NONSTRUCTURAL FLOOD PROOFING STUDY FOR ELLICOTT CITY, MD

Prepared for: **Howard County Government**
Stormwater Management Division
Bureau of Environmental Services
6751 Columbia Gateway Drive, Suite 514
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FINAL
FEBRUARY 2018

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ACRONYMS:

ADA	Americans with Disabilities Act
AE	Architectural Engineering
ASFPM	Association of State Flood Plain Managers
B&O	Baltimore & Ohio
BCR	Benefit-to-Cost Ratio
BFE	Base Flood Elevation
BFE+2	Base Flood Elevation plus Two Feet
CCE	Construction Cost Estimate
COA	Certificate of Approval
DA	Drainage Area
DFE	Design Flood Elevation
DILP	Department of Inspections, Licenses, and Permits
DPW	Department of Public Works
DPZ	Department of Planning and Zoning
FEMA	Federal Emergency Management Agency
FM	Factory Mutual
GPS	Global Positioning System
HEC-FDA	Hydraulic Engineering Center Flood Damage Analysis
HPC	Historic Preservation Commission
LAG	Lowest Adjacent Grade
MCACES	Micro-Computer Aided Cost Estimating System
MDE	Maryland Department of the Environment
MEMA	Maryland Emergency Management Agency
MEP	Maximum Extent Practicable
MHT	Maryland Historical Trust
MII	Second Generation Micro-Computer Aided Cost Estimating System
NAVD88	North American Vertical Datum 1988

NFPC	Nonstructural Flood Proofing Committee
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
RTK	Real Time Kinematic
TUFLOW	Two-Dimensional Unsteady Flow
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Service

1 INTRODUCTION

1.1 BACKGROUND

Ellicott City, Maryland, located in Howard County, was founded in 1772 and became one of the largest mill towns in the Eastern United States. It contains a branch of the Baltimore & Ohio (B&O) Railroad Museum at the Ellicott City Station, which was the first terminus of the initial line, built in 1830. The downtown historic district, often referred to as "Historic Ellicott City," is located in the valley of the upper Western Branch of the Patapsco River. Tiber Branch, Hudson Branch, Autumn Hill Branch, and New Cut Branch all converge to enter the Patapsco River in the vicinity of Ellicott City. The location of Ellicott City at the convergence of these waterways, the topography, and stormwater runoff contribute to significant flood events within Ellicott City and particularly the historic district. Given the significant historical resources in the area and the high risk of flooding, Howard County, Maryland (Howard County or County) requested that the U.S Army Corps of Engineers, Baltimore District (USACE) investigate potential nonstructural flood proofing measures for use in the study area, which includes the historic district, to provide a level of flood risk management (FRM) for residential, commercial and public buildings from floodwaters. Nonstructural flood proofing measures are physical and nonphysical FRM measures that reduce flood risk by modifying the characteristics of structures or modifying the behavior of people living in or near floodplains. These measures differ from more traditional structural measures, such as floodwalls and levees, which reduce the risk of flood waters making contact with buildings.

Although Ellicott City's proximity to the Patapsco River has always posed a significant flood risk, the final impetus to conduct this study was two recent floods: Tropical Storm Lee in 2011 and the severe flooding during the July 30, 2016 storm event. In July 2016, the approximately 6-inch rainfall within a span of two hours caused severe flash flooding, structural damage, two fatalities, and property loss in many of the residences and businesses along Main Street and in the surrounding areas, all with very little warning time. Based on data from the National Oceanic and Atmospheric Administration (NOAA), a storm of such volume and intensity has an annual recurrence probability of 0.1% (1000-year).

Nonstructural flood proofing measures would likely not have prevented damages to many of the buildings during the July 30, 2016 storm due to high flood velocities and depths. However, recent flood events and modeling highlight the need for increased flood resilience in Ellicott City for smaller, higher frequency storms. Nonstructural flood proofing measures could reduce damages during these smaller events. This nonstructural flood proofing study is part of a larger effort by the County to identify opportunities, both on the watershed and local scale, that will minimize flood damages in Ellicott City in the future.

1.2 PURPOSE AND NEED

The purpose of this investigation is to assess the potential for nonstructural FRM measures for structures located in and near the floodplain. In order to meet this purpose, the following tasks were accomplished:

- Conducted building elevation surveys for 80 buildings in the study area
- Performed nonstructural flood proofing assessments for 16 sample structures
- Developed construction cost estimates for nonstructural flood proofing measures and conducted preliminary economic assessment
- Participated in public outreach

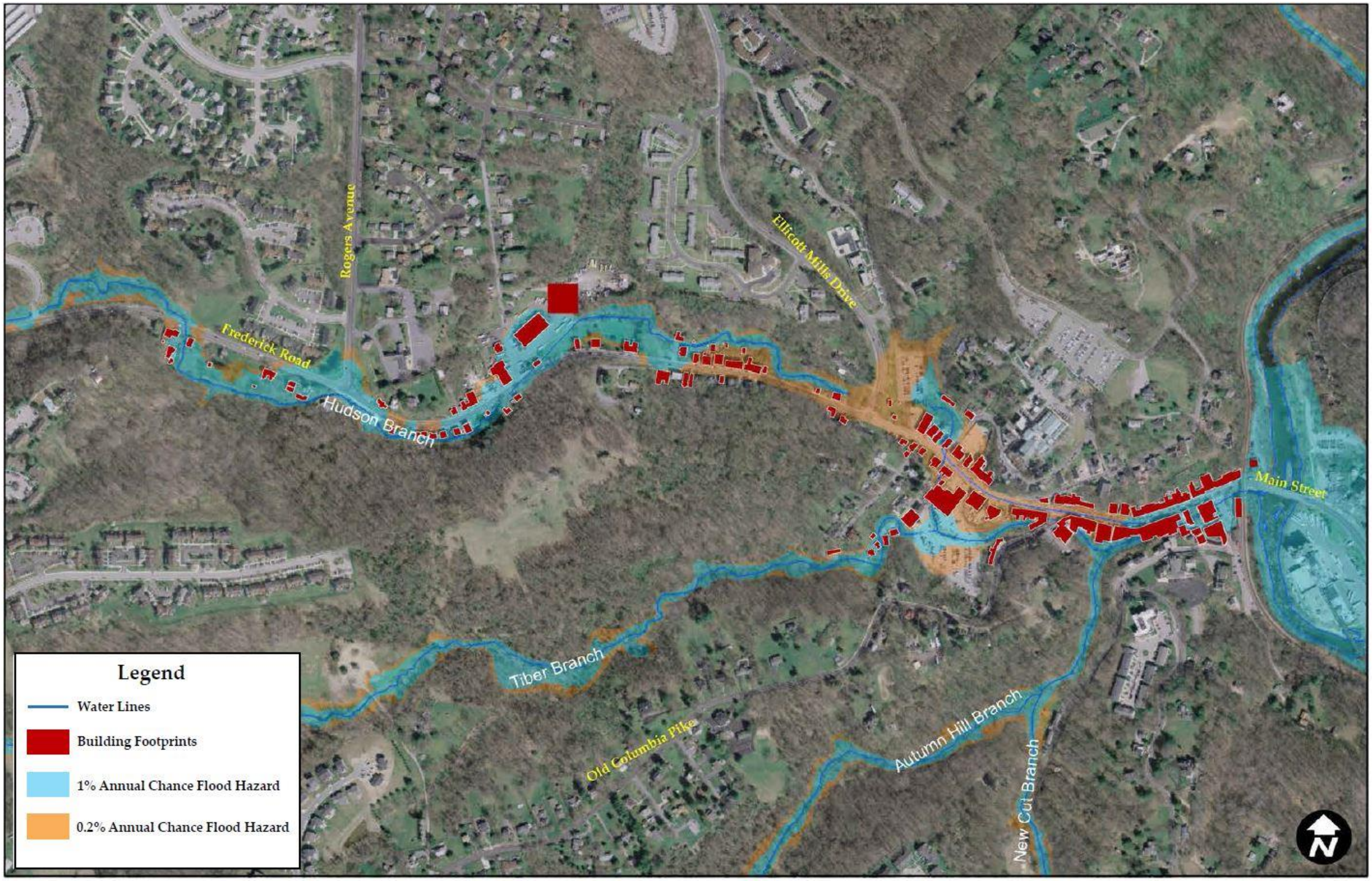
This study provides a resource for residents and property owners in Ellicott City and throughout Howard County to understand the nonstructural flood proofing options that may be suitable for them, and provide a starting point for those interested in pursuing implementation of such measures. Using 16 sample buildings, a narrative analysis, recommendations linked to specific building features, and preliminary cost data are presented in order to provide a more complete understanding of the primary considerations behind selecting nonstructural flood proofing measures. Attention is also given to the additional requirements and considerations in Ellicott City, specifically due to the nature of the historic district.

Nonstructural flood proofing measures can provide an effective option for reducing flood risk across a wide range of flood events.

1.3 STUDY AREA

The study area for this investigation is the 0.2% annual chance (500-year) floodplain in Ellicott City, Howard County, Maryland. Specifically, it is bounded by U.S. Route 29 and the Patapsco River, and is within the vicinity of MD Route 144 (Main Street) (Figure 1-1). It contains a total of approximately 140 buildings including public, residential and commercial structures. The study area also encompasses the Ellicott City Local Historic District, which was designated by the Howard County Council and recognized as the County's first historic district in 1974. In 1978, Ellicott City was listed in the National Register of Historic Places.

Figure 1-1: Map of Ellicott City Study Area



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2 STUDY OBJECTIVES AND BUILDING SELECTION

2.1 OBJECTIVES

During a nonstructural flood proofing assessment for a building, the structure must be individually inspected in order to determine what type of FRM measure is most appropriate for that particular structure given the building usage, condition, construction type, location within the floodplain, the specific flood characteristics (velocities and depths), and other site conditions. The applicable building codes within Ellicott City delineate that nonstructural flood proofing measures be designed to reduce risk at the base flood elevation (BFE) plus two feet of freeboard (“BFE+2”) (Howard County, 2017). The BFE is the 1% annual chance (100-year) flood elevation at the building. At the start of each building assessment, the “BFE+2” level of FRM was the target, and can be achieved in many cases. In cases where achieving this target was not practical, either due to the severity of flooding under the BFE condition or limitations of the particular building type or condition, FRM measures were selected that provide FRM to the maximum extent practicable (MEP). The final design flood elevations (DFEs) referenced in this report were determined based on the engineering judgment of the assessment team, to provide a target level of risk management that is both technically sound and economically feasible for building owners to implement.

An investigation was conducted of 16 properties within the study area, which were selected to be representative of Ellicott City in terms of structure types, occupancy types, and flood risk characteristics. In combination with field survey data, observations and measurements taken during site visits were used to develop final recommendations for each structure. Estimated construction costs to implement the recommended nonstructural flood proofing measures were then developed. The goal of the recommendations for each structure is to present alternatives that provide effective FRM up to the DFE that are economically feasible for building owners to implement, and fit within the guidelines set forth by the pertinent historic preservation organizations, as applicable. The ultimate intent of the assessment is to provide a tool for Ellicott City property owners to consider the applicability and feasibility of implementation of nonstructural flood proofing measures to their own buildings, based on similar structural features or flood characteristics to one or more of the 16 sample structures.

2.2 HISTORICAL CONSIDERATIONS

Ellicott City is listed as a Howard County Local Historic District (Figure 2-1), is on the National Register of Historic Places, and contains Maryland Historical Trust (MHT) Historic Easements. Therefore, modification to the structures within the historic district limits are subject to approval from various historic preservation organizations, including the Howard County Historic Preservation Commission and MHT. Through close coordination with representatives from these County and State organizations throughout the study and assessment process, every effort has been made to ensure that the recommendations set forth in the flood proofing assessment are consistent with the historic preservation guidelines as currently written and understood. However, specific approval from the pertinent historic preservation entities must be obtained prior to implementation of any nonstructural flood proofing measure, whether recommended in the flood proofing assessment or otherwise. More detailed information on historic preservation considerations is provided in Section 4.

Figure 2-1: Ellicott City Local Historic District

(Source: Howard County Department of Planning and Zoning 11/14/08)

2.3 DATA COLLECTION

Through close coordination with Howard County, National Weather Service (NWS), U.S. Geological Service (USGS), Maryland Department of the Environment (MDE), Maryland Emergency Management Agency (MEMA), McCormick Taylor and Ellicott City property owners, USACE was able to better understand the extent of the flood risk in the study area.

2.3.1 BUILDING SURVEYS

USACE performed building surveys on 80 structures within the study area in February 2017 to determine first floor elevation, low opening/first point of entry elevation, and lowest adjacent grade (LAG) (Figure 2-2). This data was used to identify the elevations at which flooding would enter the buildings. The survey included 66 commercial, 10 residential, and 4 public structures. Figure 2-3 shows the locations of the surveyed structures. Use of Real Time Kinematic (RTK) Global Positioning System (GPS) technology, as was proposed in the scope of work for this study, was not possible for the majority of the structures due to tree or building cover. As an alternative, conventional surveying methods were used. Due to the time and cost to perform conventional surveys, all of the buildings in the study area could not be surveyed. Howard County and USACE agreed to reduce the number of surveyed structures to 80. The building survey data is provided in a Microsoft Access Database format provided as an attachment to this report. All elevations included in this report are referenced to the North American Vertical Datum 1988 (NAVD88).

Figure 2-2: Building Elevation Survey Data Collected

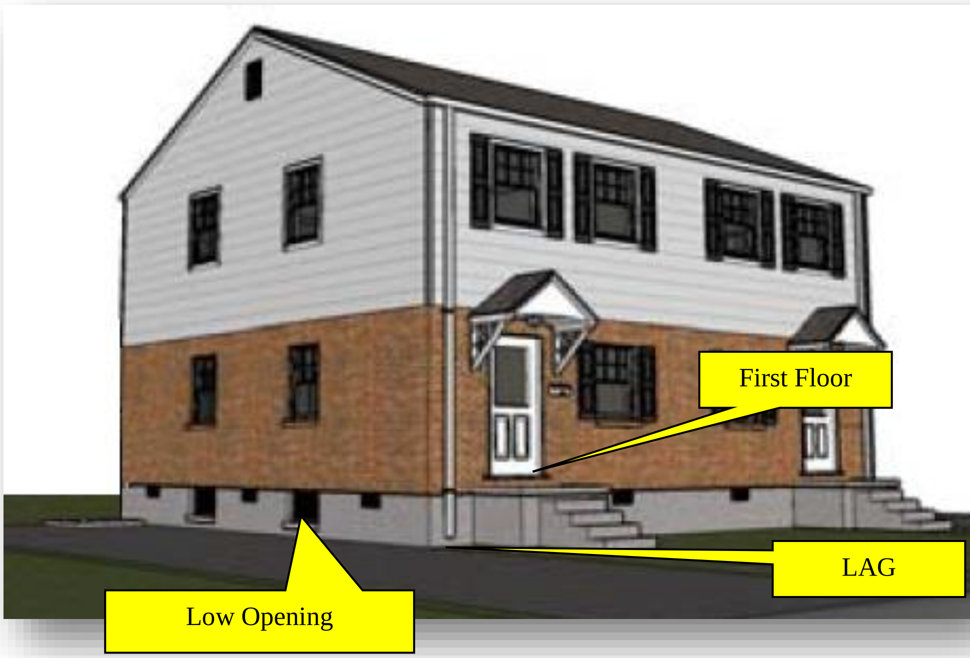
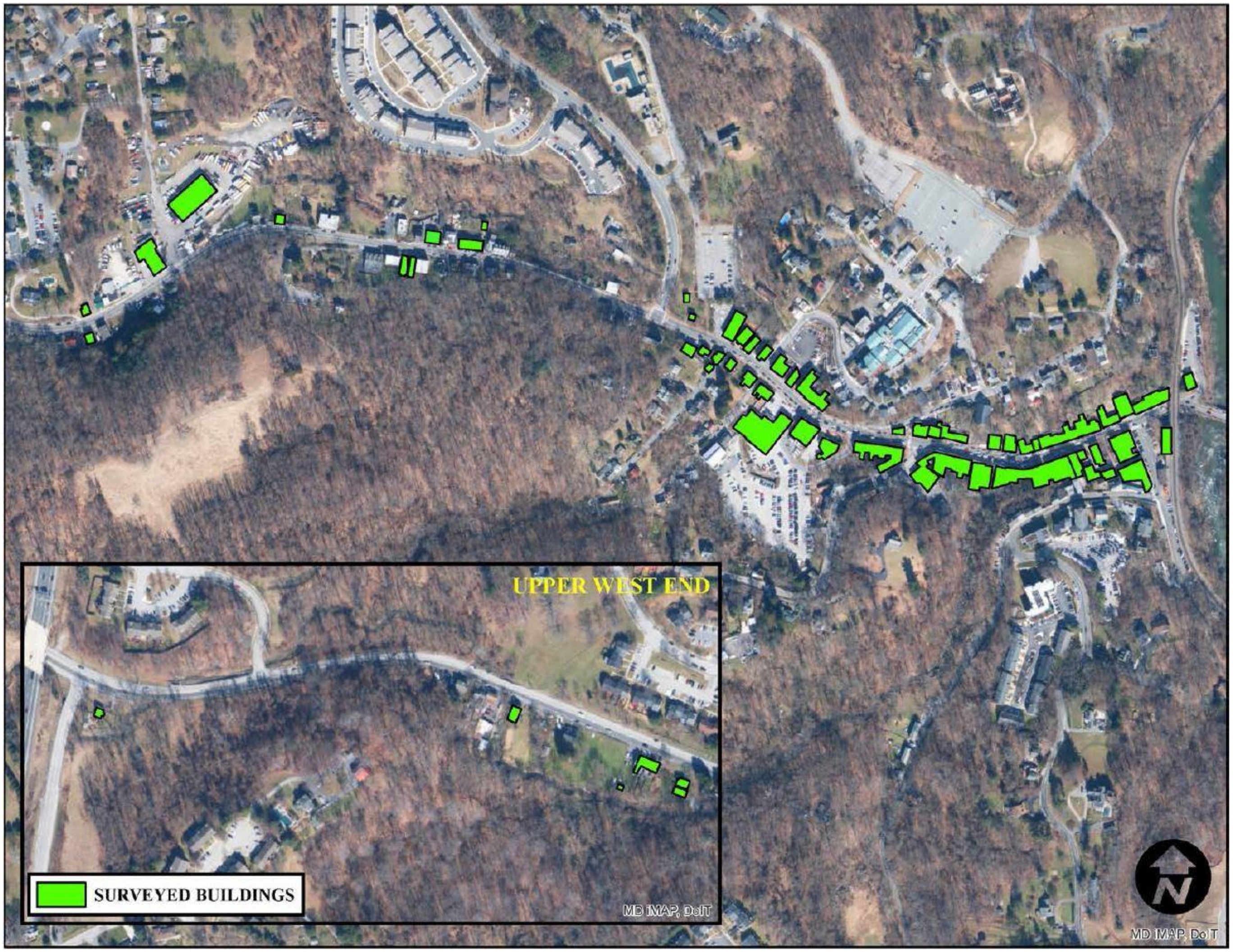


Figure 2-3: Map of Building Survey



2.3.2 HYDRAULIC AND HYDROLOGIC DATA

The hydraulic and hydrologic data utilized in the development of the flood proofing concept alternatives was sourced from the *2016 Ellicott City Hydrology/Hydraulic Study and Concept Mitigation Analysis* completed in June 2017 by McCormick Taylor (McCormick Taylor, 2017). This study was expanded from the original 2014 *Ellicott City Flood Study and Concept Mitigation Report* (McCormick Taylor, 2014) at the request of Howard County Bureau of Environmental Services for the purposes of extending a detailed hydraulic model simulating the flood flows encountered along Frederick Road / Main Street in Ellicott City, Howard County, Maryland. For the purposes of this report, USACE used the 1% annual chance (100-year) flood data and the July 30, 2016 flood data from this modeling.

McCormick Taylor Modeling- Technical Summary

Several hydrologic models of the Hudson Branch, Tiber Branch and New Cut Branch subwatersheds of the Tiber Watershed were created to calibrate a baseline hydrologic model which included the effects of existing stormwater quantity management within the watershed. Two distinct TR-20 hydrologic models were developed: one representing the Hudson Branch watershed and one representing flows from the Tiber and New Cut Branches. The drainage area (DA) for the Hudson Branch was analyzed using TR-20 with 35 sub drainage areas; the drainage area for the Tiber-New Cut branches were represented with a TR-20 model including 27 sub drainage areas. Both of the TR-20 models simulate the attenuation effects of existing stormwater management facilities through curve number reduction for smaller stormwater management facilities and stage-storage relationships for larger facilities. Hydrologic models were run for the 10-, 50-, and 100-year storm events. The hydrology of the flooding event of July 30, 2016 was also synthesized, using rain gauge data for the event provided by the National Weather Service. The TR-20 hydrologic models generated hydrographs to represent the flow of water into the hydraulic model.

A two-dimensional hydraulic model was utilized to simulate flood flows from U.S. Route 29 downstream through downtown Ellicott City, to the Tiber Branch confluence with the Patapsco River. Ten different inflow hydrographs, extracted from TR-20 model outputs, were defined to simulate all major runoff inflows into the hydraulic model for each storm event. The hydraulic model utilized a 5 foot grid to represent the detailed topographic survey of the modeled area. One-dimensional structures were added to the hydraulic model to represent flow constrictions such as culverts and storm drains. The hydrographs generated with TR-20 for the synthesized July 30, 2016 event were input into the hydraulic model, and hydraulic model outputs were compared to anecdotal and video evidence from the event. The water surface elevations calculated with the July 30, 2016 event model were compared to measurements and visual indicators, and the model was adjusted as necessary in an attempt to recreate those conditions as closely as possible. Additionally, the simulation of large culverts in the Two-Dimensional Unsteady Flow (TUFLOW) model was compared to simulations of the culverts using alternative hydraulic modeling software published by the Federal Highway Administration, HY-8. The calibrated hydraulic model was then run to simulate flooding conditions for the 10-, 50-, 100-year recurrence interval storm events.

2.4 BUILDING SELECTION

Upon completion of the initial survey and data collection process, USACE selected 16 structures to be investigated further and included in the nonstructural flood proofing assessment. The intent behind the structure selection was to choose a representative sample which, as nearly as possible, encompasses the full range of building materials, functions, and flood vulnerability present in the study area. The final building selection included three public buildings, three residential buildings, and ten commercial buildings. Figure 2-4 shows the location of the 16 structures selected by USACE for inclusion in the nonstructural flood proofing assessment. Table 2-1 provides the list of 16 buildings with selection criteria including historic status, building usage, exterior building materials, and key features. Key features were significant building features or flood risk data identified by the USACE that lead to recommendations during the nonstructural flood proofing assessment, described in detail in Section 4. A property owner can use information provided on Table 2-1 as an initial screening tool for identifying similarities between their own property and the 16 sample buildings. Even if a property outside of the selected buildings does not completely match one of the sample buildings, property owners can compare key features with selected buildings and utilize recommendations as long as building materials and historic status are similar.

Figure 2-4: Map of Selected Buildings

Table 2-1: Building Information

Structure ID	Street Address	Historic Status	Building Usage	Exterior Building Materials	Key Features
1	8000 Main St.	Local and National Historic District	Commercial	Stone Masonry	• BFE +2 < 3 ft. above first floor elevation • Unfinished Basement • Bulkhead door basement access • Exterior utilities
2	8044 Main St.	Local and National Historic District	Commercial	Stone Masonry	• BFE+2 > 5 ft. above first floor elevation • Adjacent to other structures • Storefront windows
3	8069 Main St.	Local and National Historic District	Commercial	Stone Masonry with Stucco and Wood Frame	• Floor retrofitted with new concrete slab • Directly over stream • Multiple commercial tenants

Structure ID	Street Address	Historic Status	Building Usage	Exterior Building Materials	Key Features
4	8085 Main St.	Local and National Historic District	Commercial	Brick Masonry	• Directly over stream • Storefront windows unique glass panel entrance • Building features impede stream conveyance during higher flows
5	8092 Main St.	Local and National Historic District	Commercial	Brick Masonry	• BFE+2 > 3 ft. above first floor elevation • Storefront windows and glass door entrance • Irreplaceable first floor contents
6	8202 Main St.	Local and National Historic District	Commercial	Stone Masonry	• BFE+2 below first floor elevation • Porch with crawl space • Utilities room under crawl space

Structure ID	Street Address	Historic Status	Building Usage	Exterior Building Materials	Key Features
7	8267 Main St.	Local and National Historic District and MHT Easement	Public	Stone Masonry/ Concrete	• Finished and occupied basement • Flooding from multiple directions and above BFE • Exterior utilities
8	8300 Main St.	Local and National Historic District and MHT Easement	Public	Wood	• BFE +2 < 3 ft. above first floor elevation • Irreplaceable historical materials • Unfinished basement • Exterior utilities
9	8344 Main St.	Local and National Historic District	Commercial	Wood Frame	• Unfinished basement • Significant portion of structure is wood frame construction • Detached duplex structure

Structure ID	Street Address	Historic Status	Building Usage	Exterior Building Materials	Key Features
10	8358 Main St.	Local and National Historic District	Commercial	Brick Masonry/ Wood Frame	• Significant part of structure is wood frame • Walkout basement with utilities that cannot be relocated
11	8398 Main St.	Local and National Historic District and MHT Easement	Public	Stone Masonry	• BFE +2 > 3 ft. above first floor elevation • Significant historical materials
12	8512 Main St.	Local and National Historic District	Residential	Wood Frame	• Significant portion of structure is wood frame • Occupied basement • Detached garage structure • Utilities in basement

Structure ID	Street Address	Historic Status	Building Usage	Exterior Building Materials	Key Features
13	8572 Main St.	Local and National Historic District	Residential	Stone Masonry/ Wood Frame	• BFE +2 < 3 ft. above first floor elevation • Flooding spilling over roadway affecting lower level • Exterior mechanical equipment
14	8600 Frederick Rd.	National Historic District	Commercial	Steel Frame and Masonry with Steel Aluminum Siding	• Mixed usage at first floor elevation • Large assets outside building • Exterior utilities
15	8602 Frederick Rd.	National Historic District	Commercial	Concrete/ Masonry	• BFE+2 > 3 ft. above first floor elevation • Slab on grade multi-unit structure • Exterior utilities

Structure ID	Street Address	Historic Status	Building Usage	Exterior Building Materials	Key Features
16	8637 & 8639 Frederick Rd.	National Historic District	Residential	Wood Frame	• BFE+2 > 3 ft. above first floor elevation • Building foundation on stream bank • Detached duplex structure • Exterior utilities

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3 OVERVIEW OF NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES

Nonstructural FRM measures reduce flood risk by modifying the characteristics of structures that are subject to flooding or modifying the behavior of people living in or near floodplains. In general, nonstructural FRM measures do not modify the characteristics of floods (depth, velocity) nor do they induce development in a floodplain that is inconsistent with reducing flood risk. Nonstructural FRM options consist both of measures that are physical: dry flood proofing, wet flood proofing, elevation of buildings, acquisition of structures, relocation of structures; and nonphysical: flood preparedness plans, flood insurance, evacuation plans, public warning systems, zoning, building codes and land use changes. Appendix A of this report contains factsheets that provide a brief description of nonstructural flood proofing measures and contain pertinent information regarding the individual performance and feasibility of each measure including: applicability, types of flood risk reduced, description of measure, advantages and disadvantages, impacts, required pre-flood actions, special considerations, and general cost information.

Initial screening of potential nonstructural FRM measures, which included input from representatives of pertinent historic preservation organizations, identified dry flood proofing, wet flood proofing, and structural elevation as the primary physical measures applicable in Ellicott City. Nonstructural flood proofing measures, similar to those recommended in this study, have been employed in similar situations across the country and have been proven to successfully reduce flood damage. They are effective for reducing both short- and long-term flood risk and flood damage and can be cost effective when compared to larger structural measures.

3.1 PASSIVE AND ACTIVE MEASURES

Nonstructural measures can be either passive or active. A *passive* measure is one that requires minimal pre-flood actions and includes flood doors and windows (dry flood proofing), wet flood proofing, and structural elevation. An *active* measure requires property owners to perform pre-flood actions in order to deploy an FRM measure, including temporary flood barriers. The number of pre-flood actions required was a major factor in the feasibility of a recommended nonstructural flood proofing measures due to limited warning times in Ellicott City, which is discussed in more detail in the subsequent sections of this report.

3.2 DRY FLOOD PROOFING

3.2.1 DESCRIPTION

Dry flood proofing consists of waterproofing the exterior of a structure up to a determined height in order to reduce the probability of flooding to the building interior. Dry flood proofing of a structure can generally provide effective flood risk management up to a height of 3-4 feet on the exterior walls, after which point the hydrostatic load on the walls may be high enough to significantly increase the risk of structural damage. Buildings may be dry flood proofed above this 3-4 foot height if a full structural analysis is performed and the walls are found to have sufficient flexural capacity. Full structural analysis should also be performed if erosive flood velocities are greater than 3 ft. /sec due to lateral/shear forces. In some cases, where necessary, sealant may be applied to exterior walls in order to make them sufficiently impermeable to resist water penetration up to the DFE. Otherwise, provision can be made for the installation of a temporary impermeable membrane around the building exterior just before a flood event begins, if there is adequate warning time. If a structure contains a basement area, it typically must be removed by filling prior to implementation of dry flood proofing measures to the first floor and above. Provisions must also be made for the closure of building openings, specifically doors and windows with a sill below the DFE. Such openings may have permanent framing installed which allows for the placement of a temporary flood shield to seal the opening in the case of a flood event, or otherwise existing doors, windows and frames may be completely replaced with structural flood proof products. Interior drainage collection systems and pumps are required to control the interior water level and collect seepage. Figure 3-1 shows a diagram of a typical dry flood proofed structure.

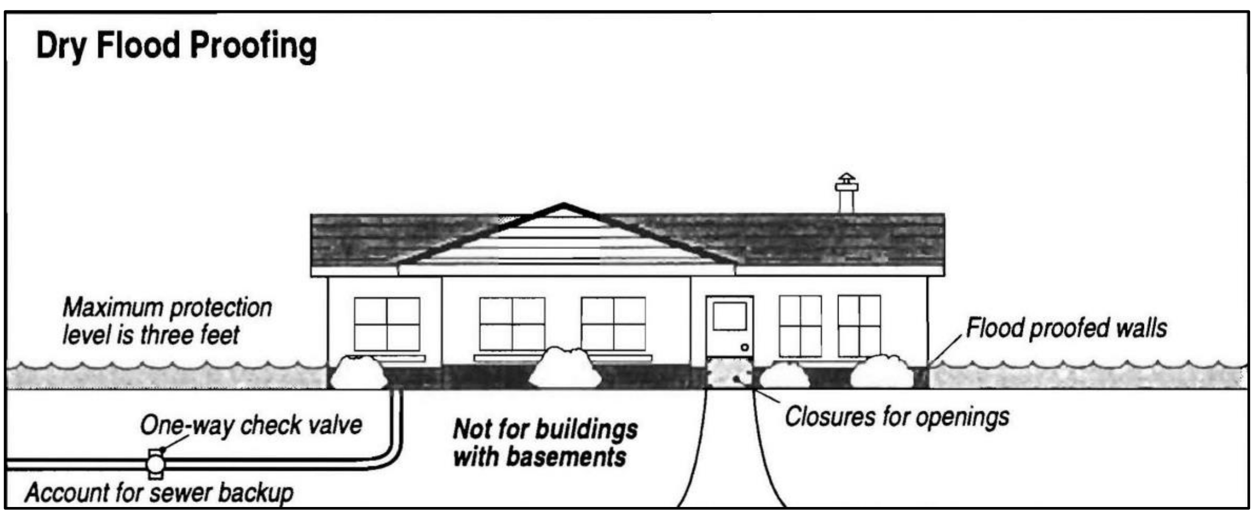
3.2.2 SUITABILITY FOR ELLICOTT CITY

Dry flood proofing is an effective nonstructural option in Ellicott City in certain applications, particularly for masonry structures where the final DFE is no greater than 3-4 feet above the finished floor elevation and flood velocities do not surpass 3 ft. / sec. Due to the short duration of flooding in Ellicott City, combined with the masonry wall construction, flood waters cannot easily penetrate through the walls; therefore, an impermeable membrane is typically not needed. Making structural improvements to sidewalks and stabilizing fill around foundations may result in dry flood proofing measures being more effective in managing higher flood velocities.

3.2.3 CHALLENGES

The challenges for dry flood proofing buildings in Ellicott City are the limited warning time (see Section 5) to implement closure barriers, maintaining historic aesthetics of structures, and, in some cases, the limited level of FRM. The number of pre-flood actions can be reduced by purchasing flood proof doors and windows that are watertight and able to resist hydrostatic force during a flood event. However, these doors are relatively expensive and, in some cases, may be difficult to implement in a way that meets the pertinent historic preservation guidelines.

Figure 3-1: Dry Flood Proofing



(Source: Federal Emergency Management Agency (FEMA))

3.3 WET FLOOD PROOFING

3.3.1 DESCRIPTION

Wet flood proofing is the process of modifying a building to allow flood waters to enter and inundate a portion of the building in order to minimize the risk of structural damage. The designed inundation area may be the sub-grade basement or crawlspace of a building, or the ground floor up to the DFE. If ceiling height permits, the interior first floor, or portions of it, may be raised, allowing for flood water to enter the structure without damaging first floor contents. Raising utilities and important building contents and equipment to higher floors above the DFE, using flood-damage-resistant materials in the building interior, and installing flood louvers or flood openings in exterior walls to equalize the hydrostatic pressure, are examples of some of the most common wet flood proofing measures. Additional provisions may be required to ensure minimal damage to the building mechanical and electrical systems in the event of a flood. Figure 3-2 shows a diagram of a typical wet flood proofed structure.

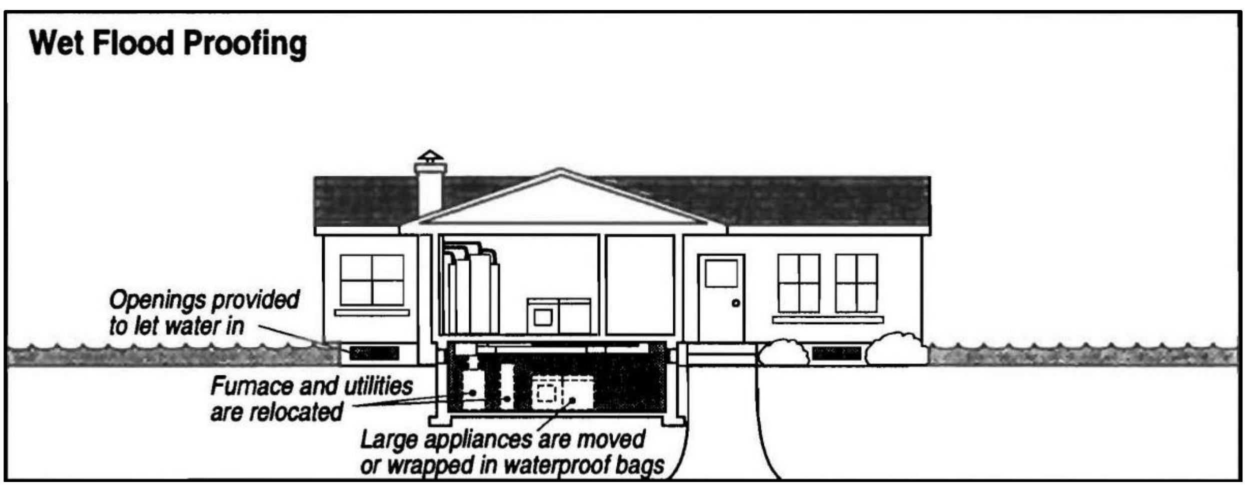
3.3.2 SUITABILITY FOR ELLICOTT CITY

Wet flood proofing is an effective nonstructural option in Ellicott City for a relatively small number of cases where structure type and first floor occupancy allow for it. The measure is very low cost, requires minimal pre-flood actions, and can be agreeable with historic preservation guidelines. Full structural analysis should also be performed if flood velocities are greater than 3 ft. /sec due to lateral/shear forces.

3.3.3 CHALLENGES

Implementation would require significant changes to interior building layout and functionality, which may not be desirable in many cases. Allowing flood waters into the structure would require all valuables and utilities to be elevated above the DFE, which may be costly depending on the original building layout. Pumping and clean-up after a flood event may also be costly.

Figure 3-2: Wet Flood Proofing



(Source: FEMA)

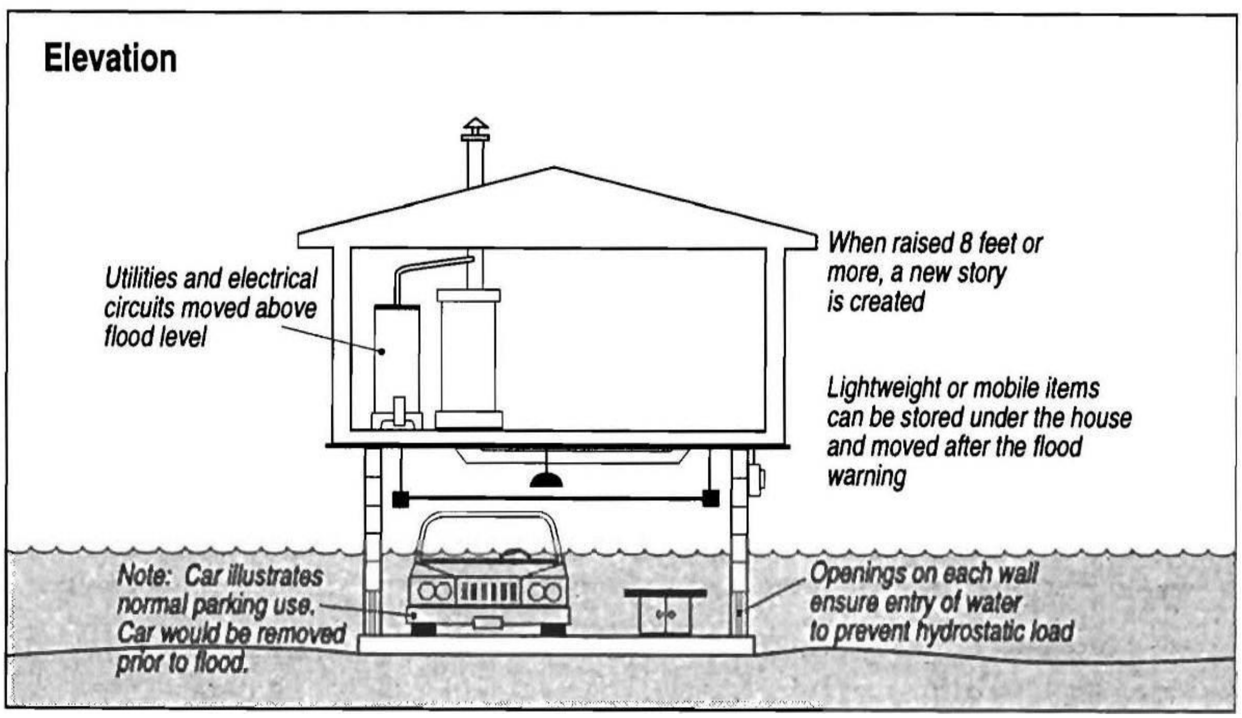
3.4 ELEVATION OF STRUCTURES

3.4.1 DESCRIPTION

Elevation involves raising flood prone buildings in place so that the lowest floor is above the DFE. The building is raised on temporary framing and set on new foundation walls, extended foundation walls, or structural fill above the DFE. For buildings that include basements or crawl spaces, the basement or crawl space can be filled in with suitable fill material, the building can be raised above the DFE, and additional utility and storage space can be added to compensate for the lost basement space. Another option for basements and crawl spaces is wet flood proofing, which would allow water to pass through without damaging the structural integrity of the building.

The primary advantage of this measure is that the risk of flooding in all flood events up to the new low opening elevation is eliminated, with minimal need for any pre- or post-flood mitigation actions. Additionally, raising the low floor elevation typically allows the property to become eligible for a reduction in flood insurance premiums. The disadvantages are that residents/tenants would need to be relocated for a period of time during construction, the relatively high cost for construction, possible impacts to the historic integrity of the building exterior, and accessibility compliance. Prior to implementing this measure, a detailed assessment of the building is required. Factors such as foundation type, soil type and bearing capacity, weight of the building, lateral forces on the building, structural condition, and height of the desired elevation above grade determine the feasibility of elevating the structure. Figure 3-3 shows a diagram of a typical elevated structure.

Figure 3-3: Elevation of Structures



(Source: FEMA)

3.4.2 SUITABILITY FOR ELLICOTT CITY

Elevation is an option on many of the detached structures in the study area, particularly those that are wood framed. However, it is not applicable in many circumstances in Ellicott City, including any structures that have shared structural walls with one or more adjacent buildings. Full structural analysis should also be performed if flood velocities are greater than 3 ft. /sec due to lateral/shear forces.

3.4.3 CHALLENGES

Although simultaneous elevation of multiple adjacent structures is technically feasible, the complication of coordination among multiple building owners is assumed to make this option difficult to implement. Compliance with the Americans with Disabilities Act (ADA) may pose a challenge related to accessibility for public buildings and businesses due to large ramps or lift additions requiring higher installation costs. Space for extended stairs and/or ramps for both residential and commercial buildings may also be limited due proximity of buildings to roadways. Another concern with elevation in Ellicott City is historic preservation. Based on input from County and State historic preservation representatives during the site visit process, the issues include consistency of new materials with existing historic materials and aesthetic consistency with surrounding structures after the elevation is complete. Close coordination with historic preservation organizations would be required to successfully elevate structures with historic significance.

3.5 RELOCATION OF BUILDINGS

3.5.1 DESCRIPTION

Relocation of buildings requires physically moving the at-risk structure. This measure achieves a high level of flood risk management when structures can be relocated from a high flood hazard area to an area that is located completely out of the floodplain. Development of relocation sites where structures could be moved to achieve the planning objectives and retain such aspects as neighborhood cohesion or cultural and historic significance can be part of any relocation project. This action removes the possibility of loss or damage from high flood events and creates a safer atmosphere.

3.5.2 SUITABILITY FOR ELLICOTT CITY

For buildings subject to high flood depths and velocities where other nonstructural flood proofing measures are not typically recommended, relocation of buildings may present the most effective option to eliminating risk of future flood damages. However, *the County has requested that USACE assess relocation of buildings as a last possible option*. This is due to historic preservation and community cohesion concerns.

3.5.3 CHALLENGES

The relocation process can be lengthy and disruptive to property owners, especially if the building houses a business. Relocation of buildings may negatively impact the historic/visual landscape of Ellicott City as described in Section 4. Also, there is limited space within the historic district where historic structures could be placed outside of the floodplain.

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4 NONSTRUCTURAL FLOOD PROOFING ASSESSMENT

4.1 STRUCTURE ASSESSMENT PROCESS

The team for the nonstructural flood proofing assessment consisted of members from USACE Baltimore District and two members of the USACE National Nonstructural Flood Proofing Committee (NFPC). Various representatives from Howard County Government including the Department of Public Works (DPW), Department of Planning and Zoning (DPZ), and Department of Inspections, Licenses, and Permits (DILP); and the Maryland Historic Trust (MHT), were present throughout the site visits, providing additional information and input for the preliminary development of nonstructural flood proofing concept alternatives.

The team conducted site visits and follow-up assessments for each structure, with the purpose of observing each structure from the exterior, interior first floor and basement, taking additional measurements and visiting with property owners. Details regarding observed structure characteristics, site conditions, site elevations, and flood elevation data were prepared for each structure and are presented in the concept sheets contained in Appendix B. The compiled information in the building concept sheets demonstrates potential flood risk and was used to develop recommendations for optimal nonstructural flood proofing measures.

The BFE+2 was used as the target for each of the flood proofing concepts. The July 30, 2016 flood elevations and velocities were used for reference. In several cases, the BFE+2 exceeds the elevation at which the included nonstructural flood proofing measures are able to manage flood risk. Particularly in the lower Main Street portion of Ellicott City, the BFE+2 regularly exceeds the first floor elevation by over 6 feet. In such cases, rather than making drastic recommendations that are far less likely to be implemented due to practicality and cost, the target elevation for nonstructural flood proofing shifted to the MEP. The highest flood elevation at which the recommended flood proofing measures are assumed to be both technically sound and economically feasible to implement is referred to as the DFE.

4.2 BUILDING CONCEPT SHEET FORMAT

The primary purpose of the building concept sheets contained in Appendix B is to identify the key building features (Table 2-1) of each structure, and describe how each of those features influences the final flood proofing recommendations. The format of the concept sheets is as follows:

FIRST PAGE:

- **General building information** including location, occupancy type, observed wall and framing materials, historic status and building photographs
- **Building schematic** showing the typical exterior wall at grade with the reference flood elevations
- **Key building features** that are particularly relevant to the flood proofing analysis and may guide the selection of flood proofing measures
- **Relevant survey and flood elevations** and the final DFE achievable through the recommended nonstructural flood proofing measures

SECOND PAGE:

- **Background information** on the building, including impact during the July 30, 2016 flood event if applicable
- **Analysis of the key building features**, describing in narrative form how the building feature and other structure or flooding characteristics suggest a particular flood proofing approach

THIRD PAGE:

- **Nonstructural flood proofing recommendations**, divided up as passive and active (non-passive) options, including a list of all the specific measures that must be implemented as a part of the overall flood proofing approach

4.3 CONSIDERATION OF PASSIVE AND ACTIVE MEASURES

Where applicable, recommendations have been divided out as passive and active options. One of the primary flood characteristics in much of Ellicott City is the possibility for very little warning time in advance of a flood event. This warning time limitation has a significant impact on the nonstructural flood proofing measures that can be expected to perform as designed, if implemented.

The clearest example of two alternative nonstructural flood proofing measures that are impacted by warning time are flood proof doors or temporary drop-in panel or stoplog closures over building entrances for dry flood proofing. Installation of flood proof doors requires replacing the door frame, hardware, and the door itself, such that the door provides FRM over the entirety or a portion of its height when closed, without any further action. For a drop-in panel or stoplog closure, the framing to hold the barrier is permanently in place, but one or more barrier pieces must be installed in order for the system to provide any benefit. Each barrier may only take minutes to install, but provision for nearby accessible storage of the barriers must be taken into consideration. Also, manpower and storage requirements may increase depending on the number of openings on the building. Factors including cost, whether the structure is residential or commercial, and the physical capabilities and availability of the building owner, may all influence whether passive flood proof doors or active temporary panel or stoplog closures are the right options for a given structure. For drop-in panels to be successful, there must be a person available immediately to install them when a flood is predicted, even during the middle of the night. Panels must also be properly stored in an accessible area of the building. Recommended pre-flood actions are provided in Section 5.

In order to provide the highest level of confidence that implemented measures will be effective in reducing flood damage as designed, the passive option is presented as the primary recommendation in most cases. However, there may be several reasons why implementation of the passive option is not feasible, including historic preservation or economic constraints. In either case, building owners are encouraged to gain a full understanding of the risks related to the specific flood characteristics of their community, the structural characteristics of their building, and the feasible flood proofing options in order to make informed decisions for managing these risks.

4.4 RECOMMENDED MEASURES

Table 4-1 summarizes the results of the nonstructural flood proofing assessment, showing the primary recommended alternatives, approximate cost of implementing primary alternatives, and how the DFE is achievable by implementing the recommended alternative compared to the initial target of the BFE+2. Appendix B contains concept sheets with detailed explanations for the selection of the primary alternatives and also provides alternate alternatives for passive and active options and associated costs.

Cost estimates represent the construction cost estimates (CCE) and were developed by USACE using a cost estimating software application called MII, a second generation of the Micro-Computer Aided Cost Estimating System (MCACES). Building elevation construction cost estimates were developed using nServo, a web-based parametric cost estimating tool supporting efficient consideration of structural elevations. These CCEs are preliminary and are based on planning level concepts. They are being provided to assist property owners in understanding the typical order of magnitude costs associated with implementing nonstructural flood proofing alternatives. CCEs do not include design costs, which vary depending on site specific conditions. Property owners considering implementation of nonstructural measures should consult with a professional Architectural Engineering (AE) firm to further investigate the structural feasibility and costs of implementing nonstructural alternatives.

Table 4-1: Summary of Results

Structure ID	Address	Usage	DFE*	BFE+ 2 ft.†	Primary Alternative	CCE‡
1	8000 Main St.	Commercial	128.3	128.8	Dry Flood Proof	$105,000
2	8044 Main St.	Commercial	130.6	134.3	Dry Flood Proof	$65,000
3	8069 Main St.	Commercial	130.1	137.6	Dry + Wet Flood Proof	$120,000
4	8085 Main St.	Commercial	129.3	139	Dry Flood Proof	$20,000
5	8092 Main St.	Commercial	135.5	140.9	Dry Flood Proof	$65,000
6	8202 Main St.	Commercial	154.9	154.2	Dry Flood Proof	$30,000
7	8267 Main St.	Public	170.1	169.5	Dry Flood Proof	$65,000
8	8300 Main St.	Public	199.0	198.5	Elevation	$115,000
9	8344 Main St.	Commercial	186.1	185.6	Elevation	$185,000
10	8358 Main St.	Commercial	187.7	187.2	Elevation	$115,000
11	8398 Main St.	Public	191.2	191.2	Elevation	$145,000
12	8512 Main St.	Residential	232.3	231.8	Elevation	$190,000
13	8572 Main St.	Residential	245.2	245.3	Dry Flood Proof	$50,000
14	8600 Frederick Rd.	Commercial	248.9	249.4	Dry + Wet Flood Proof	$145,000
15	8602 Frederick Rd.	Commercial	248.0	250.5	Wet Flood Proof	$20,000
16	8637 & 8639 Frederick Rd.	Residential	255.4	254.9	Elevation	$110,000

* *DFE: Design flood elevation refers to the target level of flood risk management that is assumed to be both technically sound and economically feasible to implement.*
† *BFE+2 ft.: Annual chance flood event plus 2 foot free board*
‡ *CCEs rounded to nearest five-thousand*

4.5 ECONOMIC ANALYSIS SUMMARY

USACE performed a preliminary economic analysis for the flood proofing recommendations to develop a benefit-to-cost ratio (BCR) for each alternative based on the reduction in future flood damages. The BCR helps to measure the cost effectiveness of a project by comparing the construction cost with the expected reduction in future flood damages, or benefits, for a 50 year[1] period of return on investment. The initial construction costs and the future estimated reduction in flood damages are annualized so that the two estimates can be compared. Damages were estimated for with- and without-project conditions by using the Hydraulic Engineering Center Flood Damage Analysis (HEC-FDA) tool, which used inputs from the McCormick Taylor modeling synthetic storm data and building content value assumptions based on industrial building codes. Actual flood damages from the 2011 and 2016 floods were not used. The model estimates flood damages from 8 different flood frequencies (from the 2-year through the 500-year) based on the depth of flooding and type of structure (commercial or residential). It is important to note that the BCRs developed using HEC-FDA only consider reduction in future damages to the building content and structure, and do not consider other important factors such as loss in business revenue, social impacts, historic preservation concerns, or manpower requirements for nonstructural flood proofing measures and associated pre-flood and post-flood actions. The BCR can be used a starting point for determining cost-effectiveness of a measure, but these factors should be heavily weighed when deciding whether or not nonstructural flood proofing should be implemented on a property in Ellicott City.

4.5.1 PASSIVE DRY FLOOD PROOFING ALTERNATIVES

Results of the preliminary economic analysis demonstrated a BCR of greater than 1 for six of the nine recommended passive dry flood proofing alternatives. Three of the nine recommended passive dry flood proofing alternatives resulted in a BCR less than 1. The favorable results can be explained by the high vulnerability of flooding throughout the study area leading to high damage estimates. Although passive dry flood proofing measures are typically more expensive (alternatives ranging between $15,000- $105,000[2] in this study), they can be effective at reducing flood damages, when applicable. Passive dry flood proofing measures have the benefit of requiring minimum pre-flood actions, which, due to the historically limited warning times, make passive measures more suitable for managing flood risk in Ellicott City. However, BCRs do not consider historic preservation standards.

4.5.2 ACTIVE DRY FLOOD PROOFING ALTERNATIVES

Results of the preliminary economic analysis demonstrated a BCR of greater than 1 for ten of the eleven recommended active dry flood proofing alternatives. One of the eleven recommended active dry flood proofing alternatives resulted in a BCR less than 1. The favorable results can be explained by the high vulnerability of flooding throughout the study area leading to high damage estimates. Active dry flood proofing measures are typically less expensive than passive dry flood

[1] Standard USACE period of return on investment.
[2] Highest cost was $325,000 for 8600 Frederick Road. However, this structure was an outlier, due its usage and size.

proofing measures (alternatives ranging between $10,000- $205,000 in this study) and can be effective at reducing flood damages, when applicable. However, BCRs do not consider manpower for pre-flood action, which, due to the historically limited warning times, make active dry flood proofing measures less suitable for managing flood risk in Ellicott City.

4.5.3 WET FLOOD PROOFING ALTERNATIVES

Results of the preliminary economic analysis demonstrated a BCR of greater than 1 for four of the four recommended wet flood proofing alternatives. Recommended wet flood proofing alternatives never resulted in BCRs less than 1. The favorable results can be explained by the high vulnerability of flooding throughout the study area leading to high damage estimates. Wet flood proofing measures are typically less expensive than dry flood proofing measures (alternatives ranging between $15,000- $25,000 in this study) and can be effective at reducing flood damages, when applicable. However, BCRs do not consider manpower and resources required to store valuables above the DFE.

4.5.4 STRUCTURAL ELEVATION ALTERNATIVES

Results of the preliminary economic analysis demonstrated a BCR of less than 1 for six of the six recommended structural elevation alternatives. The recommended structural elevation alternatives never resulted in a BCR greater than 1. The unfavorable results can be explained by the high costs of elevating structures in relation to damages reduced from flooding. Structural elevations are typically more expensive than dry flood proofing and wet flood proofing measures (alternatives ranging between $110,000 -$195,000 in this study). However, structural elevations are effective at reducing flood risk due to first floor being elevated above the BFE+2 ft. BCRs do not consider historic preservation impacts of elevating structures. Another variable that is not factored into the BCRs is socio-economic impacts of being displaced from the building during the elevation period.

4.6 HISTORIC PRESERVATION CONSIDERATIONS

The majority of the study area contains structures that are in the National Register of Historic Places, designation established in 1978. Within these same boundaries are also buildings located in Local Historic District of Ellicott City, designation established in 1974. The Maryland Historical Trust holds a preservation easement for some of the County-owned structures. These historic designations drive design standards for exterior modifications. It is the responsibility of property owners to know where their structures lie within these boundaries.

Staff from both DPZ and MHT were briefed on the recommended measures for the 16 sample buildings and general recommendations and special considerations are provided below on how measures could potentially be implemented in the future. When applicable, property owners should consult the Historic District Design Guidelines and closely coordinate with Government agencies, like DPZ, if modifications to building exteriors are desired.

Buildings in the National Register of Historic Places: "The National Register listing does not impose any regulations or design requirements on property owners unless the owner applies for and accepts tax or funding benefits." Property owners interested in implementing nonstructural flood proofing measures to structures in the National Register of Historic Places are subject to rules/guidelines in the Secretary of Interior's Standards for Rehabilitation of Historic Properties if *federal or state funding is being used to modify the exterior of a building (*Howard County, 1998). Approval for a project would require submittal of an application, along with detailed designs and development plans, to MHT prior to commencement of work. Throughout the application process, it is recommended that the property owner coordinate closely with MHT and maintain transparency with regards to plans and specifications. At the time of submitting an application, the property owner may also work with the DPZ, who is the administrator to the Howard County Preservation Commission[3], and MHT to apply for the Historic Tax Credit per Sec. 20.112 of the Howard County Code of Ordinances (Howard County, 2017).

Buildings in the Ellicott City Local Historic District: Property owners interested in implementing nonstructural flood proofing measures to structures in the Ellicott City Local Historic District are subject to rules/guidelines in the Ellicott City Historic District Design Guidelines, if they are seeking to modify the exterior of the building (Howard County, 1998). A property owner seeking approval for a project would submit an application, along with detailed designs and development plans to DPZ, who is the administrator to the Howard County Historic Preservation Commission, in order to obtain a Certificate of Approval (COA), which is mandatory before construction. Throughout the application process, it is recommended that the property owner coordinate closely with the DPZ staff and maintain transparency with regards to plans and specifications. At the time of application submission of a COA, the property owner may also work DPZ staff and MHT to apply for the Historic Tax Credit per Sec. 20.112 of the Howard County Code of Ordinances (Howard County, 2017).

Buildings in MHT Easements: Property owners interested in implementing nonstructural flood proofing measures to structures encumbered by a preservation easement held by MHT are subject to the terms of the Deed of Easement and must comply with the Secretary of Interior's Standards for the Treatment of Historic Properties. A property owner seeking approval for a project would submit an Easement Program Change/Alteration application to MHT for prior review and approval, along with detailed designs and development plans. A property encumbered by a preservation easement with MHT may also be located within a local historic district. In that case, a property owner would also submit an application to the Howard County Historic Preservation Commission for prior review and approval.

4.6.1 NONSTRUCTURAL FLOOD PROOFING IN HISTORIC AREAS

The typical recommendation for any modifications to a historic building is to minimize changes to the exterior and provide the reviewing historic preservation entity detailed information regarding proposed changes to the structure (architectural drawings, details, renderings, product sheets and specifications) during the approval process. The level of detail provided in supporting documentation may heavily influence the speed and effectiveness of the review process. If

[3] The Historic Preservation Commission is a County Executive appointed Board made up of volunteer Howard County Citizens who serve 5 year terms. The Commission is supported by the staff of DPZ, which manages all inquiries and application submittals.

possible, exterior modifications to the building should be done in a way that is least invasive to the original aesthetics of the building. Property owners should work with product and third party manufacturers to ensure that nonstructural flood proofing measures match original building materials and detailing as closely as possible. The following information below includes suggested best practices and special considerations for implementing nonstructural flood proofing measures on historic structures but may not substitute Ellicott City Historic District Design Guidance when seeking approval for projects. Property owners should always coordinate closely with the DPZ and/or MHT when considering exterior changes to historic structures.

Passive Dry Flood Proofing Measures- Flood Doors and Windows:

Replacement of historic doors/windows with flood doors/windows may depend on whether the existing door/window is considered historic, or original to the construction of the building. If the door/window is the original door/window placed during first construction of the building, flood doors/windows may not be likely options. If the historic door/window is not visible from the main street, it is more likely that the door/window replacement be allowed. Replacement of historic door/window framing, especially if it has specific architectural detailing, may not be appropriate for meeting Historic District Design Guidelines, so working closely with DPZ and/or MHT to determine the historic significance of the framing is recommended.

Active Dry Flood Proofing Measures- Temporary Barriers:

Installation of temporary barriers may depend on how they would be mounted on the building due to concerns over damage to historic materials. The less obvious the mounting bracket in the door/window frame, the more appropriate it is for installation within the Historic District. Flood barriers also have a better chance of approval if they are applied to doors and window facing away from the main street and are not visible to the public.

Wet Flood Proofing Measures:

It is recommended that flood louvers/flood openings be mounted in a non-historic portion of a building whenever possible. If they must be mounted on a historic portion of the building, the impact to the historical aesthetic must be minimized as much as possible. The property owner should work with the manufacturer to see if there is the possibility of coating the flood louver/opening to match the existing aesthetic of the building.

Building Elevations:

Structural elevations in a Historic District are dependent on the desired height of elevation. Elevating too high may have an adverse impact on the building's context, how it relates to the landscape, and its location on the property and to its neighbors. Impacts may be somewhat lessened by plantings, creative grading, or extending the building material of the first floor down to cover a foot or so of the foundation to make the elevation appear less drastic. Elevation can also alter the streetscape, especially if the rest of the houses along the street are all at the same height. On streets where houses are at different heights, this approach lessens the visual impact of an elevated structure. Some historic districts are protected in the community's zoning ordinance by a historic district overlay, which may limit building heights.

Relocation:

Relocation severs the connection between an historic building and its original context. The relationship of a building to its context involves how it sits on the landscape, the landscape itself, its relationship to any outbuildings, how it fits into a neighborhood, etc. Moving buildings from within neighborhoods creates "holes" which alter the streetscape rhythm and degrade the appearance of the historic district. However, relocation may be allowed if done sensitively and relocated to a similar context, placed in a similar location and orientation on its new lot, etc.

4.7 NATIONAL TESTING AND CERTIFICATION PROGRAM

The National Flood Barrier Testing and Certification Program has been developed by the Association of State Flood Plain Managers (ASFPM) in collaboration with Factory Mutual (FM) Approvals and USACE. The program provides rigorous unbiased testing of commercially-available temporary barrier and closure device products, among other products to evaluate their material properties, manufacturing consistency, and ability to resist hydrostatic and hydrodynamic loads. More information on the program can be found at http://nationalfloodbarrier.org/.

Ellicott City building owners considering implementation of temporary barriers and closure device products are encouraged to use certified products, in order to minimize risk that products will fail to perform as designed when they are needed the most. In any case, particular attention should be paid to the rigor of testing protocols performed on any flood proofing product that is being considered for implementation, whether certified by the National Flood Barrier Testing and Certification Program or otherwise. It should be noted, however, that during the time of this report, none of the certified barriers have “historic” facades. Property owners considering implementation of flood proofing products should consult the Historic Preservation Commission and the product vendor prior to purchase.

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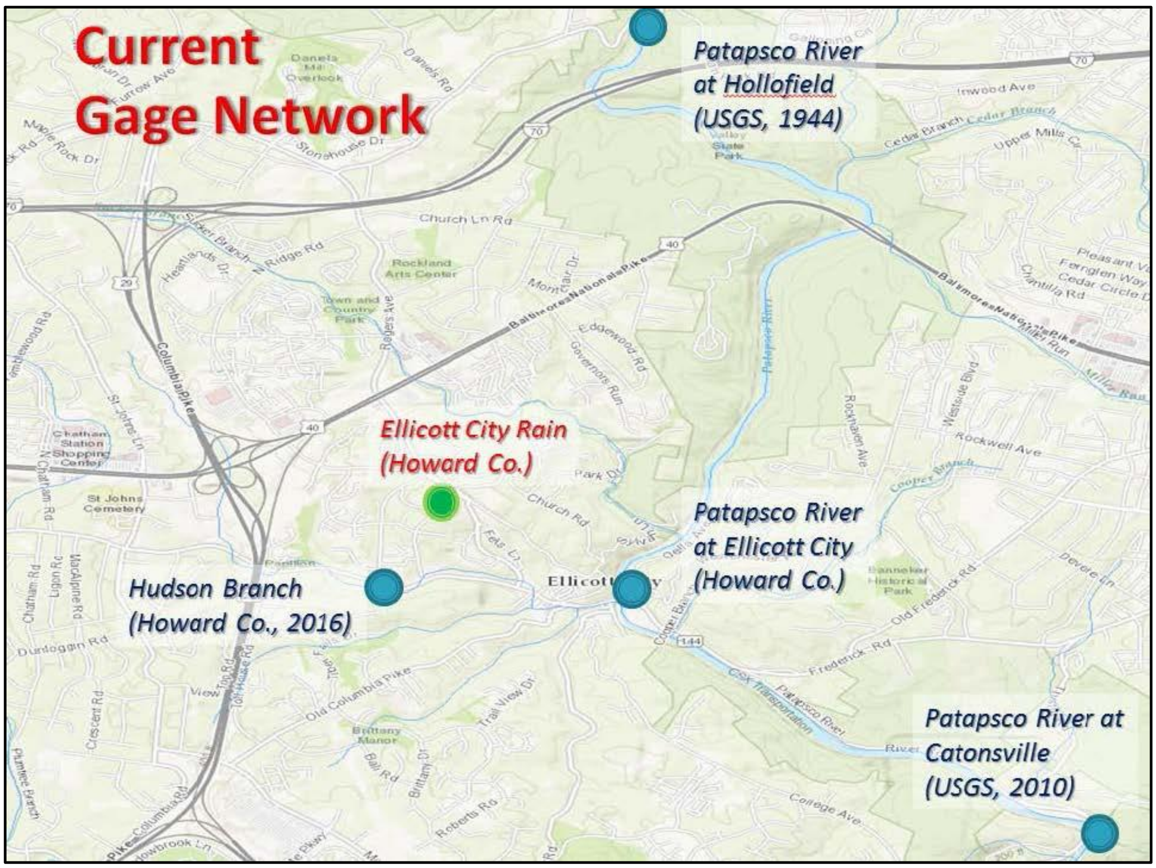
5 FLOOD WARNING AND FLOOD ACTION PLAN

5.1 FLOOD WARNING TIME

Ellicott City is at risk of flash flooding. In addition to flooding from the Patapsco River, it is also impacted by the Tiber Hudson Branch, Cat Rock Run, Autumn Hill Branch, and New Cut Branch. According to the NWS, the extreme flooding in July 2016 was likely the combination of regional geography, urbanization, and the intense short duration rainfall. NWS uses information from several rain and stream gages (Figure 5-1), and other computer models to forecast flood potential; however, there is limited warning time for residents, business owners and visitors to take action before flooding occurs.

Figure 5-1: Current Gage Network in Study Area Vicinity



(Source: NWS)

According to NWS, in July 2016, 5.92 inches of rain fell in 2 hours. The time the river took to peak from low flow was 1 hour and 45 minutes. NWS issued a flood warning at 7:18 pm and the flooding began at 8:05 pm; therefore, the warning time was only 47 minutes. Prior to the flood, NWS recognized the potential for extremely heavy rainfall somewhere in the region based on computer model guidance; however, this guidance is not sophisticated enough to pinpoint a specific location. The uncertainty in location led to a lack of confidence in flood potential until a couple hours before the flooding began. The NWS uses a "ready-set-go" approach to flood prediction and alerting. If there is 50% confidence in flood occurrence, a Flood Watch is issued. If confidence increases to 80%, a Flood (or Flash Flood) Warning is issued. Note, it is possible for confidence to rapidly increase, meaning that a watch does not necessarily precede a warning. In the 2011 flood, 3.64 inches of rain fell in 3 hours. The time the river took to peak from low flow was 2 hours and 15 minutes. NWS issued a flood warning at 11:33 am and the flooding began at 1:18 pm; therefore, the warning time was only 105 minutes (1.75 hours).

The limited amount of warning time on July 30, 2016, would not have been adequate for property owners to take any considerable actions for reducing their flood risk such as installing flood barriers on doors and windows. However, the 2011 warning time could have allowed people to take some minimal actions prior to evacuating.

Although Howard County, NWS and other stakeholders are continuing to investigate advances in models and other weather prediction techniques, the ability to predict flash flooding in this area with ample warning time and accuracy will continue to be a challenge. Residents and business owners should be vigilant in watching weather reports if any chance of significant rain is in the forecast and they should have a flood action plan in place.

5.2 FLOOD ACTION PLAN

Based on discussions with Howard County, NWS and USGS, the best recommendation for people living and working in the Ellicott City is to ensure that they have Wireless Emergency Alerts activated on their phones, which will ensure receipt of all Flash Flood Warnings. Since other types of alerts can be issued by the NWS, such as Flood Watches or Flood Warnings, people should consider signing up with county-provided or private sources of weather information to receive these types of alerts as push notifications on their phones. Utilizing the NOAA All-Hazards Alert Radio should also be considered. The following subsections provide recommended pre-flood actions for various flood proofing measures. However, life safety is paramount and evacuation outside of the flood risk area should always be considered as first priority.

5.2.1 PASSIVE MEASURES

Due to the limited flood warning time in Ellicott City, passive nonstructural flood proofing measures, which require minimal pre-flood actions, are preferred over active measures. Below are typical pre-flood actions associated with various passive measures:

Dry Flood Proofing- Flood Proof Doors/Windows:

- *General*
    - Elevate valuables to a minimum elevation above the BFE (on tables, shelves, or to higher floors). If the FRM measure fails during the flood event, this action prevents additional damages to valuable property.
- *Upon Receiving Flood Watch from NWS*
    - Ensure all flood proof doors/windows are closed to prevent flood water front entering building.
    - Ensure generators and skimmer/sump pumps are ready for deployment to pump out interior flooding from seepage during the storm event.

        - Assume 15 minutes/generator unit, if stored properly in the vicinity of the building opening.
    - Make plans to potentially shut off electricity and evacuate building and flood zone.
- *Upon Receiving Flood Warning from NWS*
    - Evacuate building (recommended if there is adequate time to safely evacuate) or climb to higher ground, or higher levels of the building (at the discretion of owner).

<u>Wet Flood Proofing:</u>

- *General*
    - Elevate valuables to a minimum elevation above the BFE (on tables, shelves, or to higher floors). This action prevents additional damages to valuable property.
    - Ensure that flood vents are not clogged with debris
- *Upon Receiving Flood Watch from NWS*
    - Make plans to potentially shut off electricity and evacuate building and flood zone.
- *Upon Receiving Flood Warning from NWS*
    - Evacuate building (recommended if there is adequate time to safely evacuate) or climb to higher ground, or higher levels of the building (at the discretion of owner)

<u>Elevation:</u>

- *General*
    - Elevate valuables to a minimum elevation above the BFE (on tables, shelves, or to higher floors).
    - Ensure that flood vents are not clogged with debris, if basement/crawl space is wet flood proofed
- *Upon Receiving Flood Watch from NWS*
    - Make plans to potentially shut off electricity and evacuate building and flood zone
- *Upon Receiving Flood Warning from NWS*
    - Evacuate building (recommended if there is adequate time to safely evacuate) or climb to higher ground, or higher levels of the building (at the discretion of owner)

5.2.2 ACTIVE MEASURES

Active measures often provide the benefit of being less expensive than passive measures. However, they also require varying amounts of manpower and strategic storage. Property owners deciding to use temporary flood panels must keep panels near the door or window where they must be placed, have the necessary tools, supplies and manpower to install them readily available.

<u>Dry Flood Proofing- Temporary Flood Panels:</u>

- *General:*
    - Elevate valuables to a minimum elevation above the BFE (on tables, shelves, or to higher floors). If the FRM measure fails during the flood event, this action prevents additional damages to valuable property.
    - Store door/window panels near (within the building) opening
    - Practice installing temporary flood panels twice each year
- *Upon Receiving Flood Watch:*
    - Ensure generators and skimmer/sump pumps are ready for deployment to pump out interior flooding from seepage during the storm event.

        - Assume 15 minutes/generator unit if stored properly in the vicinity of the building opening.
    - Install temporary door panels on doorframe[4]
        - Assume up to 15 minutes for single door frame
            - Storage must be within the building and performed by an able bodied adult.
        - Assume up to 30 minutes for double door frame
            - Storage must be within the building and performed by an able bodied adult.
        - Assume up to 30 minutes for single car garage
            - Storage must be within the building and performed by 2 able bodied adults.
        - Assume up to 60 minutes for two car garage
            - Storage must be within the building and performed by 3 able bodied adults.
    - Make plans to potentially shut off electricity and evacuate building and flood zone
- *Upon Receiving Flood Warning from NWS*
    - Evacuate building (recommended if there is adequate time to safely evacuate) or climb to higher ground, or higher levels of the building (at the discretion of owner).

5.2.3 ADDITIONAL RESOURCES

Federal agencies such as NOAA, NWS, USACE and FEMA provide online resources for property owners to learn more about flood disaster readiness:

FEMA:

FEMA provides advice on flood preparedness on its website:

- Visit http://www.ready.gov/floods

Maryland Silver Jackets:

The Maryland Silver Jackets interagency team is comprised of local, state, and federal stakeholders and facilitates collaborative solutions to state flood risk priorities. Upon request, the team can conduct flood proofing workshops to better inform the public on flood risk and flood proofing solutions.

- Visit https://silverjackets.nfrmp.us/State-Teams/Maryland

NOAA and NWS:

NWS should be monitored (NOAA Weather Radio, website) when storms are approaching. NWS homepage for text forecasts, warnings, and links to other information:

- Visit http://www.nws.noaa.gov

The National Hurricane Center (NHC) website can be used to track active tropical systems:

- Visit http://www.nhc.noaa.gov

[4] Estimated time frames provided through consultation of USACE National Flood Proofing Committee members. Times may vary depending on specific situation. Proper storage must be provided and installation performed by able bodied adults.

For information regarding current watches, warnings, and alerts:

- Visit http://www.nws.noaa.gov/alerts

USACE:

The USACE NFPC website provides links to numerous flood proofing and flood damage reduction publications:

- Visit http://www.usace.army.mil/Missions/Civil-Works/Project-Planning/nfpc/

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6 CONCLUSION

This report provides a resource for residents, businesses and property owners in Ellicott City and throughout Howard County to understand the nonstructural flood proofing options that may be suitable for them, and provides a starting point for those interested in pursuing implementation of such measures. Using 16 sample buildings, a narrative analysis and recommendations linked to specific building characteristics and key features are presented to provide a more complete understanding of the primary considerations behind selecting nonstructural flood proofing measures. The report includes measures such as dry flood proofing, wet flood proofing, building elevation, and relocation. Preliminary construction cost estimates were developed and a preliminary economic assessment was conducted to compare potential project costs and benefits based on damages to building structure and contents.

The report also provides recommended pre-flood actions associated with nonstructural flood proofing measures, which should be considered by property owners based on available manpower and storage space available on the property.

Property owners considering implementation of nonstructural measures should consult with a professional Architectural Engineering (AE) firm to further investigate the structural feasibility and costs of implementing nonstructural flood proofing measures. Proper coordination with the Howard County Preservation Commission and Maryland Historical Trust should also be considered, when applicable.

Nonstructural flood proofing measures can provide an effective option for reducing flood risk and increasing resilience across a wide range of flood events.

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7 GLOSSARY

100-year flood – The 1% annual chance exceedance expressed as a return period.

Annual chance exceedance flood – The flood that has a (stated percent - %) chance of being exceeded in any given year, such as the 1% annual chance exceedance (ACE) flood.

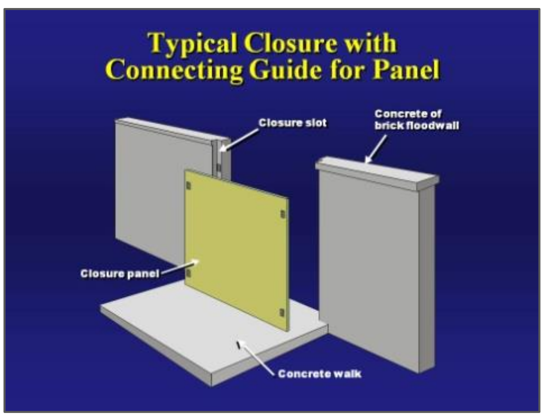
Breakaway Panel – A panel designed and constructed to collapse under water loads without causing collapse, displacement, or other structural damage to a structure's bearing walls or supporting foundation system.

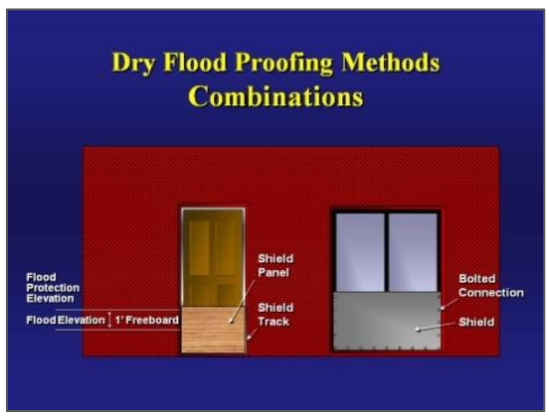
Base Flood Elevation (BFE) – Equivalent to elevation of flood waters for a 100-year (1% annual chance) event.

Base Flood Elevation plus 2 ft. of free board (BFE+2) - Equivalent to the elevation of flood waters for a 100-year (1% annual chance) event plus 2 ft. of free board.

Closures / Shields – Closures, shown in Figure 7-1, act to close the openings in flood barriers and prevent water from entering. They can be of a variety of shapes, sizes, and materials. In some cases closures are permanently attached using hinges so that they can remain open when there is not a flood threat. They may also be portable and stored in a convenient location to slip into place when a flood threatens.

Figure 7-1: Closure/ Shields





Dry Flood Proofing – Dry flood proofing involves temporarily or permanently sealing building walls with waterproofing compounds, impermeable sheeting, or other materials to prevent the entry of floodwaters into damageable structures. Dry flood proofing, as shown in Figures 7-2 and 7-3, are applicable in areas of shallow, low velocity flooding

Figure 7-2: Permanent Dry Flood Proofing

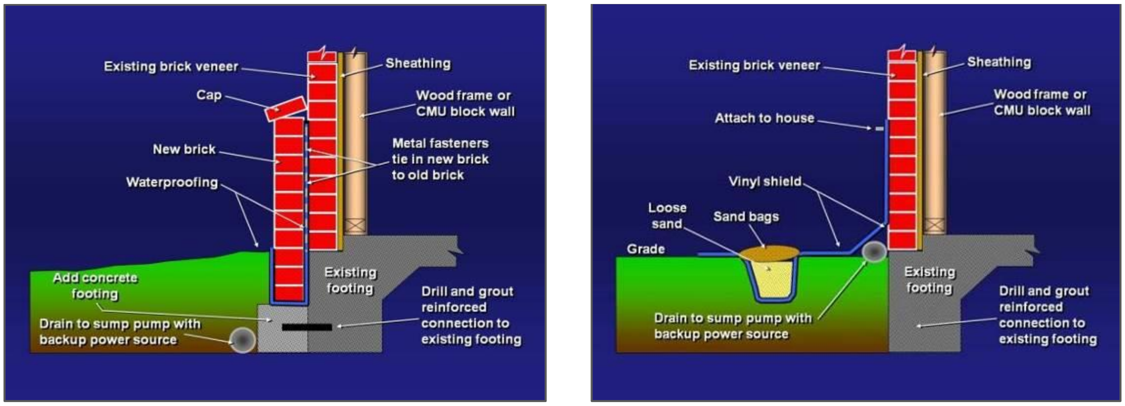


Figure 7-3: Temporary Dry Flood Proofing

Elevation – Elevation involves raising the buildings in place to reduce frequency and/or depth of flooding during high-water events. Elevation, as shown in Figure 7-4, can be done on fill, foundation walls, piers, piles, posts or columns. Selection of proper elevation method depends on flood characteristics such as flood depth or velocity, and condition of the structure.

Figure 7-4: Elevation

Federal Emergency Management Agency (FEMA) – The agency within the Emergency Preparedness and Response Directorate of the U.S. Department of Homeland Security. FEMA facilitates coordination of Federal dam safety programs and administers the National Flood Insurance Program (NFIP) and several flood mitigation planning and grant programs.

FIRM – Flood Insurance Rate Map, a product of the Federal Emergency Management Agency used to determine flood risk and insurance rates.

Flood - A flood is an overflow of water that submerges land or structures that are normally dry.

Flood Insurance – Flood insurance provides insurance to assist in recovery from a flood event. Typically not included with homeowner insurance policy.

Flood Louver / Flood Vent/ Flood Openings – Flood louvers / flood vents are a permanent opening in a wall designed to allow unobstructed passage of water (automatically) in and out of a structure thereby preventing water pressure buildup (hydrostatic pressure) that can damage or destroy foundations and bearing walls.

Flood Risk - The likelihood and consequences that may arise from flood event.

Flood Risk Management – Federal and non-Federal policies and programs for managing flood risk. This includes measures that reduce the flood hazard as well as measures that reduce the exposure and vulnerability of persons and property.

Flood Risk Management Measures - These measures include implementation of reservoirs, detention storage, channels, diversions, levees, interior drainage systems, flood-proofing, levee raising, relocation of buildings/communities, and flood warning and emergency preparedness actions. It also includes policies and programs intended to inform and to influence the decisions made by Federal, state, and local government agencies, individuals, businesses and communities in their choice of flood risk reduction measures and to locate assets in floodplain.

Flood-frequency – A graph, table, or single tabulation showing the relationship of the flood variable of interest (peak flow, peak stage, 3-hour volume, etc.) to the probability of the variable being exceeded in any given year.

Foundation Vents – Foundation vents are permanent openings in foundation walls ventilation and unrestricted passage of air for ventilation of the crawl space. In wet flood proofing applications, additional foundation vents may be required to release air pressure changes caused by rising/falling water in confined spaces (crawlspace).

Lowest Adjacent Grade (LAG) – The lowest ground elevation adjacent to the structure.

MCACES/MII - Micro-Computer Aided Cost Estimating System is a detailed cost estimating software application. MII is the second generation of MCACES. MII provides an integrated cost estimating system (software and databases) that meets the U.S. Army Corps of Engineers (USACE) requirements for preparing cost estimates.

National Flood Insurance Program (NFIP) – Federal program under which flood-prone areas are identified and flood insurance is made available to the owners of the property in participating communities.

Nonstructural Measures – Flood risk management measures that reduce the consequences of a flood event to a structure.

National Nonstructural Flood Proofing Committee (NFPC) - The National Nonstructural Flood Proofing Committee functions under the general direction of the Chief, Planning Community of Practice, Directorate of Civil Works, and HQUSACE. The objectives of the NFPC are to:

- Promote the development and use of all nonstructural flood risk reduction measures.
- Risk expertise on all aspects of nonstructural flood risk reduction and associated opportunities.
- Disseminate nonstructural flood reduction information
- Partner with Planning Centers of Expertise in all aspects of nonstructural flood risk reduction and associated opportunities.
- Provide leadership in all aspects of floodplain management

nServo- is a web-based parametric cost estimating tool supporting efficient consideration of non-structural alternatives. The tool drastically reduces the estimating effort by modeling the required scope and quantities from a handful of user inputs and applying appropriate MII-developed unit costs. This estimate methodology is consistent with current cost guidance and being coordinated through the Cost Engineering Directory of Expertise.

Probability (likelihood) – Likelihood is a measure of the chance, or degree of belief that a particular outcome or consequence will occur. A probability provides a quantitative description of the likelihood of occurrence of a particular event.

Relocation- involves moving the structure to another location away from flood hazards. Relocation is the most dependable method of protection and provides the benefit of use of the evacuated floodplain.

Return period – Alternate term 'recurrence interval.' The return period is the average time interval, usually expressed in years, between occurrences of an event of a certain magnitude. The return period is often computed as the reciprocal of the annual chance exceedance.

Risk– Measure of the probability and severity of undesirable consequences.

Structural Measures– Flood risk management measures such as dams, levees, and floodwalls focused on reducing flood hazard.

Uncertainty – Used to describe any situations without sureness, whether or not described by a probability distribution.

Wet Flood Proofing- measures that allow floodwater to enter the structure. Vulnerable, items such as utilities, appliances and furnaces are relocated or waterproofed to higher locations. By allowing floodwater to enter the structure hydrostatic forces on the inside and outside of the structure can be equalized reducing the risk of structural damage.

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APPENDIX A:

NONSTRUCTURAL FLOOD RISK MANAGEMENT MEASURES
FACTSHEETS

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Nonstructural Flood Risk Management Measures: Dry Flood Proofing

Image Source: FEMA

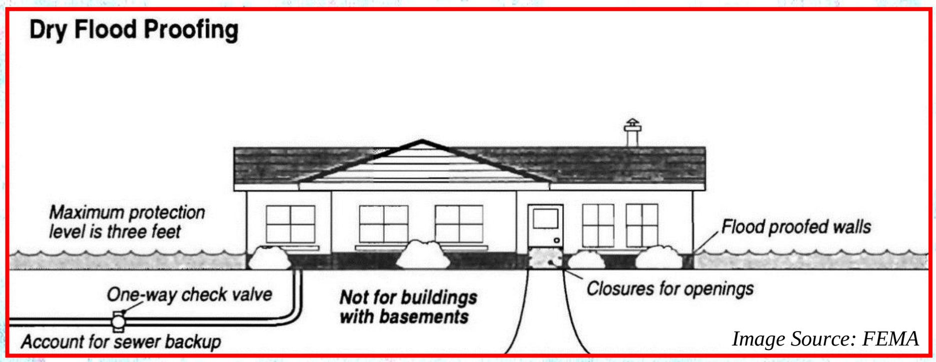


Image Source: FEMA

APPLICABILITY:

Dry flood proofing is generally applicable to any building that does not have a basement or crawl spaces, has substantially impermeable walls, and has walls and a foundation that are strong enough to resist a hydrostatic load up to the flood proofing height and lateral/shear loads from fast moving flood waters. Buildings with concrete or masonry exterior walls are the best candidates for dry flood proofing. Conventionally framed buildings typically lack sufficient strength to resist the hydrostatic load and are difficult to waterproof, which may lead to further moisture control issues in the structure. Dry flood proofing is not recommended for Coastal V-zone. It is generally applicable for flood depths of 3-4 feet of flooding and flood velocities less than 3 ft. /s.

TYPES OF FLOODING MITIGATED:

1. Coastal/Storm Surge
2. Riverine
3. Stormwater

DESCRIPTION:

Dry flood proofing consists of waterproofing a structure up to a design depth to reduce the probability that the building interior will be inundated. Dry flood proofing can generally manage flood risk up to a height of 3-4 feet on the exterior walls, after which point the hydrostatic load on the walls may be sufficiently high enough to cause structural damage. Buildings may be dry flood proofed above the 3 foot line if a full structural analysis is performed and the walls are found to have sufficient strength. Full structural analysis should also be performed if flood velocities are greater than 3 ft. /sec due to lateral/shear forces. Where necessary, sealant can be applied to exterior walls in order to make them sufficiently impermeable to resist water penetration up to the design flood risk management level. Otherwise, provisions can be made for the installation of a temporary impermeable membrane around the building exterior just before a flood event begins. Provisions must also be made for the closure of building openings, specifically doors and any windows with a sill below the design flood protection level. Such openings may have permanent framing installed which allows for the placement of a temporary flood shield to seal the opening in the case of a flood event. Interior drainage collection systems and pumps are required to control the interior water level and collect seepage.

Nonstructural Flood Risk Management Measures: Dry Flood Proofing

ADVANTAGES:

- Relatively low cost
- Does not require additional land
- Does not modify floodplain
- Does not increase flood levels on adjacent properties

VS

DISADVANTAGES:

- Building must be in good condition
- Often requires human intervention and adequate warning
- Ongoing maintenance required
- May not be feasible for adjoining structures

IMPACTS:

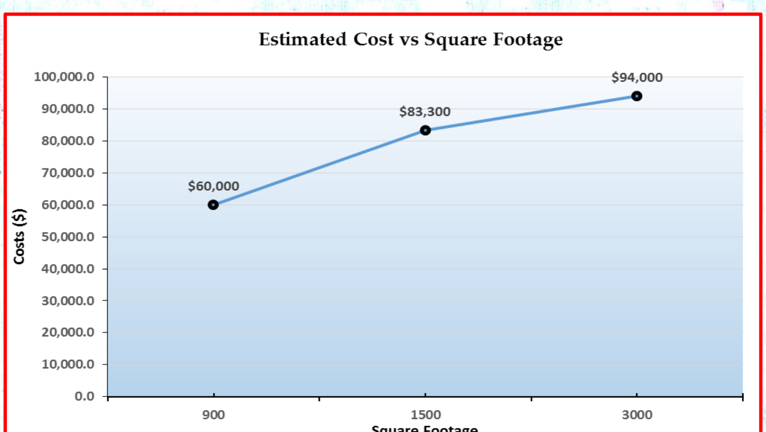
Dry flood proofing methods do not affect the hydrology of the floodplain, and therefore cause minimal environmental impact. If proper inspections of structural condition are not performed, a building that has been dry flood proofed has an increased risk of incurring structural damage in a flood event.

PRE-FLOOD ACTIONS:

Dry flood proofing may require placement of shields over building openings such as doors and windows that extend below the flood proofed elevation, and in some cases, application of a waterproof membrane over the bottom 3-4 feet of exterior wall around the full perimeter of the building. An action plan must be in place to assign responsibility for completing pre-flood actions and to ensure that the proper personnel are trained and practiced in the storage, installation, and maintenance of the required elements. Buildings should be evacuated prior to flood event.

SPECIAL CONSIDERATIONS:

Preserve structural integrity by ensuring that pooling does not occur on the dry side of flood proofing barrier. Incorporation of sump pump (skimmer style) on protected side is recommended. Preservation of integrity and aesthetics of historic buildings must be considered.



$$ COSTS: $$

- General estimated costs estimates developed using the following dimensions:
  - 900 square feet (6 window closures)
  - 1,500 square feet (6 window closures)
  - 3,000 square feet (6 window closures)
- Costs vary based on project size and location.

Nonstructural Flood Risk Management Measures: Wet Flood Proofing

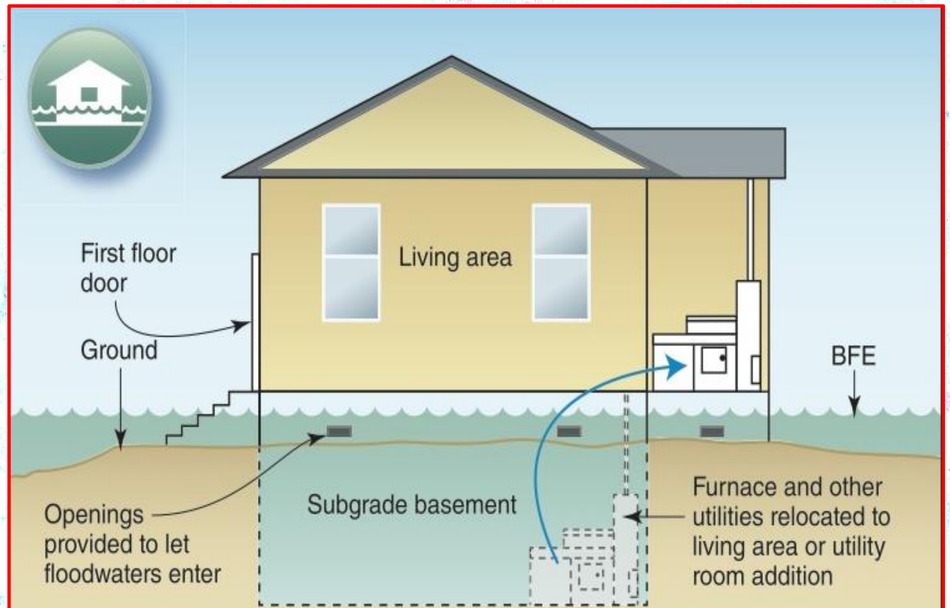
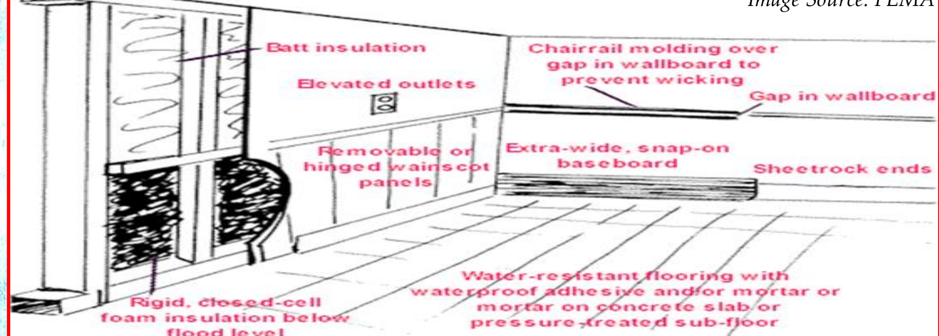


Image Source: FEMA

Image Source: FEMA



APPLICABILITY:

Wet flood proofing is applicable in structures that have an uninhabited basement, crawlspace, or other subgrade portion of the building from which all important equipment or other building contents can be relocated. Concrete or masonry construction is the most viable candidate, due to resistance to moisture damage. Depending on the duration of the design flood, other building types may also be candidates for wet flood proofing, as long as the resistance of the structure to water damage has been assessed.

TYPES OF FLOODING MITIGATED:

1. **Coastal/ Storm Surge**
2. **Riverine**
3. **Stormwater**

DESCRIPTION:

Wet flood proofing is the process of modifying a building to allow flood waters to enter and inundate a portion of the building to minimize the risk of structural damage. The designed inundation area may be the subgrade basement of a building, or otherwise the ground floor up to the design flood elevation. Raising utilities and important building contents and equipment to higher floors above the design flood elevation, using flood damage-resistant materials in the building interior, and installing flood openings in foundation walls to equalize the hydrostatic pressure are examples of some of the most common wet flood proofing measures. Additional provisions may be required to ensure minimal damage to the building mechanical and electrical systems in the event of a flood. A pumping system may also be put in place to remove water from inundated areas of the building after the event. In some cases, additional anchoring of the building to the foundation must be designed as a part of the wet flood proofing measures.

Nonstructural Flood Risk Management Measures: Wet Flood Proofing

ADVANTAGES:

- Typically low cost
- Allows internal and external hydrostatic pressures to equalize, lessening the loads on walls and floors.

VS

DISADVANTAGES:

- Allows water into structure
- May require extensive cleanup
- Pumping floodwaters out too soon after a flood may lead to structural damage.
- Ongoing maintenance required
- May not minimize the potential damage from high-velocity flood flow and wave action.

IMPACTS:

Wet flood proofing methods do not affect the hydrology of the floodplain, and therefore cause no environmental impact. May impact historic aesthetic of building.

PRE-FLOOD ACTIONS:

The extent of pre-flood actions in a wet flood proofed building depend on the specific measures necessary. In cases where a portion of the interior space below the design flood elevation is occupied, action may need to be taken to elevate or remove important electronics or other building contents in that space. The designed inundation spaces of a wet flood proofed structure should be used to minimize the amount of pre-flood action required. Structure must be evacuated prior to flooding event.

SPECIAL CONSIDERATIONS:

Need to consider relocation of utilities and valuables prior to wet flood proofing.

$$ COSTS: $$

Estimated costs for relocating damageable materials and utilities and installing in-wall flood vents:

- ~$ 14,000 (for 6 flood vents)

Cost may vary depending or damageable materials, size of wet flood proofing area, and location of project.

Nonstructural Flood Risk Management Measures: Building Elevation

Images Source: USACE

APPLICABILITY:

Most single family houses can be elevated, if they are in good condition. Large buildings, office buildings and attached (row homes) buildings may be elevated, but may present more challenges. Height limits on building elevations should be in concurrence with local ordinances and building codes.

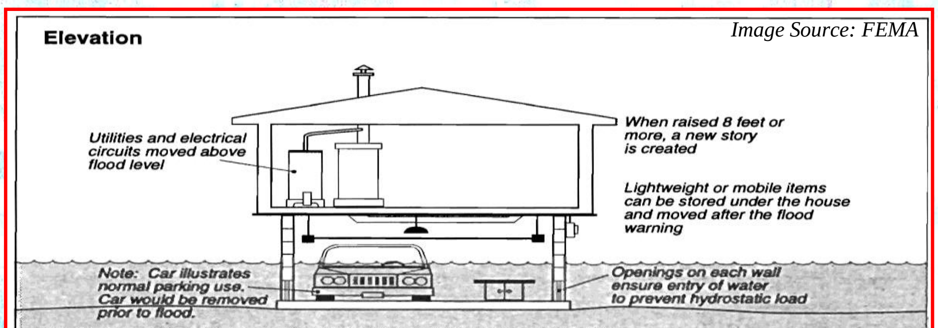


Image Source: FEMA

TYPES OF FLOODING MITIGATED:

1. **Coastal/Storm Surge**
2. **Riverine**
3. **Stormwater**

DESCRIPTION:

Elevation involves raising flood prone buildings in place so that the lowest floor is above the design flood elevation. The building is raised on temporary framing and set on extended foundation walls or structural fill above the design flood elevation. For buildings that include basements or crawl spaces, the basement or crawl space can be filled in, the building raised above the design flood elevation, and additional living space can be added to compensate for the lost basement space. Another option for basements and crawl spaces is wet flood proofing, which would allow water to pass through without damaging the structural integrity of the building. The structure can also be elevated on extended foundation wall breakaway panels, piles, piers, or posts.

Nonstructural Flood Risk Management Measures: Building Elevation

ADVANTAGES:

- Contents and structures have a reduced risk of flooding
- Maintains neighborhood cohesion by eliminating relocation of residents

VS

DISADVANTAGES:

- Must vacate structure during elevation process
- May change historical/visual landscape

IMPACTS:

Changes aesthetics of structure, especially in historically sensitive areas, may create home access issues depending on physical condition of resident(s).

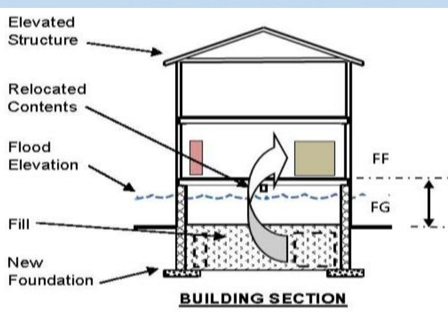
PRE-FLOOD ACTIONS:

Although building flood risk is significantly reduced, occupants are recommended to evacuate prior to impending floods.

SPECIAL CONSIDERATIONS:

Assess structural stability and relocation of utilities prior to building elevation. Community ordinances/ building codes may restrict elevation height.

$$ COSTS* $$



Elevate Structure Above Flood Elevation - Estimated Cost (2)

Structure Elevation Height (Feet)	First Floor Area (Square Feet): 600	700	800	900	1,000	1,100	1,200	1,300	1,400	1,500
8'	$132,800	$134,900	$137,100	$139,200	$141,400	$143,500	$145,600	$147,800	$149,900	$152,000
7'	$127,700	$129,900	$132,000	$134,100	$136,300	$138,400	$140,600	$142,700	$144,800	$147,000
6'	$122,700	$124,800	$126,900	$129,100	$131,200	$133,300	$135,500	$137,600	$139,800	$141,900
5'	$117,600	$119,700	$121,900	$124,000	$126,100	$128,300	$130,400	$132,500	$134,700	$136,800
4'	$112,500	$114,600	$116,800	$118,900	$121,100	$123,200	$125,300	$127,500	$129,600	$131,700
3'	$107,400	$109,600	$111,700	$113,800	$116,000	$118,100	$120,200	$122,400	$124,500	$126,700
2'	$102,400	$104,500	$106,600	$108,800	$110,900	$113,000	$115,200	$117,300	$119,400	$121,600
1'	$97,300	$99,400	$101,500	$103,700	$105,800	$108,000	$110,100	$112,200	$114,400	$116,500

** Costs based on community in central PA; costs will vary by region and project.*

Nonstructural Flood Risk Management Measures: Acquisition/Demolition

Image Source: Hartford Historical Society

APPLICABILITY:

Acquisition/ demolition is applicable to structures that are at extreme risk of flooding and typically have been flooded one or more times.

TYPES OF FLOODING MITIGATED:

1. **Coastal/Storm Surge**
2. **Riverine**
3. **Stormwater**

DESCRIPTION:

This measure consists of buying the structure and the associated land. The structure is either demolished or the structure is relocated to a location external to the floodplain. Development sites, if needed, can provide locations where displaced structures can be relocated. The site where the building was originally located typically becomes open space and restricted from development.

Nonstructural Flood Risk Management Measures: Acquisition/Demolition

ADVANTAGES:

- Elimination of flood risk
- No lives at risk
- No emergency responders needed during flood
- Restores beneficial functions of the floodplain

VS

DISADVANTAGES:

- Removal of homes and buildings requires homeowners/tenants to relocate
- Displaced owner(s) need to build/buy in community to not affect tax base

IMPACTS:

The impacts of acquisition/demolition are felt mostly by the building owners or tenants. They must relocate and build on new premises. There is a potential for loss of cultural diversity and neighborhood cohesion if many owners move elsewhere.

PRE-FLOOD ACTIONS:

Not Applicable

SPECIAL CONSIDERATIONS:

Business operations or residential characteristics (cultural diversity and cohesion) must be considered prior to demolition.

$$ COSTS: $$

Acquisition

- Acquisition costs vary based on structure value.

Demolition

- Demolition cost will vary based on location, size, and type of structure.
- For a typical 1,500 square foot building - ~$60,000

Nonstructural Flood Risk Management Measures: Relocation of Structure

Image Source: USACE

APPLICABILITY:

Relocation is typically considered for buildings that have a high risk of flooding and are typically in good condition.

TYPES OF FLOODING MITIGATED:

1. **Coastal/Storm Surge**
2. **Riverine**
3. **Stormwater**

DESCRIPTION:

This measure requires physically moving the at-risk structure. This measure achieves a high level of flood risk reduction when structures can be relocated from a high flood hazard area to an area that is located completely outside the floodplain. Development of relocation sites where structures could be moved to achieve the planning objectives and retain such aspects as neighborhood cohesion or cultural and historic significance can be part of any relocation project. This action removes the possibility of loss or damage from high flood events and creates a safer atmosphere.

Nonstructural Flood Risk Management Measures: Relocation of Structure

+ ADVANTAGES: +

- Elimination or reduction of flood risk
- No lives at risk
- No emergency responders needed during flood
- Restores property/floodplain to open space

VS

− DISADVANTAGES: −

- Process can be lengthy and disruptive
- May change historic/visual landscape of a community
- Finding a suitable location to relocate the structure may be challenging

IMPACTS:

The impacts of relocation of a structure can be significant to the tenants, but they are temporary. For commercial buildings, business activities may be disrupted during the relocation process. Relocation may have negative historic preservation impacts.

PRE-FLOOD ACTIONS:

Once relocated, there will be no danger from flood damage so pre-flood actions are not necessary.

SPECIAL CONSIDERATIONS:

Consider temporary placement of assets during relocation. May require coordination with historic preservation officials.

$$ COSTS: $$

Costs are highly variable based on size of the structure and distance of relocation.

Nonstructural Flood Risk Management Measures: Flood Preparedness Plan

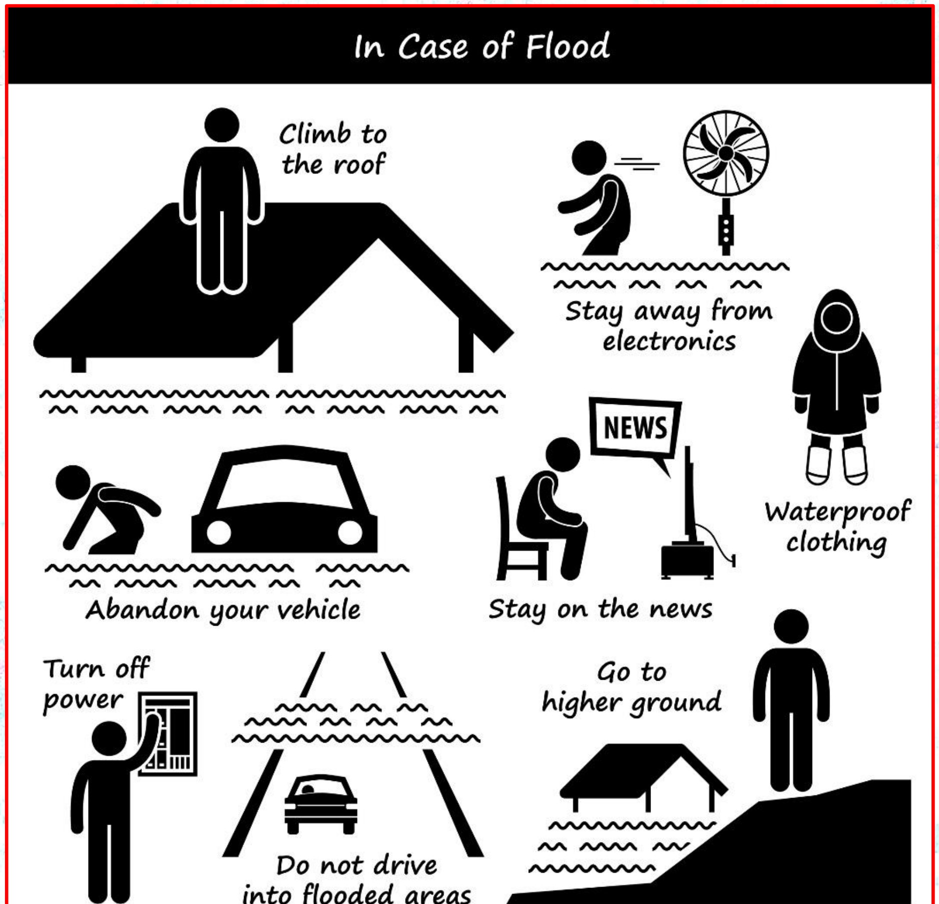


Image Source: Dreamstime.com

APPLICABILITY:

A flood preparedness plan is applicable in all situations where flooding is a possibility. It applies to all personnel affected and allows for a quick and effective response.

TYPES OF FLOODING MITIGATED:

1. **Coastal/Storm Surge**
2. **Riverine**
3. **Stormwater**

DESCRIPTION:

A flood preparedness plan is a pre-determined and pre-coordinated set of steps that promote a quick response during a flood event to improve life safety and reduce flood damages. These steps should be given to all personnel effected by the flood and kept in easily accessible areas for use. The plan should identify roles and responsibilities for persons in the flood area during a flood event. Flood warning systems and evacuation planning are applicable to vulnerable areas. Despite improved tracking and forecasting techniques, the uncertainty associated with the size of a storm, the path, or its duration necessitate that warnings be issued as early as possible. Evacuation planning is imperative for areas with limited access, such as barrier islands, high density housing areas, elderly population centers, cultural resources, and areas with limited transportation options.

Nonstructural Flood Risk Management Measures: Flood Preparedness Plan

ADVANTAGES:

- Common information shared by all
- Allows for a quick, coordinated response to help reduce the damage/impact of flooding

VS

DISADVANTAGES:

- Not applicable

IMPACTS:

Roadways may require shut down during events to prevent flooding.

PRE-FLOOD ACTIONS:

The steps of the flood preparedness plan must be decided pre-flood and taught to all personnel that may be affected. The plan will clearly lay out all of the pre-flood actions that must be implemented.

SPECIAL CONSIDERATIONS:

Flood preparedness plans require periodic updates and may require development of a communication plan.

$$ COSTS: $$

Costs for preparation of a flood preparedness plan vary depending on the level of detail and whether it is for a family, business or community. Costs are usually minimal compared to damages the plan could prevent.

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APPENDIX B:

BUILDING CONCEPT SHEETS

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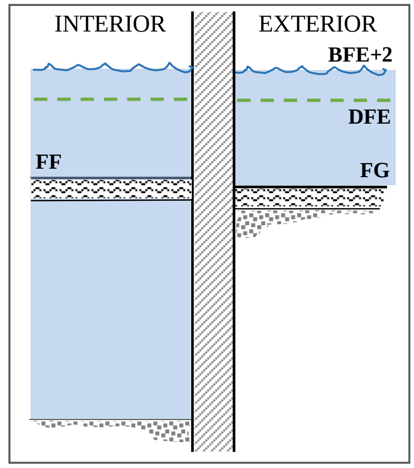
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8000 Main Street

Structure Information / Data:

Location: 8000 Main Street
Occupancy type: Commercial
No. of Stories: 2.5
Building Construction:
- Exterior Wall: Stone masonry
- Floor Construction (1st Flr.): Wood frame with supplemental steel
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Basement
- 1st floor doors: 2
- Historic Status: Local, National



BUILDING SECTION (South elevation)
Not to Scale

Key Building Features:

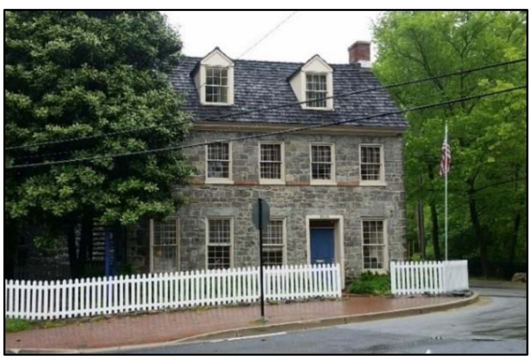
- BFE+2 ≤ 3 ft. above first floor elevation
- Unfinished basement
- Bulkhead door basement access
- Exterior utilities

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

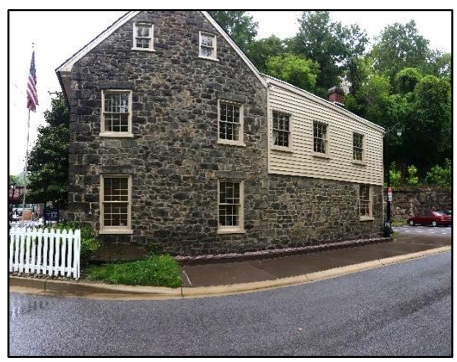
FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
126.0	126.3	126.3	0.0	128.8	128.2	2.5	127.4	0.5	0.7

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:



1. South elevation



2. East elevation, showing basement access at left

3. North elevation

4. Exterior equipment on west elevation

<u>Background</u>:

The 2.5-story masonry structure was constructed around 1790 and is located immediately adjacent to the Patapsco River. The structure has a basement with a dirt floor that is unoccupied and contains only minimal plumbing and two wall-mounted electrical panels. The only access to the basement is through a set of wooden bulkhead doors on the east elevation of the building.

The low first floor window sill is approximately 1.9 ft. above the first floor elevation. There are two points of entry into the building – 3 ft. wide single doors on the south and north elevations. The structure houses a single commercial tenant. The tenant's representative present on the site visit was not able to comment on damage due to past flood events.

<u>Analysis of Key Building Features</u>:

– **BFE +2 ≤ 3 ft. above first floor elevation**

The BFE + 2 ft. for this structure is approximately 1.9 ft. above the first floor elevation, which falls in the achievable range of flood risk management possible for ***dry flood proofing*** a stone masonry structure. Wet flood proofing the first floor is not a viable option due to the building usage and existing interior finishes, which are not sufficiently flood resistant for such an application.

Elevation of the entire structure to raise the first floor above the BFE + 2ft. is technically feasible but assumed to be undesirable due to historical preservation considerations, given that significant modification of the front building exterior would be required to provide access to the doors.

– **Unfinished basement**

Wet flood proofing the basement is not a viable option in conjunction with dry flood proofing the first floor above, particularly given the type of floor construction. ***Filling the basement with suitable fill*** is recommended in order to minimize the risk of damage to the structural walls and to minimize the required effort to pump out the basement area after a flood event. All utility equipment in the basement area should be relocated to the first floor or higher if the basement is filled.

– **Bulkhead door basement access**

In conjunction with dry flood proofing the basement, the existing basement access door would be replaced with an engineered ***flood proof hatch*** manufactured to match the dimensions of the existing opening. It may be feasible to hide the new hatch beneath the existing doors if required from a historical perspective. However, given that the opening is hidden from view from the street by a fence and plant growth in the case of this specific structure, this additional measure may not be required. Coordination with local and state historic preservation organizations is required to validate this assumption.

– **Exterior utilities**

Elevation-in-place of the exterior HVAC to the DFE is the recommended approach for flood proofing those items. The units may be placed on either wall-mounted platforms or an isolated steel platform depending on user preference. The two electrical panels are currently located above the DFE. The two electrical meters mounted immediately below the panels should be elevated approximately 1ft. to reach the DFE. As an additional consideration in the case of dry flood proofing and exterior utility equipment, it must be verified that wall penetrations below the DFE are sufficiently sealed to be waterproof. If replacement of the seal material is required, materials that match the color and texture of existing masonry mortar must be used, in accordance with applicable historic preservation requirements.

FINAL RECOMMENDATIONS

The following recommendations were used to develop the associated construction cost estimates and are specific to 8000 Main Street.

ALTERNATIVE #1 (PASSIVE)- Dry flood proofing
Construction Cost Estimate: $105,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **1.9 ft.** above the finished floor. (**Final DFE is 128.2 ft. NAVD88)**

a. ***Fill existing basement***:
    i. Fill entire basement with suitable fill.
        1. Assume 9,600 ft^3 of fill
b. ***Door openings***: Flood proof doorways.
    i. Flood proof doors at two single door locations (3 ft. wide each)
c. ***Basement access opening***:
    i. Replace existing basement access doors with flood proof hatch, framed into existing masonry opening.
d. ***Pumping***:
    i. Assume 2 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
e. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
f. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.
g. ***Elevate mechanical and electrical equipment:***
    i. Relocate two wall-mounted electrical panels in basement to the first floor.
    ii. Elevate two existing exterior electrical meters approximately 1 ft. to match adjacent panel elevation.
    iii. Elevate two at-grade HVAC units in place on a single steel platform, approximately 2.75 ft. height.

Rendering of Elevated External Utilities
(HVAC unit on the left is elevated)

<u>***ALTERNATIVE #2 (ACTIVE) - Dry flood proofing***</u>

Construction Cost Estimate: $85,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **1.9 ft.** above the finished floor. (**Final DFE is 128.2 ft. NAVD88)**

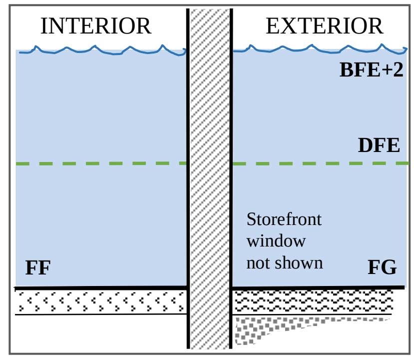
a. ***Fill existing basement***:
   i. Fill entire basement with suitable fill.
      1. Assume 9,600 ft^3 of fill
b. ***Door openings***: Flood proof doorways.
   i. Stoplog door closures and associated framing at two single door locations (3ft. wide each); assume 1.9 ft. height.
c. ***Basement access opening***:
   i. Replace existing basement access doors with flood proof hatch, framed into existing masonry opening.
d. ***Pumping***:
   i. Assume 2 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
e. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
f. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.
g. ***Elevate mechanical and electrical equipment:***
   i. Relocate two wall-mounted electrical panels in basement to the first floor.
   ii. Elevate two existing exterior electrical meters approximately 1ft. to match adjacent panel elevation.
   iii. Elevate two at-grade HVAC units in place on a single steel platform, approximately 1.9 ft. height.

Rendering of Stoplog Door Closure Panel

NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8044 Main Street

Structure Information / Data:

Location: 8044 Main Street
Occupancy type: Commercial/Residential
No. of Stories: 5
Building Construction:
- Exterior Walls: Stone masonry
- Floor Construction (1st Flr.): Concrete slab (recent retrofit)
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Grade
- 1st floor doors: 3
- Historic Status: Local, National



BUILDING SECTION (North elevation)
Not to Scale

Key Building Features:

- BFE+2 ≥ 5 ft. above first floor elevation
- Immediately adjacent to other structures
- Storefront windows

Structure/Flood Elevations Table (all elevations in ft. NAVD88)*:

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
126.6	126.6	126.6	0	134.3	130.6	7.7	133.1	11.2	11.9

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. North elevation

2. Double door on north elevation

3. Typical entrance door and storefront window

Background:

The 5-story masonry structure was constructed in 1789 and is located on the lower end of Main Street near the Patapsco River. The structure houses a single commercial tenant on the first floor with additional commercial space and residential units above. An alley on the east elevation leads to a stairway to access the upper levels of the structure. The structure is built along the rock face at the rear of the structure. The first floor elevation is approximately 0.5 ft. above the adjacent exterior grade according to measurements made in the field during the site visit. The low first floor window sill is approximately 2.5 ft. above the first floor elevation. There are three points of entry into the first floor of the building – two single doors and one double door on the south elevations.

The building owner was present at the site visit to comment on the impact of historic flood events. During the July 2016 storm, the first floor was inundated with over 5 ft. of water, causing extensive damage to the first floor interior and the building exterior. In response to this flood event, the owner had the existing floor replaced with a concrete slab on grade for improved durability.

Analysis of Key Building Features:

- **BFE+2 ≥ 5 ft. above first floor elevation**

  The flood proofing approach for a structure with such high flood depths is to make provisions that mange flood risk to the highest level possible without threatening the structural integrity of the building as a whole. In this case, ***dry flood proofing*** up to the highest possible level is the recommended approach. In an effort to eliminate the need for human intervention in making pre-flood preparations, the replacement of existing first floor doors with flood proof doors is recommended rather than the use of temporary closures. Provisions should be made for interior pumping during a high-water event and replacement of seals at all exterior wall penetration locations to minimize seepage.

  In conjunction with the implementation of dry flood proofing measures, the building owner may want to consider permanently relocating valuable first floor contents to the second floor or higher as applicable. It may be possible to dry flood proof to a higher elevation if modifications are made to the storefront.

- **Adjacent to other structures**

  The structural attachment of this building to another building on at least one side makes elevating the structure above the BFE+2 challenging. This adjacency also complicates the implementation of other flood proofing measures. In most cases within Ellicott City, it is assumed that the party walls that separate adjacent structures are similar in construction to the exterior walls. Therefore, the walls are assumed to be sufficiently watertight for effective dry flood proofing even under hydrostatic load from inundation of the adjacent structure; structural analysis should be performed to verify this assumption prior to implementation of the recommended flood proofing measures.

- **Storefront with windows**

  In conjunction with the dry flood proofing measures above, the construction of a new partial-height concrete masonry unity (CMU) wall treated with water-resistant sealant behind the wooden base of the storefront windows is recommended to minimize seepage under hydrostatic load. If the building owner desires to manage flood risk at a higher elevation than the low window sill elevation, modifications must be made either to the wooden storefront windows themselves, or other measures be taken to ***flood proof the opening behind the window***. Although it is possible to rebuild the wooden storefront with new tube steel framing and structural glass which would be minimally visible from the exterior, the recommended approach is to ***construct a new CMU wall section, treated with water-resistant sealant, in the plane of the existing exterior stone wall***, raising the elevation of the low window opening. The existing wooden window frames would remain in place to minimize aesthetic impact. The new CMU wall could be covered with drywall or other architectural finish to further minimize the aesthetic impact.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8044 Main Street.

ALTERNATIVE #1 (PASSIVE)-Dry flood proofing
Construction Cost Estimate: $65,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4 ft.** above the finished floor. (**Final DFE is 130.6 ft. NAVD88)**

a. ***New masonry wall behind storefront, in line with existing stone wall:***
    i. Approx. 40 ft. total length of reinforced CMU wall, 4.0 ft. height, treated with water-resistant sealant for each of the two storefront windows on the south elevation. Assume majority of storefront can stay in place during construction.
b. ***Door openings***: Flood proof all first floor doorways.
    i. Flood proof doors at two single door locations (3 ft. wide each) and one double door location (6 ft. wide)
c. ***Pumping***:
    i. Assume 3 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
d. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
e. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

ALTERNATIVE #2 (ACTIVE)- Dry flood proofing
Construction Cost Estimate: $40,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4 ft.** above the finished floor. (**Final DFE is 130.6 ft. NAVD88)**

a. ***New masonry wall behind storefront, in line with existing stone wall:***
    i. Approx. 40 ft. total length of reinforced CMU wall, 4.0 ft. height, treated with water-resistant sealant for each of the two storefront windows on the south elevation. Assume majority of storefront can stay in place during construction.
b. ***Door openings***: Flood proof all first floor doorways.
    i. Stoplog or panel door closures and associated framing at two single door locations (3 ft. wide each) and one double door location (6 ft. wide); assume 4.0 ft. height.
c. ***Pumping***:
    i. Assume 3 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
d. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
e. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

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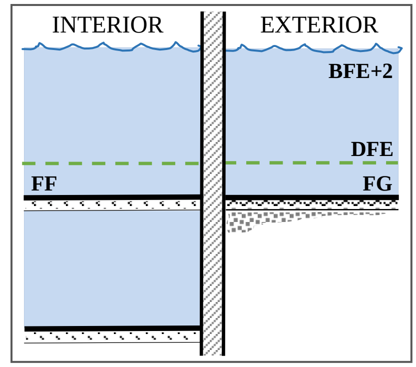
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8069 Main Street

Structure Information / Data:

Location: 8069 Main Street
Occupancy type: Commercial/Residential
No. of Stories: 3
Building Construction:
- Exterior Walls: Stone masonry with stucco and wood frame
- Floor Construction (1st Flr.): Mixed concrete slab/wood frame
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Partial basement on north side
- Historic Status: Local, National



BUILDING SECTION (North elevation)
Not to Scale

Key Building Features:

- Floor retrofitted with conrete slab
- Directly over stream with exposed upstream exterior wall
- Multiple commercial tenants

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
126.1	126.1	126.1	0.0	137.6	130.1	11.5	136.6	10.0	10.8

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. North elevation

2. West elevation showing adjacent vehicle bridge

3. East elevation

4. Small CMU addition on south elevation

Background:

According to historical building records, this 2.5-story structure was built between 1860 and 1878. More recently, a small 1-story CMU addition has been constructed at the rear of the structure. The first floor houses two commercial tenants. There is a partial basement below the northern portion of the structure, which is used for minimal storage.

The structure received significant damage during the July 2016 flood event, particularly in the portion which is directly over the stream. Water overtopped the adjacent vehicle bridge and broke through the majority of the windows on the west elevation and inundated the interior.

Analysis of Key Building Features:

- **Retrofit of original floor system with new concrete slab**
  The floor portion of this structure is located over the stream and has been ***retrofitted*** since the 2016 flood event with a new ***reinforced concrete slab*** supported by steel framing. This approach has also been adopted on several similar structures located directly over the stream during the rebuilding effort. If properly designed and constructed, this floor system could prove more durable and resilient than the original construction, greatly reducing the risk of flood damage. The atypical loading associated with a full-flow stream condition beneath the structure should be taken into account as it would apply an upward force on the slab system.

- **Located directly over stream with exposed upstream exterior wall**
  Given the severe dynamic lateral and uplift loading on the west elevation of the structure, as reported by the building tenant, ***wet flood proofing*** is the recommended approach for that portion of the structure, although extensive structural analysis should be considered. Replacement of interior finishes with flood-resistant materials and conscientious storage practices within the interior, as this tenant has already done, is an excellent approach for mitigating the risk of damage to both the structure as a whole and the important assets contained inside. A recommended additional measure is the ***installation of flood louvers/openings*** below the window sill elevation on both the west and east exterior walls, which would allow for water to enter and exit the structure during a high-water event and further reduce the risk of catastrophic damage to the structure and windows. A small skimmer/ sump pump would assist with post-flood cleanup efforts. Construction of a guardrail along the west elevation of the building may help to minimize the risk of severe debris impact on the windows and structure.

  Another recommended option on this structure would be the creation of a ***small dry flood proofed*** area in the 1-story CMU addition at the rear of the structure, which could be used for critical storage of valuable equipment or materials. The masonry walls are assumed to be sufficiently watertight for dry flood proofing without modification, so all that would be required is replacement of the existing exterior single door with a flood proof door and the installation of a flood barrier on the interior opening connecting the addition to the main structure. A dry flood proofed height of 3 ft. above the first floor elevation is recommended, and a ***partial height aluminum swing gate framed*** into the masonry or similar would be sufficient. A small dry flood proofed area as recommended in this case, is not intended as a safe space for human occupation during a high-event, but merely to reduce the risk of damage to building contents which are stored there.

- **Multiple commercial tenants in first floor**
  For structures such as this one that have multiple commercial tenants sharing the first floor space, additional coordination must be performed when selecting a flood proofing approach. In the case of this structure, the selection of ***wet flood proofing*** as a recommended approach for the tenant in the rear of the structure would increase the risk of inundation of the tenant in the front of the structure, if additional provisions are not made.

  Given that the interior finishes and building contents in the front area are not particularly suitable for wet flood proofing, and assuming that the stone masonry structure can resist significant hydrostatic and lateral forces, ***dry flood proofing to the height of the low window opening*** is recommended through the replacement of the two single doors on the north elevation with flood proof doors. The ***large window openings*** should also be ***retrofitted*** to provide flood risk management to the DFE. Best practices regarding interior pumping, sealing of exterior wall penetrations, and testing of stone masonry wall materials should be implemented. In order to be isolated from the wet flood proofed area at the rear of the structure, a partial height CMU wall up to the dry flood proofed height would be constructed, with ***aluminum swing gates installed at the two single door locations.*** Additional structural reinforcements to doors and window closure solutions may be required due to high flow depths and velocities. ***Filling of the partial basement*** on the north side would also be required if dry flood proofing is pursued.

FINAL RECOMMENDATIONS

The following recommendations were used to develop the associated construction cost estimates and are specific to 8069 Main Street.

ALTERNATIVE #1 (PASSIVE)- Dry and wet flood proofing with flood doors
Construction Cost Estimate: $120,000

WET FLOOD PROOF the portion of the structure directly above the stream. (**Final DFE is 130.1 ft. NAVD88)**

a. ***Installation of flood louvers in east and west exterior walls***
   i. Assume 8 flood louvers total, 2 ft. by 1ft. each, installed in existing masonry.
b. ***Pumping:***
   i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capactiy to run the pump.

Rendering of Wet Flood Proofing Louvers/Openings

DRY FLOOD PROOF the 1-story CMU addition at the rear of the structure up to a height of approximately **3 ft.** above the finished floor.

a. ***Exterior door openings***: Flood proof one single door on south elevation.
   i. Install a flood proof door at one single door location
b. ***Interior opening***: Flood proof existing 3 ft.-wide opening connecting CMU addition to remainder of the structure.
   i. Install an aluminum swing flood gate in single interior door opening location, 3 ft. height
c. ***Pumping***:
   i. Assume 1 skimmer/sump pump for use inside the building and portable emergency generator with suitable capacity to run the pump.

Rendering of Interior Swing Gate

DRY FLOOD PROOF the front portion of the structure up to a height of approximately **4 ft.** above the finished floor.

a. ***Exterior door openings***: Flood proof two first floor doorways on north elevation.
   i. Install flood proof doors at two single door locations (3 ft.-wide each)
b. ***Fill partial basement:***
   i. Asssume 1,600 $ft.^3$ of fill material.
c. ***Exterior window openings***: Replace existing windows on north elevation with structural flood proof windows.
   i. Assume two windows (5 ft. wide x 6 ft. high each) to be replaced with structural flood proof window
d. ***New CMU wall construction and interior openings***:
   i. Reconstruct existing wall separating the tenants within the first floor with a new partial height reinforced CMU wall, 35 ft. length, 4.0 ft. height. Assume 35 ft. of stud partition wall to be demolished and reconstructed.
   ii. Install aluminum swing flood gates in 2 single door opening locations in new interior wall, 4.0 ft. height
e. ***Pumping***:
   i. Assume 4 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
f. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
g. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

<u>ALTERNATIVE #2 (ACTIVE) Dry and wet flood proofing with stoplog closures</u>

Construction Cost Estimate: $110,000

WET FLOOD PROOF the portion of the structure directly above the stream. (**Final DFE is 1301.1 ft. NAVD88)**

a. ***Installation of flood louvers in east and west exterior walls***
   i. Assume 8 flood louvers total, 2 ft. by 1 ft. each, installed in existing masonry.
b. ***Pumping:***
   i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

DRY FLOOD PROOF the 1-story CMU addition at the rear of the structure up to a height of approximately **3 ft.** above the finished floor.

a. ***Exterior door openings***: Flood proof one single door on south elevation.

i. Install stoplog or panel door closures and associated framing at two single door locations (3 ft. wide each); assume 4.0 ft.height.

b. ***Interior opening***: Flood proof existing 3 ft.-wide opening connecting CMU addition to remainder of the structure.

i. Install an aluminum swing flood gate in single interior door opening location, 3 ft. height

c. ***Pumping***:

i. Assume 1 skimmer/sump pump for use inside the building and portable emergency generators with suitable capacity to run the pump.

DRY FLOOD PROOF the front portion of the structure up to a height of approximately **4 ft.** above the finished floor.

a. ***Exterior door openings***: Flood proof two first floor doorways on north elevation.

i. Install stoplog or panel door closures and associated framing at two single door locations (3 ft. wide each); assume 4.0 ft. height.

b. ***Fill partial basement:***

i. Assume 1,600 $ft.^3$ of fill material.

c. ***Exterior window openings***: Replace existing windows on north elevation with structural flood proof windows.

i. Assume two windows (5 ft. wide x 6 ft. high each) to be replaced with structural flood proof window

d. ***New CMU wall construction and interior openings***:

i. Reconstruct existing wall separating the tenants within the first floor with a new partial height reinforced CMU wall, 35 ft. length, 4.0 ft. height. Assume 35 ft. of stud partition wall to be demolished and reconstructed.

ii. Install aluminum swing flood gates in 2 single door opening locations in new interior wall, 4.0 ft. height

e. ***Pumping***:

i. Assume 4 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.

f. ***Sewage check valve***:

i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.

g. ***Exterior wall utility penetrations***:

i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

Rendering of Stoplog Door Closures and Structural Windows

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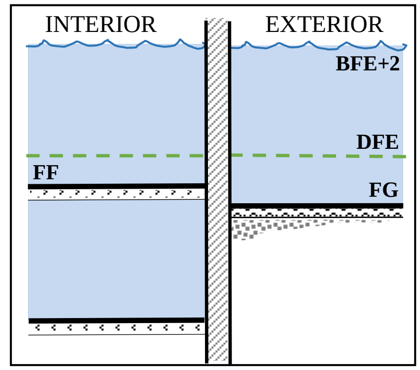
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8085 Main Street

Structure Information / Data



BUILDING SECTION (North elevation)
Not to Scale

Name/Description: Portalli's Restaurant
Location: 8085 Main Street
Occupancy type: Commercial
No. of Stories: 3
Building Construction:
- Exterior Walls: Masonry
- Floor Construction (1st Flr.): Mixed concrete slab/wood frame
- Foundation Wall: Masonry
- Grade/Crawlspace/Basement: Basement
- Historic Status: Local, National

Key Building Features:

- Directly over stream
- Storefront with unique glass panel entrance
- Building features impede stream conveyance during higher flows

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
126.9	127.8	127.8	0.9	139.0	129.3	11.2	138.2	4.5	5.0

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs

1. North elevation

2. Main entrance with new brick wall below windows, either side

3. Metal access stair reducing steam conveyance

4. Extraneous steel framing below first floor slab

<u>Background</u>:

This 3-story masonry structure, which houses a commercial tenant on the first two floors, was built pre-1878 according to existing building records. The building has a partial basement below the northern half the structure, located on the left side of the channel (facing downstream), which is currently used for limited storage. The main entry to the building on the north elevation is composed of three single doors.

The structure was heavily damaged during the July 2016 flood event, and is currently in the process of being rebuilt. The damaged exterior wall on the western elevation has been replaced in-kind with new CMU and with a wood stud wall behind. The existing floor system was replaced with a cast-in-place reinforced concrete slab with built-in beam sections.

<u>Analysis of Key Building Features</u>:

- **Located directly over stream**
  Although located directly over the stream, this structure has the benefit of an adjacent structure on the upstream side which may partially protect it from the impact of dynamic hydraulic loading under a full-flow stream condition. However, for all structures located over the stream that are considering implementing dry flood proofing, it is recommended to assess the capacity of the existing walls perpendicular to flow for the out-of-plane forces associated with water impact. ***Adding structural steel framing and a metal stud wall*** on the interior of the existing masonry wall could reduce the risk of structural failure of the wall in a high-water event, have a relatively small impact on the thickness of the wall, and be completely hidden behind a drywall finish. ***Retrofit of the typical wood floor with a structural concrete slab***, as has already been done on this structure, is recommended for minimizing seepage up through the floor under a full-flow stream condition and minimizing the risk of damage if the first floor is inundated. The floor system design must incorporate the uplift force associated with a full-flow stream condition in order to prevent catastrophic failure.

- **Storefront windows with unique glass panel entrance**
  In conjunction with the flood proofing measures above, the ***construction of a new partial-height CMU wall*** behind the wooden base of the storefront windows is recommended for structures with similar storefront windows, to minimize seepage under hydrodynamic load. This practice has already been incorporated in the reconstruction of this particular structure with a new partial-height brick wall. A ***temporary stoplog panel*** would be placed at the entrance of the building to tie in to the brick wall behind the front store windows. Additional structural reinforcements to the stoplog panel may be required due to high flow depths and velocities. ***Filling of the partial basement*** on the north side would also be required if this dry flood proofing option is pursued.

  A passive option was not recommended for this building due to the complexities associated with maintaining the three panel glass door entrance and large store front windows. If the building owner desires to manage flood risk at a higher elevation than the low window sill elevation, modifications could be made to the storefront windows in the form of new tube steel framing and structural glass. Replacement of the three panel glass door entrance with a passive flood door would likely require detailed engineering and heavily impact the aesthetics and historical significance to the structure.

- **Building features impede stream conveyance during higher flows**
  In addition to considerations relating to the structure itself, it is recommended for structures located directly over the stream to ***minimize impedance to water conveyance beneath the structure***. Although the first floor framing of this building was replaced with a cast-in-place slab system with built-in reinforced beam sections, the original structural steel framing below the building is still in place. Additionally, there is a steel staircase (which may not be owned by the subject property) adjacent to the building which provides access from the adjacent vehicle bridge down to the stream level below. This staircase is behind a locked gate and is not accessible to the public. These two building and site features themselves inhibit the flow of water in the stream channel immediately beneath the structure and can also catch debris which would cause further blockage. In the case of the steel staircase, it is

recommended to provide a mechanism by which the stair can be raised out of the channel, and lowered only when access is needed.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8085 Main Street.

ALTERNATIVE #1 (ACTIVE)- Dry flood proofing
Construction Cost Estimate: $20,000

DRY FLOOD PROOF the structure up to the height of approximately **1.5 ft.** above the finished floor.
(Final DFE is 130.8 ft. NAVD88)

a. ***New masonry wall behind existing façade:***
   i. Approx. 35 ft. total length of new reinforced CMU wall with waterproof coating, 3.0 ft. height, in two segments on either side of front entry vestibule. Tie in to structural concrete slab below.
b. ***Fill partial basement:***
   i. *Assume 1,600 ft.*^{3} of fill
c. ***Door openings***: Flood proof all first floor doorways.
   i. Stoplog or panel closures and associated framing at one location across front entry vestibule (8.0 ft. wide); assume 3.0 ft. height.
d. ***Pumping***:
   i. Assume 1 skimmer/sump pump for use inside the building and portable generator with suitable capacity to run the pump.
e. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
f. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

Rendering of Stoplog Door Closure

<u>ALTERNATIVE #2- Stream conveyance improvements</u>
Construction Cost Estimate: $15,000

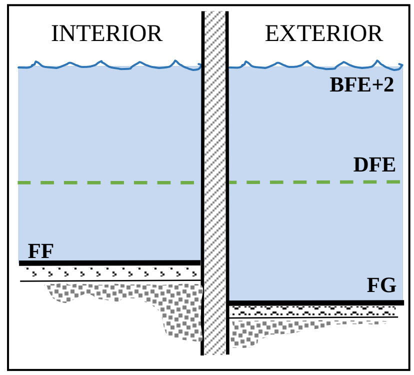
IMPROVE STREAM CONVEYANCE by removing boulders and old extraneous steel framing members beneath the structure and making provision for the staircase to be raised out of the channel when not in use.

a. ***Removal of old steel framing beneath structure***
    i. Approximately five tons of structural steel to be removed
b. ***Modification of existing stair with hinges and motor for raising and lowering stairs***

NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8092 Main Street

Structure Information / Data:

Name/Description: Second Patapsco National Bank
Location: 8092 Main Street
Occupancy type: Commercial
No. of Stories: 2
Building Construction:
Exterior Walls: Masonry
Foundation Wall: Masonry
Floor Construction (1st Flr.): Wood frame
Grade/Crawlspace/Basement: Grade
Historic Status: Local, National



BUILDING SECTION (South elevation)
Not to Scale

Key Building Features:

- BFE+2> 3 ft. above the first floor elevation
- Large storefront windows and glass door entrance
- Irreplaceable first floor contents

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
129.6	131.5	131.5	1.9	140.9	135.5	9.4	139.9	3.6	4.4

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. South Elevation, Store Front

2. West Elevation, Alleyway

3. Store Front Window

<u>Background</u>:

This two story brick masonry structure was constructed in 1886 and originally functioned as a bank building. Currently, the building houses an art gallery business on both floors.

The gallery owner was present during the site visit and commented on the impacts of the July 2016 flood event. The large front windows and glass door were broken during the flood and the first floor was inundated with flood depths greater than 5 ft.

<u>Analysis of Key Building Features</u>:

– ***BFE+2 > 3 ft. above first floor elevation***

The BFE +2 ft. for this structure is approximately 9.4 ft. above the first floor elevation. Wet flood proofing the first floor is not a viable option due to the building usage and existing interior finishes, which are not sufficiently resilient for such an application. ***Dry flood proofing*** would not manage flood risk for the entire DFE due to the height limitations of dry flood proofing on masonry walls. However, if implemented in conjunction with ***window retrofits***, it may provide flood risk management benefits for smaller flooding events. ***Swing gates or temporary closures*** would be installed at the existing door openings. A detailed structural analysis would be required to verify that the walls around the door frame could sufficiently support the hydrostatic load and dynamic flood waters. A passive option such as flood proof doors is preferred, but if such an option is precluded due to historic preservation standards, temporary closures should be placed prior to a flood event to reduce the risk of damage. Although elevation of the structure is technically feasible, this approach is not recommended due to the historical concerns associated with raising a structure over 8 ft.

– ***Large Storefront Windows and glass door entrance***

If the building owner desires to manage flood risk at a higher elevation than the low window elevation, modifications must be made to the storefront windows by reinforcing the steel frame and replacing with structural glass. In order to meet pertinent historic preservation requirements, structural modifications should be only minimally visible from the building exterior. Installation of a flood proof door for the front entrance may be challenging due to historic preservation concerns. As mentioned above, a ***swing gate*** on the inside of the door may provide benefits; the swing gate would be closed every time the business owners leaves the building as a general best practice.

– ***Irreplaceable first floor contents***

In this and similar structures that house materials that are delicate and valuable (art work), the relocation of valuable materials or providing alternate storage in watertight compartments within the structure is recommended. In this case, another recommended practice would be to elevate highly valuable art work above the DFE or potentially to the second floor.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8092 Main Street.

ALTERNATIVE #1 (PASSIVE)- Dry flood proofing
Construction Cost Estimate: $65,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4.0 ft. (Final DFE is 135.5 ft. NAVD88)**

a. ***Modifications to dry flood proof existing storefront windows***
    i. New horizontal tube steel member along top of existing window frame profile, tying-in to new steel embed plates in existing exterior masonry on either side.
    ii. Replacement of existing windows with flood proof structural windows
        1. Three panels, estimated 4 ft. by 6 ft. each.
b. ***Door openings***: Flood proof all first floor doorways.
    i. Install flood door at one door location (3 ft. wide) and swing gate at the front entrance (4 ft. height)
c. ***Pumping***:
    i. Assume 2 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
d. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
e. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

ALTERNATIVE #2 (ACTIVE)- Dry flood proofing
Construction Cost Estimate: $60,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4.0 ft. (Final DFE is 135.5 ft. NAVD88)**

a. ***Modifications to dry flood proof existing storefront windows***
    i. New horizontal tube steel member along top of existing window frame profile, tying in to new steel embed plates in existing exterior masonry on either side.
    ii. Replacement of existing windows with flood proof structural windows
        1. Three panels, estimated 4 ft. by 6 ft. each.
b. ***Door openings***: Flood proof all first floor doorways.
    i. Install stoplog or panel door closures and associated framing at two single door location (3 ft. wide); assume 4.0 ft. height.
c. ***Pumping***:
    i. Assume 2 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
d. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
e. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar in accordance with applicable historic preservation requirements.

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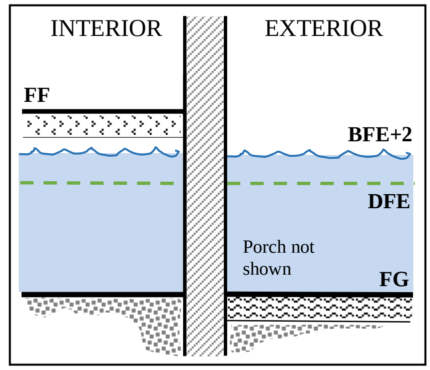
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8202 Main Street

Structure Information / Data:

Name/Description: The Howard House
Location: 8202 Main Street
Occupancy type: Commercial/Residential
No. of Stories: 4.5
Building Construction:
- Exterior Walls: Stone masonry
- Floor Construction (1st Flr.): Wood frame
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Crawlspace
- Historic Status: Local, National



BUILDING SECTION (South elevation)
Not to Scale

Key Building Features:

- BFE+2 below first floor elevation
- Porch with crawl space
- Utilities room under crawl space

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
149.2	149.6	155.3	6.6	154.2	153.6	-1.7	152.4	10.0	11.0

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. West elevation

2. Entrance to crawlspace beneath porch

3. Equipment in crawlspace

4. Porch framing in basement area

Background:

Erected circa 1850, the Howard House is made up of two buildings. The “Old Building” is a 4.5 story edifice designed in the Empire style and the focus of the assessment. The main entrance is pronounced with an ornate elevated porch. The third floor on the south elevation becomes the ground floor to the north due to the natural grade on which the building is situated. The structure is mixed-used housing with retail on the ground level and residential above.

The property owner was available on the site visit and mentioned that, while water did not enter the first floor, it did enter the utility space in the crawl space. The owner also mentioned that the front porch sustained damages due to fast moving debris.

Analysis of Key Building Features:

– **BFE+2 below first floor**
Based on the data from the building survey, the BFE+2 ft. is below the first floor elevation, therefore, flood risk management above the first floor elevation is not considered in the recommendations. Regardless, the wood floor construction of the building makes dry flood proofing at any elevation above the underside of first floor framing untenable. Flood proofing recommendation are focused on the porch and crawl space area.

– **Porch with crawl space**
During, the 2016 flood event, a vehicle being carried by flood waters slammed into the porch, causing significant damage and worsening the flood risk in the remainder of the building. A major concern is that fast moving debris could damage the foundation of the structure if the porch area is not fortified. A recommended retrofit in order to minimize future damage to the porch is to ***install bollards or a debris barrier wall*** along the south elevation for additional protection. The bollards could be installed behind the porch wall to preserve the historic aesthetic.

– **Utilities room in the crawl space**
Due to the expense associated with relocating such a large number of mechanical and electrical equipment above the BFE+2, ***dry flood proofing*** the portion of the basement where this equipment is located is a more viable option. A flood proof door can be installed and framed into the surrounding stone masonry in the wall, which separates the crawlspace area beneath the porch from the utility area beneath the main structure. As this door is essentially interior to the building (behind the front porch), it is assumed that additional historic preservation considerations are not required. It is assumed that the stone masonry walls are sufficiently watertight for effective dry flood proofing without modification, though testing would be required to validate this assumption prior to design. A sump pump should be installed at the low point of this basement area in order to remove water which may seep through the masonry walls or the new door during a high-water event.

FINAL RECOMMENDATIONS

The following recommendations were used to develop the associated construction cost estimates and are specific to 8202 Main Street.

ALTERNATIVE #1 (PASSIVE)- Dry flood proofing with armored porch
Estimated Construction Cost: $30,000

DRY FLOOD PROOF the elevated crawlspace of the structure up to the underside of the first floor framing, approximately **1.7 ft.** below the finished floor. **(Final DFE is 153.6 ft. NAVD88)**

a. ***Door openings***: Flood proof doorway to interior utility area within crawlspace on south elevation.
   i. Provide a custom-sized flood proof door and associated framing at one single door location (approximately 3 ft. wide); assume 4 ft. height.
b. ***Armor Porch***: Install bollards for additional protection underneath porch behind wooden face.
   i. Assume 8 bollards, average 5 ft. height, 3 yd^3 total of concrete for base
c. ***Pumping***:
   i. Assume 1 skimmer/sump pump for use inside the dry flood proofed utility area and an emergency generator with suitable capacity to run the pump.
d. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.

Rendering of Bollards Armoring Porch
(Bollards would be hidden behind porch if implemented to minimize historic impacts)

ALTERNATIVE #2 (ACTIVE)- Dry flood proofing with armored porch
Construction Cost Estimate: $25,000

DRY FLOOD PROOF the elevated crawlspace of the structure up to the underside of the first floor framing, approximately **1.7 ft.** below the finished floor. **(Final DFE is 153.6 ft. NAVD88)**

a. ***Door openings***: Flood proof doorway to interior utility area within crawlspace on south elevation.
    i. Provide a stoplog or panel closure and associated framing at one single door location (approximately 3 ft. wide); assume 4 ft. height.
b. ***Armor Porch***: Install bollards for additional protection underneath porch behind wooden face.
    i. Assume 8 bollards, average 5 ft. height, 3 yd^3 total of concrete for base
c. ***Pumping***:
    i. Assume 1 skimmer/sump pump for use inside the dry flood proofed utility area and an emergency generator with suitable capacity to run the pump.
d. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.

ALTERNATIVE #3 (PASSIVE)- Dry flood proofing without armored porch
Construction Cost Estimate: $15,000

DRY FLOOD PROOF the elevated crawlspace of the structure up to the underside of the first floor framing, approximately **1.7 ft.** below the finished floor. **(Final DFE is 153.6 ft. NAVD88)**

a. ***Door openings***: Flood proof doorway to interior utility area within crawlspace on south elevation.
    i. Provide a custom-sized flood proof door and associated framing at one single door location (approximately 3 ft. wide); assume 4 ft. height.
b. ***Pumping***:
    i. Assume 1 skimmer/sump pump for use inside the dry flood proofed utility area and an emergency generator with suitable capacity to run the pump.
c. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.

ALTERNATIVE #4 (ACTIVE)- Dry flood proofing without armored porch
Construction Cost Estimate: $10,000

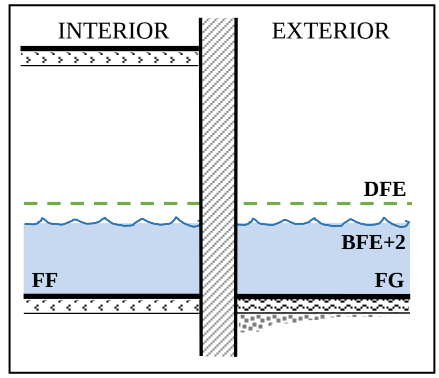
DRY FLOOD PROOF the elevated crawlspace of the structure up to the underside of the first floor framing, approximately **1.7 ft.** below the finished floor. **(Final DFE is 153.6 ft. NAVD88)**

a. ***Door openings***: Flood proof doorway to interior utility area within crawlspace on south elevation.
    i. Provide a stoplog or panel closure and associated framing at one single door location (approximately 3 ft. wide); assume 4 ft. height.
b. ***Pumping***:
    i. Assume 1 skimmer/sump pump for use inside the dry flood proofed utility area and an emergency generator with suitable capacity to run the pump.
c. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.

NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8267 Main Street

Structure Information / Data:

Name/Description: EC "Post Office" Visitors Center
Location: 8267 Main Street
Occupancy type: Administrative
No. of Stories: 2
Building Construction:
- Exterior Walls: Stone masonry/concrete
- Floor Construction (1st Flr.): Concrete
- Foundation Wall: Stone masonry/concrete
- Crawlspace/Basement: Basement with walkout
- Historic Status: MHT Easement, Local, National



BUILDING SECTION
(Lower level, east elevation)
Not to Scale

Key Building Features:

- Finished and occupied basement
- Flooding from multiple directions and above BFE
- Exterior utilities

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
167.1	167.1	167.1	0.0	169.5	170.1	2.4	167.7	2.7	2.9

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. North elevation

2. South elevation with stair to basement

3. At-grade access grate on west elevation

4. East elevation

<u>Background</u>:

The 2-story stone masonry and concrete structure is in a Maryland Historic Trust historic easement and was constructed in approximately 1940. It served as the Post Office Building prior to its current usage as a visitor center in the first floor of the structure. It also houses administrative space at the rear of the first floor and on the lower elevation. The occupied basement is accessed on the exterior through two single doors on the east and south elevations. An exterior grate flush with grade on the west elevation provides access down to a basement window, presumably to allow for the movement of large equipment in and out of the basement area.

The building representative mentioned that the building had approximately 1-3 ft. of flooding during the July 2016 flood event.

<u>Analysis of Key Building Features</u>:

- **Finished and occupied basement**
  Given the existing usage of the basement, the recommended approach is to ***dry flood proof the space***. The maximum recommended height of dry flood proofing in this case is 3 ft., which coincides with the low basement window elevation. Dry flood proofing above the low window elevation would more than double the number of openings which would require modification, and would potentially introduce additional structural concerns for the lateral loading of the concrete walls. ***Flood proof doors*** for both basement access doors would be selected to minimize impact on the historical aesthetic of the building exterior, in cooperation with guidance from pertinent historical preservation agencies. It is assumed that the existing concrete walls are sufficiently watertight for effective dry flood proofing without modification, though testing would be required to validate this assumption prior to design.

- **Flooding from multiple directions and above BFE**
  Based on dynamic flow impacts demonstrated in the hydraulic model and observed in historic flooding, it is recommended to implement ***dry flood proofing measures*** at the first floor level on the north elevation of the building. Furthermore, the access opening through a grate on the west elevation must also be addressed. The recommended approach is to construct a ***small CMU wall up to the DFE*** around the three sides of the opening and tie in with the existing building masonry wall. In this case, an approximately 2 ft.-high wall section would be sufficient to reach the DFE. The wall must be structurally isolated from the existing building structure in order to ensure that additional lateral load is not transferred to the building.

  There is also a possibility of raising the driveway grade at the northwest corner of the structure to minimize the diversion of flow from Main Street along the west side of the structure in a high water event.

- **Exterior utilities**
  There is currently a small mechanical unit located at-grade on the exterior of the south side of the structure. ***Elevation-in-place*** of the equipment above the DFE on a raised platform is recommended.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8267 Main Street.

ALTERNATIVE #1 (PASSIVE)- Dry flood proof
Construction Cost Estimate: $65,000

DRY FLOOD PROOF the basement of the structure up to the height of approximately **3.0 ft.** above the basement floor elevation. (**Final DFE is 170.1 ft. NAVD88)**

a. ***New concrete wall construction:***
   i. Construct new reinforced CMU on three sides of at-grade grate on the west elevation, tying in to existing masonry wall; assumed 2 ft. wall height
   ii. Match historical materials in accordance with guidance from pertinent historical preservation agencies
b. ***Door openings***: Flood proof doorways.
   i. Install flood proof doors at two single door locations (3 ft. wide each)
c. ***Pumping***:
   i. Assume 2 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
d. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
e. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations below the DFE to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar.

Rendering of Short CMU Wall Around NW Grate

INSTALL DOOR CLOSURE on first floor double door located on the north elevation in order to provide FRM from dynamic flow above DFE.

a. Install a stoplog or panel door closure and associated framing at one double door location (6 ft. wide); assume 3.0 ft. height.

ELEVATE EXTERIOR MECHANICAL AND ELECTRICAL EQUIPMENT

a. ***Elevate exterior mechanical and electrical equipment*** (assumed one unit) on elevated platform above the DFE.
    i. Assume one steel platform, 6 ft. by 10 ft. dimensions, 3 ft. height.

ALTERNATIVE #2 (ACTIVE)- Dry flood proof
Construction Cost Estimate: $30, 000

DRY FLOOD PROOF the basement of the structure up to the height of approximately **3.0 ft.** above the basement floor elevation. (**Final DFE is 170.1 ft. NAVD88)**

a. ***New concrete wall construction:***
    i. Construct new reinforced concrete wall on three sides of at-grade grate on the west elevation, tying in to existing masonry wall; assumed 2 ft. wall height
    ii. Match historical materials in accordance with guidance from pertinent historical preservation agencies
f. ***Door openings***: Flood proof doorways.
    i. Install stop logs at two single door locations (3 ft. wide each) at 3 ft. height
g. ***Pumping***:
    i. Assume 2 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
h. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
i. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations below the DFE to ensure watertightness. Assume four 4 in. penetrations. Match color/texture of existing masonry mortar.

INSTALL DOOR CLOSURE on first floor double door located on the north elevation in order to protect from dynamic flow above DFE.

a. Install a stoplog or panel door closure and associated framing at one double door location (6 ft. wide); assume 3.0 ft. height.

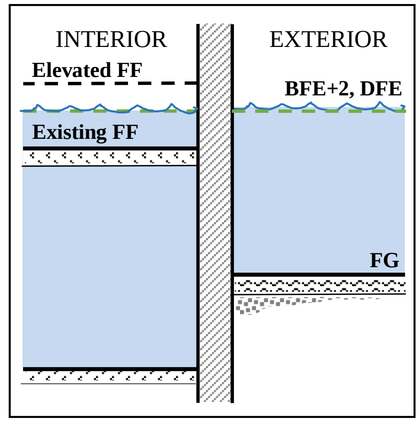
ELEVATE EXTERIOR MECHANICAL AND ELECTRICAL EQUIPMENT

a. ***Elevate all exterior mechanical and electrical equipment*** (assumed one unit) on elevated platforms above the DFE.
    i. Assume one steel platform, 6 ft. by 10 ft. dimensions, 3 ft. height.

NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8300 Main Street

Structure Information / Data

Name/Description: Thomas Isaac Log Cabin
Location: 8300 Main Street
Occupancy type: Public
No. of Stories: 1.5
Building Construction:
- Exterior Walls: Wood
- Floor Construction (1st Flr.): Wood
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Basement
- 1st floor door count: 2
- Historic Status: MHT Easement, Local, National



BUILDING SECTION (North elevation)
Not to Scale

Key Building Features:

- BFE+2 < 3 ft. above first floor elevation
- Significant historical materials
- Building susceptible to debris damage based on location
- Unfinished basement with utility
- Exterior mechanical utility

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

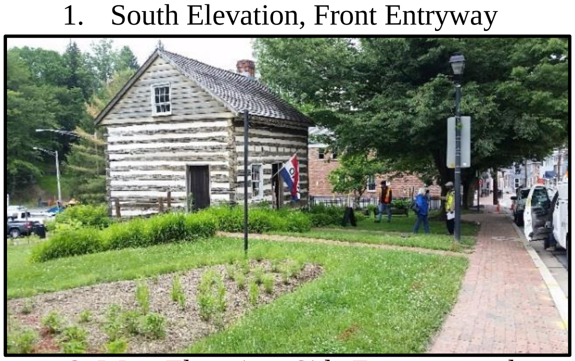
FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
192.0	194.6	197.0	5.0	198.5	198.5	1.5	196.5	0.3	3.3

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

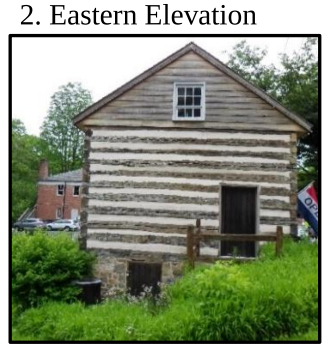
Structure Photographs:

1. South Elevation, Front Entryway

2. Eastern Elevation



3. West Elevation, Side Entryway and Potential Debris Blockage Area



4. West Elevation

Background:

The Thomas Isaac Log Cabin/ Stanton's Cabin has an MHT historical easement (HO-64) and is listed on the State Historic Sites Survey Inventory. It was built around 1780 and is a log structure built on stone masonry foundation with brick chimney insert. It was once located on the east side of Merryman Street adjacent to a small stream. Originally, it had a batten wood rectangular cellar entrance door on the north wall.

The building representative stated that there was no flooding in the first floor of the building during the July 2016 flood event, but the basement has flooded in the past.

Analysis of Key Building Features:

– **BFE+2 < 3 ft. above first floor elevation**
  The BFE+2 for this structure is approximately 2 ft. above the first floor elevation. Wet flood proofing the first floor is not a viable option due to the building usage and existing interior finishes, which are not sufficiently resilient for such an application. The recommended option for managing flood risk on this structure at an elevation higher than the first floor elevation is to ***elevate the entire structure on new or extended foundation walls*** and ***wet flood proof the basement.*** Existing stone masonry foundation walls may require repointing to ensure that they are watertight. Close coordination with the pertinent historic preservation organizations is required in order to determine that all requirements are met.

– **Irreplaceable Historic Materials Inside Building**
  Building materials inside the Log Cabin are historically significant and irreplaceable. These materials should be ***elevated above the DFE*** on platforms and stored in watertight containers during a storm event if possible. Another option would be to ***relocate*** the historic materials, however this is not feasible due to the usage of the building for tourism.

– **Building Susceptible to Debris Damage Based on Location**
  The building is located downhill of a major intersection and on the exterior of a major roadway bend, making it susceptible to debris damages traveling down Main Street. It is recommended that a ***constructed barrier that blends into the surrounding environment*** (i.e. a planter box or outdoor seating) be implemented in the south west corner of the building in the grass landscaped area. This barrier would provide impact protection from debris and potentially divert high water flows away from the building.

– **Unfinished basement with Utility**
  Partially filling the basement with suitable fill to convert to a crawlspace is a recommend option that minimizes the risk of damage to the structural walls in the case of inundation, and minimizes the required effort to pump out the basement area after a flood event. The new ground elevation should allow for sufficient ventilation and access to the framing system. There is no viable option for moving the furnace in the basement to the top floor, however it is recommended that the ***heating system be upgraded and elevated to the maximum extent practicable.*** The entrance door to the basement could also be relocated to the northern face of the foundation wall to avoid flood waters and debris hitting the door perpendicularly.

– **Exterior Utilities**
  Elevation-in-place of the exterior HVAC equipment above the DFE would be recommended. The unit may be placed on either an extended masonry platform or an isolated steel platform depending on user preference.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8300 Main Street.

ALTERNATIVE #1 (PASSIVE)- Elevate structure
Construction Cost Estimate: $115,000

ELEVATE the structure up to the height of approximately **2 ft.** above existing condition.
(Final DFE is 198.5 ft. NAVD88)

a. ***New foundation walls***: Assume 84 ft. building perimeter, 445 $ft.^2$ footprint
   i. Raise structure on temporary framing to allow for new wall construction.
   ii. Construct new masonry foundation wall around full building perimeter, 2 ft. height. Match historic appearance of existing wall.
b. ***Utility connections***:
   i. Disconnect all utilities and reconnect as required after elevation is complete.
c. ***Installation of Flood Louvers***
   i. Assume 4 flood louvers, 2 ft. by 1 ft. each, installed in new masonry wall.

WET FLOOD PROOF the basement.

a. ***Install flood louvers*** around the perimeter of the basement wall
   i. Assume 4 flood louvers total, 2 ft. by 1 ft. each, installed in new foundation wall.
b. ***Pumping***
   i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

ALTERNATIVE #2 (PASSIVE)- Construction of debris barrier
Construction Cost Estimate: $2,000

CONSTRUCTION OF DEBRIS BARRIER

a. ***Construct low masonry wall planter box***
   i. 40 ft. length of reinforced masonry wall, 6” width, with a 2 ft. height. Match historic appearance of property.

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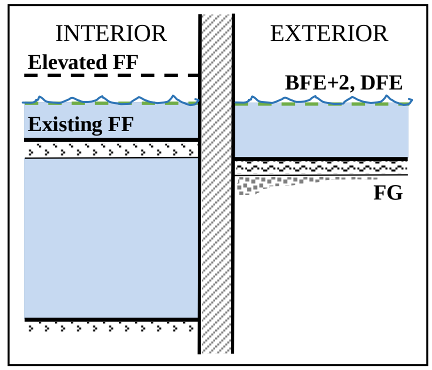
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8344 Main Street

Structure Information / Data:

Location: 8344 Main Street
Occupancy type: Commercial
No. of Stories: 2
Building Construction:
- Exterior Walls: Brick masonry/wood frame
- Floor Construction (1st Flr): Wood frame
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Basement
- Historic Status: Local, National



BUILDING SECTION (South elevation)
Not to Scale

Key Building Features:
- Significant portion of the structure is wood frame construction
- Unfinished basement
- Detached duplex structure

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
178.0	178.6	183.1	5.1	185.6	185.6	2.5	184.2	6.9	7.0

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs

1. South elevation

2. West elevation from southwest corner of building

3. North elevation from adjacent vehicle bridge

4. Basement with supplemental wood framing

Background:

The 2.5-story structure, which houses a commercial tenant on the first floor, was built in the 1860s according to existing building records. The front half of the structure is original brick masonry construction, and the rear half is a wood frame addition that was constructed at a later unknown date. The building has a basement that is currently used for limited storage and houses the boiler and water heater units. The current building tenant was not occupying the structure during the July 2016 flood and was not able to comment on flooding levels or associated damage from the event. The owner or tenant of the other half of the duplex was not available to provide interior access during the site visit. The interior conditions are assumed to be similar to those in 8344 Main Street, an assumption which must be verified prior to design of the selected flood proofing measures.

Analysis of Key Building Features:

Note: Although not addressed in detail in the analysis and recommendations, the possibility of relocating the structure elsewhere within Ellicott City may present the most effective option for protecting this historic structure. The proximity of this structure to the stream and its location at a point where the stream is suddenly completely enclosed suggests that this structure, as it is currently located, may impact the conveyance of the stream and may be exacerbating flooding in the immediate area. However, in order to present a full range of flood proofing options, relocation is not considered further in the recommendations.

- **Significant portion of structure is wood frame construction**
  Wood frame construction is not particularly suitable for either wet or dry flood proofing due to a relative lack of lateral strength compared to other wall types, and a susceptibility to excessive seepage and structural damage from periods of inundation. Given this, the recommended option for managing flood risk on this structure at an elevation higher than the first floor elevation is to ***elevate the entire structure on new or extended foundation walls and wet flood proof the basement.*** Elevation of approximately 2.5 ft. is recommended in order to elevate the first floor above the DFE. Retrofitting the wood posts with more flood resilient materials may be required if wet flood proofing is pursued. Given that the basement is only used for limited mechanical equipment and storage, ***partially filling the basement with suitable fill*** could be considered. This would increase structural stability of the new foundation walls. The addition of breakaway panels and piles may be required if structural analysis shows that foundation walls would not be able to withstand high flow velocities. Existing stone masonry foundation walls may require repointing to ensure that they are watertight. Close coordination with the pertinent historic preservation organizations is required in order to determine that all requirements are met.

- **Detached duplex structure**
  The structure is a duplex consisting of two properties, owned by different owners. Therefore, any flood proofing measure selected, especially ***structural elevation***, would require coordination due to the potential visual and structural impacts on the entire duplex structure.

- **Unfinished basement**
  Given that the basement is only used for limited mechanical equipment and storage, ***partially filling the basement with suitable fill to convert to a crawlspace*** is recommended to minimize the risk of damage to the structural walls in the case of inundation, especially if structural elevation is not pursued. The base of this crawlspace would likely be approximately 4 ft. below the underside of first floor framing in order to allow for sufficient ventilation and access to the framing system if required. In this case, all utility equipment in the basement area should be relocated to the first floor elevation or higher in order to reduce the risk of damage.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8344 Main Street.

ALTERNATIVE #1 (PASSIVE)- Elevation
Construction Cost Estimate: $185,000

ELEVATE the structure up to the height of approximately **2.5 ft.** above existing condition.
(Final DFE is 185.6 ft. NAVD88)

a. ***New foundation walls***: 180 ft. building perimeter, 900 ft.^{2} footprint
    i. Raise structure on temporary framing to allow for new wall construction.
    ii. Construct new reinforced masonry foundation wall, 3 ft. height. Match historic appearance of existing wall.
b. ***Utility connections***:
    i. Disconnect all utilities and reconnect as required after elevation is complete.

WET FLOOD PROOF BASEMENT

a. ***Installation of flood louvers in north and west exterior walls***
    i. Assume 6 flood louvers/flood openings total, 2 ft. by 1 ft. each, installed in new foundation.
b. ***Pumping***
    i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

ALTERNATIVE #2 (PASSIVE)- Wet flood proof
Construction Cost Estimate: $20,000

CONVERT EXISTING BASEMENT TO CRAWLSPACE. **(Final DFE is 182.6 ft. NAVD88)**

a. ***Partially fill entire basement*** with suitable fill to an assumed height of 4.0 ft. above the existing basement floor elevation
    i. Assume 729 ft.^{3} of fill
b. ***Relocate basement HVAC and all other utility equipment*** to first floor elevation or higher.
    i. Assume one mechanical unit to be relocated, elevate on steel platform 3 ft.x 3 ft.x 4 ft. height.

WET FLOOD PROOF NEW CRAWLSPACE.

c. ***Installation of flood louvers in north and west exterior walls***
    i. Assume 6 flood louvers/flood openings total, 2 ft. by 1 ft. each, installed in existing masonry.
d. ***Pumping***
    i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

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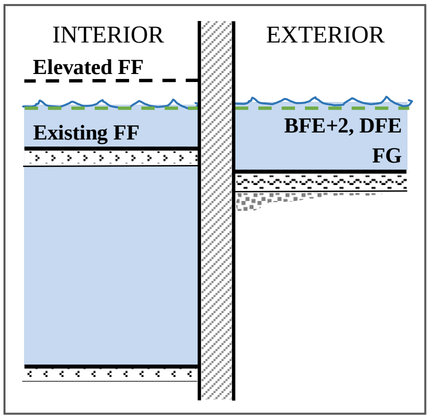
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8358 Main Street



BUILDING SECTION (South elevation)
Not to Scale

Structure Information / Data:

Location: 8358 Main Street
Occupancy type: Commercial
No. of Stories: 2.5
Building Construction:
- Exterior Walls: Wood frame
- Floor Construction (1st Flr.): Wood frame
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Basement
- Historic Status: Local, National

Key Building Features:

- Significant portion of the structure is wood frame construction
- Walkout basement with utilities that cannot be relocated

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
177.3	177.7	185.4	8.1	187.2	187.2	1.8	185.8	2.8	2.9

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:


1. South elevation


2. East elevation from southeast corner of building


3. North elevation from northeast corner of building


4. Mechanical equipment in basement

Background:

This 2.5-story wood frame structure, which currently houses a commercial tenant on the first floor, was built in the 1869 according to existing building records. The building sits on stone masonry foundation walls and has a basement that opens up at grade on the north elevation of the structure. All mechanical and electrical equipment has been relocated from the basement to higher floors of the structure, with the exception of a boiler unit. The building owner reported that the boiler was not moved due to space concerns and the difficulty and cost associated with relocation. The building owner reported that flooding during the July 2016 flood was minimal, if any, in the first floor.

Analysis of Key Building Features:

- **Significant portion of structure is wood frame construction**
  Wood frame construction is not particularly suitable for either wet or dry flood proofing due to a relative lack of lateral strength compared to other wall types and a susceptibility to excessive seepage and structural damage from periods of inundation. The recommended option for managing flood risk on this structure at an elevation higher than the first floor elevation is to ***elevate the entire structure on new or extended foundation walls and wet flood proof the basement***. A minimum elevation of approximately 2.3 ft. is recommended for this particular structure in order to elevate the first floor above the DFE. Given that the basement is only used for limited mechanical equipment and storage, ***partially filling the basement with suitable fill*** could be considered. This would increase structural stability of the new foundation walls. The addition of breakaway panels and piles may be required if structural analysis shows that foundation walls would not be able to withstand high flow velocities. Existing stone masonry foundation walls may require repointing to ensure that they are watertight. Close coordination with the pertinent historic preservation organizations is required in order to determine that all requirements are met.

- **Walkout basement with utilities that cannot be relocated**
  In general, ***wet flood proofing the basement*** is the recommended approach for this type of structure. Given that the basement is unfinished and constructed of stone masonry and concrete, there is a low risk of significant damage to the structure itself or the interior materials due to inundation. The ***installation of flood louvers/flood openings*** in the exterior stone masonry walls is recommended in order to allow water to safely enter and exit the structure during a high-water event and reduce the risk of catastrophic damage to the structure and basement windows.

  Given the significant cost and difficulty of relocating the existing boiler to a higher elevation, another option is to ***construct an interior wall around the unit*** to create a small dry flood proofed area within the basement. This approach would not provide the same flood risk management as relocating, but is a suitable option. The wall can tie in to existing basement walls to reduce material costs, however care must be taken in the design to ensure that additional load from the new walls are not transferred to the existing walls.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8358 Main Street.

ALTERNATIVE #1 (PASSIVE)- Elevation
Construction Cost Estimate: $195,000

ELEVATE the structure up to the height of approximately **2.3 ft.** above existing condition. (**Final DFE is 187.2 ft. NAVD88)**

c. ***New foundation walls***:
    i. Raise structure on temporary framing to allow for new wall construction.
    ii. Construct new masonry foundation wall around full building perimeter, 2.3 ft. height. Match historic appearance of existing wall.
d. ***Utility connections***:
    i. Disconnect all utilities and reconnect as required after elevation is complete.

WET FLOOD PROOF the basement.

e. ***Install flood louvers*** around the perimeter of the basement wall
    i. Assume 6 flood louvers total, 2 ft. by 1 ft. each, installed in new foundation wall.
f. ***Pumping***
    i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

ALTERNATIVE #2 (PASSIVE)- Wet flood proofing
Construction Cost Estimate: $25,000

WET FLOOD PROOF the basement. (**Final DFE is 182.7 ft. NAVD88)**

a. ***Install flood louvers*** around the perimeter of the basement wall
    i. Assume 6 flood louvers total, 2 ft. by 1 ft. each, installed in existing masonry.
b. ***Pumping***
    i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

DRY FLOOD PROOF a localized area of the basement around the existing boiler unit.

a. ***New masonry wall***:
    i. Construct a new CMU wall on two sides of the boiler unit; estimated 5 ft. height. Tie in to existing adjacent basement walls to create a waterproof seal, but ensure that new wall design does not impart additional load to existing walls. Leave 36”-wide opening in wall for access.
    ii. Install a flood proof swing gate closure over the wall opening.

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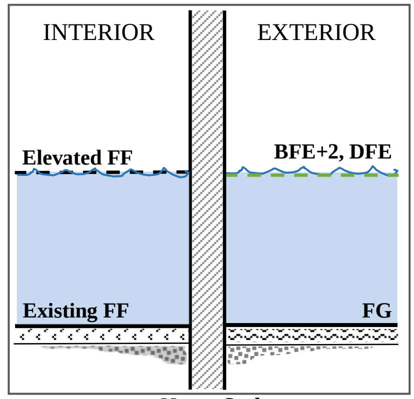
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8398 Main Street

Structure Information / Data:

Name/Description: Little Courthouse
Location: 8398 Main Street
Occupancy type: Historic/ Commercial
No. of Stories: 2.5
Building Construction:
- Exterior Walls: Stone masonry
- Floor Construction (1st Flr.): Wood
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: N/A
- 1st floor doors - single: 2
- Historic Status: MHT Easement, Local, National



BUILDING SECTION (North elevation)
Not to Scale

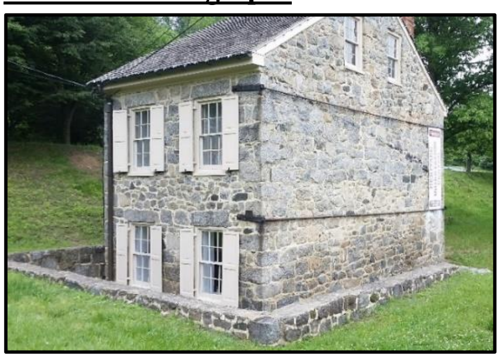
Key Features:
- BFE+2 > 3 ft. above first floor elevation
- Irreplaceable historic materials

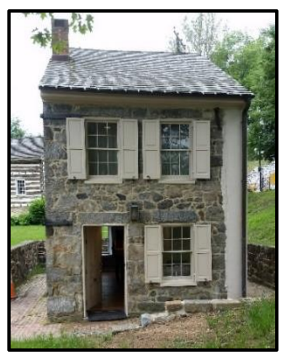
Structure/Flood Elevations Table (all elevations in ft. NAVD88):

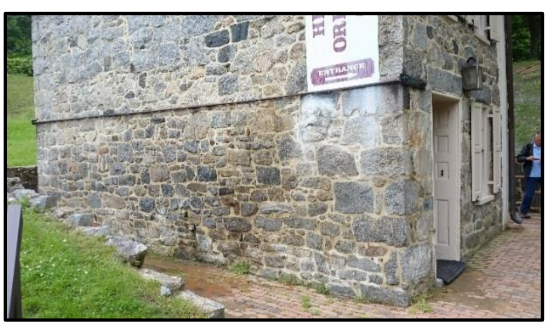
FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
185.9	185.9	185.9	0.0	191.2	191.2	5.3	189.6	5.1	5.4

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:


1. South and East Elevation


2. North Elevation, Front Entryway



3. East Elevation, Stone foundation and exterior wall


4. West Elevation

Background:

This building is a historic structure with an MHT Easement and was originally a court house. It currently functions as an orientation center for historic Ellicott City.

The building representative stated that there was substantial flooding coming in through the entrance of the building, likely through seepage as the door did not break. The building has flooded in the past and as a result has been completely gutted on multiple occasions.

Analysis of Key Building Features:

– **BFE+2 > 3 ft. above first floor elevation**
  The DFE for this structure is approximately 5.3 ft. above the first floor elevation. Wet flood proofing the first floor is not a viable option due to the building usage and existing interior finishes, which are not sufficiently resilient for such an application. The recommended measure for this structure would be to ***elevate on fill.*** Due to the height of the BFE+2, elevating the structure on new or extended foundation walls would heavily impact historical aesthetics. By raising the structure on fill, there would be the potential for maintaining the aesthetics of the building, while raising it out of the floodplain.

  Dry flood proofing would not manage flood risk for the entire DFE due to the low window sills. However, it may provide flood risk management benefits for ***smaller flooding events***. There is potential for installing ***flood proof doors*** on the interior of the entry doorways, which would minimize impacts to historical preservation aesthetics. A detailed structural analysis would be required to verify that the walls around the door frame could sufficiently support the hydrostatic and dynamic loads from flood waters.

– **Irreplaceable Historic Materials Inside Building**
  The building contains materials that are historically significant and irreplaceable. These materials ***should be elevated above the DFE*** on platforms and stored in watertight containers during a storm event if possible. Another option would be to ***relocate*** the historic materials, however this is likely not feasible due to the usage of the building for tourism.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8398 Main Street.

ALTERNATIVE #1 (PASSIVE)- Elevate on fill
Construction Cost Estimate: $145,000

ELEVATE the structure up to the height of approximately **5.3 ft.** above existing condition.
(**Final DFE is 191.2 NAVD88)**

a. ***Elevate on fill, 5.3 ft. above existing condition***
   i. Approximately 290 yd^3 fill required.

ALTERNATIVE #2 (PASSIVE)- Dry flood proofing
Construction Cost Estimate:$30,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **2.5 ft.** above the finished floor to the low window opening. (**Final DFE is 188.4 NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Flood proof doors at two single door locations (3 ft. wide each)
b. ***Pumping***:
   i. Assume 2 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.

ALTERNATIVE #3 (ACTIVE)- Dry flood proofing
Construction Cost Estimate: $15,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **2.5 ft..** above the finished floor to the low window opening. (**Final DFE is 188.4 NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Stoplog closures at two single door locations (3 ft. wide each)
b. ***Pumping***:
   i. Assume 2 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.

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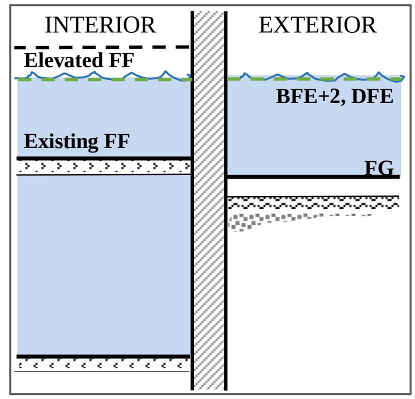
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8512 Main Street



BUILDING SECTION (South elevation)
Not to Scale

Structure Information / Data

Location:	8512 Main Street
Occupancy type:	Residential
No. of Stories:	2.5
Building Construction:	
Exterior Walls:	Wood frame
Floor Construction (1st Flr.):	Wood frame
Foundation Wall:	Stone masonry
Grade/Crawlspace/Basement:	Basement
Historic Status:	Local, National

Key Building Features:

- Significant portion of the structure is wood frame construction
- Occupied basement
- Detached garage structure

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
221.4	221.4	228.9	7.6	231.8	231.8	2.9	230.2	4.1	4.6

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevation, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. South elevation

2. West elevation

3. North elevation

4. Typical mechanical equipment in basement

<u>Background</u>:

This 2.5-story wood frame structure is located immediately adjacent to the stream and has a finished basement that opens up at grade on the north elevation of the structure. The basement is used for storage, occupied space at times, and houses multiple mechanical units. The basement has a concrete floor and is accessed by a single door on the north elevation.

The building owner reported that the structure was flooded to an approximate height of between 2-4 ft. within the basement area during the July 2016 flood event, as well as extensive damage to the driveway pavement due to scour. The building also received 2-3 ft. of flooding in the first floor.

<u>Analysis of Key Building Features</u>:

- **Significant portion of structure is wood frame construction**
  Wood frame construction is not particularly suitable for either wet or dry flood proofing due to a relative lack of lateral strength compared to other wall types, and a susceptibility to excessive seepage and structural damage from periods of inundation. The recommended option for managing flood risk on this structure at an elevation higher than the first floor elevation, if desired, is to ***elevate the entire structure on new or extended foundation walls and wet flood proof the basement***. A minimum elevation of approximately 3.4 ft. is recommended for this particular structure in order to elevate the first floor above the DFE. Detailed structural analysis should be performed to ensure that foundation walls would be able to withstand high flow velocities. Existing stone masonry foundation walls may require repointing to ensure that they are watertight. Close coordination with the pertinent historic preservation organizations is required in order to determine that all requirements are met.

  A feature of this particular structure that increases its resilience to flooding is the approximately ***1 ft.-high concrete planters*** on the south elevation between the porch and the adjacent sidewalk. In conjunction with the concrete steps up to the porch, these planters serve as a passive watertight barrier that would reduce the risk of flooding to the structure as well as partially ***protect the historic front porch from debris impact*** during a high-water event.

- **Occupied basement**
  Although the tenant utilizes the basement area extensively for storage, and has used it as occupied space at times, several modifications have been made that are recommended as potential measures for other similar structures to make the space more resilient to flooding. The basement floor is concrete, the interior stud walls have been replaced with aluminum studs rather than timber, and the drywall below the high-water mark of the July 2016 flood event replaced with aluminum sheeting. The use of these flood resilient materials, while not completely mitigating the risk of flooding in the basement area, effectively manage risk of damage and reduce the cost to the owner.

  Given the structure type and condition, the recommended approach for the basement area is to ***wet flood proof,*** as the tenant has already initiated. As much as possible, storage ***should be on elevated shelves*** to minimize the risk of damage, and ***critical or valuable items stored elsewhere***. In addition, ***flood louvers/flood openings should be installed*** through the exterior masonry walls to allow water to safely enter and exit the structure during a high-water event and reduce the risk of catastrophic damage to the structure as well as the basement windows. A small skimmer/sump pump would assist with post-flood recovery efforts.

  It is recommended that all utility equipment in the basement area be relocated to the first floor or higher in order to reduce the risk of damage. On this structure in particular, relocation to the second floor is recommended, given that flood proofing of the first floor is not feasible unless the entire building is elevated.

- **Detached Garage Structure**
  The structure contains a wood framed garage. It is recommended that valuable ***content inside of the detached garage structure be stored at an elevation above the DFE***. During a flood event, ***vehicles should be relocated to high ground to prevent flood damages if time permits to do so in a safe manner.***

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8512 Main Street.

ALTERNATIVE #1 (PASSIVE)- Elevation
Construction Cost Estimate: $190,000

ELEVATE the structure up to the height of approximately **3.4 ft.** above existing condition.
(**Final DFE is 231.8 NAVD88)**

a. ***New foundation walls***: Assume 180 ft. building perimeter, 900 $ft.^2$ footprint
   i. Raise structure on temporary framing to allow for new wall construction.
   ii. Construct new masonry foundation wall around full building perimeter, 3.4 ft. height. Match historic appearance of existing wall.
b. ***Utility connections***:
   i. Disconnect all utilities and reconnect as required after elevation is complete.

WET FLOOD PROOF the basement of the structure.

a. ***Install flood louvers/ openings*** around the perimeter of the basement wall
   i. Assume 8 flood louvers total, 2 ft. by 1 ft. each, installed in existing masonry.
b. ***Pumping***
   i. Assume 1 skimmer/sump pump and portable generators with suitable capacity to run the pump.

ALTERNATIVE #2 (PASSIVE)- Wet flood proofing
Construction Cost Estimate: $15,000

WET FLOOD PROOF the basement of the structure. (**Final DFE is 228.9 NAVD88)**

a. ***Install flood louvers/ openings*** around the perimeter of the basement wall
   i. Assume 8 flood louvers total, 2 ft. by 1 ft. each, installed in existing masonry.
b. ***Pumping***
   i. Assume 1 skimmer/sump pump and portable generators with suitable capacity to run the pump.

ELEVATE MECHANICAL AND ELECTRICAL EQUIPMENT

a. ***Relocate all basement mechanical and electrical equipment*** (assume three mechanical units and one wall-mounted electrical panel) above the DFE
   i. Elevation on a single steel platform, 4 ft. x10 ft. x4 ft. height

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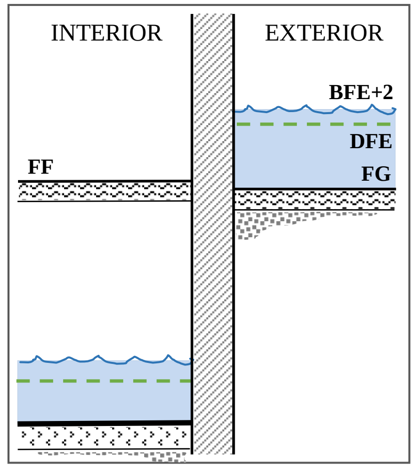
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8572 Main Street

Structure Information / Data:

Name/Description: Residential structure in the West End
Location: 8572 Main Street
Occupancy type: Residential
No. of Stories: 2
Building Construction:
- Exterior Walls: Stone masonry/wood frame
- Floor Construction (1st Flr.): Wood frame
- Foundation Wall: Stone masonry/concrete
- Crawlspace/Basement: Basement with walkout
- Historic Status: Local, National



BUILDING SECTION (South elevation)
Not to Scale

Key Building Features:

- BFE+2< 3 ft. above first floor elevation
- Flooding spilling over roadway affecting lower level
- Exterior utilities

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
233.3	235.9	242.9	9.5	245.3	244.9	2.4	243.1	3.0	3.2

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:


1. South elevation


2. West Elevation, Basement Walkout


3. North elevation


4. Northwest corner

Background:

This building was once the Catherine Kuhn House (MHT Record HO-482) and is a half stone frame duplex with shared brick stove chimney.

The structure houses a single residential tenant who stated that the buildings experienced moderate flooding during the July 2016 event. The building is susceptible to flooding from overland flow down Main Street in the front of the building and the first floor. The building is also located in a grass depression that is at the confluence of a storm drain pipe carrying water from the west and the stream, which backs up water from the north east when over capacity.

Analysis of Key Building Features:

– ***BFE+2 < 3 ft. above first floor elevation***

The BFE+2 ft. for this structure is approximately 2.4 ft. above the first floor elevation. Although it is typically undesirable to dry flood proof the first floor of a structure with wooden floors and basement, flood waters in this situation enters the first floor from overland flow coming from Main Street, so hydrostatic forces are not as concerning. It would be recommended to place ***door closures*** in front of the two entrance doorways to prevent water from entering the building through the first floor. Detailed structural analysis should be performed to ensure that door closures would be able to withstand the dynamic load of the flood water.

- ***Flooding spilling over roadway affecting lower level***

Due to the location of the structure, it is susceptible to both flooding from Main Street (primary flood threat) on the south elevation and the stream/culvert conveyances on the north elevation (secondary flood threat). There is also flood risk to the lower level from water rolling down the hill on the south elevation of the structure. Typically, dry flood proofing is not recommended for wood frame portions of structure due to the lack of structural stability. In this case, flood proofing would increase resiliency to minor flooding (< 2 ft.), while likely not eliminating flood risk. Therefore, the structure would benefit from placement of a ***non-permeable liner underneath the exterior siding*** on the north end of the building and a ***temporary stoplog panel to be placed across the doorway***. Due to the wood frame construction, the maximum height of flood risk management recommended would be 1-2 ft. Detailed structural analysis of the exterior walls on the north side of the building is recommended prior to implementation of any dry flood proofing measures.

– ***Exterior Utilities***

Elevation-in-place of the exterior HVAC equipment above the DFE would be recommended. The unit may be placed on either an extended masonry platform or an isolated steel platform depending on user preference.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8572 Main Street.

ALTERNATIVE #1: (PASSIVE)- Dry flood proofing
Construction Cost Estimate:$50,000

DRY FLOOD PROOF the first floor entrance doorway up to a height of 2.0 ft.
(Final DFE is 244.9 ft. NAVD88)

a. ***Door openings***: Flood proof doorways.
    i. Flood proof doors at two single door locations (3 ft. wide each)
    ii. Stoplog or panel door closures and associated framing at north elevation single door location (3 ft. wide each); assume 2.0 ft. height
b. ***Nonpermeable membrane beneath siding:***
    i. Amount of permeable membrane: ~144 $ft.^2$ (2 ft height x 72 ft.)
c. ***Basement access opening***:
    i. Replace existing basement access doors with certified flood proof hatch framed into existing masonry opening.
d. ***Pumping***:
    i. Assume 2 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
e. ***Elevate mechanical and electrical equipment:***
    i. Relocate HVAC unit to elevation of the first floor and elevate HVAC unit in place on a single steel platform by approximately 2 ft.

ALTERNATIVE #2 (ACTIVE)- Dry flood proofing
Construction Cost Estimate: $25,000

DRY FLOOD PROOF the first floor entrance doorway up to a height of 2.0 ft.
(Final DFE is 244.9 ft. NAVD88)

a. ***Door openings***: Flood proof doorways.
    i. Stoplog or panel door closures and associated framing at three single door locations (3 ft. wide each); assume 2.0 ft. height
b. ***Nonpermeable membrane beneath siding:***
    i. Amount of permeable membrane: ~144 $ft.^2$ (2 ft height x 72 ft.)
c. ***Basement access opening***:
    i. Replace existing basement access doors with flood proof hatch, framed into existing masonry opening.
d. ***Pumping***:
    i. Assume 2 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
e. ***Elevate mechanical and electrical equipment:***
    i. Relocate HVAC unit to elevation of the first floor and elevate HVAC unit in place on a single steel platform by approximately 2 ft.

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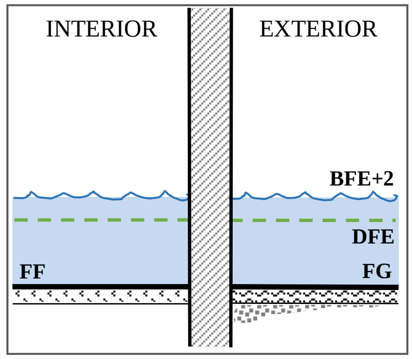
NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8600 Main Street

Structure Information / Data:

Name/Description: West End Service
Location: 8600 Frederick Road
Occupancy type: Commercial
No. of Stories: 1
Building Construction:
- Exterior Walls: Steel frame and masonry with aluminum siding
- Floor Construction (1st Flr.): Concrete
- Foundation Wall: Reinforced concrete
- Grade/Crawlspace/Basement: N/A
- 1st floor doors: 4
- Historic Status: National



BUILDING SECTION (South elevation)
Not to Scale

Key Building Features:
- Mixed usage at first floor elevation
- Large assets outside of building
- Exterior utilities

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

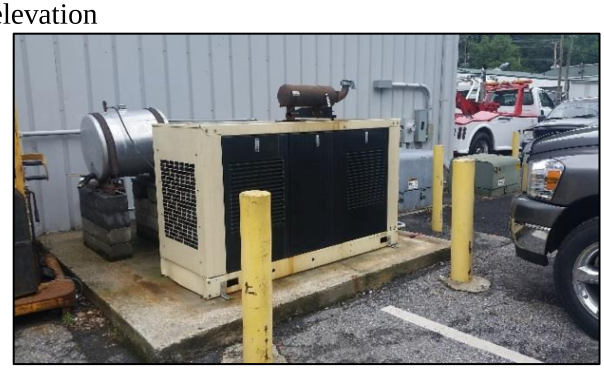
FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
245.8	246.4	246.4	0.6	249.4	248.9	3.0	247.6	4.0	6.7

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. South elevation

2. East elevation



3. Exterior mechanical on north elevation

<u>Background</u>:

The approximately 13,000 square foot single-story steel frame structure is set back from the main road. The building houses West End Services Inc., which is a full service sales and tow truck dealership. It contains office spaces, storage on the west side of the building, and a large garage, where trucks are serviced. The garage and office buildings are separated by a fire wall on the inside of the building. The office space is accessed through four single doorways, while the storage area is accessed from the exterior on the north elevation through two single doorways and a garage door. The structure has six garage bay doorways that provide access to the east portion of the building.

The building representative mentioned that the building had received minor flooding during the July 2016 flood event, and the majority of damages were due to trucks in the lower parking lot area being inundated.

<u>Analysis of Key Building Features:</u>

– **Mixed usage at first floor elevation**

The building would be a strong candidate for ***dry flood proofing*** in the office area since the BFE+2 ft. is less than 3 ft. above the first floor elevation. However, due to the metal siding construction of the exterior wall, ***retrofits would have to be completed*** to provide structural stability to the wall against hydrostatic forces. A ***short masonry wall would be constructed*** on the interior so that exterior aesthetics of the building are not impacted. Also, because the building is not in the local historic district, flood proof doors, which are typically stainless steel, would potentially blend in well with the overall building exterior and provide adequate flood risk management to the DFE.

Wet flood proofing the first floor is the recommended approach for providing flood risk management to the garage in the east area of the building. Due to the building construction, ***flood louvers/openings*** could be placed in the exterior wall to allow water to pass through the building during a flood event. Non-water resistant storage materials and mechanical equipment should be placed on ***storage shelves*** above the DFE and large trucks should be moved to higher ground (east of the building). A small skimmer/sump pump would assist with post-flood recovery efforts.

– **Large assets outside of the building**

The building contains large trucks in the low grade parking lot area, which is susceptible to levels of flooding greater than 3 ft. The recommended approach would be to ***store large assets on nearby higher ground*** if available, especially when a storm event is anticipated. If storage area is limited, an alternative offsite location should be identified as part of an overall flood preparedness plan. During a flood event, ***vehicles should be relocated to high ground to prevent flood damages if time permits to do so in a safe manner.***

– **Exterior utilities**

Elevation-in-place of the exterior HVAC equipment on raised platforms above the DFE is recommended. As an additional consideration, when dry flood proofing a structure with exterior mechanical equipment, it must be verified that exterior wall penetrations below the DFE are sufficiently sealed to be watertight.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8600 Main Street.

ALTERNATIVE #1 (PASSIVE)- Dry flood proofing and wet flood proofing

Construction Cost Estimate: $145,000

DRY FLOOD PROOF the office and storage area in the western half of the structure up to the height of approximately **3 ft.** above the finished floor. (**Final DFE is 248.9 ft. NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Install flood proof doors at five single door locations (3 ft. wide each)
   ii. Install flood proof barrier at one garage door opening (12 ft.wide)
b. ***Pumping***:
   i. Assume six skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
c. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
d. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume ten 4 in. penetrations.

WET FLOOD PROOF the garage area in the eastern half of the structure.

a. ***Installation of flood louvers in east exterior wall***
   i. Assume 6 flood louvers total, 2 ft. by 1 ft. each, installed in existing masonry wall
b. ***Pumping***
   i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

ELEVATE EXTERIOR MECHANICAL AND ELECTRICAL EQUIPMENT

a. ***Elevate all exterior mechanical and electrical equipment*** (assumed five units total) on elevated platform above the DFE
   i. Assume one platform, 10 ft. x 25 ft., 4 ft. height

ALTERNATIVE #2 (ACTIVE)- Dry flood proofing and wet flood proofing

Construction Cost Estimate: $110,000

DRY FLOOD PROOF the office and storage area in the western half of the structure up to the height of approximately **3 ft.** above the finished floor. (**Final DFE is 248.9 ft. NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Install flood proof doors at five single door locations (3 ft. wide each)
   ii. Install stoplogs at one garage doorway opening (12 ft.wide)
b. ***Pumping***:
   i. Assume six skimmer/pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
c. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
d. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume ten 4 in. penetrations.

WET FLOOD PROOF the garage area in the eastern half of the structure.

a. ***Installation of flood louvers in east exterior wall***
   i. Assume 6 flood louvers total, 2 ft. by 1 ft. each, installed in existing masonry wall

b. ***Pumping***
   i. Assume 1 skimmer/sump pump and portable emergency generator with suitable capacity to run the pump.

ELEVATE EXTERIOR MECHANICAL AND ELECTRICAL EQUIPMENT

a. ***Elevate all exterior mechanical and electrical equipment*** (assumed five units total) on elevated platform above the DFE
   i. Assume one platform, 10 ft. x 25 ft., 4 ft. height

ALTERNATIVE #3 (ACTIVE)- Dry flood proofing and wet flood proofing
Construction Cost Estimate: $65,000

DRY FLOOD PROOF the office and storage area in the western half of the structure up to the height of approximately **3 ft.** above the finished floor. (**Final DFE is 248.9 ft. NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Stop logs at five single door locations (3 ft. wide each) and one garage door location (12 ft. wide)
b. ***Pumping***:
   i. Assume six skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
c. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
d. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume ten 4 in. penetrations.

WET FLOOD PROOF the garage area in the eastern half of the structure.

a. ***Installation of flood louvers in east exterior wall***
   i. Assume 6 flood louvers total, 2 ft. by 1ft. each, installed in existing masonry wall
b. ***Pumping***
   i. Assume 1 skimmer/sump pump and portable generator with suitable capacity to run the pump.

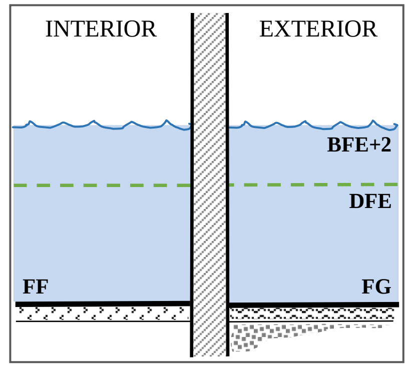
ELEVATE EXTERIOR MECHANICAL AND ELECTRICAL EQUIPMENT

a. ***Elevate all exterior mechanical and electrical equipment*** (assumed five units total) on elevated platform above the DFE
   i. Assume one platform, 10 ft.x 25 ft., 4 ft. height

NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8602 Main Street

Structure Information / Data:

Name/Description: Multiple Businesses
Location: 8602 Frederick Road
Occupancy type: Commercial
No. of Stories: 1
Building Construction:
- Exterior Walls: Masonry
- Floor Construction (1st Flr): Concrete
- Foundation Wall: Masonry
- Crawlspace/Basement: N/A
- 1st floor doors: 4
- 1st floor garage doors: 4
- Historic Status: National



BUILDING SECTION (East elevation)
Not to Scale

Key Building Features:

- BFE+2 > 3 ft. above first floor elevation
- Slab on grade multi-unit structure
- Exterior Utilities

Structure/Flood Elevations Table (all elevations in ft. NAVD88):

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
244.0	244.0	244.0	0.0	250.5	248.0	6.5	248.7	6.5	6.8

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. East Elevation

2. Interior of Automotive Repair Shop

3. West Elevation, Raised on higher ground

4. Interior of Art Gallery

<u>Background</u>:

8602 Main Street houses multiple commercial spaces, including an Art Gallery and Automobile Body Shop, and is owned by West End Services. The building sits within a depression and has a parking lot on the east end. The first floor elevation is at the elevation of the adjacent exterior grade. The building is slab-on grade construction. There are multiple points of entry for each compartment of the structure.

During the site visit, the buildings tenant representative was available and mentioned that flooding greater than 3 ft. occurred throughout the various businesses during the July 2016 flood event.

<u>Analysis of Key Building Features</u>:

– **BFE+2 > 3 ft. above first floor elevation**
The BFE +2 for this structure is approximately 6.5 ft. above the first floor elevation. ***Wet flood proofing*** the first floor would be recommended due to the building usage and existing interior finishes. This would include ***placement of flood louvers/openings*** to allow water to flow through the structure during an event. A small skimmer/sump pump would assist with post-flood recovery efforts. ***Dry flood proofing may also provide benefits for lesser flooding events.*** A commercial structure of this type, which does not have historical significance, would benefit from dry flood proofing through placement of flood proof doors for entry doors and garages. If proper analysis is complete, flood proof doors could provide flood risk management up to the height of the window sills. Detailed structural analysis should be performed when considering flood proofing the structure due to high flow velocities and depths.

– **Slab on grade multi-unit structure**
The building consists of multiple business units housed in slab on grade foundation. This would make elevation highly complicated and expensive and therefore was not recommended, though technically feasible. ***Equipment inside buildings similar to the body automotive repair shop would be elevated above the height of the DFE*** to prevent damages and potential fuel/oil spillage. Buildings similar to the Art Gallery, which houses materials that are irreplaceable and highly vulnerable to water damage, may benefit from ***dry flood proofing***. Owners for business such as this should also consider ***relocating*** to a building that would not be impacted by flood damages.

– **Exterior Utilities**
Elevation-in-place of the exterior electrical equipment above the DFE would be recommended. As an additional consideration in the case of dry flood proofing, it must be verified that ***exterior wall penetrations*** below the DFE are ***sufficiently sealed to be waterproofed***.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8602 Main Street.

ALTERNATIVE #1 (PASSIVE)- Wet flood proofing
Construction Cost Estimate:$20,000

WET FLOOD PROOF first floor of each compartment. (**Final DFE is 248 ft. NAVD88)**

a. ***Install flood louver around the perimeter of the structure walls***
   i. Assume 10 flood louvers total, 2 ft. by 1ft., installed in existing masonry.
b. ***Elevate mechanical and electrical equipment:***
   i. Elevate existing exterior electrical meters approximately 6.5 ft. to clear DFE.
c. ***Pumping***
   i. Assume 4 skimmer/sump pumps and portable emergency generators with suitable capacity to run the pumps.

ALTERNATIVE #2 (PASSIVE)- Dry flood proofing with mechanical garage doors
Construction Cost Estimate: $325,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4 ft.** above the finished floor. (**Final DFE is 248 ft. NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Flood proof doors at four single door locations (3 ft. wide each)
   ii. Flood proof barriers at four garage door openings (12 ft. wide)
b. ***Pumping***:
   i. Assume 8 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
c. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
d. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations.
e. ***Elevate mechanical and electrical equipment:***
   i. Elevate existing exterior electrical meters approximately 4 ft. to reach DFE

ALTERNATIVE #3 (ACTIVE)- Dry flood proofing with stoplog closures for all openings
Construction Cost Estimates: $185,000

DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4 ft.** above the finished floor. (**Final DFE is 248 ft. NAVD88)**

a. ***Door openings***: Flood proof doorways.
   i. Stoplogs at four single door locations (3 ft. wide each)
   ii. Stoplogs closures at four garage doors (12 ft. wide)
b. ***Pumping***:
   i. Assume 8 skimmer/sump pumps for use inside the building and portable emergency generators with suitable capacity to run the pumps.
c. ***Sewage check valve***:
   i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
d. ***Exterior wall utility penetrations***:
   i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations.
e. ***Elevate mechanical and electrical equipment:***
   i. Elevate existing exterior electrical meters approximately 4 ft. to reach DFE

ALTERNATIVE #4 (ACTIVE)- Dry flood proofing with stoplogs at garage doors
Construction Cost Estimates: $205,000

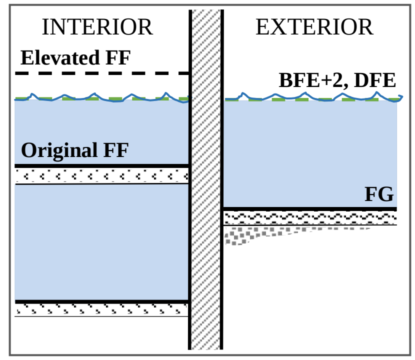
DRY FLOOD PROOF all applicable portions of the structure up to the height of approximately **4 ft.** above the finished floor. (**Final DFE is 248 ft. NAVD88)**

a. ***Door openings***: Flood proof doorways.
    i. Flood proof doors at four single door locations (3 ft.wide each)
    ii. Stoplogs closures at four garage doors (12 ft. wide)
b. ***Pumping***:
    i. Assume 8 skimmer/sump pumps for use inside the building and portable generators with suitable capacity to run the pumps.
c. ***Sewage check valve***:
    i. Assume one check valve to be placed on sanitary line in order to prevent backflow during flood event.
d. ***Exterior wall utility penetrations***:
    i. Replace seal at utility penetration locations to ensure watertightness. Assume four 4 in. penetrations.
e. ***Elevate mechanical and electrical equipment:***
    i. Elevate existing exterior electrical meters approximately 5 ft. to reach DFE

NONSTRUCTURAL FLOOD PROOFING CONCEPT SHEET
8637 & 8639 Main Street

Structure Information / Data:

Name/Description: Residential Duplex
Location: 8637 & 8639 Main St.
Occupancy type: Residential
No. of Stories: 2
Building Construction:
- Exterior Walls: Wood frame
- Floor Construction (1st Flr.): Wood frame
- Foundation Wall: Stone masonry
- Grade/Crawlspace/Basement: Crawlspace
- 1st floor doors 4
- Historic Status: National



BUILDING SECTION (North elevation)
Not to Scale

Key Building Features:
- BFE+2> 3 ft. above first floor elevation
- Building foundation on stream embankment
- Detached duplex structure
- Exterior utilities

Structure/Flood Elevations Table (all elevations in ft. NAVD88)*:

FG	LO	FF	FF-FG	BFE+2	Prim. DFE	ΔBFE+2 -FF	30 July 2016 Flood Elevation	1% Annual Chance Flood Velocity (ft./s)	30 July 2016 Velocity (ft./s)
250.2	250.6	251.4	1.2	254.9	254.9	3.5	253.5	7.3	7.5

FG: Finished Grade; LO: Low Opening; FF: First Floor Elevation; BFE: Base Flood Elevation (1% Annual Chance Flood Event); Prim. DFE: Design Flood Elevation for primary alternative; 30 July 2016, BFE elevations, and velocities were obtained from McCormick Taylor Hydraulic Modeling*

Structure Photographs:

1. North elevation

2. South elevation, stream adjacent to structure

3. Exterior mechanical units on west elevation

4. North and east elevations from northeast corner

Background:

The 2-story wood frame structure is located immediately adjacent to the Hudson Branch. The building structure is a duplex: 8637 and 8639 Main Street. Both sides of the duplex are owned by the same property owner and have the same layouts. The building is outside the local historic district. The building drops down approximately 14” in the back portion.

The property owner was present during the site visit and stated that the building had received substantial flooding during the July 2016 storm and 2011 Tropical Storm Lee.

Analysis of Key Building Features:

– **BFE+2 > 3 ft. above the first floor elevation**
Dry flood proofing would not be viable option. Wood frame construction is not particularly suitable for either dry flood proofing due to a relative lack of lateral strength compared to other wall types, and susceptibility to excessive seepage and structural damage from periods of inundation. Wet flood proofing would also not be a viable solution due to the construction of the building. Flood water passing through the building would damage the wood structure and mold would develop if not dried out quickly.

The recommended approach would be to ***elevate the entire structure on new or extended foundation walls*** and ***wet flood proof the new crawl space area.*** Due to the area in the back of the building being 14” lower than the first floor, the building should be raised to a minimum of 5.2 ft. Given that the crawlspace is only used for limited storage, ***partially filling the crawlspace with suitable fill*** could be considered. This would increase structural stability of the new foundation walls. The addition of breakaway panels and piles may be required if structural analysis shows that new foundation walls would not be able to withstand high flow velocities. Existing stone masonry foundation walls may require repointing to ensure that they are watertight. Close coordination with the pertinent historic preservation organizations is required in order to determine that all requirements are met.

– **Detached duplex structure**
Elevation of the structure is the recommended the approach due to the duplex layout. The entire structure could be elevated simultaneously and the symmetric layout of the building would allow for aesthetic impacts to be minimized. This particular structure is also owned by a single property owner, which would preclude the need for coordination with another property owner for elevating both sides of the structure.

- **Building Foundation on Creek Embankment**

The building foundation is built into the stream embankment, which makes the building both susceptible to structural damage from erosion of the embankment and flooding. If elevation is the selected option, large rip-rap placement on the embankment should be considered for dissipating flows and reducing shear stresses to the building foundation. This would require close coordination and approval from local, state and federal agencies.

The most effective option for reducing flood risk would be to relocate the building to higher ground, however this may be difficult and should be closely coordinated with the property owner and local permitting authority.

– **Exterior Utilities**
Elevation-in-place of the exterior HVAC equipment above the DFE would be recommended. The unit may be placed on either a wall-mounted platform, extended masonry platform or an isolated steel platform depending on user preference.

FINAL RECOMMENDATIONS:

The following recommendations were used to develop the associated construction cost estimates and are specific to 8637& 8639 Main Street.

ALTERNATIVE #1 (PASSIVE)- Elevation
Construction Cost Estimate: $110,000

ELEVATE the structure up to the height of approximately **5.2 ft.** above existing condition.
(**Final DFE is 254.9 ft. NAVD88)**

a. ***New foundation walls***:
   i. Raise structure on temporary framing to allow for new wall construction.
   ii. Construct new masonry foundation wall around full building perimeter, 4 ft. height. Match historic appearance of existing wall.
b. ***Utility connections***:
   i. Disconnect all utilities and reconnect after elevation is complete.
c. ***Elevate mechanical and electrical equipment:***
   i. Relocate and elevate HVAC unit in place on a single steel platform, approximately 5.2 ft. once placed at elevation of the first floor

ALTERNATIVE #2 (PASSIVE)- Stream Energy Dissipators
Construction Cost Estimate: $5,000

ENERGY DISSIPATION IN THE STREAM BANK to reduce erosive forces near building foundation.

a. ***Place rip-rap (or energy dissipater) in stream bank***
   i. Large rip-rap stone for 20 linear ft.
   ii. Elevate two exiting exterior HVAC units in place on a single steel platform, approximately 5.2 ft. in height.

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