Appendix D:

Lower Meramec River Basin

Nonstructural Flood Mitigation Assessment by

USACE National Nonstructural Committee

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Table of Contents

1 Introduction 1
1.1 Community Description 2
1.1.1 Arnold 2
1.1.2 Fenton 3
1.1.3 Eureka 3
1.1.4 Pacific 4
1.1.5 Union 4
1.2 Consequences of Flood Risks 5
2 Nonstructural Flood Risk Adaptive Measures 6
2.1 Floodplain and Flood Risk Characteristics 8
2.2 Executive Order 11988; Floodplain Management (EO11988) 8
2.3 Critical Facilities 8
2.4 Common Nonstructural Flood Risk Adaptive Measures 9
2.4.1 Acquisition with Demolition/Salvage of the Structure 9
2.4.2 Relocation of Structure 9
2.4.3 Basement Abandonment 9
2.4.4 Elevation of Structure. 10
2.4.5 Dry Flood Proofing 10
2.4.6 Wet Flood Proofing 11
2.4.7 Berms, Levees, and Floodwalls 12
2.4.8 Public Alert Flood Warning, Flood Emergency Preparedness, Evacuation Plans and Pertinent Equipment Installation 13
2.4.9 Land Acquisition 13
2.4.10 Floodplain Regulation and Floodplain Management 13
2.4.11 National Flood Insurance Program 13
2.5 Temporary Flood Risk Adaptive Measures 14
2.5.1 Common Temporary Flood Risk Adaptive Measures 14
2.5.2 Implementing Temporary Measures 15
2.5.3 Flood Characteristics Dictating Temporary Measures 16
2.5.4 Planning and Preparation of Temporary Measures 16
2.5.4.1 Site Preparation 17
2.5.4.2 Removal of Interior Flood Water 18
2.5.4.3 Materials and Equipment Required for Temporary Measures 18
3 Nonstructural Assessment Objectives 21
3.1 Description of Structure Dataset 22
4 Description of Nonstructural Assessment 24
5 Recommendation of Nonstructural Flood Risk Adaptive Measures 24
6 Floodplain Management Recommendations for Minimizing Damages 26
6.1 Local Drainage and Utility Protection 26
7 Flood Insurance Premium Reduction from Nonstructural Measures 26
8 Managing Flood Risk 27

8.1 Flood Preparedness Planning 27
8.2 Future Development 27
8.3 Risk Management through Flood Insurance 28
9 Assessment Conclusions 28

List of Figures

Figure 1; Lower Meramec River Basin Assessment Area Map.....1
Figure 2; City of Arnold Location Map.....2
Figure 3; City of Fenton Location Map.....3
Figure 4; City or Eureka Location Map.....3
Figure 5; City of Pacific Location Map.....4
Figure 6; City of Union Location Map.....4
Figure 7; Elevation of Structure (Diagrammatic Section) 10
Figure 8; Dry Flood Proofing (Diagrammatic Detail) 11
Figure 9; Wet Flood Proofing (Diagrammatic Detail/Section).....11
Figure 10; Berms, Levees, Floodwalls (Diagrammatic Detail) 12
Figure 11; Localized Interior Drainage and Utilities.....25
Figure 12; Flood Insurance Premium Reduction through Elevation.....26

List of Tables

Page

Table 1; Lower Meramec River Basin Structure Inventory Data 22
Table 2; Recommended Nonstructural Mitigation Measures.....24

Enclosures

Enclosure A; Structure Assessment Sheets
Enclosure B; Glossary

APPENDIX D
Nonstructural Assessment

1 Introduction

This reconnaissance level nonstructural assessment has been conducted in support of the U.S. Army Corps of Engineers (USACE) St. Louis District to assess the flood risk within the Lower Meramec River Basin. The 17 sample structures investigated as part of this assessment consist of residential, nonresidential commercial structures, and one public structure. The objective of this assessment is to identify potential opportunities for implementation of flood risk adaptive measures, generally referred to as nonstructural mitigation measures, in order to reduce flood damages from future flood events. A general location map for the Lower Meramec River Basin is presented in Figure 1.

The nonstructural assessment focused on structures at risk of flooding from the Meramec River in Jefferson, Franklin, and St. Louis counties. The Meramec River is a right-bank tributary of the Mississippi River, having a total length of approximately 230 miles and draining 3,980 square miles of Ozark uplands. The river has an elevation change of 1,025 feet between its headwaters and its mouth. Flooding on the Meramec River is usually a result of heavy rainfall in the upstream basin.

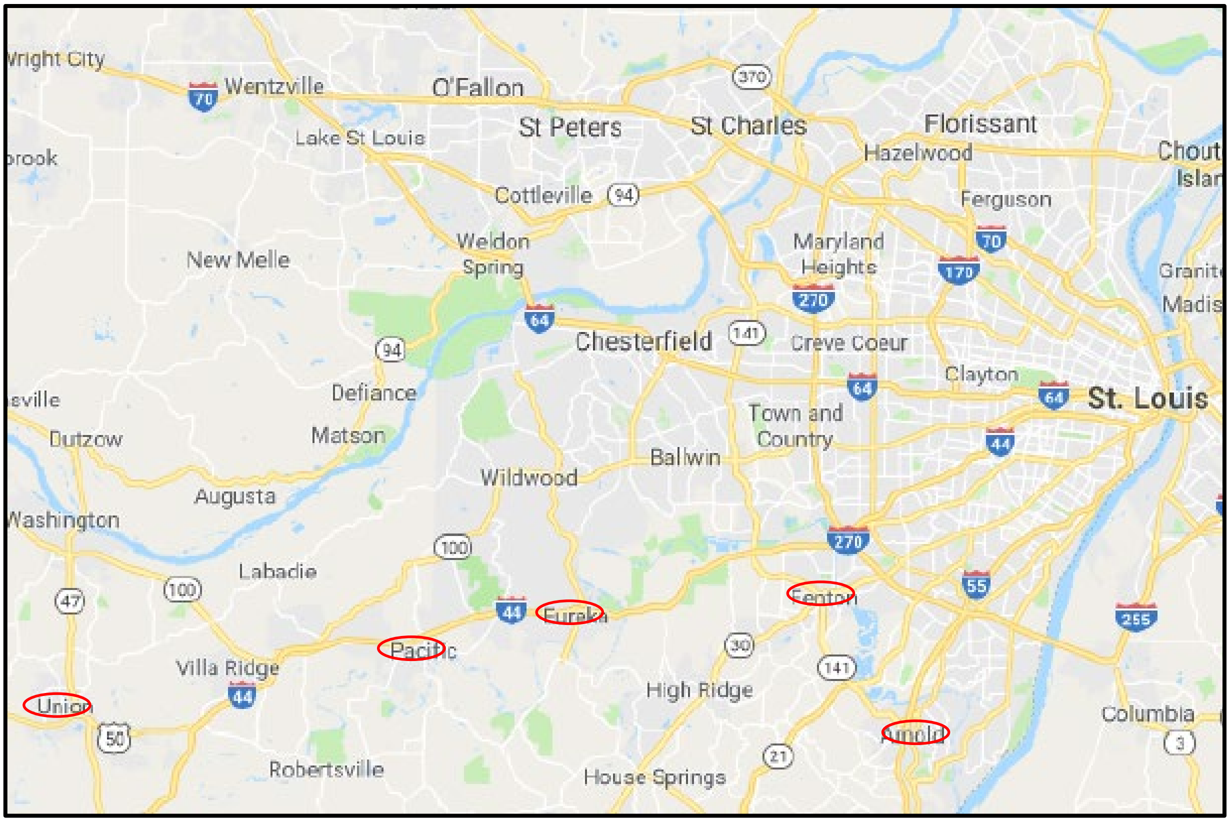

Figure 1. Lower Meramec River Basin Assessment Area Map

1.1 Community Description

This nonstructural assessment was conducted within the Lower Meramec River Basin on a sampling of residential, commercial, and light industrial structures which were identified within the communities of Arnold, Fenton, Eureka, Pacific, Union, and some structures located within unincorporated St. Louis and Jefferson Counties. All communities and unincorporated areas in the vicinity of the Meramec River were adversely impacted by flooding in 2015 and 2017. The two flood events brought record and near record flood stages throughout the lower basin. Flooding was widespread, impacting residential areas, commercial and industrial centers, as well as transportation routes. Location maps are shown in Figures 2 through 6.

1.1.1 Arnold

The City of Arnold had a 2010 population of 20,808 and is trending upward. The city is located at the confluence of the Meramec and Mississippi Rivers. The Meramec River crested at a record level of 47.26 feet on December 31, 2015, after a weekend of heavy rain, impacting over 300 homes and breaking the previous record crest set during the flood of 1993. Flooding occurred again in 2017 after heavy rains, with the Meramec River cresting at 45.62 feet on May 3. Approximately 20 homes were impacted during this flood event. This assessment investigates four residential structures in the Arnold area.

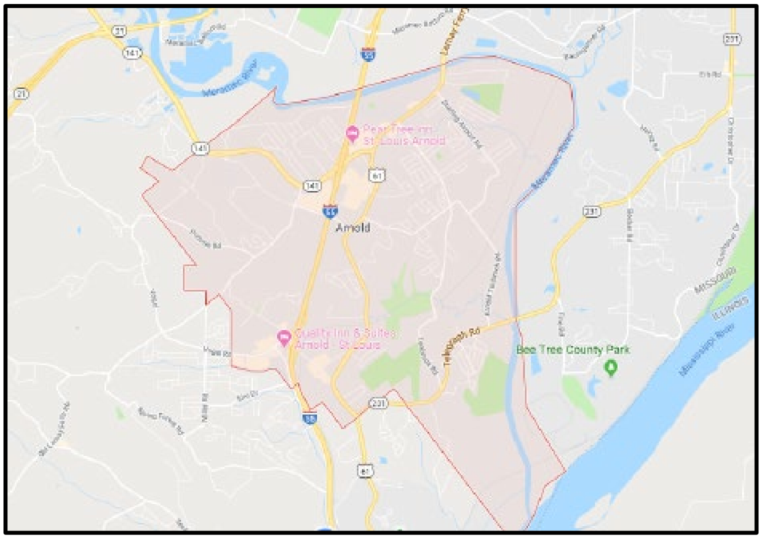

Figure 2. City of Arnold Location Map

1.1.2 Fenton

The City of Fenton is located along the right-bank of the Meramec River in St. Louis County. The city had a 2010 population of 4,047 and experienced severe flooding during December 2015 and again during May 2017, when more than 10 inches of rain fell in the area. This assessment investigates six commercial structures in the Fenton area.

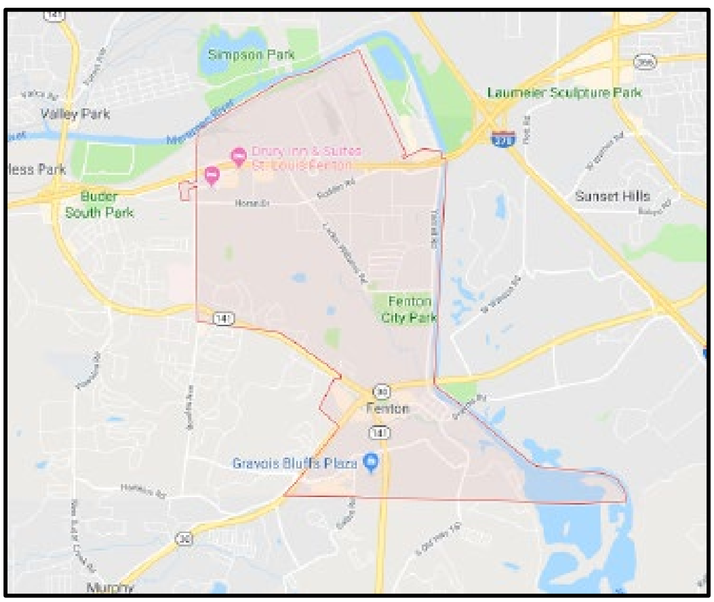

Figure 3. City of Fenton Location Map

1.1.3 Eureka

The City of Eureka, which is located in St. Louis County, had a 2010 population of 10,189. Eureka is located along the left-bank of the Meramec River. This assessment investigates three commercial structures in the Eureka area.

Figure 4. City of Eureka Location Map

1.1.4 Pacific

The City of Pacific is located in Franklin and St. Louis counties along the left-bank of the Meramec River. The 2010 population was estimated at 7,002. This assessment investigated three commercial structures in the Pacific area.

Figure 5. City of Pacific Location Map

1.1.5 Union

The City of Union is located in Franklin County, along the Bourbeuse River which is a right-bank tributary of the Meramec River. Union was founded in 1826 and designated as the county seat in 1827. The 2010 population was estimated at 10,204. Even though sandbags and fill material was provided during previous floods to residents and business owners, the effort to protect structures and to evacuate valuables is a significant effort.

Figure 6. City of Union Location Map

1.2 Consequences of Flood Risks

According to the 2015 St. Louis County Flood Insurance Study, major floods have occurred along the Meramec River on the average of approximately once every 6 years. While significant flooding occurred in 2015 and again in 2017, the potential exists for loss of life and extreme property damages during any flood event which exceeds the capacity of the channel.

Flooding along the Meramec River has the potential to impact residential, commercial, and public sector development and may require the response and recovery efforts of federal, state, and county governments, as well as local and neighboring governments, residents and outside volunteers. When flooding occurs, the drain on human and financial resources is significant.

This reconnaissance level nonstructural assessment focuses on at-risk structures and contains the detailed technical assessment used for investigating the incorporation of nonstructural measures to reduce flood risk within the assessment area. Without the incorporation of nonstructural mitigation as discussed in this report or other structural measures, such as levees, floodwalls, or channel modifications, the existing structures are at risk of being damaged or destroyed during future flood events.

Depth of flooding relative to the first floor of a structure is one of the most practical indicators of flood risk for a structure and goes beyond the normal tendency to only indicate the 1% Annual Exceedance Probability (AEP) formerly referred to as the annual chance exceedance (ACE) or 0.2% AEP flood elevation at a structure. A 1% AEP depth of flooding measurement of two feet, when comparing to the first floor, would indicate that the 1% AEP flood event would be expected to flood the structure two feet above the first floor. A depth of flooding measurement of negative two feet would indicate that flooding may not reach the first floor, but instead could cause damage in a subfloor space such as a basement or crawlspace. Since the ground surface elevation changes spatially, the depth of flooding statistic provides the best overall characterization of flood risk to individual structures by being able to compare flood prone structures across an entire floodplain.

While nonstructural mitigation measures are specific to the individual structure being investigated, when considered for the mitigation of flood damages, the cumulative effect is to determine a strategy for incorporating a full range of nonstructural measures which are economically feasible, socially acceptable, environmentally adequate, and which will reduce the cumulative risk of flooding. Each individual structure assessed may require a different nonstructural technique to be applied depending upon the type of construction. While this assessment relies on data collected in the field for implementation, the assessment is not conclusive as to the ultimate feasibility of the alternatives presented. Because of the limited scope of this investigation, this assessment was conducted as reconnaissance level detail and would require additional detailed analyses to determine economic feasibility for implementation.

Nonstructural flood risk adaptive measures require different implementation processes than structural measures. Since each structure is owned and typically occupied, nonstructural implementation agreements must be entered into with each individual owner. Nonstructural measures are proven methods and techniques specifically directed at reducing flood risk and flood damages in floodplains. Numerous structures across the nation are subject to reduced risk and damage or no risk and no damage due to implementation of nonstructural measures. Nonstructural measures are very effective for both short and long term flood risk and flood damage reduction and can be very cost effective when compared to other types of flood risk management (levee systems, detention, and channel modification) measures.

The ability of nonstructural measures to be implemented in very small increments, each increment producing flood risk reduction benefits is an important characteristic of this form of flood risk management. Also important is the ability to implement measures over intermediate and long periods of time such that layering of measures, each one providing a higher degree of risk reduction, is possible and may be a probable scenario for implementation given both federal and non-federal funding constraints.

2 Nonstructural Flood Risk Adaptive Measures

The overall purpose of a nonstructural flood risk adaptive measure is to reduce flood risk, decrease flood damages, and to potentially eliminate life-loss. Flood risk adaptive measures reduce risk by modifying the characteristics of vulnerable structures and structures that are subject to flooding or modifying the behavior of people living in or near floodplains. In general, nonstructural measures do not modify the characteristics of floods (stage, velocity, duration) nor do they induce development in a floodplain that is inconsistent with reducing flood risk. Some nonstructural measures that can be formulated for implementation include removing structures from the floodplain by relocation or acquisition; wet or dry flood proofing structures; implementing flood warning and emergency preparedness activities; and implementing floodplain regulation. The National Flood Insurance Program (NFIP) is also considered among nonstructural measures since it contains programs to provide minimum standards for floodplain regulation, to provide flood insurance, and to provide flood hazard mitigation. Some flood risk adaptive measures considered for flood damage reduction by USACE, such as dry flood proofing a residential structure, do not result in a flood insurance premium reduction for the owner as it would for a nonresidential structure. The intent of USACE is to recommend engineered applications of nonstructural flood risk adaptive measures which will reduce the risk and prevent future flood damages to a specific structure, even if an insurance premium reduction is not available for certain techniques.

In contrast, structural measures reduce flood risk by modifying the probability or frequency of flooding at a particular location. For instance, a levee will prevent flooding of the protected area, changing the natural probability of flooding for that location. Structural measures do not modify the characteristics of existing development in the floodplain. While structural measures may decrease the frequency of flooding at a specific location, they can actually increase flood risk if the consequences of flooding are allowed to increase through development.

Some of the basic considerations used to develop nonstructural measures are as follows.

- Relocate structures from the floodplain to a flood-free location.
- Acquire the floodplain land on which the relocated structures previously existed and enforce deed restrictions so the land will never be developed in the future for uses that are subject to flood risk.
- Acquire floodplain land that is in existing open space use to prevent future development that could be at flood risk.
- Acquire structures within the floodplain, demolish them, and enforce deed restrictions to prevent future development that could be at flood risk.
- Elevate structures to above a specified flood elevation.
- Dry flood proof structures (traditional structure waterproofing)
- Wet flood proof structures (retrofitting existing structures below a design flood elevation with water resistant materials and allowing flood water to flow through the structure)
- Develop evacuation procedures.
- Develop public alert flood warning systems.
- Develop and implement emergency flood preparedness plans.
- Employ educational outreach programs aimed at reducing flood risk.

Each of these general categories of nonstructural measures can be applied as a single measure or can be applied in combination with one another or with structural measures to reduce or eliminate flood risk. The range of benefits, costs, and residual damages associated with application of each measure is broad. The extent and severity of social and economic impacts associated with the various measures can be likewise broad and must be identified for any plan. Depending upon the nonstructural measures selected for application and the relative percentage of each applied, the future land use pattern of the area could look considerably different in specific areas.

The consequences associated with locating damageable property and people within floodplain areas can be extreme to property owners and floodplain occupants. Within the context of this assessment, an objective is to identify strategies and measures that can be used in tandem to reduce flood risk. Some strategies and measures may be more suited for federal action while others will be more attuned to local regulatory action and administration. In either case, these measures must be effective, socially acceptable, environmentally suitable, and mindful of the existing neighborhood and community social and economic systems within which they would be implemented. It is the intent of this assessment to identify such nonstructural measures.

2.1 Floodplain and Flood Risk Characteristics

The most major historic floods in the assessment area are due to significant rainfall within the Meramec River Basin watershed as well as other factors. Flood warning, in conjunction with stream gages which are collecting instantaneous data, should be used as an effective method in directing the evacuation of people from the affected floodplain.

The Lower Meramec River Basin consists of residential, commercial, and governmental/public development. Basements and crawl spaces exist in some of the structures. Age of development ranges from very old to relatively new.

2.2 Executive Order 11988; Floodplain Management (EO11988)

This Executive Order (EO11988) was issued by President Carter on 24 May 1977. In issuing EO11988, the President stated "…in order to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative, it is hereby ordered that each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities…." The nonstructural measures assessment contained herein was conducted in complete compliance with EO11988 meaning that any nonstructural measures that are incorporated into alternatives recommended for implementation support the vision of EO11988.

2.3 Critical Facilities

Facilities and structures which provide services for health, welfare, and public safety may become inoperable during a flood event and result in additional adverse impacts or hardship on the affected population and are therefore considered to be critical facilities. They are essential during a flood to provide health, welfare, and human safety to the public. Critical facilities generally provide those services required during the flood such as police and fire protection, emergency operations, evacuation sites, and medical services. Facilities which house the elderly, disabled, or those requiring medical assistance require extensive evacuation time and are considered significant. Schools could also be considered critical facilities as they may require extensive evacuation times and often times serve as a shelter in communities during emergency events. Facilities that could, if flooded, add to the severity of the disaster such as power stations, waste water treatment plants, and toxic material storage sites are considered critical. Each significant and critical facility within the guidelines of EO11988 should be located at a flood free site. If this is not possible or practicable, the facility should be located external to the 0.2% annual chance exceedance flood event (500-year) floodplain. If this is not possible or practicable, the facility must be, at a minimum, protected to the extent that it can function as intended during all floods up to and equal to a 500-year event.

2.4 Common Nonstructural Flood Risk Adaptive Measures

The following flood risk adaptive measures are commonly utilized for reducing flood risk within urban and rural areas across the nation. Each measure must meet specific criteria that would make it acceptable to addressing the flood characteristics and site conditions. Some measures, due to the characteristics of the flood event, site location, and structure characteristics, are more implementable than others. This assessment strives to identify the most effective measure for implementation.

The measures described in report Sections 2.4.1 through 2.4.8 are physical nonstructural measures, which means that these are measures which are applied to the physical structure in order to reduce flood damages. The measures do not affect the stage, velocity, or duration of the flood event as the measure is adapting the structure to the flood risk.

2.4.1 Acquisition with Demolition/Salvage of the Structure

This measure consists of purchasing the structure and the associated land from the owner as part of the measure. The structure is either demolished or the structure is sold to others and relocated to a location external to the floodplain. In some instances, communities are finding a benefit in salvaging materials (wiring, plumbing, fixtures) from acquired structures rather than filling up landfills with the demolished structure. Development sites, if needed, can be a consideration as part of project development in order to have locations where displaced people can construct new homes or businesses.

2.4.2 Relocation of Structure

This measure requires physically moving the at-risk structure and purchasing the land upon which the structure is located. 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 of the floodplain. Development of relocation sites where structures could be moved to achieve the planning objectives of reducing flood risk and retaining such aspects as community tax base, neighborhood cohesion, or cultural and historic significance can be part of any relocation project.

2.4.3 Basement Abandonment

This measure consists of relocation of the basement/crawlspace storage, utilities, mechanical equipment, electrical panels and circuits to above the base flood elevation (BFE) or design flood elevation (DFE). This involves filling in the existing basement/crawlspace without elevating the remainder of the structure if the structures' first floor is currently located above the BFE or DFE, whichever is higher. It may include placing an addition onto the structure as part of the measure to compensate for the loss of habitable basement space to the owner and to house the furnace, water heater, water softener, and other utilities and appliances. If the addition could not be developed because of limited space within the property parcel or because the owner did not want it, partial compensation for the lost basement/crawlspace area would be negotiable. Typically, basement/crawlspace areas are not of the same value as above ground finished living space.

2.4.4 Elevation of Structure.

This measure requires lifting the entire structure or the habitable area to above a specified flood elevation, as shown in Figure 7. If a basement exists and had been fully developed prior to elevation and could not be developed post-elevation, compensation for removal of the basement space would be in order to the owner. Typically, basement space is not of the same value as above ground finished living space. This measure is applicable anywhere within the study area unless the required elevation is greater than a maximum of 12 feet above the adjacent grade, where the recommendation would be for acquisition or relocation. Velocity and hydrodynamic forces on the structure would also have to be considered to ensure stability of the elevated structure.

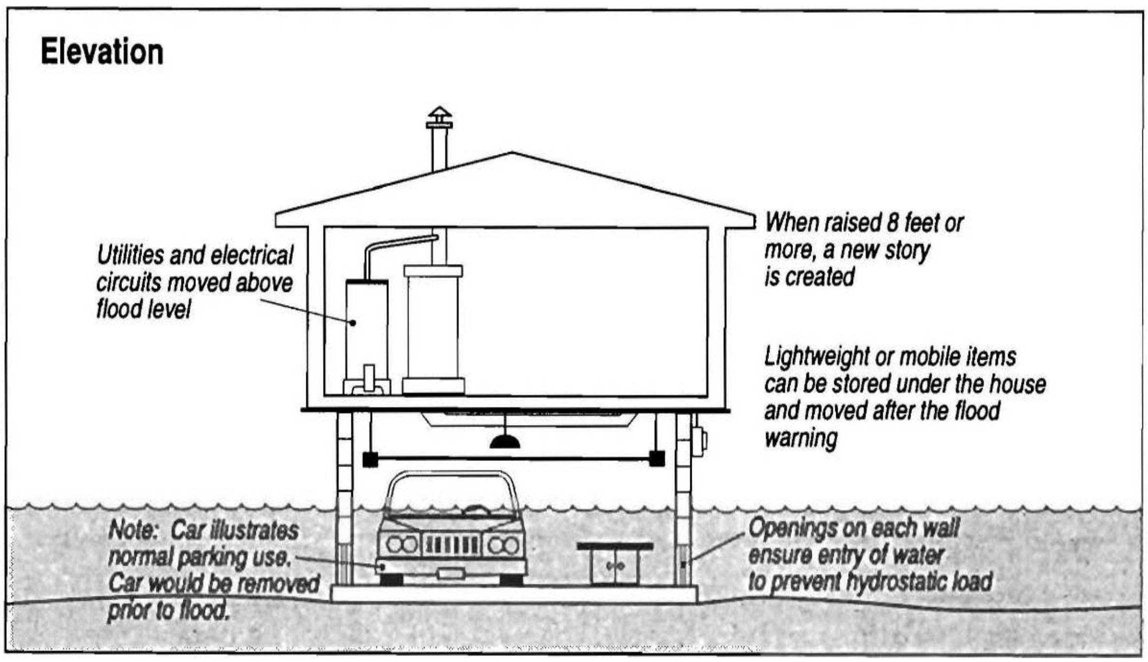

Figure 7. Elevation of Structure (Diagrammatic Section)

2.4.5 Dry Flood Proofing

This measure consists of waterproofing the structure. While this measure is generally acceptable with commercial structures, it can be conducted on residential homes as well as all other types of structures. An example is shown in Figure 8. This measure achieves flood risk reduction benefits for nonresidential structures but it is not recognized by the NFIP for any flood insurance premium rate reduction if applied to residential structures. Based upon testing, a "conventional" built structure can generally be dry flood proofed up to between 3 to 4 feet on the exterior walls. A structural analysis of the wall strength would be required if it was desired to achieve a higher level of protection. A sump pump and drain system may be required as part of the project to remove seepage or interior drainage. Closure panels are required for all openings. This concept does not work with basements or crawl spaces due to the possible infiltration of flood waters, unless complex and expensive cut-off walls are integrated into the design. These walls would resist failure of the basement/crawlspace walls and essentially failure of the entire structure envelope. For structures with basements and/or crawlspaces, the only way that dry flood proofing could be considered to work is for the first floor to be made impermeable to the passage of floodwater.

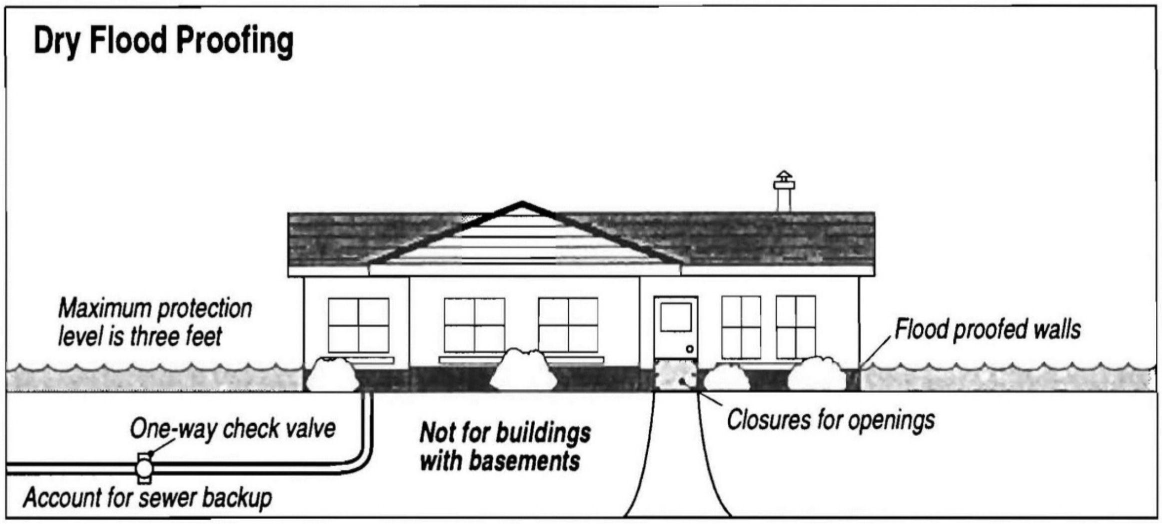

Figure 8. Dry Flood Proofing (Diagrammatic Detail)

2.4.6 Wet Flood Proofing.

This measure is applicable as either a stand-alone measure or as a measure combined with other nonstructural measures such as elevation or dry flood proofing. As a stand-alone measure, all construction materials and finishing materials to a specified height are required to be water resistant. An example is shown in Figure 9. All utilities must be elevated above the design flood elevation. Because of these requirements, wet flood proofing of finished residential structures is generally not recommended. Wet flood proofing is applicable to commercial and industrial structures and should be considered for combining with a flood warning system, flood preparedness, and flood response plan. This measure is generally not applicable to large flood depths and high velocity flows due to possible failure of structure walls.

Figure 9. Wet Flood Proofing (Diagrammatic Detail/Section)

2.4.7 Berms, Levees, and Floodwalls

Although these items are structural in nature, and if considered for implementation by USACE require USACE levee design criteria, they can sometimes be applied to individual structures without adversely impacting the floodplain by increasing stages, velocities, or durations. These measures are intended to reduce the frequency of flooding but not eliminate floodplain management and flood insurance requirements. An example is shown in Figure 10.

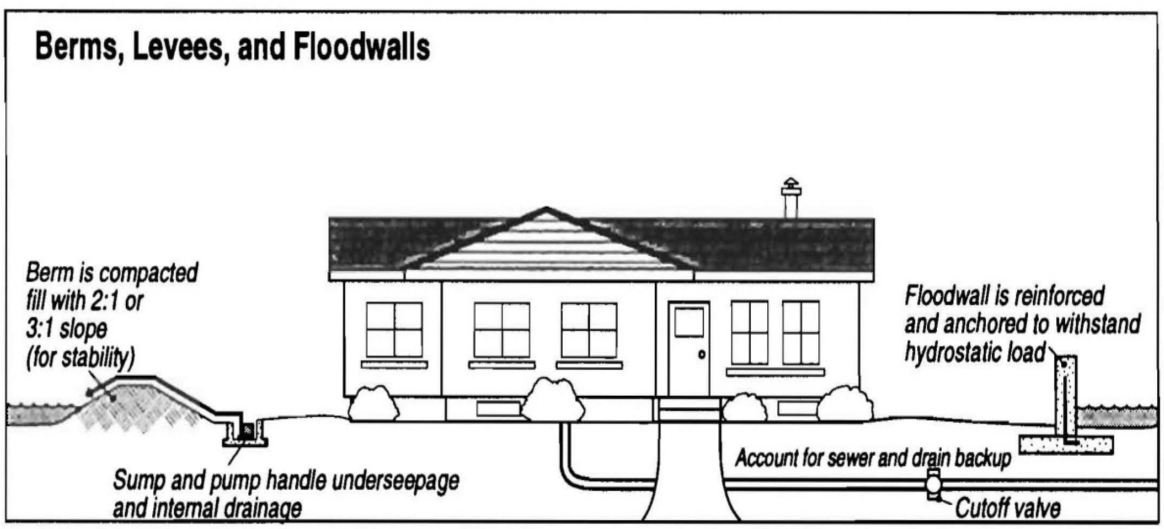

Figure 10. Berms, Levees, Floodwalls (Diagrammatic Detail)

The following report Sections 2.4.8 through 2.4.11 refer to nonphysical nonstructural measures which are implemented as floodplain management programs as a comprehensive approach to address flood risk within a floodplain. These measures may be implemented individually or in combination with other measures in an attempt to eliminate all flood risk.

2.4.8 Public Alert Flood Warning, Flood Emergency Preparedness, Evacuation Plans and Pertinent Equipment Installation

Any flood risk management plan should consider the development and implementation of flood warning systems and emergency preparedness planning. The development of such plans and the installation of pertinent equipment such as data collection devices (rain gages, stream gages) and data processing equipment can become an integral feature of a project. Evacuation planning should consider vertical evacuation as well as lateral evacuation. Reunification sites should be a featured component of any evacuation plan.

2.4.9 Land Acquisition

Land acquisition can be in the form of fee title or permanent easement with fee title. Land use after acquisition is open space use via deed restriction that prohibits any type of development that can sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project can be converted to a new use such as ecosystem restoration and/or recreation that is open space based such as trails, shoreline access, and interpretive markers and possible recreation fields. Conversion of previously developed land to open space means that infrastructure no longer has need for utilities, streets, and sidewalks which can be removed as part of the project By incorporating “ new uses of the permanently evacuated floodplains” into the nonstructural flood risk reduction project, economic feasibility of the buyout or relocation projects is enhanced due to transfer of some flood risk management costs to ecosystem restoration and by adding the benefits and costs of recreation.

2.4.10 Floodplain Regulation and Floodplain Management

Floodplain regulation and floodplain management have proven to be very effective in reducing flood risk and flood damage. The basic principles of these tools are founded in the NFIP, which requires minimum standards of floodplain management and floodplain regulation for those communities that participate in the NFIP. While the minimum standards have not resulted in substantial flood risk reduction, incorporation of more stringent building codes and zoning ordinances may meet community objectives of eliminating flood risk. Communities can establish more stringent ordinances.

2.4.11 National Flood Insurance Program

The NFIP was created as a result of the passage of the National Flood Insurance Act of 1968. Congress enacted the NFIP primarily in response to the lack of availability of private insurance and continued increases in federal disaster assistance due to floods. At the time, flooding was viewed as an uninsurable risk and coverage was virtually unavailable from private insurance markets following frequent widespread flooding along the Mississippi River in the early 1960s. The NFIP is a federal program, managed by the Federal Emergency Management Administration (FEMA), and has three components: to provide flood insurance, to improve floodplain management, and to develop maps of flood hazard zones. The NFIP contains 3 basic components: Risk Management, Mitigation, and Federal Flood Insurance. Four mitigation programs exist within the NFIP. They are the Public

Assistance Program, the Hazard Mitigation Grant Program, the Pre-Disaster Mitigation Program, and the Flood Mitigation Assistance Program. Within the floodplain regulation portion of the NFIP, the program serves as a nonstructural measure indirectly through adoption of minimum floodplain management standards by communities participating in the NFIP.

2.5 Temporary Flood Risk Adaptive Measures

Reducing flood risk is an objective which should be conducted through permanent measures.

Knowing the characteristics of flooding, such as the available warning time for making preparations, the projected depth of floodwaters, and the areal extent of flooding, along with the anticipated duration, are all factors which will allow community officials, business owners, and homeowners to make personal decisions regarding their ability to reduce property damages. Temporary flood proofing measures are those which, in order to protect a structure and its contents, must be implemented every time there is a risk of flooding. While the most effective and efficient process for reducing property damages is to implement permanent measures, where even features such as doorway and window barriers can be readily installed, there may be the need for interim temporary measures until permanent measures can be implemented. It is recommended that each owner transition to more permanent flood prevention measures as soon as reasonably possible.

This section of the report focuses on the use of temporary measures and the precautions which should be considered prior to implementation. The responsibility for flood proofing, including the detailed planning, purchase of flood proofing materials, and implementation, lies solely with the owner or tenant of each structure.

Each building owner and the tenant who occupies the building during the time of flooding should weigh the time and costs associated with implementing temporary flood proofing measures numerous times as opposed to the long-term security and peace of mind that can come with implementing permanent measures.

2.5.1 Common Temporary Flood Risk Adaptive Measures

The most common temporary measures that are recommended for at-risk structures across the Lower Meramec Basin are: 1) polyethylene sheeting hung on the structure exterior (usually to a height of 3 feet above the first floor elevation and continued on the ground surface 4 feet out from the structure exterior), in combination with door and window closures, 2) clear liquid sealant applied to the structure exterior, in combination with caulking of large cracks in the exterior and placement of door and window closures, 3) sandbag berms located around all or a portion of the structure, and 4) any of the barriers certified through the National Flood Barrier Testing and Certification Program [see http://nationalfloodbarrier.org/].

A key difference between these temporary measures is that hydrostatic forces are applied to the structure walls when using the polyethylene sheeting and clear liquid sealant measures, but not with sandbag berms or the certified barriers.

2.5.2 Implementing Temporary Measures

Implementation of temporary measures can be successful in reducing or preventing flood damages when conducted correctly. The scope of this assessment does not allow for USACE to evaluate the individual structures and their sites in sufficient detail to guarantee the success of temporary flood proofing, as there are several factors that the owner or tenant must consider when implementing temporary measures:

- Because of the serious nature of flooding and of the unknowns associated with the depth, velocity, and duration, as well as the condition of the structure, it is generally considered wise not to allow temporary flood proofing measures to be placed to a height of over 3 or 4 feet above the elevation of the first floor of the structure. The hydrostatic and hydrodynamic forces of floodwaters on the exterior walls can cause a catastrophic collapse due to the lack of lateral resistance from the structure as the floodwaters rise higher against the sides of the structure. And, since the characteristics of a flood (depth, velocity and duration) may change during a flood event, it must be noted that it is possible for failure of foundation systems and closure panels to occur at a flood depth of less than 3 or 4 feet. If a basement or crawlspace exists, the effect of floodwaters on those foundation walls must also be taken into consideration. While a foundation wall may provide more resistance to flooding than a conventional wood wall, the depth of flooding and duration of flooding on the foundation wall needs to be assessed. Without a proper structural analysis of individual structures by a certified professional or contractor, failure of a structure can occur due to the hydrostatic and hydrodynamic pressures caused by water pooling up against or flowing directly into a structure. It is the highest recommendation of the team of engineers preparing this report that after the flood proofing measures have been implemented, all persons evacuate the structure to a predetermined location of safety.
- Though obvious, it must be stated that a structure could be exposed to a flood event of a depth greater than for which temporary flood proofing measures have been erected.
- Smaller, more frequent storm events that can cause localized flooding can occur in the communities in the Lower Meramec Basin. In these events, there may not be sufficient warning time for the owners or tenants to implement the temporary measures.
- Preparing a structure for a flood requires significant effort, and it is impossible to accurately predict even one day in advance the depth to which flood waters from an approaching storm may rise. Therefore, the owner or tenant cannot be certain that the projected flood event will actually occur. The owner or tenant must find his own comfort level and balance the risk of not having the structure properly flood proofed, versus the risk that the effort to flood proof was not necessary.
- In order to prevent unsanitary water from backing up into the structure, the owner should ensure that the sanitary drain line is fitted with a backflow preventer.
- Downspouts and associated drainages must be considered. If a certified barrier or sandbag berm is erected, the downspouts need to be modified so they can be directed over the barrier; this would greatly reduce the amount of water to be

pumped from within the protected area. Also, there may be drain lines that carry water from the downspout that pass under the certified barrier or sandbag berm, which must be plugged to prevent flood water from flowing through the line into the protected area.

- If the exterior construction is not structurally sufficient to withstand a significant water load the force of water at a depth of three feet (or perhaps less) could collapse walls. Therefore, it is recommended that when the temporary measures include placement of polyethylene sheeting on the exterior of a structure, a thick layer of plywood (up to 1 inch) be attached to the exterior surface of the structure up to the level of protection. The plywood could be attached to wall studs using countersunk threaded anchors with bolts, and sheeting would be placed over the plywood. Again, structural evaluation by a certified professional or contractor is recommended.

2.5.3 Flood Characteristics Dictating Temporary Measures

There are numerous characteristics associated with temporary flood proofing, many of which may be unknown to the owner or tenant. Some of these include: 1) characteristics of the flood itself (depth, duration, and velocity. Note that velocities will generally be greater near the channel), 2) the precise condition of the structure being protected (condition of the foundation, crawlspace, basement, and type of construction of the first floor and side walls), and 3) the surrounding site conditions (soil permeability, the density of landscaping, and the location of utilities as well as other external features).

2.5.4 Planning and Preparation of Temporary Measures

The information provided in this section of the report is the basis for developing temporary mitigation measures to reduce the possibility of extensive flood damages. In order for flood proofing to be successful, a thorough plan for each individual structure needs to be developed and implemented. The plans will vary from structure to structure, depending upon structure type, projected depth of flooding, the velocity of floodwaters, the time available to implement the measures, and the availability of flood proofing materials. In some instances, due to the depth of flooding or the projected velocity of the floodwaters, rather than attempt to keep floodwater out of the structure, it may be more cost effective to remove or elevate to a higher interior location those items (business records, electronics, computers, heirlooms, artwork, etc.) which contain a high value, intrinsic or monetary, so as to avoid exceptional loss.

For individuals wishing to implement temporary flood proofing measures, a plan should be developed to ensure that the measures can be employed as quickly as possible when the threat of flooding is imminent. Locations for storage of the materials and equipment should be designated far in advance of an event. Storage can occur on or off-site; however, if materials and equipment are maintained off-site, arrangements should be made to transport these materials and equipment to the site for implementation. Because the limited time available to install temporary measures is a critical factor in the prevention of flood damages, site preparation, maintaining the proper inventory of flood proofing materials, and having a well prepared emergency response plan are crucial to a successful outcome. Early preparation can make the difference between minimal dollar damages and a catastrophic loss. While even the best laid plans may go awry, nationwide data indicate that the owners who pay attention to the details, establish a thorough step-by-step process for implementing their temporary flood proof measures, and prepare themselves and their structures prior to the start of the flood season fare far better than those individuals who rush against time to install temporary measures which have not been thoroughly planned out.

It is imperative that the structure owner or tenant determine the type and amount of materials required to be on hand each year through the forecasted flood season. A checklist of these items or material requirements should be prepared, including the sequence of placement of materials in order to establish the most time-effective process for implementing the temporary measures. Each year prior to the start of the flood season, the owner or tenant should review the checklist, replace missing or damaged items, and prepare to implement the entire flood proofing measure during the first signs or indication of imminent flooding.

In addition, the owner and/or tenant should develop a procedure for ensuring that all employees, residents, and others who may have been in the structure prior to the flood event are accounted for after evacuation. This may be accomplished by planning to contact all personnel via cell phone and/or by arranging to meet at a designated location.

Once the owner or tenant has established a temporary protection plan for the structure, it may be beneficial to test the plan for efficiency and effectiveness in order to optimize the plan. The flood fight materials and equipment should be stored in such a manner that they will not be damaged and should be monitored on a regular basis to ensure that these materials will be effective when and if needed. For instance, blue plastic tarps can become damaged with holes from animals or normal weathering and should be replaced if any damage occurs, and plywood should be stored such that it will not rot or be damaged by termites or storage in a wet or damp environment.

While protection of the structure and of the structure contents are of high importance, during any flood event there is a possibility of extensive damage to the structure. It is worth repeating that, in order to prevent extensive loss or damage to high value items, it is recommended that the emergency response plan also consider relocating away from the structure or to a higher elevation those items which would be difficult or impossible to replace.

Again, it is imperative that each structure owner understand that the intent of these proposed measures is to provide only temporary protection from flooding. After the temporary measures have been implemented, after the sump pump(s) has been positioned and flooding appears to be imminent, the owner and all associated persons should evacuate the premises during the flood event. There is always a possibility that catastrophic failure of a structure or loss of life could occur during a flood event.

2.5.4.1 Site Preparation

The type and amount of site preparation will vary with each structure. For many structures, one recommendation is that in order to prevent floodwaters from entering a structure and causing damage, the site surrounding the structure should be prepped to a condition which allows relatively easy and quick installation of temporary flood proofing measures. For each structure, the owner or tenant should try to achieve at least 4 feet of leveled access area around all exposed sides of the structure. The placement of polyethylene (also known as polyurethane or plastic) sheeting and/or sandbags as a preventive barrier to flooding requires a leveled surface in order to resist seepage into the protected area.

While shrubs, flowers, and trees provide character and add value to a property, it is important that they be removed from within the “leveled access area” in order to establish a preventive barrier to flooding. If the owner is unable to remove landscape items, it is important that a uniform barrier of protection be established by placing polyethylene sheeting or sandbags as close to the protruding plant as possible to develop a cohesive barrier between the ground and the employed flood proofing measures. Even a small weakness in the flood proofing measure could result in catastrophic failure and damage.

In certain circumstances, it will benefit the owner to identify appurtenances such as fence posts, gates, storage sheds, and utility boxes which may prevent the establishment of a waterproof barrier. These items should be removed as much as possible from the “leveled access area.” Utilities and HVAC units must be considered. Where possible, vital utilities and HVAC units should be raised in height to a reasonable level. Otherwise, provisions in the flood proofing plan need to include the protection of these utilities and units. Also, these items are usually associated with wall openings through which flood waters may enter a structure. These openings must be sealed, along with any other holes or cracks in the exterior walls and foundation.

2.5.4.2 Removal of Interior Flood Water

The removal of flood waters from a structure to prevent inundation of the first floor can be one of the most important and critical ways to protect a structure from flooding. The use of sump pumps is one of the best and easiest methods to accomplish this. For most of the assessed structures, USACE’s recommendation is to install one or more sump pumps. Loss of electricity during a flood event must also be considered; therefore, it is recommended that the owner utilize pumps that can be powered with a battery power supply. In most cases, the installation of these pumps is relatively simple, and in some cases, the use of multiple pumps may be necessary.

2.5.4.3 Materials and Equipment Required for Temporary Measures

The owner should ensure that the materials recommended for protecting the structure have been obtained prior to the start of the flood season. Materials required for implementing a preventive barrier to flooding should be stockpiled in an accessible location. Materials remaining from the previous flood season should be inspected to determine condition for reuse. Some of the more frequent materials required for implementing successful temporary flood proofing measures include:

- Polyethylene Sheeting. This sheeting material (also known as visqueen, polyurethane, or plastic sheeting) is often recommended for use when employing a temporary waterproof barrier around a structure. The sheeting should be purchased in rolls, typically 5-6 mm thick, and will be cut long enough to extend from no more than 3 feet above the first floor of the structure to, at a minimum, 4 feet out from the structure. The further the “leveled access area” and polyethylene material extend beyond the exterior wall of the structure, the longer the flow path for floodwaters to enter a structure, including the crawlspace or basement, is extended, increasing the resistance to flooding. The shorter the flow path is to a foundation, the higher the risks of complete soil saturation around a foundation, resulting in complete inundation of the crawlspace or basement. Once the floodwaters have access to the crawlspace or basement, it becomes more difficult to remove the floodwaters and to prevent or limit damages.

- Connectors for Attaching Polyethylene Sheeting to Structure Exterior. The type of connector needed depends upon the type of exterior surface of the structure to which the sheeting is being fastened. Hooks, whether self-tapping or through drilled anchor connection, are normally recommended for use in fastening the polyethylene sheeting to the structure. Spacing of the hooks should be such that no span is greater than 2 feet. Hooks should be placed permanently for continuous use from one flood season to the next.
- Water Resistant Tape for Polyethylene Sheeting. For firm cohesiveness between the polyethylene sheeting and the exterior structure surface or between adjacent polyethylene sheets, water resistant tape for polyethylene sheeting is recommended for use. These tapes incorporate PVC adhesives and are ideal for use in outdoor situations. Consideration should be made for vinyl coated cloth tapes for effectiveness where product performance is critical; these tapes can sustain harsh weather conditions and can be used for repairs to many surface types. It is further recommended that tapes contain water resistant properties, all-weather properties, brittle resistance, and anti-aging properties.
- Closures panels (plywood and other material). A temporary closure system consisting of 1-inch thick plywood or Oriented Strand Board is often recommended for flood barrier construction at doorways and windows; no closure should have a horizontal or vertical span in excess of 3 feet without incorporating additional supports. Because 1-inch paneling may be expensive, a 1-inch closure can be pre-made by using a grid of screws to connect two boards of lesser thickness. Vent openings can usually be protected with a lesser thickness. Do not use materials that are not water resistant. The closure panel should be measured, cut, and identified for the specific location in the temporary flood barrier and should be available for use from one flood season to the next. The panels should be held in place with water resistant caulking, nails, screws and/or liquid nail. For doorways which open inwards, or for over the top of window glass, the closure panel should extend onto the exterior wall.
- Sand and Sandbags. Considered to be one of the most durable and easily employed flood-fight products on the market, sandbags are an integral component of many temporary barriers to flooding. Sandbags should be made of nylon or polyethylene. Generally, bags can be placed in a single row up to 3 bags high. Berms more than 3 bags high should be built in pyramid fashion; these berms should be as many bags-wide at the base as they are bags-high. Bags should be filled between half-way and two-thirds full, should not be tied and should be placed with the top of the bag tucked under the bag. After placement of each layer, the bags should be walked on to provide a better seal with adjacent bags. The bags in each course should be

placed so that they cover to the maximum possible extent the joints in between the bags in the same course and also between the bags in the course below. Additional guidance on sandbagging is available from USACE. Sandbag closures at doorways and similar openings can work well but must be carefully sealed at the ends. The owner may prefer to use a plywood or other type closure panel.

- Caulk and Clear Sealant for Structure Exterior. If any portion of the structure to be protected consists of brick, stone, stucco, concrete, cinder block, or tile, a water resistant sealant may be recommended for use. It is best to use a clear liquid sealant which may be applied by brush, roller, or spray. The sealant should be applied to all porous surfaces which have been thoroughly cleaned and dried to allow deep penetration and maximum resistance to the effects of water. The sealant should be extended above the area of proposed protection for best coverage. While at this time, no government testing programs have rated these commercial sealants, manufacturer's information indicate that commercial sealants may last up to 20 years without discoloration. In addition, if large cracks and voids in the structure exterior need to be filled; many products carried by local hardware companies are compatible with the materials on the exterior of the structures.
- Certified Temporary Flood Barriers. Preventing flood waters from entering a structure requires the use of temporary flood barriers. While there are many products marketed as flood barriers, very few have tested and achieved certification for preventing damages. The Association of State Flood Plain Managers in collaboration with FM Approvals, the independent testing arm of international insurance carrier, FM Global, and the USACE NNC have implemented a national program of testing and certifying flood barrier products used for flood proofing and flood fighting. The purpose of this program is to provide an unbiased process for evaluating products in terms of resistance to water forces, material properties, and consistency of product manufacturing. This is accomplished by testing the product against water related forces in a laboratory setting, testing the product against material forces in a laboratory setting, and periodic inspection of the product manufacturing process for consistency of product relative to the particular product that received the original water and material testing. Upon products meeting the consistency of manufacturing criteria and meeting the established standards for the material and water testing, the certification part of the program becomes available to the product. Since the testing part of the program is conducted in a laboratory setting, not all forces and impacts to which the product could be subjected to during an actual flood event will be tested. Certification will also reflect, in terms of flood proofing, the suitability of the product, the performance of the product based on the product deployment literature, the durability and reliability of the product, and the consistency of the product. All products will be examined and evaluated on a model by model, type by type, plant by plant, and manufacturer by manufacturer basis. For additional information on this program and a list of certified products, visit http://nationalfloodbarrier.org/.
- Interior Drainage Pump and Power Supply. In order to prevent flood damages due to seepage of floodwaters through the temporary flood barrier or resulting from a rising water table, it may be recommended that pumps be incorporated into the

protection measures. Pumps will be needed inside the structure to collect seepage. At a minimum, one pump with a capacity of at least 20 gallons per minute should be considered for installation in the structure for every 2,000 square feet of floor space. 115-volt AC powered pumps can be used provided electricity is available throughout the flood event. The owner may consider installing a permanent sump pump with sump pit or bring in one or more pumps for temporary use. If loss of electrical power during a flood is a concern, the owner could employ a gasoline-powered electric generator to power the AC pump or use one or more battery-powered sump pumps. The user will have to be aware that the battery life is limited; therefore, a spare battery should be kept on-hand. The life of the battery recommended in the battery powered back-up sump pump is 10 to 14.5 hours of pump use. Because it is impossible to know how much the pump will be operating, the user will need to monitor it often and be prepared to replace the battery. If there is no basement or crawl space, the owner may elect to use a floor-type pump that can maintain the depth of water on the floor to 1/8 inch. If the structure being protected does have a basement or crawlspace, the pump needs to be placed at the lowest elevation in order to work most efficiently. In some instances the owner may consider cutting a small hole through the floor of a closet space, for concealment purposes, and lowering the pump to the lower level. For a slab on grade structure, the pump should be placed in a location upon the floor where floodwaters may begin to collect. In all cases, the owner should consider placing the pump at a location where the discharge hose is easily positioned to extend beyond the limits of the protection measures. The discharge side of the pump should be sized to match a common 1-inch diameter garden hose or should be equipped with an adaptor to 1 inch. If there is a sandbag berm, a pump with significant capacity will be needed to collect rainfall, seepage and rising groundwater within the area of the berm.

3 Nonstructural Assessment Objectives

This nonstructural assessment consists of a sampling of at-risk residential and commercial structures and one public building located in Eureka. For a nonstructural assessment, each structure must be individually investigated for purposes of determining what type of flood risk adaptive measure is most appropriate for that particular structure, given structure construction, where the structure is located within the floodplain, structure condition, the local flood characteristics (depth, velocities, and duration), and other site conditions (soil, permeability, vegetation). A 1% AEP flood was considered the benchmark for implementation of nonstructural measures to mitigate the flood risk. Detailed structure information was collected in the field and combined with information obtained by USACE-St. Louis with additional assistance from assessment communities.

Assessment objectives included a review and confirmation of the flood problem and determination of the appropriate nonstructural technique for each sample structure. Several influences on each structure were required to be evaluated to determine if the nonstructural measures considered would be appropriate for a given structure. In particular, each structure has to be in relatively good condition, i.e., has to be structurally sound, in order to withstand elevation, relocation, or flood proofing. If the structure is in poor condition, then only filling in the basement/crawlspace, if one exists, would be considered, without investigating elevation, relocation, or flood proofing for partially reducing the flood risk. Also, adequate space located around the structure is needed to maneuver the necessary equipment if elevation is determined to be the designated nonstructural technique.

Abandoning the basement/crawlspace by filling with clean sand or pea gravel also includes relocating utilities, mechanical equipment (furnace, water heater, water softener, and appliances), possibly ductwork and plumbing, electrical panels and circuits, as well as some storage to a new location above the BFE. These measures were considered because they would both reduce future flood damages to the structure and reduce flood insurance premiums for the owner, which start at the lowest habitable floor elevation.

For dry flood proofing, the depth of flooding has to be limited to between three to four feet above ground elevation and the exterior walls of the structure have to be of such structural integrity as to being able to withstand the lateral forces applied by floodwaters.

Relocation of a structure is also considered if the depth of flooding is determined to be greater than 12 feet, where, if the depth at the structure is greater than 12 feet it would require the structure to be elevated to such a height that it would be unreasonable to inhabit the structure, would place first responders at risk, or the costs to elevate may significantly increase due to the need for structural stability to resist wind forces on the elevated structure.

The assessment indicated that there are a significant number of at risk structures located throughout the study area. While most of the commercial structures appear to have been constructed at ground or street level elevation, the residential structures vary in the first floor height off of the ground depending upon the style of the structure and whether a crawlspace or basement were contained within the structure. The size of structures also varied from single story to multi-story for residential structures and from individual stand-alone to multi-bay commercial structures. Many of the commercial structures were constructed as slab-on-grade, with walls being constructed of masonry, metal, or wood.

3.1 Description of Structure Dataset

For this nonstructural assessment, information was collected for a sampling of 17 structures located throughout the study area. The assessed structures are summarized in Table 1.

Table 1 Lower Meramec River Basin Structure Inventory Data

Structure ID #	Address	Occupancy	First Floor Elevation	Ground Elevation	1% Elevation
1	478 Spruce, Arnold	Res	418.6	411.6	419.7
2	4551 Kerth Forest Drive, Uninc. St. Louis County	Res	426.4	418.4	417.0
3	6544 Suson Woods Dr, Uninc. St. Louis County	Res	unknown	437.1	N/A
4	64 Gravois Road, Fenton	Com	417.0	416.9	425.6

Structure ID #	Address	Occupancy	First Floor Elevation	Ground Elevation	1% Elevation
5	62 Gravois Road, Fenton	Com	414.8	414.7	426.3
6	10 Gravois Road, Fenton	Com	420.2	420.1	425.7
7	3644 Scarlet Oak, Fenton	Com	429.0	428.9	432.6
8	3615 Treecourt Ind. Blvd, Fenton	Com	429.0	428.0	432.5
9	2477 Marshall Road, Fenton	Com	431.0	430.5	432.8
10	145 S. Central, Eureka	Com	447.0	446.0	450.6
11	333 Bald Hill Road, Eureka	Pub	449.7	449.2	450.1
12	1400 S Outer Road, Eureka	Com	450.4	450.3	450.7
12	Dickey Bub, 1 Union City Plaza	Com	515.2	515.1	516.7
14	220 S First Street, Pacific	Com	460.9	460.4	471.0
15	1101 S. Denton Road, Pacific	Com	458.3	457.9	465.0
16	625 S Fourth Street, Pacific	Com	461.6	461.1	471.2
17	447 & 449 Mabel Drive, Arnold	Res	418.7	417.4	420.0

Most of the inventory structure data was obtained through research conducted by the USACE-St. Louis District and additional information and photographs were collected during the field investigation. The depths of flooding were obtained from data developed by FEMA for their floodplain mapping program. Ground elevations adjacent to structures were obtained from Light Detection and Ranging terrain data obtained by the USACE-St. Louis District. The assessment conducted was reconnaissance level in detail. Prior to mitigation being implemented on an individual structure additional detailed data would be required. For this assessment, the level of detail from the data collected is sufficient to identify potential nonstructural measures which could be effective in reducing future flood risk, life loss, and property damage.

4 Description of Nonstructural Assessment

USACE NNC and personnel from USACE-St. Louis District conducted a site visit followed by an office assessment for each of the 17 sample structures. Homeowners and businesses were contacted by their local governments and then by the U.S. Army Corps of Engineers to sign Rights of Entry giving consent for the government to enter their properties. The field visit allowed the USACE team to observe each structure from the exterior/interior and to reaffirm the previous data collected for each individual structure. Structure and site conditions, as well as flood elevations, were compiled with field observations onto structure data/assessment sheets. The compiled information on the structure data/assessment sheets helped to demonstrate the potential flood risk and were used to identify potential nonstructural measures for implementation.

The Base Flood Elevation (1% annual chance exceedance flood elevation) was targeted for mitigation recommendations. Each structure was assessed using a similar format. The assessments and recommendations focused on mitigating structures by utilizing elevation, dry flood proofing, wet flood proofing, basement/crawlspace abandonment, or relocation/acquisition. Nonstructural flood risk adaptive measures which would be compliant with the NFIP and would reduce flood insurance premiums for the structure owner were primarily considered for potential implementation.

The nonstructural measures presented in this report are stand-alone mitigation techniques for individual structures or combination techniques to provide the most effective level of flood risk management through property damage reduction.

The following assumptions were incorporated into the assessment because of the reconnaissance level of detail:

1. Basement utilities, equipment and storage are proposed to be relocated to existing space or to a new utility addition onto the existing structure and above the mitigation flood elevation. A more detailed investigation would be required to determine the specific area to accommodate these items.
2. Inventory data has been adjusted based on field observations.
3. Dry flood proofing was limited to four-feet in height unless the structure appeared to have the structural integrity to be capable of withstanding greater forces.
4. If the flood elevation is greater than the first floor elevation and a basement/crawlspace exists, the first floor cannot be dry flood proofed without eliminating the basement/crawlspace by the placement of fill material.

5 Recommendation of Nonstructural Flood Risk Adaptive Measures

Based upon the data collected for the 17 sample structures and the potential depth of flooding for the 1% annual chance exceedance flood event, the recommended mitigation measures are identified in Table 2. The heart of the nonstructural assessment regarding the recommended nonstructural technique for each of the sample structures is provided in Enclosure A which contains the individual assessment sheets for each structure.

Table 2. Recommended Nonstructural Mitigation Measures

Structure ID #	Address	Occupancy	Nonstructural Technique Proposed
1	478 Spruce, Arnold	Res	Abandon Basement / Elevate on Extended Foundation
2	4551 Kerth Forest Drive, Uninc. St. Louis County	Res	Fill Basement to Grade / Wet Flood Proof Crawl space
3	6544 Suson Woods Dr, Arnold	Res	Fill Basement to Grade / Wet Flood Proof Crawl Space
4	64 Gravois Road, Fenton	Com	Elevate Utilities / Wet Flood Proof Structure
5	62 Gravois Road, Fenton	Com	Elevate Utilities / Wet Flood Proof Structure
6	10 Gravois Road, Fenton	Com	Elevate Utilities / Wet Flood Proof Structure
7	3644 Scarlet Oak, Fenton	Com	Dry Flood Proof / Install Certified Barriers
8	3615 Treecourt Ind Blvd, Fenton	Com	Dry Flood Proof / Install Certified Barriers
9	2477 Marshall Road, Fenton	Com	Dry Flood Proof / Install Certified Barriers
10	145 S. Central, Eureka	Com	Dry Flood Proof / Install Certified Barriers
11	333 Bald Hill Road, Eureka	Com	Verify Check Valves Exist / Install Emergency Pump
12	1400 S Outer Road, Eureka	Com	Dry Flood Proof / Install Certified Barriers
12	Dickey Bub, 1 Union City Plaza	Com	Dry Flood Proof / Install Certified Barriers
14	220 S First Street, Pacific	Com	Dry Flood Proof / Install Certified Barriers
15	1101 S. Denton Road, Pacific	Com	Dry Flood Proof / Install Certified Barriers
16	625 S Fourth Street, Pacific	Com	Dry Flood Proof / Install Certified Barriers
17	447 & 449 Mabel Drive, Arnold	Res	Abandon Basement / Elevate on Extended Foundation

It was beyond the scope of this assessment to determine the economic feasibility of implementing any of the recommended nonstructural mitigation techniques. To do so would require a detailed feasibility level cost estimate for each of the mitigation measures, then annualizing the cost over a 50-year project life to determine the annual cost per individual structure. Similarly, the annual benefits derived from each individual mitigation measure would be required. A comparison of annual benefits and costs could be conducted by estimating the reduction in future flood damages, where those prevented damages are the benefits of implementing a nonstructural technique, then annualized. If the annualized benefits for a structure are divided by the annualized costs for that structure, a benefit to cost ratio (BCR) can be determined. A BCR greater than 1.0 indicates that the nonstructural mitigation measure has more benefits than costs and is worth further consideration for implementation

6 Floodplain Management Recommendations for Minimizing Damages

In addition to the nonstructural measures recommended in the previous sections, there are additional low impact measures/actions which should be considered for minimizing future flood damages in the vicinity of existing properties. Simple precautionary actions can be the difference between a minor clean-up and a major replacement after a flood event.

6.1 Local Drainage and Utility Protection

During the field assessment, it became apparent from viewing some of the sample structures that local drainage problems and utility damages were prevalent within the study area and that owners could take actions to minimize future damages. As shown in Figure 11, these are two examples of actions being taken to reduce future flood damages. Many of the downspouts discharging rooftop runoff (photograph on left) were not properly directing water away from the foundation, causing erosion and thereby exposing and weakening the foundation and providing potential pathways for floodwaters to enter or further damage some structures. The owner in this instance connected corrugated plastic drains to the downspouts and routed the runoff away from the structure.

Figure 11 Localized Interior Drainage and Utilities

After having had floodwaters damage an external HVAC system, the owner elevated the replacement system (photograph on right) onto layers of concrete modular units. It is also recommended that the owner secure and stabilize the platform to ensure that in the future, moving floodwaters do not cause the platform to fail.

7 Flood Insurance Premium Reduction from Nonstructural Measures

Implementation of nonstructural measures may result in reduced flood insurance premiums under the NFIP for certain structure types. Insurance premiums for structures located within the Special Flood Hazard Area are functions of the elevation of the first floor of the structure (which may be a basement or crawlspace floor, if either exists) with respect to the BFE. The lowest habitable floor elevation will dictate the premium rate for flood insurance.

For residential structures, elevation has the effect of reducing the flood insurance premium because the structure is being moved away from the flood risk. It is important to note that the insurance is based upon a single flood event, the 1% AEP flood event, and not a range of flood events. If the residential structure is elevated to be above the 1% flood, there is still a possibility that a larger flood event could occur. Figure 15 illustrates the potential reduction in insurance premium for a sample structure elevated on extended foundation walls.

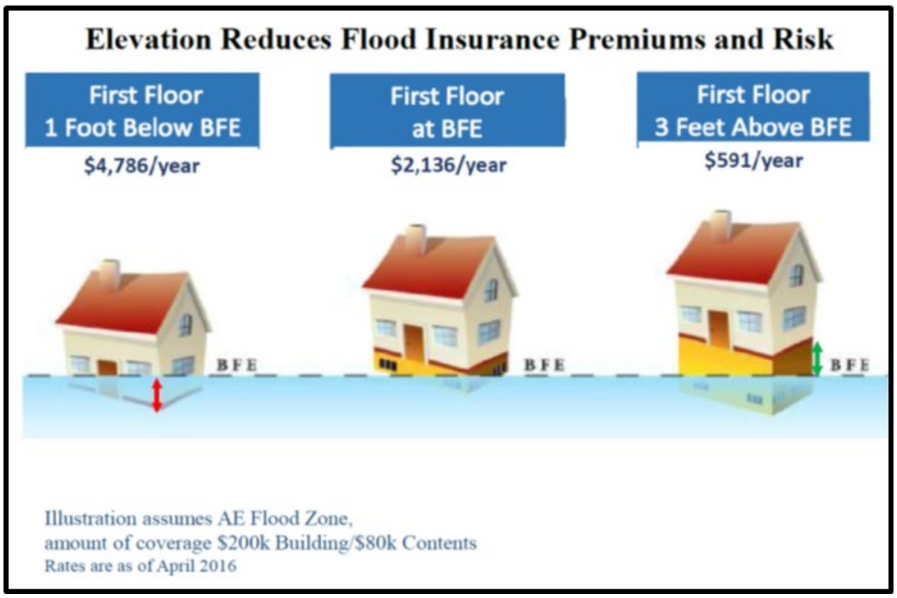

Figure 12 Flood Insurance Premium Reduction through Elevation

Currently, with regards to residential structures, no other physical nonstructural measure, other than elevation, acquisition, or relocation of the structure provides a benefit by reducing the flood insurance premium. While wet flood proofing and dry flood proofing a residential structure have the potential to reduce property damages associated with flooding, neither technique results in a reduction in insurance premiums. FEMA was directed by Congress under the Homeowner Flood Insurance Affordability Act of 2014 to produce guidelines for structure owners regarding alternative mitigation efforts, other than structure elevation, acquisition, or relocation, to reduce flood risk to residential structures that cannot be elevated due to structural characteristics. This request by Congress requires alternative forms of mitigation measures to be considered in the calculation of flood insurance premium rates. At the time of the publication of this report, the guidelines have not been finalized.

However, for nonstructural mitigation of commercial structures, a reduction in flood insurance premium may be obtainable if the flood risk for an individual structure can be reduced through mitigation such as elevation or dry flood proofing. As discussed in Section 2.4.5, dry flood proofing is the prevention of flood waters from entering a commercial structure through implementation of engineered systems.

If dry flood proofing is a consideration for reducing flood risk, it is recommended that the structure owner employ closure barriers which have been certified through the National Flood Barrier Testing and Certification program. The purpose of the testing program is to provide a process for evaluating flood fight products in terms of their resistance to floodwaters, their material properties, and consistency of product manufacturing. Products are tested against water forces in the USACE Engineer Research and Development Center laboratory, tested against material forces in an FM Approval laboratory setting, and undergo periodic inspection of the manufacturing process for consistency of product.

Additional information regarding the certification program can be found at the following Association of State Floodplain Managers web site: http://nationalfloodbarrier.org/

8 Managing Flood Risk

Existing hydrologic and hydraulic analyses indicate that the flood hazard along the Lower Meramec River has the potential to be very severe.

Based upon the nonstructural assessment of 17 sample structures to determine an estimation of their exposure to flooding, there are several potential opportunities for managing the flood risk. From this assessment it appears that flood risk can be managed through implementation of nonstructural measures, by increasing overall risk preparedness, managing development through local zoning and building codes, or a combination of all three. These measures are discussed in greater detail below.

8.1 Flood Preparedness Planning

Community outreach initiatives such as providing flood information pamphlets and flood maps, conducting workshops, and erecting high water mark and flood history signs can increase the awareness of flood risk among residents and draw interest toward incorporation of long-term flood risk activities. Results from this assessment may be used by local and county officials to conduct emergency preparedness activities such as evaluating roles and responsibilities, flood fight plans, and response capabilities in the event of a flood.

8.2 Future Development

Local zoning and/or building codes may be used to reduce flood risk for new construction and for community efforts in managing flood risk required by the NFIP. Given the flood risk identified along the Lower Meramec River, it is highly recommended that the communities coordinate with the State Emergency Management Agency regarding potential ordinances that could be adopted by a community for increasing their long-term flood resiliency.

8.3 Risk Management through Flood Insurance

The communities featured in this assessment currently participate in the NFIP, so flood insurance is available for all structures in each community regardless of their flood zone designation. Whether or not a structure is modified by implementing a nonstructural technique, flood insurance is advocated because future flooding could be greater than what has been experienced in the past or may be more severe than what a structure has been mitigated to withstand.

9 Assessment Conclusions

The communities of Arnold, Fenton, Eureka, and Pacific are located along the Meramec River and Union is located along the Bourbeuse River, which is a tributary to the Meramec River. Numerous residential and nonresidential structures reside within the 1% annual exceedance floodplain and are at risk of flooding. The USACE-St. Louis District collaborated with these communities on a nonstructural assessment to identify potential nonstructural measures on a sampling of 17 structures which have incurred flood damages in the past.

As a function of this assessment, the primary characteristics of flooding, such as depth, velocity, duration, and areal extent were combined with structure attributes for each of the 17 sample structures to determine the flood risk for the target 1% annual chance exceedance flood event. From this information, potential nonstructural measures for each structure could be determined. The measures proposed were scaled to the flood risk for the individual structure. As an example, if the 1% annual chance exceedance flood depth were no greater than a foot or two above the first floor elevation of a structure, there would be no need to consider acquisition or relocation of the structure, when elevating or dry flood proofing the structure may significantly decrease the flood risk and ensure that the structure remains active on the property tax rolls.

Since flooding within the assessment area could occur after a significant rainfall event, this assessment also provides practical information for the implementation of temporary measures as a stop-gap consideration prior to implementing permanent measures. Materials and equipment needs are described in Section 2.5 in an effort to provide the owner/tenant with enough background information to develop a successful temporary measures flood response plan.

With regards to the implementation of permanent nonstructural measures, the assessment identified one practical technique for each of the sample structures, which could be implemented to reduce flood risk. Enclosure A contains copies of the individual assessment sheet for each of the 17 sample structures which identify the proposed nonstructural measure for consideration.

As stated earlier in this report, for structures located within the regulatory floodway, it is USACE policy to only recommend acquisition or relocation of such structures in order to prevent occupation of an area of flood risk established for conveyance of the 1% annual chance exceedance flood.

The recent flood events of 2015-2016 and 2017 caused substantial damages to many structures and the probability of recurrence is high for structures previously damaged. This assessment should be used as a tool to educate community officials, residents, and business owners about the risk of flooding as well as the potential opportunities for reducing the flood risk through the nonstructural techniques presented.

Enclosure A

Structure Assessment Sheets

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STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#1	478 Spruce, Arnold, MO

Structure Photographs	
	
Front	Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling)
Configuration -	One story with a walkout basement, attached carport, rear addition, gable roof.
Construction -	Concrete foundation walls (basement). Wood framed with siding.
Condition -	Very good
Other -	Addition – One story, crawlspace, wood framed, panel siding, flat roof.

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior (basement). The structure was occupied and in very good condition. The property owner was present during the site visit.

Site: The structure is situated on a suburban site and is free standing on the property. The areas around the structure are grass except for a large paved pad on the right side. The grade at the front of the structure slopes down away from the structure toward the access road. The grade at the front and rear of the structure slopes down, side (carport) to side (concrete pad), from the first floor level to the basement level.

Structure: The structure is wood framed construction with a walkout basement and gable roof. The basement foundation walls are concrete. The basement floor is a concrete slab on grade. The exterior walls (above the foundation/basement level) have siding. The basement is finished and furnished. The rear addition appears to be a wood deck enclosed with fiberglass corrugated panels founded on wood posts.

Systems/Utilities: The structure's systems and utilities are located in the basement (below the BFE). The exterior HVAC is located on an elevated platform and appears to be below the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
418.6 ft	411.6 ft	*410.6 ft	419.7 ft	1.1 ft	*8.1 ft	*9.1 ft

ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation;

B – Basement Floor Elevation; CS – Crawl Space Ground Elevation;

BFE – Base Flood Elevation; Δ – Delta (Elevation Difference);

NA – Not Applicable; * - Estimated

Flood Risk
Flood Risk: The first floor is approximately 1.1 feet below the BFE. The basement and addition crawl space are below the BFE and would be totally inundated. The structure's construction, finishes, systems, utilities, storage and contents / furnishings in the basement would incur substantial damage.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the building's utilities / systems / storage to an upper level above BFE.
2. Evacuate the basement. Remove all damageable finishes, furnishings and contents.
3. Elevate the structure on extended foundation walls.
4. Fill the basement to the level of the adjacent exterior grade (sloped).
5. Elevate the exterior HVAC equipment on platforms above the BFE.
6. Wet flood proof the crawl space (filled basement). Install flood vents / louvers in the existing foundation walls.
7. Evacuate the structure during a flood event to prevent loss of life.

Note: The property owner has a plan and provisions to dry flood proof the basement to the underside of the first floor construction, a height of approximately 7 feet above the basement floor. The property owner has been successful in the past employing this method. USACE does not recommend this as a viable solution due to potential safety issues and potential structural failure of the basement foundation walls.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#2	4551 Kerth Forest Drive, unincorporated St. Louis County, MO

Structure Photographs	
	
Front	Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling).
Configuration -	Two story with a walkout basement, attached garage, gable roof.
Construction –	Concrete foundation walls. Wood framed with brick veneer / siding.
Condition -	Excellent.
Other -	Concrete pool and surround at rear.

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior (basement). The structure was occupied and is in excellent condition. The property owner was present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area around the structure is grass except for the paved driveway at the front and the pool area / basketball court at the rear (basement level). The grade at the front of the structure slopes slightly down away from the structure toward the access road. The grade at the sides of the structure slopes down from front to rear from the first-floor level to the basement level. The grade at the rear of the structure (pool area) is level. **Structure:** The structure is wood framed construction with a walkout basement and gable roof. The basement foundation walls are concrete. The basement floor is a concrete slab on grade. The exterior walls have brick veneer on the front and siding on the sides and rear. The basement is finished and furnished. **Systems/Utilities:** The structure's systems and utilities are located in the basement and appear to be at or below the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
426.4 ft	418.4 ft	*418.4 ft	417.0 ft	-9.4 ft	-1.4 ft	*-1.4 ft
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 9.4 feet above the BFE. The basement is below the BFE and would be inundated approximately 1.4 feet. The structure's construction, finishes, systems, utilities, storage, and contents/furnishings at the basement level (below the BFE) would incur substantial damage.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigation measures are recommended:

Option one:

1. Relocate the interior building's utilities / systems/storage above the BFE and / or to the upper levels (above BFE).
2. Elevate the exterior HVAC equipment on platforms above the BFE, if applicable.
3. Evacuate the basement. Remove all damageable finishes and contents.
4. Fill the basement to the level of the adjacent exterior grade (sloped).
5. Wet flood proof the crawl space (filled basement). Install flood vents / louvers in the exterior basement walls.
6. Evacuate the structure during a flood event to prevent loss of life.

Option two:

1. Relocate the interior building utilities / systems / storage above the BFE and/or to the upper levels (above BFE).
2. Elevate the exterior HVAC equipment on platforms above the BFE, if applicable.
3. Dry flood proof exposed walls at rear of structure (temporary or permanent) to the BFE.
4. Install flood barriers at door openings (temporary or permanent).
5. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
6. Provide interior drainage system with water pump to expel infiltrated water.
7. Provide emergency power to the water pump.
8. Evacuate the structure during a flood event to prevent loss of life.

Note: The property owner has experienced flooding in the basement in the past and incurred extensive damages.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#3	6544 Suson Woods Drive, St. Louis County, MO

Structure Photographs	
	
Front	Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling)
Configuration -	Two story with a walkout basement, attached garage, gable roof.
Construction -	Concrete foundation walls (basement). Wood framed with siding.
Condition -	Good.
Other -	Structure sited below the level of the access road.

Site Visit Observations
General: The structure was viewed / observed from the exterior only. The structure was occupied and in good condition. The property owner was not present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area around the structure is grass except for the paved driveway at the front and paved patio / wood deck at the rear (basement level). The grade at the front of the structure slopes slightly upward toward the access road. The grade at the sides of the structure slopes down front to rear from the first floor level to the basement level. The grade at the rear slopes down away from the structure, except for the level patio / deck area adjacent to the structure. **Structure:** The structure is wood framed construction with a walkout basement and gable roof. The basement floor is a concrete slab on grade. The exterior walls (above the foundation / basement level) have siding. The basement appears to be unfinished. **Systems/Utilities:** The structure's systems and utilities appear to be located in the basement. The structure interior was not accessible and not observed.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
N/A	N/A	N/A	N/A	N/A	N/A	N/A
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: Unknown – Ground and structure elevations not provided. The structure walk-out elevation (rear / basement level) appears to be higher than the FEMA 100-year elevation of 417.

Recommendation

Based on the structure characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

Option one:

1. Relocate the interior building's utilities / systems / storage to a level above BFE, if applicable.
2. Elevate the exterior HVAC equipement on platforms above the BFE, if applicable.
3. Evacuate the basement. Remove all damageable finishes, furnishings and contents.
4. Fill the basement to the level of the adjacent exterior grade (sloped).
5. Wet flood proof crawl space (filled basement). Install flood vents/louvers in existing foundation walls.
6. Evacuate the structure during a flood event to prevent loss of life.

Option two:

1. Dry flood proof exposed the walls at rear of structure (temporary or permanent) to the BFE.
2. Elevated the exterior HVAC equipemet on platforms above the BFE, if applicable.
3. Install flood barriers at door openings (temporary or permanent).
4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
5. Provide interior drainage system with water pump to expel infiltrated water.
6. Provide emergency power to the water pump.
7. Evacuate the structure during a flood event to prevent loss of life.

Note: Past flood history of the structure is unknown.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#4	64 Gravois Rd, Fenton, MO

Structure Photographs	
	
Front	Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Boat sales, service and repair).
Configuration -	One story, concrete slab on grade, flat roof.
Construction –	Masonry exterior walls with metal framed roof. Wood framed interior.
Condition -	Very Good.
Other -	Multi-level first floor (garage lower elevation than office / showroom).

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in very good condition. The property owner was present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area around the structure is paved. The grade around the structure slopes toward the rear of the site. **Structure:** The structure is masonry (exterior / interior bearing walls) with a flat roof. The floor is a concrete slab on grade. The structure's interior partitions are wood framed / finished (office / showroom area). The floor elevation in the garage area is several feet below the showroom / office area floor elevation (first floor). **Systems/Utilities:** The much of the structure's systems and utilities are elevated and appear to be higher than the BFE. One exterior HVAC is located on the roof (above the BFE); another is located at grade on the side of the structure (below the BFE).

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
417.0 ft	416.9 ft	NA	425.6 ft	8.6 ft	8.7 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 8.6 feet below the BFE. The garage area is several feet lower. The first floor and lower level garage will be totally inundated. The structure's construction, finishes, systems, utilities, storage and contents / furnishings at the first-floor showroom / office and lower garage area are substantially below the BFE and will incur significant damage.

Recommendation

Based on the structure characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the building utilities / systems / storage to upper level above BFE if applicable.
2. Elevate the exterior HVAC equipment onto platform or onto the roof, above the BFE.
3. Remove water damagable construction material and finishes and replace with water resistant construction and fininshes.
4. Wet flood proof the structure. Install flood vents/louvers in the existing walls.
5. Plan for evacuation of moveable equipment and structure contents prior to flood event when adequate warning is given.
6. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. The property owner indicated the structure experienced flooding on the first floor during past flood events and incurred extensive damages. When a flood warning is given the property owner evacuates the structure contents and stores them off site. Interior finishes have been replaced after previous flood events with easily removable water resistant construction in the showroom / office area. Some equipment is stored on mobile racks to facilitate evacuation.
2. Loose equipment, containers and debris on the site will easily float away during a flood event, being lost or causing environmental hazard.
3. The structure (lower garage area) may be able to be dry flood proofed up to approximately three feet above the floor to increase resiliency and reduce risk /damages associated with lesser flood events.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#5	62 Gravois Rd, Fenton, MO

Structure Photographs

	
Front	Rear/Side

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – HVAC / Plumbing sales and service).
Configuration -	One story, concrete slab on grade, gable roof.
Construction -	Masonry exterior bearing walls with wood truss roof. Wood framed interior.
Condition -	Good.
Other -	Auxiliary structure adjacent to main structure – Metal building/slab on grade.

Site Visit Observations
General: The structure was viewed / observed from the exterior only. The structure was occupied and in good condition. The property owner was not present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area around the structure is paved. The grade around the structure is level at the front and rear of the site. The grade at the sides of the structure slope down from front to rear. **Structure:** The structure is masonry (exterior bearing walls) with a low sloping gable roof. The floor is a concrete slab on grade. The structure's interior partitions appear to be wood framed / finished. **Systems/Utilities:** Location of the structure's interior systems and utilities are unknown. The structure was not observed from the interior. The one exterior HVAC is located on the roof (above the BFE) / another is supported on the side wall and appears to be below the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
414.8 ft	414.7 ft	NA	426.3 ft	11.5 ft	11.6 ft	NA

ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation;

B – Basement Floor Elevation; CS – Crawl Space Ground Elevation;

BFE – Base Flood Elevation; Δ – Delta (Elevation Difference);

NA – Not Applicable; * - Estimated

Flood Risk
Flood Risk: The first floor is approximately 11.5 feet below the BFE. The first floor will be totally inundated. The structure's construction, finishes, systems, utilities, storage and contents/furnishings at the first floor are substantially below the BFE and will incur significant damage.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the building utilities / systems / storage to upper level above BFE, if applicable.
2. Remove water damagable construction material and finishes and replace with water resistant construction and fininshes.
3. Wet flood proof the structure. Install flood vents/louvers in the existing walls.
4. Plan for evacuation of moveable equipment and structure contents prior to flood event when adequate warning is given.
5. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. Past flood history of the structure is unknown.
2. Loose equipment, containers and debris on the site will easily flood away during a flood event, being lost or causing environmental hazard.
3. The structure may be able to be floodproofed up to approximately three feet above the first floor to increase resiliency and reduce risk / damages associated with lesser flood events.
4. The adjacent auxiliary structure cannot be protected (dry flood proofed).

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#6	10 Gravois Rd, Fenton, MO

Structure Photographs

Front	Side/Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Automobile / Equipment sales and service).
Configuration -	One story, concrete slab on grade, flat roof.
Construction -	Masonry exterior walls with metal framed roof. Wood framed interior.
Condition -	Very good.
Other -	None

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property owner was present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area around the structure is paved at the front with gravel / grass at the sides and rear. The grade around the structure is level at the front and rear of the site. The grade at the sides of the structure slopes slightly down from front to rear. **Structure:** The structure is masonry (exterior bearing walls) with a steel framed flat roof. The floor is a concrete slab on grade. The structure's interior partitions are wood framed / finished (office). A storage area / mezzanine (above the BFE) is located above the office area. **Systems/Utilities:** The structure's systems and utilities are located above the BFE. The exterior HVAC unit is located on a low platform and appears to be below the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
420.2 ft	420.1 ft	NA	425.7 ft	5.5 ft	5.6 ft	NA

ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation;

B – Basement Floor Elevation; CS – Crawl Space Ground Elevation;

BFE – Base Flood Elevation; Δ – Delta (Elevation Difference);

NA – Not Applicable; * - Estimated

Flood Risk
Flood Risk: The first floor is approximately 5.5 feet below the BFE. The first floor will be substantially inundated. The structure's construction, finishes, systems, utilities, storage and contents/furnishings at the first floor showroom / office and lower garage area are substantially below the BFE and will incur significant damage.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the building utilities / systems / storage to upper level above BFE if applicable.
2. Elevate the exterior HVAC equipment on platforms or onto the roof, above the BFE.
3. Remove water damagable construction material and finishes and replace with water resistant construction and fininshes.
4. Wet flood proof the structure. Install flood vents / louvers in the existing walls.
5. Plan for evacuation of moveable equipment and structure contents prior to flood event when adequate warning is given.
6. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. The property owner indicated the structure experienced flooding on the first floor during past flood events and incurred extensive damages. When a flood warning is given the property owner evacuates the structure contents and stores them off site. Interior finish has been replaced after previous flood event with easily removable construction / panel system in the office area.
2. Loose equipment, containers, and debris on the site will easily float away during a flood event, being lost or causing environmental hazard.
3. The structure may be able to be dry flood proofed up to approximately three feet above the first floor to increase resiliency and reduce risk /damages associated with lesser flood events.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#7	3644 Scarlet Oak, Fenton, MO

Structure Photographs	
	
Front/Side	Front

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial Office/Laboratory/Manufacturing/Warehouse).
Configuration -	One story, concrete slab on grade, flat roof.
Construction –	Masonry exterior bearing walls with metal framed roof. Wood frame interior.
Condition -	Good.
Other -	Specialized Equipment, Multiple interconnected structures and occupancies. Large / sprawling structure(s)

Site Visit Observations
General: The structure was viewed/observed from the exterior and interior. The structure was occupied and in good condition. The property owner was present during the site visit. **Site:** The complex of structures are situated on a suburban site and free standing on the property. The areas in front and on the sides of the structures are paved. **Structure:** The structures are metal framed with masonry and metal sided exterior walls with a flat roof. Interior partitions are masonry and wood framed. The first floor is a concrete slab on elevated fill. **Systems/Utilities:** the structure's systems and utilities appear to be elevated and located above the BFE.

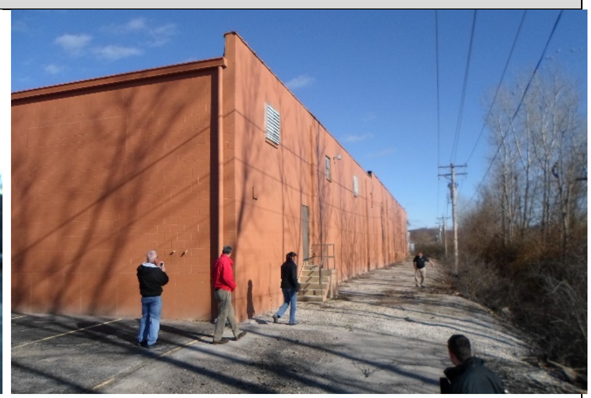
Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
429.0 ft	428.9 ft	NA	432.6 ft	3.6 ft	3.7 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 3.6 feet below the BFE.

Recommendation
Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended: 1. Relocate the interior building utilities/systems/storage above the BFE, as applicable. 2. Dry flood proof exterior walls of structures (temporary or permanent) to the BFE. Exterior walls may need to be modified for structural integrity and to stop water penetration. 3. Install certified flood barriers at door openings (temporary or permanent). 4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable. 5. Provide interior drainage system with water pump to expel infiltrated water. 6. Provide emergency power to interior water pumps. 7. Evacuate the structure during a flood event to prevent loss of life. Notes: 1. The property owner indicated that they utilize expensive specialized equipment in their manufacturing process. 2. Areas within the structure could be isolated or compartmentalized utilizing dry flood proofing measures to protect critical areas.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#8	3615 Treecourt Industrial Blvd, Fenton (unincorporated), MO

Structure Photographs	
	
Front	Side/Rear

Structure Characteristics	
Characteristic	Description
Occupancy -	Nonresidential (Commercial – office /warehouse).
Configuration -	One story, concrete slab on grade, flat roof.
Construction -	Masonry exterior bearing walls, interior metal support columns, with metal framed roof (warehouse area). Wood frame front office area.
Condition -	Good.
Other -	Large / sprawling structure(s)

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property owner and tenant were present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area in front and on the sides of the structure are paved. The grade at the front of the structure slopes down away toward the access road. The grade at the sides and rear are level. A small stream is located adjacent and parallel to the rear of the structure. **Structure:** The structures are metal framed with masonry exterior walls and a flat roof. Interior partitions are masonry and wood framed. The first floor is a concrete slab on elevated fill. Some water penetration through cracks in the floor has occurred in the past. **Systems/Utilities:** The structure's systems and utilities appear to be elevated and located above the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
429.0 ft	428.0 ft	NA	432.5 ft	3.5 ft	4.5 ft	NA

ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation;

B – Basement Floor Elevation; CS – Crawl Space Ground Elevation;

BFE – Base Flood Elevation; Δ – Delta (Elevation Difference);

NA – Not Applicable; * - Estimated

Flood Risk
Flood Risk: The first floor is approximately 3.5 feet below the BFE.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the interior building utilities / systems / storage above the BFE, is applicable.
2. Dry flood proof exterior walls of the structure (temporary or permanent) to the BFE. Exterior walls may need to be modified for structural integrity and to stop water penetration.
3. Install flood barriers at door openings (temporary or permanent).
4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
5. Provide interior drainage system with water pump to expel infiltrated water.
6. Provide emergency power to the water pump.
7. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. The property owner representatives / tenant indicated the structure has experienced flooding in the past.
2. The property owner indicated that they utilize expensive specialized equipment in their manufacturing process.
3. Critical areas within the structure could be isolated or compartmentalized utilizing dry flood proofing measures.
4. The property owner representatives / tenant indicated elevating storage shelving above the BFE was not feasible.
5. The property owner representatives / tenant indicated the products stored in the warehouse are hazardous to the environment and are evacuated to an area not at flood risk. They have an evacuation plan and resources to execute it.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#9	2477 Marshall Road, Fenton, MO

Structure Photographs	
	
Front	Side/Site

Structure Characteristics	
Characteristic	Description
Occupancy -	Nonresidential (Commercial – golf-pro shop).
Configuration -	One story, concrete slab on grade, gable roof, attached garage.
Construction –	Pre-engineered metal building with metal siding, gable roof. Wood frame interior.
Condition -	Excellent.
Other -	None

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in excellent condition. The property owner representatives were present during the site visit. **Site:** The structure is situated on a suburban site and is free standing on the property. The areas at the front and on the side parking area of the structure are paved. The area on the other side and at the rear are grass. The grade around the structure slopes down and slightly away. **Structure:** The structure is a pre-engineered metal building with a gable roof. The floor is a concrete slab. The exterior walls have metal panel siding. The structure's interior partitions are wood framed / finished. **Systems/Utilities:** The structure's systems and utilities are located on the first-floor level. The exterior HAVC units are located at grade at the rear of the structure.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
431.0 ft	430.5 ft	NA	432.8 ft	1.8 ft	2.3 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 1.8 feet below the BFE.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the interior building utilities / systems/storage above the BFE.
2. Elevate the exterior HVAC equipment on platforms above the BFE.
3. Dry flood proof exterior walls of the structure (temporary or permanent) to the BFE. Exterior wall may need to be modified for structural integrity and to stop water penetration.
4. Install flood barriers at door openings (temporary or permanent).
5. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
6. Provide interior drainage system with water pump to expel infiltrated water.
7. Provide emergency power to the water pump.
8. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. The property owner indicated the structure has experienced flooding in the past and incurred extensive damages.
2. The property owner (representative) indicated the structure was to be replaced with a new structure with a higher first floor elevation. If this is the case, it is recommended the new first floor elevation be as high as feasibly possible without affecting access to the structure and not affect its use. Elevating the existing structure is not cost effective and/or feasible.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#10	145 S. Central, Eureka, MO

Structure Photographs	
	
Front	Side

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Restaurant/Bar).
Configuration -	Multiple structures (2) / additions, one and two story, gable / flat roofs.
Construction –	Varies – Wooded framed and masonry, crawl space and concrete slab, gable and flat roofs.
Condition -	Good.
Other -	Historic structure(s)

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property owner was present during the site visit.
Site: The structures are situated on an urban site, on a corner lot and abuts an adjacent structure / property. The areas around the structure are paved (sidewalks / roadway / parking area). The grade around the structure is level.
Structure: Multiple structures and additions make up this property. The structures abut one another and are interconnected. One main structure is wood framed with crawl space, a gable roof and siding. A rear addition to this structure is wood framed with a concrete slab on grade floor and gable roof. Another main structure is masonry with a concrete slab on grad floor and flat roof. A rear addition is masonry with a concrete slab on grade floor and flat roof. The structures have historic significance.
Systems/Utilities: The structure's systems and utilities appear to be located above the BFE. Exterior HVAC equipment is located on the roofs.

Structure and Flood Elevations						
FF	LAG	CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
447.0 ft	*446.0 ft	445.3 ft	450.6 ft	3.6 ft	4.6 ft	5.3 ft
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 3.6 feet below the BFE.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Relocate the interior building utilities / systems/storage above the BFE, if applicable.
2. Dry flood proof exterior walls of the structure (temporary or permanent) to the BFE. Exterior wall may need to be modified for structural integrity and to stop water penetration.
3. Install flood barriers at door openings (temporary or permanent).
4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
5. Provide interior drainage system with water pump to expel infiltrated water.
6. Provide emergency power to the water pump.
7. Evacuate the structure during a flood event to prevent loss of life.

Notes: The property owner indicated the structure has experienced flooding in the past and incurred extensive damages.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#11	333 Bald Hill Road, Eureka, MO

Structure Photographs	
	
Front	Side

Structure Characteristics	
Characteristic	Description
Occupancy -	Nonresidential (Public – office / community center).
Configuration -	One story, concrete slab on grade, gable roof.
Construction -	Masonry exterior bearing walls with wood framed roof. Masonry and wood framed interior.
Condition -	Excellent.
Other -	Dry flood proofing measures are in place.

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property tenants were present during the site visit. **Site:** The structure is situated on a suburban site and is free standing on the property. The areas around the structure are grass for several feet with paved areas beyond. The grade around the structure is level. **Structure:** The structure is masonry with a gable roof. Interior partition areas are wood framed /finished. The floor is a concrete slab on grade. Flood barrier systems have been installed at all exterior door openings. **Systems/Utilities:** The structure's systems and utilities are located on the first floor level and appear to be above the BFE. The exterior HAVC units are located on the roof (above the BFE).

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
449.7 ft	449.2 ft	NA	450.1 ft	0.4 ft	0.9 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 0.4 feet below the BFE. Measures have been installed to dry flood proof the structure.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Verify installation of check valve(s) (automatic and/or manual) in the sewer line(s).
2. Provide interior better drainage system with water pump to expel infiltrated water.
3. Provide emergency power to the water pump.
4. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. Stop logs for the door opening closure systems are located in an adjacent storage building. The property tenant escorting the site visit team was not aware of the location of the stop logs. It would be preferable for the closure system to be stored in the structure they will be used in.
2. Storage of the above mentioned stop logs could be better. Storing these items haphazardly could damage them or cause them to be lost over time. Lost or damaged items could impair the flood barrier system from working properly.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#12	1400 S Outer Road, Eureka, MO

Structure Photographs	
	
Front	Side/Site

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Automobile sales and service).
Configuration -	One story, concrete slab on grade, flat roof.
Construction -	Pre-engineered metal building. Wood framed interior.
Condition -	Very good.
Other -	Auxiliary structure adjacent to main structure – Metal building / slab on grade.

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property owner was present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The area around the structure is paved. The grade around the structure is level. **Structure:** The structure is a pre-engineered metal building with a flat roof. The floor is a concrete slab on grade. The structure's interior partitions appear to be wood framed / finished (office / showroom area). **Systems/Utilities:** The structure's systems and utilities are located on the first floor level and appear to be above the BFE. The exterior HVAC units are elevated and appear to be above the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
450.4 ft	450.3 ft	NA	450.7 ft	0.3 ft	0.4 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 0.3 feet below the BFE.

Recommendation
Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

Office / Showroom area:

1. Relocate the interior building utilities / systems / storage above the BFE, as applicable.
2. Dry flood proof exterior walls of the structure (temporary or permanent) to the BFE. Exterior walls may need to be modified for structural integrity and to stop water penetration.
3. Install flood barriers at door openings (temporary or permanent).
4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
5. Provide interior drainage system with water pump to expel infiltrated water.
6. Provide emergency power to the water pump.
7. Evacuate the structure during a flood event to prevent loss of life.

Garage area:

1. Elevate garage equipment onto platforms / shelving (above the BFE) and/or movable racks shelving for easy evacuation.
2. Wet flood proof the structure. Install flood vents/louvers in the existing walls.
3. Plan for evacuation of moveable equipment and structure contents prior to flood event when adequate warning is given.
4. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. The property owner indicated that the structure has experienced flooding in the past and incurred damages.
2. Recommendation of relocating the interior building utilities / systems/storage as high as feasibly possible. This will reduce damages for flood events higher than the BFE.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#13	Dickey Bub, 1 Union Village Plaza

Structure Photographs	
	
Front	Front

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Retail Store).
Configuration -	One story, concrete slab on grade, flat roof. Interior storage mezzanine.
Construction –	Metal structure, concrete slab on grade, masonry exterior walls, flat roof. Wood framed interior partitions.
Condition -	Very Good.
Other -	Auxiliary structures adjacent to main structure at the side and rear. Metal buildings / slab on grade.

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property owner was present during the site visit. **Site:** The structure is situated on a suburban site and free standing on the property. The areas in front and on one side of the structure are paved. The rear and other side of the structure are grass and gravel. The grade around the structure is level. **Structure:** The structure is metal columns with masonry exterior walls and a flat roof. Interior partitions are wood framed and provide support for an elevated storage mezzanine at the rear of the structure. The floor is a concrete slab on grade. The auxiliary structures appear to be pre-engineered metal buildings with concrete slab on grade floors. There is a large equipment storage area in the parking area in front of the structure. **Systems/Utilities:** The structure's systems and utilities appear to be elevated above the BFE. A large electric transformer is located at the rear of the structure at grade on a concrete pad.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
515.2 ft	515.1 ft	NA	516.7 ft	1.5 ft	1.6 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 1.5 feet below the BFE.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

Option one:

1. Relocate the interior building utilities / systems / storage above the BFE.
2. Elevate the large transformer at rear of structure on platform above the BFE or construct a barrier (wall) around it.
3. Dry flood proof exterior walls of the structure to the BFE. Exterior wall may need to be modified to reduced / stop potential water penetration.
4. Install flood barriers at door openings (temporary or permanent).
5. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
6. Provide interior drainage system with water pump to expel infiltrated water.
7. Provide emergency power to the water pump.
8. Evacuate the structure during a flood event to prevent loss of life.

Option two:

1. Relocate the interior building utilities / systems / storage above the BFE.
2. Dry flood proof front and side exterior walls of the structure to the BFE. Exterior wall may need to be modified to reduced / stop potential water penetration.
3. Construct barrier (wall) at the side and rear of the structure to isolate side /rear property from flood water.
4. Install flood barriers at door openings (temporary or permanent).
5. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
6. Provide interior drainage system with water pump to expel infiltrated water.
7. Provide emergency power to the water pump.
8. Evacuate the structure during a flood event to prevent loss of life.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#14	220 First Street, Pacific, MO

Structure Photographs	
	
Front/Side	Side/Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Restaurant / bar / offices).
Configuration -	Multiple structures (2), two and three story, flat roofs.
Construction –	Varies – Wooded framed and masonry, crawl space and concrete slab, flat roofs.
Condition -	Good.
Other -	Historic structures, Hydraulic elevator

Site Visit Observations
General: The structures were viewed / observed from the exterior and interior (partial). Limited access was provided to the first floor areas. The structure was occupied and in good condition. The property owner representative was present during the site visit.

Site: The structures are situated on a suburban site and free standing on the property. The areas around the structures are paved (sidewalks/roadway/parking area/patio) The grade is level.

Structure: Multiple structures make up this property. The structures abut one another and are interconnected. One structure (three story) is masonry with a crawl space and flat roof. The other structure (two story) is wood framed with a concrete slab on fill floor and a flat roof. The structures have historic significance. A large refrigerator unit is located at grade on the rear/side of the structure.

Systems/Utilities: The structure's systems and utilities appear to be located on the first floor level below the BFE. The exterior HVAC units are elevated on platforms above grade, but appear to be below the BFE.

Structure and Flood Elevations						
FF	LAG	CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
460.9 ft	460.4 ft	*457.9 ft	471.0 ft	10.1 ft	10.6 ft	*13.1 ft
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 10.1 feet below the base flood elevation (BFE). The first floor will be totally inundated. The structure's construction, finishes, systems, utilities, storage and contents/furnishings at the first floor are substantially below the BFE and will incur significant damage.

Recommendation
Based on the structure's characteristics, site visit observations, structure / flood elevation data, and the flood risk, flood proofing this structure to the BFE is not feasible. The structure may be able to be dry flood proofed up to approximately two feet above the first floor (top of window sills) to increase resiliency and reduce risk / damages associated with lesser flood events: 1. Relocate the interior building utilities / systems / storage above the BFE if applicable. 2. Dry flood proof exterior walls of the structure (temporary or permanent). Exterior wall may need to be modified for structural integrity and to stop water penetration. 3. Install flood barriers at door openings (temporary or permanent). 4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable. 5. Provide interior drainage system with water pump to expel infiltrated water. 6. Provide emergency power to the water pump. 7. Evacuate the structure during a flood event to prevent loss of life. **<u>Note:</u>** This is a historic structure. Modifying the exterior and changing the aesthetics in any way would be very challenging.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#15	1101 S. Denton Road, Pacific, MO

Structure Photographs	
	
Front (wing)	Front/Side

Structure Characteristics	
Characteristic	Description
Occupancy -…	Nonresidential (Commercial – Manufacturing / warehouse / offices).
Configuration -	Multiple structures / additions, concrete slab on grade, flat roof.
Construction –	Varies – masonry / metal sided exterior walls, flat roof. Wood framed interior partitions.
Condition -	Very Good.
Other -	Large / sprawling structure(s)

Site Visit Observations
General: The structure was viewed / observed from the exterior (partial) and interior (partial). Limited access was provided to the first floor areas. The structure was occupied and in very good condition. The property owner representatives were present during the site visit. **Site:** The structure is situated on a suburban site and is free standing on the property. The area around the structure is mostly grass with intermittent paved areas. The grade around the structure is level. **Structure:** The structures are metal framed with masonry and metal sided exterior walls with a flat roof. Interior partitions are masonry and wood framed. The first floor is a concrete slab on grade. **Systems/Utilities:** The structure's interior systems and utilities appear to be elevated above the BFE. The exterior HVAC units are elevated on platforms above grade, but appear to be below the BFE. Manufacturing equipment appears to be below the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
458.3 ft	457.9 ft	NA	465.0 ft	6.7 ft	7.1 ft	CA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 6.7 feet below the base flood elevation (BFE).

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, flood proofing this structure to the BFE is not feasible. The structure may be able to be flood proofed up to approximately three feet above the first floor to increase resiliency and reduce risk / damages associated with lesser flood events:

1. Relocate the interior building utilities / systems / storage above the BFE, as applicable.
2. Elevate the exterior HVAC equipment on platforms above the BFE or to the roof.
3. Dry flood proof exterior walls of the structure (temporary or permanent) to the BFE. Exterior wall may need to be modified for structural integrity and to stop water penetration.
4. Install flood barriers at door openings (temporary or permanent).
5. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
6. Provide interior drainage system with water pump to expel infiltrated water.
7. Provide emergency power to the water pump.
8. Evacuate the structure during a flood event to prevent loss of life.

Notes:

1. The property owner representatives indicated that the structure has experienced flooding in the past.
2. The property owner representatives indicated that they have purchased a bladder type barrier to protect the structure during a flood event and have a plan and have resources to install it.
3. Areas within the structure could be isolated or compartmentalized by dry flood proofing measures to protect critical areas.
4. The property owner representatives indicated that elevating specialized manufacturing equipment in this facility would be very costly and not cost effective / feasible.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#16	625 S Fourth Street, Pacific, MO

Structure Photographs	
	
Front/Site	Side

Structure Characteristics	
Characteristic	Description
Occupancy –	Nonresidential (Commercial – Hardware store / Building supply).
Configuration –	Multiple structures - One story, concrete slab on grade, flat / gable roofs
Construction –	Wood framed exterior walls with wooded framed roofs. Wood frame interior partitions.
Condition –	Very Good.
Other –	Auxiliary structures on site –wood pole buildings / slab on grade.

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The structure was occupied and in good condition. The property owner was present during the site visit. **Site:** The structure is situated on a suburban site and is free standing on the property. The areas around the structure are paved. The grade around the structure is level. **Structure:** Multiple structures make up this property (retail store and warehouse). The structures abut one another and are interconnected. One structure (retail) is wood frame with wood panel siding and a flat roof. The other structure (warehouse) is wood framed (pole building) with wood panel siding and a flat roof. Both structures have concrete slab on grade floors. **Systems/Utilities:** The structure's systems and utilities appear to be located on the first floor level below the BFE. The exterior HVAC units are elevated above grade on a platform, but appear to be below the BFE.

Structure and Flood Elevations						
FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
461.6 ft	461.1 ft	NA	471.2 ft	9.6 ft	10.1 ft	NA
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 9.6 feet below the BFE. The first floor will be totally inundated. The structure's construction, finishes, systems, utilities, storage and contents/furnishings at the first floor are substantially below the BFE and will incur significant damage.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, flood proofing this structure to the BFE is not feasible. The structure may be able to be dry flood proofed up to approximately three feet above the first floor to increase resiliency and reduce risk / damages associated with lesser flood events:

Hardware store:

1. Relocate the interior building utilities / systems / storage above the BFE if applicable.
2. Dry flood proof exterior walls of the structure (temporary or permanent). Exterior wall may need to be modified for structural integrity and to stop water penetration.
3. Install flood barriers at door openings (temporary or permanent).
4. Install check valve(s) (automatic and/or manual) on sewer lines, if applicable.
5. Provide interior drainage system with water pump to expel infiltrated water.
6. Provide emergency power to the water pump.
7. Evacuate the structure during a flood event to prevent loss of life.

Warehouse:

1. Elevate the equipmnet onto platforms / shelving (above the BFE) and/or movable racks shelving for easy evacuation.
2. Wet flood proof the structure. Install flood vents/louvers in the existing walls.
3. Plan for evacuation of moveable equipment and structure contents prior to flood event when adequate warning is given.
4. Evacuate the structure during a flood event to prevent loss of life.

Notes: The property owner indicated the structure has experienced flooding in the past and incurred extensive damages.

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#17	447 & 449 Mabel Drive, Arnold, MO

Structure Photographs	
	
Front	Side/Rear

Structure Characteristics	
Characteristic	Description
Occupancy -…	Residential (Two Family Dwelling - Duplex).
Configuration -	One story with crawlspace, gable roof.
Construction -	Concrete foundation. Wood framed with siding.
Condition -	Very good.
Other -	None

Site Visit Observations
General: The structure was viewed / observed from the exterior and interior. The crawlspace was not observed. The structure was partially occupied (one unit vacant) and in good condition. The property owners and the renter (occupied unit) were present during the site visit. **Site:** The structure is situated on a suburban site and is free standing on the property. The area around the structure is grass except for the paved driveways. The grade at the front of the structure slopes away toward the access road. The grade at the front and rear of the structure slopes down from side to side. The grade at the sides is level. **Structure:** The structure is wood framed construction with a crawl space and gable roof. The exterior walls have siding. **Systems/Utilities:** The structure's systems and utilities are located on the first floor level. The exterior HVAC units are located at grade.

Structure and Flood Elevations						
FF	LAG	CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
418.7 ft	417.4 ft	*417.4 ft	420.0 ft	1.3 ft	2.6 ft	*2.6 ft
ABBREVIATIONS: FF – First Floor Elevation; LAG – Low Adjacent Grade Elevation; B – Basement Floor Elevation; CS – Crawl Space Ground Elevation; BFE – Base Flood Elevation; Δ – Delta (Elevation Difference); NA – Not Applicable; * - Estimated						

Flood Risk
Flood Risk: The first floor is approximately 1.3 feet below the BFE.

Recommendation

Based on the structure's characteristics, site visit observations, structure / flood elevation data and the flood risk, the following mitigations are recommended:

1. Elevate the structure on extended foundation walls.
2. Elevate the exterior HVAC equipment on platforms above the BFE
3. Fill the basement to adjacent exterior grade level (sloped), if applicable.
4. Wet flood proof the crawl space. Install flood vents / louvers in existing foundation walls.
5. Evacuate the structure during a flood event to prevent loss of life.

Note: The property owners indicated the structure experienced flooding on the first floor during past flood events and incurred extensive damages.