledge and prepare themselves and their home is one of the best tools to use outside of zoning regulations.
- Consider moving the Floodplain Management Section out of the Zoning Ordinance into a separate Floodplain Management Ordinance. This allows for the Floodplain Manager to regulate activities within the floodplain with some flexibility on interpretation of the regulations.
- The Borough should work with the Historic Architectural Review Board (HARB) to develop guidance documents for both building owners and contractors of appropriate flood/water resistant building materials and construction methods that are suitable for historic structures. This guidance should follow the National Park Services Flood Adaptation Guidelines.

- The Borough should consider refining the exemptions from the floodplain management regulations for contributing historic buildings by placing variance-type exclusions on the requirements as defined by the National Flood Insurance Project (NFIM). Such exclusions can include elevating mechanical and electrical equipment and no bedrooms below the Base Flood Elevation.
- The Borough should consider defining a Floodplain Overlay District that extends beyond the 100-year floodplain developed by FEMA due to the limitations described above. Developing an expanded floodplain will better protect Structures from future flooding events
- The Borough already has regulations and an approval process in place for conversions of dwellings. Additionally, existing dwelling unit construction, reconstruction, and/or elevation may increase the number of residents living in the floodplain it is recommended to consider additional regulation that sets thresholds for footprint expansions and/or prohibits the conversion of single-family dwellings to multi-family dwelling located within the floodway unless strict conformance with the floodplain regulations are adhered to.
- Based on the review of the Borough ordinances and the results received from the public engagement surveys and meetings, the Borough may want to consider requiring flood notification (including the recommendation of flood insurance) for all new property leases and property deed transfers to ensure residents are aware of their flood risk when renting or purchasing a property.
- It is recommended that the Borough consider revising the minimum height of 1.5-feet to a minimum height of 2-feet to allow for protection from events greater than the 100-yr event as well being prepared for potential future increases to the 100-yr rainfall event which results in a higher 100-yr flood elevation.

8.3 - ADDITIONAL ITEMS FOR FLOOD RESILIENCY CONSIDERATION

Floodplain Management Policies

Floodplain management helps to decrease and mitigate the impacts of wet weather events, including flooding, while having policy focused on future development and reducing the possibility of increased flooding. Floodplain management serves as a tool used to limit the impacts of flooding by mitigating the conflicts of land use within the floodplain.

To have effective floodplain management policy, it needs to focus on both preventative provisions as well as corrective measures. Both preventative and corrective policies help restrict future development within the floodplain and increase resiliency of the community from the impacts of flooding within the floodplain and problem areas over time.

Recommendations to improve and strengthen the Borough's existing Floodplain Management Policies include:

- The Borough should continue to participate in FEMA's Community Rating System (CRS) by reviewing their status and by seeking new ways to increase their rating. Last Assessment was submitted to the Borough in October 2022. A flood insurance assessment will be re-assessed in 2025. It was recommended in 2022 that the Borough work on the following to increase rating:
    - CRS Activity 370 – Flood Insurance Assessment
        - Increase direct mailings to residents in the regulatory floodprone areas
        - Direct contact with these areas through community and neighborhood events (ensure floodplain development and code regulations are discussed as it relates to the Borough's floodplain ordinance).

        - Continue using social media, Borough's web site, and other digital media for sharing of the message.
    - CRS Activity 450 – Erosion and Sediment Control – Review previous CRS review comments and submit documentation required from Erosion and Sediment Section of the Ordinance for review towards increasing CRS rating.
    - CRS Activity 450 – Stormwater Management – Borough should submit revised stormwater ordinance for review towards increasing CRS rating.

- Develop and implement a maintenance program for the Borough's stormwater drainage system. This would require the evaluation of all storm drains and develop a replacement and maintenance schedule of stormwater drainage infrastructure. The stormwater conveyance system is important, as they are designed to operate at full conveyance, but when they become clogged or unable to operate as intended, then the system is no longer working at full capacity. Therefore, it is important that municipalities have a plan in place for the inspection and maintenance of channels as well as conveyance and storage facilities.

Riparian Zone Protection

Riparian zones, the areas between the aquatic zone and the adjacent uplands, provide benefits related to flood protection and water quality. Riparian zones provide a temporary storage area that allows water velocities to be reduced and allow for infiltration of some water. Through the slowing of the waters and infiltration, pollutants are filtered out and helps to reduce streambank erosion which increases sedimentation in the water channels. Severe flooding is becoming more frequent due to more extreme weather events, leading to a greater risk of destructive impacts to properties and residents in riparian areas. Riparian zone restoration, protection, and sustainable management in still functioning riparian areas helps mitigate flooding adjacent to and downstream of those areas.

Recommendations for Riparian Zone Protection include:

- Adopt and enforce the riparian buffer provisions of the PADEP Model Stormwater Ordinance, which includes regulations that require the establishment of riparian buffers on all new development near the water course. The Model Ordinance also includes requirements in accordance with the proposed changes to the statewide erosion and sedimentation plan.
    - The model ordinance does include the exemption for roadway maintenance activities and there is a waiver for linear projects.
- Adopt stream specific guidelines in areas where flooding problems have been 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 to 1,000 feet. Variable riparian zone widths may be based on a specific flood event.
- Encourage the establishment of riparian buffers. There are regulatory approaches that help to limit the future development, however they have nearly no effect on the existing land use that currently exists within the riparian areas. There are incentive programs that can help with providing technical and financial assistance for property owners, that could help them establish riparian corridors.
- Encourage collaboration with upstream municipalities to strengthen riparian zone protection.

Green Infrastructure and Low Impact Development

Development and even improvements to properties that impact the impervious area of a lot can have impacts on stormwater, which can increase flooding. Green stormwater infrastructure can help to limit the impacts of development in terms of stormwater, through various solutions. FEMA encourages green infrastructure strategies for flood mitigation and resiliency.

Recommendations can include:

- An incentive program could be offered to help with technical or financial assistance to property owners that want to implement green infrastructure on their property.
- Updating the Borough's Stormwater Ordinance as it relates to these practices. The 2022 PADEP Model Stormwater Ordinance currently includes Low Impact Development and Green Infrastructure as optional content for inclusion in Local Stormwater Ordinances for additional regulation.
- Consider requiring or encouraging Green Infrastructure techniques in other Borough Community Plans (e.g., open space or parks plans)

Limiting Impervious Cover

Studies have found that once 10% of the land area within a watershed is impervious, the waterways begin to show signs of degradation. Through the limitation of impervious cover, the impacts that impervious area have on the hydrologic cycle may be reduced.

Recommendations to help decrease impervious land cover:

- Narrowing of Road Widths: For example, it is often assumed that roadways have 12-foot travel lanes and additional widths of impervious area for shoulders or sidewalks. If existing lanes are 12 feet, reducing them to 11 feet could decrease impervious coverage of the roadways and add space within the tree lawn areas. This should be considered when roadways are being improved or repaved.
- On Street Parking: Limiting on street parking when feasible could reduce impervious coverage. Another option is to construct on street parking utilizing permeable pavement solutions, that allow for infiltration.
- Parking Requirements and Dimensions: The Borough could consider reducing the minimum and maximum number of parking spaces required for land use types, based on societal changes in recent years. The Borough could also look at the parking space size and set the requirements at 8 feet by 18 feet long to help reduce impervious area. Lastly, within parking lots the Borough should have requirements in place to require minimum green space or permeable pavement within parking lots that allow for run off infiltration.
- Total impervious coverage on a lot: The Borough could consider reducing the percentage of impervious land coverage that is permitted on a lot unless stormwater management is implemented on the lot. Similarly, the Borough could look to require permeable pavement for larger off-street parking areas (i.e., 5 spaces or more) or minimum green space percentages based on land use types.

Overlay Zoning

Overlay districts add an additional layer of regulatory standards, permitted uses, or applies specific development criteria onto existing zoning regulations. The Borough already has a Floodplain Overlay District, but below are two (2) additional overlay zoning districts that are related to stormwater management and flood control:

- Impervious overlay zoning could be added in areas with documented stormwater problems to help set maximums for impervious area coverage.
- Riparian zoning overlay district could be an appropriate overlay district to help with water quality, floodplain management and stormwater management.

8.4 - SUMMARY

These recommendations are policy related actions that could be beneficial to the Borough, related to flooding and stormwater management. In order for the policy recommendations above to have an impact, the Borough must have the capacity to implement and regulate them. Policy recommendations like these may take time to see the results however, when implemented can greatly impact the future of the Borough and its resiliency.

SECTION 9 - LIMESTONE/BULL RUN HYDROLOGIC AND HYDRAULIC STUDY

9.1 - OVERVIEW

The intent of this Hydrologic and Hydraulic study is to investigate potential future projects that could alleviate issues caused by flash flooding on Limestone/Bull Run. The focus study of Limestone/Bull Run was undertaken to develop an understanding of how pre-existing, existing, and near-term conditions have and will be affected by flood plain and stream bank restoration projects. Potential projects such as bridge widening and flood plain restoration will be analyzed to determine what types of projects will be most effective in reducing inundation extents and velocities.

The study area begins at the 10th Street bridge and extends to approximately 100-yards downstream of the St. George Street culvert. The width of the study area generally extends beyond the established 100-year floodplain. This analysis is focused solely on flooding conditions of Limestone/Bull Run: tailwater effects from the West Branch Susquehanna were not considered. The results shown in this study demonstrates designed flooding events on Limestone/Bull Run under the condition that the West Branch Susquehanna River is not at flood stage. The results in this study have no bearing on the established water surface elevations associated with the regulatory floodplain.

This Hydrologic and Hydraulic Analysis is subject to uncertainties associated with modeling and data limitations. The hydrologic data used for this analysis was developed using the SIR 2008-5102 methodology, as there was no available flow data or rain data for the watershed. The SIR 2008-5102 methodology uses information from nearby comparable streams to produce an estimation of peak flows. Therefore, the hydrologic data may not accurately reflect the actual conditions of the watershed.

Furthermore, the hydraulic model used in this analysis is subject to limitations and assumptions, including but not limited to the simplification of complex physical processes, variations in channel roughness, and uncertainties in estimating boundary conditions. As a result, the hydraulic model may not accurately predict the flow behavior under all conditions.

It is also important to note that this analysis was conducted to understand how changes to the stream corridors terrain and obstruction geometry affects velocity, water surface elevation, and inundation extents. Results should be interpreted in light of the uncertainties and limitations of the models used. The authors of this report assume no liability for any damages or losses arising from the use of this analysis.

9.2 - HYDROLOGY

Union County FEMA FIS

Peak flow data for the 10, 50, 100, and 500-year event were available in the Union County FIS, revised 2021. Peak flows for Limestone/Bull Run were based on the regional flood frequency method developed by USACE (Reference 15). The skew coefficient was modified to better correlate with the flood frequency curved developed by NRCS. Discharge values were also adjusted to account for effects of urbanization.

USGS SIR 2008-5102

The Regression Equations for Estimating Flood Flows at Selected Recurrence Intervals for Ungauged Streams in Pennsylvania published by USGS in the Scientific Investigations Report 2008-5102 was used to

calculate peak flow data calculated for Limestone/Bull Run. This methodology utilizes basin characteristics to determine the peak flows for a variety of design storms.

LandStudies StreamStats

In the Hydrology and Hydraulic study conducted by LandStudies for the Bull Run Watershed Action Plan, data drawn from StreamStats, an online hydrology analysis tool administered by the United States Geological Survey (USGS).

Synthetic Hydrographs

In order to complete a hydraulic analysis of Limestone/Bull Run, a hydrograph was needed for each storm event. A synthetic hydrograph for the 100-year event was developed by LandStudies. A logarithmic decay regression was applied to the LandStudies hydrograph in order to extend the duration of the storm event. Synthetic hydrographs for the 2- and 10-year event were developed by adjusting a unit hydrograph to the time to peak utilized by LandStudies and an assumed duration of 16 hours. A synthetic hydrograph for the FEMA 100-year event was developed by adjusting a unit hydrograph to the assumed time to peak of 1.3 hours. Table 9.1 summarizes the assumed peak flows for the events considered.

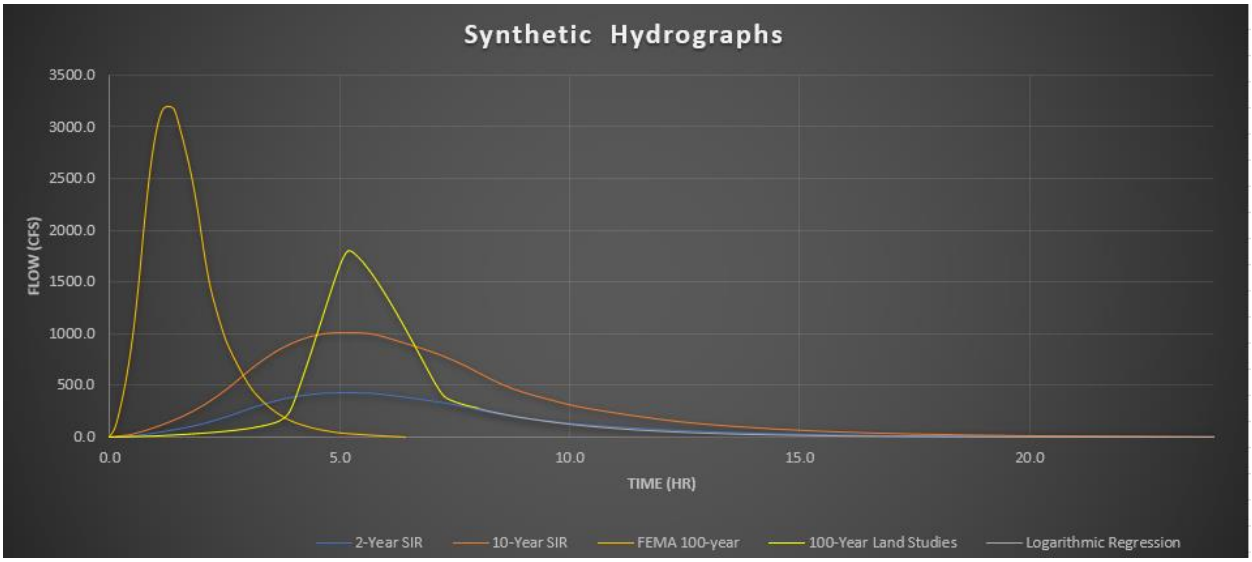


Figure 9.1: Synthetic Hydrographs

Table 9.1: Peak Discharge Data

Recurrence interval	2	10	100
Data Set	Peak Flow (cfs)		
LandStudies StreamStats	-	-	1796
SIR 2008-5102	428	1005	2032
FEMA	-	1250	3200

9.3 - HYDRAULICS

The United States Army Corp of Engineers (USACE) Hydrological Center River Analysis System (HEC-RAS) program version 6.2 was used to calculate water surface elevation and velocities for the 2, 10, and 100-year storms in the reach of Limestone/Bull run bounded by 10th street and St. George Street.

Model Development

The hydraulic analysis in this study was completed using the USACE HEC-RAS version 6.2 program. In total, 15 plans for 2D unsteady flow analysis were created and analyzed based on existing and proposed conditions. Results are available in Appendix D.

The model used in this analysis is the expansion of the 2D model developed by Land Studies for stream bank restoration that was part of the Watershed Action Plan of 2017. The extents of the Land Studies hydraulic model (downstream side of 7th Street Bridge to upstream side of St. George Street) were expanded to include the reach of interest (downstream side of 10th Street Bridge to approximately 100 yards downstream of St. George Street).

Terrains

The existing terrains were produced using AutoCAD Civil 3D. The pre-existing and the existing terrain are a combination of USGS Digital Elevation Model file overlain by the Land studies model terrain files. The planned future condition is a combination of the existing terrain overlain by the proposed flood plain restoration north of Market Street and South of the Rail Trail. The terrains for potential project options including bridge expansion or removal were developed using RAS Mapper's terrain modification function. The terrain for the potential flood plain restoration project was developed utilizing AutoCAD Civil 3D.

2D Flow Areas

The extent of the 2D Flow area for pre-existing, existing, and future, and proposed geometries were generally based on elevation. An elevation of 555 feet to 565 feet was used as the basis for the perimeter. The 2D flow area utilizes 6 foot by 6-foot point spacing which created approximately 156,000 cells for both existing and proposed geometries. Breaklines were utilized to capture abrupt changes in grade along the top of channel for both existing and proposed conditions.

Boundary Conditions

The upstream boundary of the upstream boundary condition for the model was set approximately on the east side of the 10th Street Bridge, and flow hydrographs were inserted at the upstream boundary condition in accordance with the synthetic hydrographs section. The downstream boundary condition for the model was set approximately 300 linear feet downstream of the St. George Street and normal depth was used as the boundary condition. Tailwater conditions induced by the West Branch Susquehanna River were ignored at the downstream boundary condition because this analysis is concerned solely with flash flooding conditions on Limestone/Bull Run.

Manning's n

Manning's n values for the existing and proposed geometries are based on the Union County FEMA FIS. Based on the FIS, the existing channel Manning's n values range from 0.015 to 0.045 and the existing overbank Manning's n value ranges from 0.025 to 0.120. For the model the existing/proposed channel

Manning's n was 0.04, and the existing/proposed overbanks Manning's n was 0.04. These values were derived from the Land Studies hydraulic model.

SA/2D Connections

The SA/2D Connections are included in the model for both existing and proposed geometries. These connections were introduced at structure locations that The Route 15 Culvert, 7th Street Bridge, the Walking Bridge (Cherry Alley), St. Louis Street Bridge, the Railroad Bridge Relief Culvert, the St. George Street Culvert, and the Ball Field Fence were modelled as SA/2D Connections in order to convey flow from on portion of the 2D flow area to another. The Route 15 Bridge was assumed to have two box culverts 80 feet in length, each box a span of 25 feet, and a rise of 6 feet. The 7th Street Bridge was assumed to have a culvert length of 54 feet, a 17-foot span, and a 6-foot rise. The Walking Bridge was assumed to have 4 feet of clearance from the thalweg to bottom of deck, to be set upon 8-foot-wide abutments set approximately 40 feet apart. The height of the Walking bridge was modelled as 6 feet to account for the covered nature of the bridge. The St. Louis Street Bridge was assumed to have a culvert length of 42 feet, a 26-foot span, and a 6-foot rise. The Railroad Bridge Relief culvert was designed to have a culvert length of 35 feet, an 8-foot span, and a 6-foot rise. The St. George Street Bridge was assumed to have a culvert length of 85 feet, a 22-foot span, and a 7-foot rise. Invert elevations for all structures generally match the existing upstream and downstream elevations of the main channel. The Railroad Bridge Relief Culvert inlet and outlet inverts were set at an elevation of 443.25 feet and 442.7 feet respectively. The structures that were not modelled as SA/2D Connections were treated as horizontal contractions in flow for simplification of the model.

Ball Field Fence Modelling Approach

One intent of Scenario 2 was to analyze how the fence of the baseball field affects flow. To simulate a semipermeable lateral structure, the Ball Field Fence was modelled as a SA/2D connection with a series of gates. A rating curve was developed by calculating the decrease in velocity across the fence due to head loss caused by the contraction of flow (Table 9.2). The fence was assumed to be 92.5% voids across the profile. The bottom 2 feet of the fence were assumed to be in a clogged condition due to debris. Head loss was calculated using the equation:

$$h_L = \frac{V_1^2}{2g(\frac{1}{k_c} + 1)}$$

Where Kc is a loss coefficient based on the ratio of flow areas for flow transitions, and g is acceleration due to gravity. Subsequently, following equation was used to calculate the velocity out based upon the head loss at a certain stage.

$$V_2 = \sqrt{V_1^2 - 2gh_L}$$

By inputting the known velocities and the calculated head losses into equation above, the rating curve for flow through the fence is produced. Applying the rating curve to the gates of the SA/2D connection, the flow that permeates through the structure will be a function of the water surface elevation on the upstream side.

Table 9.2: Ball Field Fence Rating Curve

Stage	Elevation (feet)	Flow (cfs)
0	451	0.0
1	452	92.4
2	453	296.4
3	454	545.5
4	455	832.5
5	456	1143.8
6	457	1485.2
7	458	1851.7
8	459	2224.8

Computation Settings

The computation settings for the model generally used default setting, such as the shallow water equations: Eulerian-Lagrangian Method. The Non-conservative Turbulence method was also applied. All output intervals were set to 1 minute to better visualize results, and the computation interval was based on the Advanced Time step Control. Rather than choosing a single time step for each plan, a variable time step based on courant number was utilized. The maximum courant number was 3.2, the minimum courant was set at 0.7, the number of steps below minimum before doubling was set at 1, the maximum number of doubling base time step was set at 2, and the maximum number of halving base time step was set at 5. These values aided in maintaining model stability.

9.4 - SCENARIOS

Scenario 0.A

Scenario 0.A represents the conditions of the project area prior to the stream bank restoration in the Hufnagle Park and Kidsburg. During inspection of the Route 15 bridge, a heavy sediment deposit was noted in between the piling and the northern abutment. To reflect this condition, the Route 15 bridge was modelled as partially clogged. Figure 9.2 shows terrain associated with Scenario 0.A. Figure 9.3 shows the representation of the clogged condition of the Route 15 bridge.

Scenario 0.B

Scenario 0.B reflects the current condition of the project area as of 2023. These conditions include the stream bank restoration projects in Hufnagle Park and Kidsburg. This scenario also considers the Route 15 bridge to be partially clogged. Decrease in velocities were generally noted on the overbanks and an increase was seen in the main flow channels. In the 2-year event, and increase was seen on the overbanks. This is due to the streambank restoration allowing water to flow in areas it could not previously access. A decrease in water surface elevations was noted between Market Street and the Railroad Bridge in the 2-year SIR results. Figure 9.2 shows terrain modifications associated with Scenario 0.B.

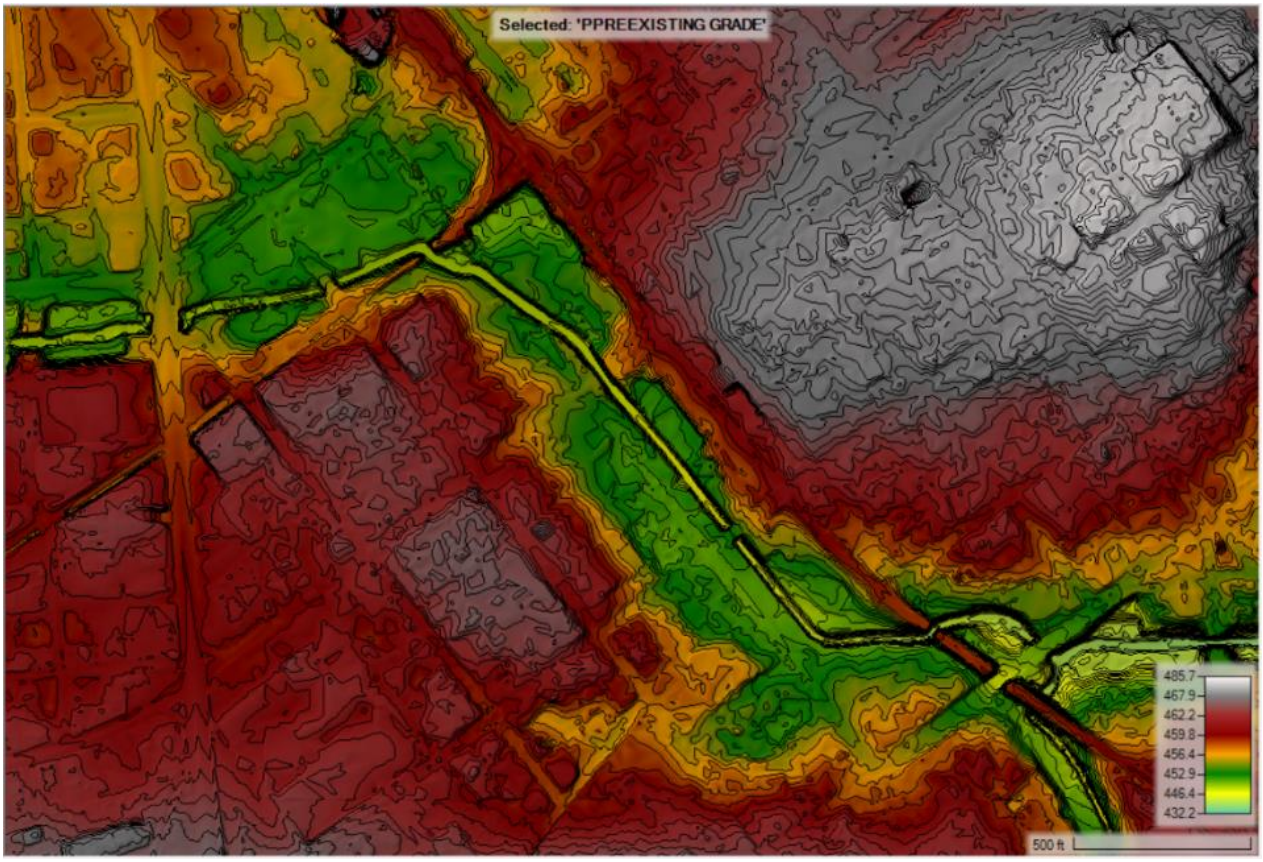


Figure 9.2: Terrain associated with pre-existing conditions

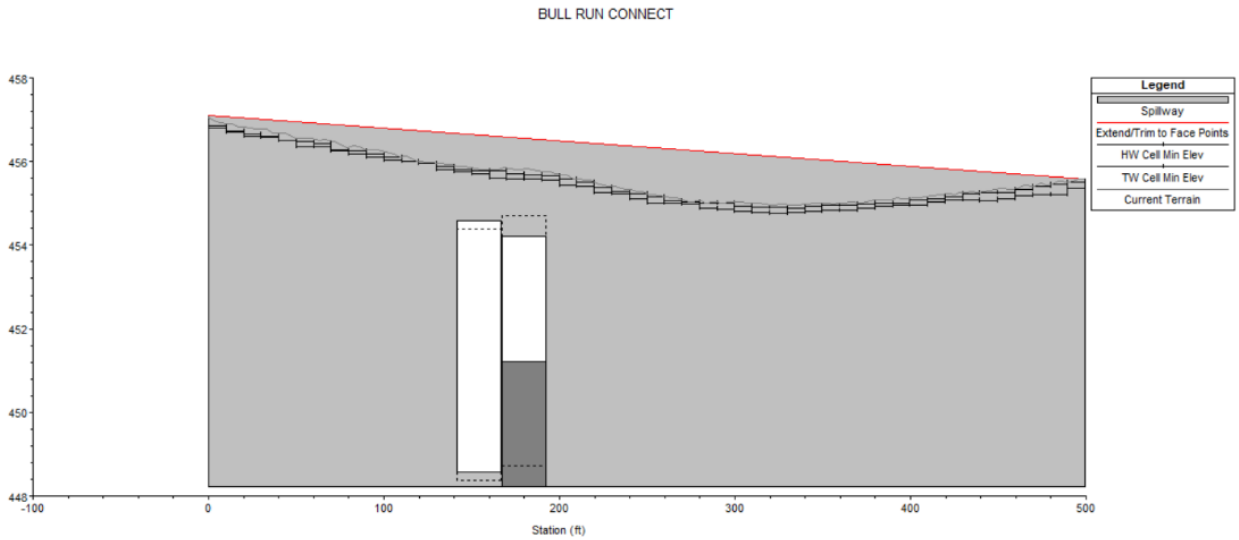


Figure 9.3: Route 15 clogged condition

Scenario 1.A

Scenario 1.A includes the stream bank restoration projects from Scenario 0.B. In addition, Scenario 1.A includes proposed floodplain restoration projects in Hufnagle Park and the area north of Market Street and

just south of the Rail Trail. This scenario also considers the Route 15 bridge to partially clogged. Figure 9.4 shows terrain modifications associated with Scenario 1.A.

When compared to Scenario 0.B, a slight decrease in water surface elevation was observed between the 10th Street and Market Street in the 100-year StreamStats results. A decrease in water surface elevation was observed along the in the 2-year SIR results. In the region between the Rail Trail and Market Street, an increase in velocity was observed on the west side of the stream and a decrease was observed on the east side. Increased velocities were also noted around the St. Louis Street Bridge. In the 2-year event, an increase in velocities was observed on the overbanks and a decrease was observed in the main channel at the location of the proposed flood plain restoration locations. Figure 9.6 shows simulated water surface elevation results along stream centerline comparing Scenarios 1.A and Scenario 0.B.

Scenario 1.B

Scenario 1.B utilizes the same terrain as Scenario 1.A; however, Scenario 1.B treats the Route 15 Bridge as clear of debris and operating at full capacity. Scenarios 2 through 10 build off the Scenario 1.B terrain. Scenario 1.B is considered the base run that the proposed scenarios are compared against. Figure 9.5 shows terrain modifications associated with Scenario 1.B.

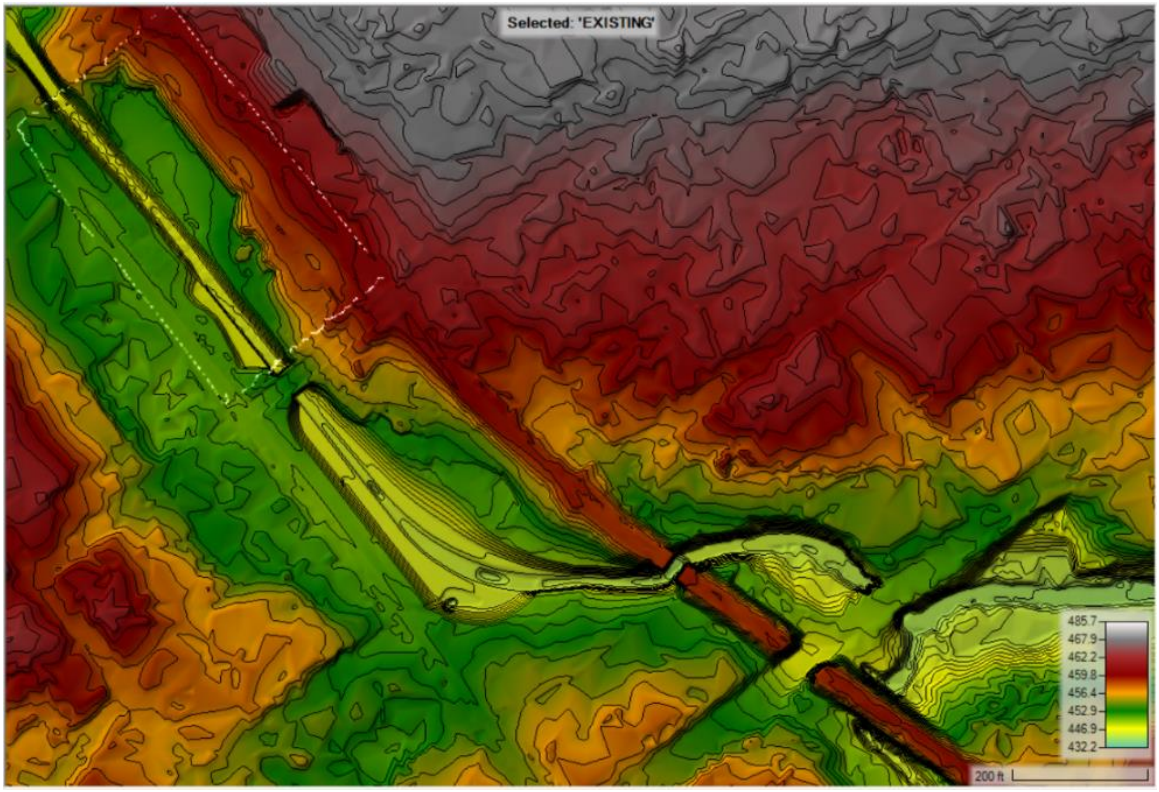


Figure 9.4: Terrain modifications associated with existing conditions (Scenario 0.B)

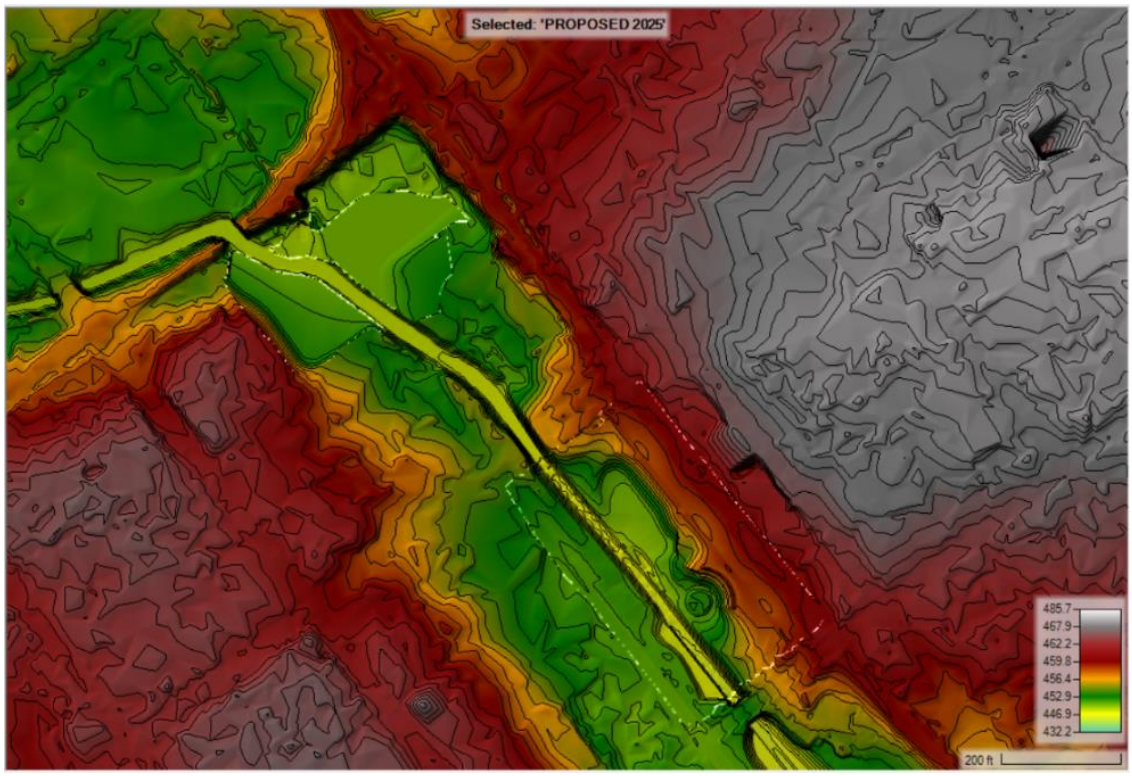


Figure 9.5: Terrain modification associated with the near term conditions (Scenarios 1.A and 1.B)

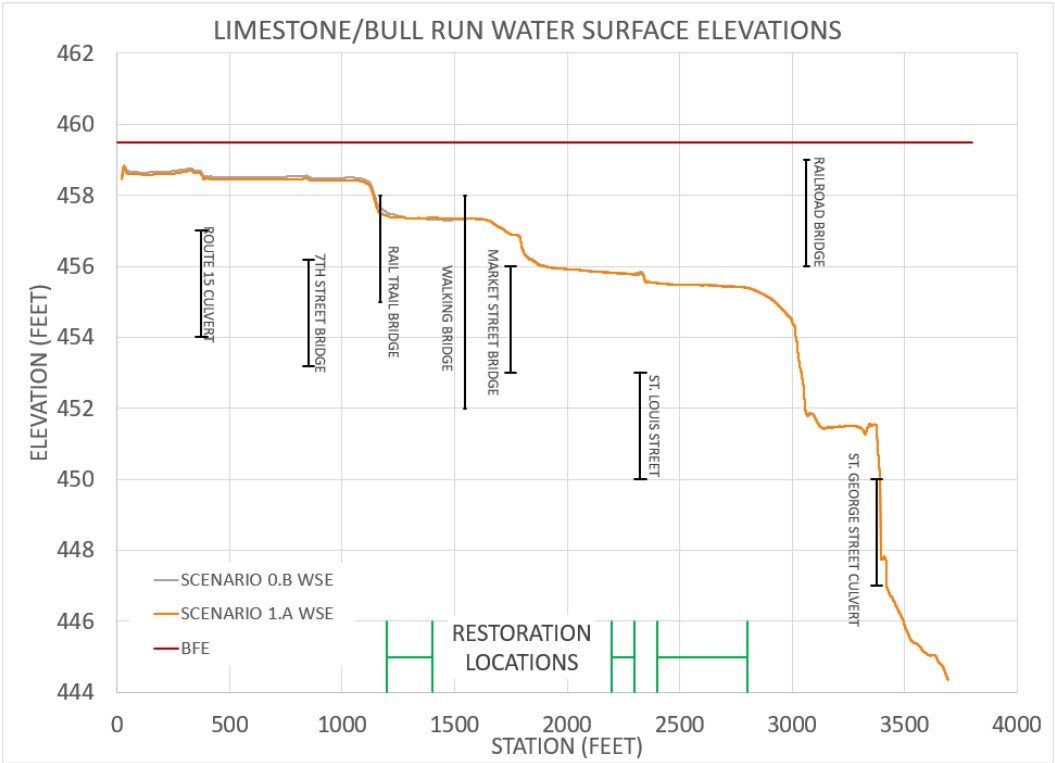


Figure 9.6: Water surface elevation results along stream Centerline; Scenario 0.B and Scenario 1.A (100-year FEMA)

When compared to the results of Scenario 1.A, water surface elevations are generally lower. A decrease in water surface elevation was observed in between the Rail Trail and Market Street in the 100-year FEMA results. A decrease in water surface elevation was observed between the Market Street Bridge and the floodplain restoration in the 100-year StreamStats, and the 10-year SIR results. An increase in velocities were observed downstream of the Route 15 Bridge and upstream of the 7th Street Bridge in the 100-year FEMA results. Increase in velocity was observed above and below the Route 15 Bridge in the 100-year StreamStats, the 10-year SIR, and 2-year SIR. Figure 9.7 shows simulated water surface elevation results along stream centerline comparing Scenarios 1.A and Scenario 1.B.

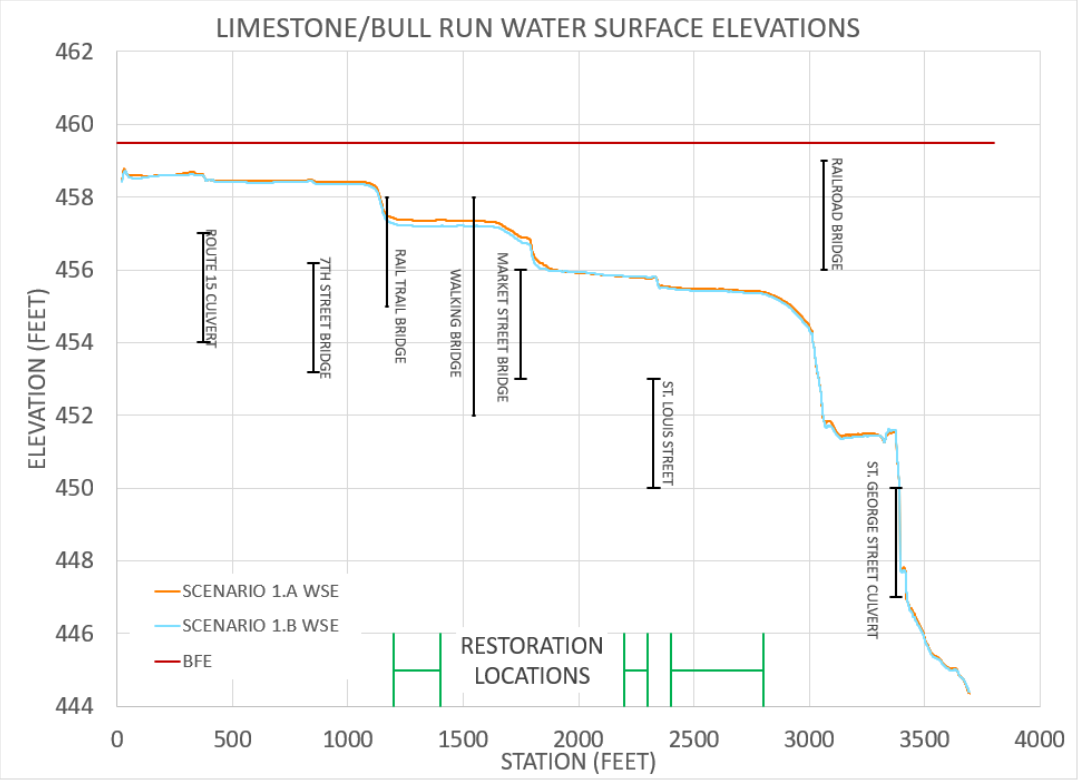


Figure 9.7: Water surface elevation results along stream Centerline; Scenario 1.B and Scenario 1.A (100-year FEMA)

Scenario 2

Scenario 2 aims to examine how the fence around the Danny Green Fields and the walking bridge in-between the Rail Trail and North Market Street. The footprint around the ball field fence was manipulated so that the elevation was constant along the length of the fence. This was done in order to apply the rating curve to the fence. Figure 9.8 shows terrain modifications associated with Scenario 2.

An increase in water surface elevation was noted upstream of the ball field fence and the walking bridge. An increase in water surface elevation was observed across the entire reach in the 2-year SIR results. An increase in velocity was noted in the stream banks downstream of the 7th Street Bridge and the overbanks in the proximity of the walking bridge. An increase was observed in the section of St. Mary Street bounded by 5th and 7th Street. In the 100-year Stream Stats and the 10-year SIR results, an increase was observed in

the main channel above and below the Route 15 Bridge. In the 10-year and the 2-year SIR results, an increase in velocities was observed in the overbank above and below the Route 15 Bridge. Figure 9.9 shows simulated water surface elevation results along stream centerline comparing Scenarios 2 and Scenario 1.B.

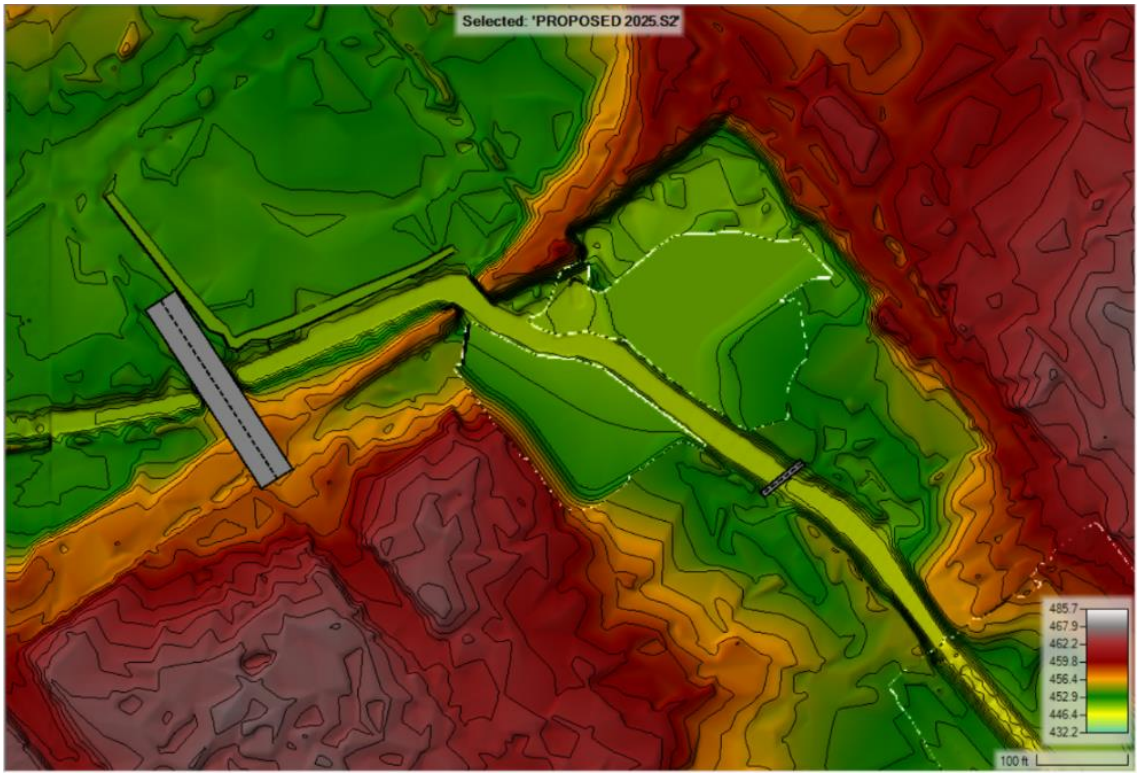


Figure 9.8: Terrain modifications associated with Scenario 2

Scenario 3

Scenario 3 examines the effects of widening the Route 15 Bridge opening by a factor of 1.5. Velocities upstream slightly decreased, and velocities downstream increased in the 100-year FEMA results. An increase in velocities were observed in the proximity of the Route 15 Bridge in the 100 -year Stream stats, the 10-year SIR, and the 2-year SIR results. An increase in velocities was also observed around the St. Louis Bridge in the 100-year Stream Stats results. The water surface elevation produced by Scenario 3 were slightly higher than the base run, and generally aligned with water surface elevations of Scenario 0.B. Figure 9.10 shows simulated water surface elevation results along stream centerline comparing Scenarios 3 and Scenario 1.B.

Scenario 4

Scenario 4 examines the effects of removing the 7th Street Bridge. Figure 9.11 shows terrain modifications associated with Scenario 4. An increase in water surface elevation was observed in between the Rail Trail Bridge and Market Street. Minimal change in water surface elevation was observed. An increase in velocities was observed at the Route 15 Bridge and the 7th Street Bridge in the 100-year StreamStats, the 10-year SIR, and the 2-year SIR results. Figure 9.12 shows simulated water surface elevation results along stream centerline comparing Scenarios 4 and Scenario 1.B.

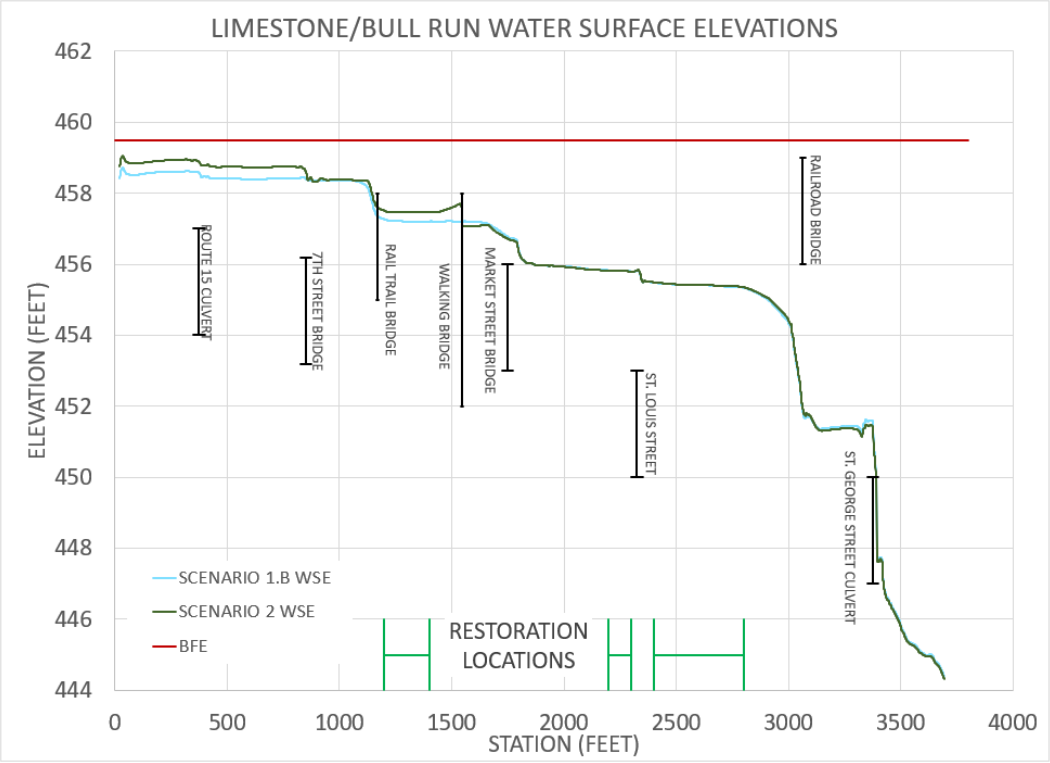


Figure 9.9: Water surface elevation results along stream centerline; Scenario 2 and Scenario 1.B (100-year FEMA)

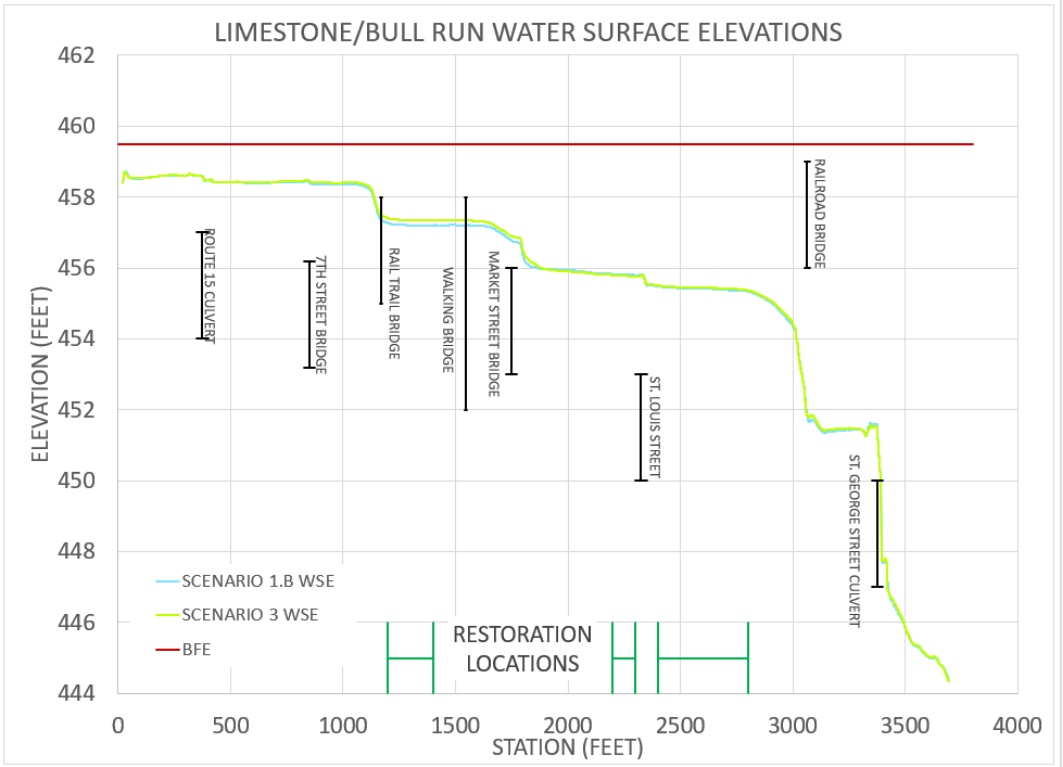


Figure 9.10: Water surface elevation results along stream centerline; Scenario 3 and Scenario 1.B (100-year FEMA)

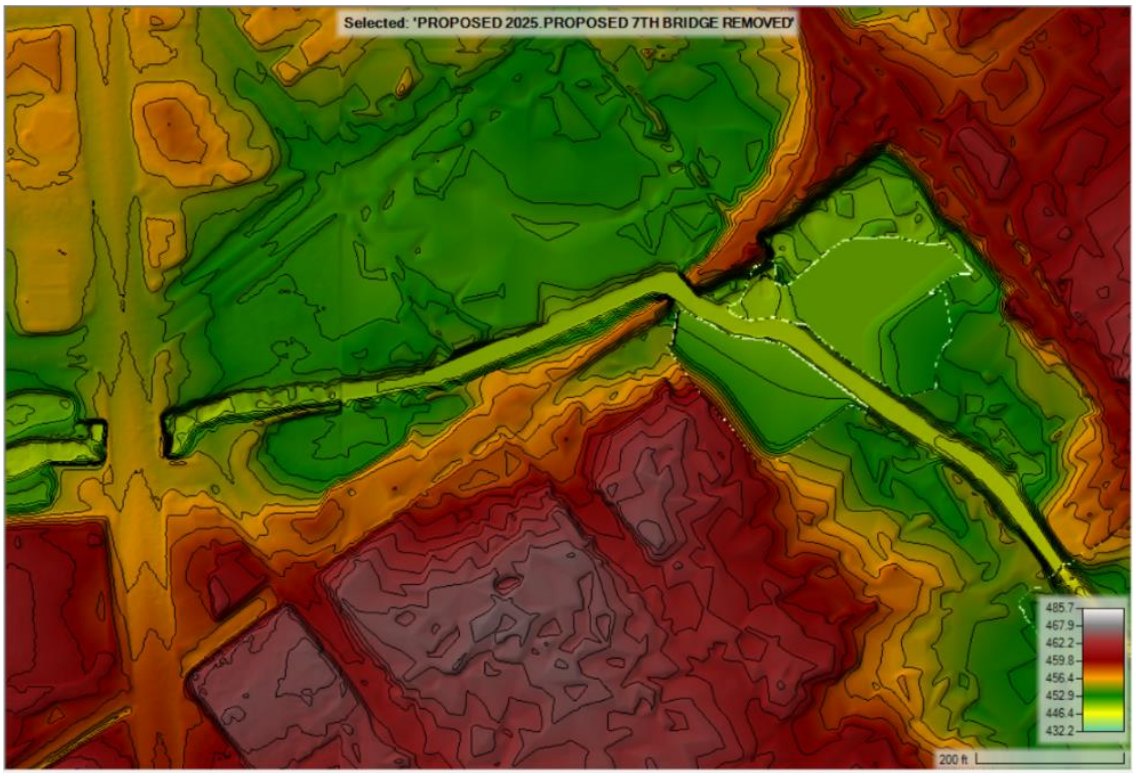


Figure 9.11: Terrain modifications associated with Scenario 4

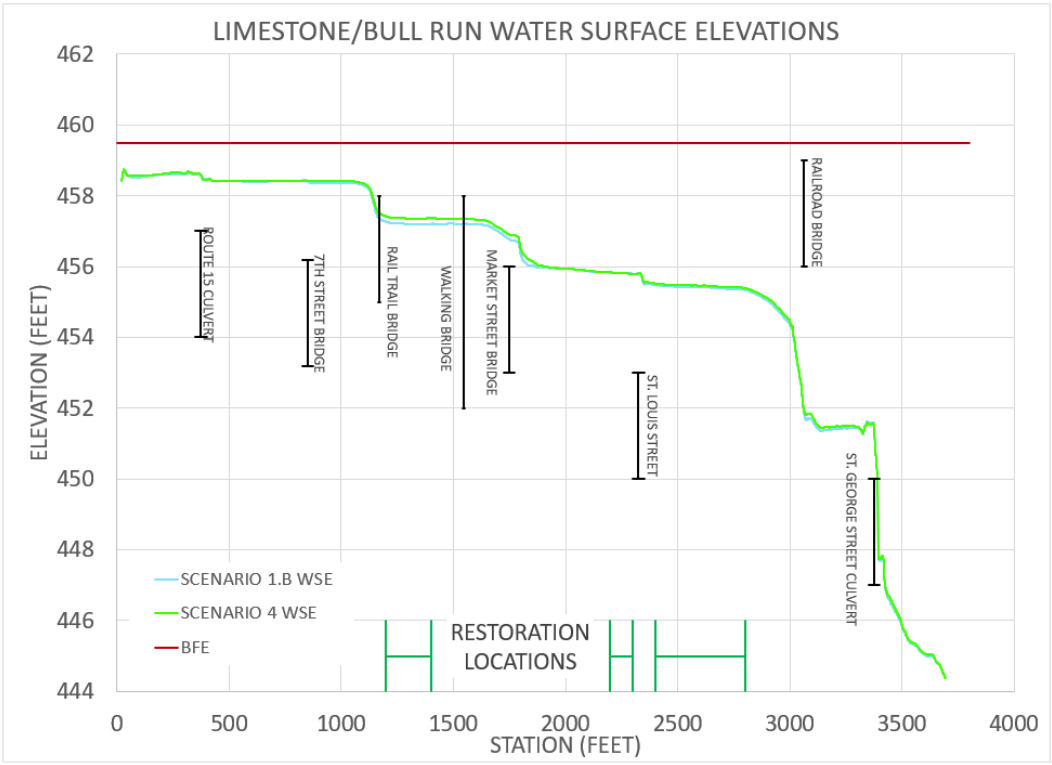


Figure 9.12: Water surface elevation results along stream centerline; Scenario 4 and Scenario 1.B (100-year FEMA)

Scenario 5

Scenario 5 examines the effects of widening the Rail Trail Bridge by a factor of 2. Figure 9.13 shows terrain modifications associated with Scenario 5.

A decrease in water surface elevations was observed in the reach upstream of the Rail Trail, and a slight increase was observed downstream to the Market Street bridge. An increase in water surface elevation was observed along the entire reach in the 2-year SIR results. A decrease in velocity was observed on the southwest section of stream between 7th Street and Market Street. An increase in velocities was observed around the St. Louis Street Bridge in the 100-year StreamStats results. An increase in velocity was observed at the St. Louis Street Bridge in the 100-year StreamStats results. Figure 9.14 shows simulated water surface elevation results along stream centerline comparing Scenarios 5 and Scenario 1.B.

Scenario 6

Scenario 6 examines the effects of expanding the Market Street Bridge by a factor of 1.5. Figure 9.15 shows terrain modifications associated with Scenario 6. A slight decrease in water surface elevation was noted above the Market Street bridge, and an increase was observed below the bridge in the 100-year FEMA, and the 10-year SIR results. An increase in water surface elevation was observed along the entire reach in the 2-year SIR results. A decrease in velocity was noted at the footprint of the Market Street Bridge and along 6th Street. An increase in velocity was observe at the Route 15 Bridge in the 100-year StreamStats, the 10-year SIR, and 2-year SIR results. An increase in Velocity was also observed at the St. Louis Street bridge in the 100-year StreamStats results. Figure 9.16 shows simulated water surface elevation results along stream centerline comparing Scenarios 6 and Scenario 1.B.

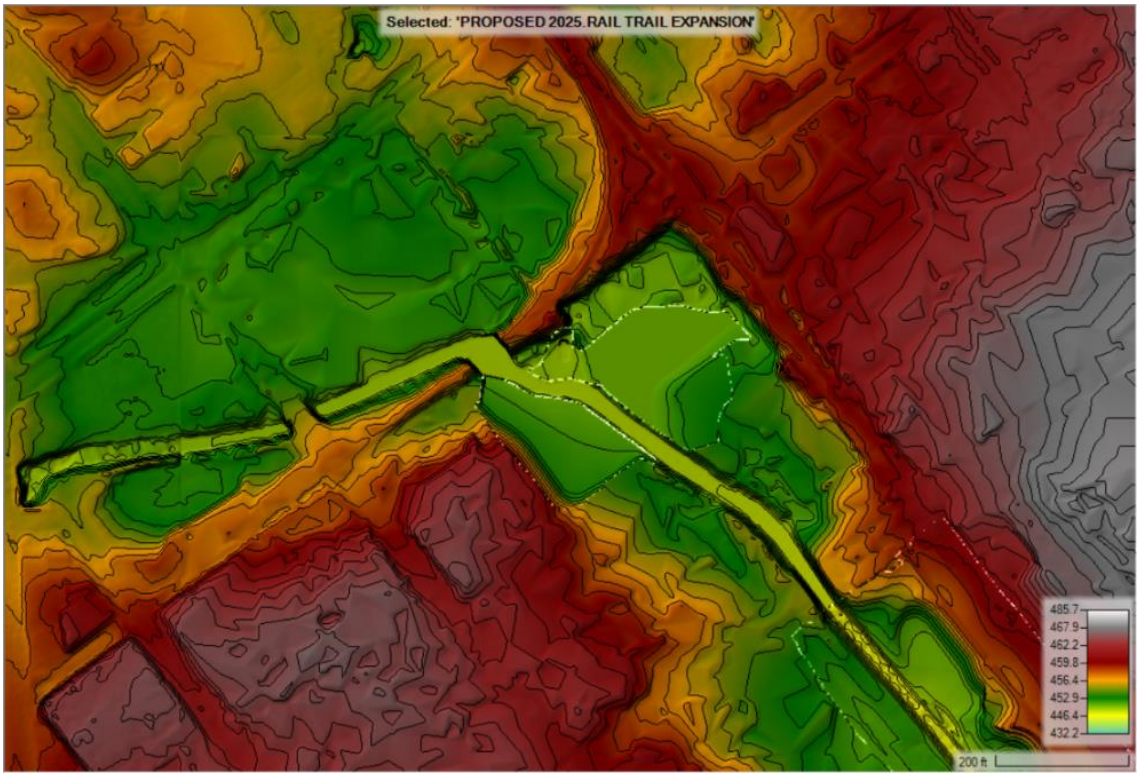


Figure 9.13: Terrain modifications associated with Scenario 5

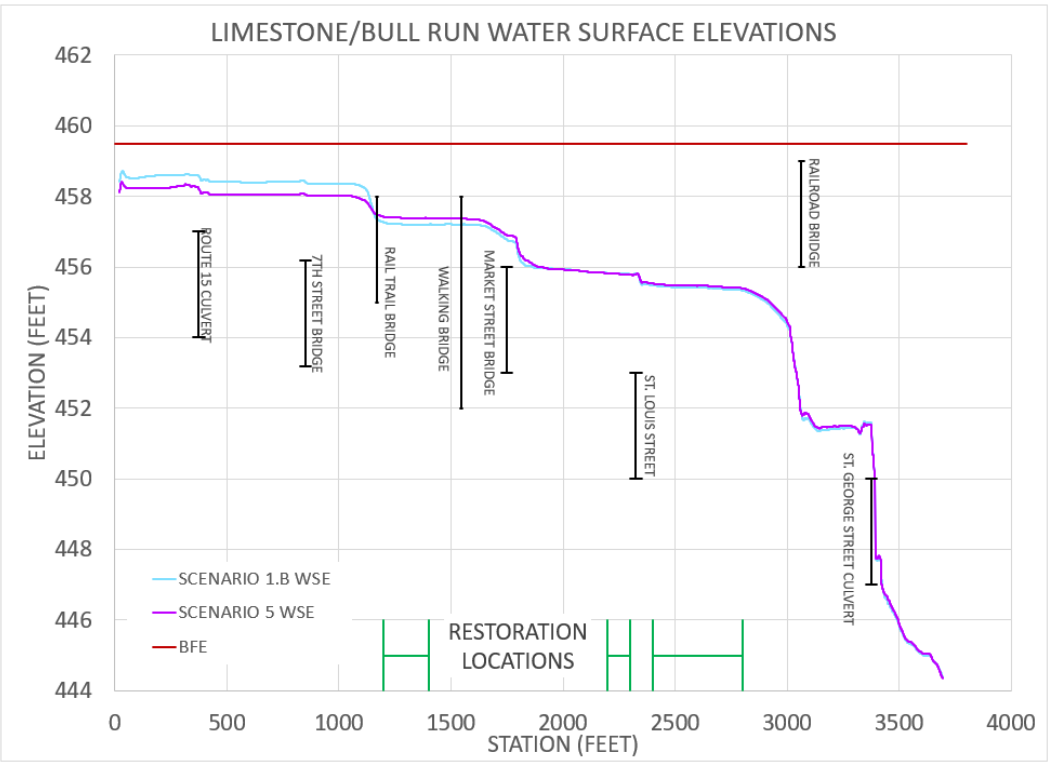


Figure 9.14: Water surface elevation results along stream centerline; Scenario 5 and Scenario 1.B (100-year FEMA)

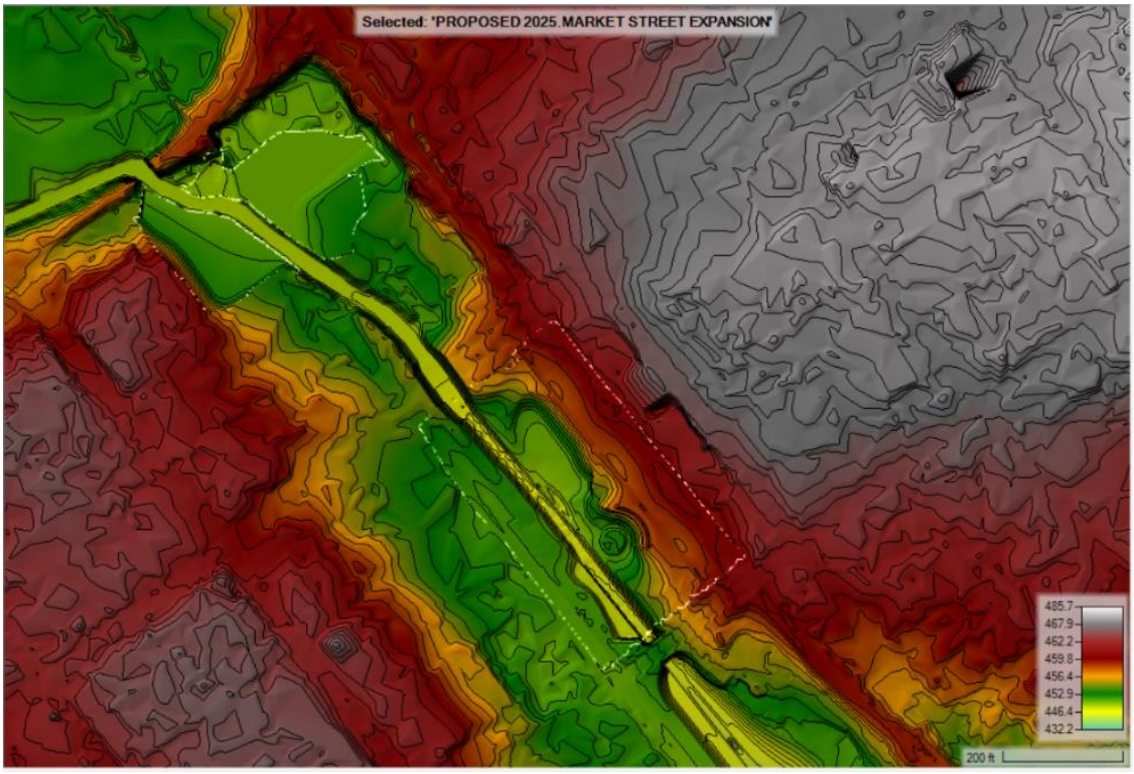


Figure 9.15: Terrain modifications associated with Scenario 6

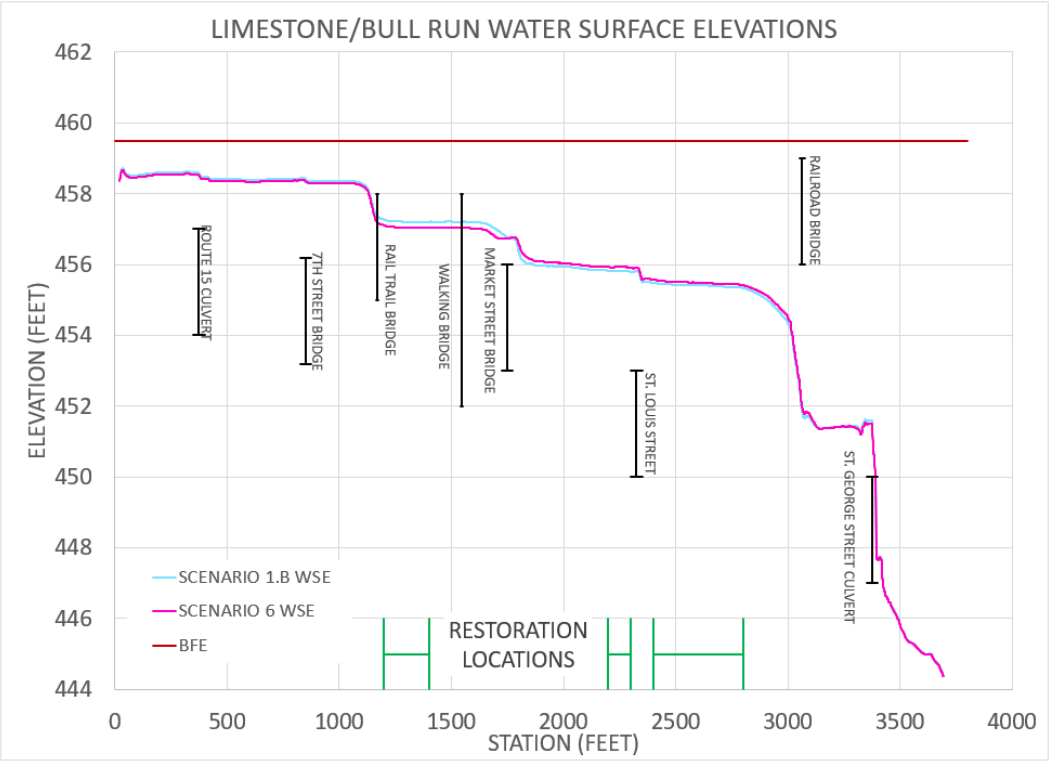


Figure 9.16: Water surface elevation results along stream centerline; Scenario 6 and Scenario 1.B (100-year FEMA)

Scenario 7

Scenario 7 examines the effects of widening the St. Louis Street Bridge by a factor of 2. No significant change in water surface elevations was observed in the 100-year FEMA, 100-year SIR, and the 10-year SIR results. An increase in water surface elevation was observed along the entire reach in the 2-year SIR results. A decrease in velocity was observed upstream of the 7th Street Bridge and the Route 15 Bridge, and a decrease along South 6th street was noted. Figure 9.17 shows simulated water surface elevation results along stream centerline comparing Scenarios 7 and Scenario 1.B.

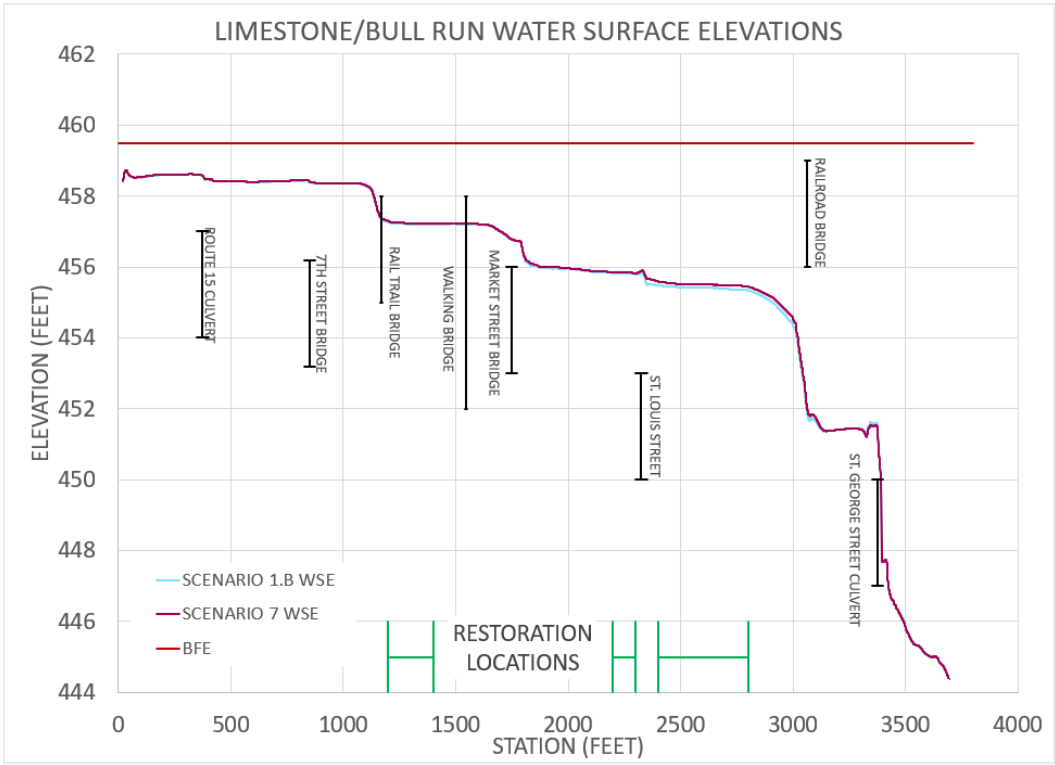


Figure 9.17: Water surface elevation results along stream centerline; Scenario 7 and Scenario 1.B (100-year FEMA)

Scenario 8

Scenario 8 examines the effects of removing the 7th Street Bridge and Rail Trail Bridge and benching the floodplain on the south side of the stream in-between 7th Street and the Rail Trail. Figure 9.18 shows terrain modifications associated with Scenario 8.

A decrease in water surface elevation was noted upstream of the Rail Trail in the 100-year FEMA, 100-year StreamStats, and the 10-year SIR results. No significant change in water surface elevations were noted in the 2-year SIR results. A notable decrease in inundation to the north of the stream was observed. Velocities in the streambed were noted to decrease in between the Rail Trail and Market Street, and approximately a hundred yards upstream and downstream of the Railroad Bridge. Velocities in the stream bed were noted to increase between Route 15 and 7th Street. Velocities on the stream bank were noted to increase between the Rail Trail and Route 15, and between the Railroad Bridge and St. George Street.

Increased velocities on St. Anthony Street immediately east of Route 15 and along South 6th Street were observed. Areas of concentrated increase in velocity was observed along St. George Street. One of these regions is at the southeast corner of the railroad embankment that is bounded by the stream and St. George Street. The other region is located on the westerly downstream embankment of the St. George Street Culvert. Figure 9.19 shows simulated water surface elevation results along stream centerline comparing Scenarios 8 and Scenario 1.B.

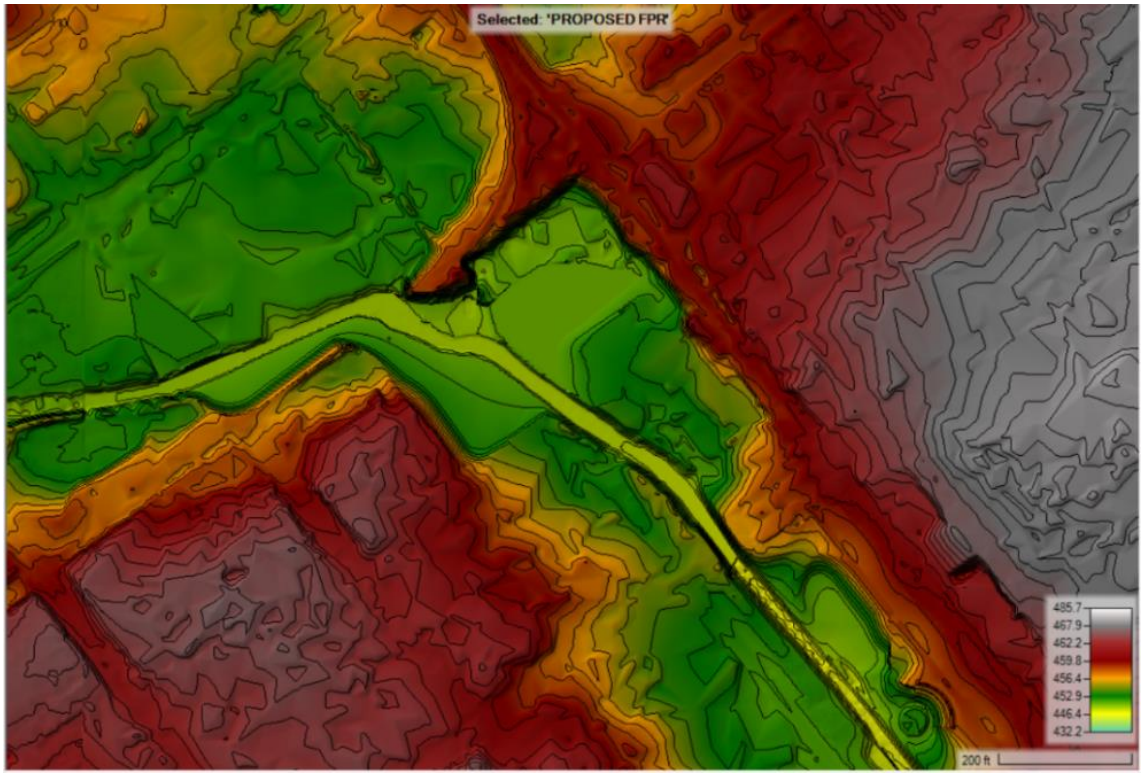


Figure 9.18: Terrain modifications associated with Scenario 8

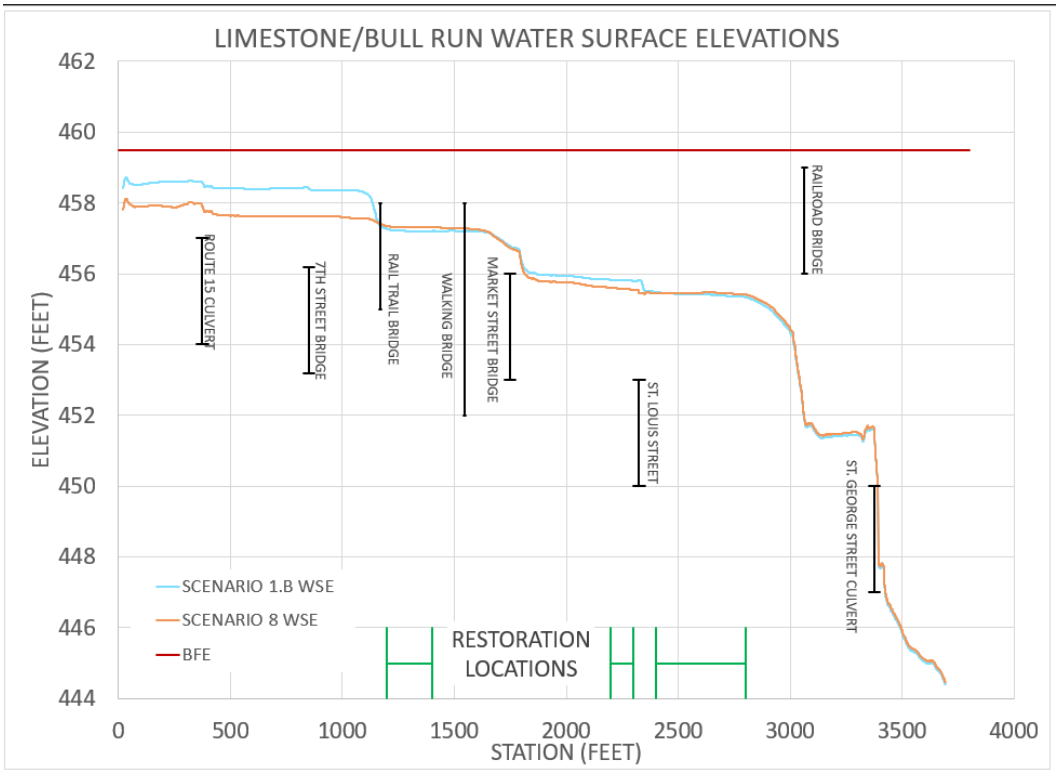


Figure 9.19: Water surface elevation results along stream centerline; Scenario 8 and Scenario 1.B (100-year FEMA)

Scenario 9

Scenario 9 examines the effects of installing a relief culvert in the southern abutment of the Railroad Bridge in-between St. Louis Street and St. George Street. The Railroad bridge was observed to be a major constraint in flow. This was observed in the centerline profiles in which all scenarios regressed to a similar water surface elevation. The floodplain was benched upstream and downstream of the relief culvert to allow water to enter the relief culvert. The culvert was set 3 feet above stream bed elevation. Figure 9.21 shows terrain modifications associated with Scenario 9.

A decrease in water surface elevation was noted between Market Street and the Railroad Bridge in the 100-year FEMA, 100-year StreamStats, and the 10-year SIR results. An increase in water surface elevation was observed in the 2-year SIR results. Figure 9.22 shows simulated water surface elevation results along stream centerline comparing Scenarios 9 and Scenario 1.B. Increased velocities on St. Mary Street immediately east of Route 15 and along South 6th Street were observed in the 100-year FEMA results. In-between the Rail Trail and Market Street, velocity increased on the east side of the stream, and decreases were observed on the west side in the 100-year FEMA Results. A decrease in velocity was observed at the Route 15 Bridge in the 100-year StreamStats and the 2-year SIR results. An increase in velocity was observed at the Route 15 Bridge in the 10-year SIR results. An increase in velocities was observed below the St. Louis Street Bridge and a decrease at the Railroad Bridge was observed in the 100-year StreamStats, the 10-year SIR, and the 2-year SIR results. Figure 9.23 shows simulated velocity differences comparing Scenarios 9 and Scenario 1.B.

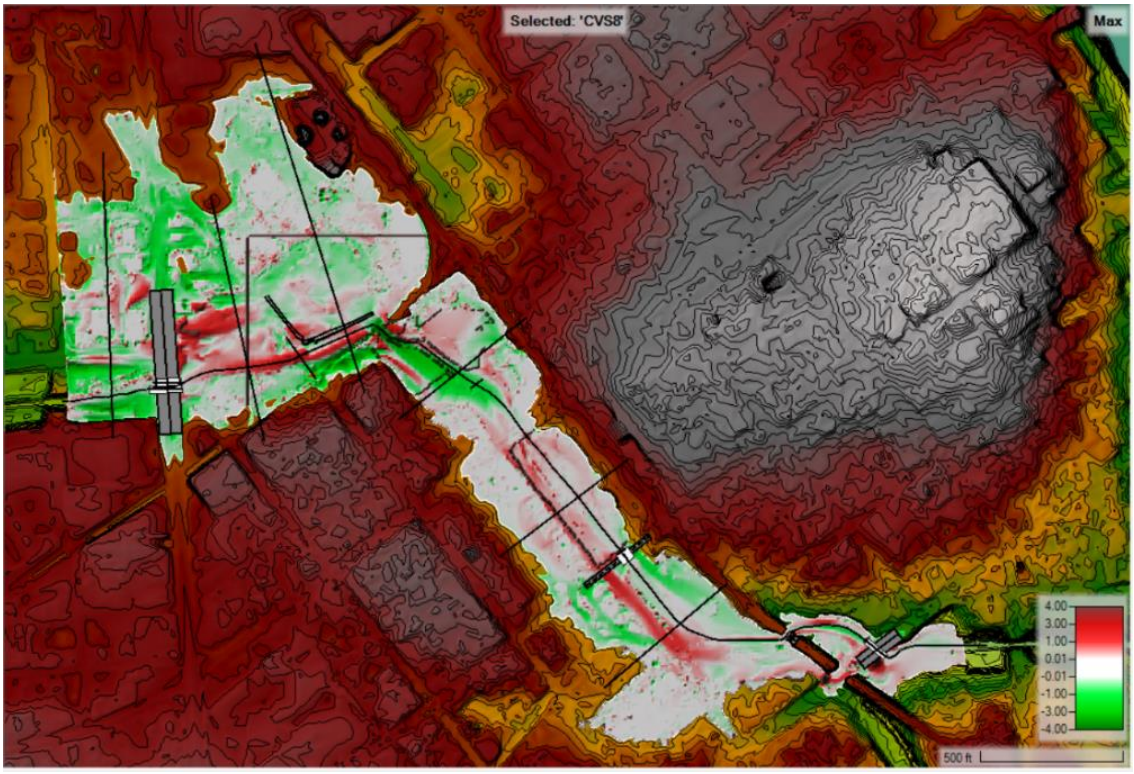


Figure 9.20: Scenario 8 and Scenario 1.B velocities compared (100-year FEMA)

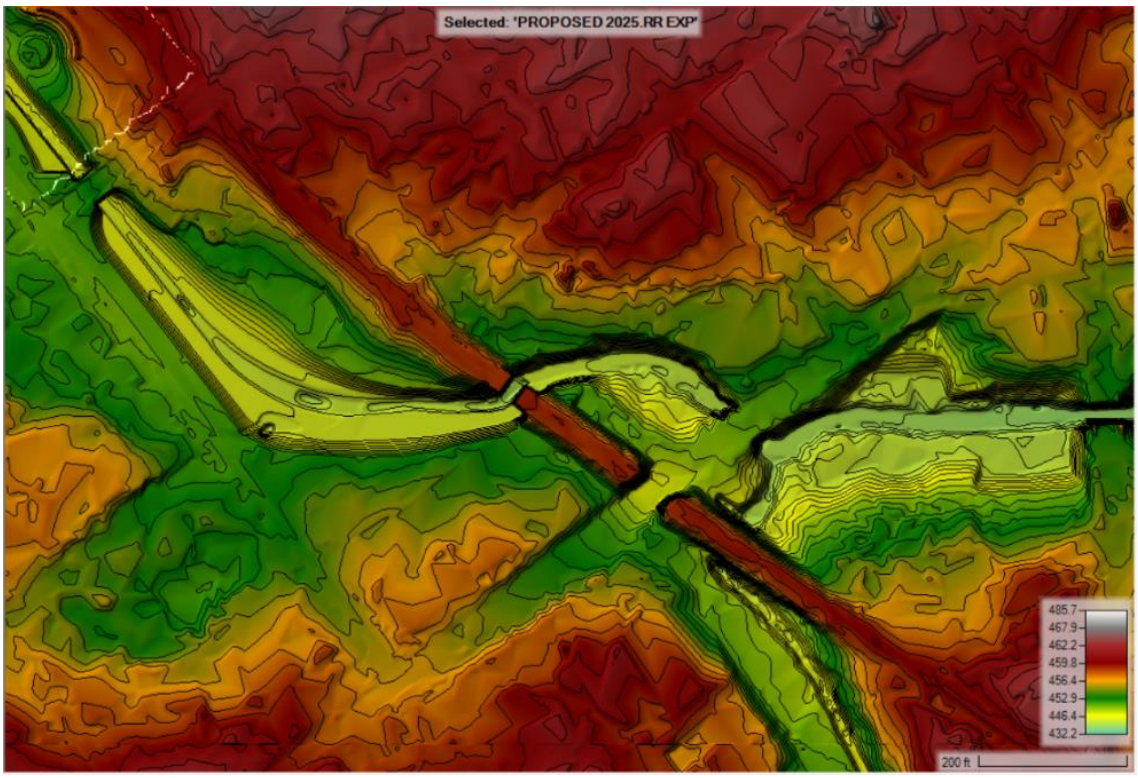


Figure 9.21: Terrain modifications associated with Scenario 9

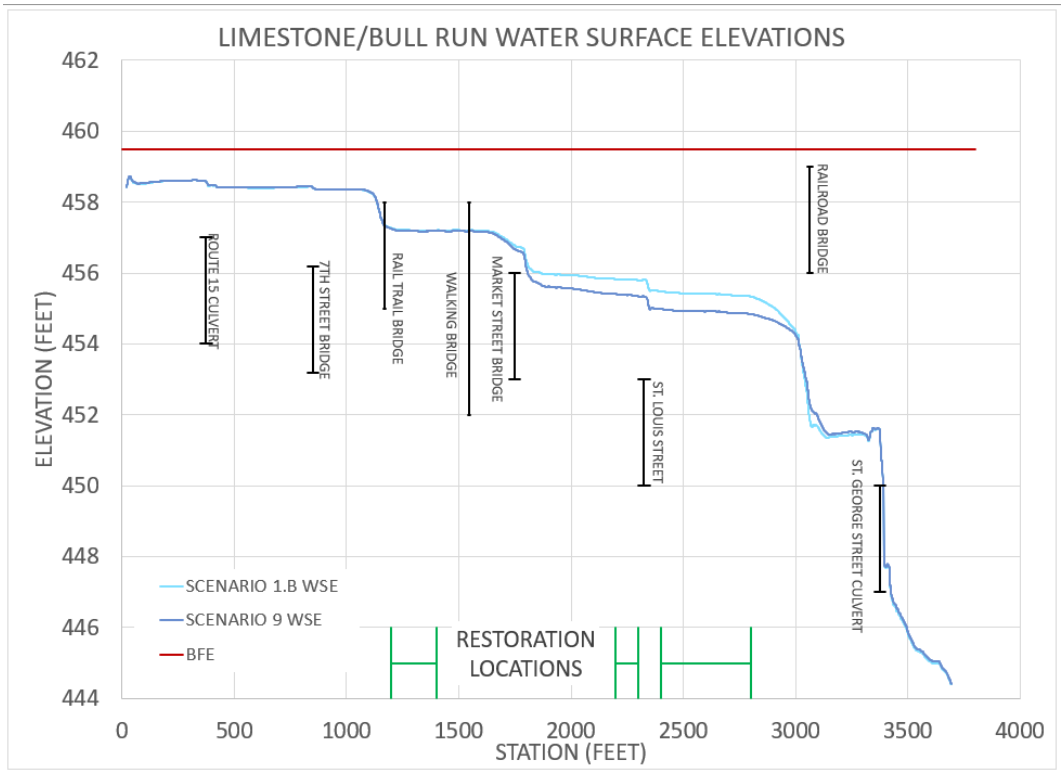


Figure 9.22: Water surface elevation results along stream centerline; Scenario 9 and Scenario 1.B (100-year FEMA)

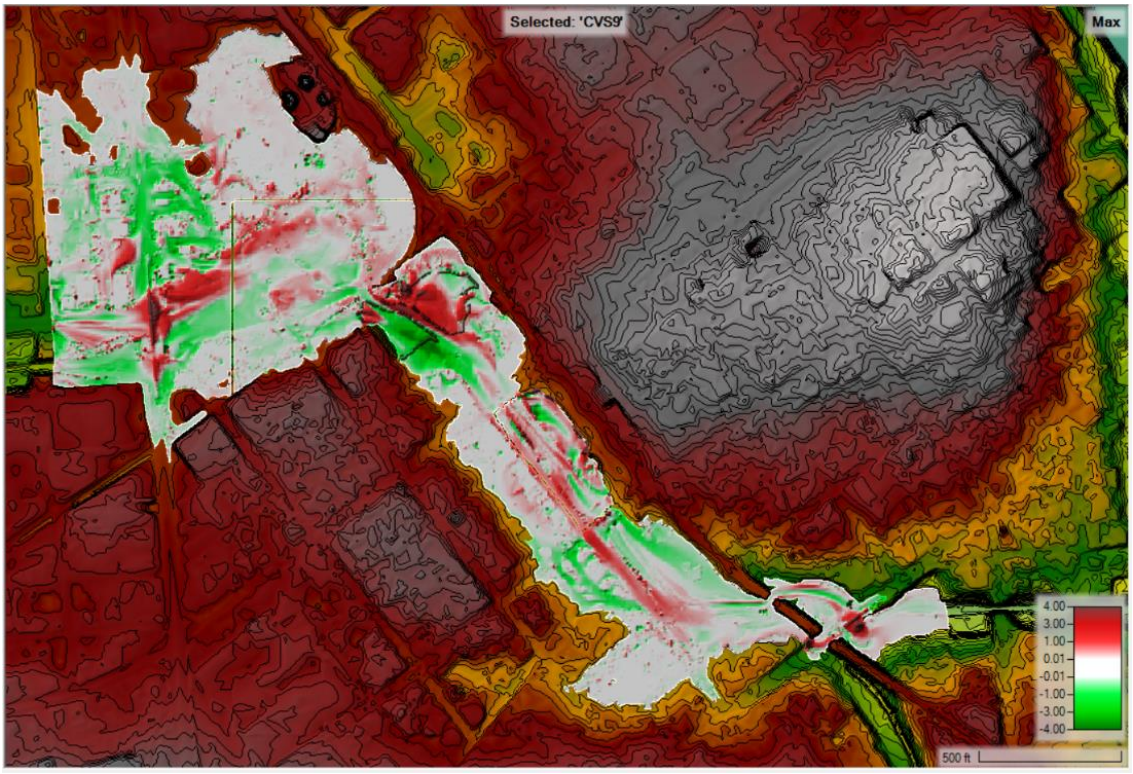


Figure 9.23: Scenario 9 and Scenario 1.B velocities compared (100-year FEMA)

Scenario 10

Scenario 10 is a combination of Scenarios 3, 6, 7, 8, and 9. Additionally, a relief swale was introduced on the western side of the railroad embankment between the stream and St. George Street. Figure 9.24 shows terrain modifications associated with Scenario 10.

The water surface elevation of Scenario 10 was generally in line with the results of Scenario 9: a decrease in water surface elevation was noted between Market Street and the Railroad Bridge. Figure 9.25 shows simulated water surface elevation results along stream centerline comparing Scenarios 10 and Scenario 1.B. An increase of velocity was observed below Market Street and downstream of the St. Louis Street Bridge. A decrease in velocities was observed at the Railroad Bridge. An increase in velocities was observed at the Route 15 Bridge to the Rail Trail Bridge in the 100-year StreamStats, the 10-year SIR, and the 2-year SIR results. Figure 9.26 shows simulated velocity differences comparing Scenarios 10 and Scenario 1.B.

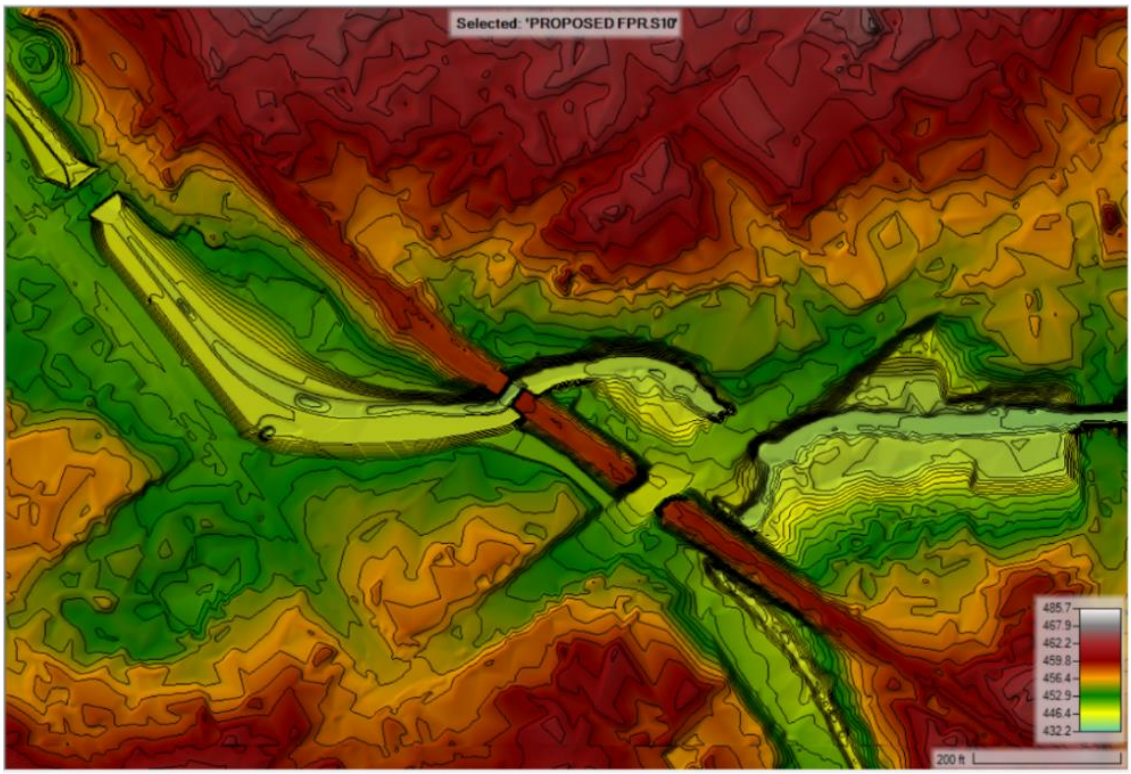


Figure 9.24: Terrain modifications associated with Scenario 10

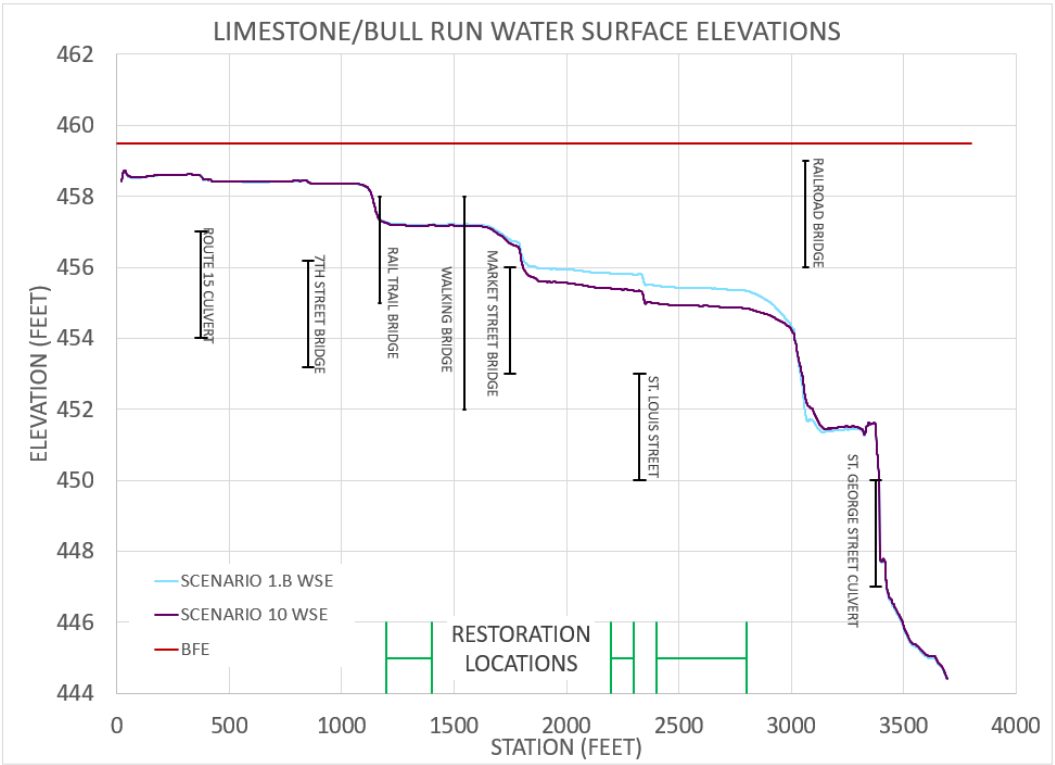


Figure 9.25: Water surface elevation results along stream centerline; Scenario 10 and Scenario 1.B (100-year FEMA)

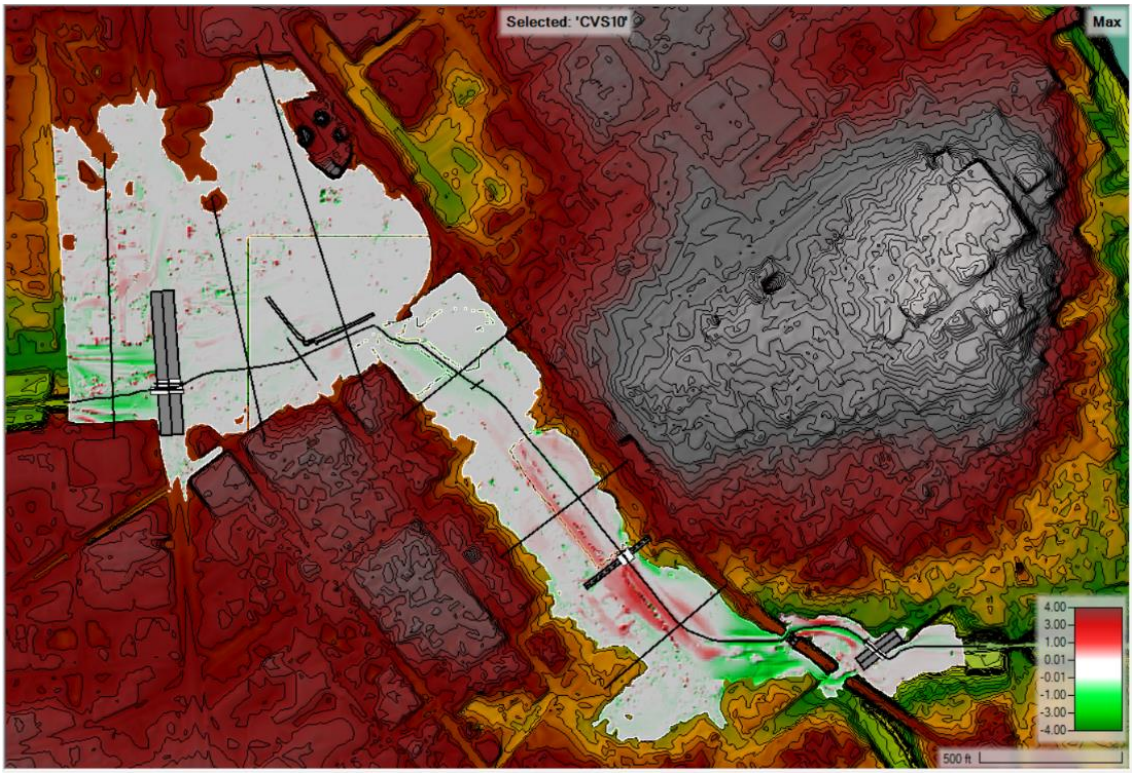


Figure 9.26: Scenario 10 and Scenario 1.B velocities compared (100-year FEMA)

Scenario 10.1

Scenario 10.1 iterates upon Scenario 10 by examining the same set of conditions with the exclusion of Scenario 3. A notable decrease of water surface elevation was observed from the 10th Street Bridge to the Railroad Bridge. Figure 9.27 shows simulated water surface elevation results along stream centerline comparing Scenarios 9 and Scenario 1.B. Changes in velocity generally mirrored Scenario 8 in the region north of Market Street. An increase in velocities was observed in the corridor between Market Street and the flood plain restoration implemented between the St. Louis Street and the Railroad Bridge. Figure 9.28 shows simulated velocity differences comparing Scenarios 10 and Scenario 10.1.

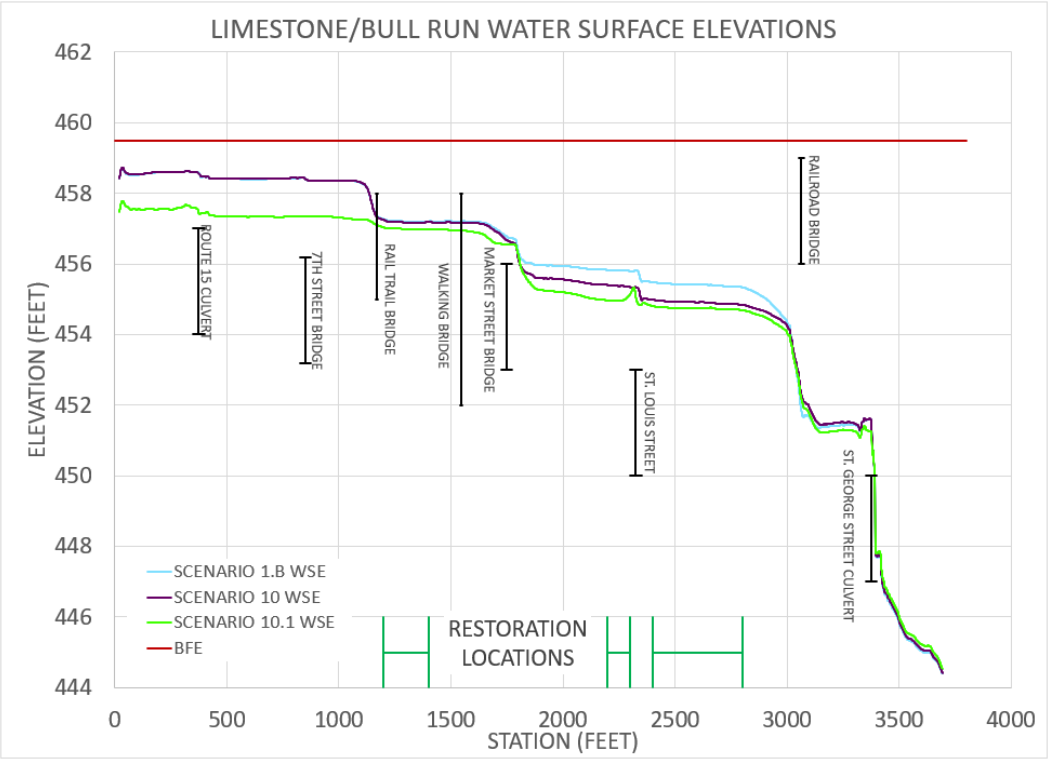


Figure 9.27: Water surface elevation results along stream centerline; Scenario 10.1 and Scenario 1.B (100-year FEMA)

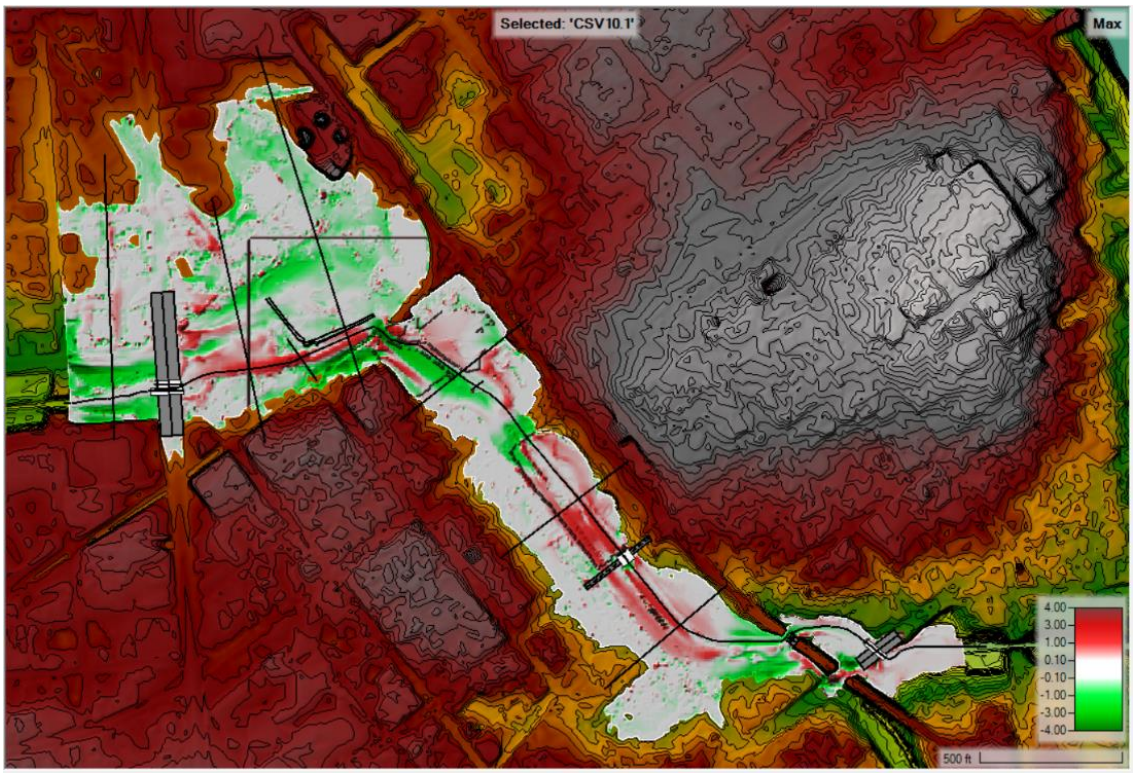


Figure 9.28: Scenario 10 and Scenario 10.1 velocities compared (100-year FEMA)

9.5 - CONCLUSIONS AND RECOMMENDATIONS

Overall, it appears that widening or removal of an individual bridge openings has limited effect on reduction of water surface elevation, velocity, and inundation extents for the 100-year event. It was observed that the removal or widening of a bridge causes the effects of water surface elevation, velocity, or inundation extents to be shifted either upstream or downstream of the opening. The individual adjustment approach is ineffective.

Scenarios 8 and 9, combinations of floodplain restoration and bridge expansion, demonstrated potential for reduction in water surface elevation. Scenario 8 demonstrated a notable reduction of inundation extents to the north of the stream. Although a reduction in water surface elevation was noted in Scenario 9, minimal reduction in inundation extents was observed due to the steep geometry of the corridor between Market Street and St. George Street.

Comparing the combined Scenarios 10 and 10.1, it is demonstrated that widening the Route 15 Bridge increases the water surface elevation downstream. By allowing the water impounded behind the Route 15 Bridge to flow more freely, the positive effects of the other opening expansion, bridge removals, and floodplain restoration are negated. If a combined approach is taken, it is recommended that the bridge opening is not adjusted. PennDOT should be made aware of the sediment deposit under the Route 15 Bridge. We advise opening this dialogue on the removal of the sediment so that a determination of how the structure will best function. Further analysis of the backwater effect of the Route 15 bridge on the west Lewisburg neighborhood would be required to truly understand the effects of increasing the bridge opening.

Further Hydraulic analysis is recommended. The St. George Street culvert appears to create a significant constraint of flow on Limestone/Bull Run. This is evident in the centerline profiles results in which all the scenarios appear to regress to the mean below the culvert. This culvert was not analyzed because it was outside the defined scope. Further hydraulic analysis of the region below St. George Street could lead to a better understanding of flash flooding on Limestone/Bull Run and the identification of potential projects.

Installation of a stream gauge is advised. The SIR 2008-5102 methodology is based on the behavior of gauged stream in the proximity. Installing a stream gauge and recording real flow data will aid in calibration of hydrologic and hydraulic models. Installation of two stream gauges would be further advantageous to better understand the hydrologic response time of the watershed. A gauge located upstream, outside the Borough that can observe early stages of flooding, and one on the downstream end to record the intensity of events passing through the 6th Street corridor. A minimum of one year of flow data should be collected, however, a continuous monitoring installation would allow for more data and has the potential to support real time awareness of flow conditions, supplementing an early warning system.

Coordination with East Buffalo Township is advised. Stormwater management practice's designed to reduce surface runoff are located in the East Buffalo Township's portion of the Limestone/Bull Run watershed. An inventory of the existing BMP's and their characteristics (location, capacity, design discharge), would be useful in determining if there is any further opportunity in attenuating surface runoff before it enters Limestone/Bull Run. Furthermore, coordinating the installation of a stream gauge in East Buffalo Township would aid in understanding the hydrology of the watershed. A stream gauge further upstream could also be useful in identifying incoming flash flooding events.

SECTION 10 - GREEN INFRASTRUCTURE DEMONSTRATION PROJECT SUMMARY

10.1 – OVERVIEW

Green infrastructure, also known as green stormwater infrastructure or low impact development practices, allows for more natural hydrologic functions to facilitate stormwater management, such as enhanced infiltration and evapotranspiration. Green infrastructure is also successful at improving stormwater runoff water quality, increasing groundwater recharge, improving biodiversity locally and downstream, and providing positive secondary benefits to residents and the community. These practices are useful at addressing site scale stormwater management issues and could be used through retrofit at large scales to decrease watershed runoff and flood flows. Green infrastructure is also a useful tool for urban areas to mitigate the negative impacts of new development and create sustainable, livable communities.

Lewisburg Borough is interested in utilizing green infrastructure on a broader scale to improve the Borough's stormwater conveyance capacity and improve the condition of local waterways through increases in wet weather runoff management and resiliency from flooding events. To promote the benefits of green infrastructure, the Borough identified two demonstration project sites as part of this Flood Mitigation Study. Part of the process included engaging with community residents to inform them of the associated community and to determine green infrastructure type preferences. This section of the report reviews various green infrastructure options, showcases the green infrastructure demonstration project selection process, and introduces the design concept.

10.2 – STORMWATER RUNOFF AND FLOODING

Stormwater runoff increases with greater proportion of impervious surfaces in a watershed or catchment area and results in greater runoff quantity, or volume, and runoff rate. Watersheds are the area that drains into a body of water, while catchment areas are smaller areas within the watershed, which are often easier to manage through stormwater management practices. Additional stormwater runoff occurs as the pervious 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.

As land surface disturbances have increased in Lewisburg, so has the problems of managing the increased quantity of stormwater runoff and providing sufficient space to discharge and convey large flows from flooding events. These disturbances in land surfaces also result in negative impacts from smaller storm events, such as the 2-year frequency event. When such events are not fully controlled, they have the potential to negatively impact receiving bodies of waters, such as scouring of drainage channels and streambank erosion, resulting in loss of channel stability and poor water quality. The aggregate of individual land surface cover changes dramatically influences stormwater runoff and flooding conditions. This cumulative effect of development and encroachment on stream corridors results in flooding of both small and large streams, with substantial financial property damage and risk to the public health and welfare. Property flooding can occur in many ways throughout the Borough – via riverine overbank flooding from the creeks and rivers, through pluvial flooding of the land surface, and groundwater intrusion through buildings and building foundations. A flood mitigation tool that may be used by the Borough to reduce the likelihood of riverine and pluvial flooding is promotion of the use of green infrastructure, new asset management protocols, and retrofit projects.

10.3 – MARGINAL COST OF GREEN INFRASTRUCTURE COMPARE TO TRADITIONAL STORMWATER INFRASTRUCTURE

Stormwater management design practices have continued to evolve with the recognition that redirecting stormwater flows to waterbodies rapidly is not a preferred method for watershed health and flood resiliency. With this awareness, it should be noted that green infrastructure is cost competitive compared to 'traditional', peak flow conveyance stormwater infrastructure when considering downstream project impacts, secondary benefits, and life cycle costs.

10.4 - EXAMPLES OF GREEN INFRASTRUCTURE MANAGEMENT PRACTICES

This section provides descriptions of green stormwater infrastructure management practice types. Table 10.1 provides a summary of the relative cost, maintenance requirements, flood benefits, and applicability to land use types.

Rain Gardens

Rain gardens are small, shallow, sunken areas of plantings that collect stormwater runoff. They are designed to mimic the natural ways water flows over and absorbs into land to reduce stormwater pollution. Stormwater accumulates in the rain garden until the water can drain through the soil. Rain gardens can have underground storage to store additional stormwater runoff volume. Rain gardens are very common green infrastructure systems. They enhance aesthetics, improve stormwater runoff water quality, and are flexible to the installation site's constraints. This type of green infrastructure can be installed at homes, schools, parks, open lots, and other places within the developed/urban environment.

Curbed Planter Boxes

Planter boxes are similar to rain gardens but are in urban settings that have vertical walls with either open or closed bottoms. They can be utilized along streets, sidewalks, and in parking lots. A variation of the curbed planter box is a bumpout or curb extension, which would extend into the street area. The soil and vegetation is placed lower than the connected impervious area to capture stormwater from roads and sidewalks. Stormwater is accepted in the planter boxes or bumpouts on the surface and is infiltrated through the soil and plant layer into the subsurface area that could be filled with gravel to provide additional stormwater storage. Excess runoff can then be released back into an adjacent stormwater system. Curbed planter boxes and bumpouts are easily adapted to spatial constraints, making them ideal for urban applications.

Bioswales

Bioswales are essentially rain gardens that are more linear, often along curbs and parking lots. They use vegetation or mulch to slow and filter stormwater flows. Bioswales are used as an alternative to gutters, pipes, and rip-rap lined ditches. Similar to other vegetated green infrastructure, bioswales reduce stormwater runoff through infiltration and improve water quality through filtering through soil medium. Their linear nature and use as a conveyance tool requires appropriate vegetation selection. They can be utilized in a variety of settings and work well in sloped areas, and similar to rain gardens and curbed planter boxes, can be adapted to site constraints.

Green Streets and Alleys

Public streets and sidewalks make up a significant portion of the impervious area in Lewisburg. Green Streets and Alleys are created by integrating green infrastructure into a single design that helps store and filter water. They can include many of the green infrastructure practices listed in this section. Practices that work well include curbed planter boxes and bumpouts, permeable pavement, trees, and bioswales. A Green Streets and Alleys program in Lewisburg could redefine street design standards to incorporate green infrastructure as streets are resurfaced or reconstructed.

Green Parking

Parking lots are another impervious surface that comprise a significant portion of impervious area in Lewisburg. Similar to Green Streets and Alleys, Green Parking utilizes a number of green infrastructure elements into a parking lot design to help with stormwater management. Green design elements in parking lots assist with redefining the visual aspects of parking lots, with certain designs providing a dual function of providing buffers from adjacent parcels and streets while accepting stormwater runoff. Practices that work well in parking lots include curbed planter boxes, rain gardens, bioswales, trees, and permeable pavement.

Downspout Disconnection

Disconnecting roof leaders or downspouts allows roof runoff to be collected and managed in adjacent vegetated or pervious areas. Rerouting rooftop drainage in this manner rather than directing it directly to a stormwater conveyance system allows for greater infiltration, filtration, and evapotranspiration without a large footprint for the practice. It is also possible to redirect roof runoff to rainwater harvesting systems such as rain barrels or systems to allow for stormwater reuse. This practice can be used for most elevated impervious surfaces, and works best where when sufficient pervious areas adjacent to the building provide adequate area for runoff to spread and dissipate into the surface.

Rainwater Harvesting

Rainwater harvesting is the collection and storage of stormwater runoff from building roofs. The containers are usually referred to as rain barrels (smaller) or cisterns (larger) and allow for the collection and capture of roof runoff for later use. Rain barrels are typically located near a single downspout on the ground surface, while cisterns can be located on the surface or subsurface and may collect runoff from several downspouts. The stored runoff can be used for non-potable needs, such as watering vegetation or washing outdoor areas and cars, but is not safe for drinking. This allows for homeowners to conserve supplied water usage. To maximize stormwater runoff management potential, a user may install a system to allow for the automatic draining of rainwater harvesting systems to ensure full capacity is available for the next runoff event. Combined with other green infrastructure, rainwater harvesting reduces the amount of runoff that flows into the downstream.

Green Roofs

Green roofs are partially or fully covered roofs with growing vegetation and media that helps allow rainfall infiltration and evapotranspiration of stored water. Green roof systems can vary in depth, which allows for differing vegetation to grow depending on the system design and building structure loading requirements. Green roofs provide similar stormwater reduction and filtration benefits to other green infrastructure, while providing a unique aesthetic to buildings and reducing energy costs for heating and cooling. An additional function of the green roof is its potential for providing vegetated open spaces in elevated areas of buildings or urban areas. Green roof applications are limited to flatter building roofs or elevated building surfaces and require sufficient structural strength of the supporting building.

Permeable Pavement

Permeable pavement is a collection of paving that allows stormwater to pass through the surface instead of running over it. It is a way to help infiltrate, treat or store stormwater where it falls. Permeable pavements include interlocking pavers, pervious concreate, porous asphalt, and also manufactured plastic gridded cells or pavers. Permeable pavements can be used in nearly all areas where traditional pavement is used, but tends to perform the best in areas with more limited traffic such as walkways, parking areas, and alleys. Below the surface of the permeable pavement is an area where stormwater can be stored to allow infiltration into the subsurface soil or slowly released to a stormwater conveyance system via a distribution pipe network and connected control structure. Permeable pavement can be combined with vegetated green infrastructure systems to allow for larger combined benefits.

Tree Canopy

Tree canopy over streets and impervious areas reduces runoff while providing a range of additional benefits. Trees planting engages homeowners, businesses, and community groups. Tree canopy improves air quality and public health, and similar to other green infrastructure they provide aesthetic benefits compared to non-vegetated areas. It is important to note that tree canopy requires additional green infrastructure approaches since the tree canopy does not reduce runoff volumes during winter/dormancy.

Land Conservation

Land conservation is another positive tool for communities to use towards reducing the risks of stormwater runoff and flooding. Natural and sensitive areas that should be a focus of this effort include floodways, riparian areas, wetlands, and parks. Land conservation involves protecting these areas from land development, avoiding encroachment and disturbance, and limiting alterations to preserve their function as flood conveyance and floodwater ponding areas. Floodplain management ordinances can be used as means to protect natural and sensitive areas near floodway and floodplain areas.

Table 10.1 Green Infrastructure Summary and Application by Land Use

	Descriptors			Land Use Application					
Green Infrastructure Opportunity	Cost	Maintenance	Flooding Benefit	Streets	Commercial / Industrial	Public Facilities	Parking	Residential	Parks
Curbed Plantar Boxes	med	high	med	●			●		
Bioswales	low	med	med	●	●	●	●	●	●
Green Streets and Alleys	med	med	med	●	●	●		●	
Green Parking	med	med	med	●		●	●	●	●
Land Conservation	low	low	high		●			●	●
Downspout Disconnection	low	low	low		●	●		●	●
Rainwater Harvesting	med	med	med		●	●		●	●
Rain Gardens	low	med	med		●	●	●	●	●
Green Roofs	high	med	med		●	●		●	●
Permeable Pavement	med	med	med	●	●	●	●	●	●
Tree Canopy	low	low	low	●	●	●	●	●	●

10.5 - PROJECT OPPORTUNITY AND PRIORITIZATION ANALYSIS

Green infrastructure opportunities in Lewisburg present themselves across the Borough. For this project selection, opportunities were focused in areas that are generally publicly owned – streets, public parking areas, parks, and public facilities. Figure 10.1 provides a partial view of the areas that present potential for green infrastructure. A full map of general Borough green infrastructure opportunities is provided in Appendix E.

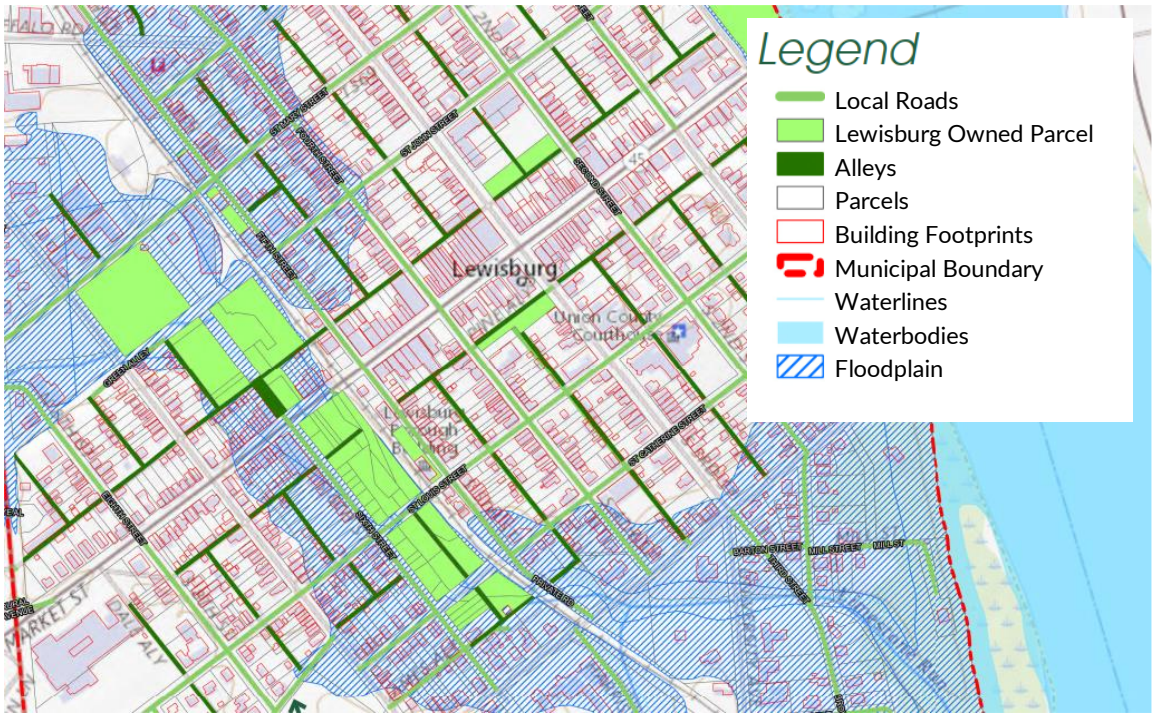


Figure 10.1 Green Infrastructure Opportunity Map

Upon review of potential green infrastructure opportunities in the Borough, the project team proposed 17 different project opportunities at 9 sites based on desktop analysis and site visits. Green infrastructure practice opportunities at these sites consist of permeable pavement, curbed planters, bioretention basin, rain garden, and bioswale practices. Table 10.2 provides a summary of the potential site/practice combinations used to identify the selected demonstration projects.

Table 10.2 Green Infrastructure Selected Sites for Consideration

Location	Short Name	Type	Description
Lewisburg Area Recreation Park - East of 15th St	Parking East	Permeable Pavement	Replace existing pavement with permeable pavement and redirect adjacent storm pipe to infiltration bed
Lewisburg Area Recreation Park - Ice Rink	Ice Rink	Rain Garden	Rain garden conversion of ice rink for warm months
Apple Tree Ally - St. L. to St. C	Apple Tree B	Permeable Pavement	Replace existing pavement with permeable pavement and redirect adjacent building downspouts
Ikeler St & Maclay Ave	Ikeler	Permeable Pavement	Permeable pavement along road shoulders/parking; existing pavement is in deteriorating condition
Lewisburg Area Recreation Park - East of 15th St	Parking East	Rain Garden	Rain garden between parking/tennis courts
Blackberry Ally - St. L. to St. C	Blackberry B	Permeable Pavement	Replace existing pavement with permeable pavement and redirect adjacent building downspouts

Location	Short Name	Type	Description
Blackberry Ally - St. C. to St. G	Blackberry A	Permeable Pavement	Replace existing pavement with permeable pavement and redirect adjacent building downspouts
Blackberry Aly. - St. L. to St. C	Blackberry B	Curbed Planter	Curbed planters at intersection of Alley and St. Catharine
Ikeler St & Maclay Ave	Ikeler	Curbed Planter	Curbed planters at intersection of Ikeler and Maclay
Lewisburg Area Recreation Park - West of 15th St	Parking West	Rain Garden	Rain garden on north side of parking lot in natural drainage way
Blackberry Aly. - St. C. to St. G	Blackberry A	Curbed Planter	Curbed planters at intersection of Alley and St. George
Lewisburg Area Recreation Park - West of 15th St	Parking West	Bioswale	Bioswale on north side of parking lot in natural drainage way
St. Lawrence St West Side	Lawrence	Rain Garden	Rain garden along St. Lawrence from ice rink parking to intersection
Apple Tree Aly. - St. L. to St. C	Apple Tree B	Curbed Planter	Curbed planters at intersection of Alley and St. Louis
Apple Tree Ally - St. C. to St. G	Apple Tree A	Permeable Pavement	Replace existing pavement with permeable pavement and redirect adjacent building downspouts
Apple Tree Aly. - St. C. to St. G	Apple Tree A	Curbed Planter	Curbed planters at intersection of Alley and St. George
St. Lawrence St West Side	Lawrence	Curbed Planter	Curbed planter along St. Lawrence from ice rink parking to intersection

A prioritization matrix was developed to analyze and evaluate options based on multiple criteria. The matrix provides an objective comparison of the potential projects based on the goal of implementing green infrastructure and the priorities of the community.

The potential projects were evaluated based on six criteria. The drainage area captured and the practice footprint were delineated to determine how effective each potential project was at collecting and sequestering runoff. The community was polled on their preference for the type of green infrastructure practice at the Town Hall meeting, with summary of input provided in Table 10.3. Borough officials provided their ranking of potential project list based on site constraints and green infrastructure practice knowledge. The final two criteria considered included the ability to connect to the storm sewer system and ability to combine with other projects was also considered. Table 10.4 provides a list of criteria that were used to assess each combination of site and project type. Every potential project was assigned a score in these categories, and each category was weighted equally. The top potential projects were determined by the highest scores. Table 10.5 provides the criteria assigned to each site and project type. Table 10.6 documents the prioritization summary based on the relative ranks of each site and project combination. Appendix E provides further documentation of each project site and practice type drainage and practice area characteristics.

Table 10.3 Green Infrastructure Vote Tally from February 22, 2023 Townhall

Green Infrastructure Type	% of Votes
Curbed Plantar Boxes	12%
Bioswales	4%
Green Streets and Alleys	12%
Green Parking	8%
Land Conservation	4%
Downspout Disconnection	0%
Rainwater Harvesting	8%
Rain Gardens	16%
Green Roofs	4%
Permeable Pavement	16%
Tree Canopy	16%

Table 10.4 Prioritization Rating Criteria

Criteria	Description	Value
Drainage Area to Practice Location	Cumulative drainage to the practice location, higher rank/score for greater drainage area	Acres
Stormwater Management Practice Area	Available land surface area for the stormwater management practice, higher rank/score for greater surface area. Greater surface area allows for better infiltration and/or stormwater flow attenuation (typically)	Square Feet
Storm Sewer Connection	Whether or not an existing adjacent stormwater pipe is available to connect a practice slow drain/overflow, sites with a connection get a higher rank/score	Yes/No
Multi-Project Potential	Whether or not a location is need of additional work or other projects are planned, i.e. street resurfacing; higher rank/score for sites with multi project potential	Yes/No
Community Preference	Green infrastructure practice type preference rank from Town Hall meeting; more votes receives higher rank/score	Town Hall Vote Rank
Borough Preference	Green infrastructure practice type preference rank from Town Hall meeting; more votes receives higher rank/score	Rank

Table 10.5 Green Infrastructure Selected Sites for Consideration

Short Name	Type	Borough Preference	Community Preference	Drainage Area	Practice Area	Storm Sewer Connection	Multi Project Potential
		Rank (1-17)	Rank (1-7)	Acres	Sq Ft	Yes/No	Yes/No
Parking East	Permeable Pavement	1	1	3.02	249,406	Yes	No
Ice Rink	Rain Garden	8	3	5.85	180,846	Yes	No
Apple Tree B	Permeable Pavement	2	1	0.74	52,934	Yes	Yes
Ikeler	Permeable Pavement	12	1	4.26	96,068	No	Yes
Parking East	Rain Garden	14	3	3.83	284,883	Yes	No
Blackberry B	Permeable Pavement	4	1	1.25	73,098	No	Yes
Blackberry A	Permeable Pavement	13	1	1.83	84,200	No	Yes
Blackberry B	Curbed Planter	7	3	3.16	137,466	No	No
Ikeler	Curbed Planter	11	3	4.36	64,253	No	Yes
Parking West	Rain Garden	17	3	1.85	117,520	Yes	No
Blackberry A	Curbed Planter	6	3	1.74	85,768	No	No
Parking West	Bioswale	15	7	1.85	117,520	Yes	No
Lawrence	Rain Garden	5	3	1.35	58,642	No	No
Apple Tree B	Curbed Planter	3	3	0.49	77,277	No	No
Apple Tree A	Permeable Pavement	16	1	0.5	33,493	Yes	No
Apple Tree A	Curbed Planter	9	3	0.72	33,493	Yes	No
Lawrence	Curbed Planter	10	3	1.72	16,231	No	No

Table 10.6 Green Infrastructure Selected Sites for Consideration

Short Name	Type	Borough Preference	Community Preference	Drainage Area	Practice Area	Storm Sewer Connection	Multi-Project Potential	Score Total	Rank
		Score	Score	Score	Score	Score	Score	Score	Rank
Parking East	Permeable Pavement	17	14.5	12	16	13.5	6.5	13.3	**1**
Ice Rink	Rain Garden	10	6.5	17	15	13.5	6.5	11.4	**2**
Apple Tree B	Permeable Pavement	16	14.5	4	4	13.5	15	11.2	**3**
Ikeler	Permeable Pavement	6	14.5	15	11	5	15	11.1	4
Parking East	Rain Garden	4	6.5	14	17	13.5	6.5	10.3	5
Blackberry B	Permeable Pavement	14	14.5	5	7	5	15	10.1	6
Blackberry A	Permeable Pavement	5	14.5	9	9	5	15	9.6	7
Blackberry B	Curbed Planter	11	6.5	13	14	5	6.5	9.3	8
Ikeler	Curbed Planter	7	6.5	16	6	5	15	9.3	9
Parking West	Rain Garden	1	6.5	10.5	12.5	13.5	6.5	8.4	10
Blackberry A	Curbed Planter	12	6.5	8	10	5	6.5	8.0	11
Parking West	Bioswale	3	1	10.5	12.5	13.5	6.5	7.8	12
Lawrence	Rain Garden	13	6.5	6	5	5	6.5	7.0	13
Apple Tree B	Curbed Planter	15	6.5	1	8	5	6.5	7.0	13
Apple Tree A	Permeable Pavement	2	14.5	2	2.5	13.5	6.5	6.8	15
Apple Tree A	Curbed Planter	9	6.5	3	2.5	13.5	6.5	6.8	16
Lawrence	Curbed Planter	8	6.5	7	1	5	6.5	5.7	17

10.6 - SELECTED GREEN INFRASTRUCTURE DEMONSTRATION PROJECTS

Based upon the green infrastructure prioritization, two projects were selected to develop conceptual designs for the Green Infrastructure Demonstration, both utilizing permeable pavement.

Lewisburg Area Recreation Park – East Parking Lot Permeable Pavement

The Lewisburg Area Recreation Park East Parking Lot Project will replace existing pavement with permeable pavement and redirect the adjacent storm pipe to the infiltration bed. The subsurface infiltration bed below the pavement would then be connected to the adjacent stormwater system, allowing excessive runoff events to pass through. There is potential to add additional green infrastructure features with this project, such as redirecting downspouts from the adjacent pool building into the subsurface and installing rain garden vegetation on the north side of the parking lot. Runoff from the upstream residential area would flow through the vegetation before connecting the subsurface infiltration bed of the permeable pavement parking lot. Figure 10.2 provides the conceptual design of the Lewisburg Area Recreation Park East Parking Lot Permeable Pavement project.

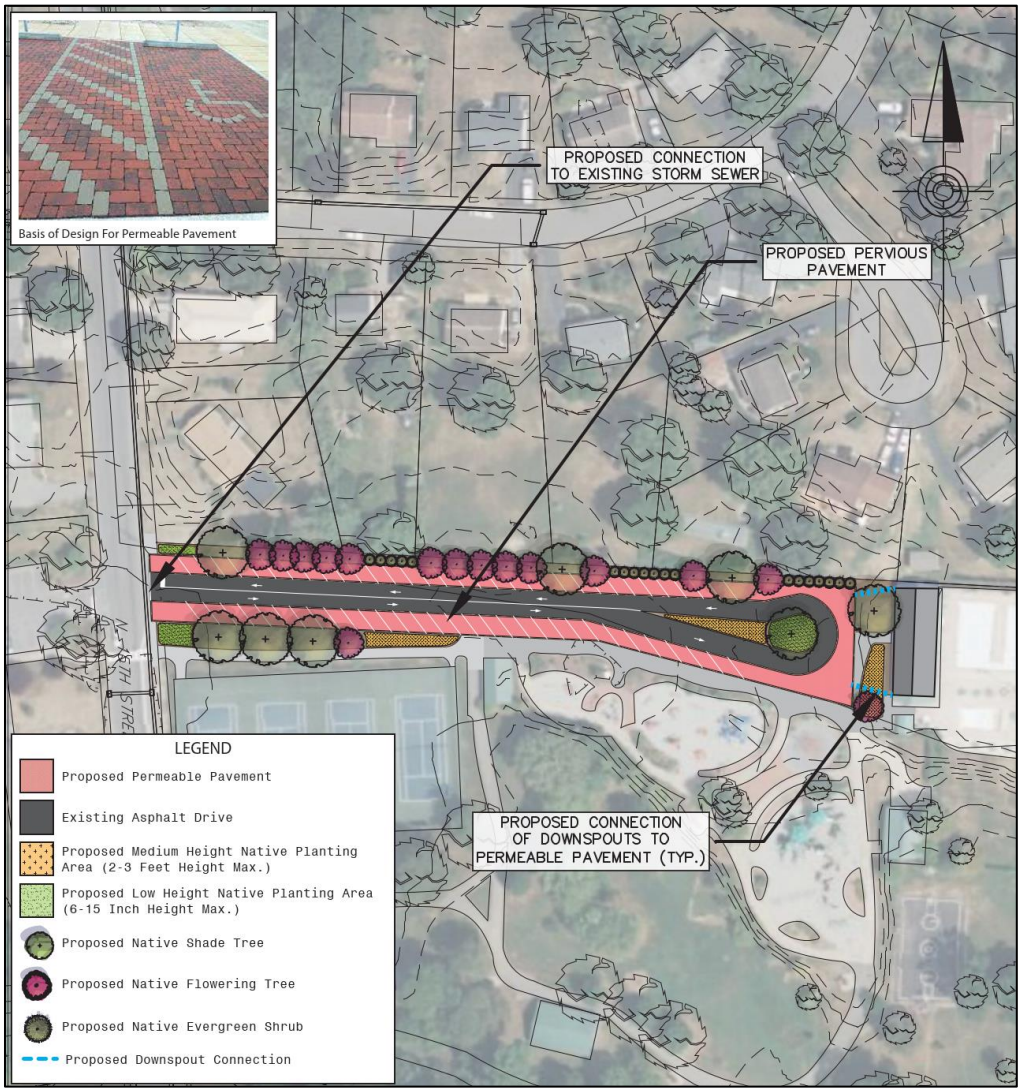


Figure 10.2 Green Infrastructure Demonstration for Lewisburg Recreation Park

Apple Tree Alley Permeable Pavement

The Apple Tree Alley Project will span from St. Louis Street and St. Catherine Street. The associated work includes replacing existing pavement with permeable pavement and redirecting adjacent building downspouts to the subsurface gravel infiltration bed. The subsurface infiltration bed below the permeable pavement system would then be connected to the adjacent stormwater system, allowing excessive runoff events to pass through. As was the case with the parking lot option, there are opportunities to add additional green stormwater infrastructure features at this project site as well. Curbed planter boxes could be installed at the Alley entrances along St. Louis and/or St. Catherine Streets. Stormwater could be redirected from the street surface to these curbed planter boxes. This addition would provide additional aesthetic and visual benefits. Figure 10.3 provides the conceptual design of the Apple Tree Alley Permeable Pavement project.

Figure 10.3 Green Infrastructure Demonstration for Apple Tree Alley

Preliminary Construction Cost

Preliminary construction cost was developed for each selected green infrastructure demonstration project site. As part of the cost estimating process, the cost for a traditional asphalt full depth restoration for each project site. Table 10.7 provides the summary of these preliminary construction cost estimates. Although the green infrastructure approach at these two sites, on average, is approximately 60-80% higher than the traditional full depth asphalt restoration, the green infrastructure approach provides additional benefits beyond traditional asphalt restoration, such as on-site stormwater management, minimization of downstream waterway impacts, and aesthetics. Note that full life cycle costs and secondary benefits were not evaluated through this study, and when accounted for, would likely increase the cost benefit of green infrastructure versus traditional asphalt restoration. When taking into consideration the triple bottom line benefits to residents - social, economic, and environmental benefits, green infrastructure often presents itself as the more cost-effective solution in urbanized neighborhoods.

Table 10.7 Preliminary Construction Cost Summary – Green Infrastructure versus Traditional

Project Name	Type	With Green Infrastructure	Traditional
Parking East	Permeable Pavement	$355,700	$219,500
Apple Tree Alley	Permeable Pavement	$114,000	$62,000

SECTION 11 - RECOMMENDATIONS AND PROJECT PRIORITIZATION

The Lewisburg Flood Mitigation Study is a comprehensive effort to assist the Borough to implement a set of prioritized initiatives while allocating resources to improve upon the community's flood resiliency. The project team was assigned to perform the study and identify actionable steps and recommendations towards achieving flood resiliency and mitigating adverse impacts from flooding events. This section summarizes recommendations and prioritized projects. This includes items such as recommendations for areas and issues for further evaluation. The recommendations in this section are intended to provide Borough officials with the information to prioritize next steps for increasing Lewisburg's flood resiliency. Table 11.1 provides the summary of early or short-term recommendations, items that could be completed in the next 24 to 36 months. Table 11.2 provides the summary of medium-term recommendations, items that could be completed within the next 3 - 6 years. Table 11.3 provides the summary of long-term recommendations, items that will take longer than 6 years to complete. Table 11.4 provides a summary of additional items for the Borough to consider, but do not have a recommended timeline.

Table 11.1 Short-Term Recommendations (2-3 years)

Item	Description
A1	Implement Borough Operational Action Recovery Plan.
A3	Consider updates to Borough ordinances pertaining to historic structures in the floodplain, freeboard, and impervious area requirements. Further define a floodplain overlay district that extends beyond the 100-year floodplain.
A4	Integrate Becoming Flood Resilient Community Toolbox resources into Borough website. Continue public education and outreach through providing Becoming Flood Resilient Community Toolbox resources at local events, public meetings, during flood awareness week.
A5	Review Borough Community Rating Service improvements during regular renewal cycle and provide documentation to support higher point calculations based on improved planning, communications, and resources developed during short-term recommendations implementation.

Table 11.2 Medium-Term Recommendations (3-6 years)

Item	Description
B1	Seek funding to conduct H&H analysis of Limestone/Bull Run west of Route 15 to better understand the backwater effects of bridge removals have on this neighborhood. Further, conduct H&H analysis of Limestone/Bull Run below St. George to discover potential future solutions.
B2	Program and implement a green infrastructure demonstration project.
B3	Seek funding to work with individual businesses to create flood preparation/action/recovery plans for specific commercial properties located in the floodway of Limestone/Bull Run.

Table 11.3 Long-Term Recommendations (6 to 10 years)

Item	Description

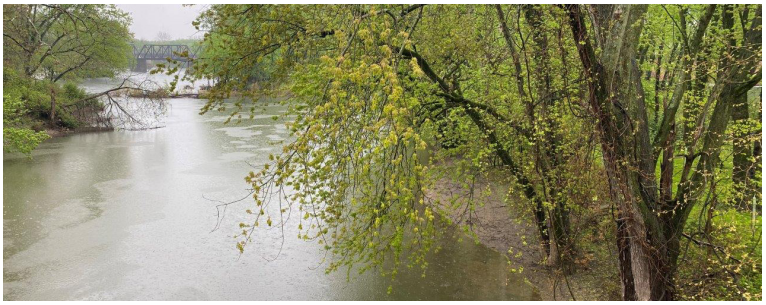
C1	Enact dedicated flood mitigation revenue stream to support private property retrofits/mitigation measures. Evaluate creating dedicated flood mitigation revenue stream for Borough flood mitigation capital projects and Borough disaster relief funding.
C2	Work with appropriate local, state, and federal agencies to have stream gauges installed in Limestone/Bull Run Watershed to monitor runoff events to inform additional study of the watershed response and to potentially provide real time early warning system support.
C3	Consider removal of select bridges/culverts (7th Street and Rail Trail) and installation of additional culvert capacity under railroad embankment below Kidsburg playground in the Limestone/Bull Run corridor.

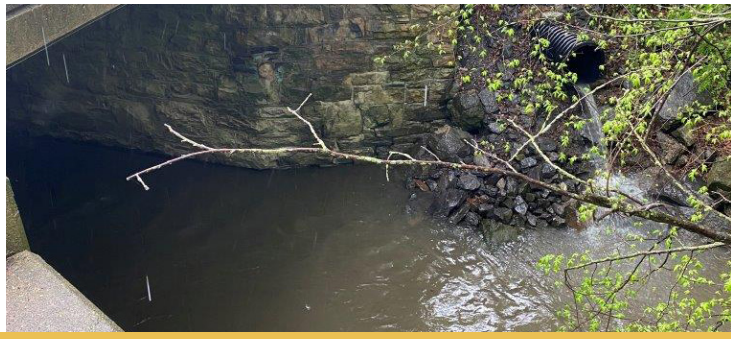
Table 11.4 Additional Items to Consider

Item	Description
X1	Implement additional green infrastructure demonstration projects.
X2	Implement more floodplain restoration projects.
X3	Evaluate and implement partnering with adjacent municipalities on ordinance updates/flood mitigation in Limestone/Bull Run watershed.
X4	Evaluate retrofitting existing watershed stormwater management basins.
X5	Perform a feasibility study of a neighborhood-wide green infrastructure implementation.
X6	Continue to explore additional projects like those on Limestone/Bull Run, on Beck Street, and individual properties.
X7	Develop and implement a maintenance program for the Borough's stormwater drainage systems.
X8	Adopt and enforce the riparian buffer provisions of the PADEP Model Stormwater Ordinance, which includes regulations that require the establishment of riparian buffers on all new development near the water course.







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