Appendix D
U.S. Army Corps of Engineers
National Nonstructural Committee Assessment
Upper Joachim Creek

January 2019

United States Army Corps of Engineers-St. Louis District
Supported by the National Nonstructural Committee

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City of De Soto in Jefferson County, Missouri Nonstructural Flood Mitigation Assessment

1.0 Introduction

This reconnaissance level nonstructural assessment has been conducted in support of the United States Army Corps of Engineers (USACE)-St. Louis District to assess the flood risk within the City of De Soto, Missouri. The 10 sample structures assessed consist of residential, nonresidential commercial structures, and a public structure. The objective of this assessment is to identify potential opportunities for potential flood risk adaptive measures, generally referred to as nonstructural mitigation measures. A general location map for De Soto is presented in Figure 1.

The nonstructural assessment focused on structures at risk of flooding from Joachim Creek. The stream is located in Jefferson and St. Francois counties and is a right-bank tributary of the Mississippi River.

Figure 1
De Soto, Missouri Location Map

The City of De Soto is located in Jefferson County, approximately 45 miles south of St. Louis in the Upper Joachim Creek watershed. The watershed has a total drainage area of 39,154 acres, and the City of De Soto, is the only incorporated city in the watershed. Currently, there are 1,642 acres of Federal Emergency Management Agency mapped special flood hazard area in the watershed, most of which are located within the city limits. The City has historically been prone to flash flooding but has experienced an increase both in frequency and intensity in recent years with five flood events in the last four years. A review of the 2006 FEMA Flood Insurance Study for Jefferson County (29099CV001A) indicated a channel roughness coefficient for Joachim Creek, which is similar to, if not smoother than, the other channel roughness coefficients in Jefferson County. The roughness coefficient for the overbank areas (0.080-0.120) was a little higher than other streams, possibly indicating that vegetation was a little thicker in the overbank areas of Joachim Creek. In general, the smaller the roughness coefficient, the smoother the flow, which may result in lower stages. Conversely, the larger the roughness coefficient, the greater the stages. The 1% annual chance exceedance (ACE) velocity, determined from hydraulic computer modeling of Joachim Creek at De Soto, was less than 3 feet per second for each of the structures assessed. The preliminary FEMA floodplain map for the 1% ACE flood event is shown in Figure 2.

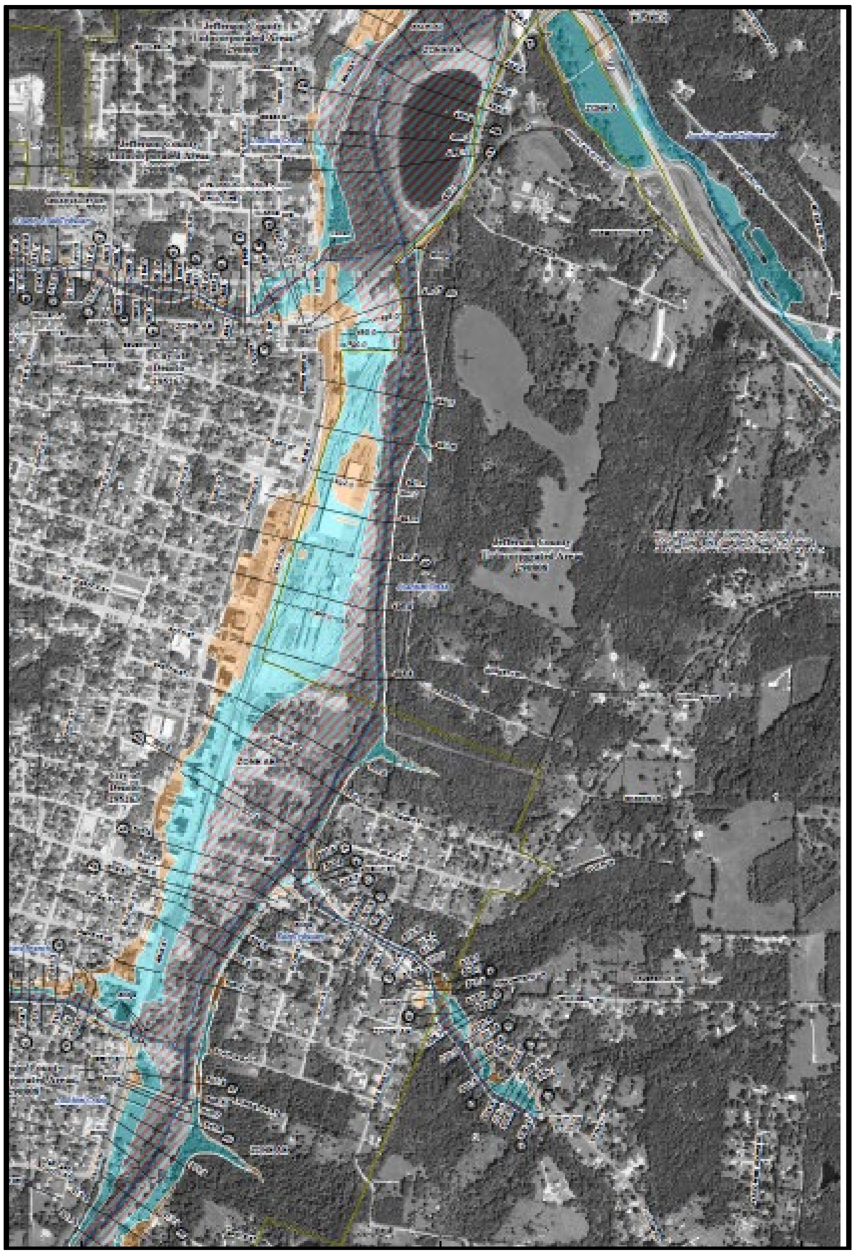

Figure 2
Preliminary 1% ACE FEMA Floodplain Map for the City of De Soto, MO

Photographs of recent flooding at two locations in De Soto are shown in Figures 3 and 4. Several of the structures investigated for this nonstructural assessment were located in the vicinity of the flooding depicted in these photographs.

Figure 3
City of De Soto 2013 Flood Event along De Witt Street

Figure 4
City of De Soto 2013 Flood Event along Veterans Drive

1.1 Consequences of Flood Risks. Flooding along Joachim Creek at De Soto has become a burden on the city in recent years. The potential exists for loss of life and extreme property damages during any flood event which exceeds the capacity of the channel.

Flooding in and around the City of De Soto requires the response and recovery efforts of Federal, State, and Jefferson County, as well as local and neighboring governments, residents and outside volunteers. When flooding occurs, the drain on human and financial resources is significant. Damages to residential, commercial and public facilities adversely impacts the community residents and the commercial businesses.

Whether hydrologic conditions remain the same or change in the future, all structures located within the vicinity of the assessment area are at risk of flooding. This assessment focuses on at-risk structures and contains the detailed technical assessment used for investigating the incorporation of nonstructural measures within the assessment area. Without the incorporation of nonstructural mitigation or other structural measures such as levees, floodwalls, and channel modifications, these structures are at risk of being damaged or destroyed from flooding occurring in the future.

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 just measure first floor elevation by indicating how high flood depths are expected to rise in association with the 1% ACE or 0.2% ACE flood events. A depth of flooding measurement of two feet, when comparing to the first floor, would indicate that a 1% ACE 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 the 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.

Table 1, which is taken from the Upper Joachim Creek Floodplain Management Plan, summarizes elevation statistics for flood prone structures in De Soto. Within the De Soto city limits, and according to observations, 12% of the current structures contain basements or crawlspaces, indicating that flood damages may begin at elevations below the first floor due to below grade garage openings, basement windows, sewer backups, utility penetrations, or seepage through foundation cracks. Table 1 also indicates that there are 49 structures experiencing flooding at the 10% ACE flood event, 128 structures experiencing flooding at the 25% ACE flood event, 202 structures experiencing flooding at the 2% ACE, 231 structures experiencing flooding at the 1% ACE, and 332 structures experiencing flooding at the 0.2% ACE flood event.

Table 1
Structures Impacted by Flooding by Flood Event

	10% ACE	4% ACE	2% ACE	1% ACE	0.2% ACE
Structures Impacted	49	128	202	231	332
Average Flood Depth (feet)	0.7	1.9	2.7	3.8	6.1
Average Flood Velocity (fps)	1.0	1.2	1.3	1.5	1.6

While nonstructural 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 will reduce the cumulative risk of flooding. Each individual structure assessed may require a different nonstructural technique. While this assessment relies on data collected in the field for implementation, the assessment is not conclusive as to the ultimate feasibility of the alternative. 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 such that layering of measures, each one providing a higher degree of risk reduction, is possible and given both Federal and non-Federal funding constraints, may be probable.

2.0 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 leveed 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 source of the most major historic floods in the assessment area is due to significant rainfall within the watersheds being conveyed along Joachim Creek. Because of the characteristics of the runoff within the watershed (flashy and relatively deep), flood warning is not favorable for enabling timely and successful human intervention to reduce flood damages from occurring to most personal property by operating closures or evacuating all valuables. 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 floodplain located within the City and surrounding areas of De Soto consists of residential, commercial, and governmental/public development. Basements and crawl spaces exist in some of the structures. Age of development is 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 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. 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 - 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). 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 or whichever is higher. 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 is a consideration. 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 5. 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.

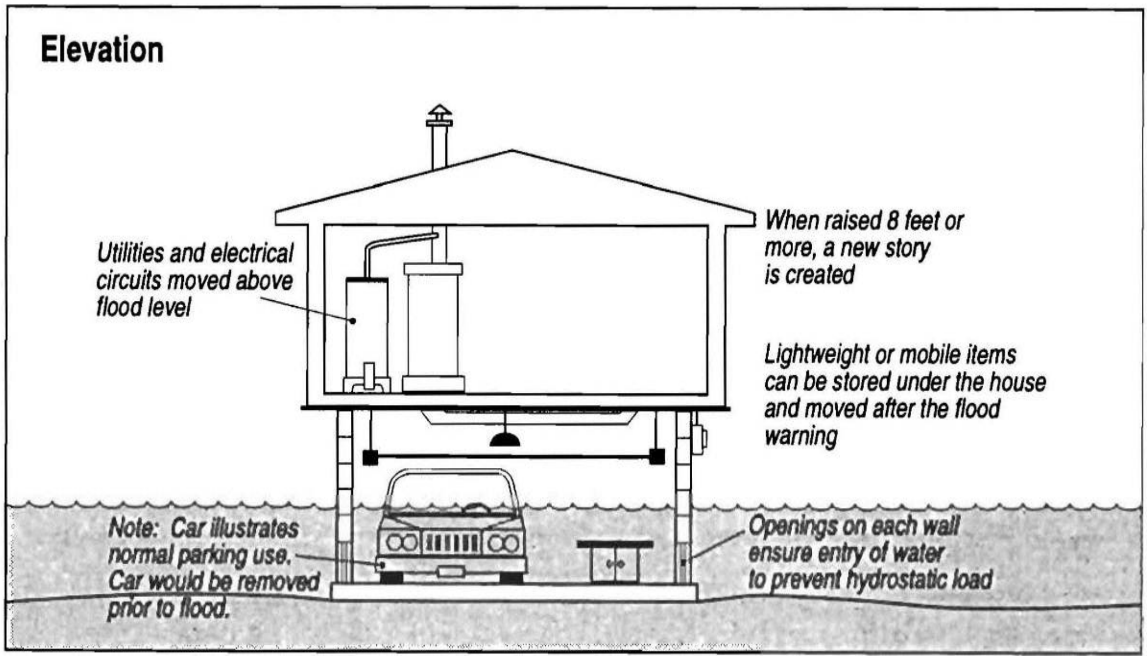

Figure 5
Elevation of Structure (Diagrammatic Section)

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 6. 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.

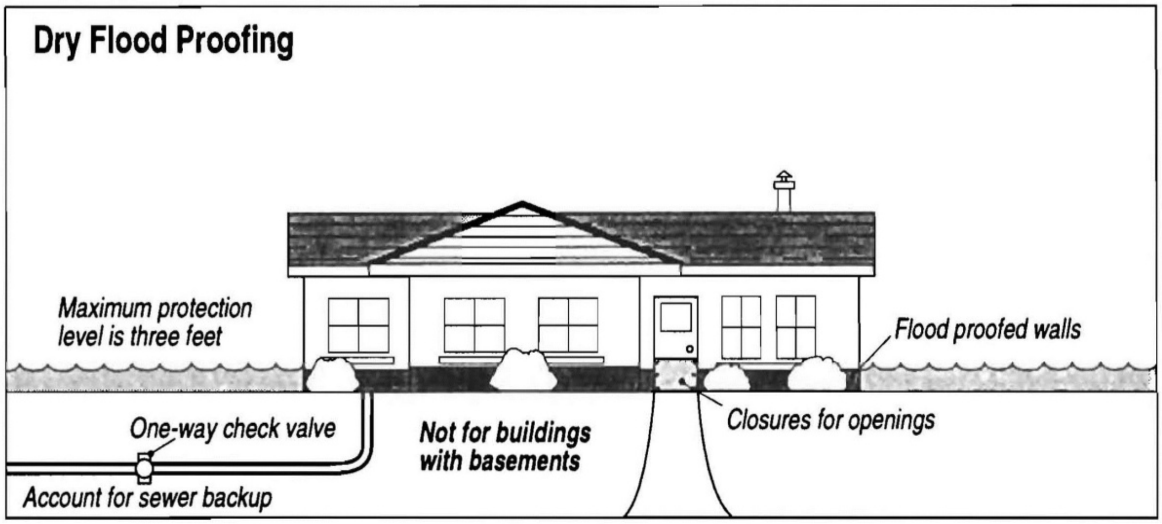

Figure 6
Dry Flood Proofing (Diagrammatic Detail)

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 7. 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 7
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 8.

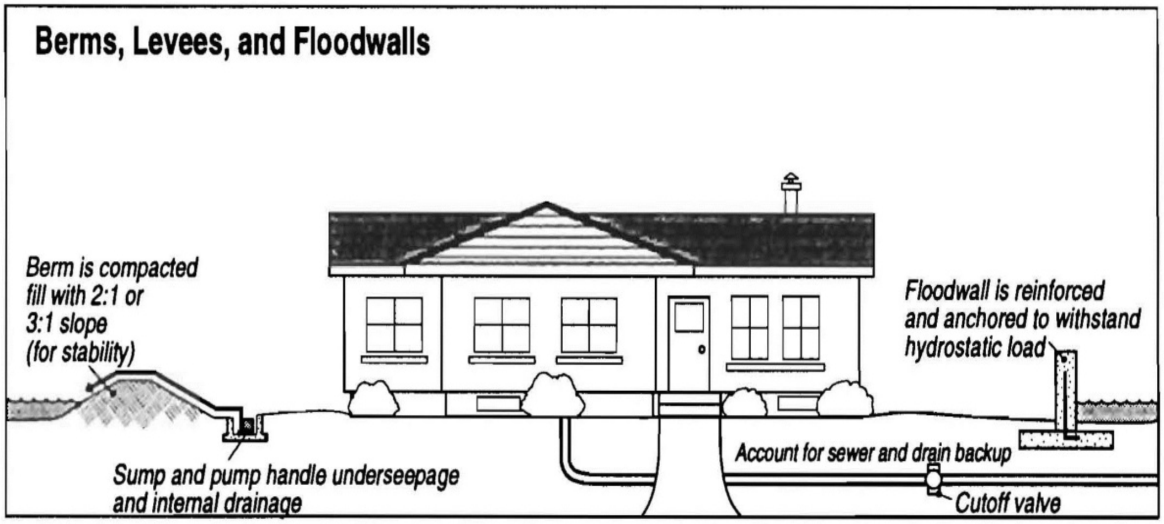

Figure 8
Berms, Levees, Floodwalls (Diagrammatic Detail)

The following report Sections 2.4.8 – 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 National Flood Insurance Program (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, flood 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 Agency (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 part 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 City of De Soto 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 the Corps of Engineers 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 to not 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 City of De Soto. 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 his 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).

<u>2.5.4 Planning and Preparation of Temporary Measures.</u> The information provided in this report section 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 of the recommendations is that, in order to prevent floodwaters from entering a structure and causing damage, the site surrounding the structure 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, the Corps' 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.

<u>2.5.4.3 Materials and Equipment Required for Temporary Measures.</u> 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 includes:

- 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 mils 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, this type tape 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 containing water resistant properties, all-weather properties, brittle resistance, and anti-aging properties be obtained.

- Closures panels (plywood and other material). A temporary closure system consisting of 1-inch thick plywood or Oriented Strand Board (OSB) 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 the Corps of Engineers.

  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 sprayer. 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 certifification for preventing damages. The Association of State Flood Plain Managers (ASFPM) in collaboration with FM Approvals, the independent testing arm of international insurance carrier, FM Global, and the USACE National Nonstructural Committee (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 of 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 can 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 could 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 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.

3.0 Nonstructural Assessment Objectives

This nonstructural assessment consists of a sampling of at-risk residential and commercial structures, and one critical facility (fire & rescue). 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, what the local flood characteristics are (velocities, stages, and duration), and other site conditions (soil, permeability, vegetation). A 1% annual chance exceedance flood was considered as 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 the community.

Assessment objectives included a review and confirmation of the flood problem and determination of the appropriate nonstructural technique for each sample structure. There were several influences on each structure which 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 dry flood proofing, for partially reducing the flood risk. Also, there needs to be adequate space located around the structure to maneuver the necessary equipment if elevation is the designated nonstructural technique.

Abandoning the basement/crawlspace by filling with clean sand of 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 3 to 4 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 is considered if the depth of flooding is determined to be greater than 12-feet. For floodwaters greater than 12-feet it is 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 also 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. Most of the structures were constructed during a period of time ranging from the 1800's through the 1900's. 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, and wood.

3.1 Description of Structure Dataset

For this nonstructural assessment, information was collected for a sampling of 10 structures located within the Upper Joachim Creek Watershed as shown in Figure 9. The structures are represented by blue dots on the figure and are summarized in Table 2.

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 and velocities were obtained from data recently developed by FEMA for ongoing floodplain mapping activities. Ground elevations adjacent to structures were obtained from Light Detection and Ranging (LiDAR) terrain data obtained by the USACE-St. Louis District. The assessment conducted was reconnaissance level in detail. If mitigation could be 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.

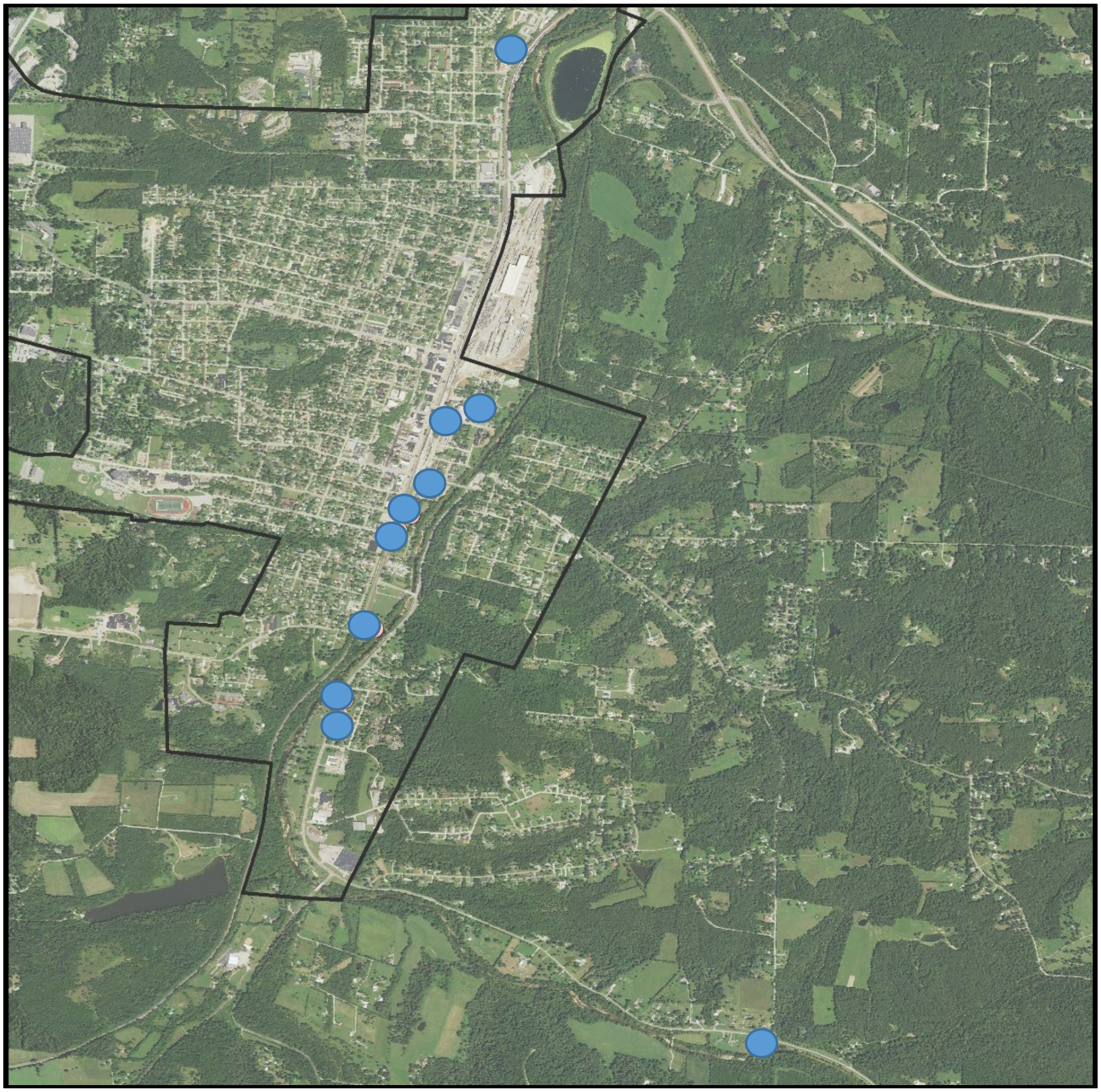

Figure 9
Aerial View of Assessment Structure Locations

Table 2
City of De Soto Structure Inventory Data

Address	Structure Identification #	Occupancy	First Floor Elevation	Ground Elevation	1% Elevation	1% Velocity
1800 N MAIN ST 63020	01	Commercial	481.2	481.1	485.5	0.02
1507 VETERANS DR 63020	02	Residential	511.9	509.9	514.6	1.97
1517 VETERANS DR 63020	03	Residential	511.0	509.6	515.5	1.79
1224 DEWITT ST 63020	04	Residential	510.7	507.3	511.6	2.26
E 721 MAIN ST 63020	05	Commercial	500.6	500.5	505.7	1.65
811 DEWITT ST 63020	06	Residential	501.1	499.7	506.5	1.73
E 211 2ND ST 63020	07	Residential	unknown	495.7	500.1	1.59
E 301 MAIN ST 63020	08	Commercial	496.4	496.3	500.6	1.73
E 201 MILLER ST 63020	09	Public	499.3	499.2	504.1	2.01
4616 STATE RD V 63020	10	Residential	544.8	542.1	unknown	unknown

4.0 Description of Nonstructural Assessment

A site visit followed by an office assessment was conducted by members of the USACE National Nonstructural Committee (NNC) and personnel from USACE-St. Louis District for each of the 10 sample structures. 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 exceedance flood elevation) was targeted for mitigation recommendations. Each structure was assessed using a similar format. The assessments and recommendations focused on mitigating structures 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 National Flood Insurance Program and would reduce flood insurance premiums for the structure owner were primarily considered.

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 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 adjusted based on field observations.

3. Dry flood proofing was limited to between 3 or 4 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.

5.0 Recommendation of Nonstructural Flood Risk Adaptive Measures

Based upon the data collected for the 10 sample structures and the potential depth of flooding for the 1% annual chance exceedance flood event, the recommended mitigation measures are identified in Table 3. The heart of the nonstructural assessment regarding the recommended nonstructural technique for each of the sample structures is provided in Enclosure 1 which contains the individual assessment sheets.

Table 3
Recommended Nonstructural Mitigation Measures

Address	Structure Identification #	Occupancy	Nonstructural Technique Proposed
1800 N MAIN ST 63020	01	Commercial	Wet/Dry Flood Proofing
1507 VETERANS DR 63020	02	Residential	Abandon Basement/Elevate Structure
1517 VETERANS DR 63020	03	Residential	Elevate Structure/Wet Flood Proof Crawlspace
1224 DEWITT ST 63020	04	Residential	Abandon Basement/Elevate Structure
E 721 MAIN ST 63020	05	Commercial	Wet Flood Proof/Elevate Utilities
811 DEWITT ST 63020	06	Residential	Elevate Structure/Wet Flood Proof Crawlspace
E 211 2ND ST 63020	07	Residential	Abandon Basement/Elevate Structure
E 301 MAIN ST 63020	08	Commercial	Dry Flood Proof/Elevate Utilities
E 201 MILLER ST 63020	09	Public	Wet Flood Proof/Elevate Utilities
4616 STATE RD V 63020	10	Residential	Abandon Basement/Elevate Structure

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 annualize 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. By estimating the reduction in future flood damages, where those prevented damages are the benefits of implementing a nonstructural technique, then annualized, a comparison of annual benefits and costs could be conducted. 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.

6.0 Floodplain Management Recommendations for Minimizing Damages

In addition to the nonstructural measures recommended in the previous sections, there are additional low impact development measures/actions which should be considered for minimizing future flood damages in the vicinity of existing stormwater systems or individual properties.

6.1 Streetscapes, Rain Barrels and Rain Gardens
As the frequency and intensity of rainfall and runoff appears to be on the rise, the installation of streetscapes, rain barrels, and rain gardens provide additional storage for excessive runoff which exceeds the capacity of stormwater systems.

6.1.1 Streetscapes. This detention storage feature, shown in figure 10, receives rainwater which exceeds the capacity of the stormwater system during a rainfall event. The storage is temporary, with the streetscape draining back into the stormwater system as capacity is regained. Many streetscapes are planted with trees, shrubs, and flowers, to make them appear more aesthetically pleasing.

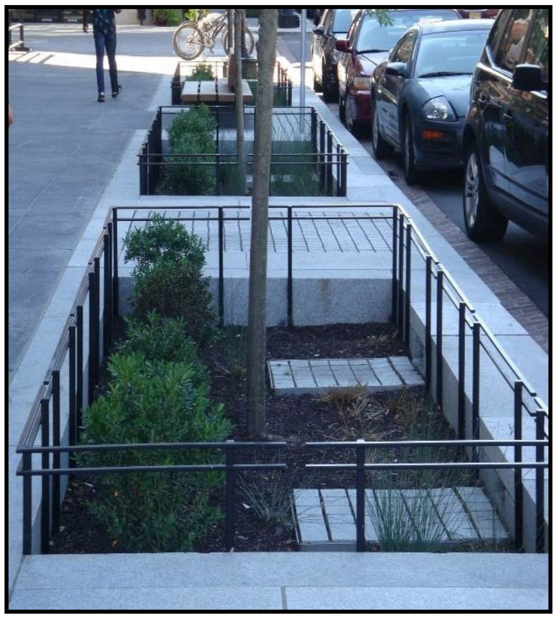

Figure 10
Streetscape Detention Storage

6.1.2 Rain Barrels. A rain barrel, shown in Figure 11, provides a finite amount of storage and can be easily attached to rooftop drainage for either residential or commercial structures via downspouts. The rain barrel is equipped with a hose bib for draining the barrel after the rain event passes.

Figure 11
Rain Barrel Detention Storage

6.1.3 Rain Garden. This temporary detention storage feature, shown in Figure 12, can be sized and located on residential or commercial property to effectively collect runoff from problematic drainage areas. Similar to streetscapes, the rain garden can be landscaped with trees, shrubs, flowers, and other plantings which are aesthetically pleasing but also tolerate excessive water. The rain garden slowly drains into the ground, without the use of engineered pipes and culverts.

Figure 12
Rain Garden Detention Storage

6.2 Local Drainage

During the field assessment, it became apparent from viewing most of the sample structures that local drainage problems were prevalent within the study area. As shown in Figure 13, many of the downspouts discharging rooftop runoff were not properly directing water away from the foundation. In many instances the downspouts were discharging runoff against the foundation, causing surface erosion and foundation issues, thereby providing pathways for floodwaters to enter the basement/crawlspace areas of some of the structures.

It was also noticeable, as shown in Figure 13, that the close proximity of houses to each other was also exacerbating the local drainage problems. At several locations it appeared that the runoff from a structure located at a higher elevation was being directed toward the adjacent structure, which appeared to be at a lower elevation. The excessive runoff from the rooftops was being directed against the foundation of the lower structure, causing surface erosion and foundation issues, thereby providing pathways for floodwaters to enter the basement/crawlspace areas of some of the structures.

Figure 13
Localized Interior Drainage

6.3 Joachim Creek Channel Capacity

The field investigation, revealed significant reaches of the channel have a solid rock bottom with vegetation only located along the banks of the channel, shown in Figure 14 (left photo), there were reaches of channel where sediment had accumulated, forming an island with vegetation, shown in Figure 14 (right photo), which could reduce natural channel capacity. Further hydraulic analysis is needed, which is beyond the scope of this nonstructural assessment.

Figure 14
Joachim Creek Channel Capacity

7.0 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% ACE 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.

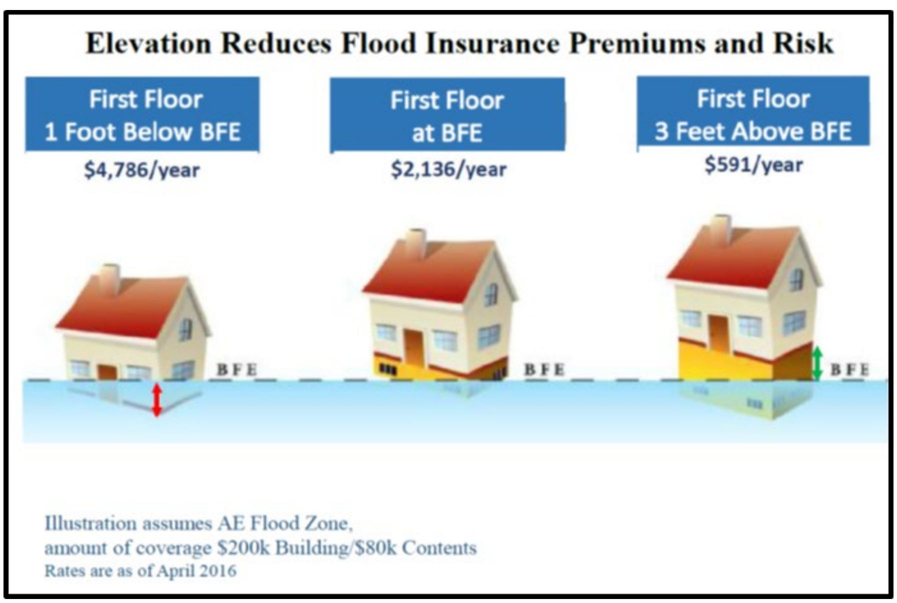

Figure 15
Flood Insurance Premium Reduction through Elevation

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 (HIFAA) 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 had 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/

8.0 Managing Flood Risk

The intermediate results of the hydrologic and hydraulic analyses by FEMA indicates that the flood hazard for the City of De Soto is more severe than currently illustrated on the effective Flood Insurance Rate Map (FIRM).

Based upon the nonstructural assessment of 10 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. These measures are discussed in greater detail below.

8.1 Flood Preparedness Planning

Community outreach initiatives such as providing flood information pamphlets, conducting workshops, erecting high water mark and flood history signs, can increase the awareness of flood risk among residents, which can lead to better response time in the event of a flood. 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 flood risk management required by the National Flood Insurance Program (NFIP). Given the flood risk identified at De Soto, it is highly recommended that the community coordinate with the State Emergency Management Agency (SEMA) regarding potential ordinances that could be adopted by the community for increasing flood risk management.

8.3 Risk Management through Flood Insurance

The City of De Soto participates in the NFIP, so flood insurance is available for all structures in the 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.

9.0 Assessment Conclusions

The City of De Soto is located along the banks of Joachim Creek, where numerous residential and nonresidential structures are located within the 1% annual exceedance floodplain. The USACE-St. Louis District collaborated with the City of De Soto on a nonstructural assessment to identify potential nonstructural measures on a sampling of 10 structures located within the Special Flood Hazard.

As a function of the assessment, the primary characteristics of flooding, such as depth, velocity, duration, and areal extent were combined with structure attributes for each of the 10 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 each 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.

Since flooding within the city could occur after a significant rainfall event, this assessment also provides practical information for the implementation of temporary measures. Materials and equipment needs are described in order to provide the owner/tenant with enough background information to develop a successful emergency 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 1 contains copies of the individual assessment sheet for each of the 10 sample structures which identify the proposed nonstructural measure for consideration.

As the assessment was being completed, new floodplain mapping by FEMA appeared to indicate an expansion of the regulatory floodway along Joachim Creek. 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% ACE flood event.

In order for the City of De Soto to achieve the greatest amount of flood risk reduction possible, it may be desirable for the city to consider structural features as well as the nonstructural measures discussed. Consideration could be given to channel modifications/channel clearing in the reach between Miller Street and E Kingston to reduce flood elevations and contain flooding to within the general channel area. City officials should be aware that detailed computer modeling would be required to determine the benefits from channel modification/channel clearing and that a Clean Water Act Section 404 Permit and floodplain permit would be required for any activity within the channel.

Through discussions with business owners and a cursory site visit of North Main Street and the area of development located to the north of Essex Street and to the west of North Main Street, it appears that runoff from this area may be adversely impacting several of the commercial businesses by bypassing the existing stormwater system and flowing directly overland to the backside of these structures. There was also concern over the capacity of an existing culvert located below the Union Pacific Railroad, in the vicinity of Mueller Motors on North Main Street, to adequately convey the stormwater system discharges and overland flows culminating at this location. This area should be given more consideration.

Recent flood events have caused significant damages to many structures and the probability of occurrence is high for structures previously damaged by flooding. This assessment should be used as a tool to educate city officials and residents to the risk of flooding as well as the potential opportunities for reducing the flood risk by the techniques identified.

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ENCLOSURE 1

Structure Assessment Sheets

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STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#1	1800 N Main Street, De Soto, MO 63020

Structure Photographs

Front

Side/Site

Structure Characteristics

Characteristic	Description
Occupancy -… Configuration - Construction - Condition - Other -	Nonresidential (Commercial – Automobile/Equipment service and repair). One story, concrete slab on grade, flat roof. Masonry exterior bearing walls with metal framed roof. Wood frame interior. Good. Auxiliary structure adjacent to main structure – Metal building / slab on grade.

Structure and Flood Elevations

FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
481.2 ft	481.1 ft	NA	485.5 ft	4.3 ft	4.4 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) * - Estimated

Site Visit Observations & Flood Risk

General: The structure was viewed/observed from the exterior and interior. The structure was occupied and in good condition. The property owner and user 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 around the structure slopes slightly away for the structure toward the access road. A drainage ditch at the rear of the structures diverts storm water way from the structure.

Structure: The structure is masonry with a flat roof. Interior partitions in the office/ parts storage area are wood framed and provide support for elevated storage mezzanine above.

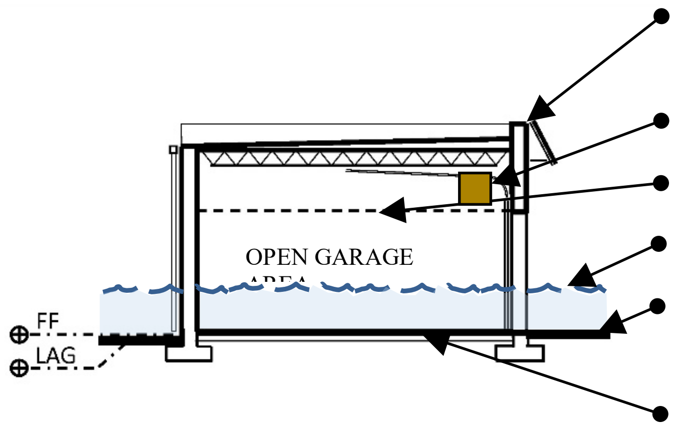
Systems/Utilities: Existing systems and utilities are elevated.

Flood Risk: The first floor is approximately 4.3 feet below the base flood elevation (BFE).

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#1	N 1800 Main Street, De Soto, MO 63020

Diagrammatic Building Section (Existing)



BUILDING SECTION
NOT TO SCALE

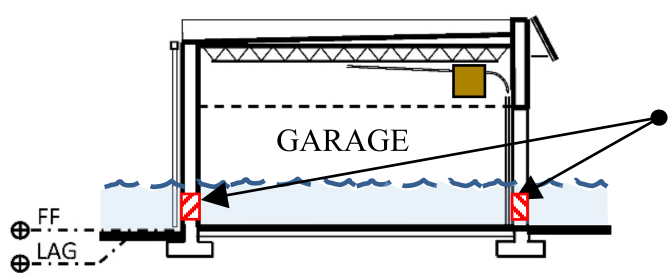
Recommendation

1. Relocate building utilities/systems/storage above BFE.
2. Wet flood proof the garage area.
3. Dry flood proof office/storage area.

GARAGE

Diagrammatic Building Section (Recommendation)

SEE DIAGRAMATIC STRUCTURE SECTION ABOVE FOR TYPICAL DRAWING NOTES



BUILDING SECTION
NOT TO SCALE

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#2	1507 Veterans Drive, De Soto, MO 63020

Structure Photographs

Front

Rear

Structure Characteristics

Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling)
Configuration -	One story with basement, attached garage, rear addition, gable roof.
Construction -	Concrete Foundation. Wood frame with brick veneer (front) and siding.
Condition - …	Very good
Other -………	Addition – One story, crawlspace, wood framed, gable roof

Structure and Flood Elevations

FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
511.9 ft	509.9 ft	*503.9 ft	514.6 ft	2.7ft	4.7ft	10.7ft

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) — * - Estimated

Site Visit Observations & Flood Risk

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 grass except for the driveway. The grade around the structure slopes slightly away for the structure toward the access road.

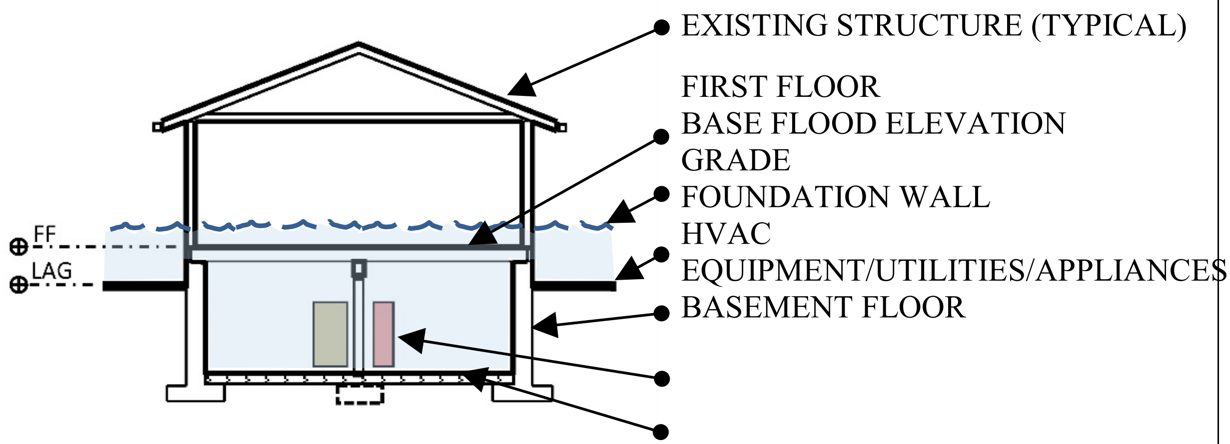
Structure: The structure is wood framed construction with a basement and gable roof. The front has brick veneer and the sides and rear has siding. The basement is unfinished and vacant except for the structure's systems, utilities and some minor storage. The rear addition is similar construction but with a crawl space.

Systems/Utilities: Existing systems and utilities are located in the basement.

Flood Risk: The first floor is approximately 2.7 feet below the base flood elevation (BFE). The basement and addition crawl space are below the BFE and would be totally inundated.

STRUCTURE DATA SHEET (CONTINUED)	
Structure ID	**Structure Address**
#2	1507 Veterans Drive, De Soto, MO 63020

Diagrammatic Structure Section (Existing)

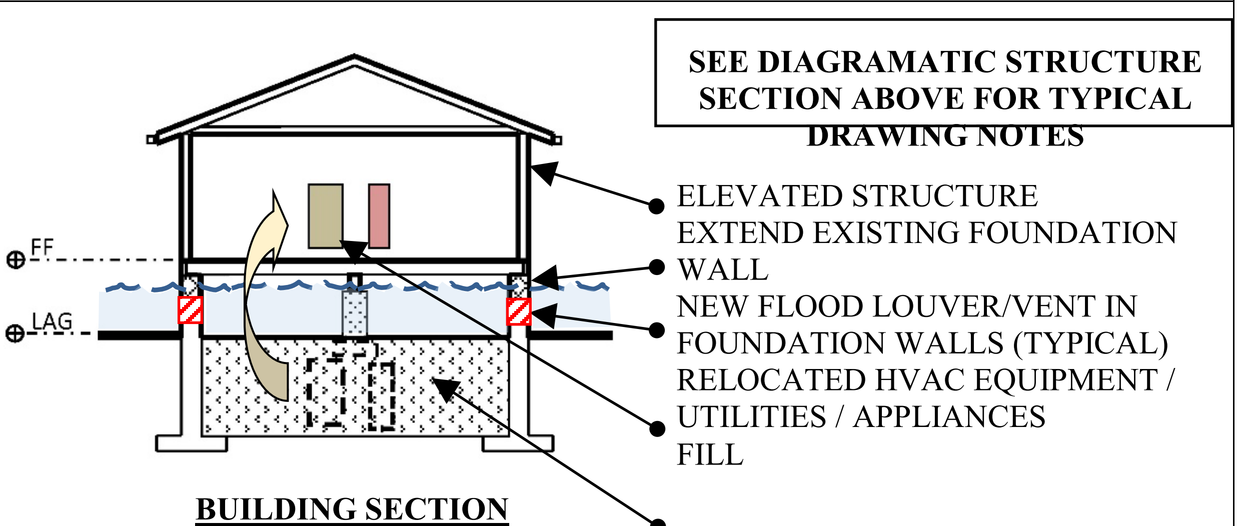


BUILDING SECTION
NOT TO SCALE

Recommendation

1. Relocate building utilities/systems/storage to upper level above BFE.
2. Fill basement to grade level.
3. Elevate structure on extended foundation walls.
4. Wet flood proof crawl space.

Diagrammatic Structure Section (Recommendation)



BUILDING SECTION
NOT TO SCALE

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#3	1517 Veterans Drive, De Soto, MO 63020

Structure Photographs

	
Front	Rear

Structure Characteristics

Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling).
Configuration -	One story with crawlspace, attached garage, rear addition, gable roof.
Construction -	Concrete foundation. Masonry exterior walls and wood frame interior/roof.
Condition - …	Very good.
Other -………	Addition – One story, slab on grade, wood framed w/ brick veneer, gable roof.

Structure and Flood Elevations

FF	LAG	*CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
511.0 ft	509.6 ft	508.0 ft	515.5 ft	4.5ft	5.9 ft	7.5 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) — * - Estimated

Site Visit Observations & Flood Risk

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 grass except for the driveway. The grade around the structure slopes slightly away from the structure toward the access road.

Structure: The structure is masonry construction with a crawl space and gable roof. The front has brick veneer and the sides and rear has siding. The rear addition is wood framed with brick veneer construction build on a slab on grade.

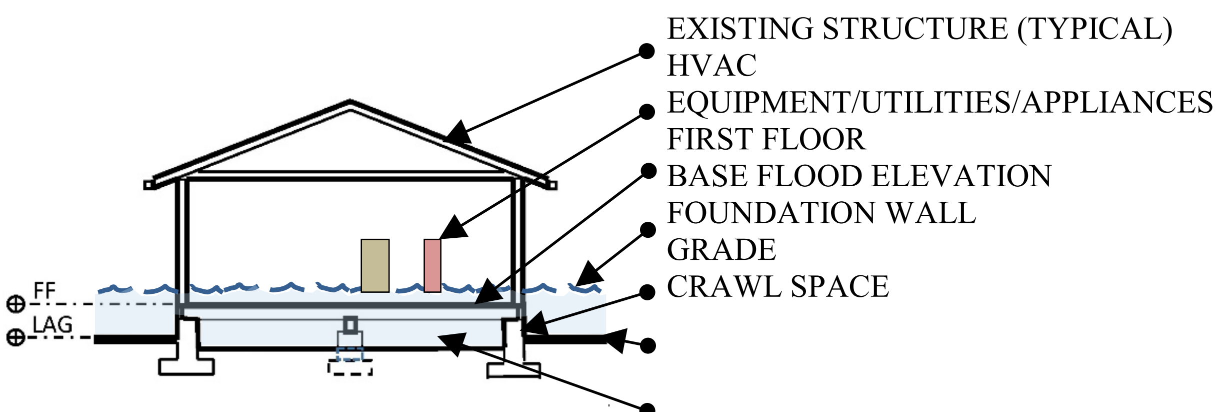
Systems/Utilities: Existing systems and utilities are located on the first floor level.

Flood Risk: The first floor (main floor) is approximately 4.7 feet below the base flood elevation (BFE). The rear addition floor is several inches lower than the first floor (main floor). The crawl space is below the BFE and would be totally inundated.

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#3	1517 Veterans Drive, De Soto, MO 63020

Diagrammatic Structure Section (Existing)



BUILDING SECTION
NOT TO SCALE

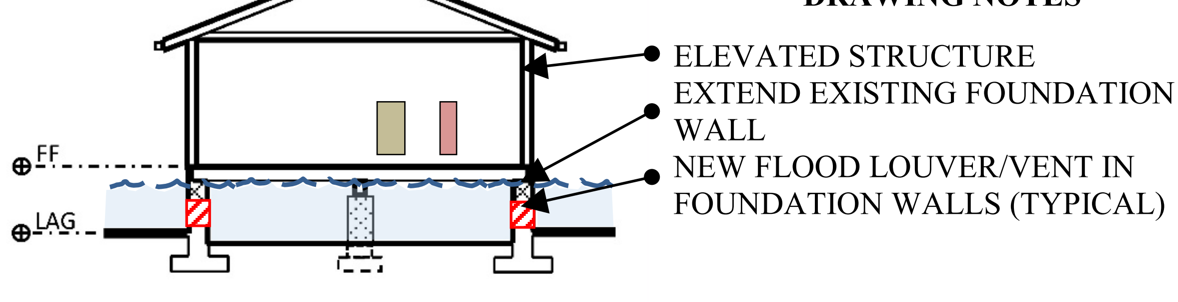
Recommendation

1. Relocate/elevate building utilities/systems/storage to upper level above BFE.
2. Fill crawl space to grade level (if necessary).
3. Elevate structure on extended foundation walls.
4. Wet flood proof crawl space.

Diagrammatic Structure Section (Recommendation)

SEE DIAGRAMATIC STRUCTURE SECTION ABOVE FOR TYPICAL

DRAWING NOTES



BUILDING SECTION
NOT TO SCALE

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#4	1224 Dewitt Street, De Soto, MO 63020

Structure Photographs

Front /Side

Rear/Side

Structure Characteristics

Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling).
Configuration -	One story with basement/crawlspace/slab, multiple additions, gable roof.
Construction -	Concrete foundation. Wood frame with siding.
Condition - …	Very good
Other -………	Additions – One story, wood framed, siding, gable roof.

Structure and Flood Elevations

FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
510.7 ft	507.3 ft	*502.7 ft	511.6 ft	0.9 ft	4.3 ft	8.9 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) — * - Estimated

Site Visit Observations & Flood Risk

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 grass except for the driveway. The grade around the structure level.

Structure: The structure is wood framed construction with a partial basement, partial crawl space and partial concrete slab with multiple gable roofs. The exterior walls have siding. The basement is unfinished and houses structure's systems, utilities, and storage.

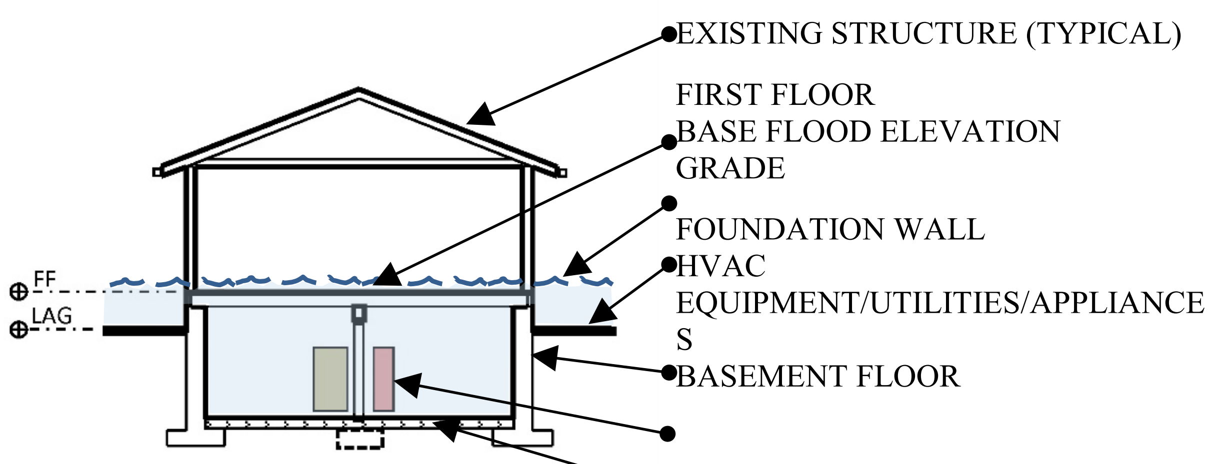
Systems/Utilities: Existing systems and utilities are located in the basement.

Flood Risk: The first floor is approximately 0.9 feet below the base flood elevation (BFE). The basement and crawl space are below the BFE and would be totally inundated.

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#4	1224 Dewitt Street, De Soto, MO 63020

Diagrammatic Structure Section (Existing)



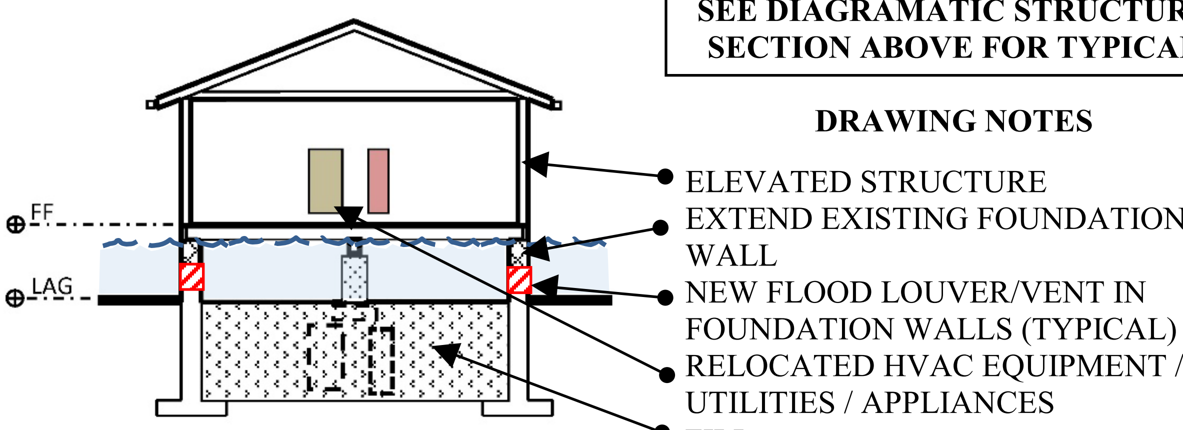
BUILDING SECTION
NOT TO SCALE

Recommendation

1. Relocate/elevate building utilities/systems/storage to upper level above BFE.
2. Fill basement to grade level.
3. Elevate structure on new foundation walls.
4. Wet flood proof crawl space.

Diagrammatic Structure Section (Recommendation)

SEE DIAGRAMATIC STRUCTURE SECTION ABOVE FOR TYPICAL



BUILDING SECTION
NOT TO SCALE

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#5	E 721 Main Street De Soto, MO 63020

Structure Photographs

	
Front	Rear

Structure and Flood Elevations

Characteristic	Description
Occupancy -	Nonresidential (Commercial – Auto service / repair / storage).
Configuration -	One story, concrete slab on grade (1st floor), gable roof.
Construction -	Masonry exterior bearing walls with wood framed roof.
Condition - …	Good
Other - ………	NA

Hydraulic Data

FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
500.6 ft	500.5 ft	NA	505.7 ft	5.1 ft	5.2 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)
* - Estimated

Site Visit Observations & Flood Risk

General: The structure was viewed/observed from the exterior and interior. The structure was vacant (except for some equipment storage) 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 gravel. The grade around the structure is level.

Structure: The structure is masonry with a gable roof. Interior partitions in the small office area are wood framed (under renovation).

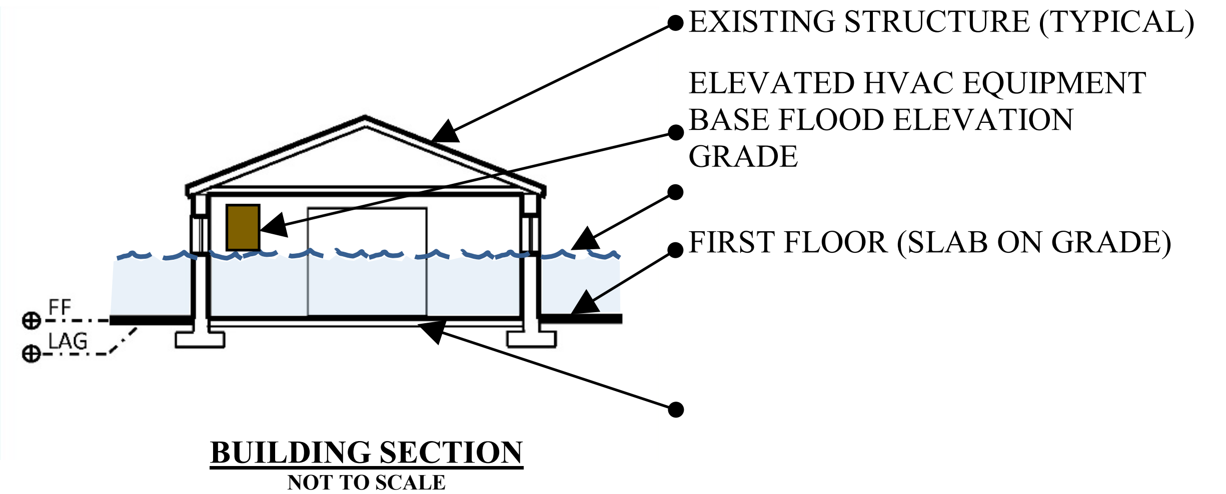
Systems/Utilities: Existing systems and utilities are elevated.

Flood Risk: The first floor is approximately 5.1 feet below the base flood elevation (BFE).

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#5	E 721 Main Street De Soto, MO 63020

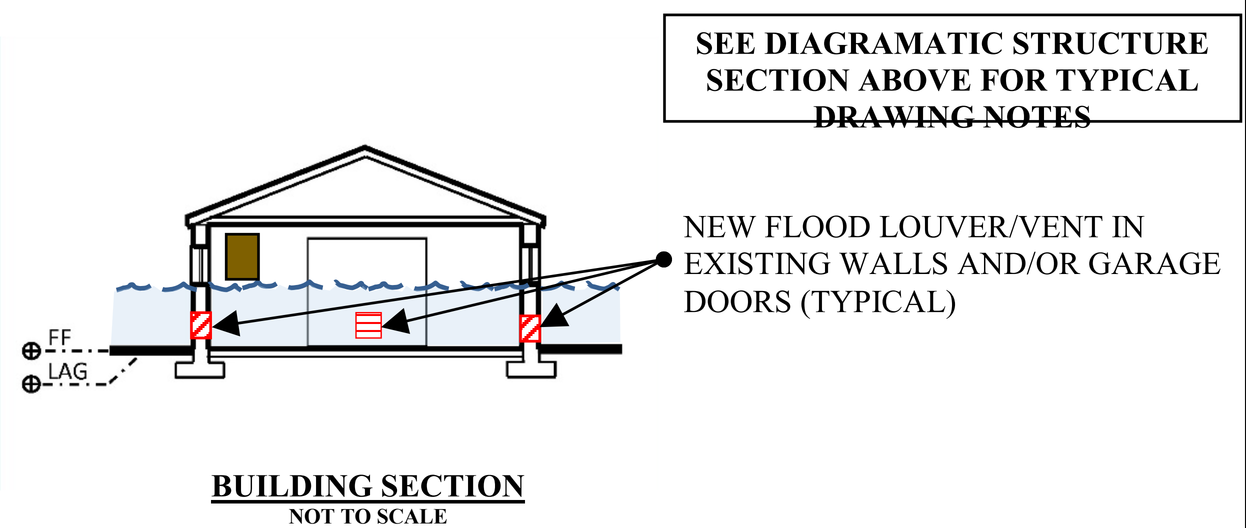
Diagrammatic Structure Section (Existing)



Recommendation

1. Relocate building utilities/systems/storage above BFE.
2. Wet flood proof the garage area.

Diagrammatic Structure Section (Recommendation)



STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#6	811 Dewitt Street, De Soto, MO 63020

Structure Photographs

Front

Rear

Structure Characteristics

Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling).
Configuration -	One and one half story with crawlspace, rear addition(s), gable roof.
Construction -	Masonry (stone) foundation. Wood frame with siding.
Condition - …	Very good.
Other -………	Addition – One story, wood frame (rail car), siding, gable roof.

Structure and Flood Elevations

FF	LAG	CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
501.1 ft	499.7 ft	*499.7 ft	506.5 ft	5.4 ft	6.8 ft	6.8 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)
* - Estimated

Site Visit Observations & Flood Risk

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 grass. The grade around the structure is level.

Structure: The structure is wood framed construction with a crawl space and gable roof. The exterior walls have siding. The structure was built around a railroad car frame and added onto over time.

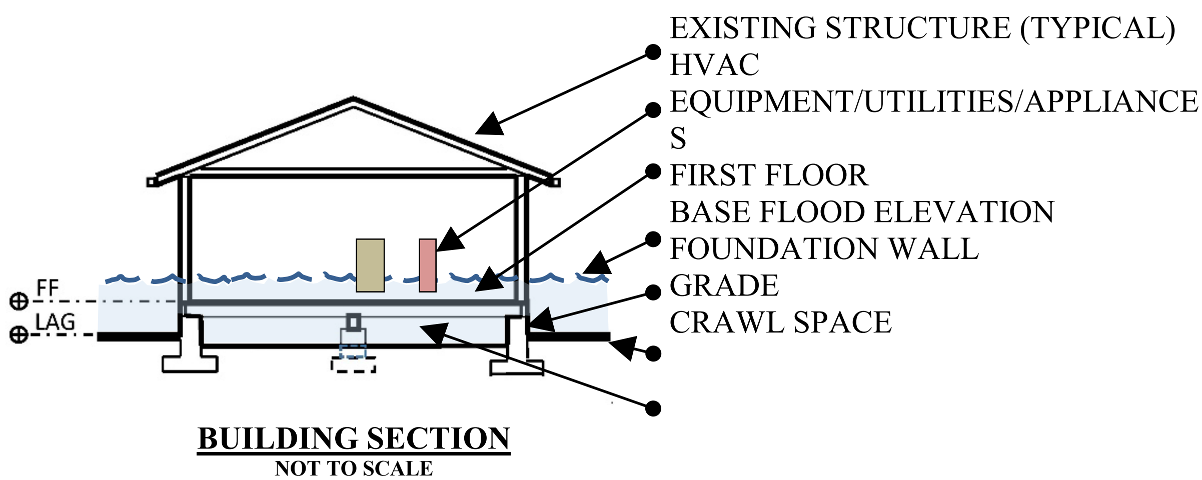
Systems/Utilities: Existing systems and utilities on the first floor.

Flood Risk: The first floor is approximately 5.4 feet below the base flood elevation (BFE). The crawl space is below the BFE and would be totally inundated.

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#6	811 Dewitt Street, De Soto, MO 63020

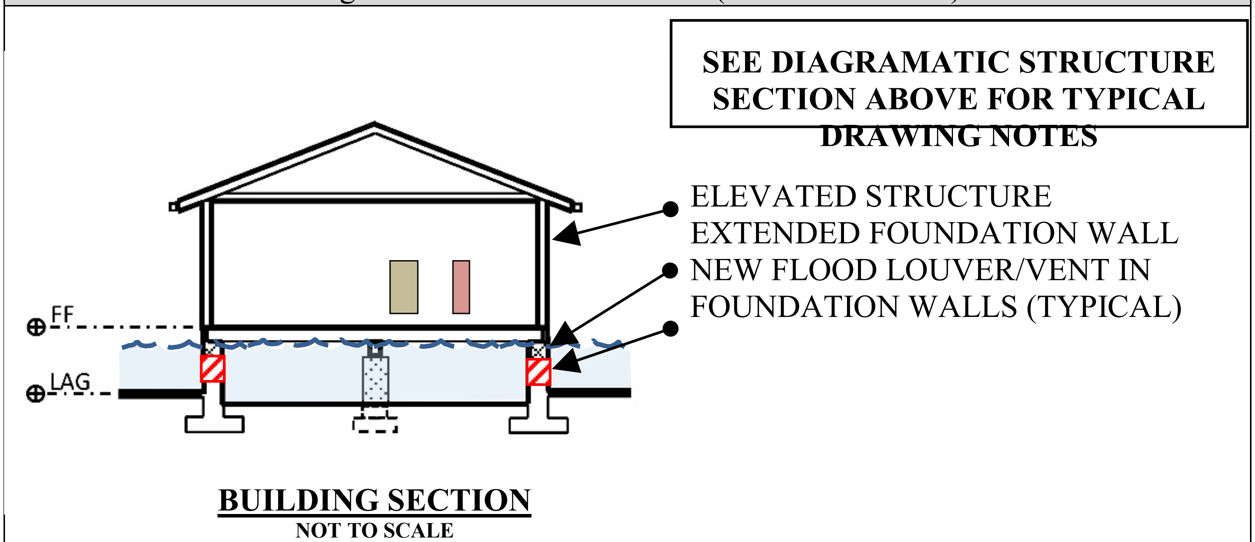
Diagrammatic Structure Section (Existing)



Recommendation

1. Relocate/elevate building utilities/systems/storage to upper level above BFE.
2. Fill crawl space to grade level (if necessary).
3. Elevate structure on new foundation.
4. Wet flood proof crawl space.

Diagrammatic Structure Section (Recommendation)



STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#7	E 211 2nd Street, De Soto, MO 63020

Structure Photographs

Front

Rear

Structure Characteristics

Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling)
Configuration -	One story with partial basement, addition(s), gable roof.
Construction -	Masonry (stone) foundation. Wood frame with siding.
Condition - …	Very good
Other -………	Addition(s) – One story, crawlspace, wood framed, siding, gable roof

Structure and Flood Elevations

FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
*497.7 ft	495.7 ft	*490.7 ft	500.1 ft	2.4 ft	4.4 ft	9.4 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)
* - Estimated

Site Visit Observations & Flood Risk

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 grass. The grade around the structure is level.

Structure: The structure is wood framed construction with a partial basement and partial crawl space with multiple gable roofs. The exterior walls have siding. The partial basement is unfinished and vacant except for the structure's systems and utilities.

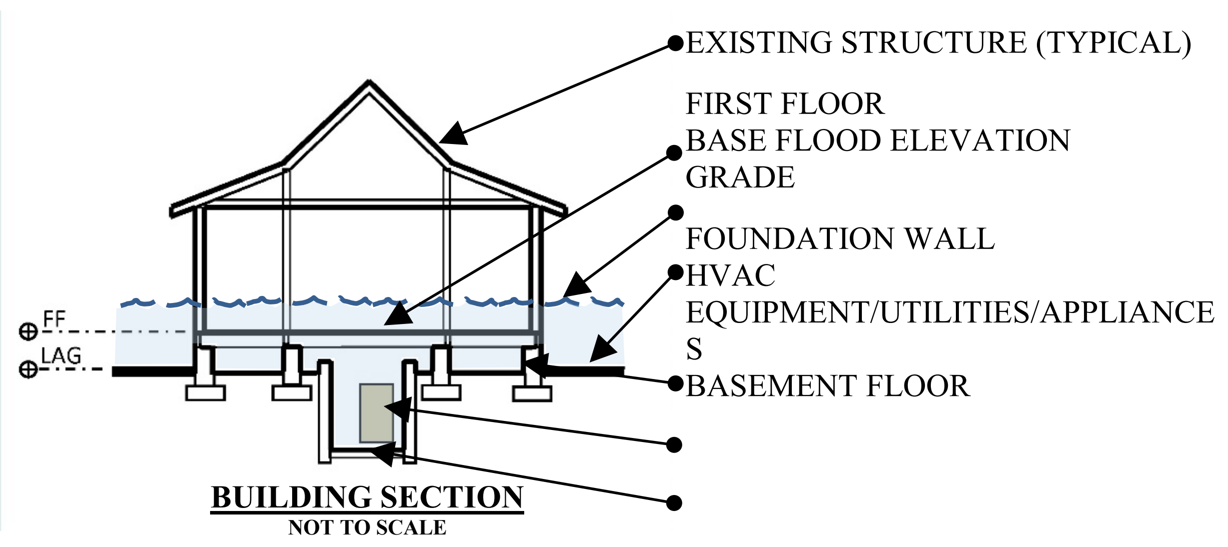
Systems/Utilities: Existing systems and utilities are located in the basement.

Flood Risk: The first floor is approximately 2.4 feet below the base flood elevation (BFE). The basement and crawl space are below the BFE and would be totally inundated.

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#7	E 211 2nd Street, De Soto, MO 63020

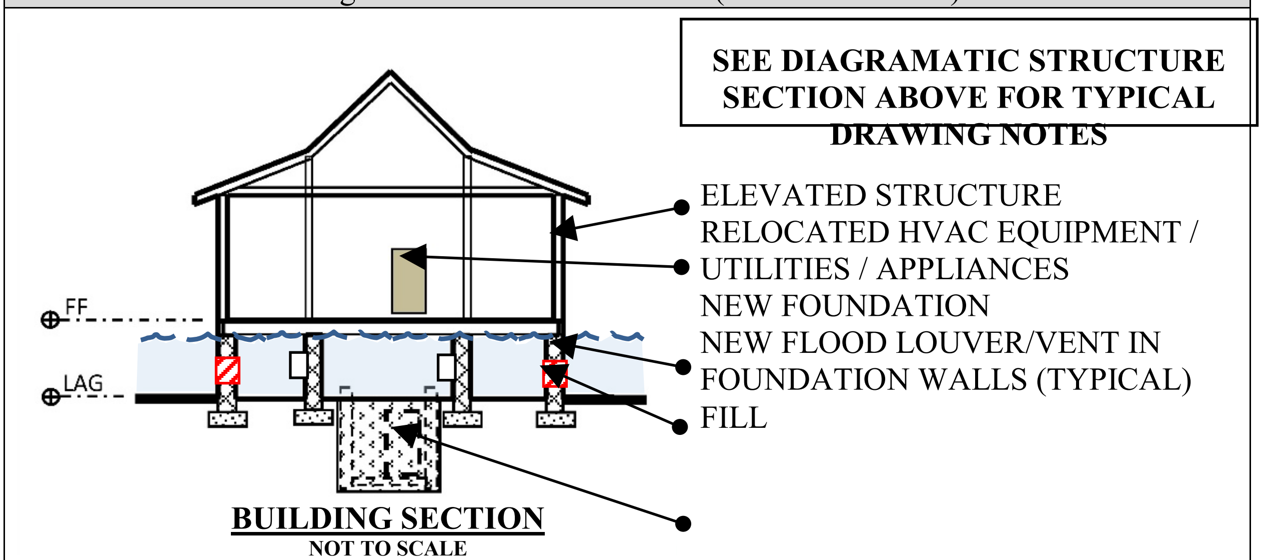
Diagrammatic Structure Section (Existing)



Recommendation

1. Relocate building utilities/systems/storage to upper level above BFE.
2. Fill basement/crawl space to grade level.
3. Elevate structure on new foundation.
4. Wet flood proof crawl space.

Diagrammatic Structure Section (Recommendation)



STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#8	E 301 Main Street, De Soto, MO 63020

Structure Photographs

	
Front	Rear

Structure Characteristics

Characteristic	Description
Occupancy -	Nonresidential (Commercial – Restaurant/Bar).
Configuration -	One story, concrete slab on grade (1st floor), flat roof.
Construction -	Masonry exterior bearing walls with metal framed roof.
Condition - …	Good
Other - ………	Party wall at adjacent structure.

Structure and Flood Elevations

FF	LAG	CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
496.4 ft	496.3 ft	NA	500.6 ft	4.2 ft	4.3 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) * - Estimated

Site Visit Observations & Flood Risk

General: The structure was viewed/observed from the exterior and interior. The structure was occupied and in good condition. The property user was present during the site visit.

Site: The structure is situated on an urban site with an adjacent structure on one side. The areas around the structure are paved. The grade around the structure is level.

Structure: The structure is masonry with a flat roof. Interior partitions are wood framed.

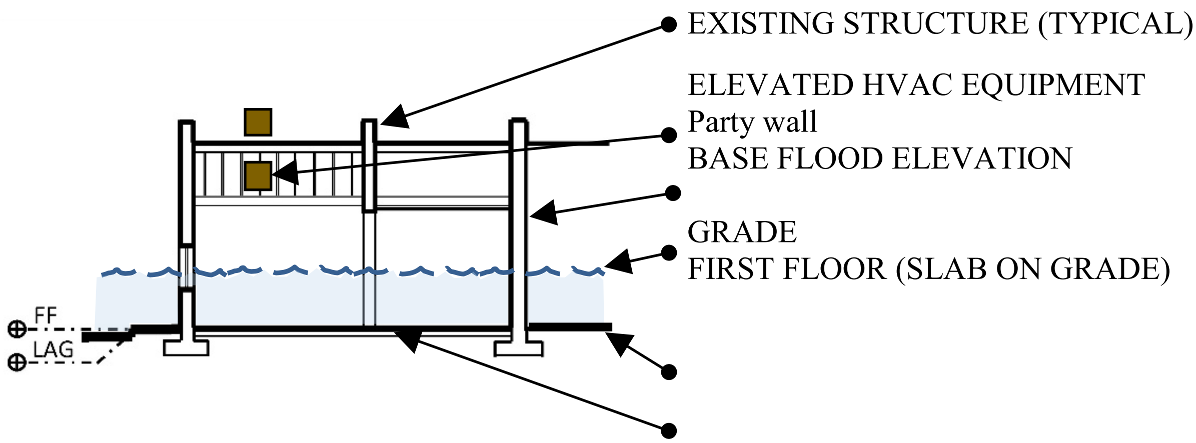
Systems/Utilities: Existing systems and utilities are both elevated and/or at the first floor level.

Flood Risk: The first floor is approximately 4.2 feet below the base flood elevation (BFE).

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#8	E 301 Main Street, De Soto, MO 63020

Diagrammatic Structure Section (Existing)

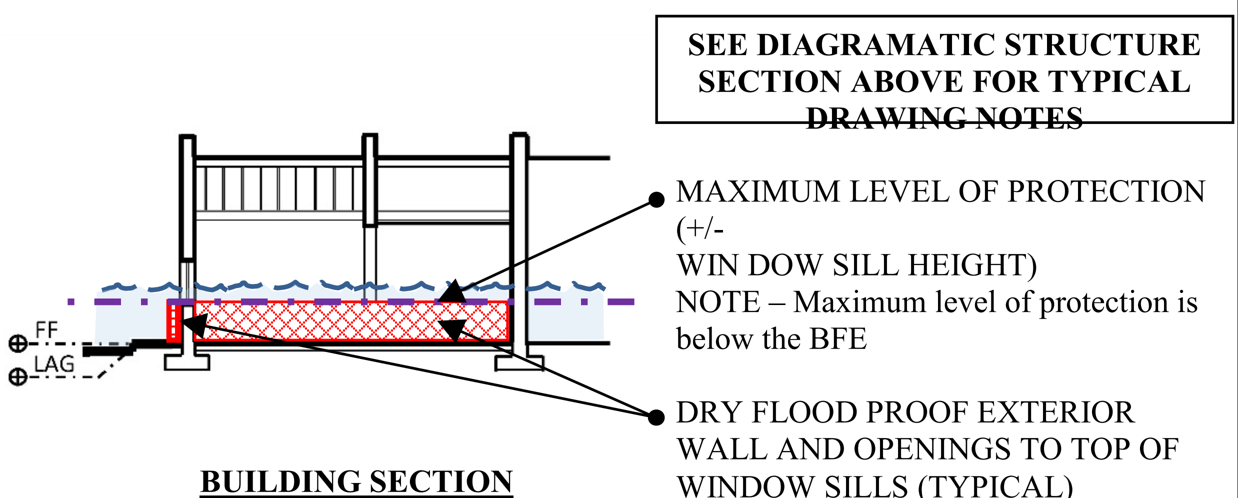


BUILDING SECTION
NOT TO SCALE

Recommendation

1. Relocate building utilities/systems/storage to level above BFE.
2. Dry flood proof front and rear of structure and side/party walls. Repair, maintain, and modify exterior walls as necessary to reduce infiltration of flood water. Include backflow preventer in sewer and sump with emergency power. Note - party walls may require further investigation/attention to determine construction and viability to flood proof.

Diagrammatic Structure Section (Recommendation)



BUILDING SECTION
NOT TO SCALE

STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#9	E 201 Miller Street, Desoto, MO 63020

Structure Photographs

	
Front	Rear

Structure and Flood Elevations

Characteristic	Description
Occupancy -	Nonresidential (Public – Fire Station).
Configuration -	Two story, concrete slab on grade (1st floor), flat roof.
Construction -	Masonry exterior bearing walls with metal framed roof.
Condition - …	Excellent.
Other - ………	Critical Facility.

Hydraulic Data

FF	LAG	CS	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-CS
499.3 ft	499.2 ft	NA	504.1ft	4.8 ft	4.9 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) — * - Estimated

Site Visit Observations & Flood Risk

General: The structure was viewed/observed from the exterior and interior first floor level. The second floor area was not viewed/observed. The structure was occupied and in excellent condition. The property user 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 away from the structure toward the access road at the front and is level at the sides and rear.

Structure: The structure is masonry with a flat roof. The first floor interior partitions/walls are masonry. The partial second floor area is wood frames with low hip roof.

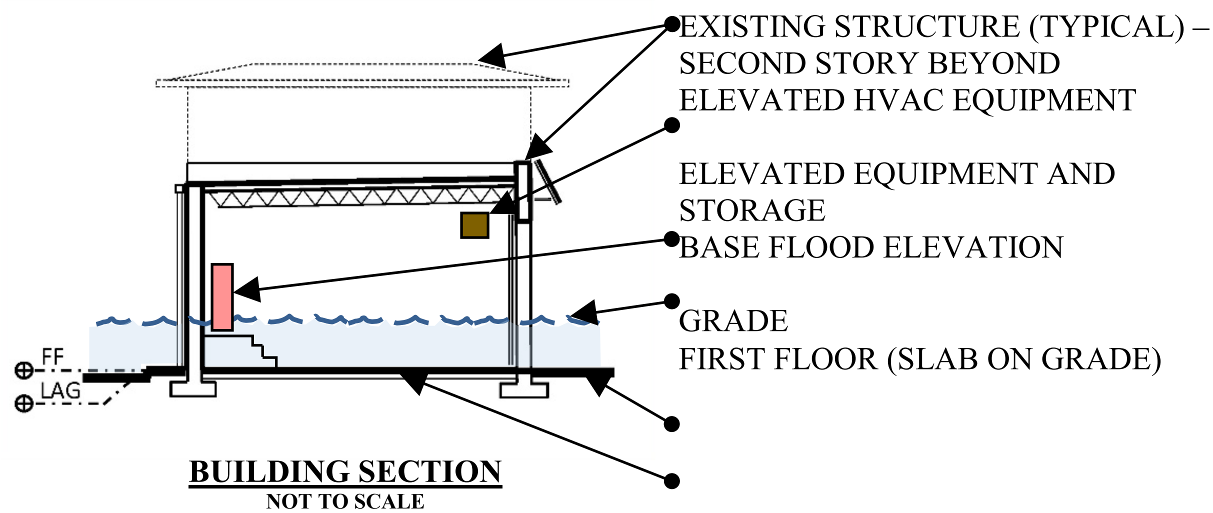
Systems/Utilities: Existing systems and utilities are elevated. Storage platform floor is elevated, for equipment and storage areas.

Flood Risk: The first floor is approximately 4.8 feet below the base flood elevation (BFE).

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#9	E 201 Miller Street, Desoto, MO 63020

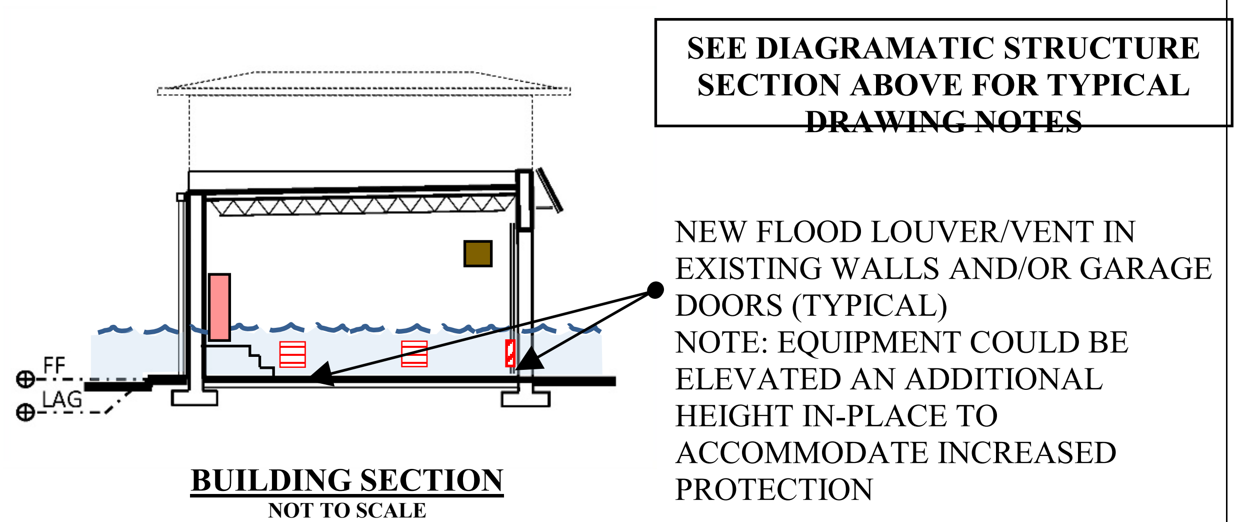
Diagrammatic Structure Section (Existing)



Recommendation

1. Elevate all equipment and storage above the BFE to the greatest extent possible/feasible.
2. Wet flood proof structure.

Diagrammatic Structure Section (Recommendation)



STRUCTURE ASSESSMENT SHEET

Structure ID	Structure Address
#10	4616 State Road, De Soto, MO, 63020

Structure Photographs

Front

Rear/Side

Structure and Flood Elevations

Characteristic	Description
Occupancy -…	Residential (Single Family Dwelling).
Configuration -	One story and one half story with basement, gable roof.
Construction -	Concrete foundation. Wood frame with siding.
Condition - …	Good
Other -………	NA

Hydraulic Data

FF	LAG	B	BFE	Δ BFE-FF	Δ BFE-LAG	Δ BFE-B
544.8’	542.1’	*535.8’	TBD	TBD	TBD	TBD

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) — * - Estimated

Site Visit Observations & Flood Risk

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 grass. The grade around the structure slopes slightly away for the structure toward the rear.

Structure: The structure is wood framed construction with a basement and gable roof. The exterior walls have siding. The basement is unfinished and vacant except for the structure’s systems, utilities, and some minor storage.

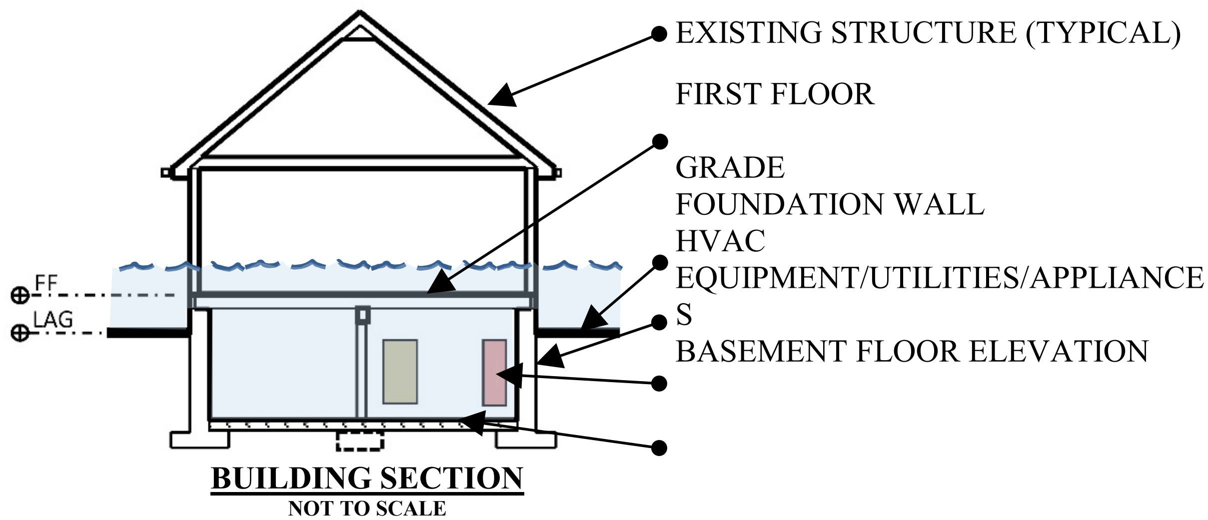
Systems/Utilities: Existing systems and utilities are located in the basement.

Flood Risk: FEMA Map Center indicates this reach of Joachim Creek as a Zone A, rather than a Zone AE, so BFE elevation is not available. Past flood events have inundated the first floor of the structure.

STRUCTURE DATA SHEET (CONTINUED)

Structure ID	Structure Address
#10	4616 State Road, De Soto, MO, 63020

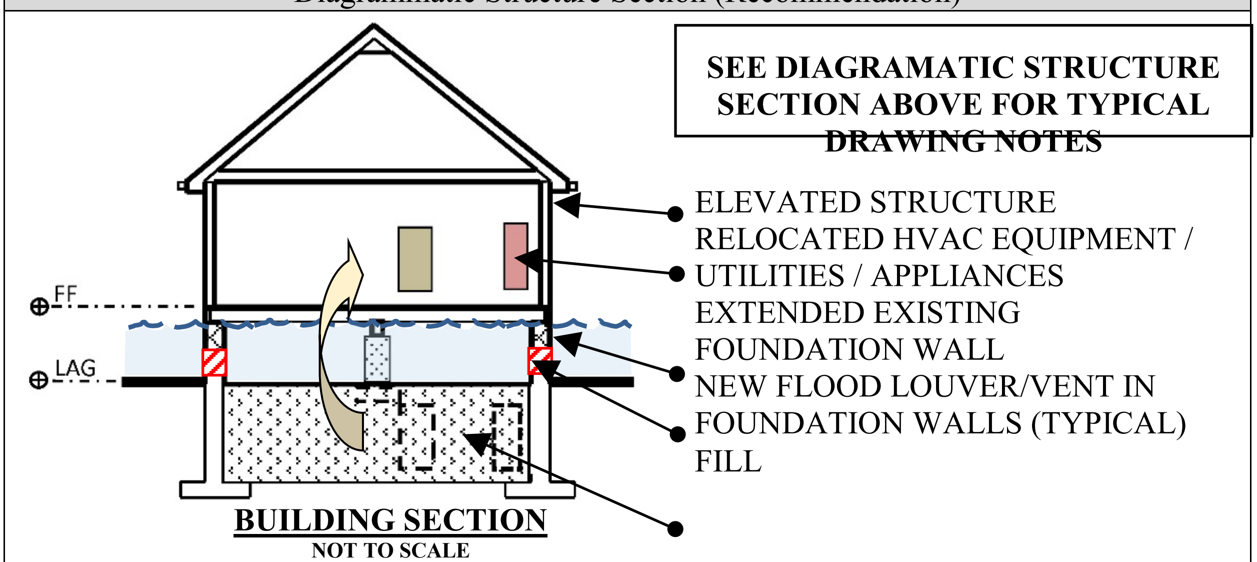
Diagrammatic Structure Section (Existing)



Recommendation

1. Relocate building utilities/systems/storage to upper level above BFE. A building addition may be constructed to house utilities/systems (above BFE).
2. Fill basement to grade level.
3. Elevate structure on extended foundation wall.
4. Wet flood proof crawl space.

Diagrammatic Structure Section (Recommendation)



ENCLOSURE 2

Glossary

This assessment uses terminology and acronyms which, while common within engineering, architectural, and nonstructural analyses, are defined within this section of the report to support the layperson's knowledge of such potential nonstructural techniques.

100-Year Flood: The 1% annual chance of exceedance event expressed as a return period.

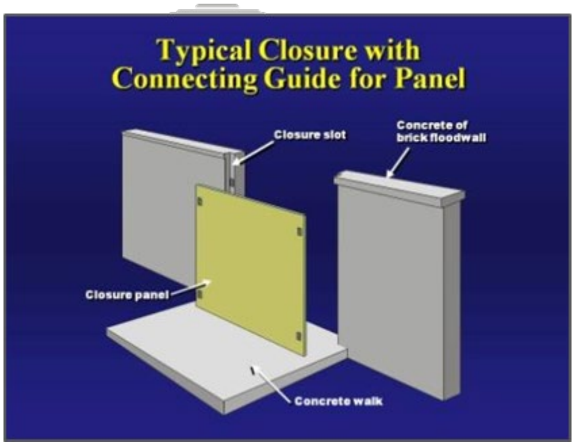
Annual Chance of Exceedance Flood: The flood that has a (stated as a percentage, %) chance of being exceeded in any given year, such as the 1% annual chance of exceedance (ACE) flood.

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

Base Flood Elevation (BFE): Elevation of flood waters for a 1% annual chance of exceedance event.

Base Flood Elevation Plus Free Board (BFE+ X feet): Equivalent to the elevation of floodwaters for a 100-year (1% ACE) event plus X feet of free board.

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



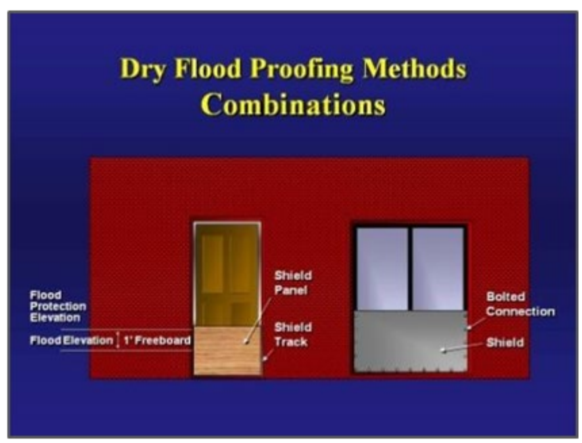


Figure 1
Closure/ Shields

Dry Flood Proofing: This nonstructural technique involves temporarily or permanently sealing exterior building walls with water proofing compounds, impermeable sheeting, or other water resistant materials to prevent the entry of floodwaters into structures. Dry flood proofing, as shown in Figures 2 and 3, is applicable in areas of shallow, low velocity, flooding. If the closures are not passive, in a natural sealed position, then there must be ample warning time for the owner/tenant to be able to install the closure(s) and safely evacuate the premises prior to the arrival of floodwaters.

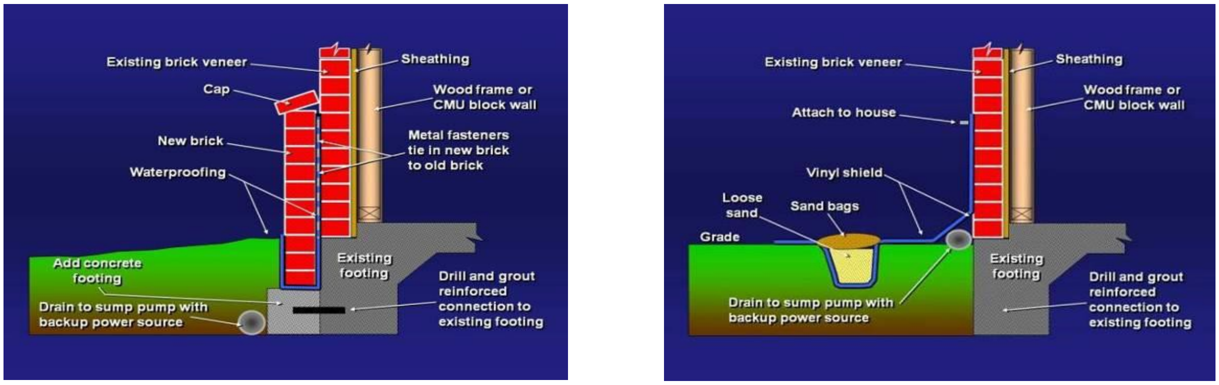


Figure 2
Permanent Dry Flood Proofing

Figure 3
Temporary Dry Flood Proofing

Elevation: As a nonstructural technique, involves raising the structure in place to reduce frequency and/or depth of flooding during high-water events. Elevation can be completed on fill, foundation walls, piers, piles, posts or columns. Selection of proper elevation method depends on flood characteristics such as flood depth or velocity, and condition of the structure and site.

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

FIRM: Flood Insurance Rate Map, a product of the Federal Emergency Management Agency's floodplain mapping program used to determine flood risk and insurance rates.

Flood: A *flood* is an overflow of water, which exceeds the capacity of the natural channel and submerges land and/or structures that are normally dry.

Flood Insurance: Monetary compensation to homeowners and business owners to assist in recovery from a flood for insured structures. Typically not included with homeowner policy.

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

Flood Risk: A function of the probability of a flood event multiplied by the consequences.

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

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

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

Floodway (Regulatory): The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to convey the base flood without cumulatively increasing the water surface elevation more than a designated height.

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

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

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

Nonstructural Measures: Flood risk management measures that reduce the consequences of a flood event to a structure by adapting the structure to the flood characteristics without changing the frequency of flooding.

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

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

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

Relocation: Involves moving the structure to another location away from flood hazards. Relocation is a dependable method of protection and provides the benefit of use of the evacuated floodplain.

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

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

Structural Measures: Flood risk management measures such as dams, levees, and floodwalls focused on reducing flood risk by modifying the frequency of flooding.

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

Wet Flood Proofing: Measures that allow floodwater to enter the structure without consequence. Vulnerable items such as utilities, appliances, and furnaces are relocated or waterproofed to higher elevations. By allowing floodwater to enter the structure hydrostatic forces on the inside and outside of the structure can be equalized reducing the risk of structural damage.

Abbreviations / Acronyms

ACE............................Annual Chance of Exceedance
A/E.............................Architect/Engineer
ASFPM ....Association of State Floodplain Managers
AIA ....American Institute of Architects
BFE……………………Base Flood Elevation
CFM ....Certified Floodplain Manager
CFS……..…………..Cubic Feet per Second
DFE ....Design Flood Elevation
EO ....Executive Order
FEMA ....Federal Emergency Management Agency
FF ....First Flood
FG ....Finish Grade
FIRM..........................Flood Insurance Rate Map
FPM............................Floodplain Management
FPMP ....Floodplain Management Plan
FRAM ....Flood Risk Adaptive Measure
FRM………………...Flood Risk Management
FT ....Feet
HQUSACE.................Headquarters, U.S. Army Corps of Engineers
ID# ....Identification Number
HVAC ....Heating Ventilation and Air Conditioning
LAG…………………Low Adjacent Grade
LO ....Low Opening
MVS............................United States Amy Corps of Engineers, St. Louis District
NFIP ....National Flood Insurance Program
NNC ....National Nonstructural Committee
P.E..............................Professional Engineer
USACE ....United States Army Corps of Engineers
w/................................With
Δ…............................Delta/Difference
1% ACE ....One Percent Annual Chance of Exceedance
~…..Approximate