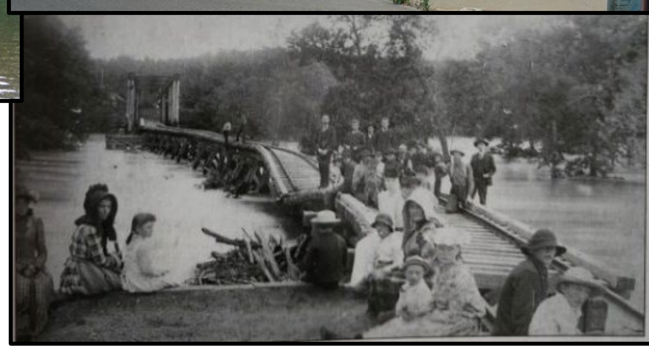
Flood Hazard Analysis and Mitigation Plan
City of Steelville, Missouri
(Floodplain Management Services)



Presented to: City of Steelville, Missouri

Prepared by:
U.S. Army Corps of Engineers
St. Louis District
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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE), in collaboration with the City of Steelville, MO, evaluated opportunities to manage flood risks along Yadkin Creek in Steelville. This report is intended to provide local officials adequate information to inform future decisions regarding flood risk management within the Steelville area. The study evaluated the flood-prone sections within the City of Steelville as well as examined opportunities to manage flood inundation risk as the city anticipates a revised Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) that will designate an expanded flood hazard area. Several businesses and homeowners may be impacted by the revised FIRM, both with actual flood risk as well as the economic impact of flood insurance requirements.

Hydrologic modeling indicates that flooding in the study area is considered “flash flooding” and occurs when precipitation and stormwater runoff from surrounding steep, hilly terrain is not able to properly drain along Yadkin and Whittenburg Creeks. The area most affected is the downtown portion of Steelville, along Main Street and Highway 8. The Flood Hazard Analysis Report provides the city with the evaluation of structural measures (detention basins and channel modifications) and nonstructural measures (floodproofing, acquisition, etc.) based on the ability to detain water and increase channel capacity in order to reduce flood risk to flood-prone structures for the 1% Annual Exceedance Probability (AEP) (100 YR) flood event. The feasibility of detention basins and channel modifications were evaluated independently and in combination for effectiveness on managing flood risk resulting in an array of structural flood risk management alternatives. A nonstructural flood risk management plan was developed as part of the report and provides the city with flood risk mitigation methods for the 257 structures affected by a 1% AEP flood event.

The evaluation was conducted on the following array of Structural Alternatives: (1) Three (3) detention basins, (2) Yadkin and Whittenburg Creeks Channel modification and (3) Combination of three (3) detention basins and channel modification to Yadkin and Whittenburg Creeks. Using the intersection of Main Street and 4th Street as a reference point, Alternatives 1-3 show a reduction in flood risk at varying levels depending on the AEP flood event. Focusing on the 1% AEP flood event, Alternatives 1-3 have varying degrees of effectiveness at reducing flood depths in the study area. Alternative 1 would reduce flooding depths by approximately 1.6 feet, or 45%, and Alternative 3 would reduce flooding depths by approximately 2.4 feet, or 68%. For a 1% AEP flood event, Alternative 2 reduces flooding depths by approximately 0.7 feet, or 19%.

While these structural measures may provide a reduction of flood risk, it appears that detention basins and channel modifications do not completely eliminate the risk of flooding to structures and therefore may not be considered viable options for the 1% AEP event. In addition, the study provides detail on numerous considerations the city would need to address if pursuing detention basins and channel modification that would result in the need for additional funding to determine feasibility.

A Nonstructural Flood Mitigation Plan (APPENDIX D) is presented as part of this report and outlines effective, viable Nonstructural Mitigation methods for structures in flood-prone areas for 1% AEP event. The evaluation indicated that dry floodproofing of flood-prone structures is an effective mitigation method for the majority of structures due to flood depths of less than 3 feet. However, due to the

nature of flash flooding in the study area, dry floodproofing is not a standalone viable measure and requires the addition of nonphysical nonstructural measures such as the implementation of an early warning system or sirens for public awareness. Additional nonphysical nonstructural methods, such as land use policies and building and zoning regulations are effective flood risk mitigation methods for the city to implement. Estimated costs for the structural alternatives and the nonstructural mitigation methods are included as part of this report (APPENDIX B).

This report provides planning-level support to the city through the USACE Floodplain Management Services (FPMS) program, and not considered a decision document used to make Federal investment decisions; therefore, there are no official recommendations and construction will not take place as part of this study.

The city officials may choose to implement any or all of the measures identified as funding becomes available. USACE will provide supplemental reports including the *Meramec Watershed Low Water Crossing Mitigation Plan, Missouri*, that was completed by the Meramec Low Water Crossing Multi-Jurisdictional State Risk Management Team via the Silver Jackets program (April 2023) and the *Lower Meramec Basin, Multi-Jurisdictional Floodplain Management Plan, April 2020*, in particular *APPENDIX E: Analysis of National Nonstructural Committee Assessment.*

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1.0 STUDY PURPOSE

The purpose of this report is to provide City of Steelville, MO officials sufficient information to make future decisions regarding flood risk management along Yadkin Creek in the downtown area. The study evaluated the flood-prone sections within the City of Steelville, as well as examined opportunities to manage flood inundation risks as the city anticipates a revised Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) designating an expanded flood hazard area. Several businesses and homeowners may be impacted by the revised FIRM, both with actual flood risk as well as the economic impact of flood insurance requirements. This report provides the city with an analysis of potential structural and nonstructural flood risk mitigation measures to manage flood inundation risk to structures located along Yadkin Creek within the City of Steelville.

1.1 Study Scope

Within the Whittenburg Creek watershed, the study scope focuses on the flood-prone areas within the City of Steelville, MO, evaluating flood inundation caused by Yadkin Creek. The study area includes 262 flood-prone structures potentially impacted by a 0.2% AEP (500YR) flood, however, the study focused on evaluation of measures for the 257 structures impacted by a 1% annual exceedance probability (AEP) (100YR) event. The study scope specifically focused on evaluating two structural measures, including detention areas and channel modifications, as well as nonstructural solutions in order to identify potential alternatives to manage flood risk from a 1% AEP (100 YR) flood event. Detention areas were evaluated for potential storage areas designed to mitigate adverse flood impacts by detaining water, thereby reducing flood waters downstream. The potential for a channel modification was evaluated to increase capacity of the channel of Yadkin Creek downstream to the confluence of Whittenburg Creek in Steelville.

The scope of this study also includes the identification of a single nonstructural plan for the 257 flood-prone structures within the 1% AEP. The evaluation of nonstructural flood risk management methods includes acquisition (buyout), relocation, elevation and wet/dry floodproofing for individual structures. A Structure Inventory (APPENDIX C: Structure Inventory) was developed to identify the flood-prone structures within the study area includes corresponding information such as structure attributes and inundation data for various AEP events, as well as site conditions, structure attributes, social equity, and environmental effects. The analysis is comprised of existing data.

The hydrologic evaluation for this study included flooding due to precipitation and runoff. Flooding associated with local drainage was not included as part of the scope. Also, the City requested that the area in the vicinity of the Steelville Manufacturing building be included in the evaluation. However, the source of flooding at this location is not caused by Yadkin Creek, and therefore could not be included in the study scope. Sources referenced throughout the main report include data from the City of Steelville, Crawford County, FEMA, U.S. Army Corps of Engineers (USACE), the Missouri State Emergency Management Agency (SEMA), U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA).

Throughout this report, flood events and their resultant inundation will be referred to by Annual Exceedance Probability (AEP), which is the probability that this level of flooding may be realized or exceeded in any given year. For example, a flood event with a 1% AEP would have a 1% probability of occurring every year. This is a change in terminology from the commonly used term “annual chance of exceedance” (ACE). Additionally, in the past, flood events have often been described by their “return period” – or the estimated average length of time between flood events of a similar magnitude. A 1% AEP event would have been referred to as having a 100-year return period or being a 100-year event. This terminology is no longer used because it falsely conveys a sense of time and lowers public risk perceptions. TABLE 1 provides a list of common AEP flooding events for reference, with their equivalent “return period.”

TABLE 1. COMPARISON OF AEP, ACE, AND RETURN PERIOD TERMINOLOGY

AEP/ACE	Return Period*
20%	5-year
10%	10-year
4%	25-year
2%	50-year
1%	100-year
0.5%	200-year
0.2%	500-year
0.1%	1000-year
*Note: Return Period is a term that can be misleading, is often misunderstood, and is no longer used by USACE (see ER 1110-2-1450).	

2.0 STUDY BACKGROUND

2.1 Study Authority

This study is a special study under the Flood Plain Management Services (FPMS) program and is authorized by Section 206 of the Flood Control Act of 1960 (P.L. 86-645), as amended (see excerpt below). The FPMS program allows USACE to conduct small, conceptual studies for local communities. This program is for planning-level assistance only, and it is possible that additional analyses beyond this report would be needed in order to further design or construct the various flood risk reduction measures in the report.

“In recognition of the increasing use and development of the flood plains of the rivers of the United States and of the need for information on flood hazards to serve as a guide to such development, and as a basis for avoiding future flood hazards by regulation of use by States and political subdivisions thereof, and to assure that Federal departments and agencies may take proper cognizance of flood hazards, the Secretary of the Army, through the Chief of Engineers, is hereby authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods of various magnitudes and frequencies, identification of areas subject to floods due to accumulated snags and other debris, and general criteria for guidance of Federal and non-Federal

interests and agencies in the use of flood plain areas; and to provide advice to other Federal agencies and local interests for their use in planning to ameliorate the flood hazard, to avoid repetitive flooding impacts, to anticipate, prepare, and adapt to changing climatic conditions and extreme weather events, and to withstand, respond to, and recover rapidly from disruption due to the flood hazards."

2.2 Study Location

The City of Steelville, Missouri is located in the east-central portion of the state, approximately 91 miles southwest of St. Louis. The city serves as the seat of Crawford County and is approximately 2.42 square miles with a population of 1,472 residents (2020 US Census). The study area focuses on the flood-prone areas of Steelville along Yadkin Creek, including surrounding areas for structural measures, such as potential detention areas. The study area is shown below in FIGURES 1 and 2, encompassing approximately 1,550 acres. FIGURE 1 shows the watershed and the general location of the study area. FIGURE 2 shows the study area in greater detail.

2.3 FEMA Risk Rating 2.0

Currently, FEMA is revising national flood hazard analysis and maps, or Flood Insurance Rate Maps (FIRMS), as part of *Risk Rating 2.0* effort. In Missouri, FEMA has released a portion of preliminary FIRMs by County; at the time of this study effort, the final information for Crawford County is not yet available.

For this report, the May 2010 FIRM (FIGURE 3) is used to depict current flood boundaries as of 2023. However, the St. Louis District acquired the preliminary FEMA Flood Insurance Study (FIS) data and revised hydraulic model from FEMA's contractor, WSP (formerly known as Wood PLC), to develop the 2-D HEC RAS model used for this study.

2.4 Yadkin Creek Flood History

The city experiences flooding from a combination of precipitation, stormwater runoff from nearby hilly terrain, and overbank flooding of Yadkin Creek. Flash floods are a concern for the study area since the population at risk are given a small window of time from the start of the rain to the overflowing of the Yadkin Creek. In June 2015, Tropical Depression Bill resulted in approximately seven (7) inches of rainfall in the Steelville region causing Yadkin Creek to overflow out of the banks and caused the Steelville Fire Protection District to rescue residents in an area on Cedar Lane. This 2015 flood inundated the Steelville City Hall and Police Station. According to the City of Steelville, local officials do not have a current plan for flood fighting operations and no existing flood risk reduction measures are in place. With the exception of the historic flood of 1898 (Section 2.4.1), there is no recorded history of inundation of critical infrastructure or lives lost.

There are no regular recorded gage readings on Yadkin or Whittenburg Creeks in Steelville. Due to the absence of this data, the flood data from a nearby gage on the Meramec River was reviewed to provide insight on similar flooding events that Yadkin Creek may have experienced. These flood elevations do not directly correlate to Yadkin Creek at Steelville as Meramec River backwater does not affect Yadkin Creek in Steelville.

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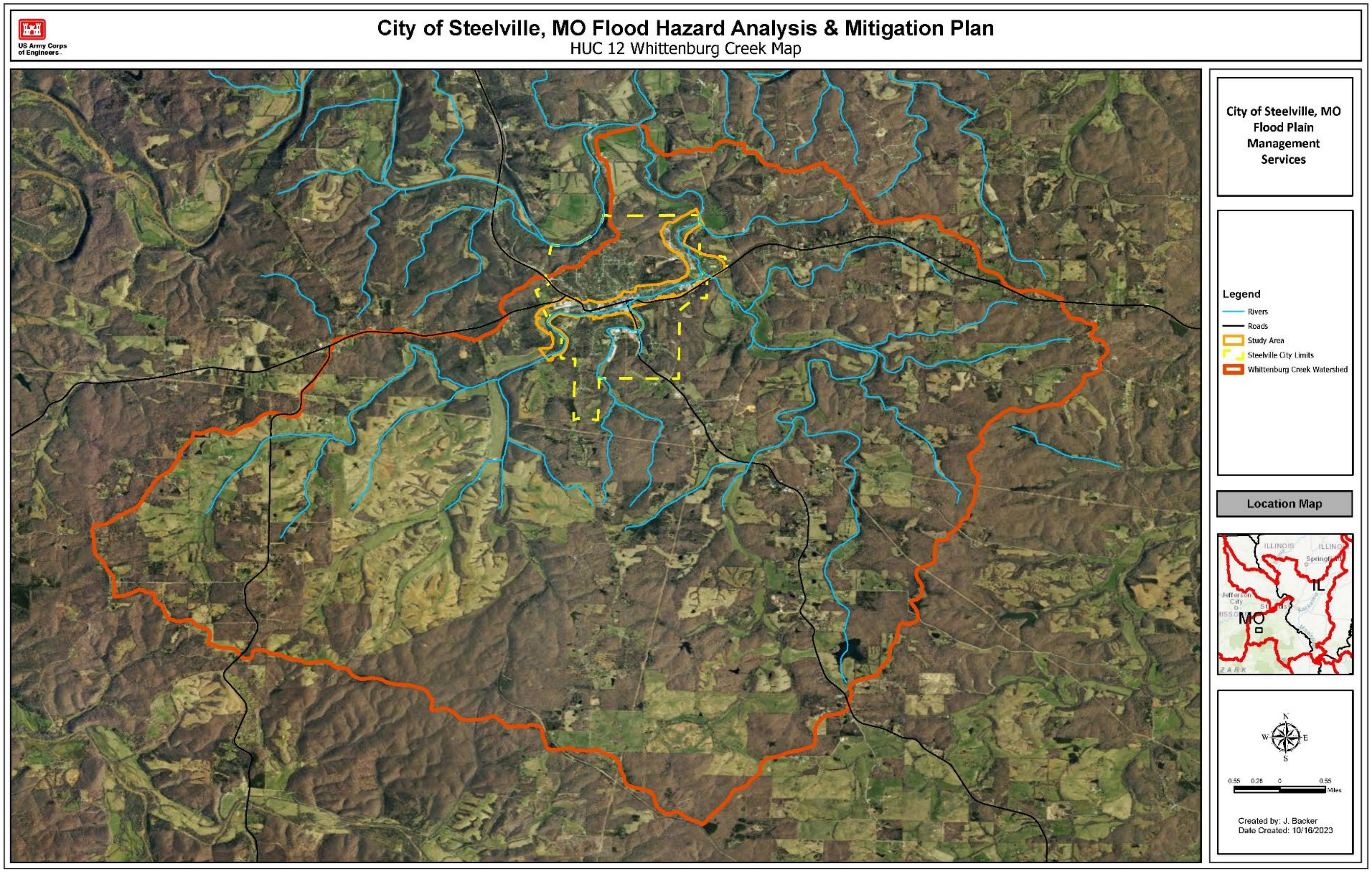

FIGURE 1. STUDY LOCATION WITHIN WHITTENBURG CREEK WATERSHED

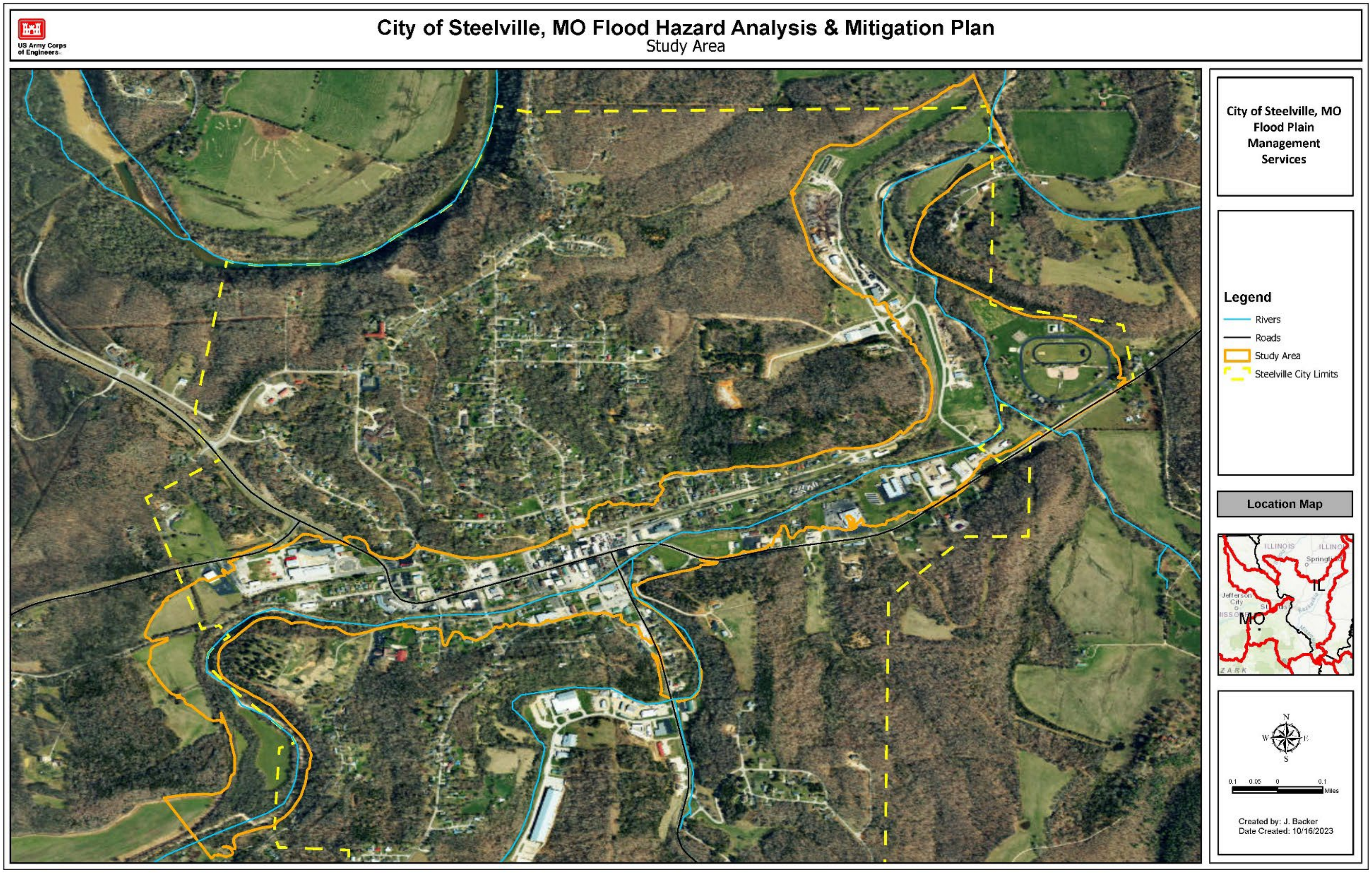

FIGURE 2. STUDY AREA

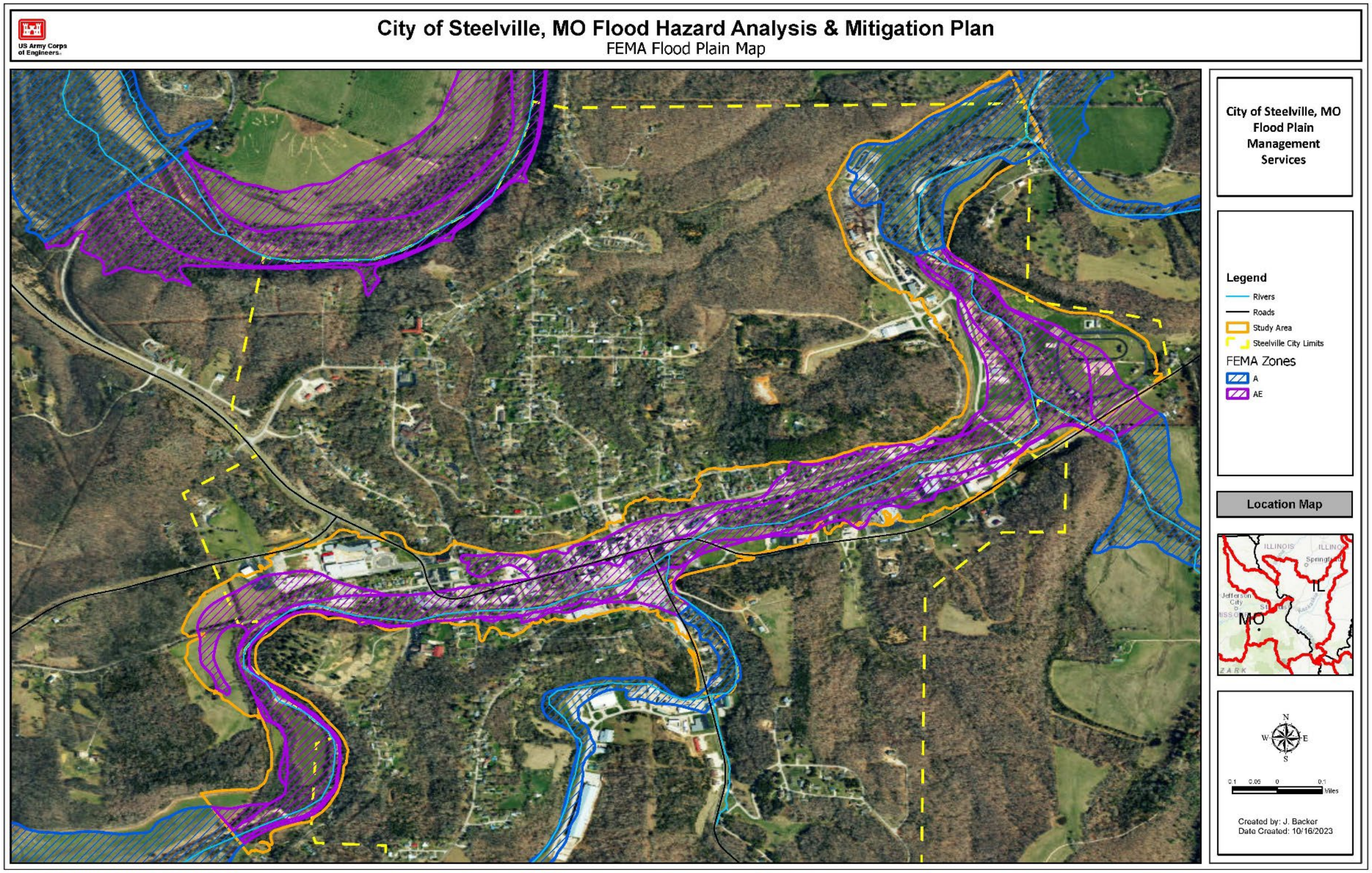

FIGURE 3. STEELVILLE, MO AREA FEMA FLOOD INSURANCE RATE MAP (1% AEP)

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At the Meramec River, Steelville Gage (Gage Station 07013000) on the Meramec River, the top 10 record flood events have occurred since 1998. Per the National Weather Service (NWS), the historic crest of the Meramec River was 28.71 feet May 1st, 2017. The Steelville Gage is located upstream of the confluence of Whittenburg Creek and collects daily water discharge data. Historical USGS records are available beginning in October 1922. This USGS gage data does not directly correlate to flooding levels seen near Steelville due to the distance between the city and the gage and other topographical factors but are included to provide general flooding history in the vicinity of the watershed and study area.

Additional information can be found on the USGS website (https://waterdata.usgs.gov). TABLE 2 shows the Flood Categories Major Flood Stage, Moderate Flood Stage, Minor Stage, and Action (Flood) Stage, according to the NWS. TABLE 3 shows the ten (10) highest historical flood crests for Meramec River gage near Steelville, MO.

TABLE 2. FLOOD CATEGORIES, USGS MERAMEC RIVER NEAR STEELVILLE, MO

USGS Meramec River Near Steelville, MO (07013000) Gage Data	
Flood Categories	Stage (Gage Height, ft)
Major Flood Stage	**25.0**
Moderate Flood Stage	**20.0**
Minor Stage	**12.0**
Action Stage	**10.0**

TABLE 3. HISTORIC FLOOD CRESTS, STEELVILLE, MO

USGS Gage: Meramec River Near Steelville, MO (07013000)	
Historic Crests	
Stage (Gage Height, ft.)	**Date**
28.71 ft	**1 May 2017**
27.22 ft	**27 July 1998**
26.84 ft	**19 March 2008**
26.50 ft	**20 August 1915**
26.15 ft	**28 June 1985**
25.60 ft	**4 December 1982**
24.87 ft	**29 December 2015**
24.20 ft	**9 June 1945**
24.10 ft	**27 October 1919**
23.90 ft	**26 June 1935**

2.4.1 Yadkin Creek Flood of 1898

In July 1898, the City of Steelville experienced a historical flood event. According to the city's historical records, the flood was caused primarily by the accumulation of debris trapped against a railroad trestle, which acted as a dam. Subsequent rainfall events caused the accumulation to release, resulting in a 15 – 20-foot rise in Yadkin Creek. The flooding led to extensive damage to the downstream community and resulted in 13 deaths.

3.0 EXISTING CONDITIONS AND FUTURE WITHOUT PROJECT

3.1 Hydrologic and Hydraulic Conditions

The study area encompasses a portion of the HUC12 (12-digit Hydrologic Unit Code) Whittenburg Creek watershed where Yadkin Creek runs through the downtown portion of Steelville and combines with Whittenburg Creek, which is a tributary to the Meramec River (FIGURE 4). Yadkin Creek originates upstream of the study area, passes through the downtown area, and ends at the confluence with Whittenburg Creek. The area is low lying along the Yadkin and Whittenburg Creeks and surrounded by steep hills rising approximately 300 feet in elevation to the top of the watershed. Elevations in the report are referenced in the North American Vertical Datum (NAVD)88 vertical datum unless otherwise noted.

A significant portion of Steelville is in the floodplain of Yadkin Creek and is surrounded by steep, hilly terrain which causes the accumulation of precipitation runoff in the valley where the city is located. During periods of high precipitation, Yadkin Creek cannot accommodate the volume of water that drains into the area. Yadkin Creek continues into Whittenburg Creek, which also does not have the capacity to drain the volume of water that occurs during 10%, 4%, 2%, 1%, and 0.2% AEP flood events. Results of modeling efforts can be seen in APPENDIX A: Hydraulics and Hydrologic Analysis.

For this study, a 2-D Hydrologic Engineering Center-River Analysis System (HEC-RAS) hydraulic model developed by WSP for a FEMA Flood Insurance Study (FIS) was modified to produce inundation results for the study area. It was necessary to complete revisions to the WSP model to ensure accuracy. The revisions were coordinated with WSP and are detailed in APPENDIX A: Hydraulics and Hydrologic Analysis. Precipitation hydrographs as well as a Light Detection and Ranging (LiDAR) dataset of the study area were utilized to produce depth grids for economic analysis. The model outputs, such as depth grids and velocities, were utilized as part of the existing condition analysis as well as formulation and evaluation of structural and nonstructural alternatives.

Hydrologic modeling indicates that flooding occurs outside of the main channel into the left and right overbank areas of Yadkin Creek. The area most impacted by rain events is the downtown portion of Steelville, along Main Street and Highway 8, as well as Industrial Drive and other roads within the study area. Without flood risk management measures, the overbank flooding of Yadkin Creek will continue to occur due to limited channel capacity during flood events.

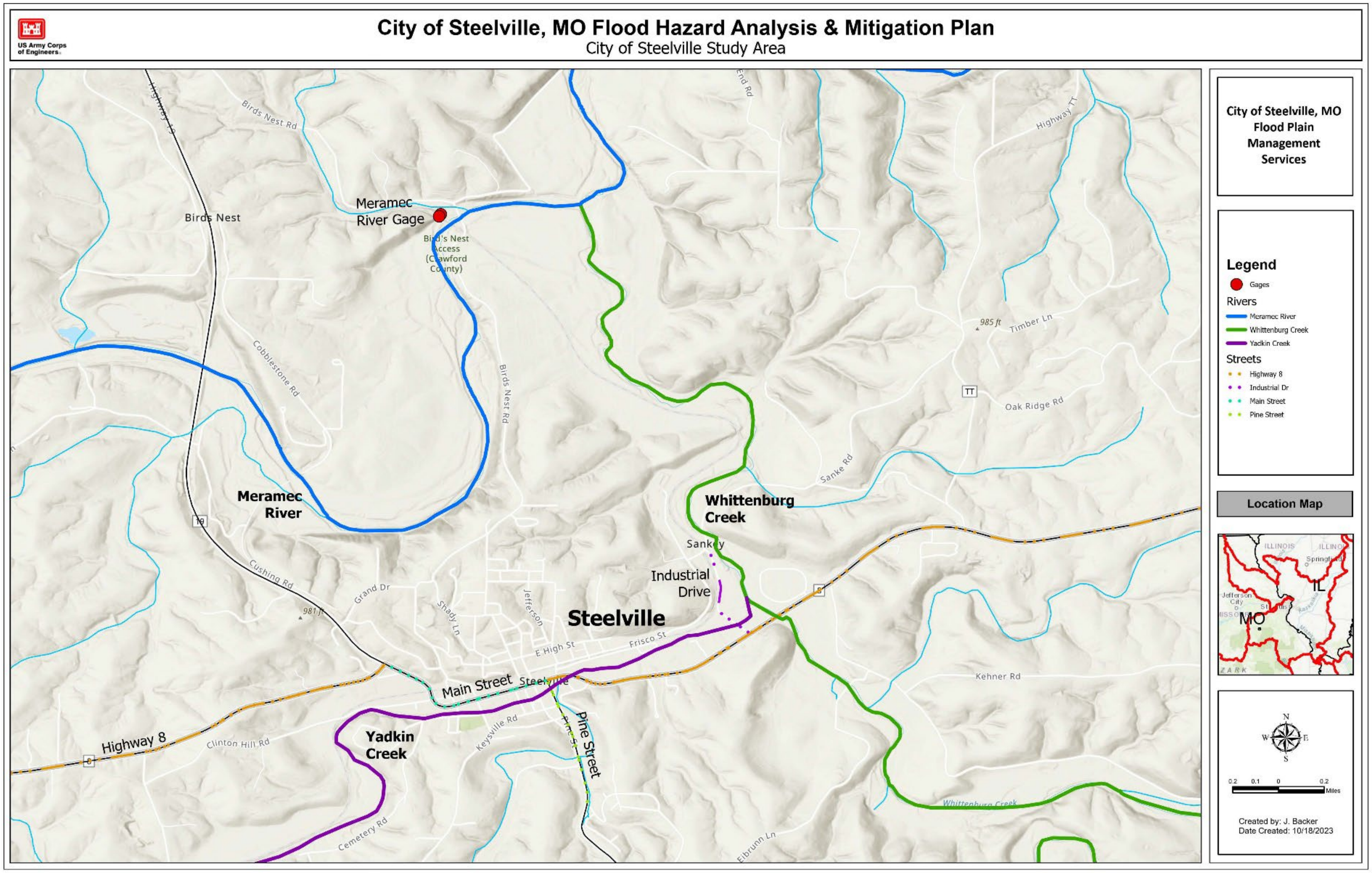

FIGURE 4. WHITTENBURG WATERSHED NEAR CITY OF STEELVILLE, MO

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For the purposes of this report, an AEP flood event is the resulting flood elevation caused by a localized precipitation event. The nature of flooding within the study area is considered "flash" flooding from Yadkin Creek. Flash floods typically occur in a short period of time (6 hours or less) and are caused by excessive rain. Flash floods are a concern given the small window of time from the start of rain events and the overflowing of the channel. Yadkin Creek overbank flooding occurs at approximately the 10% AEP event when precipitation and stormwater runoff from higher elevations is not able to properly drain. Modeling indicates that Yadkin Creek overflows approximately 1 hour and 45 minutes after the start of the rain. In that timeframe, 5 inches of rain (2.85 inches per hour) enter the system.

The preliminary FEMA FIS information obtained from WSP indicates that the footprint of the FEMA flood inundation areas have increased in the vicinity of Steelville and now include areas located in higher elevations, such as the Steelville Manufacturing property. As part of this report, a brief evaluation of the area near Steelville Manufacturing property determined that the source of flooding in this area is due to runoff from the surrounding steep terrain and not exacerbated by Yadkin Creek.

3.1.1 Low Water Crossings (LWC)

Although sediment modeling was not completed as part of the scope of this study, large deposits of gravel were seen during site visits and reported by the City as an ongoing maintenance issue in both Yadkin and Whittenburg Creeks. This gravel load is of particular concern for the City at three (3) low water crossings on Yadkin Creek located at the Intersection of 3rd Street and Water Street, Greenway Trail crossing, and Industrial Drive, immediately upstream of confluence of Yadkin and Whittenburg Creek.

According to city officials, due to the amount of gravel load moving through the creek, the size of the openings under the crossings are not able to effectively move bed material downstream to keep flow openings clear of creek gravel. The deposition of bed load (gravel load) causes the City Public Works to continually remove material to maintain flow through the openings of the low water crossings. The gravel deposits are likely to reduce the channel capacity of the creeks if not properly maintained. The study area contains a series of low water crossings in Yadkin Creek that allow pedestrian and vehicular crossings while serving a significant role in the conveyance of flow during high water events through the downtown area. Hydrologic and Hydraulic (H&H) modeling indicated that the series of low water crossings located within the downtown area restrict the drainage capacity for Yadkin and Whittenburg Creeks.

The hydrologic and hydraulic future conditions along Yadkin Creek will likely follow the same trend seen in existing conditions which is likely to result in increased Flood Insurance rates, as the revised Flood Insurance Studies are completed by FEMA.

3.2 Economic Conditions

The City of Steelville is located in the foothills of the Missouri Ozarks area and centrally located to the confluence of several Ozark streams and the Meramec River, making it a popular destination for outdoor recreation, including rafting, canoeing and kayaking.

A survey of existing structures was conducted, composed of review of the National Structure Inventory 2022 (NSI 2022), Google Street view, and a windshield survey of a sample of flood-prone structures to determine certain structural characteristics, such as foundation type, structure condition, and first floor elevation. The NSI is a system of databases containing structure inventories of varying quality and spatial coverage that is used in the assessment and analysis of natural hazards, such as flooding. All of the commercial, industrial and public structures that were surveyed contain slab foundations, and the residential structures have either basements, crawl spaces, or slab foundations. When accounting for the first floor elevations, each step from the ground to the first floor was considered to be 6 inches in height. Individual structure surveys and assessments would be required prior to implementing specific nonstructural mitigation measure.

The Structure Inventory for the study area comprises 262 structures located in the 0.2% AEP floodplain and consists of 51% residential structures, 41% commercial structures, 6% publicly owned structures, and 2% industrial structures. The 0.2% AEP flood event would inundate the City of Steelville along the Main Street, Highway 8, and Industrial Drive.

Despite the flood risk, the study area retains a large number of homeowners and recent home sales (based on August 2023 home sales listed at www.zillow.com). Of the 262 total structures in the study area that are impacted by the 1% AEP, almost all remain occupied. The average flood-prone home was built in 1964 in Steelville, and pre-dates the NFIP and delineation onto the FIRM. Those homes that pre-date the NFIP were grandfathered into the NFIP and have lower flood insurance rates and less restrictive regulatory requirements. Lower rates and lesser regulatory requirements persist until a change in ownership or substantial improvement occurs. FIGURE 5 shows the results of the structure inventory.

3.3 Environmental Conditions

Depending on the city's preferred project, impacts to Yadkin Creek could require permitting through the USACE Regulatory Branch. The USACE is able to utilize Nationwide Permits for minor or minimal work, but an individual permit may be required for more extensive impacts to Yadkin Creek. Individual permits typically require coordination with other natural resource agencies as well as the public.

Based on the USFWS National Wetland Inventory Maps (NWI), there are no mapped wetlands along Yadkin Creek at this location, although this has not been field verified. The soil types typically found in the riparian area around Yadkin Creek are well drained soils that are composed of sand and gravel and are not conducive to supporting wetland features.

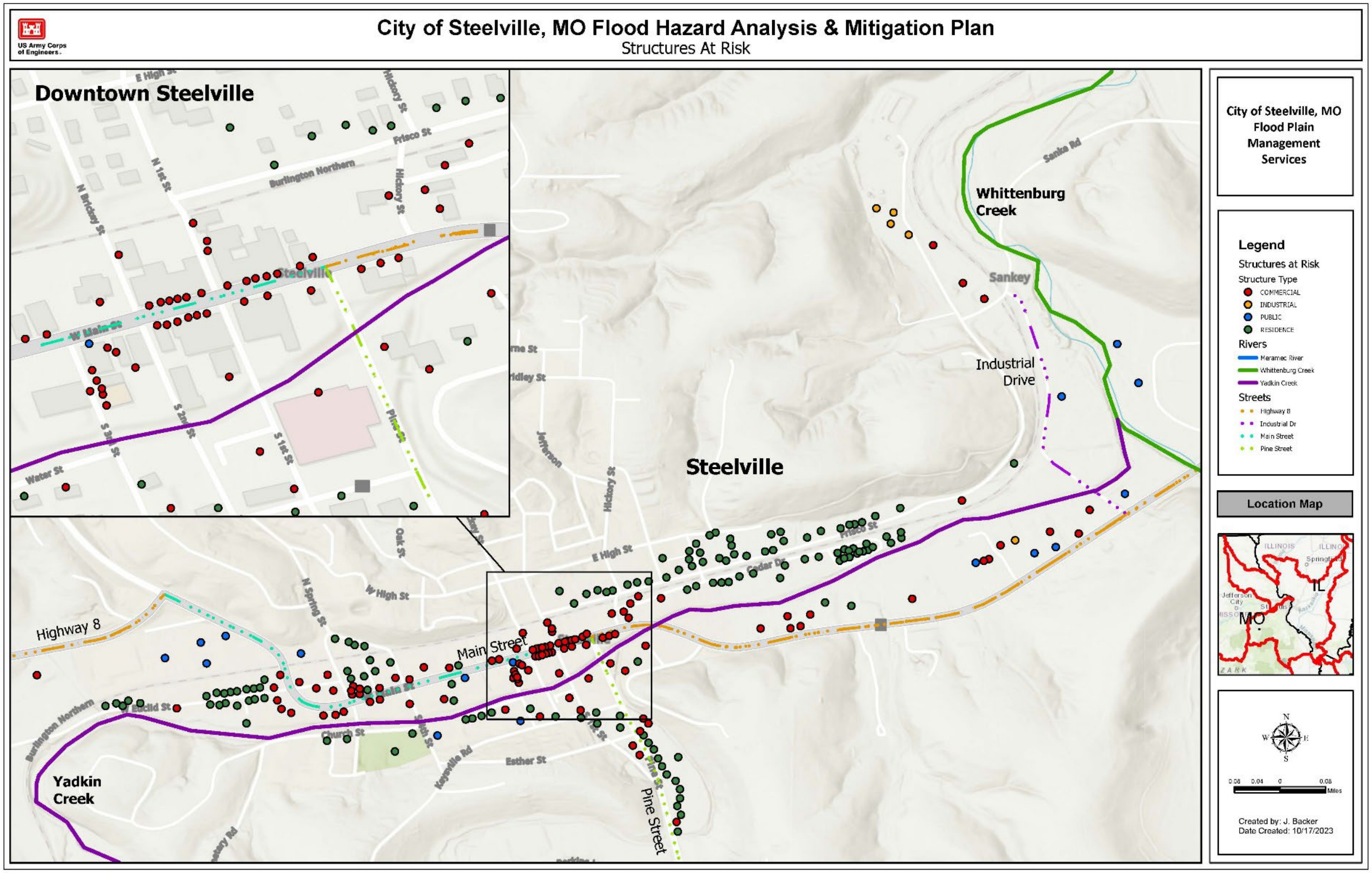

FIGURE 5. CITY OF STEELVILLE, MO STRUCTURES AT RISK 1% AEP (100YR) EVENT

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The USACE Regulatory Office has previously coordinated with the City of Steelville regarding flooding concerns along Yadkin Creek. The city has ongoing creek maintenance associated with bank stabilization, culvert replacement, bridge construction, trail improvement and brush clearing. Natural resource agencies and the USACE have developed regulations designed to keep our large and diverse stream networks connected where roads are constructed over a stream (often referred to as stream crossings). Thus, low water crossing projects (i.e., culvert/bridge installations, removals, retrofits, and replacements) in Missouri may require permits and compliance with these regulations as well as other Federal, state, and local regulations.

3.3.1 Environmental Justice

Executive Order (E.O.) 12898 directs federal agencies to take the appropriate steps to identify and address any disproportionately high and adverse human health or environmental effects of federal programs, policies, and activities on minority and low-income populations. Minority populations are those persons who identify themselves as Black, Hispanic, Asian American, American Indian/Alaskan Native, Pacific Islander, and persons of multiple races. A minority population exists where the percentage of minorities in an affected area either exceeds 50 percent or is meaningfully greater than in the general population. There are no minority populations located within the vicinity of the study area.

In addition, E.O. 14008 established the Justice40 Initiative which aims to provide 40% of the overall benefits of certain Federal investments to disadvantaged communities who are marginalized, underserved, and overburdened. The Climate and Economic Justice Screening Tool, 2023 (CEJST) uses datasets as indicators of burdens. The burdens are organized into categories. A community is highlighted as disadvantaged on the CEJST map if it is in a census tract that is 1) at or above the threshold for one or more environmental, climate, or other burdens, and 2) at or above the threshold for an associated socioeconomic burden. In addition, a census tract that is completely surrounded by disadvantaged communities and is at or above the 50% percentile for low income is also considered disadvantaged.

USACE has recently authorized programs specifically for communities classified as "economically disadvantaged", that offer opportunities for assistance with technical support and financial resources related to flood risk management purposes. Based on CEJST, the City of Steelville is located within Tract Number 29055450400 (FIGURE 6) and is considered an economically disadvantaged community within Crawford County due to being ranked above the threshold for the following categories:

- 95% (above 90th percentile) expected population loss rate, which includes fatalities and injuries resulting from natural hazards each year.
- 68% (Above 65th percentile) low income, which includes people in households where income is less than or equal to twice the federal poverty level, not including students enrolled in higher education.
- 19% (above 10th percentile) of people ages 25 years or older whose high school education is less than a high school diploma.
- 90th (equal to or above 90 percentile) of energy cost, average annual energy costs divided by household income.

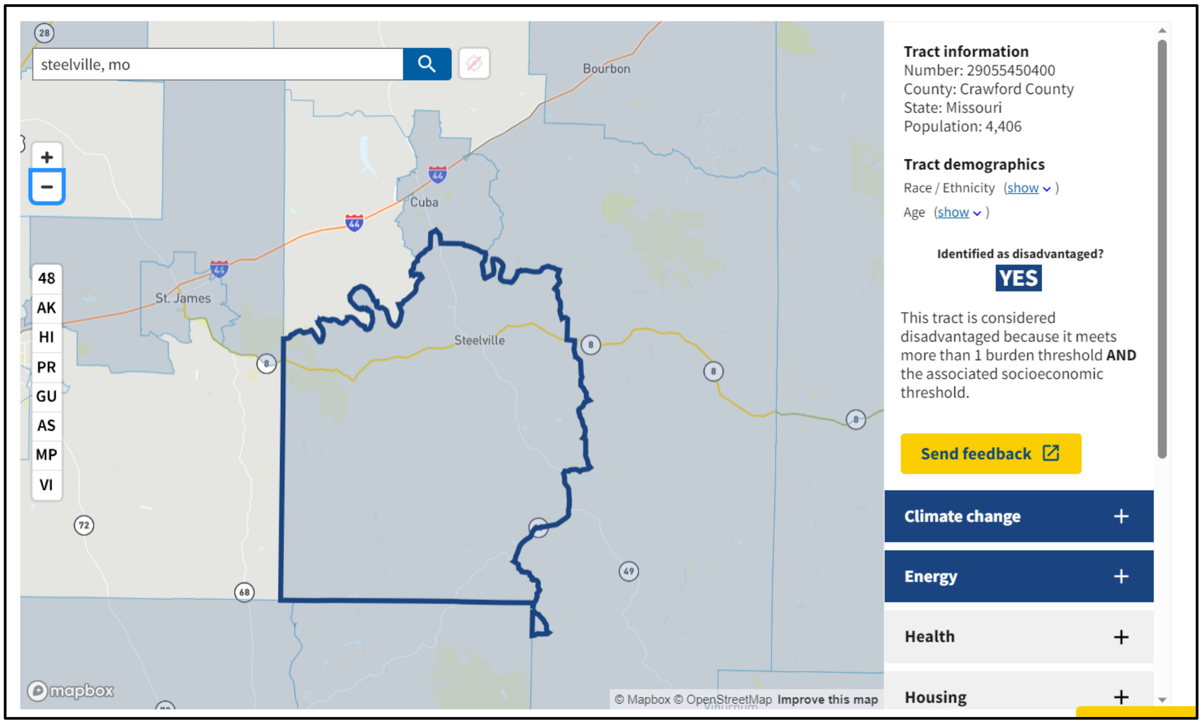

FIGURE 6. STEELVILLE, MO AREA JUSTICE40 COMMUNITY (SOURCE: CEJST SCREENING TOOL: (GEOPLATFORM.GOV))

4.0 STUDY ASSUMPTIONS AND CONSTRAINTS

4.1 Study Assumptions

The alternatives presented in this report are evaluated to mitigate flood damages up to the 1% AEP flood event and does not provide flood mitigation methods for greater (less frequent) flood events. For hydraulic and hydrologic modeling methodology and assumptions refer to APPENDIX.

For the purpose of this study, when evaluating structural measures, it was assumed that the railroad right-of-way is required to remain undisturbed. This required the use of culverts to route water from Yadkin Creek to the proposed detention basins. If it is determined that the railroad can be impacted, the use of large and expensive culverts would not be necessary and the orientation of the detention basins could be altered.

The design of the containment levees for each detention basin would be based on the results of subsurface exploration along its alignments. The final design would include settlement and seepage analyses to ensure the containment levee's stability and ability to contain water. For the purposes of developing quantities for cost estimates, it was assumed that containment levees with 1V:3H side slopes and 12-foot crests that would accommodate maintenance access are acceptable. Additionally, it was assumed that all cut material is impermeable soil, such as clay, and could be used as fill onsite.
Any remaining spoils would be hauled offsite. Open Roads Designer's Terrain to Terrain analysis was used to determine earthwork quantities.

In order to minimize impacts to structures adjacent to Yadkin Creek while providing significant channel deepening, a 3-foot dredge corridor with 1V:2H side slopes was used to analyze the Yadkin Creek channel in the area of Steelville. These 1V:2H side slopes were used throughout for simplicity, but slope stability and strength would have to be evaluated in design if construction is pursued. In order to estimate bank stabilization needs, a typical design was applied at one curve and extrapolated to all other significant curves in the reach. This typical design used 20 inch thick R200 Riprap with a 6 inch thick bedding layer and a 48 inch thick layer of C-stone for grade control structures. Further soil sampling would be required to confirm bank stabilization requirements and possible uses of dredged material. For the purposes of this study, it is assumed that all dredged or excavated material is suitable for use as clean fill. It is assumed that the creek channel will be maintained at design capacity by removing sediment, debris, or other obstructions.

4.2 Constraints and Considerations

Constraints are restrictions that limit the study planning process. Some constraints are general and common to all studies, such as resource constraints and legal and policy constraints. Resource constraints are those associated with limits on knowledge, expertise, experience, ability, data, information, funding, and time. Legal and policy constraints are those defined by law, policy and guidance. Other constraints are specific and unique to each study. Study considerations include information that may influence the study process or conclusions.

The following specific constraints were identified for this study:

- The study is limited to the scope and funding identified in the Floodplain Management Services agreement between the USACE and the City of Steelville.
- The planning team assumed that the existing railroad in the study area would not be able to be removed, relocated, or modified.
- Ensure no negative impacts on other areas with proposed modifications.

The following are considerations for the study:

- Proposed structural alternatives related to detention areas include real estate that is located beyond City of Steelville and may require outside entities and/or government endorsement to aid in project implementation and potential funding.
- A channel modification may increase flows or create a higher water surface elevation elsewhere in the channel that may require mitigation, potentially through additional infrastructure investment, flowage easement acquisition, etc.
- There is limited space between business structures and the creek for the installation of structural alternatives such as levee and floodwalls.
- Avoid or minimize environmental and cultural impacts.
- Maximize cost efficiency of flood management measures.
- Uncertainty in cooperation of property owners to administer and maintain proposed alternatives.
- Flash flood events limit opportunities for property owners to install active nonstructural floodproofing measures.

5.0 CITY OF STEELVILLE, MO FLOODPLAIN ANALYSIS

5.1 Steelville Elevation Analysis

Light Detection and Ranging (LiDAR) from Missouri Spatial Data Information Service (MSDIS) data displays the ground surface elevation across a spatial map. FIGURE 7 shows 1-meter resolution LiDAR data for Steelville and demonstrates the flooding concerns for the downtown area. The valley like terrain of Steelville allows for water to accumulate from the adjacent hilly landscape. Given the elevation change of approximately 300 feet from the top of the watershed to downtown Steelville, precipitation can quickly flow towards the Steelville area and create pools of water along Yadkin Creek, flooding Main Street and Highway 8.

5.2 Flood Susceptibility

Flood susceptibility is the likelihood of flood damages occurring in an area based on the physical attributes of that area. There are three primary ways to measure flood susceptibility in structures:

1) First Floor Elevation
2) Beginning Damage Elevation
3) Depth of Flooding Relative to First Floor

First floor elevation is defined as the ground surface elevation plus the foundation height, which was measured during the windshield survey sampling of structures in the study area. First floor elevation can be used to quickly identify structures that are more likely to be flood-prone, relative to neighboring structures. Additionally, the first-floor elevation signifies where the majority of damages to contents and the building envelope begin. While first floor elevation measurements provide an assessment of the elevation significant at which damages will begin, they do not properly illustrate where water enters the building, or the depths of flooding given a particular flood event.

Beginning damage elevation is defined as the lowest point at which water begins to enter the building and is dependent on the building's foundation type. Beginning damage elevation is measured as ground surface elevation plus any distance up to a basement window, crawl-space vent, or door or window leading into the structure. The beginning damage elevation statistic is a more accurate data point than first-floor elevation because it accounts for the different types of building foundations.

Depth of flooding relative to the first floor is the most precise indicator of flood susceptibility and goes beyond the normal measure of first floor elevation by indicating how high flood depths are expected to rise to give the 1% AEP or 0.2% AEP flood events. A depth of flooding measurement of two (2) feet would indicate that a 1% AEP flood event would expect to flood the structure two (2) feet above the first floor. A depth of flooding measurement of negative two (-2) 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 susceptibility by being able to compare flood-prone structures across a floodplain or even separate studies.

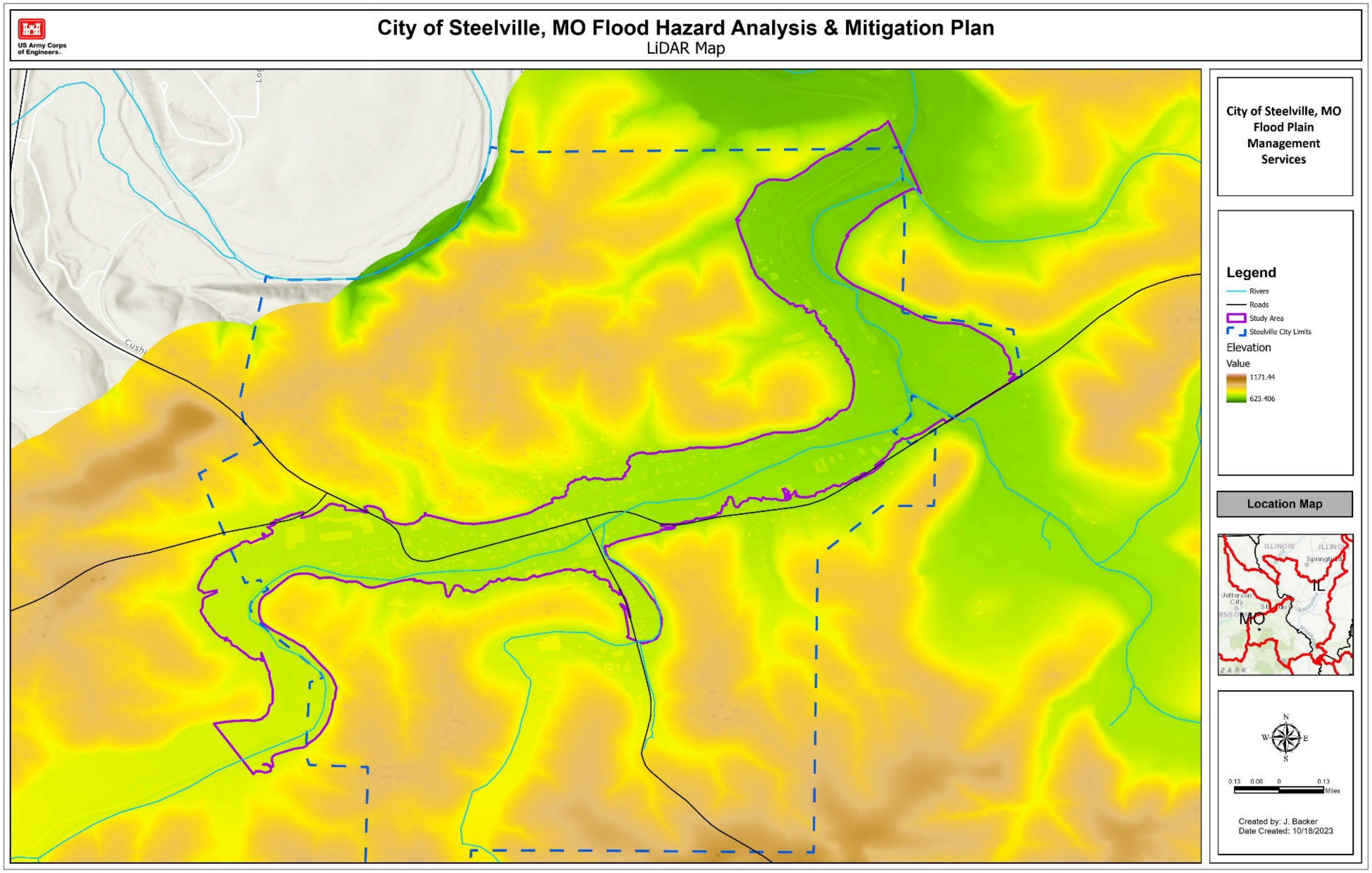

FIGURE 7. LIDAR GROUND SURFACE ELEVATION

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The elevation of the individual flood-prone structures is included in APPENDIX. The foundation types consist of 72% slab, 20% basement and 8% crawlspace foundations. TABLE 4 describes the elevation statistics for each of the flood events. Also included is the total count of structures impacted by each of the flood frequency events listed in TABLE 4. There are 192 structures that may begin to see inundation at the 4% AEP flood event and 231 structures that may begin to experience damages at the 2% AEP flood event. At the 1% AEP, 257 structures will begin to see damages due to flooding, and five additional structures will be included in the floodplain at the 0.2% AEP. TABLE 4 indicates that on average, the beginning damage elevations are lower than the average ground surface elevation for the structures in the study area. The potential flood risk mitigation methods for these residences with basements or crawlspaces will be based on inundation that occurs below the ground surface elevation.

TABLE 4. CITY OF STEELVILLE, MO ELEVATION STATISTICS (FT, NAVD)*

Frequency Of Flooding	4% AEP(25Yr)	2% AEP(50Yr)	1% AEP(100Yr)	0.2% AEP(500Yr)
Cumulative Total Structures	192	231	257	262
Average Ground Surface Elevation	756.0	756.0	755.7	755.7
Average Foundation Height	1.11	1.2	1.2	1.7
Average First Floor Elevation	757.1	757.2	756.9	757.4
Average Beginning Damage Elevation	753.4	753.1	752.7	752.1

5.3 Hydraulics and Hydrology

Hydrologic and hydraulic analysis methods utilized preliminary revised FEMA models for Whittenburg Creek developed by WSP. FEMA models consist of a Hydrologic Engineering Center's River Analysis System (HEC-RAS) creek model. HEC-RAS is a computer model that allows an engineer to compute one or two-dimensional flow calculations. The hydraulic model outputs used for this report include the 10%, 4%, 2%, 1%, and 0.2% AEP event depth grids. The depth grids can be used in a GIS environment to determine how deep floodwaters will flow at a given location for a given flood frequency event. For more information regarding modeling efforts, refer to APPENDIX.

5.4 Flood Depths and Velocities

Structures in the study area receive flood velocities from both Yadkin Creek flow and the flow of accumulated precipitation from the surrounding steep sloping terrain. HEC-RAS flood depth and velocity grids were used for economic analysis and development of nonstructural measures. Inundation depths can be wide ranging depending on location and whether the point of analysis is at the channel or the flooded areas adjacent to it. Within the study area, the highest flood depths occur along the centerline of Yadkin Creek, between Main Street and the confluence with Whittenburg Creek, with depths ranging from approximately 5 to 16 feet at the 1% AEP. In the downtown area, the flood depths range from approximately 1 foot to 8 feet.

Velocities can vary depending on geographic location, ranging from 1 ft/s to 8 ft/s in portions of the study area; however, the mean velocities are estimated at 3 ft/s for the 1% AEP. Velocities in the creek channel are higher, ranging between 4 ft/s to 10 ft/s along the portion of Yadkin Creek that passes through Main Street and ends at the confluence with Whittenburg Creek. The areas with higher depths and velocities could lead to the risk of structural collapse of buildings due to force of the flooding. FIGURE 8 depicts flow velocity for the 1% AEP, with velocities greater than 8 ft/s occurring elsewhere in the watershed and outside the study area.

Structure stability thresholds were utilized from USACE Risk Management Center's (RMC) Life Sim 2.0, Life Sim 2.0 is utilized for estimating life loss with the fundamental intent of simulating population redistribution during an evacuation. Life loss and economic damages are then determined by the hazard, such as flooding. It is designed to simulate the entire warning and evacuation process for estimating potential life loss and direct economic damages resulting from catastrophic floods. Structure stability criteria is one of the pre-determined inputs in the Life Sim 2.0 Software. For example, a two–story wood anchored structure has a stability threshold of about 9.8 ft/s velocity at 3 ft flood depths. Although some structures in the study area receive 8-8.5 ft/s of flood velocities at 3 foot flood depths, on average the structures in the study area are receiving flood velocities of less than 3 ft/s which is an acceptable level for structure stability criteria. Flood velocities less than 3 ft/s are considered "slow" by the USACE National Nonstructural Floodproofing Committee and should only be mitigated if flood depths are the primary driver of damages. TABLE 5 shows the average depths (relative to ground surface elevation) and velocities at each flood frequency for structures in Steelville.

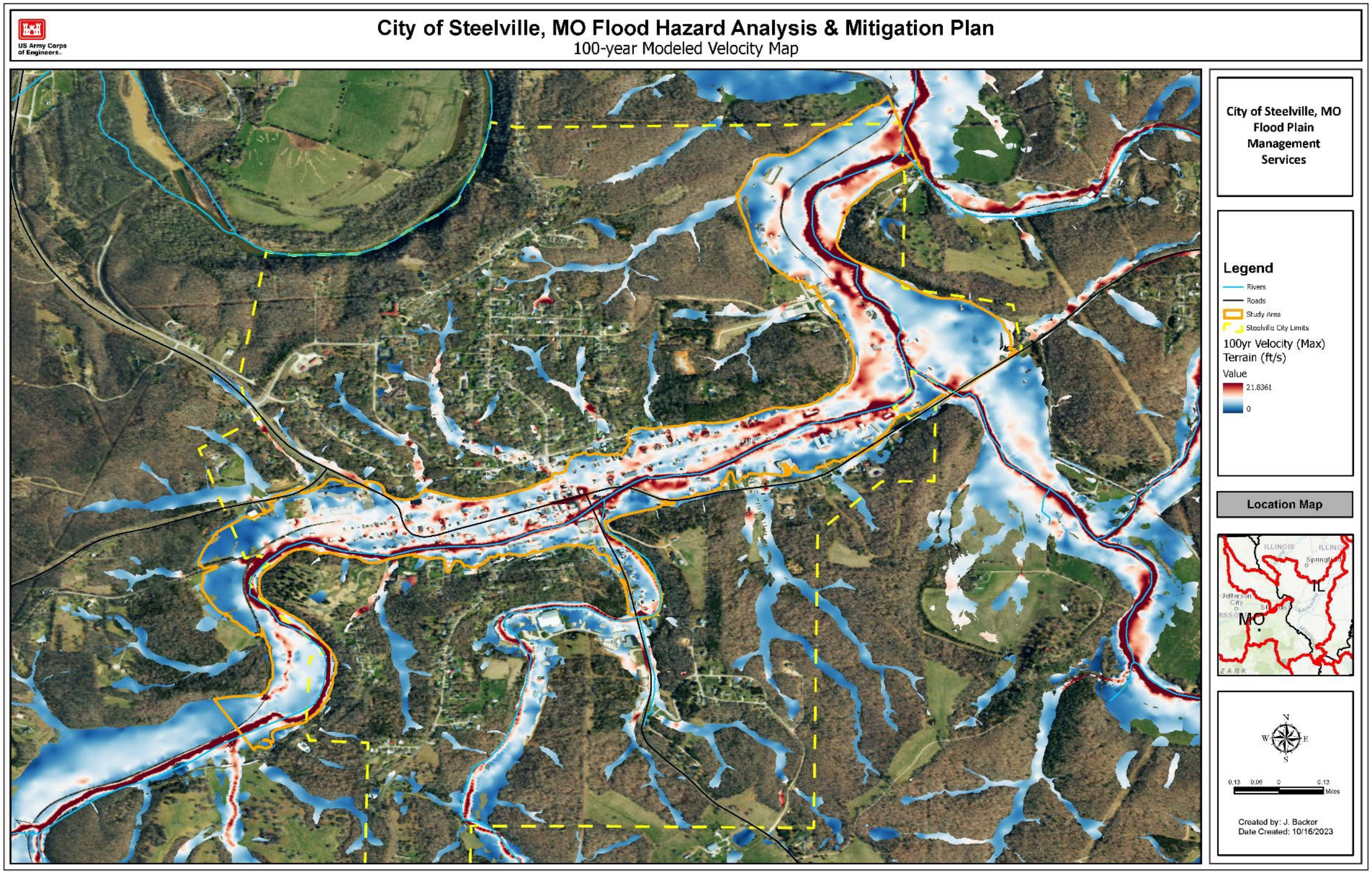

FIGURE 8. YADKIN CREEK NEAR STEELVILLE, MO FLOW VELOCITY (1% AEP)

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TABLE 5. CITY OF STEELVILLE, MO FLOOD DEPTHS AND VELOCITIES

Frequency Of Flooding	4% AEP(25Yr)	2% AEP(50Yr)	1% AEP(100Yr)	0.2% AEP(500Yr)
Cumulative Total Structures	192	231	257	262
Average Depth of Flooding (ft)	1.1	1.8	2.5	4.6
Average Velocity of Flooding	2.9	2.9	2.8	2.7

FIGURES 9 through 12 show the distribution of the number of structures at each flood depth increment for the 4%, 2%, 1%, and 0.2% flood events. The water depth data for the distribution depth graphics are not relative to first floor elevations. The structures are distributed based on their beginning damage elevations (Section 5.2).

At the 4% AEP event, most of the structures are inundated at two (2) feet or less depths at beginning damage elevations. As the severity of flooding increases with less frequent flood events, there is an increase of the number of structures receiving higher flood depths. At the 1% AEP, most of the structures receive 4 feet or less of flood depths when evaluating the structures based on their beginning damage elevations. When the first-floor elevations are considered, this would mean that most of the structures would receive less than 3 feet of flood depths at the 1% AEP. FIGURES 9 through 12 indicate that the majority of the structures receive less than 3 feet flood depths relative to the first-floor elevations, which makes the dry floodproofing approach a viable option for those structures.

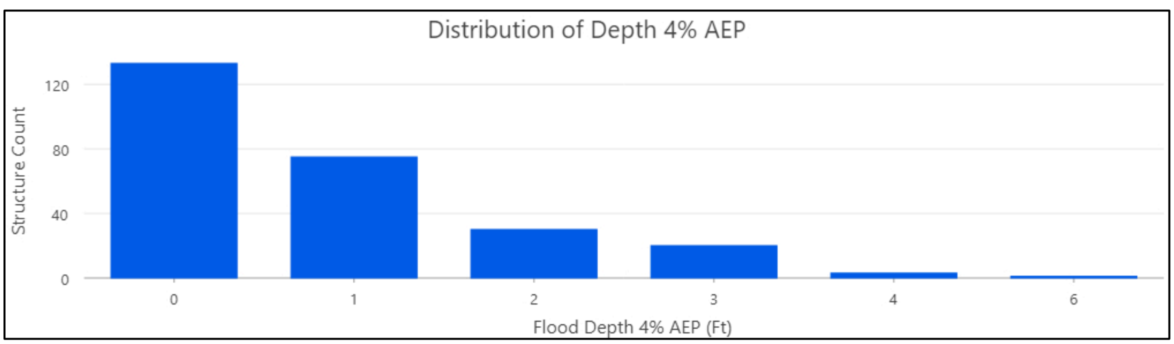

FIGURE 9. 4% AEP (25 YEAR) DEPTH FREQUENCY

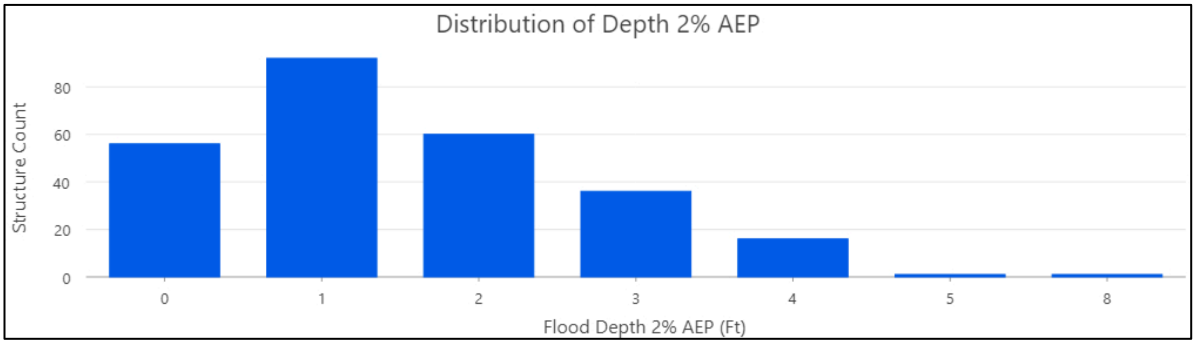

FIGURE 10. 2% AEP (50YR) DEPTH FREQUENCY

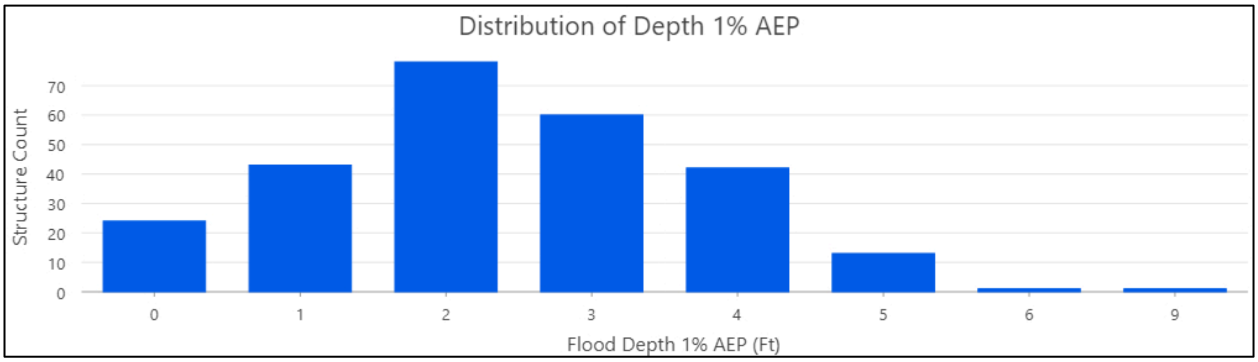

FIGURE 11. 1% AEP (100YR) DEPTH FREQUENCY

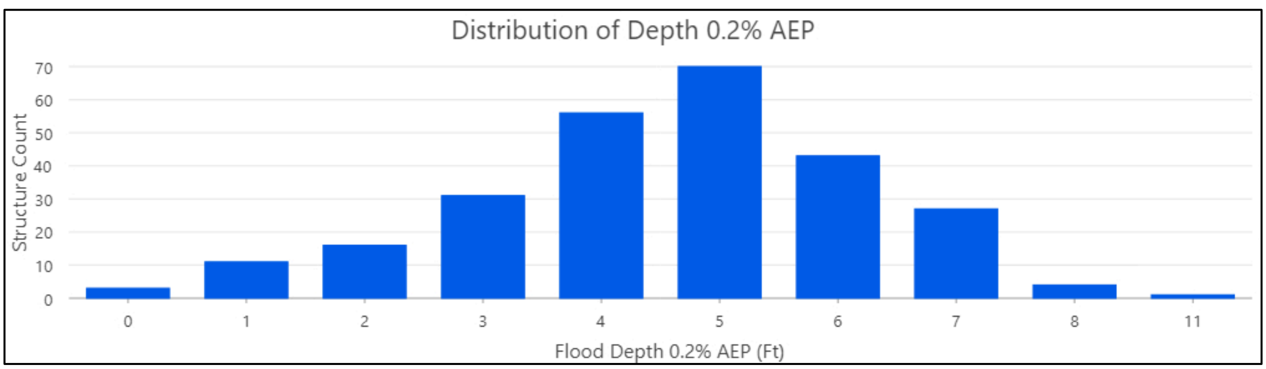

FIGURE 12. 0.2% AEP (500YR) DEPTH FREQUENCY

FIGURE 13 shows the depth of inundation relative to the ground surface elevation of structures within the study area and highlights the flooding problem for the City of Steelville. With increased rainfall, water levels of the Whittenburg and Yadkin Creeks increase. When the Yadkin Creek reaches its carrying capacity and overflows, it inundates the City of Steelville due to its close proximity. FIGURE 13 also shows the significant amount of accumulated rainfall in the surrounding steep hills that flows towards the City of Steelville. During high water events, major roads, including Main Street and Highway 8, can become inundated due to their proximity to the Yadkin Creek.

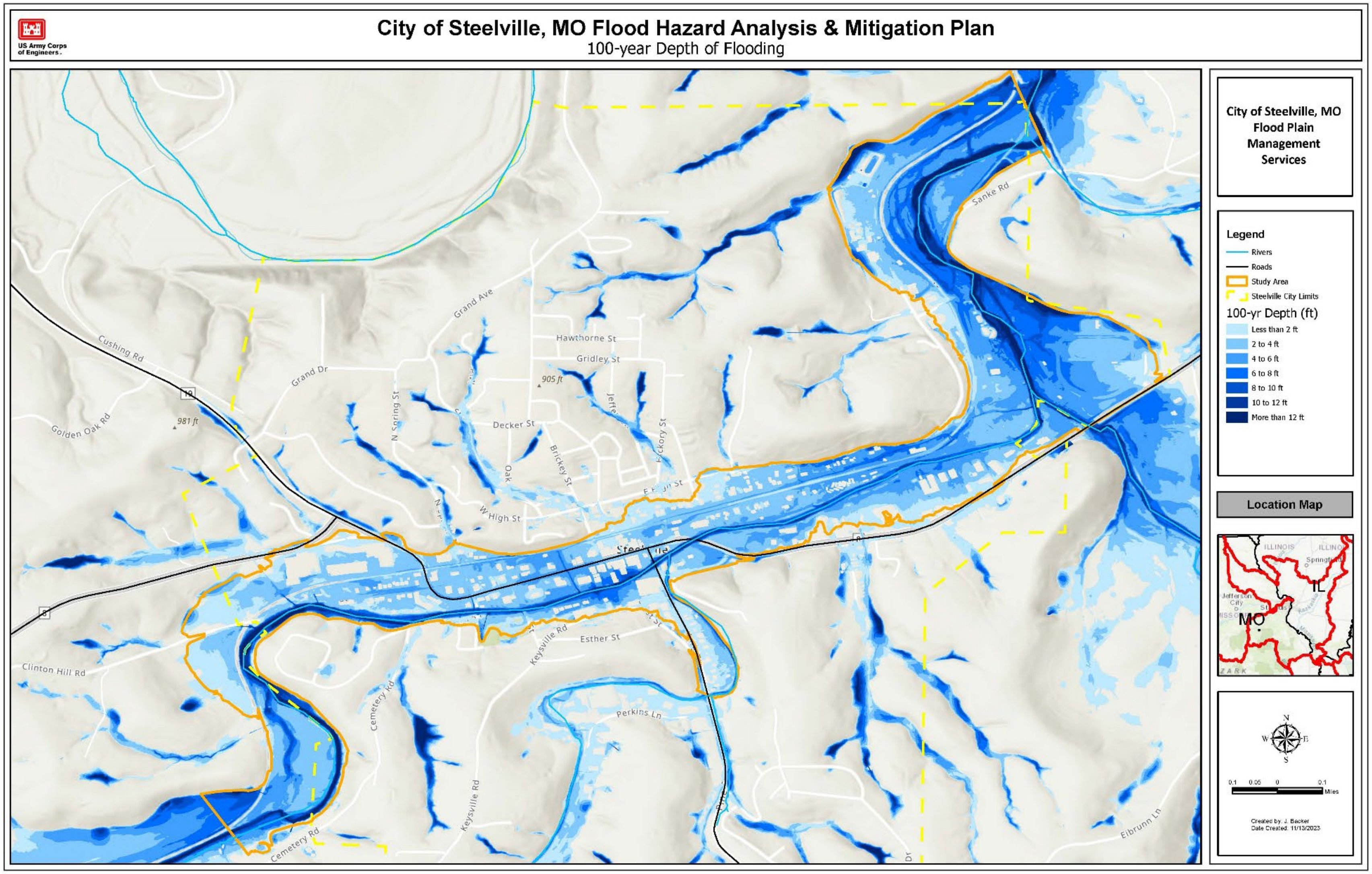

FIGURE 13. YADKIN CREEK NEAR STEELVILLE, MO DEPTH OF FLOODING (1% AEP)

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TABLE 6 shows the distribution of the flood-prone structures based on flood depth. The depths for these structures are relative to first floor elevations which means that the elevation change from the ground to the door is subtracted by the total flood inundation of the structure. These categories outline the types of potentially viable nonstructural mitigation methods for the study area for the 1% AEP. In TABLE 6, “Flood depths below 0 ft” is defining structures that have subfloors that receive flood damages below first floor elevations. The “Unaffected” structures receive flood waters of up to 0.5-1 feet, but they are not affected because they have a slab foundation with ground surface elevation to first floor elevation of 1.5-2 feet.

TABLE 6. CITY OF STEELVILLE, MO FLOOD-PRONE STRUCTURES FIRST FLOOR FLOOD DEPTH STATISTICS

	4% AEP(25Yr)	2% AEP(50Yr)	1% AEP(100Yr)	0.2% AEP(500Yr)
Flood Depths above 3 ft	3	10	32	37
Flood depths between 0 and 3 ft	86	141	168	163
Flood depths below 0 ft	8	22	32	34
Unaffected	165	89	30	28

FIGURE 14 shows the depth of flooding for each flood-prone structure in the study area for the 1% AEP event. The majority of structures receive 0-3 feet flood depth (indicated in white / yellow), dry floodproofing could potentially be a viable option to reduce damages caused by flooding. For structures with flood depths of >3 Feet at the 1% AEP, only four have the potential to be mitigated by wet floodproofing due to structural attributes (discussed in greater detail in 7.0 EVALUATION OF NONSTRUCTURAL MEASURES). For structures that cannot be wet floodproofed, elevated, or acquired due to their structure attributes, the most viable nonstructural method would most likely dry floodproofing to reduce flood risk to at least the 4% AEP flood frequency level.

5.5 Structure Valuation

There are 262 structures located in the 0.2% AEP, which is considered to be the designated flood-prone area within the study limits. As previously mentioned, structural attributes, including foundation types and foundation height were noted during a windshield survey. The structural characteristics within the study area consist of brick façade commercial structures that range from one to three stories in height, residences consisting of veneer siding, and industrial structures with metal exterior. The square footage and the year the structure was built were gathered from NSI 2022 and 2021 Parcel data provided by Crawford County, MO. The County’s Tax Assessor structure valuations (excluding land values) taken from NSI 2022 were multiplied by the Engineering News Record (ENR) price index ratio to determine the values of the structures from 2021 to 2023. TABLE 7 summarizes average structural attributes by structure type.

TABLE 7. STEELVILLE STRUCTURAL ATTRIBUTES BY STRUCTURE TYPE

Structure by Type	Average Foundation Height(ft)	Average Square Footage	Average Year Built	Average structure Value
Commercial	0.7	4,159	1965	$ 821,942
Residential	1.7	1,190	1964	$ 155,294
Industrial	0.5	6,079	1962	$ 473,069
Public	0.5	12,966	1964	$ 1,755,246

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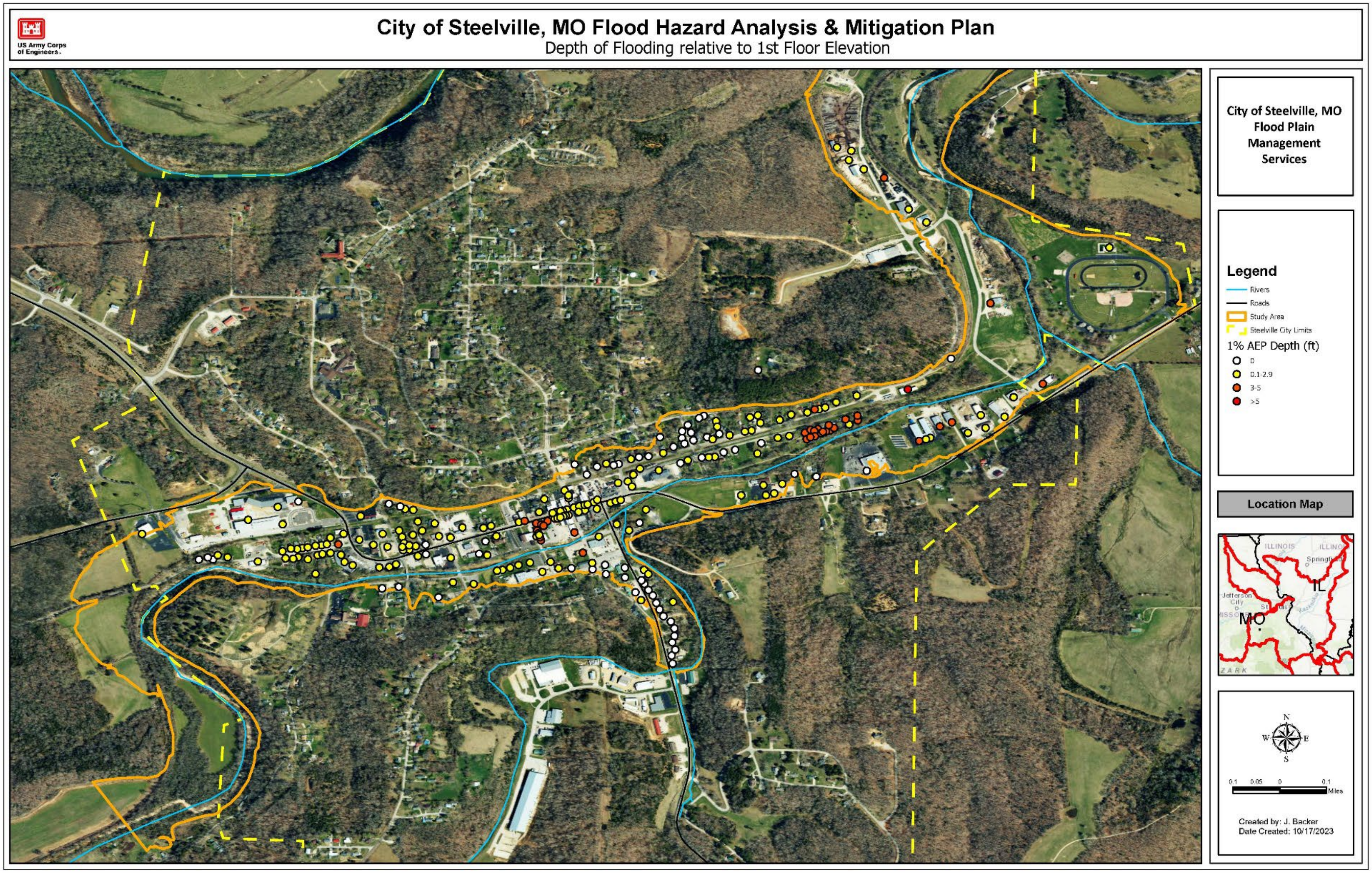

FIGURE 14. STEELVILLE, MO DEPTH OF FLOODING RELATIVE TO 1ST FLOOR ELEVATION (1% AEP EVENT)

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6.0 EVALUATION OF STRUCTURAL MEASURES TO REDUCE FUTURE FLOOD DAMAGES

Structural flood risk management measures are physical modifications to the floodplain or floodway designed to reduce the frequency of damaging levels of flood inundation. Structural measures can be designed to act as a physical barrier between floodwaters and structures at risk of being damaged by those floodwaters or as a means of storing floodwaters upstream. Examples of structural measures include dams with reservoirs, dry dams, channelization measures, levees, walls, diversion channels, pumps, and bridge modifications. As part of structural measure evaluation, Bentley's Open Road Designer software was used to analyze existing terrain features and to model the proposed structural measures. Within the study area, there is limited space between business structures and Yadkin Creek for the installation of structural measures such as levee and floodwalls and not included in the scope of this study.

The scope of the study included the evaluation of the following structural measures:

1. Detention basins
2. Channel modification, including evaluating low water crossings and culverts.
3. Combination of detention basins and channel modification

6.1 Evaluation of Detention Basins

Detention areas were evaluated as a potential flood risk reduction measure in order to reduce volume of water in Yadkin Creek in the City of Steelville. A detention basin is a storage area designed to mitigate adverse flood impacts by detaining water and gradually releasing it back into the channel, thereby reducing the peak flood elevation downstream. Detention basins function in similar manners to flood risk management dams and provide flood risk benefits across different storm and flood events.

There are two types of detention basin designs: "In-Line", where the basin is placed on the normal stormwater drainage path with the purpose of intercepting the stormwater prior to making it to the channel, and "Off-Line", where the basin is placed along the channel and floodwater overflows into the channel, reducing the water level downstream. Both types of detention basins were considered for this study. Due to the real estate challenges related to lack of space near railroad right-of-way and Yadkin Creek, an in-line detention basin was determined to be a nonviable option.

For this study, a typical off-line detention basin was evaluated. The conceptual design includes a containment levee, weir control structure, culvert, and concrete swale to drain the basin after flood events. The proposed design of the containment levees for each basin would be based on the results of subsurface exploration along its alignments. The design would include settlement and seepage analysis to ensure the containment levee's ability to contain water. A conceptual design for a typical off-line detention basin is presented in FIGURE 15. The basins were designed as dry detention areas which means the basin would remain dry during non-flood conditions, so that maximum storage would be available during storm events.

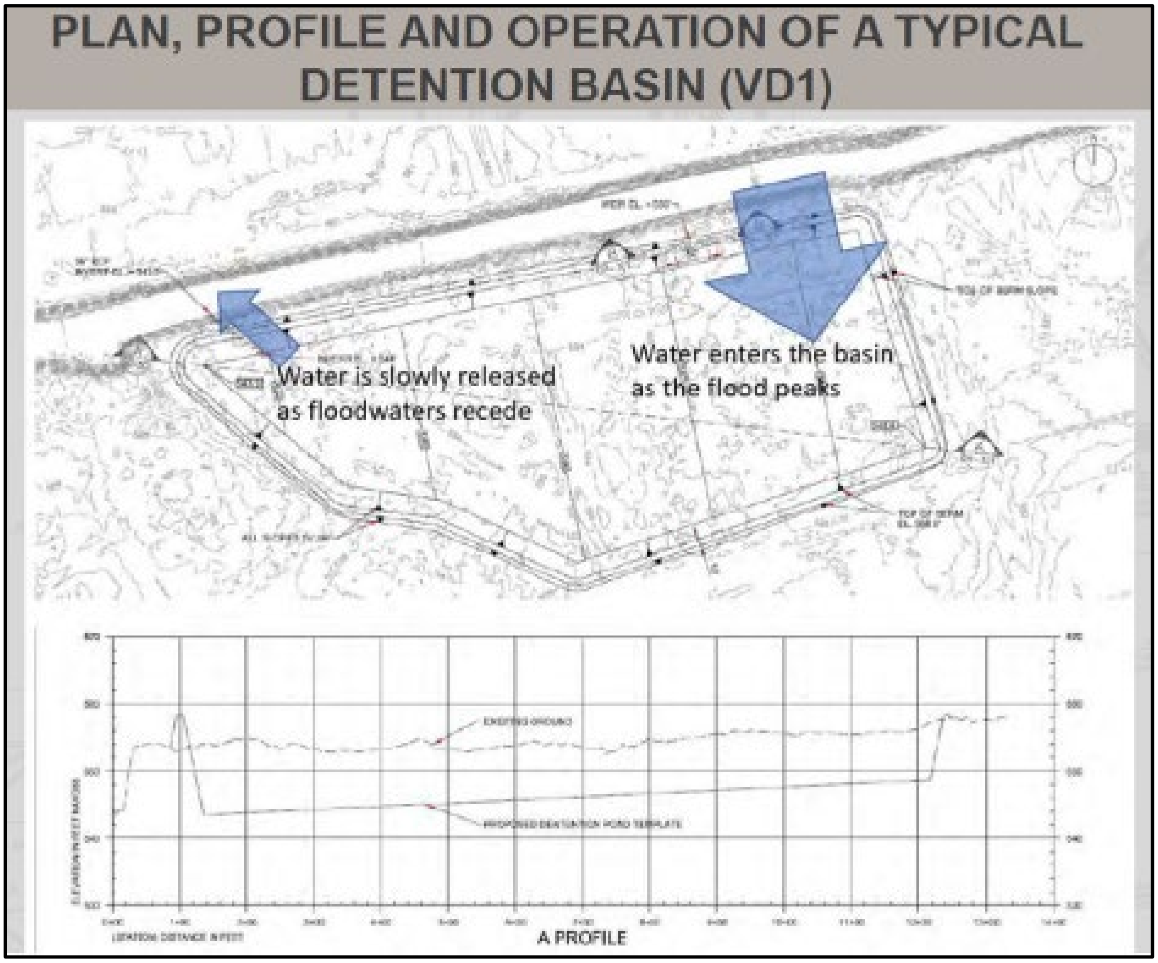

FIGURE 15. CONCEPTUAL DESIGN FOR TYPICAL OFFLINE DETENTION BASIN

Considerations for selecting the potential detention basin sites included using undeveloped acreage that is located upstream of the study area, areas that are in close proximity to Yadkin Creek, and areas with suitable existing ground elevations that will allow for floodwaters to flow in while also able to detain a significant amount of water. For this study, the proposed detention basins are located in agricultural areas. For the purpose of this study, we assumed the railroad right-of-way is required to remain undisturbed. This required the use of culverts to route water from Yadkin Creek to the proposed detention basins. If it is determined that the railroad can be impacted, the use of large and expensive culverts would not be necessary, and the orientation of the detention basins could be altered.

6.1.1 Alternative 1: Combination of Three (3) Detention Basins

Through hydrologic modeling and evaluation, it was determined that it was necessary to construct multiple detention basins in order to provide flood risk reduction. Alternative 1 (FIGURE 16) includes the construction of three (3) detention basins, each consisting of a containment levee, inlet structure, and a three feet wide concrete swale that drains to an outlet pipe. The design of each of the proposed detention basins would include stone revetment (riprap) placed at the inlet and outlet of each detention basin to slow water velocities and to reduce the potential for scour. The containment levees have 1V:3H side slopes and a 12’ crown to allow for maintenance access. Material excavated for construction of the detention basin could be utilized for the construction of the containment levee, however suitability of material is unknown and would have to be further evaluated. Detention basin 1 was designed with a concrete weir structure, but due to the proximity to the railroad, detention basins 2 and 3 utilize parallel culverts to avoid disturbance to the railroad and to route floodwaters from Yadkin Creek into the detention basins. The interior height of the proposed basins (from levee top to toe) is consistent throughout each basin, the exterior height would be dependent on the surrounding ground elevation.

Detention Basin 1 is located adjacent to Yadkin Creek near Steelville City Cemetery consisting of approximately 12 acres and a storage volume of approximately 129 acre-feet. This location is a large undeveloped area, but it is also in an area that floods, which will require the construction of a containment levee. The containment levee top elevation is 790’ (NAVD88) and the containment levee bottom elevation is 774’ (NAVD88).

Detention Basin 2 is located adjacent to Yadkin Creek, upstream from Detention Basin 1, between Cedar Lane and Church Street, consisting of an area of approximately 37 acres and a storage volume of approximately 335 acre-feet. This location is in an agricultural field that partially floods, which will require the construction of a containment levee. The containment levee top elevation is 805’ (NAVD88) and containment levee bottom elevation is 795’ (NAVD88).

Detention Basin 3 is located adjacent to Yadkin Creek, upstream of Detention Basin 2, near Cedar Lane, consisting of an area of approximately 25.5 acres and a storage volume of approximately 206 acre-feet. This location is in an agricultural field that floods, which will require the construction of a containment levee. The containment levee top elevation is 821’ (NAVD88) and design bottom elevation is 810’ (NAVD88).

Using the intersection of Main Street and 4th Street as a reference point, the combination of the three (3) proposed detention basins reduced flood conditions at varying levels depending on the flood event. For more frequent rain events (10%-2% AEP), Alternative 1 would reduce flooding depths by approximately 25%-31%. Analysis showed an approximate 0.2 foot flood depth reduction during the 10% AEP event, approximately 0.4 foot flood depth reduction during the 4% AEP event, and approximately 0.8 foot flood depth reduction for the 2% AEP event. For less frequent events, such as 0.2% AEP, the three (3) detention basins were not as effective, only reducing flooding depths by approximately 1 foot or 18%. For a 1% AEP flood event, the combination of 3 detention basins would reduce flooding depths by approximately 1.6 feet, or 45%.

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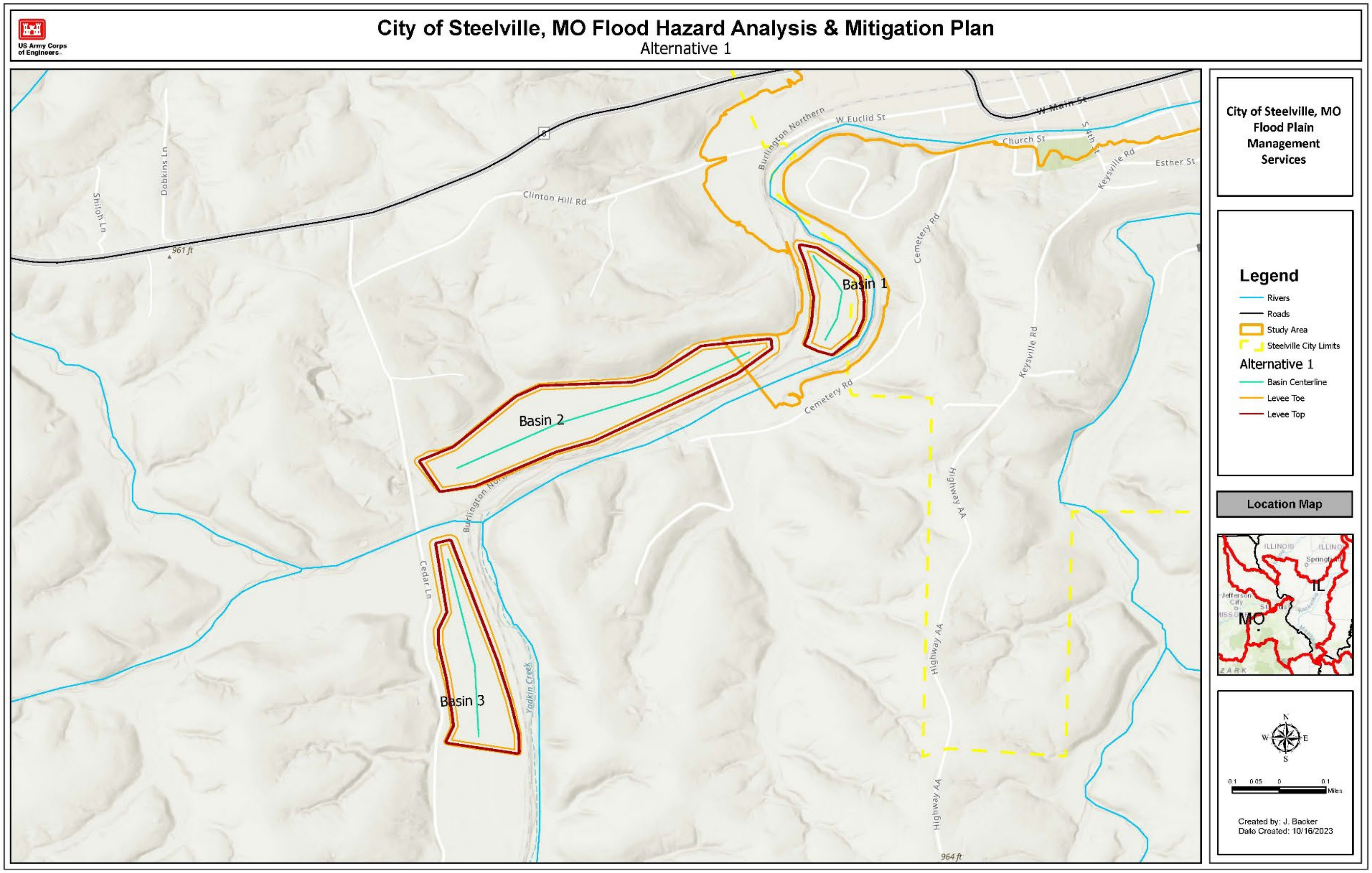

FIGURE 16. PROPOSED ALTERNATIVE 1: COMBINATION OF 3 DETENTION BASINS

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6.1.2 Cost Estimate: Alternative 1: Three (3) Detention Basins

A total estimated cost for Alternative 1, along with mobilization / demobilization and other contingencies, is $22,130,000 (FY23). Planning, engineering, and design (PED) along with contingencies, construction management and real estate costs were included based off standard percentages of the total construction costs. The cost estimate for this alternative is based off historical construction data. Appendix B: Cost Estimate - TABLE B1 contains a cost breakdown for Alternative 1.

6.2 Evaluation of Channel Modification

The potential for a creek channel modification within Yadkin and Whittenburg Creeks was analyzed for this study, with the primary method being dredging (deepening) the channel in combination with widening the channel by excavation. This provides a greater channel capacity and thus keeps more floodwater within the creek banks and reduces the water surface elevation at the focus area for the project. 1V:2H channel side slopes were used throughout the channel modification for simplicity, but slope stability and strength design will be required to be evaluated if the city chooses to pursue this structural measure.

FIGURE 17 shows a typical cross section of a channel modification and FIGURE 18 shows potential slope stabilization methods to be used to prevent erosion after excavation of the channel. All details in FIGURE 18 are conceptual and not to be used for construction and would require further evaluation. A typical bank stabilization (FIGURE 19) was developed for one stream bend in Steelville that included half bank full protection on the upstream and downstream ends of the concave bank and a two-thirds bank full protection throughout the middle reach of the stream bend. The convex bank has half bank full protection at the downstream portion of the bend. Additionally, a grade control structure is present at the end of the bend to provide protection from head cutting. The quantities for bank stabilization were related to stream bend length and then extrapolated to the other bends located throughout the study area in order to determine bank stabilization costs.

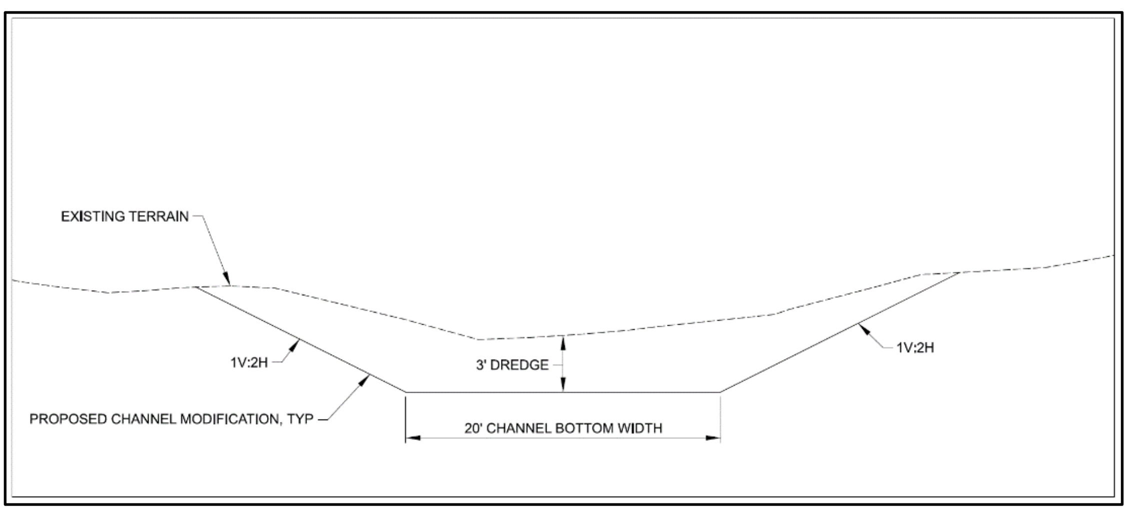

FIGURE 17. CONCEPTUAL DESIGN OF A CHANNEL MODIFICATION

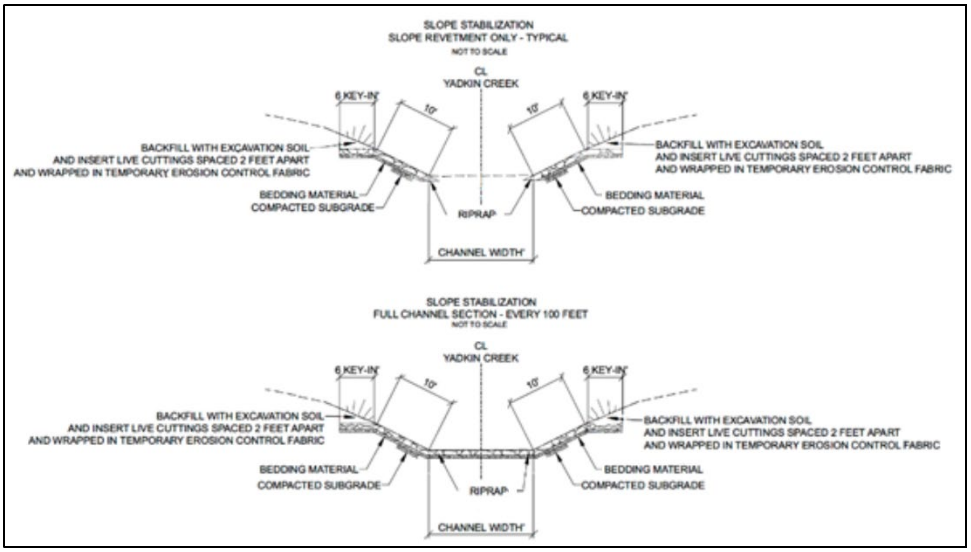

FIGURE 18. CONCEPTUAL CHANNEL SIDE SLOPE STABILIZATION DESIGN

FIGURE 19. TYPICAL BANKS STABILIZATION PLAN VIEW

6.2.1 Alternative 2: Yadkin and Whittenburg Creeks Channel Modification

This alternative includes the dredging of the creek channel combined with channel widening to provide a greater channel capacity within Yadkin Creek and downstream of the confluence of Whittenburg Creek. The proposed channel modification would begin upstream of Steelville, north of Cemetery Road, and extend downstream to the County Road 545 (Sanke Road) bridge spanning Whittenburg Creek (FIGURE 20). Although Yadkin Creek is the primary cause of flooding in Steelville, it is critical to extend the channel modification past the confluence of Yadkin and Whittenburg Creek to provide channel continuity and prevent bottlenecking and backflow. This alternative provides an additional 43.1 acre-feet of storage. For this analysis, dredging the creek channel would consist of lowering the current surveyed bottom channel by three feet by removing existing sediment / gravel. Channel widening provides greater channel capacity by cutting back the side slopes (1V:2H) of the current channel shape. (FIGURE 17 shown above). Additional capacity varies from 100-300 sq. feet per cross section along the approximately 14,500 feet long channel modification. Channel bottom width increases from 20 feet to 40 feet downstream of the confluence of Yadkin and Whittenburg Creeks.

A channel modification design requires a continuous open channel free from obstruction for efficient flow of water. Because of this, all low water crossings and bridges were removed during model analysis of the study area (Yadkin and Whittenburg Creeks) to avoid flow constriction and to maximize the conveyance of flow. In order to avoid additional major infrastructure construction, the proposed dredging and widening for this study was adjusted to flow under the Highway 8 bridge in its current configuration. Additionally, modeling showed negligible flood depth reduction associated with the removal of this bridge. As a result, the Highway 8 bridge was not considered for removal or redesign in this study. If channel modifications are pursued, further design and analysis will be required.

Considerations associated with the proposed channel modification would include the ability to provide long term maintenance of the channel and identifying the responsible party for maintenance activities. Other considerations include determining the placement of excavated dredged material, environmental impacts, and verifying bank stabilization requirements. Real estate considerations associated with widening of the creek channel include acquisition, easements, adjoining landowner impacts, and creating impacts (positive or negative) on upstream or downstream areas. The designed slopes for the channel modification would require slope stabilization to protect the slopes from erosion from the creek flows. A conceptual slope stabilization design is provided in FIGURE 18 (above).

Using the intersection of Main Street and 4th Street as a reference point, the proposed channel modification could potentially reduce flood risk at varying levels depending on the flood event. For a 1% AEP flood event, the channel modification reduced flooding depths by 0.7 feet, or 19%. For more frequent flood events (10%-2% AEP), Alternative 2 could potentially reduce flood depths by approximately 32%-67%. Analysis shows an approximate 0.2-foot flood depth reduction during the 10% AEP event, approximately 1.1 foot flood depth reduction during the 4% AEP event, and approximately 0.9 foot flood depth reduction for the 2% AEP event. For less frequent events (0.2% AEP), the channel modification was not as effective, only reducing flooding depths by 0.6 feet or 10%. The proposed modification to Yadkin Creek provides additional capacity within the creek channel, which reduces flood depths in Steelville, but as a standalone measure, the proposed channel modification does not provide enough flood depth reduction at infrequent flood events (1%-0.2%) to be considered a viable option.

6.2.2 Cost Estimate: Alternative 2: Channel Modification

An approximate total cost for Alternative 2, along with mobilization / demobilization and other contingencies is approximately $4,875,000 (FY23). Planning, engineering, and design (PED) along with contingencies, construction management, and real estate costs were included based off standard percentages of the total construction costs. The cost estimate for this measure is based off historical construction data. APPENDIX B: Cost Estimates contains a cost breakdown for Alternative 2.

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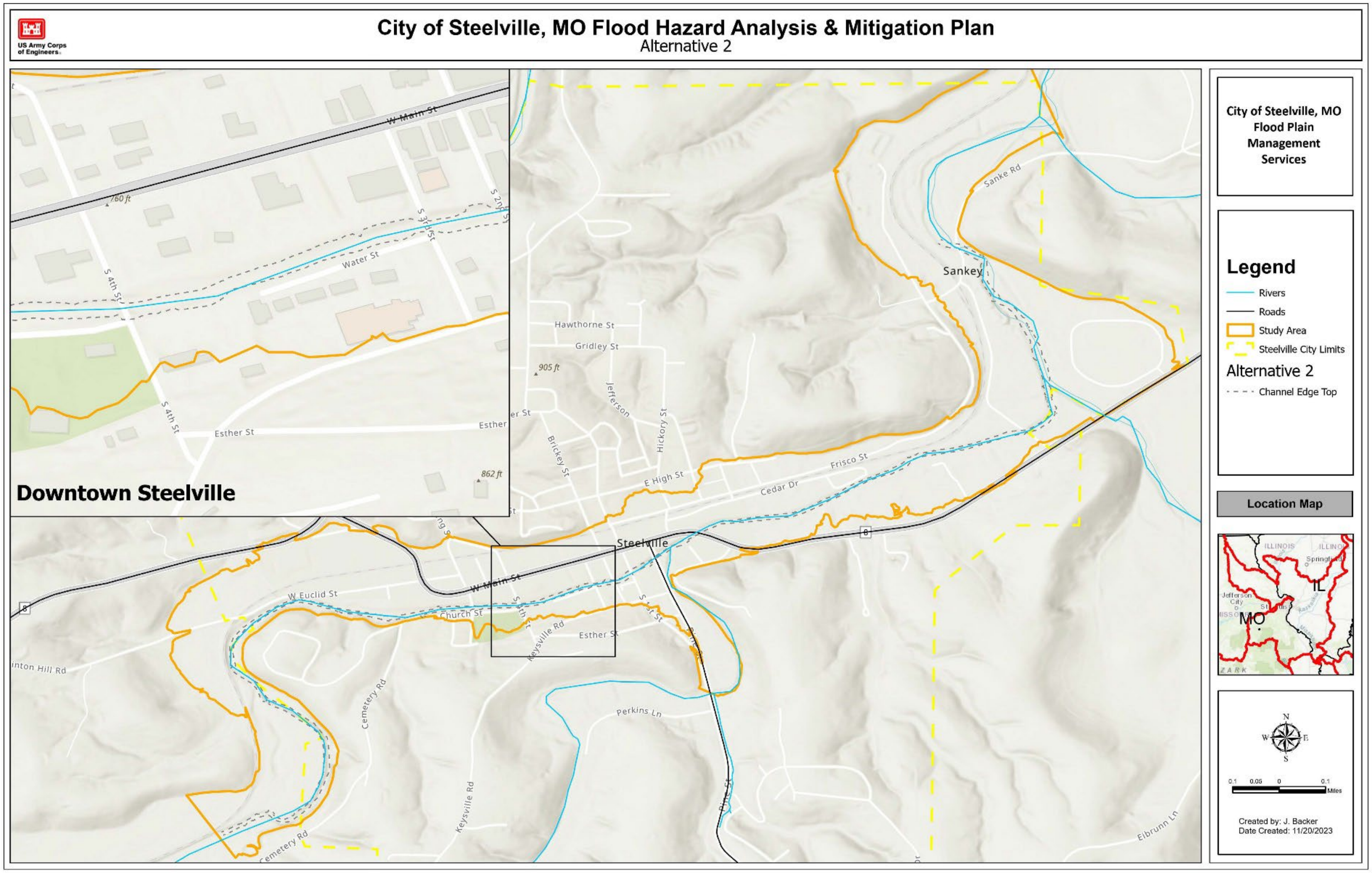

FIGURE 20. PROPOSED ALTERNATIVE 2: CHANNEL MODIFICATION

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6.3 Evaluation of Combination of Channel Modification and Detention Basins

This alternative involves the combination of dredging Yadkin Creek to increase flow capacity combined with detention basins for the purposes of upstream stormwater detention.

6.3.1 Alternative 3: Combination of 3' dredge of channel with three (3) detention basins

Alternative 3 (FIGURE 21) includes the proposed channel modification included in Alternative 2 combined with three detention basins, similar to basins described in Alternative 1. In this alternative, detention basins 1 and 2 are proposed to be reconfigured and deepened to provide additional capacity. The proposed design of detention basin 3 remains unchanged. The redesigned versions of detention basins 1 and 2 provide 144.3 acre-feet and 469.3 acre-feet of storage respectively. The combination of the three detention basins and the channel modification has the potential to store a total of 862.7 acre-feet of water. When comparing flood depths at 4th street and Main, Alternative 3 is most effective at reducing flood depths in the study area.

Using the intersection of Main Street and 4th Street as a reference point, the proposed combination of three (3) detention basins and a channel modification could potentially reduce flood risk at varying levels depending on the flood event. For a 1% AEP flood event, the combination of detention basins and a channel modification reduces flooding depths by approximately 2.4 feet, or 68%. For more frequent flood events (10%-2% AEP), Alternative 3 reduced flooding depths by approximately 32%-76%. Analysis showed approximately 0.2 foot flood depth reduction during the 10% AEP event, approximately 1.2 foot flood depth reduction during the 4% AEP event, and approximately 1.7 foot flood depth reduction for the 2% AEP event. For less frequent events (0.2% AEP), the combination of detention basins and a channel modification were not as effective, reducing flooding depths by approximately 2.2 feet or 37%.

6.3.2 Cost Estimate: Alternative 3: Combination Channel Modification and three (3) Detention Basins

An approximate total cost for Alternative 3, along with mobilization / demobilization and other contingencies is approximately $28,790,074 (FY23). Planning, engineering, and design (PED) along with contingencies, construction management, and real estate costs were included based off standard percentages of the total construction costs. The cost estimate for this measure is based off historical construction data. APPENDIX contains a cost breakdown for Alternative 3.

6.4 Low Water Crossings

As described in Section 3.1.1, the study area includes a series of low water crossings (LWC) along Yadkin and Whittenburg Creeks which constrict the conveyance of flow during flood events. In order to maximize the effectiveness of a proposed channel modification during modeling, it is typical to omit structures, such as bridges and low water crossings, that would potentially constrict flows within a channel. Low water crossings and bridges were removed as part of modeled structural Alternatives 2 and 3, that included a proposed channel modification. However, Highway 8 was included in the model to avoid major infrastructure construction, such as a bridge or a road redesign and construction.

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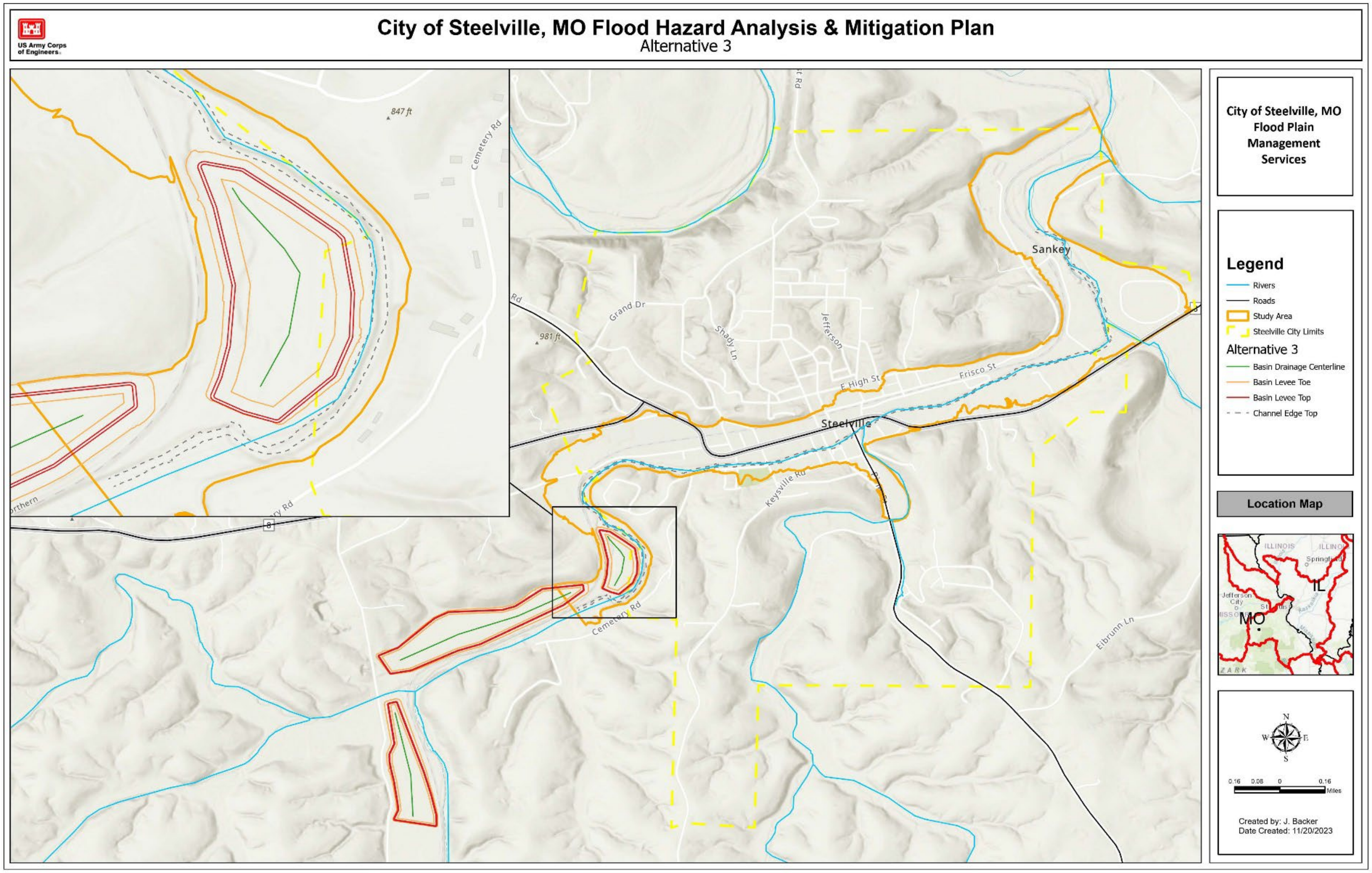

FIGURE 21. PROPOSED ALTERNATIVE 3: COMBINATION OF DETENTION BASINS AND 3' CHANNEL MODIFICATION, YADKIN CREEK

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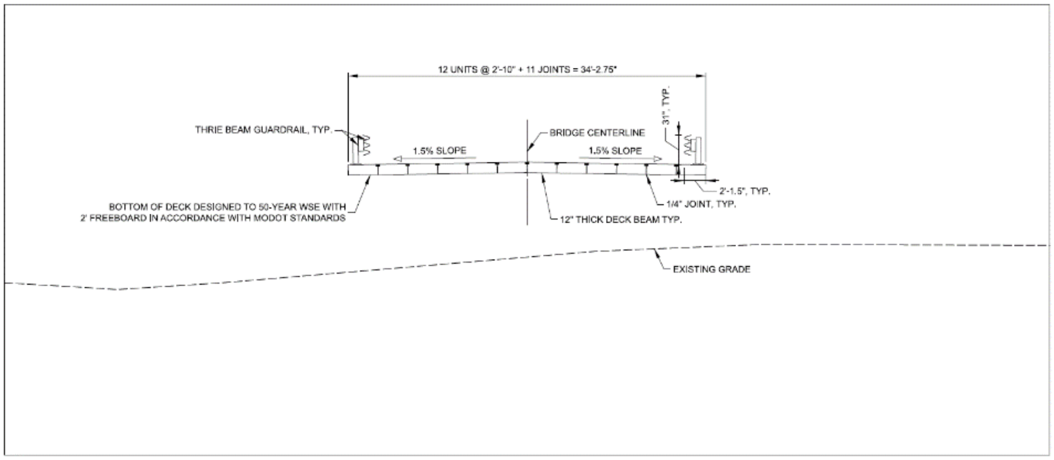
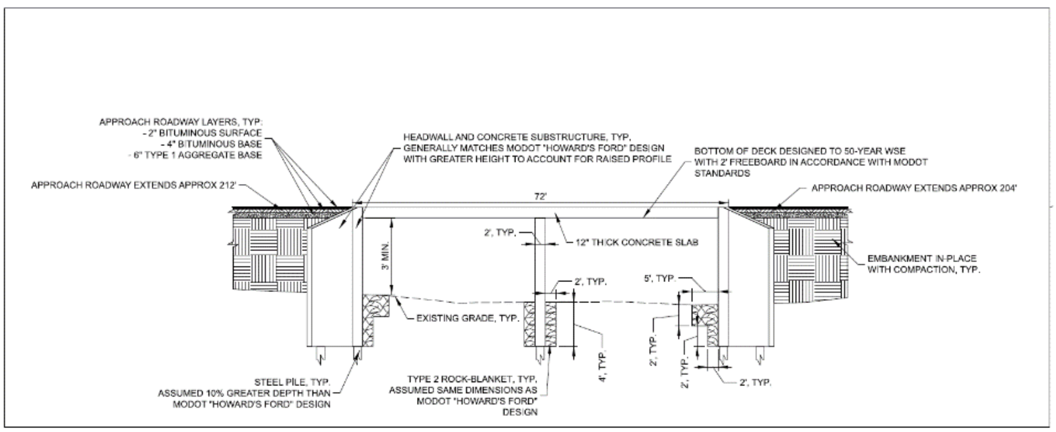
City officials expressed the need for modifications to the three low water crossings located at 3rd Street, Green Trail crossing, and Industrial Drive. Individual designs for low water crossing modifications in the study were not completed as part of this report. However, in April 2023, the Meramec Low Water Crossing Multi-Jurisdictional State Risk Management Team via the Silver Jackets program completed the *Meramec Watershed Low Water Crossing Mitigation Plan, Missouri*. The geographic scope of the report includes the Steelville area and provides specific information for the Industrial Drive low water crossing location (Section 6.4.1 below). The report includes conceptual designs for a low water bridge crossing, prefabricated arch crossing, and an oversized culvert crossing, as well as considerations and estimated costs for each design. The city could potentially utilize these conceptual designs (FIGURES 22, 23, 24) for low water crossing replacement in the study area. Estimated costs to remove the low water crossings that constrict the flow of Yadkin creek were accounted for in Alternatives 2 and 3 (channel modifications) cost estimates in APPENDIX B. Parametric costs for replacement of a low water crossing were taken from the *Meramec Watershed Low Water Crossing Mitigation Plan* and are provided for consideration by the city. The estimated costs for low water crossing replacement were not included in the alternatives. The cost estimates for low water crossing replacement may vary depending on the quantities needed for each line item, therefore, further analysis would be required if low water crossing replacements are pursued in the future. A copy of the *Meramec Watershed Low Water Crossing Mitigation Plan* will be provided to the city as supplemental information to this report.

6.4.1 Industrial Drive Low Water Crossing

As part of the *2023 Meramec Watershed Low Water Crossing Mitigation Plan*, the Industrial Drive crossing was one of the 118 crossings examined for several critical categories such as life safety, hydraulic conditions, traffic volume, and aquatic organism passage. The Industrial Drive crossing ranks high overall in several categories. For example, this crossing on Yadkin Creek directly impacts 144 structures with a daytime Population at Risk (PAR) of 644. Population at risk (PAR) is defined as the number of people within a study area that would be subject to inundation during a flood event. The Industrial Drive crossing is also considered the highest risk for life safety with 10 estimated life loss at the 95th percentile. The life loss estimation was conducted on USACE's Life Sim model for the 1% AEP on the Meramec River basin.

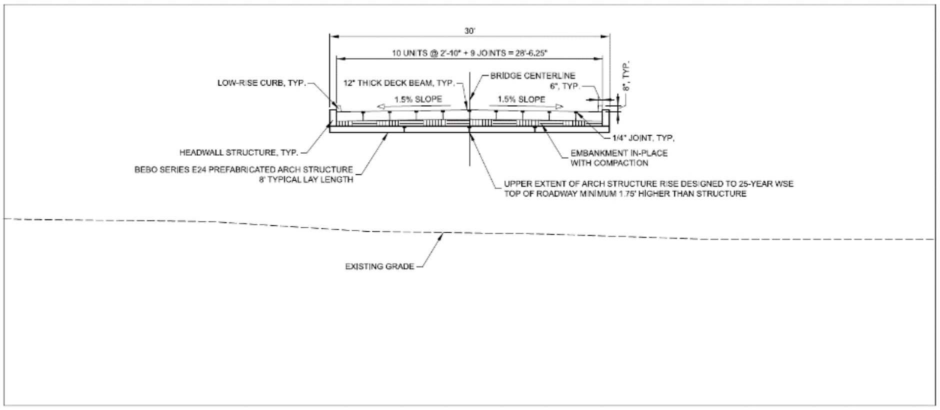


H1 LOW-WATER BRIDGE DESIGN CROSS-SECTION VIEW
SCALE: NTS

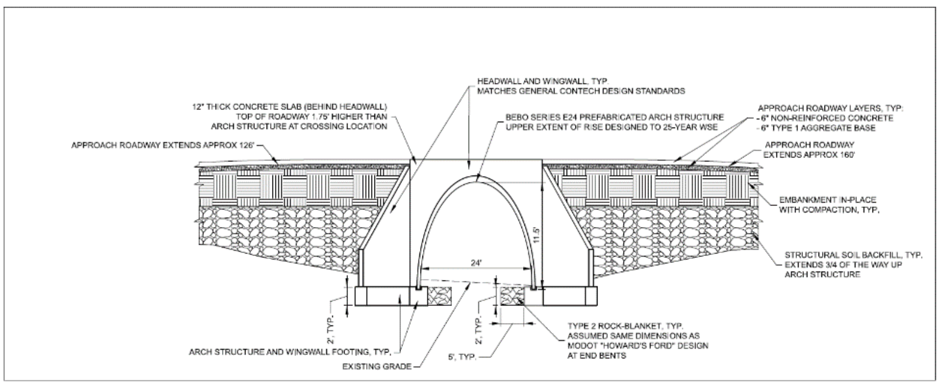


A1 LOW-WATER BRIDGE DESIGN PROFILE VIEW
SCALE: NTS

FIGURE 22 – TYPICAL LOW WATER BRIDGE DESIGN



H1 PREFABRICATED ARCH CROSSING DESIGN CROSS-SECTION VIEW
SCALE: NTS



A1 PREFABRICATED ARCH CROSSING DESIGN PROFILE VIEW
SCALE: NTS

FIGURE 23 – TYPICAL PREFABRICATED ARCH CROSSING DESIGN

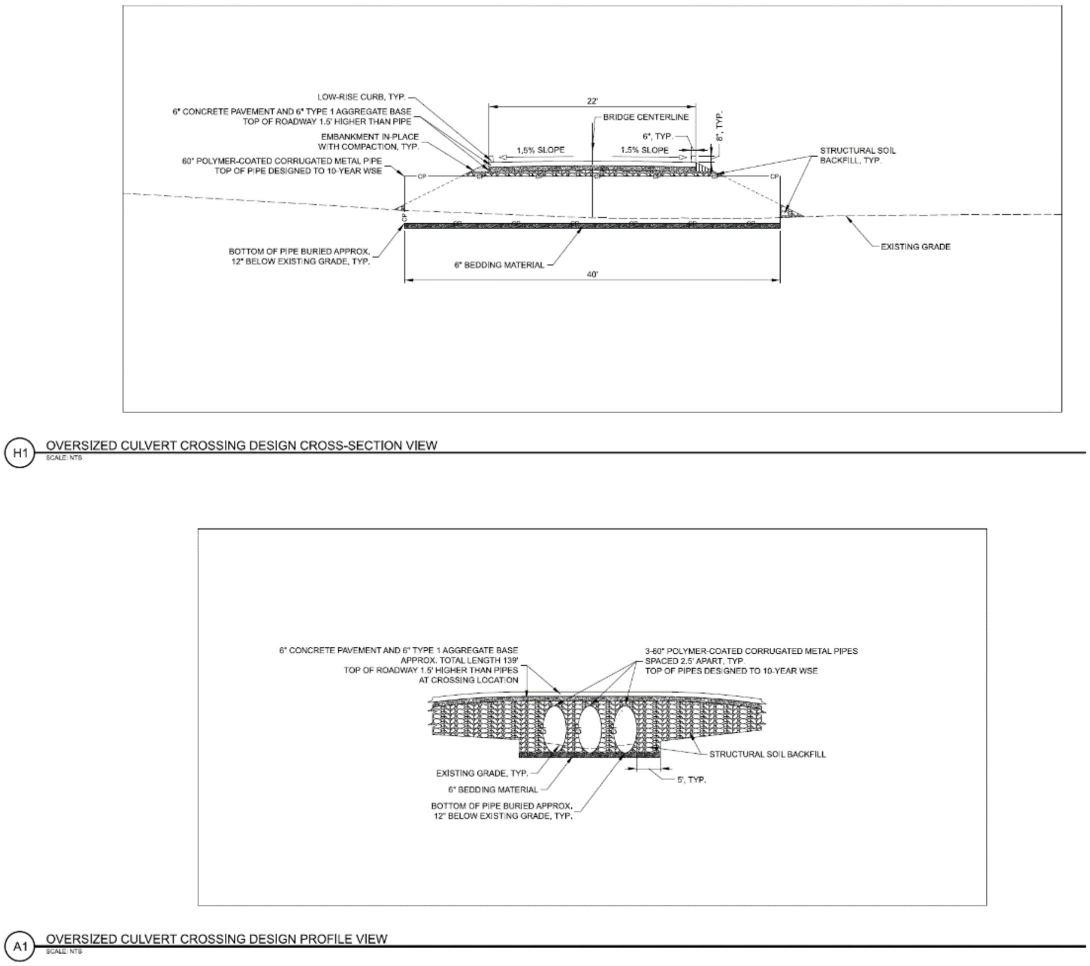


FIGURE 24 – TYPICAL OVERSIZED CULVERT CROSSING DESIGN

7.0 EVALUATION OF NONSTRUCTURAL MEASURES

7.1 General Nonstructural Mitigation Measures

Nonstructural measures reduce flood damages without significantly altering the nature or extent of flooding. Damage reduction from nonstructural measures is accomplished by changing the use of the floodplains or by accommodating existing uses to the flood hazard. They can be considered independently or in combination with structural measures. Nonstructural floodproofing is an umbrella term that incorporates flood mitigation techniques that do not involve structural methods such as berms, levees, floodwalls, flood gates, etc. Instead, nonstructural floodproofing can be broken down into three major strategies:

1. Dry or Wet Floodproofing
2. Elevation
3. Structure Acquisition or Relocation

The nonstructural plan develops mitigation methods based on the structure foundation type, occupancy type and local flooding characteristics. Each flood-prone structure in the study area has been evaluated for its structural attributes, hydraulic conditions and estimated cost of nonstructural flood mitigation. All alternatives in this report are preliminary and are subject to a detailed field survey and site-specific cost estimate. APPENDIX includes a summary of Nonstructural flood mitigation methods for flood-prone structures in the study area. For more information on various flood mitigation products, reference the Flood Mitigation Certification Program (https://floodmitigationcertification.org/), which was created in 2012 by the Association of State Floodplain Managers in partnership with Floodplain Managers and the USACE.

7.1.1 Dry Floodproofing

Dry floodproofing attempts to keep water away from the structure by creating a watertight seal with exterior barriers such as impervious sheeting, waterproof walls, watertight shields for doors and windows, and drainage collection systems such as a sump pump. Dry floodproofing is best for slab foundation structures and flood depths of approximately three (3) feet or less, which limits hydrostatic forces pushing on subfloor areas. This measure achieves flood risk management benefits but is not recognized by the NFIP for any flood insurance premium rate reduction if applied to residential structures. In certain flooding scenarios (such as flash flooding) the temporary dry floodproofing measures (such as installing door barriers) require some early warning for the owner/tenant to be able to install the closure(s) and safely evacuate the premises prior to the arrival of floodwaters. FIGURE 25 shows a diagram that summarizes the features of dry floodproofing.

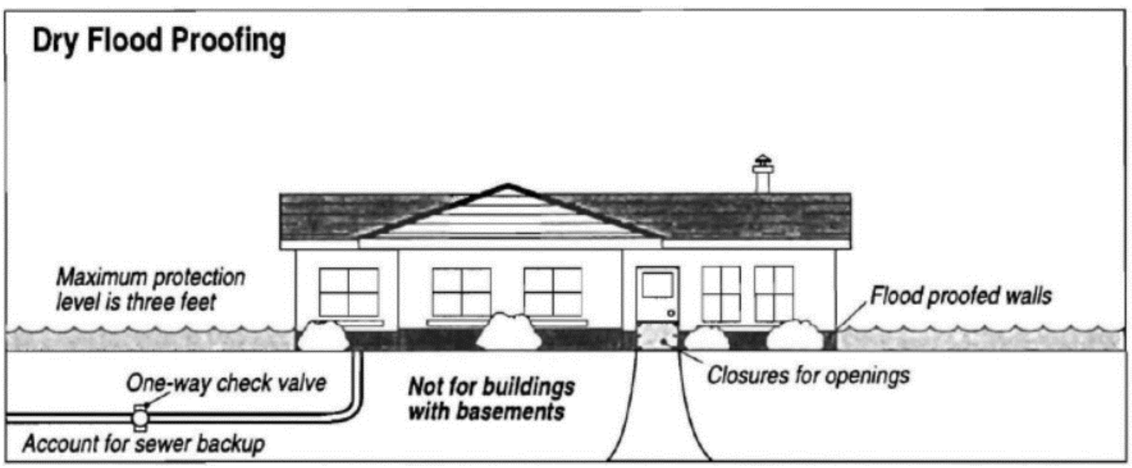


FIGURE 25. NONSTRUCTURAL DRY FLOODPROOFING DIAGRAM

7.1.2 Wet Floodproofing

Wet floodproofing allows water to enter the structure as it naturally would, but this inundation would not cause damages because the utilities, appliances, or other high value items would have already been moved to a higher elevation within the structure. The benefit of allowing water into a structure is to equalize or lessen the load on floors and walls from the effects of hydrostatic forces. While not typically recommended, a residential structure can be wet floodproofed by being constructed and finished with water resistant materials as shown in FIGURE 26. Wet floodproofing is best suited for warehouse structures given the open floorplans that can be retrofitted to elevate high value machinery and inventory. If the structure does have a subfloor area such as a basement, it is commonly recommended to fill the basement with sand or other material and relocate the lost square footage into a new addition above the base flood elevation. It is worth noting that wet floodproofing cannot be used to bring a residential structure into compliance with the community's floodplain management ordinance.

FIGURE 26. WET FLOODPROOFING DIAGRAM

7.1.3 Elevation

Elevation is the lifting (or raising) of an existing structure to an elevation which reduces flood damages to a desired level (typically equal to or greater than the 1% annual chance flood elevation). The final elevation should place the first floor and associated ductwork, plumbing, mechanical and electrical systems above the design water surface elevation (FIGURE 27). In many elevation scenarios, due to the costs incurred for mobilizing, the additional feet in elevating the structure after the first foot is lesser in cost. Elevation can be performed using fill material, on extended foundation walls, on piers, posts, piles, and columns. It is possible that the structure being assessed has an existing crawlspace or basement which would require abandoning to reduce future flood damages and to implement the structural supports for the elevation. Abandonment would consist of filling in the existing basement or crawlspace with clean fill material and possibly capping with concrete. If the basement or crawlspace is abandoned, a small addition may need to be constructed on the side of the structure above the projected water surface elevation to contain utilities and mechanical equipment. If the addition could not be implemented because of limited space within the parcel or because the owner did not want it, partial compensation for the lost space would be paid to the owner.

Elevating a structure is generally considered more expensive than floodproofing but is more likely to provide more benefits by raising the structure above the base flood elevation. For this strategy, the structure is elevated from its existing foundation material onto a new foundation. Each foundation type has its own challenge to elevate with crawlspace foundations being easiest and slab foundations being the most challenging. Similar to other floodproofing alternatives, any utility from a basement would be lost as the only subfloor area allowed under NFIP regulations would be an enclosure with the appropriate number of vents to allow for hydrostatic pressure equalization.

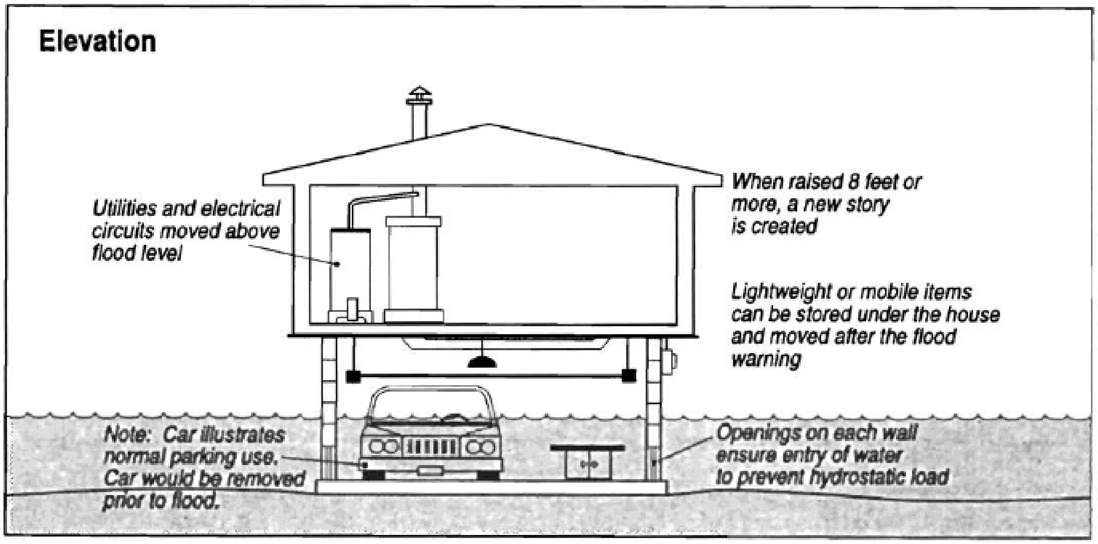


FIGURE 27. NONSTRUCTURAL ELEVATION DIAGRAM

7.1.4 Acquisition and Relocation

Structure acquisitions (buyouts) and relocations are mitigation strategies that remove the hazard from the floodplain which is the only nonstructural alternative that permanently reduces flood risk.

Relocations: The relocation of a structure requires physically moving the existing at-risk structure away from the flood hazard area to a location which is completely outside of the floodplain. The land where the structure was originally located is purchased, becoming deed restricted to prevent development from occurring in the future, and becomes available for open space management as stipulated by the NFIP. Relocation makes the most sense when at-risk structures can be relocated from a high flood risk area to a location of no flood risk. Where possible, relocating a structure within its existing community continues to support the local tax structure which could otherwise be adversely impacted by a significant number of acquisitions and provides societal cohesion for the displaced property owners. Permanent relocation and conversion to open space reduces the risk for flood damages, causes no increase in flood potential elsewhere, and improves the natural riparian environment.

Acquisitions: Property acquisition consists of purchasing the at-risk structure and land that the structure sat upon. The structure is either demolished or sold to others and relocated to a site outside of the floodplain. The land where the structure was originally located is purchased, becoming deed restricted to prevent development from occurring in the future, and becomes available for open space management as stipulated by the NFIP. Property acquisition and structure removal are usually associated with frequently damaged structures. Implementation of other measures may be effective but if a structure is subject to repeated damage, this measure may represent the best alternative to eliminating risks to the property and residents in perpetuity. Acquisition and conversion to open space reduces the opportunity for flood damages, causes no increase in flood potential elsewhere, and improves the natural riparian environment.

7.1.5 Nonphysical Nonstructural Mitigation

Nonphysical nonstructural mitigation measures consist of plans to prepare for, respond to, and recover from flood events based on known flood hazards and vulnerabilities. Based on the time and scale of flooding, the following nonphysical nonstructural mitigation measures could be further evaluated as potentially viable options for the City of Steelville. TABLE 8 outlines potential applicable measures based on time scale.

Public Flood Warning Systems: 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. Shelter locations and reunification sites should be featured components of any evacuation plan.

Land Use Policies and Regulations: Land use regulations include the following potential actions:

- Regulatory NFIP floodplain management ordinance
- Regulatory NFIP flood maps and floodways
- Development permitting
- Zoning Maps
- Building codes
- Critical structure development practices
- Redevelopment processes
- Freeboard or stream setback ordinances
- Comprehensive plans

This tool covers both development policies and land use regulations. Development policies could be found in the various community-wide plans for the city and the county (i.e., comprehensive plans, master plans, economic development strategic plans, etc.). These policies help guide the community decisions of where new development or redevelopment should occur.

Warning Dissemination, Multi-Media: As a flood risk communication tool, multi-media approaches have considerably advanced technologically, although other more traditional means are also still very much relevant. Communities could promote use of social media and website announcements during major flooding events. Another effective tool would be to formalize public media engagement in a new emergency action plan.

Flood Emergency Preparedness Plans (or Emergency Action Plans): Inter-related to the flood warning system is an emergency preparedness plan for flooding. Generally speaking, emergency preparedness plans include several topics related to identifying the risk:

- *Emergency Operation Plan* – An emergency operation plan is the core of the emergency preparedness plan. The flood emergency operation plan is designed to provide needed actions based on existing or forecasted water levels. Using flood inundation mapping, Emergency Managers for the city and county can define action stages when certain emergency response actions should be initiated. These action stages could be the activation of an Emergency Operation Center, the signaling of emergency sirens, warning lights and multi-media warnings, mobilization of emergency personnel, closing of roads at risk of flooding and evacuation of impacted areas.

- *Emergency Communication Plan* – As with any emergency situation, communicating to the public is key to describe the event, discuss what risks are associated with the event, and explain what actions should be taken to lessen the impacts of the event. An emergency can be chaotic and at times communicating the risk and other needed information is not always adequately accomplished. An emergency communication plan can create a framework to establish who will provide the needed communication to the public, what communication media will be used and generally what the message will be. The added benefits to a detailed emergency communication plan are the effective use of emergency personnel, the timely flow of information about the risk, and the establishment of a dedicated and reliable source of information which will reduce the duplication of messages and/or confusion and rumors.

- *Emergency Evacuation Plan* – By their very nature, emergencies are not predictable and can occur anytime and anywhere. The timing of flood emergencies is generally unpredictable, but the location of a flood event is well known. With modern flood models and mapping software, the location, depth and even velocity of a ravine flood event can be provided to emergency response professionals. Armed with this information, it can readily be shown what areas of the community will flood first and how large the impact from the flooding will be. This information is invaluable to determining how many people will be impacted, social characteristics that may create unique circumstances or challenges in evacuating an area (i.e., low car ownership population, English as a second language population), and what routes will be available to get the impacted people out of harm's way. This information can also assist in determining short and long term emergency shelter needs and locations of these shelters.

TABLE 8. EXAMPLE TIME SCALE OF FLOOD EVENTS AND APPLICABLE NONPHYSICAL MEASURES

Time Scale	Applicable Measures
Hours	Risk communication Flood warning systems
Days to Weeks	Flood emergency preparedness plan Evacuation plan
Months to Years	Floodplain management plan Floodplain mapping
Multiple Years	Zoning/land use Building codes

7.2 Flood Nonstructural Mitigation Methodology

This study utilized the *Lower Meramec Basin, Multi-Jurisdictional Floodplain Management Plan, April 2020: APPENDIX E: Analysis of National Nonstructural Committee Assessment* for development of flood mitigation methodology. Each structure in the 0.2% AEP floodplain within the study area was individually evaluated and included engineering and economic considerations to develop the final nonstructural mitigation plan.

7.2.1 Engineering Considerations

Engineering considerations are the foundation of the methodology required to perform a feasible nonstructural mitigation project. Section 5, *Steelville, MO Floodplain Analysis,* provides an overview on the study engineering considerations. Also, for reference, APPENDIX, shows engineering criteria which can be used as guidance to develop nonstructural mitigation methods.

7.2.2 Economic Considerations

Floodproofing: The rationale for floodproofing was based on the structure's foundation, occupancy type and local flood characteristics. Wet floodproofing was applied to commercial and industrial structures characterized similarly to a warehouse style building that could allow water to flow in without having to be concerned with hydrostatic pressures. Dry floodproofing was applied to all non-warehouse style structures experiencing less than three feet of flooding relative to the first-floor elevation. Floodproofing structures with depths of flooding below the first floor was the most cost-effective alternative since most flood related damages could be mitigated by filling the subfloor area and relocating utilities above the first floor. Filling in the subfloors of the structures will have additional real estate costs due to loss of square footage. For structures with flooding greater than the first-floor elevation, the cost-effectiveness decreased given the additional veneer and watertight doors required to mitigate flooding.

Elevation: The rationale for elevating structures was based on local flood characteristics and the least cost mitigation approach. Elevating structures is an effective flood mitigation approach up to ten feet of rise and, assuming proper slope grading and fill compaction, is not subject to hydrostatic pressures. Elevating structures has a high upfront cost resulting from filling in subfloor areas and lifting structures onto a new foundation. As a result, elevation is limited to structures with significant flood depths (at least three feet) given that floodproofing is more cost-effective for shallower flood events. If elevation of the structure were to occur in the floodway, it would have to be changed to elevating on piles, piers or other systems that would avoid obstructing the floodway and therefore allow flood flows to bypass the structure. Elevating structures is more expensive than floodproofing but also provides more benefits by raising the structure above the base flood elevation. For this strategy, the structure is elevated from its existing foundation material onto a new foundation.

Different foundation types present unique challenges with respect to structural elevation, with crawlspace foundations being the easiest and slab foundations being the most challenging. Similar to other floodproofing alternatives, any usefulness from a basement would be lost as the only subfloor area allowed under NFIP regulations would be an enclosure with the appropriate number of vents to allow for hydrostatic pressure equalization. The lost square footage on the subfloor of the structure due to filling in the subfloor adds to the total cost of mitigating that structure. The elevation mitigation approach assumes that each structure was elevated above the base flood elevation.

Acquisition: The rationale for acquisition was based on identification of acquisition as the least cost mitigation approach. Some structures were also identified for acquisition where acquisition was not the least cost mitigation approach. In these situations, acquisition was selected if the structure met any of the following criteria: 1) Located in the floodway and the cost was lower than elevation, and 2) Total cost within 25% of other nonstructural measures.

It was assumed that since acquisition completely removes the flood hazard into perpetuity, that the property owner and city would elect to acquire the structure rather than paying marginally more for a mitigation measure that does not fully remove the risk of damage, especially for more infrequent flooding larger than the 1% AEP event.

Acquisition is a costly nonstructural alternative; however, it is also the most permanent. Property acquisition and structure removal are usually associated with frequently damaged structures. Implementation of other measures may be effective but if a structure is subject to repeated flood damage, this measure may represent the best alternative to eliminating risks to the property and residents in perpetuity. Acquisition and conversion to open space reduces the opportunity for flood damages, causes no increase in flood potential elsewhere, and improves the natural riparian environment. The land where the structure had been originally located is purchased, becoming deed restricted to prevent development from occurring in the future. This could potentially present issues with loss of community support to the local tax structure which could otherwise be adversely impacted by a significant number of acquisitions and provides societal cohesion for the displaced property owners.

7.2.3 Social Considerations

The study area contains an area of mobile homes near Cedar Street. A mobile home is a large trailer or transportable structure that is parked in a particular place and used as a permanent dwelling. While it is not guaranteed that single-family structures have significantly more income and resources, national statistics show that occupants of mobile homes generally have a lower median income than single-family households. Mobile home parks are typically made up of one wholly owned parcel in which multiple tenants rent mobile home pads. The renting individuals may own or rent the mobile home which sits on the mobile home pad. One effective mitigation strategy is to purchase the land parcel from willing landowners, which may force the mobile home occupants to relocate out of the flood-prone area. The challenge from an engineering and economic perspective is that large mobile home parks have variable levels of flood depths based on topography. Some portions of a parcel may contain mobile homes with deeper flood heights where other portions of the parcel are not expected to be inundated.

If nonstructural mitigation measures were only to consider engineering and economic considerations, it may be expected that mobile homes without flood risk be left as is, and instead of acquiring the entire parcel and relocating its tenants, that only flood-prone mobile homes would be targeted. This approach does not take into account community fragmentation and does not address the issue that landowners are allowed to rent out flood-prone mobile home pads to tenants. By acquiring the entire parcel and relocating its occupants, the land can be legally required to remain as open space permanently, thereby removing the flood hazard.

The rationale for relocating mobile home structures is based on local flood characteristics and social considerations. For this report, relocation was reserved for tenants that would not receive the same relocation assistance under the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (URA) that homeowners would receive. Tenant Uniform Relocation Act (URA) support is limited in scope to include out-of-pocket moving expenses and compensation for an increase in rent and utility costs incurred with the relocation, with a maximum payment of $7,200. Additional services are also available to tenants. This payment ceiling is considerably lower than if the mobile home tenant owned the parcel they park on, as in that case they may be eligible for up to $31,000 in assistance. The conundrum of tenants living in flood-prone areas, especially mobile homes, is that the landowner is responsible for making the decision to accept a voluntary buyout, yet it may not be in the landowner's financial interest to do so. If the landowner accepts a buyout, they may only be compensated for the value of the land and not the improvements such as utility hookups and concrete pads. Additionally, the landowner is subject to losing monthly rental income from the tenants who rent mobile home pads. However, the landowner would no longer have to pay property taxes or upkeep on the property; nor (potentially) income tax on the rental income. On the tenant's side, mobile home tenants are limited in compensation and are typically not restricted as to where they can relocate as landowners are after acquisition. This dichotomy, if not managed properly, leads either to a landowner being reluctant to sell, or mobile home tenants potentially moving from one flood-prone location to another flood-prone location to maintain comparable costs of living.

All mobile homes associated with this report are suggested to be relocated to an area outside of the floodplain and the cost associated with this relocation is based on the tenant relocation assistance value of $7,200 from the Tenant Uniform Relocation Act (URA). A formal relocation analysis is outside of the scope of this report and is the responsibility of the municipality to find a suitable parcel for mobile homes to relocate to.

7.2.4 Nonstructural Cost Estimation and Comparison

Cost estimates have been developed for the nonstructural mitigation plan for a 1% AEP event. A preliminary cost estimate was developed for each flood-prone structure using the three (3) available nonstructural mitigation approaches discussed in Section 7.1 and based on the cost assumptions described below. The costs identified in the report are not an engineering recommendation and should only be used for comparing nonstructural mitigation approaches and evaluating cost effectiveness. The cost estimates used in this report were developed based on the original square footage and layout of each structure, including number of floors for each structure. These costs were analyzed based on flood depths during a 1% AEP flood event and include structure characteristics, such as foundation heights, structure type, etc.

Estimated costs were developed based off the original square footage of which was converted into perimeter based off the number off floors for each structure and those floors' specific square footage. These costs were analyzed based off the 1% AEP flood depths and foundation heights/type. Costs include Mobilization/Demobilization (10% of overall nonstructural Mitigation costs), Nonstructural Mitigation (Buyouts, Dry Floodproofing, Wet Floodproofing, Filling Basements/Crawl Spaces, and

Elevating structures when and where applicable), 41% Contingency, Planning Engineering and Design (15% of overall nonstructural Mitigation costs including contingency), Construction Management (10% of overall nonstructural Mitigation costs including contingency), and Real Estate (TABLE 9).

Cost estimates were developed using the USACE River Des Peres, University City General Reevaluation Report Flood Risk Management study (FY23) nonstructural parametric costs, any escalation of these costs are included in the contingencies. Dry floodproofing costs include the installation of door/garage barriers along with a three foot floodproofing membrane and residential structural reinforcement (includes demolition, reinforcing install, replace exterior sheeting, re-install brick veneer per square foot (SF)), and check valves where applicable. Cost estimates developed for wet floodproofing of a structure include the installation of door/garage barriers along with flood vents, epoxy and repainting the basements, and relocating electrical outlets. Basements and crawl spaces will also be filled where applicable based off SF/floor. Cost estimates developed of acquisition of a structure include the building and foundation demolition and site restoration such as grading, where applicable. Real estate costs are included in each of the nonstructural methods total cost estimates.

Although the report focused on 1% AEP event, nonstructural mitigation measures were also evaluated for the 0.2% AEP flood event. There are a total of 262 flood-prone structures in the 0.2% AEP event. The estimated total cost to mitigate the 262 flood-prone structures would presumably be a higher cost and ultimately not cost effective given the additional mitigation measures required for such an infrequent flood event. As average flood depths for structures increase from 2.5 feet at the 1% AEP to 4.6 feet at the 0.2% AEP, dry floodproofing is no longer a viable mitigation approach for more than 60% of the structures in the 0.2% AEP event. An alternate method for mitigating a structure with higher flood depths would be to potentially elevate (raise) the structure, which would also significantly increase cost.

TABLE 9. COST ESTIMATES FOR NONSTRUCTURAL FLOOD RISK MITIGATION PLAN (APPENDIX D)

DESCRIPTION	ESTIMATED AMOUNT
Mobilization/Demobilization	$1,420,307
Non-Structural Mitigation	$14,203,068
Contingency (41%)	$6,405,584
Planning, Engineering, and Design (15%)	$3,304,344
Construction Management (10%)	$2,202,896
Real Estate	$10,344,254
Total	**$37,880,000**

TABLE 10 shows a comparison of six random sample of structures within the study area for which the proposed mitigation method is either dry floodproofing or elevation. Even though the required elevation is between one to three feet to fully mitigate these structures, the estimated cost for elevation in comparison to dry floodproofing is approximately twice the cost for all of the structures. Generally, elevating structures is more expensive than floodproofing but could potentially be more beneficial resulting in the structure placed above the base flood elevation. Raising the structure above the base flood elevation means that property owners are no longer required to be in the flood insurance program which reduces the monthly costs of owning that property and presumably would not be required to mitigate for future flood events.

For the majority of structures in the Steelville area, dry floodproofing is the mitigation method that was the least cost and engineeringly feasible alternative. For the structures that dry floodproofing was not engineeringly feasible, the options to either buyout or wet floodproofing the structure was the most feasible option. The structures in TABLE 10 can be referenced in APPENDIX D labeled as Structure FID.

TABLE 10. CITY OF STEELVILLE SAMPLE 1% AEP NONSTRUCTURAL METHODS

Structure FID	Structure SQFT	1% AEP Depths	Ft Needed to Elevate	Elevation Total Costs	Dry Flood Proof Total Costs
537715668	1198	0.36	1	$ 112,534	$ 65,758
537715669	957	2.53	3	$ 130,811	$ 55,889
537715681	800	0.468	1	$ 79,500	$ 49,460
537715695	1092	2.895	3	$ 147,416	$ 61,417
537715698	1152	1.814	2	$ 131,756	$ 63,874
537715700	816	2.268	3	$ 113,468	$ 50,115

When comparing cost estimates for the different types of nonstructural mitigation methods, a combination of dry floodproofing, wet floodproofing and acquisitions is considered to be a cost-effective option for the Steelville area. The cost estimate is considered parametric and does not incorporate standard construction contingencies. Some non-monetary characteristics of dry floodproofing to consider include that it is an active measure and requires occupants to physically place stop logs or barriers in front of low openings to prevent floodwater intrusion. For structures in Steelville, the installation of barricades and stop logs in and around the structures are more important in the City of Steelville since the population at risk are given a small window of time from the start of the rain to the overflowing of the Yadkin Creek.

The implementation of nonstructural nonphysical measures would be required to be implemented to ensure floodproofing would be a viable method of flood risk reduction for the Steelville area. Cost estimates for nonphysical nonstructural methods such as an early warning system were not developed as part of this study.

8.0 SUMMARY OF STRUCTURAL AND NONSTRUCTURAL FLOOD MITIGATION

8.1 Structural Flood Mitigation Summary

Detention areas were evaluated for potential storage areas designed to mitigate adverse flood impacts by detaining water, thereby reducing flood waters downstream. Channel modifications were evaluated for the potential to increase capacity of Yadkin Creek channel near the City of Steelville. Each alternative was evaluated on the ability to detain water and increase channel capacity in order to reduce flood risk to flood-prone structures for the 1% AEP event. While these structural measures may reduce the risk of flooding in flood-prone areas, it appears that detention basins and a channel modification do not completely eliminate the risk of flooding to structures.

Using the intersection of Main Street and 4th Street as a reference point, Alternatives 1-3 show a reduction in flood risk at varying levels depending on the AEP flood event. This intersection point was chosen for its central location in downtown Steelville, however, the conditions at this point of reference may not be representative of flooding throughout the entirety of Steelville. For the 1% AEP flood event, Alternatives 1-3 have varying degrees of effectiveness at reducing flood depths in the study area. While these structural measures may reduce the risk of flooding in flood-prone areas, it appears that detention basins and a channel modification do not completely eliminate the risk of flooding to structures for the 1% AEP flood event. For the 1% AEP flood event, Alternative 1 would reduce flooding depths by approximately 1.6 feet, or 45%, and Alternative 3 would reduce flooding depths by approximately 2.4 feet, or 68%. For a 1% AEP flood event, Alternative 2 reduces flooding depths by approximately 0.7 feet, or 19%. While these structural measures may provide a reduction of flood risk, it appears that detention basins and channel modifications do not completely eliminate the risk of flooding to structures and therefore may not be considered viable options. In addition, the study does not provide details on potential numerous considerations the city would need to address if pursuing detention basins and channel modification, which may result in additional costs.

Alternatives 1-3 show a reduction in flood risk at varying levels depending on the AEP flood event and are summarized and compared to existing conditions in TABLES 11 and 12. For more frequent rain events (10%-2% AEP), the detention basins would reduce flooding depths by approximately 25%-31%. Analysis showed an approximate 0.2 foot flood depth reduction during the 10% AEP event, approximately 0.4 foot flood depth reduction during the 4% AEP event, and approximately 0.8 foot flood depth reduction for the 2% AEP event. A channel modification to Yadkin and Whittenburg Creeks could potentially reduce flood depths by approximately 32%-67%. Analysis shows an approximate 0.2 foot flood depth reduction during the 10% AEP event, approximately 1.1 foot flood depth reduction during the 4% AEP event, and approximately 0.9 foot flood depth reduction for the 2% AEP event. The combination of detention basins and channel modifications could reduce flooding depths by approximately 32%-76%. Analysis showed approximately 0.2 foot flood depth reduction during the 10% AEP event, approximately 1.2 foot flood depth reduction during the 4% AEP event, and approximately 1.7 foot flood depth reduction for the 2% AEP event.

For less frequent events, such as 0.2% AEP, the three (3) detention basins were not as effective, only reducing flooding depths by approximately 1 foot or 18%. The channel modification was not as effective, only reducing flooding depths by 0.6 feet or 10%. The proposed modification to Yadkin Creek provides additional capacity within the creek channel, which reduces flood depths in Steelville, but as a standalone measure, the proposed channel modification does not provide enough flood depth reduction at infrequent flood events (1%-0.2%) to be considered a viable option. The combination of detention basins and a channel modification were not as effective, reducing flooding depths by approximately 2.2 feet or 37%.

Alternative 2 is effective at reducing flood depths during the less frequent events (10%-4% AEP) by up to 67%.

Alternative 3 provides the most flood depth reduction across all events and reduces the flood depth of a 1% AEP event to approximately 1.2 feet at the reference point of 4th and Main Street. Alternative 3 also reduces flood depths by 37% during the 0.2% AEP to a level of approximately 3.8 feet but does not fully mitigate flood risk.

TABLES 11 and 12 shows a summary of structural Alternatives 1-3 and the corresponding reduction in flood depth at 4th and Main Street. TABLE 11 shows estimated flood depths with existing conditions in comparison to flood depths with structural Alternatives 1-3 at the reference point of 4th and Main Street. TABLE 12 summarizes these changes in flood depths and the reductions in flooding between existing conditions and each structural alternative for the 10%, 4%, 2%, 1%, and 0.2% AEP events. The values in TABLES 11 and 12 may vary by flood event due to several factors, including the timing of a hydrologic event and how the proposed design, such as inlet/outlet structures, and the flood event hydraulically function together. It should be noted that this is only a snapshot of modeled conditions at a specific location in the study area and may not accurately portray flood depth reduction throughout the Steelville area.

TABLE 11. FLOOD DEPTH FOR EXISTING CONDITIONS AND STRUCTURAL ALTERNATIVES

	Depth of Flooding (ft)			
AEP	**Existing Conditions**	**Alternative 1**	**Alternative 2**	**Alternative 3**
10%	0.5	0.3	0.3	0.3
4%	1.6	1.2	0.5	0.4
2%	2.5	1.7	1.7	0.9
1%	3.6	2.0	2.9	1.2
0.20%	6.0	4.9	5.4	3.8

TABLE 12. FLOOD DEPTH REDUCTION RELATIVE TO EXISTING CONDITIONS FOR STRUCTURAL ALTERNATIVES

AEP	**Alternative 1**		**Alternative 2**		**Alternative 3**	
	Depth Difference(ft)	**% Reduction**	**Depth Difference(ft)**	**% Reduction**	**Depth Difference(ft)**	**% Reduction**
10%	-0.2	31%	-0.2	32%	-0.2	32%
4%	-0.4	25%	-1.1	67%	-1.2	76%
2%	-0.8	32%	-0.9	33%	-1.7	66%
1%	-1.6	45%	-0.7	19%	-2.4	68%
0.20%	-1.1	18%	-0.6	10%	-2.2	37%

Depending on the structural alternative, if implemented, the city would be required to address numerous considerations associated with proposed detention basins and channel modifications, including the ability to provide long term maintenance and identifying the responsible party for maintenance activities. Other considerations include determining the placement of excavated dredged material (primarily gravel), environmental impacts, and verifying bank stabilization requirements. Real estate considerations associated with widening of the creek channel include acquisition, easements, adjoining landowner impacts, and creating impacts (positive or negative) on upstream or downstream areas. From the conceptual level design models, water surface elevations generally increase upstream of detention basins and decrease downstream of basins. For channel modification, elevations increase downstream and decrease upstream of the modification. Additional investigations would be required to accurately characterize these changes in elevation and any changes in velocity. Additionally, the designed slopes for a channel modification would require slope stabilization to protect the slopes from erosion from the creek flows.

8.2 Nonstructural Flood Mitigation Summary

Each flood-prone structure in the study area has been evaluated for its structural attributes, hydraulic conditions, and estimated cost of nonstructural flood mitigation. All proposed nonstructural mitigation methods in this report are preliminary and are subject to a detailed field survey and site-specific cost estimate.

APPENDIX provides a comprehensive list of structures located in Steelville, sorted by the depth of flooding relative to the first-floor elevation. Appendix D: Nonstructural Flood Mitigation Plan (1% AEP) for Flood-prone Structures summarizes the nonstructural plan that contains the proposed nonstructural mitigation methods for each flood-prone structure in the 1% AEP (FIGURE 28). TABLE 13 provides a summary of mitigation methods outlined in APPENDIX D.

For the majority of the flood-prone structures in the study area, dry floodproofing appears to be an effective and cost-efficient alternative to reduce flood risk in Steelville area. However, the implementation of nonstructural nonphysical measures would be required to be implemented to ensure floodproofing would be a viable method of flood risk reduction for the Steelville area. Cost estimates for nonphysical nonstructural methods such as an early warning system, were not developed as part of this study. For the structures in which dry floodproofing is not feasible, the structure could potentially be mitigated through acquisition or wet floodproofing. In addition, the summary below provides the city with nonstructural mitigation alternatives to reduce future flood damage and considered to be cost effective:

1. Dry floodproofing is a cost effective and feasible approach for structures that are unable to allow water to inundate the first-floor elevation. These structures may require the utilities and other equipment to be located on the first floor to prevent flood damages.
2. Wet floodproofing, if feasible, is a cost effective and feasible alternative for industrial/warehouse type structures, in which water is able to freely flow in and out of the structures with minimal damages, if any, to the contents inside.
3. For the structures that cannot be mitigated through dry or wet floodproofing, acquisition (buyout) could be another effective alternative.

   a. Generally, the buyout mitigation alternative works well for structures such as mobile homes. Costs for moving a mobile structure is relatively lower than costs for altering a structure with foundations to the ground.
4. The structures with inundation below first floor elevation that have either a basement or crawlspace will require the subfloor to be filled to reduce the possible damages that flood waters could cause to the structure. The costs associated with loss of square footage due to subfloor fill and mitigation costs are included in APPENDIX D.
5. For structures that receive greater than 3 feet of inundation, and no other mitigation method is feasible, the proposed mitigation method is dry floodproofing. However, risk reduction will only be to either the 4% AEP event or the 2% AEP event for these specific structures (marked with an asterisk (*) in APPENDIX C).
6. The areas with higher depths and velocities could lead to the risk of structural collapse based on the force of the flooding. For structures such as FID 537723664 and 537717725 that may meet these criteria, while dry floodproofing can prevent flood damages, it cannot prevent structural collapse. Prior to implementing dry floodproofing, a more detailed analysis of velocities should be conducted for this limited number of structures.
7. Some warehouse type structures that could freely allow water to get in and out of the structures and that did not have utilities directly on the ground level were captured with wet floodproof mitigation technique. The 24 structures without any mitigations are the structures that are on a slab foundation with some elevation between their ground surface elevation and their first-floor elevation. Since that structure is a slab with potentially 1-2 feet of Ground Surface Elevation (GSE) to First Floor Elevation (FFE), even if 0.5 feet of water is getting to the structure, damages for that structure will not begin until water is higher than the first-floor elevation.

TABLE 13. SUMMARY OF NONSTRUCTURAL MITIGATION METHODS FOR 1% AEP (APPENDIX D)

Mitigation Method	Number of Structures	Estimated Cost
No Recommendation	24	$0
Wet Floodproofing	4	$489,180
Dry Floodproofing/Fill Basement/ Fill Crawlspace	212	$26,332,849
Elevation	0	$0
Acquisition / Relocation	17	$4,051,394
Total	**257**	

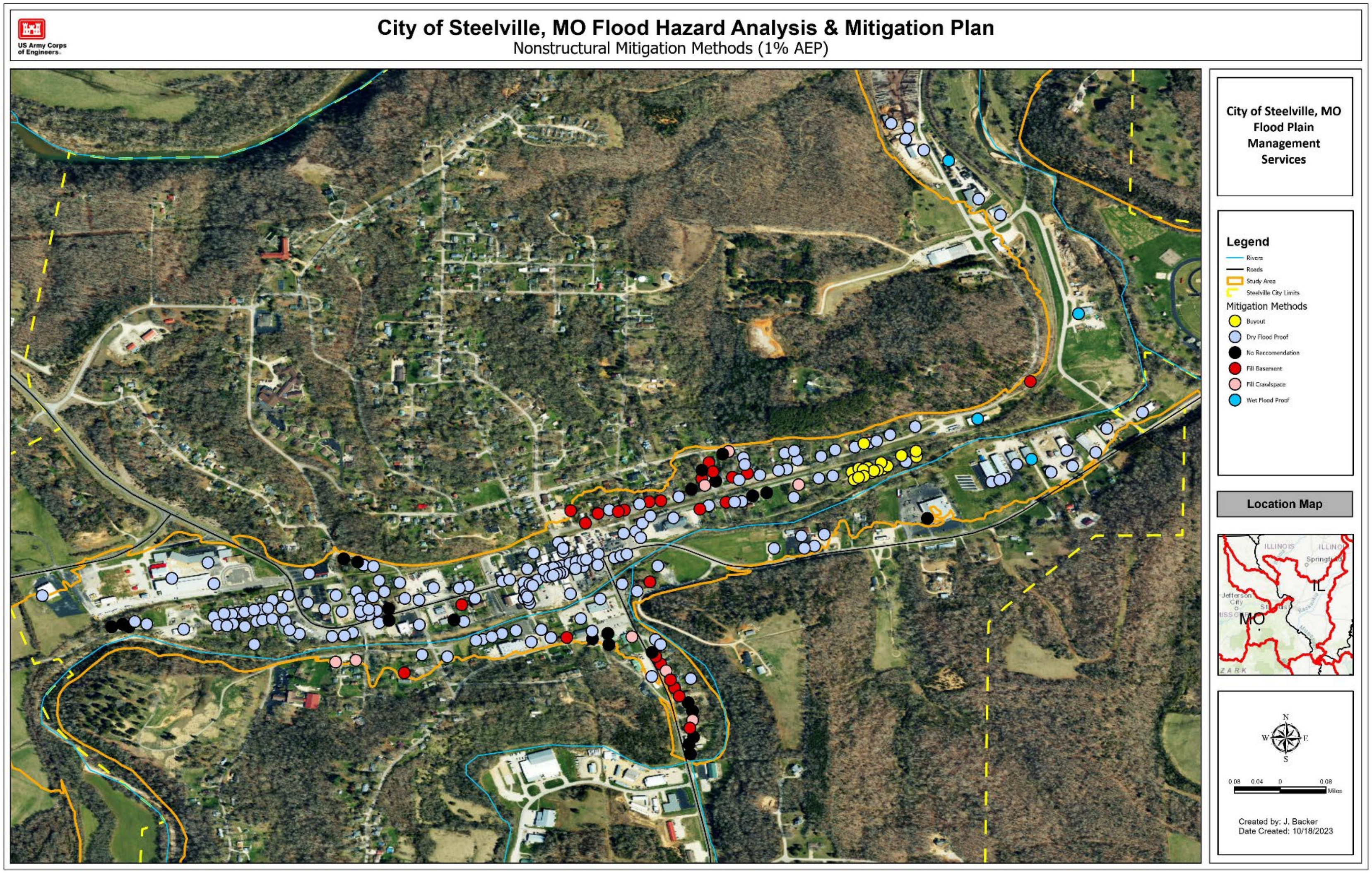


FIGURE 28. STEELVILLE, MO 1% AEP NONSTRUCTURAL MITIGATION METHODS

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8.2.1 Nonphysical Nonstructural Measures

As described in Section 7.1.5, nonphysical nonstructural measures would be necessary in order for floodproofing to be viable in reducing flood risk in Steelville. Some types of preventative measures are early warning systems, public information programs and public alert systems. Early warning systems would serve as proactive communication to residents in order to prepare for flood hazards, including installation of dry floodproofing methods. Early Warning systems such as sirens or gages are highly recommended for owners/tenants that are floodproofing their structures to reduce damages from particularly flashy flooding like the one area of Steelville experiences. Public information programs will help inform the public, including the most efficient and effective ways to floodproof structures.

The following is a summary of viable nonphysical nonstructural methods for the Steelville area:

- Temporary dry floodproofing measures, such as installing door barriers, in addition to an early warning system for the owner/tenant to be able to install the closure(s) and safely evacuate the premises prior to the arrival of floodwaters.
- Implementation of an early warning system that incorporates multiple media tools that are tied to National Weather Service or possibly the USGS Water Alert flood warning system.
- Creation of a Flood Emergency Preparedness Plan / Emergency Action Plan that provides preparedness plans for Steelville area on several topics related to flood risk reduction, such as Emergency Operation Plan, Emergency Communication Plan, Evacuation Plan, and After-Action Plan.
- Implementation of land use policies could potentially assist in development policies and land use regulations. Development policies could be found in the various community-wide plans for the city and the county (i.e., comprehensive plans, master plans, economic development strategic plans, etc.). These policies could help guide the community decisions on where new development or redevelopment should occur. The city could use these tools to implement a wide variety of site and building requirements, restrictions, and prohibitions to protect new developments as well as existing developments.

8.3 Cost Comparison

Estimated costs for the structural alternatives and the nonstructural plan were developed based on historical cost data for the St. Louis District. Nonphysical nonstructural cost estimates were not developed as part of this study. The cost estimates include costs for Lands, Easements, Rights of Way, Relocations and Disposal sites (LERRDs), Planning, Engineering and Design, Construction Management, and appropriate contingencies. Costs were derived using available information from insert date. TABLE 14 shows the various alternatives and their associated costs.

TABLE 14. COST COMPARISON STRUCTURAL AND NONSTRUCTURAL MITIGATION METHODS

	Structural Alternatives			Non-Structural Alternatives				
	Alternative 1: 3 Detention Basins	Alternative 2: 3' Channel Modification	Alternative 3: 3 Detention Basins + 3' Channel Modification Combination	Buyout*	Dry Flood Proofing**	Wet Flood Proofing	No Recommendation/Fill Basement or Crawl Space	TOTAL NON-STRUCTURAL COST
Lands & Damages	$782,657	$257,417	$1,040,074	$3,441,140	$6,850,714	$52,400	$0	$10,344,254
Buildings, Grounds and Utilities	$12,823,771	$2,864,143	$16,083,019	$671,279	$12,849,148	$617,007	$1,485,941	$15,623,375
Contingency	$4,876,229	$1,035,857	$6,116,981	$275,225	$5,268,151	$252,973	$609,236	$6,405,584
Planning, Engineering & Design	$2,660,000	$585,000	$3,330,000	$141,976	$2,717,595	$130,497	$314,276	$3,304,344
Construction Management	$1,770,000	$390,000	$2,220,000	$94,650	$1,811,730	$86,998	$209,518	$2,202,896
Total Cost	**$22,130,000**	**$4,875,000**	**$28,790,074**	$4,624,270	$29,497,338	$1,139,874	$2,618,970	**$37,880,000**

***Includes elevating structure 52**
****Includes filling crawl space for structure 215**

8.4 Real Estate Costs

The cost estimates include costs associated with Real Estate. For Structural Alternative 3, the proposed features are located in 100 parcels which will require a combination of the following: Standard Estates, Fee Simple, Perpetual Easements, and temporary construction easement. The following Rough Order of Magnitude (ROM) estimate generated for Real Estate costs for Alternative 3 is approximately $1,040,074. The real estate costs associated with the Buyout estimate of $3,441,140, includes the fair market value of the Real Estate, appraisal fee, title opinion, negotiations, closing cost and relocation assistance. The real estate cost estimates for dry and wet floodproofing consist of the fair market value of any loss in living square footage due to floodproofing, appraisal fee, title opinion, negotiations, closing cost. The fair market value of loss in living space could be offset if there is a net benefit to the floodproofing. An offsetting analysis was not conducted as part of this study due to the level of detailed required to do such analysis.

The Real Estate requirements for the identified Non-Structural methods, specifically for dry/wet floodproofing, will require a Non-Standard Estate such as a Restrictive Covenant. There are various acquisition options concerning floodproofing and to date, there is minimal USACE guidance on a standard pathway. The method of acquisition varies and can be completed through the following four methods: (1) USACE led Contracting with a Non-Federal Sponsor (NFS) support (authorized under Section 204 of WRDA 1986), (2) NFS led Contracting with USACE Support, (3) Section 202 Hybrid - property owner contracting with USACE and NFS support, or (4) a grant-like program. Although, dry and wet floodproofing programs are voluntary methods utilized on "willing" participants, this potentially disqualifies program participants from benefits found within The Uniform Relocation Assistance and Real Property Acquisition Policies Act, absent discretionary approval from the secretarial level. This does not avoid the topic of a federal agency obligation to follow the principles laid out within the 5th Amendment of the USC concerning just compensation, which applies to both physical and regulatory takings.

8.5 Conclusion

Without the implementation of flood risk reduction measures, the flooding along Yadkin Creek is likely to continue, resulting in flood damages to the flood-prone structures in the City of Steelville. This report evaluated both structural and nonstructural measures and developed potential flood risk management alternatives for city officials to make informed decisions to potentially reduce flooding impacts. While the implementation of a structural alternative, such as channel modification, detention basin, or a combination thereof, may provide varying levels of flood risk reduction, the level of reduction is not considered to fully mitigate flood risk in the study area for the 1% AEP flood event. In addition, the city would be required to address substantial considerations associated with proposed detention basins and channel modifications, such as the ability to provide long term maintenance, real estate, placement of excavated or dredged material, and environmental impacts, that would most likely make a structural alternative non-viable for the city to pursue at this time.

The proposed nonstructural mitigation methods in APPENDIX D provide (APPENDIX) individual flood risk reduction methods for the 257 structures in the 1% AEP event for the City of Steelville. The majority of flood-prone structures in the study area have flood depths that can be mitigated through dry floodproofing; however, due to the flashy nature of flooding in the Steelville area, it would be necessary to combine floodproofing with nonphysical nonstructural measures, such as sirens or updated river gages. Other nonstructural options including wet floodproofing, elevation, and acquisition, could be viable, but are considered cost prohibitive. Given this, when feasible, dry floodproofing of flood-prone structures, in combination with an early warning system is an effective nonstructural flood reduction mitigation method for a 1% AEP event. Additional nonphysical nonstructural methods, such as land use policies and building and zoning regulations, are effective flood risk mitigation methods for the city to implement. The implementation of the nonstructural plan and nonphysical nonstructural methods are viable approaches to mitigate flood risk within the City of Steelville.

9.0 FUTURE ACTIONS

Investing in reducing flood risk in Steelville's inventory of structures also provides an incentive to pursue an application for the FEMA Community Rating System (CRS) program, which provides flood insurance premium discounts for communities who participate in the National Flood Insurance Program (NFIP) and take actions to reduce flood risk.

Steelville is classified as an "economically disadvantaged" community as designated in the Climate and Economic Justice Screening Tool (CEJST), which in certain circumstances could allow it to request assistance under other USACE community support programs at full federal expense. Examples of these programs include the Planning Assistance to States (PAS) Program for planning and technical support or Section 165(a) of the Continuing Authorities Program (CAP) for planning and potential construction of a federal project.

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US Army Corps of Engineers

Flood Hazard Analysis and Mitigation Plan
City of Steelville, MO

Appendix A: Hydraulics and Hydrologic Analysis

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1.0 Introduction

APPENDIX A discusses the H&H (Hydraulics and Hydrologic) modeling efforts carried out for this study, including model modifications, alternatives, results and assumptions made during the process. The study focused on modeling of existing conditions, as well as the effectiveness of alternatives aimed at managing flood risk to the City of Steelville.

2.0 Models

2.1 Original Model

A 2-D HEC RAS (Hydrologic Engineering Center's River Analysis System) model was developed by the private engineering firm WSP (formally known as Wood PLC) to create a new FEMA Flood Insurance Study for the City of Steelville in Crawford County, MO. Precipitation hydrographs were utilized as inputs for gridded precipitation in the unsteady flow files in the model. Inundation boundaries were calculated for Annual Exceedance Probabilities (AEP) of 0.2%, 1%, 2%, 4%, and 10%. The original model included surveyed Light Detection and Ranging (LiDAR) terrain files with structures built into the terrain as part of existing conditions. The model geometry included multiple inline structures in the form of bridges, low water crossings and culverts along Yadkin and Whittenburg Creeks. Some computation cells were contained solely on top of elevated structures which resulted in water being shown ponded on top of buildings and similar structures. This led to unrealistic depths and water surface elevations (WSE) at or near these structures due to the sloping of water to meet bottom water surface elevations. This is illustrated in FIGURE A1 which highlights multiple locations where this occurs, as well as FIGURE A3 which shows WSEs plotted in HEC RAS at the location of Profile Line 21 (FIGURE A2) for the 1% AEP flood event.

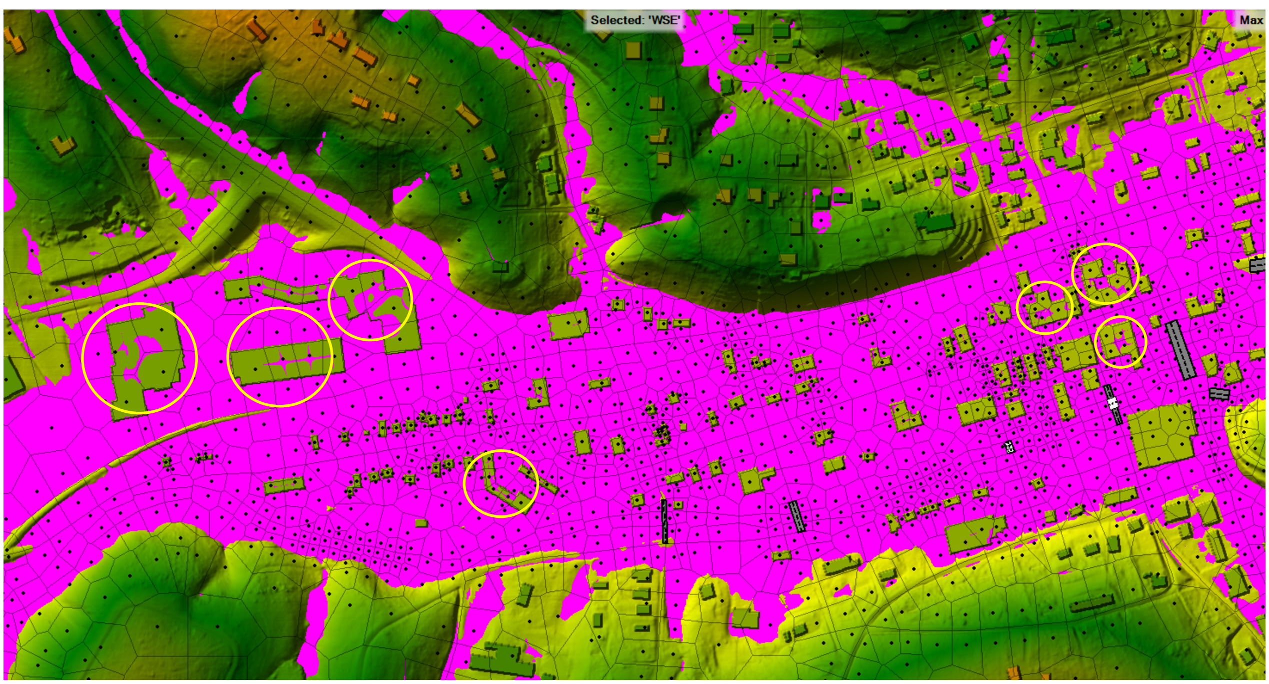

Figure A1. Original Model: Water on Top of Buildings for 100YR Flood

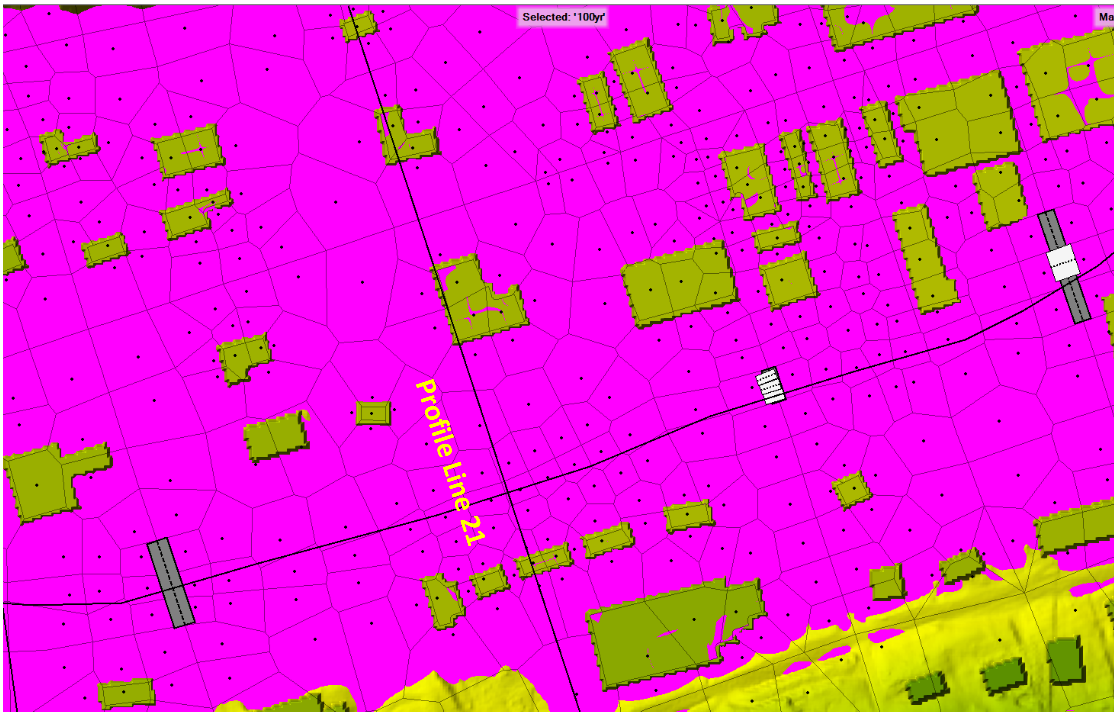

Figure A2. Original Model: Location of Profile Line 21

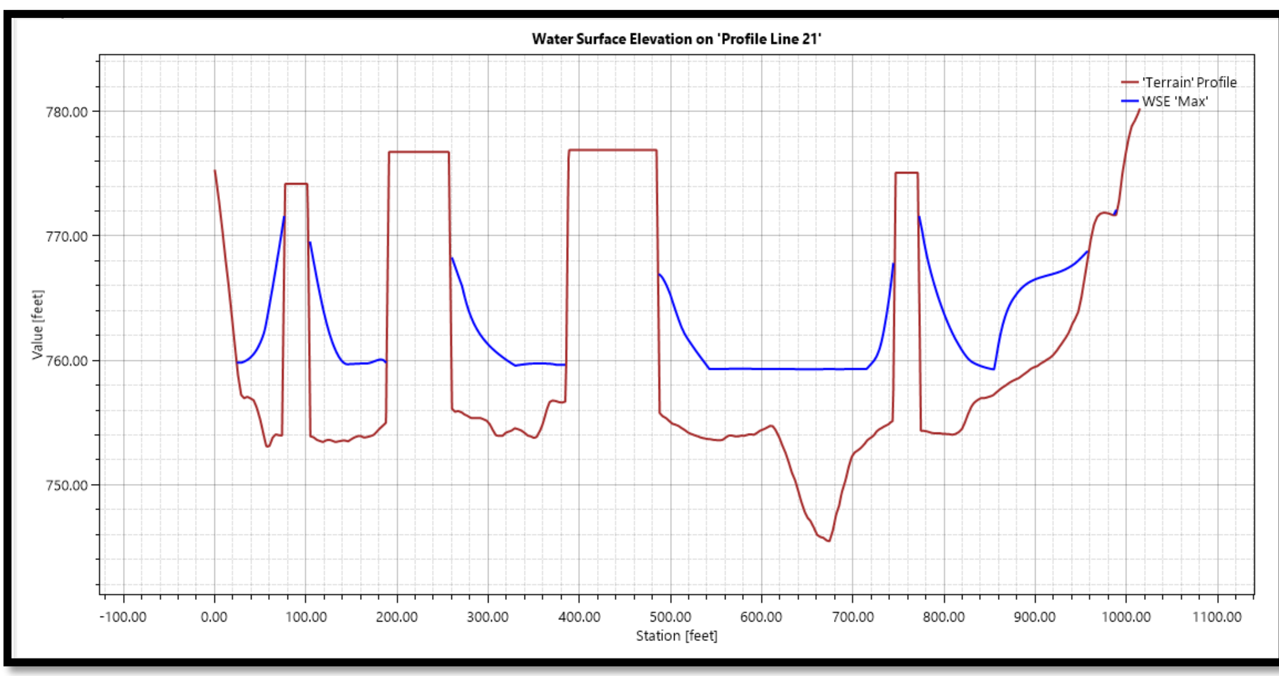

Figure A3. Original Model: Water Surface Elevation at Profile Line 21

In addition, low water crossing “Yak60”, which was included in the model as an inline structure, showed highly elevated WSEs and depths due to instabilities when running the model. FIGURES A4 and A5 illustrates this in more detail at the location of Profile Line 22

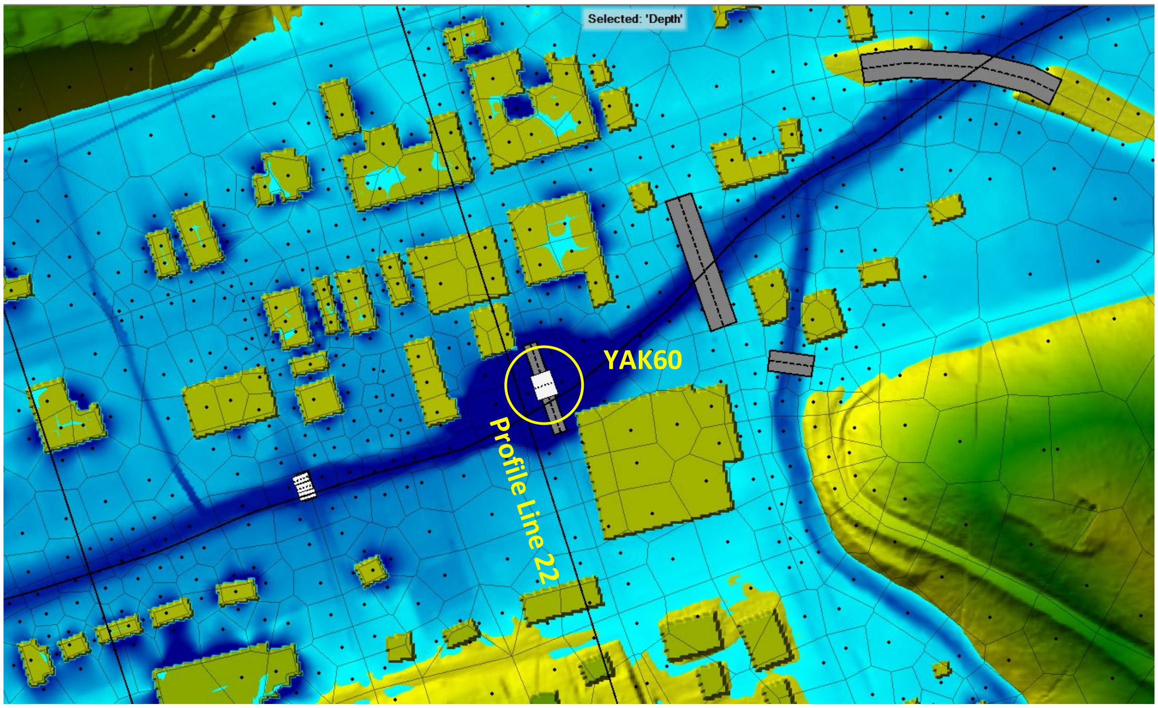

Figure A4. Profile Line 22 at YAK60 Low Water Crossing

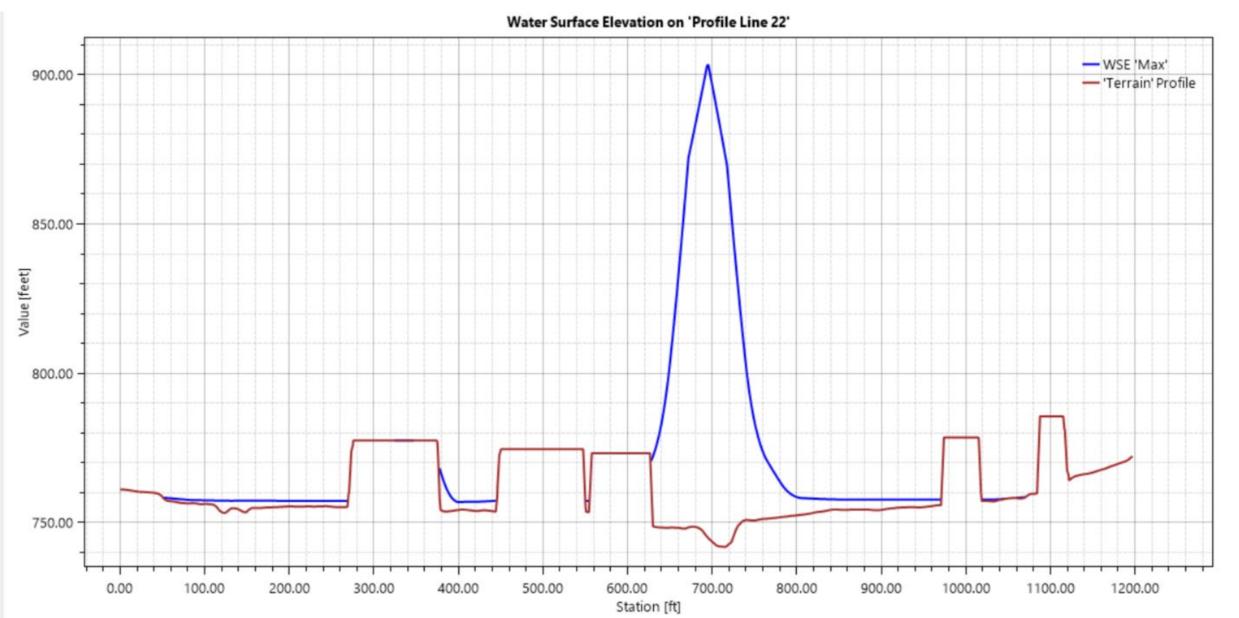

Figure A5. Water Surface Elevation at YAK60 Low Water Crossing

2.2 Revised Model

The model was revised to resolve the issue of ponding on top of the buildings. A “Horizontal” render mode was considered as a possible solution given that a “Sloping” render mode was being used for presenting results in the original model. However, even though it would have resolved the sloping issue, it would also have eliminated all sloping from being shown in the model results; therefore, a different approach was taken. Cells solely contained on top of elevated structures in the terrain were modified to include adjacent areas of lower elevations. This was able to resolve the issue because HEC RAS reads the lowest terrain elevation on each cell to determine the location that gets water first. A comparison of results between existing and revised WSE slopes can be seen in FIGURE A6 for Profile Line 21.

Low water crossing YAK60 was also modified to reduce instabilities causing high WSEs to appear. Cells were added to provide more detail on the channel where the 2D Area Connection used for culvert computations was located. Culvert inverts were raised to be above minimum cell elevation values to allow the model to run. FIGURE A7 shows differences in results for both the existing and revised model at Profile Line 21.

Differences between the original model depths and the revised model depths could be seen up to 1 foot where buildings were more densely packed and close to 0 feet where buildings were not present or further apart. Any differences observed could be due to cell modifications done to resolve the issues stated above or because of instabilities created by structures being densely packed in the downtown portion of Steelville. FIGURE A8 illustrates these differences, with a range of +1 to -1 foot depicted as the color pink to green in the map legend.

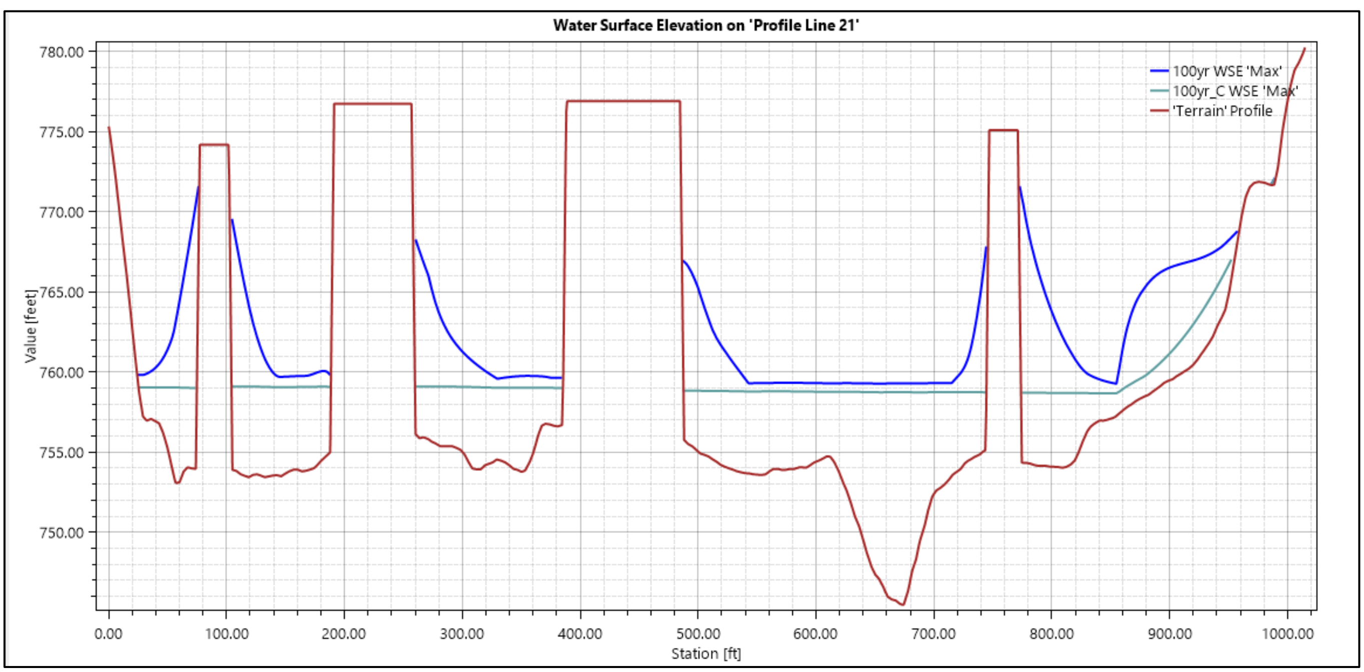

Figure A6. Profile Line 21 Shown on Figure A3 and A4

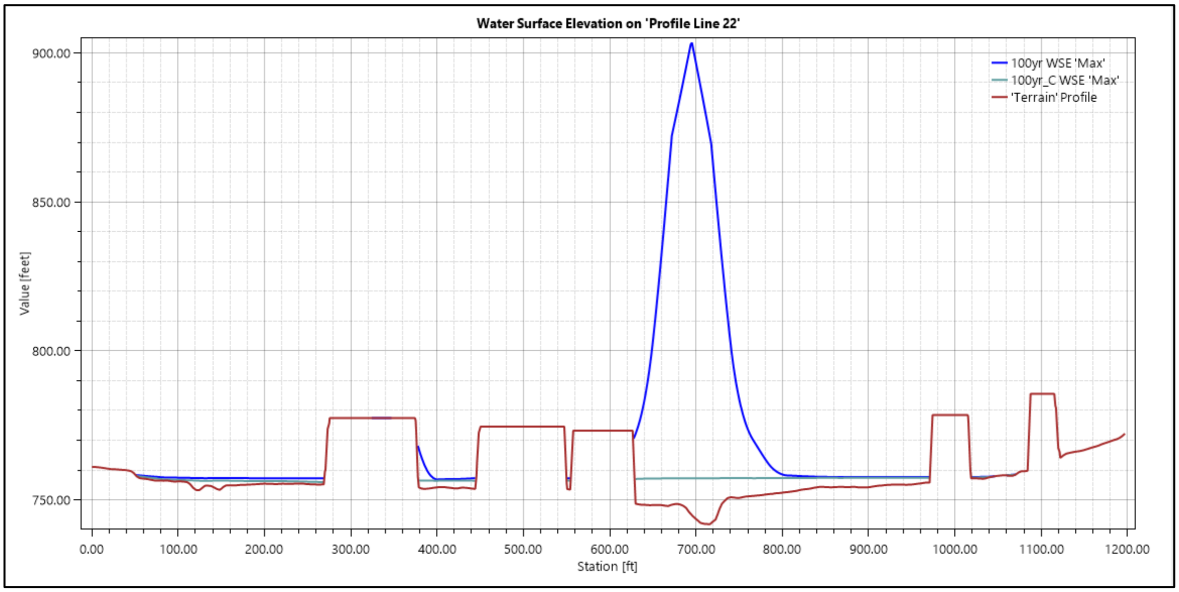

Figure A7. Water Surface Elevation Comparison at YAK60 Low Water Crossing for Original and Modified Model

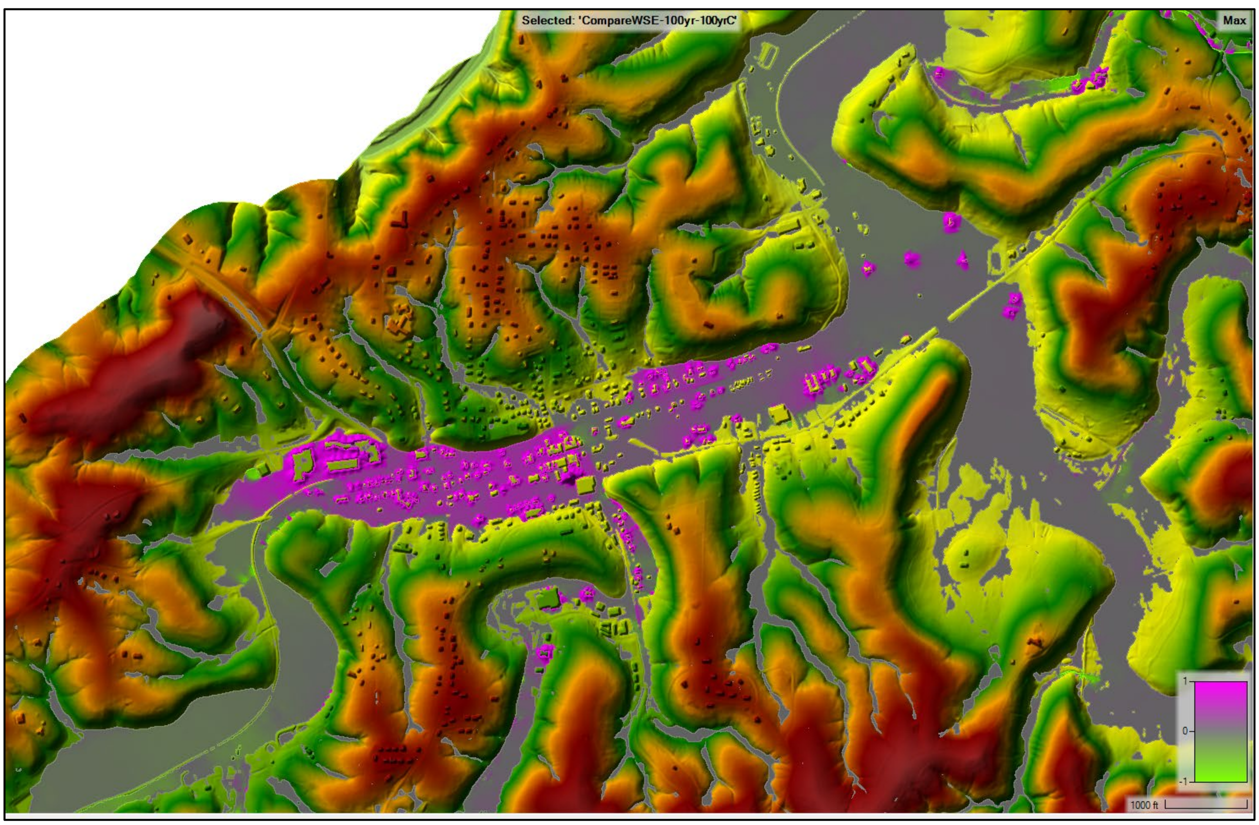

Figure A8. Layer Comparison Between Original and Modified Model for 1% AEP Flood

2.3 Modeled Alternatives

Several structural alternatives were considered as part of this study to reduce flooding coming from Yadkin Creek in the downtown portion of Steelville. Alternatives modeled were designed based on the 1% AEP flood with terrains keeping the same Spatial reference system and vertical datum as the original model (NAD83 and NAVD88). A breakdown of the alternatives can be found in TABLE A1.

Table A1. Modeled Structural Alternatives

Alternatives	Description
1. Detention Basins	3 Detention Basins upstream of Steelville leaving existing conditions on Yadkin and Whittenburg Creeks
2. Detention Basins	3ft Channel Excavation on Yadkin and Whittenburg Creeks
3. Channel Modification and Detention	3 Detention Basins upstream of Steelville with 3ft Channel Excavation on Yadkin and Whittenburg Creeks
*LWR Crossings and Bridges along Yadkin and Whittenburg Creeks were removed for Alternatives 1 and 3, except for bridge across Highway 8 due to channel modification along the Creeks.	

Terrain modifications to model alternatives such as detention basins and channel excavation were designed utilizing Bentley's Open Roads Designer and were later converted to TIFF files in Blue Marge Geographic's Global Mapper. These were then utilized to generate new terrains in HEC-RAS. Refinement regions were enforced around the edges of the basins to prevent water from leaking outside of the storage areas and cell sizes were set to 35 inside all detention basins. An effort was made to keep the cell sizes as close to existing conditions as possible, including inside the excavated channel. This was done to minimize differences in results that were not directly caused by modeled alternatives. Detention basins included in the model can be seen in FIGURES A9 and A10.

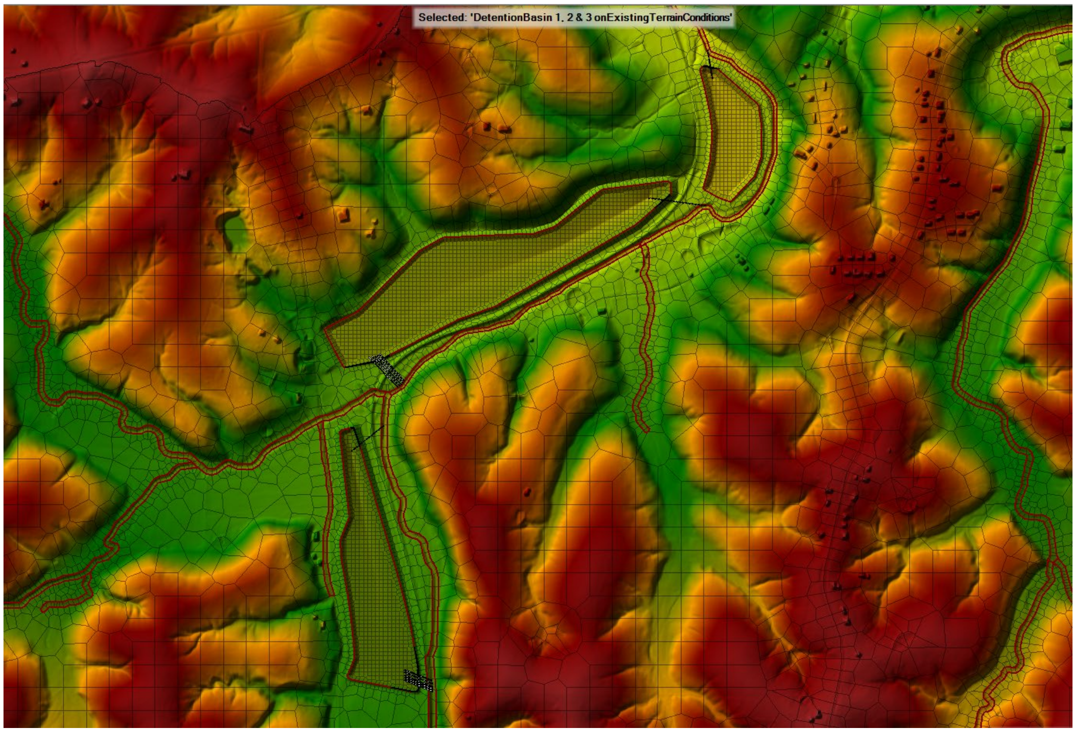

Figure A9. Detention Basins 1 - 3 with Existing Conditions on Yadkin Creek

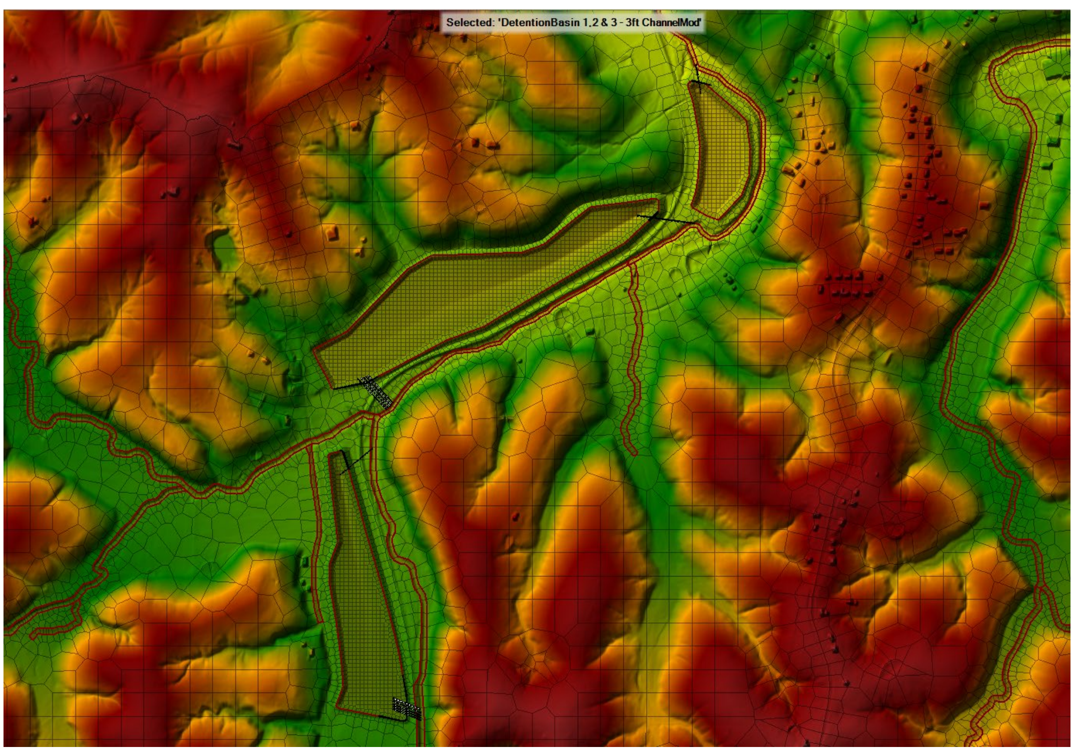

Figure A10. Detention Basins 1 - 3 with 3ft Channel Excavation on Yadkin Creek

Detention Basin 1 was modeled with a weir inlet structure. Due to the presence of a railroad between the channel and the proposed Detention Basins 2 and 3, culverts on SA/2D Connections were utilized instead of weirs to model inflows into Detention Basins 2 and 3.

3.0 Hydraulic Model Outputs

Given that gridded precipitation hydrographs were utilized for this model instead of flow from boundary conditions, areas that are not necessarily flooded by the creeks may be shown as flooded. This is because, when a precipitation hydrograph is used on a 2-D grid, precipitation is falling on the entire grid, not just on the channel. Existing condition results for all rain events, as well as results for the modeled alternatives at the 1% AEP event, can be seen below in FIGURES A11 through A15. The model outputs, such as depth grids and velocities, were utilized as part of the existing condition analysis as well as formulation and evaluation of structural and nonstructural alternatives.

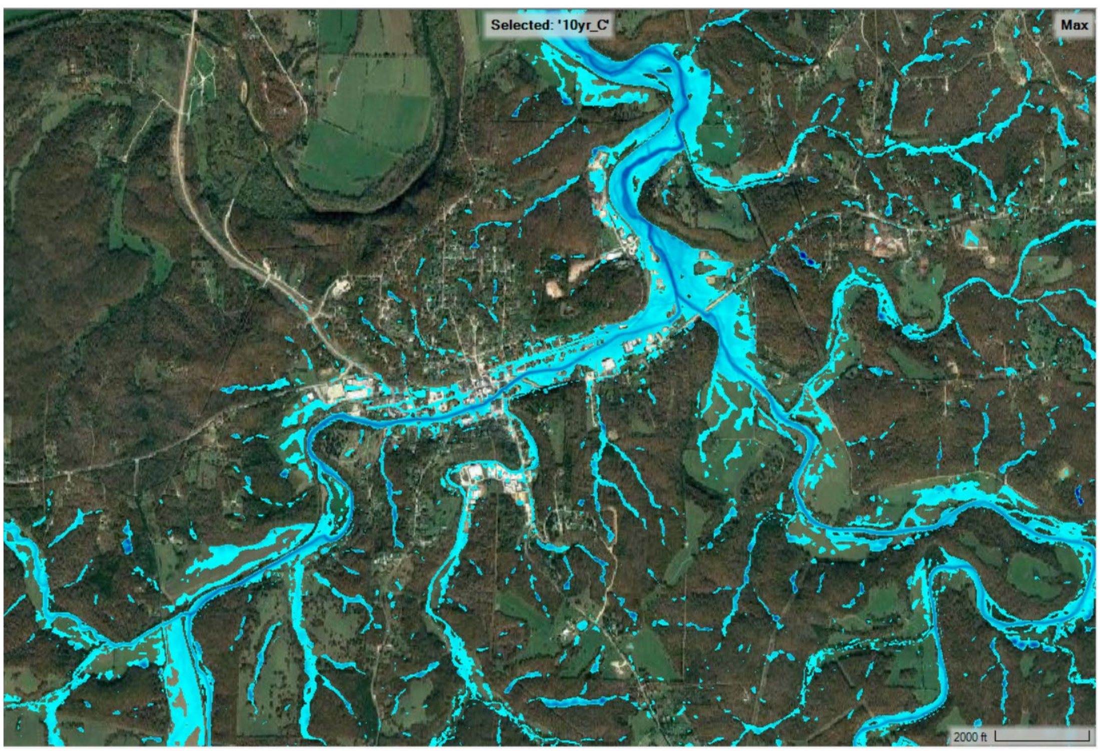

Figure A11. 10% AEP Flood for Existing Conditions

Figure A12. 4% AEP Flood for Existing Conditions

Figure A13. 2% AEP Flood for Existing Conditions

Figure A14. 1% AEP Flood for Existing Conditions

Figure A15. 0.2% AEP Flood for Existing Conditions

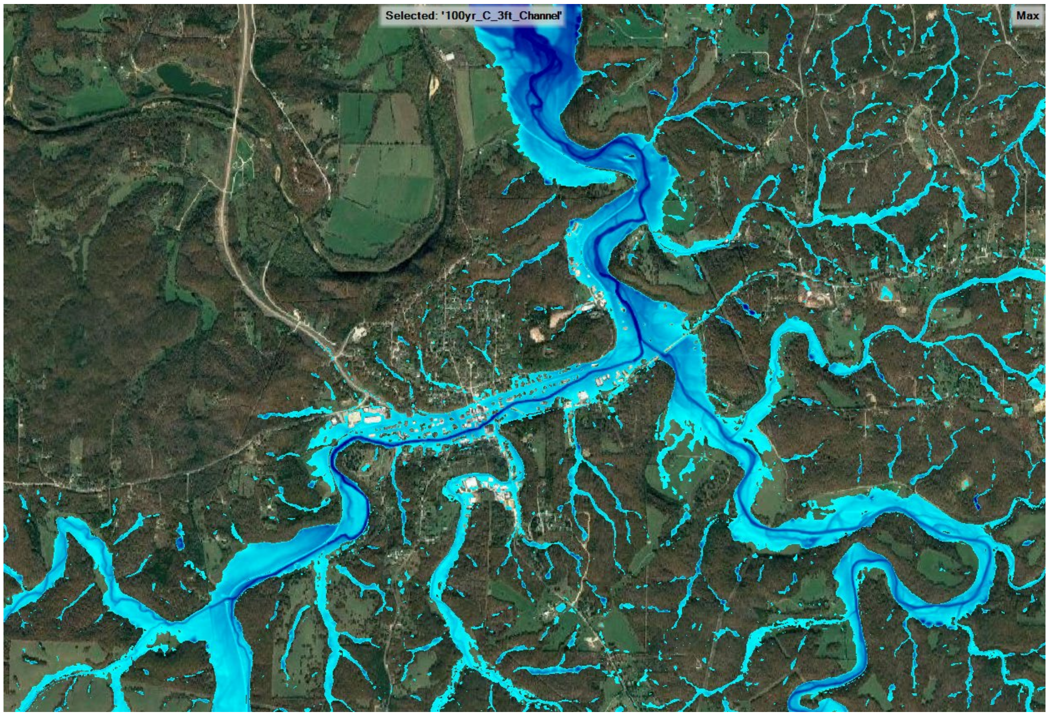

Figure A16. 1% AEP Flood for Channel Modification

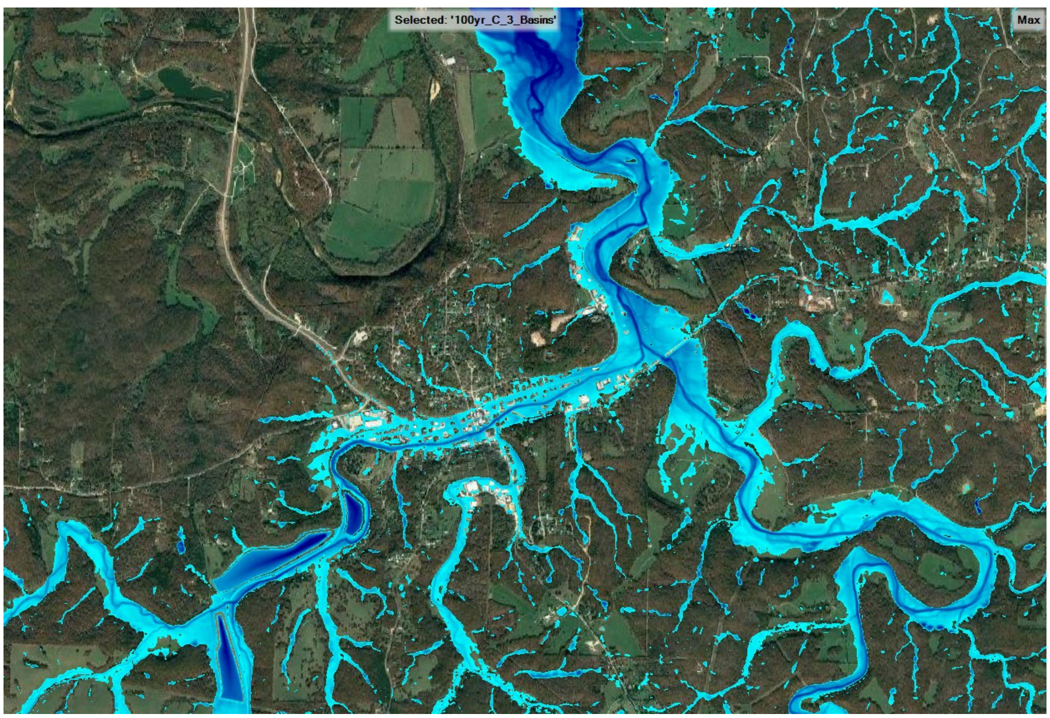

Figure A17. 1% AEP Flood for Detention Basins Only

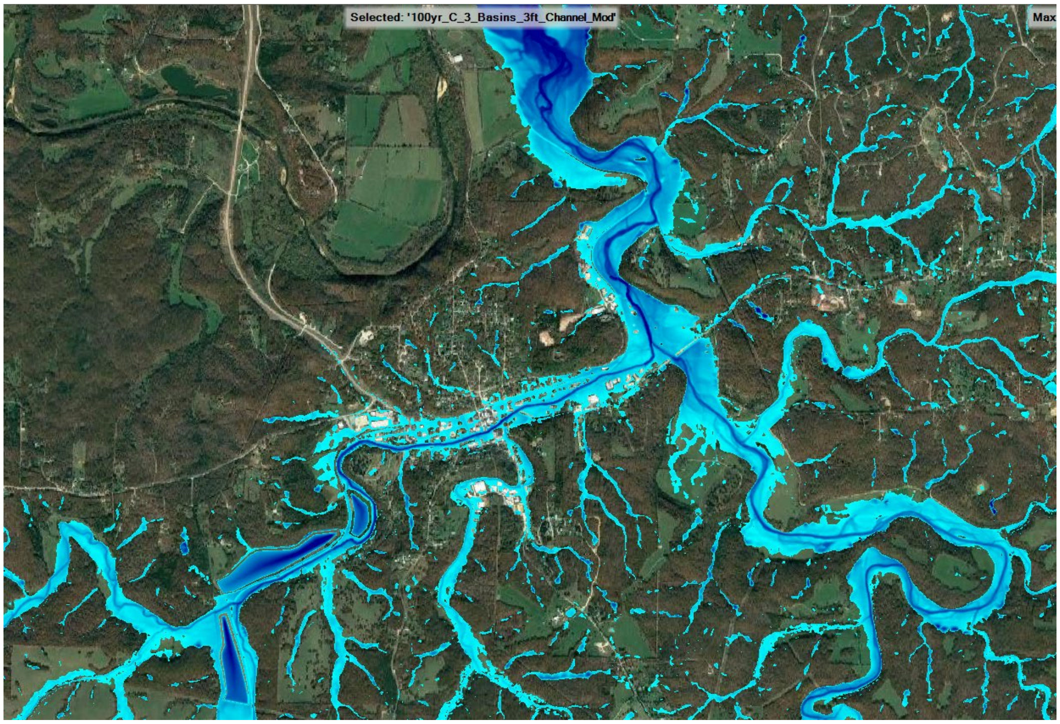

Figure A18. 1% AEP Flood for Channel Modification and Detention Basins

3.1 Model Timing

The hydrographs used for modeling have a 6-day duration, starting at an arbitrary date (01JAN2000) in which precipitation falls at different time steps and intensities as the event progresses. Precipitation hydrographs utilized for modeling show increased rainfall shortly after time step 01JAN2000 10:30 a.m. is reached. According to the model, for the 1% AEP, Yadkin Creek overflows at time step 01JAN2000 12:15 p.m., which is approximately 1 hour and 45 minutes after the intensity of the event surpasses 0.03 inches. FIGURE A19 shows the hydrograph utilized to model the 1% AEP event.

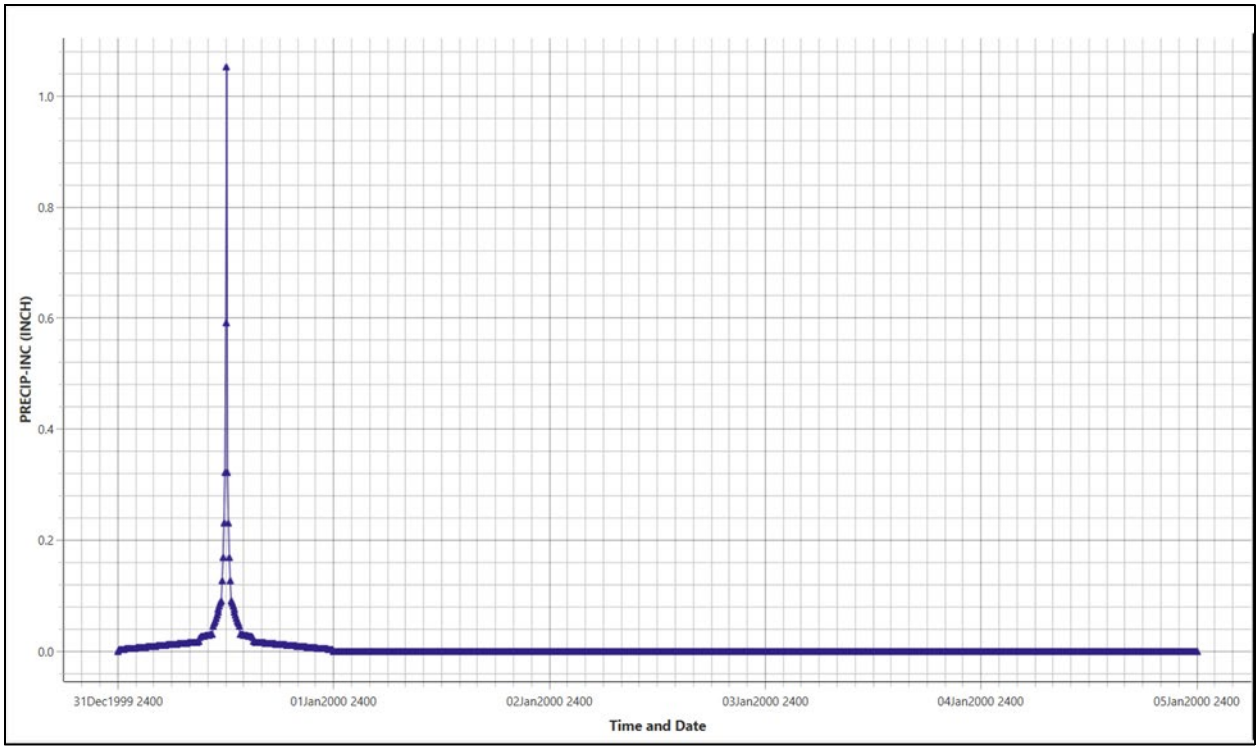

Figure A19. 1% AEP Event Precipitation Hydrograph

4.0 Uncertainty

Several uncertainties can be identified during the modeling process for this project. One of the uncertainties come from calibration efforts to get the modified model to match the original model developed by WSP engineers. Given that no high-water marks could be identified for the City of Steelville, calibration attempts were primarily focused on getting the modified model to match the original model as close as possible. However, given the modifications that were made to YAK60 and the cells on top of buildings, some discrepancies remained regarding WSEs.

Calibrations were attempted with multipliers on the unsteady flow files, but no significant improvement could be obtained over current model discrepancies; however, even though discrepancies remained present up to 1 foot in the downtown portion of the study area, they were close to 0 feet in surrounding areas. Issues encountered with the model were reported to WSP engineers and the model was modified as detailed in this appendix.

It is also important to note that flow frequencies are developed based on past historical data and can change as additional data is being recorded daily, meaning that results could change if more data becomes available.

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Appendix B: Cost Estimates

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Table B1. Cost Estimate Alternative 1: Three (3) Detention Basins

ITEM	ESTIMATED AMOUNT
Mobilization and Demobilization	$1,165,800
Clearing and Grubbing	$32,900
Turfing	$387,100
Concrete Pipes 96" Diameter	$4,229,400
Concrete Pipes 24" Diameter	$77,341
Concrete Pipes 21" Diameter	$19,908
Cut	$5,273,328
Fill	$1,190,108
Riprap, R140	$53,038
Riprap, R1000	$123,456
Bedding	$35,973
Concrete Swale	$190,023
Concrete Weir	$45,396
SUBTOTAL:	$12,823,771
CONTINGENCIES: (38%)------------------------	$4,876,229
SUBTOTAL:-------------------	$17,700,000
Engineering & Design (15%)-------------------------------------	$2,660,000
Construction Management (10%)---	$1,770,000
TOTAL COST	**$22,130,000**

Table B2. Cost Estimate Alternative 2: Proposed Channel Modification

ITEM	ESTIMATED AMOUNT
Mobilization and Demobilization	$260,400
Clearing and Grubbing	$37,600
Turfing	$78,400
Cut	$1,269,824
Riprap, R200	$559,912
C-Stone Riprap	$27,315
Bedding	$250,362
Low-Water Crossing Demolition	$380,330
SUBTOTAL:	$2,864,143
CONTINGENCIES: (36%)------------------------	$1,035,857
SUBTOTAL:-------------------	$3,900,000
Engineering & Design (15%)------------------------------------	$585,000
Construction Management (10%)------------------------------------	$390,000
TOTAL COST	**$4,875,000**

Table B3. Cost Estimate Alternative 3: Combination of 3 Detention Basins and 3' Channel Modification

ITEM	ESTIMATED AMOUNT
Real Estate	$1,040,074
Mobilization and Demobilization	$1,462,100
Clearing and Grubbing	$70,500
Turfing	$475,300
Concrete Pipes 96" Diameter	$4,246,200
Concrete Pipes 24" Diameter	$72,128
Concrete Pipes 21" Diameter	$25,200
Cut	$6,703,320
Fill	$1,361,656
Riprap, R140	$53,038
Riprap, R1000	$123,456
Riprap, R200	$559,912
C-Stone Riprap	$27,315
Bedding	$286,272
Concrete Swale	$190,896
Concrete Weir	$45,396
Low-Water Crossing Demolition	$380,330
SUBTOTAL:	$16,083,019
CONTINGENCIES: (38%)------------------------	$6,116,981
SUBTOTAL:-------------------	$22,200,000
Engineering & Design (15%)-------------------------------------	$3,330,000
Construction Management (10%)---	$2,220,000
Real Estate	$1,040,074
TOTAL COST	**$28,790,074**

Table B4. Proposed Non-Structural Cost Estimate

DESCRIPTION	ESTIMATED AMOUNT
Mobilization/Demobilization	$1,420,307
Non-Structural Mitigation	$14,203,068
Contingency (41%)	$6,405,584
Planning, Engineering, and Design (15%)	$3,304,344
Construction Management (10%)	$2,202,896
Real Estate	$10,344,254
Total	**$37,880,000**

Table B5. Cost Estimate Replacement of Low Water Crossing with Low-Water Bridge

Meramec Low Water Crossing Silver Jacket 3/1/2023
Low-Water Bridge 6/12/2023

**Excludes Real Estate & Mitigation Costs

ITEM	ESTIMATED AMOUNT	
Mobilization and Demobilization	$176,000	
Bridge Items		
Removal of Existing Structure	$272,000	
Cofferdam	$108,000	
Excavation	$2,200	
12" Concrete Solid Slab Beams	$786,240	
Reinforced Concrete	$156,000	
Structural Steel Pile	$272,320	
Pile Point Reinforcement	$11,200	
Plain Neoprene Bearing Pad	$28,800	
Bridge Guardrail	$174,900	
Roadway Items		
Clearing and Grubbing	$18,000	
Excavation	$2,000	
Rock Blanket	$4,600	
Aggregate Base	$17,200	
Embankment	$61,600	
Establishment of Turf	$5,800	
Pavement Base (Asphalt)	$54,600	
Pavement Surfacing (Asphalt)	$39,900	
Geotextile	$10,200	
Moveable Barricades	$1,860	
Construction Signs	$2,760	
Silt Fence	$851	
SUBTOTAL:	$2,207,000	
Contingency:	$772,000	35%
CONSTRUCTION SUBTOTAL:	$2,979,000	
E & D :	$540,000	18%
S & A :	$300,000	10%
TOTAL COST:	**$3,819,000**	

Table B6. Cost Estimate Replacement of Low Water Crossing with Prefabricated Arch Crossing

Meramec Low Water Crossing Silver Jacket 3/1/2023

Prefabricated Arch Crossing 5/17/2023

**Excludes Real Estate & Mitigation Costs

ITEM	ESTIMATED AMOUNT	
Mobilization and Demobilization	$92,000	
Bridge Items		
Removal of Existing Structure	$64,000	
Cofferdam	$54,000	
Excavation	$1,200	
12" Concrete Solid Slab Beams	$288,000	
Reinforced Concrete	$96,000	
Concrete Curb	$3,000	
Roadway Items		
Clearing and Grubbing	$18,000	
Excavation	$1,000	
Rock Blanket	$2,250	
Aggregate Base	$9,000	
Embankment	$15,180	
Establishment of Turf	$5,800	
Concrete Pavement	$46,800	
Geotextile	$5,400	
Moveable Barricades	$1,860	
Construction Signs	$2,760	
Silt Fence	$322	
Backfill	$28,600	
SUBTOTAL:	$735,000	
Contingency:	$257,000	35%
CONSTRUCTION SUBTOTAL:	$992,000	
E & D :	$180,000	18%
S & A :	$100,000	10%
TOTAL COST:	**$1,272,000**	

Table B7. Cost Estimate for Replacing LWC with Oversized Culvert Crossing

Meramec Low Water Crossing Silver Jacket 3/1/2023
Oversized Culvert Crossing 6/12/2023

**Excludes Real Estate & Mitigation Costs

ITEM	ESTIMATED AMOUNT	
Mobilization and Demobilization	$48,000	
Bridge Items		
Removal of Existing Structure	$48,000	
Cofferdam	$54,000	
Excavation	$1,400	
60" Corrugated Steel Pipes	$61,200	
Concrete Curb	$3,000	
Roadway Items		
Clearing and Grubbing	$18,000	
Excavation	$1,000	
Bedding Material	$1,800	
Aggregate Base	$4,000	
Embankment	$2,000	
Establishment of Turf	$5,800	
Concrete Pavement	$20,800	
Geotextile	$2,400	
Moveable Barricades	$1,860	
Construction Signs	$2,760	
Silt Fence	$184	
Backfill	$10,660	
SUBTOTAL:	$287,000	
Contingency:	$100,000	35%
CONSTRUCTION SUBTOTAL:	$387,000	
E & D :	$70,000	18%
S & A :	$40,000	10%
TOTAL COST:	**$497,000**	

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Appendix C: Flood-prone Structure Inventory

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APPENDIX C includes a table of flood-prone structures sorted by depth of flooding relative to the first-floor elevation. First floor elevation is defined as the ground surface elevation plus the elevation of the foundation height. A positive value of “5” can be interpreted as flood waters inundating the structure with 5 feet of water above the first floor, typically relative to where the front door of the structure is located. A negative value of “-2” can be interpreted as 2 feet of water below the first floor, meaning floodwaters have the probability of inundating subfloor areas but may not reach the first floor of the structure. An Esri ArcGIS shapefile will be provided to the City of Steelville to better sort and interpret the data presented in this appendix.

TABLE C1. FLOOD-PRONE STRUCTURE INVENTORY, STEELVILLE, MO

FD ID	Site Street	Appraised Value	Foundation Height	Ground Surface Elevation	4% AEP (25Yr)	2% AEP (50Yr)	1% AEP (100Yr)	0.2% AEP (500Yr)
537731187	634 Frisco Street	$ 175,205	2.0	732.6	-1.7	-1.1	-0.6	1.1
537723709	10 Ivy St	$ 113,192	0.5	763.8	NA	NA	0.0	2.0
537727187	100 Main St	$ 229,958	0.5	753.1	-0.1	1.2	2.2	4.3
537723667	101 B Cedar St	$ 106,472	0.5	750.5	-0.2	1.0	2.0	4.1
537715682	101 Cedar St	$ 185,437	1.5	747.2	0.7	2.0	3.0	5.1
537715665	101 E Main St	$ 514,547	0.5	744.2	0.4	1.6	2.6	4.7
537715676	101 Hickory St	$ 552,791	0.5	749.4	NA	0.8	1.9	4.2
537700948	101 Main St	$ 517,344	0.5	748.1	NA	0.3	1.4	3.5
537729911	101 MO-8	$ 614,254	0.5	758.7	NA	0.3	1.7	5.0
537723656	101 N First St	$ 591,153	0.5	752.7	0.1	0.5	1.4	3.6
537704930	101 N Spring St	$ 109,460	0.5	759.9	0.1	0.7	1.5	3.7
537726238	101 Pine St	$ 584,383	0.5	745.3	-0.4	0.6	1.4	3.7
537723766	101 S 3rd St	$ 609,117	0.5	753.1	2.4	3.6	4.7	6.9
537717723	101 W Euclid St	$ 1,166,107	0.5	775.2	NA	0.7	1.6	3.7
537730610	101 W. Keysville	$ 1,063,548	0.5	758.1	0.2	0.6	1.3	3.4
537723767	101B S 3rd St	$ 380,698	0.5	753.1	2.0	3.2	4.2	6.5
537723776	101C S 3rd St	$ 1,251,992	1.5	753.3	0.6	1.8	2.9	5.2
537723676	101D S 3rd St	$ 167,562	1.5	756.0	1.2	2.5	3.5	5.8
537723675	101F S 3rd St	$ 502,686	1.5	756.0	1.2	2.5	3.6	5.9
537727189	102 Main St	$ 143,724	0.5	753.1	0.4	1.5	2.5	4.6
537717725	103 Main St	$ 888,925	0.5	776.0	-0.4	0.7	1.7	3.8
537704914	103 N Spring St	$ 109,431	2.0	759.1	-1.0	-0.3	0.5	2.8
537723666	104 Hickory St	$ 397,496	0.5	750.5	0.1	1.6	2.6	4.8
537727191	104 Main St	$ 468,782	0.5	753.1	0.3	1.3	2.3	4.4
537730816	104-108 First Street	$ 175,948	4.0	748.3	2.2	3.5	4.6	6.8
537727177	105 Frisco St	$ 130,996	2.0	753.9	NA	NA	-2.0	-1.2
537723663	105 Main St	$ 1,002,793	0.5	752.0	0.3	1.5	2.6	4.7
537725244	105 Main St	$ 1,655,943	0.5	755.2	NA	0.4	1.4	3.5
537704908	105 N Spring St	$ 160,142	2.0	759.1	-1.4	-0.5	0.4	2.8
537723653	105B Main St	$ 1,265,702	0.5	749.0	0.5	1.7	2.7	4.9
537729987	106 E Keysville St	$ 462,170	2.0	758.5	NA	-2.0	-1.8	-0.2
537726252	106 E Main St	$ 1,600,456	2.0	756.3	-0.9	0.4	1.4	3.5
537727183	107 Frisco St	$ 125,543	2.0	752.4	NA	-1.8	-1.4	0.6
537715670	107 Hickory St	$ 225,432	0.5	748.7	0.0	1.5	2.5	4.8

537716465	107 Main St	$	308,924	0.5	780.5	NA	0.6	1.6	3.7
537715699	107 S 3rd St	$	1,085,441	2.5	755.0	0.3	1.5	2.6	4.9
537731191	108 Elm Ave	$	148,882	2.0	760.4	-0.3	0.6	1.7	4.0
537730815	108-110 W MAIN	$	219,935	0.5	750.1	0.3	1.4	2.4	4.5
537723664	109 E Main St	$	775,822	1.5	752.0	-0.2	1.0	2.1	4.2
537717720	109 Main St	$	486,978	0.5	778.5	-0.4	0.7	1.7	3.8
537723669	109 N First St	$	448,261	0.5	752.5	0.1	0.6	1.3	3.4
537715664	110 Cedar St	$	2,189,117	0.5	747.5	0.5	1.6	2.5	4.4
537704912	110 Elm Ave	$	130,445	2.0	758.7	-1.7	-0.9	0.1	2.4
537704918	111 Elm Ave	$	138,816	2.0	757.3	-0.1	0.9	1.9	4.3
537727875	112 B Main St	$	291,653	1.0	752.7	NA	-0.9	0.1	2.2
537723654	112 Main St	$	351,584	0.5	749.0	0.5	1.8	2.8	5.0
537726249	112 W Euclid St	$	149,064	2.0	763.0	-0.5	0.5	1.5	3.6
537730810	113 Main Street	$	175,948	0.5	755.9	-0.2	1.0	2.0	4.1
537723659	113 N First St	$	583,266	0.5	752.1	-0.4	0.5	1.3	3.3
537694977	113 W Euclid St	$	138,205	0.5	762.5	0.3	1.3	2.3	4.5
537694953	113B W Euclid St	$	130,132	0.5	762.4	-0.1	0.9	2.0	4.2
537727193	116 Main St	$	702,719	0.5	753.0	0.6	1.8	2.8	4.9
537723708	116 W Euclid St	$	124,785	2.0	765.3	NA	-1.0	0.2	2.5
537726248	116 W Euclid St	$	123,060	2.0	763.0	-0.9	0.1	1.2	3.4
537716463	117 E Main St	$	313,668	0.5	784.3	0.4	1.3	2.3	4.4
537723650	117 E Main St	$	304,345	0.5	751.5	-0.3	1.0	2.0	4.1
537694951	117 W Euclid St	$	135,368	2.0	762.3	-1.4	-0.3	0.7	2.9
537715677	118 Cedar St	$	103,665	2.0	746.1	NA	-1.1	-0.3	1.4
537730814	118 MAIN STREET	$	169,350	0.5	752.8	0.4	1.5	2.6	4.7
537723707	118 W Euclid St	$	160,847	2.0	765.8	NA	-0.8	0.4	2.7
537715668	120 Cedar St	$	160,772	2.0	745.9	-1.3	-0.4	0.4	2.1
537726245	120 W Euclid St	$	112,114	0.5	763.5	-0.5	0.6	1.7	3.9
537694981	121 W Euclid St	$	155,140	2.0	762.6	-1.0	0.1	1.1	3.3
537727179	123 N Brickey St	$	1,482,879	0.5	761.1	-0.4	0.4	1.2	3.3
537729910	144 N 4th St	$	205,642	2.0	757.8	-1.4	-0.2	0.9	3.4
537723652	145 Matred St	$	86,496	0.5	749.0	1.0	1.7	2.3	4.6
537726239	155 Matred St	$	188,335	2.0	750.1	-1.8	-0.9	-0.2	2.3
537726235	161 Matred St	$	390,379	0.5	751.1	NA	NA	0.1	2.6
537729827	175 W Euclid st	$	543,044	0.5	760.4	-0.3	1.0	1.9	4.1
537723670	19 Main St	$	2,091,868	0.5	751.7	0.8	1.9	2.9	5.0
537730101	200 Pine St	$	1,090,681	0.5	755.6	-0.5	1.0	2.1	4.3
537727173	201 Frisco St	$	195,680	2.0	751.6	NA	NA	-1.1	1.0
537723768	201 Keysville Rd	$	123,677	2.0	760.3	NA	-1.7	-0.6	1.6
537730102	201 Main St	$	863,890	0.5	755.6	NA	0.4	1.3	3.4
537715675	202 Cedar St	$	124,623	1.5	745.2	NA	NA	-1.0	0.8

537731186	202 LYNN STREET	$ 140,341	2.0	743.4	-1.5	-0.4	0.7	3.0
537723772	202 Main St	$ 336,702	0.5	752.8	0.9	2.1	3.1	5.2
537723689	202 S Spring St	$ 149,463	1.5	769.6	-1.5	-1.3	-1.2	-0.8
537727175	203 Frisco St	$ 124,623	1.5	750.7	-1.2	-0.7	0.2	2.5
537730604	203 Industrial Dr	$ 122,322	0.5	727.7	1.0	2.3	3.6	6.7
537723674	203 S 4th St	$ 225,582	0.5	756.0	-0.2	0.7	1.6	3.8
537715681	204 Cedar St	$ 99,836	1.5	744.9	-0.8	-0.2	0.5	2.3
537730220	204 Cherry St	$ 115,290	2.0	745.9	-1.9	-1.5	-0.8	1.4
537727861	204 Lynn St	$ 119,475	2.0	743.0	-1.6	-0.7	0.4	2.7
537726236	204 Main St	$ 1,185,007	0.5	750.4	0.3	1.2	2.1	4.2
537730606	204 S 1st St	$ 479,034	0.5	754.6	0.6	1.8	2.9	5.0
537726237	204B Main St	$ 789,927	0.5	750.4	0.3	1.2	2.1	4.3
537727863	205 Cherry St	$ 194,204	2.0	743.9	NA	-1.7	-0.7	1.5
537727181	205 Frisco St	$ 170,556	2.0	750.8	NA	-2.0	-1.0	1.2
537723764	205 S 3rd St	$ 102,589	1.5	752.9	0.5	1.7	2.8	5.1
537694969	205 W Euclid St	$ 140,187	2.0	762.8	-0.8	0.4	1.5	3.8
537716471	205 Walnut St	$ 158,378	2.0	750.0	NA	NA	NA	-1.8
537730813	206 MAIN STREET	$ 384,667	0.5	752.6	1.5	2.7	3.7	5.9
537727169	207 Frisco St	$ 170,556	2.0	750.4	NA	NA	-1.2	1.0
537723682	207 Main St	$ 495,768	0.5	754.5	1.4	2.5	3.5	5.7
537715667	208 Cedar St	$ 111,348	1.5	745.1	-1.0	-0.4	0.3	2.1
537730811	208 E MAIN STREET	$ 175,948	0.5	740.6	-0.2	0.5	1.3	3.5
537730812	208 MAIN STREET	$ 219,935	0.5	752.6	1.7	2.8	3.9	6.0
537704910	208 N 4th St	$ 144,192	2.0	757.6	NA	-0.8	0.3	2.8
537723710	208 W Euclid St	$ 187,423	2.0	763.8	-1.9	-0.8	0.3	2.6
537700950	21 MO-8	$ 542,529	0.5	743.7	1.2	1.9	2.7	4.7
537715673	210 Cedar St	$ 147,313	2.0	744.5	-1.3	-0.7	0.0	1.8
537704861	210 S 4th St	$ 114,438	2.0	783.7	-1.9	-1.8	-1.8	-1.0
537723678	211 Main St	$ 349,803	2.0	754.4	-0.1	1.0	2.1	4.3
537715674	212 Cedar St	$ 131,980	2.0	743.4	-1.3	-0.7	0.0	1.9
537723765	212 Main St	$ 693,824	0.5	753.1	1.8	2.9	3.9	6.1
537694959	212 S 3rd St	$ 36,503	0.5	762.7	NA	NA	0.3	2.5
537694967	213 W Euclid St	$ 109,227	1.5	762.8	-1.1	0.2	1.3	3.6
537723706	214 W Euclid St	$ 165,554	2.0	764.7	NA	-0.7	0.4	2.7
537723769	215 3rd St	$ 422,152	0.5	757.6	NA	NA	0.7	3.0
537723771	215B 3rd St	$ 264,795	0.5	757.6	NA	NA	0.7	3.0
537723770	215C 3rd St	$ 1,271,017	0.5	757.6	NA	NA	0.7	3.0
537731158	217 EUCLID ST	$ 113,520	2.0	768.9	-1.8	-0.8	0.1	2.0
537694983	217 W Euclid St	$ 197,441	2.0	763.0	-0.4	0.9	2.0	4.4
537715678	218 Cedar St	$ 119,763	1.5	741.1	NA	-0.9	-0.1	1.9
537731161	218B CEDAR ST	$ 50,592	2.0	871.8	-0.7	0.0	0.7	2.7

537723677	219 Main St	$	999,750	0.5	756.4	-0.2	1.0	2.0	4.4
537704902	220 N 4th St	$	137,196	2.0	758.0	-1.8	-0.7	0.4	2.8
537694985	223 W Euclid St	$	135,974	2.0	763.3	-0.5	0.8	2.0	4.4
537715666	224 Cedar St	$	112,370	2.0	740.3	-0.1	0.6	1.3	3.4
537715659	226 Cedar Dr	$	172,646	0.5	737.1	3.0	3.7	4.7	7.0
537715669	226 Cedar St	$	139,936	2.0	739.7	1.2	1.8	2.5	4.7
537723672	227a Main St	$	202,726	0.5	756.6	0.5	1.7	2.8	5.2
537727222	228 F Cedar Dr	$	141,991	0.5	769.0	2.6	3.2	3.9	6.1
537694479	228A Cedar Dr	$	109,786	0.5	812.5	2.3	2.9	3.6	5.8
537701288	228B Cedar Dr	$	142,077	0.5	778.4	2.2	2.8	3.5	5.7
537715683	228C Cedar Dr	$	148,698	0.5	761.5	2.4	3.1	3.7	5.9
537731185	228D Cedar Dr	$	50,592	0.5	819.2	2.3	2.9	3.6	5.7
537731184	228E Cedar Dr	$	102,927	0.5	780.4	2.5	3.2	3.8	6.0
537715663	228G Cedar Dr	$	109,786	0.5	738.5	2.2	2.7	3.5	5.7
537715662	228H Cedar Dr	$	109,786	0.5	738.4	2.6	3.2	3.9	6.2
537715671	228I Cedar Dr	$	113,242	0.5	747.2	2.2	2.7	3.5	5.7
537715661	228J Cedar Dr	$	109,786	0.5	738.4	2.0	2.6	3.4	5.6
537694507	228K Cedar Dr	$	146,096	0.5	807.8	1.8	2.4	3.2	5.4
537715660	228L Cedar Dr	$	109,786	0.5	738.1	2.4	2.9	3.7	6.0
537715658	228M Cedar Dr	$	109,786	0.5	738.0	1.9	2.4	3.2	5.5
537715657	228N Cedar Dr	$	109,786	0.5	737.1	3.0	3.7	4.5	6.8
537694495	228O Cedar Dr	$	115,129	0.5	811.3	1.3	2.0	3.8	6.1
537694485	228P Cedar Dr	$	105,573	0.5	775.2	2.2	2.9	3.8	6.1
537704898	230 S Spring St	$	262,107	1.5	773.2	-1.1	-1.0	-0.9	-0.1
537694965	231 W Euclid St	$	102,304	1.5	763.4	-0.6	0.8	2.0	4.4
537704904	232 N 4th St	$	143,961	2.0	758.9	NA	-2.0	-0.9	1.6
537700946	25 E MO-8	$	1,875,722	0.5	748.1	0.3	1.0	1.7	3.7
537700952	25 MO-8	$	380,804	0.5	744.5	1.3	2.0	2.7	4.7
537705106	26 Mo-8	$	6,915,673	0.5	765.9	0.0	0.0	0.4	1.4
537694979	271 W Euclid St	$	49,053	2.0	768.3	-0.1	0.8	1.7	3.6
537694975	283 W Euclid St	$	126,466	2.0	769.5	NA	-1.2	-0.2	1.7
537694987	285 W Euclid St	$	151,389	2.0	769.9	-2.0	-1.1	-0.1	1.9
537700944	29 MO-8	$	1,184,571	0.5	743.4	0.7	1.4	2.1	4.1
537694542	300 S 1st St	$	149,565	2.0	767.3	NA	NA	-1.8	-0.5
537716473	301 Frisco St	$	191,160	2.0	748.3	-1.2	-0.1	1.0	3.2
537730809	302 Water St	$	170,580	0.5	755.7	1.4	2.6	3.7	6.0
537701602	303 B Pine St	$	2,248,864	0.5	755.2	-0.3	0.5	1.0	2.1
537716469	303 Frisco St	$	153,338	2.0	749.4	-1.8	-1.0	0.0	2.1
537701596	303 Pine St	$	492,693	0.5	756.6	NA	0.2	0.8	2.0
537729990	303 S 1st St	$	170,637	2.0	758.7	-2.0	-1.9	-1.9	-1.2
537694955	303 W Euclid	$	203,047	2.0	770.4	NA	-1.1	0.0	2.3

537729991	304 Pine St	$	203,484	2.0	758.7	NA	NA	NA	-1.7
537704881	304 S 3rd St	$	152,210	1.0	758.6	NA	-0.5	0.2	2.2
537715695	304 Water St	$	157,103	2.0	754.3	0.7	1.8	2.9	5.2
537716470	305 Frisco St	$	153,361	2.0	748.8	NA	-1.6	-0.6	1.4
537701604	305 Pine St	$	283,540	0.5	758.6	NA	-0.4	0.0	1.2
537729988	306 Pine St	$	919,604	-	761.0	NA	NA	NA	0.2
537715698	306 Water St	$	184,403	2.0	754.2	-0.3	0.7	1.8	4.2
537701567	307 Pine St	$	175,764	2.0	758.7	NA	NA	-1.9	-0.8
537694957	308 Main St	$	43,804	1.5	762.7	-1.4	-0.3	0.8	3.1
537715693	308 Water St	$	103,665	2.0	754.5	-0.7	0.3	1.3	3.7
537701560	309 Pine St	$	193,633	2.0	759.2	NA	NA	-1.2	-0.1
537727877	31 MO-8	$	175,951	0.5	752.9	-0.3	0.2	0.9	2.8
537715703	310 Main St	$	135,796	3.3	756.8	NA	-2.8	-1.7	0.6
537729986	310 S 1st St	$	449,012	1.5	757.6	NA	NA	-1.1	0.3
537715696	310 Water St	$	151,753	2.0	755.6	-0.8	0.2	1.3	3.6
537715700	310B Main St	$	112,624	2.0	776.5	0.1	1.2	2.3	4.7
537725245	311 Main St	$	225,319	2.5	756.6	-1.7	-0.5	0.6	2.9
537701579	311 Pine St	$	117,227	1.5	761.1	NA	NA	-1.4	0.1
537701591	313 Pine St	$	179,319	2.0	761.1	NA	NA	-2.0	-0.4
537701556	313B Pine St	$	117,381	2.0	759.6	-1.0	-0.2	0.5	1.9
537729989	314 Pine St	$	767,201	0.5	762.6	-0.1	-0.1	0.1	0.8
537701571	315 Pine St	$	140,920	2.0	762.5	NA	-2.0	-1.7	-0.2
537701589	317 Pine St	$	160,929	2.0	763.9	NA	NA	-1.7	-0.4
537701540	319 Pine St	$	132,216	2.0	764.5	NA	-1.9	-1.3	0.1
537723677	321 Main St	$	999,750	0.5	756.4	0.2	1.4	2.5	4.9
537701575	323 Pine St	$	121,524	1.5	765.1	NA	NA	-1.2	0.2
537701598	323 Pine St	$	121,524	1.5	765.5	-1.1	-0.8	-0.4	0.9
537701608	325 Pine St	$	132,583	2.0	766.4	-1.7	-1.4	-1.0	0.2
537701577	327 Pine St	$	128,730	1.5	767.6	-1.0	-0.5	0.0	1.2
537716456	329 Pine St	$	728,362	0.5	776.9	NA	NA	-0.2	0.7
537700958	33 MO-8	$	124,306	2.0	747.9	NA	NA	NA	-1.2
537717712	333 Pine St	$	177,923	1.5	842.1	-1.4	-0.7	-0.1	1.0
537704906	352 N 4th St	$	133,329	2.0	759.8	-1.5	-1.3	-0.8	1.2
537715702	388 Main St	$	783,780	0.5	757.1	NA	NA	-0.1	2.2
537716472	401 Frisco St	$	166,494	1.5	747.0	-1.2	-0.5	0.4	2.2
537729915	401 Main St	$	78,332	0.5	758.7	NA	-0.5	1.0	3.4
537729914	403 W Main St	$	239,148	2.5	758.7	-2.0	-1.4	-0.5	1.8
537726246	404 Main St	$	1,366,054	0.5	760.9	-0.4	0.4	1.2	3.4
537729907	404 W Main St	$	181,536	2.0	758.8	NA	-1.6	-0.9	1.3
537727161	405 Frisco St	$	660,546	2.5	746.5	-2.1	-1.4	-0.8	0.8
537704920	405 Main St	$	114,815	1.5	758.9	-0.7	-0.2	0.7	2.9

537727165	407 Frisco St	$	264,932	1.5	746.1	NA	-0.8	-0.1	1.7
537704928	407 Main St	$	45,534	0.5	759.9	-0.1	0.5	1.4	3.6
537704924	407A Main St	$	75,131	0.5	759.9	0.3	0.8	1.6	3.8
537727163	407B Frisco St	$	342,426	2.0	746.4	NA	-1.9	-1.1	0.8
537704932	407B Main St	$	330,254	0.5	759.9	-0.4	0.2	1.0	3.3
537704926	407C Main St	$	109,281	0.5	759.9	0.7	1.2	2.0	4.2
537729905	408 Main St	$	358,364	0.5	758.6	0.2	0.8	1.6	3.7
537701194	451 Industrial Dr	$	390,641	0.5	727.8	-0.1	0.1	0.5	4.0
537700940	47 E MO-8	$	4,554,524	0.5	743.2	-0.3	-0.3	-0.1	0.3
537727862	501 Frisco St	$	209,960	2.0	744.5	-1.8	-0.9	-0.1	1.9
537727866	501B Frisco St	$	255,753	2.0	744.8	-1.9	-1.0	-0.1	2.0
537726251	502 Main St	$	434,234	0.5	760.4	0.1	0.6	1.4	3.7
537727860	503 Frisco St	$	151,849	2.0	743.3	NA	NA	-1.4	0.7
537729927	503 Main St	$	487,828	0.5	760.9	1.0	1.9	2.8	5.0
537729928	503 Main St	$	549,723	0.5	760.2	0.3	1.0	1.8	4.0
537727859	504 E High St	$	104,592	0.5	743.6	NA	NA	-0.2	2.2
537727864	504 Frisco St	$	111,011	2.0	742.9	NA	-1.1	0.0	2.3
537729913	504 Main St	$	195,830	0.5	758.7	0.8	1.4	2.1	4.4
537727865	505 Frisco St	$	108,124	1.5	742.7	-0.4	0.7	1.6	3.8
537727858	506 E High St	$	119,563	1.5	742.8	NA	NA	-1.3	1.1
537726250	510 B Main St	$	1,564,488	0.5	763.6	NA	-0.1	0.8	2.9
537717740	510 Main St	$	390,110	0.5	773.6	-0.2	1.0	1.9	4.0
537726247	510C Main St	$	533,256	0.5	762.3	NA	-0.5	0.5	2.6
537729912	510D Main St	$	209,985	0.5	758.7	0.4	0.9	1.7	4.0
537701192	522 Industrial Dr	$	756,252	0.5	722.4	NA	NA	1.0	5.4
537701216	552 Industrial Dr	$	468,434	0.5	721.7	NA	NA	1.4	5.8
537701180	552B Industrial Dr	$	532,176	0.5	722.6	-0.4	-0.4	1.2	5.3
537727867	597 B Industrial Dr	$	1,382,251	0.5	726.1	0.5	0.9	3.6	8.0
537727868	597 Industrial Dr	$	600,683	0.5	723.9	0.0	0.1	2.6	6.8
537701258	601 Frisco St	$	155,225	2.0	742.5	-1.7	-0.8	0.4	2.8
537729828	601 W Main St	$	1,461,130	0.5	761.1	0.5	1.4	2.4	4.7
537701304	602 Industrial Dr	$	391,388	0.5	721.2	NA	NA	0.7	5.2
537694971	602 Main St	$	258,661	0.5	761.4	1.0	2.0	2.9	5.1
537694961	604 Main St	$	255,523	0.5	762.7	-0.4	0.6	1.6	3.7
537701312	605 Frisco St	$	133,539	1.5	742.0	-1.3	-0.1	1.2	3.7
537723797	606 Main St	$	2,437,366	0.5	831.8	-0.1	1.2	2.2	4.5
537701210	607 Frisco St	$	111,435	2.0	740.9	NA	-1.0	0.5	3.1
537701232	609 Frisco St	$	100,558	2.0	739.8	-1.8	-0.6	1.0	3.7
537701240	609 Frisco St	$	100,558	2.0	741.4	NA	-1.3	0.2	2.9
537701274	609 Frisco St	$	100,558	2.0	740.7	-1.5	-0.4	1.1	3.8
537729904	61 B MO-8	$	314,050	0.5	758.5	0.6	1.4	2.3	4.5

537723662	61 MO-8	$	1,202,677	0.5	752.0	0.8	1.6	2.5	4.8
537701204	613 Frisco St	$	131,980	2.0	738.2	-1.1	0.7	2.4	5.1
537701224	615 Frisco St	$	145,376	2.0	738.0	-1.1	0.5	2.0	4.7
537701200	619 Frisco St	$	170,637	2.0	738.1	-1.4	0.2	1.7	4.3
537700964	61C MO-8	$	837,013	0.5	735.6	0.4	1.2	2.1	4.3
537701286	621 Frisco St	$	87,773	2.0	737.4	0.2	1.7	3.0	5.6
537701266	623 Frisco St	$	147,220	2.0	736.7	0.0	1.4	2.8	5.3
537701280	625 Frisco St	$	108,403	2.0	736.9	-0.1	1.3	2.6	5.1
537701186	627 Frisco St	$	154,544	2.0	736.7	-0.5	0.7	1.8	4.2
537700956	63 C MO-8	$	3,595,574	0.5	736.9	-0.1	0.3	1.0	3.0
537700938	63 MO-8	$	7,035,926	0.5	735.6	1.2	2.0	2.9	5.0
537701222	631 Frisco St	$	163,752	2.0	736.2	0.5	1.6	2.6	5.0
537723668	63B MO-8	$	143,341	0.5	750.5	2.1	2.8	3.7	5.8
537730808	69 MO-8	$	175,406	0.5	737.4	-0.1	-0.1	0.3	2.4
537715672	700 Frisco St	$	1,240,897	0.5	735.0	3.4	4.2	5.1	7.2
537701612	73 MO-8	$	154,296	0.5	812.0	-0.3	0.6	1.7	3.9
537700962	75 MO-8	$	1,722,486	0.5	734.5	NA	-0.5	0.1	2.4
537700936	77 MO-8	$	707,933	0.5	731.8	0.7	1.4	2.2	4.7
537729903	810 B Main St	$	9,406,832	0.5	758.5	0.2	0.9	2.1	4.6
537729906	810 Main St	$	7,624,508	0.5	758.8	0.4	0.8	2.0	4.7
537723655	8185 MO-8	$	354,692	0.5	752.7	0.8	1.8	2.9	5.6
537729926	868 Main St	$	48,222	0.5	760.9	-0.1	0.4	1.6	4.1
537704922	868B Main St	$	204,484	0.5	759.9	NA	NA	NA	1.6

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US Army Corps of Engineers®

Flood Hazard Analysis and Mitigation Plan
City of Steelville, MO

Appendix D: Nonstructural Flood Mitigation Plan for Flood-prone Structures (1% AEP)

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The nonstructural measures to reduce future flood damages are based on the structure foundation type, occupancy type and local flooding characteristics. Each flood-prone structure in the study area has been evaluated for its structural attributes, hydraulic conditions and estimated cost of nonstructural flood mitigation. All options in this report are preliminary and are subject to a detailed field survey and site-specific cost estimate.

TABLE D1 shows the most viable flood risk mitigation method for individual structures in the 1% AEP as well as key structural attributes. The 1% AEP flood column in the table represents the depth of flooding relative to the first-floor elevation, meaning negative values are below the first floor. Along with the viable mitigation methods provided in TABLE D1, it also includes site addresses for each structure, appraised values, ground surface elevation and floodproofing costs.

The structures that are getting inundated at lower than their first-floor elevations and that have either basements or crawlspaces will need their subfloors filled with rocks in order to be mitigated for flood waters.

Some of the structures receiving flood depths of higher than 3 feet (dry floodproof approach mitigates all the way to 3 feet) but no other mitigation approach besides dry floodproofing is feasible for those structures are marked with an asterisk (*) for “dry floodproofing” recommendation. The structures that have dry floodproofing recommendations marked with an asterisk can provide risk reduction at least to the 4% AEP year event. Depending on individual structure depths, they can even provide risk reduction of up to the 2% AEP event.

TABLE D1. NONSTRUCTURAL FLOOD MITIGATION PLAN FOR FLOOD-PRONE STRUCTURES (1% AEP)

FID	Site Street	Appraised Value	1% AEP (100Yr)	Ground Surface	Floodproof Cost	Recommendation
537731187	634 Frisco Street	$ 175,205	-0.55	732.6	$ 319,742	Fill Basement
537723709	10 Ivy St	$ 113,192	0.01	763.8	$ 48,052	Dry Flood Proof
537727187	100 Main St	$ 229,958	2.21	753.1	$ 77,684	Dry Flood Proof
537715682	101 Cedar St	$ 185,437	2.99	747.2	$ 65,897	Dry flood proof
537715665	101 E Main St	$ 514,547	2.61	744.2	$ 50,988	Dry Flood Proof
537715676	101 Hickory St	$ 552,791	1.89	749.4	$ 62,318	Dry Flood Proof
537700948	101 Main St	$ 517,344	1.35	748.1	$ 101,950	Dry Flood Proof
537729911	101 MO-8	$ 614,254	1.74	758.7	$ 44,091	Dry Flood Proof
537723656	101 N First St	$ 591,153	1.36	752.7	$ 52,258	Dry Flood Proof
537704930	101 N Spring St	$ 109,460	1.47	759.9	$ 37,894	Dry Flood Proof
537726238	101 Pine St	$ 584,383	1.38	745.3	$ 66,543	Dry Flood Proof
537723766	101 S 3rd St	$ 609,117	4.66	753.1	$ 67,213	Dry Flood Proof*
537717723	101 W Euclid St	$ 1,166,107	1.65	775.2	$ 117,332	Dry Flood Proof
537730610	101 W. Keysville	$ 1,063,548	1.35	758.1	$ 88,612	Dry Flood Proof
537723667	101B Cedar St	$ 106,472	1.98	750.5	$ 41,552	Dry Flood Proof
537723767	101B S 3rd St	$ 380,698	4.23	753.1	$ 54,421	Dry Flood Proof*
537723776	101C S 3rd St	$ 1,251,992	2.92	753.3	$ 47,950	Dry Flood Proof
537723676	101D S 3rd St	$ 167,562	3.55	756.0	$ 53,463	Dry Flood Proof*
537723675	101F S 3rd St	$ 502,686	3.56	756.0	$ 71,350	Dry Flood Proof*
537727189	102 Main St	$ 143,724	2.53	753.1	$ 56,444	Dry Flood Proof
537717725	103 Main St	$ 888,925	1.70	776.0	$ 53,350	Dry Flood Proof
537704914	103 N Spring St	$ 109,431	0.54	759.1	$ 48,723	Dry Flood Proof
537723666	104 Hickory St	$ 397,496	2.62	750.5	$ 53,404	Dry Flood Proof
537727191	104 Main St	$ 468,782	2.32	753.1	$ 57,878	Dry Flood Proof
537730816	104-108 First Street	$ 175,948	4.63	748.3	$ 78,100	Dry Flood Proof*
537727177	105 Frisco St	$ 130,996	-1.96	753.9	$ 206,204	Fill Basement
537723663	105 Main St	$ 1,002,793	2.56	752.0	$ 87,125	Dry Flood Proof
537725244	105 Main St	$ 1,655,943	1.41	755.2	$ 200,896	Dry Flood Proof
537704908	105 N Spring St	$ 160,142	0.44	759.1	$ 65,431	Dry Flood Proof
537723653	105B Main St	$ 1,265,702	2.75	749.0	$ 53,811	Dry Flood Proof
537729987	106 E Keysville St	$ 462,170	-1.78	758.5	$ -	No Reccomendation
537726252	106 E Main St	$ 1,600,456	1.42	756.3	$ 136,600	Dry Flood Proof
537727183	107 Frisco St	$ 125,543	-1.38	752.4	$ 195,476	Fill Basement
537715670	107 Hickory St	$ 225,432	2.51	748.7	$ 50,625	Dry Flood Proof
537716465	107 Main St	$ 308,924	1.58	780.5	$ 67,615	Dry Flood Proof

537715699	107 S 3rd St	$ 1,085,441	2.61	755.0	$ 124,475	Dry Flood Proof
537731191	108 Elm Ave	$ 148,882	1.65	760.4	$ 60,025	Dry Flood Proof
537730815	108-110 W MAIN	$ 219,935	2.41	750.1	$ 62,463	Dry Flood Proof
537723664	109 E Main St	$ 775,822	2.09	752.0	$ 76,320	Dry Flood Proof
537717720	109 Main St	$ 486,978	1.69	778.5	$ 60,297	Dry Flood Proof
537723669	109 N First St	$ 448,261	1.31	752.5	$ 68,341	Dry Flood Proof
537715664	110 Cedar St	$ 2,189,117	2.46	747.5	$ 162,003	Dry Flood Proof
537704912	110 Elm Ave	$ 130,445	0.08	758.7	$ 59,124	Dry Flood Proof
537704918	111 Elm Ave	$ 138,816	1.92	757.3	$ 38,977	Dry Flood Proof
537723654	112 Main St	$ 351,584	2.83	749.0	$ 104,796	Dry Flood Proof
537726249	112 W Euclid St	$ 149,064	1.48	763.0	$ 297,017	Dry Flood Proof
537727875	112B Main St	$ 291,653	0.11	752.7	$ 46,039	Dry Flood Proof
537694953	113 B W Euclid St	$ 130,132	1.98	762.4	$ 55,889	Dry Flood Proof
537730810	113 Main Street	$ 175,948	1.97	755.9	$ 62,350	Dry Flood Proof
537723659	113 N First St	$ 583,266	1.31	752.1	$ 48,812	Dry Flood Proof
537694977	113 W Euclid St	$ 138,205	2.33	762.5	$ 60,107	Dry Flood Proof
537727193	116 Main St	$ 702,719	2.79	753.0	$ 68,341	Dry Flood Proof
537723708	116 W Euclid St	$ 124,785	0.19	765.3	$ 269,779	Dry Flood Proof
537726248	116 W Euclid St	$ 123,060	1.16	763.0	$ 226,673	Dry Flood Proof
537716463	117 E Main St	$ 313,668	2.31	784.3	$ 62,586	Dry Flood Proof
537723650	117 E Main St	$ 304,345	2.03	751.5	$ 62,281	Dry Flood Proof
537694951	117 W Euclid St	$ 135,368	0.70	762.3	$ 308,124	Dry Flood Proof
537715677	118 Cedar St	$ 103,665	-0.32	746.1	$ 174,020	Fill Basement
537730814	118 MAIN STREET	$ 169,350	2.55	752.8	$ 41,763	Dry Flood Proof
537723707	118 W Euclid St	$ 160,847	0.40	765.8	$ 408,615	Dry Flood Proof
537715668	120 Cedar St	$ 160,772	0.36	745.9	$ 65,758	Dry Flood Proof
537726245	120 W Euclid St	$ 112,114	1.66	763.5	$ 56,012	Dry Flood Proof
537694981	121 W Euclid St	$ 155,140	1.13	762.6	$ 315,264	Dry Flood Proof
537727179	123 N Brickey St	$ 1,482,879	1.24	761.1	$ 68,200	Dry Flood Proof
537729910	144 N 4th St	$ 205,642	0.91	757.8	$ 87,257	Dry Flood Proof
537723652	145 Matred St	$ 86,496	2.28	749.0	$ 43,338	Dry Flood Proof
537726239	155 Matred St	$ 188,335	-0.18	750.1	$ 355,352	Fill Basement
537726235	161 Matred St	$ 390,379	0.11	751.1	$ 50,394	Dry Flood Proof
537729827	175 W Euclid st	$ 543,044	1.87	760.4	$ 60,918	Dry Flood Proof
537723670	19 Main St	$ 2,091,868	2.95	751.7	$ 197,558	Dry Flood Proof
537730101	200 Pine St	$ 1,090,681	2.13	755.6	$ 113,242	Dry Flood Proof
537727173	201 Frisco St	$ 195,680	-1.12	751.6	$ 375,170	Fill Basement
537723768	201 Keysville Rd	$ 123,677	-0.61	760.3	$ 34,800	Fill Basement
537730102	201 Main St	$ 863,890	1.34	755.6	$ 75,842	Dry Flood Proof

537715675	202 Cedar St	$ 124,623	-0.95	745.2	$ 270,572	Fill Basement
537731186	202 LYNN STREET	$ 140,341	0.65	743.4	$ 327,429	Dry Flood Proof
537723772	202 Main St	$ 336,702	3.08	752.8	$ 81,486	Dry Flood Proof*
537723689	202 S Spring St	$ 149,463	-1.24	769.6	$ 27,113	Fill Crawlspace
537727175	203 Frisco St	$ 124,623	0.25	750.7	$ 63,874	Dry Flood Proof
537730604	203 Industrial Dr	$ 122,322	3.61	727.7	$ 109,600	Wet Flood Proof
537723674	203 S 4th St	$ 225,582	1.60	756.0	$ 81,700	Dry Flood Proof
537715681	204 Cedar St	$ 99,836	0.47	744.9	$ 49,460	Dry Flood Proof
537730220	204 Cherry St	$ 115,290	-0.77	745.9	$ -	No Reccomendation
537727861	204 Lynn St	$ 119,475	0.36	743.0	$ 217,682	Dry Flood Proof
537726236	204 Main St	$ 1,185,007	2.14	750.4	$ 87,348	Dry Flood Proof
537730606	204 S 1st St	$ 479,034	2.90	754.6	$ 58,908	Dry Flood Proof
537726237	204B Main St	$ 789,927	2.11	750.4	$ 78,306	Dry Flood Proof
537727863	205 Cherry St	$ 194,204	-0.74	743.9	$ 371,818	Fill Basement
537727181	205 Frisco St	$ 170,556	-0.98	750.8	$ 306,556	Fill Basement
537723764	205 S 3rd St	$ 102,589	2.81	752.9	$ 50,770	Dry Flood Proof
537694969	205 W Euclid St	$ 140,187	1.50	762.8	$ 270,572	Dry Flood Proof
537730813	206 MAIN STREET	$ 384,667	3.73	752.6	$ 52,776	Dry Flood Proof*
537727169	207 Frisco St	$ 170,556	-1.21	750.4	$ 306,556	Fill Basement
537723682	207 Main St	$ 495,768	3.51	754.5	$ 76,131	Dry Flood Proof*
537715667	208 Cedar St	$ 111,348	0.30	745.1	$ 55,521	Dry Flood Proof
537730811	208 E MAIN STREET	$ 175,948	1.33	740.6	$ 42,100	Dry Flood Proof
537730812	208 MAIN STREET	$ 219,935	3.87	752.6	$ 44,350	Dry Flood Proof*
537704910	208 N 4th St	$ 144,192	0.30	757.6	$ 57,978	Dry Flood Proof
537723710	208 W Euclid St	$ 187,423	0.33	763.8	$ 418,664	Dry Flood Proof
537700950	21 MO-8	$ 542,529	2.66	743.7	$ 48,560	Dry Flood Proof
537715673	210 Cedar St	$ 147,313	-0.04	744.5	$ -	No Reccomendation
537704861	210 S 4th St	$ 114,438	-1.77	783.7	$ 206,780	Fill Basement
537723678	211 Main St	$ 349,803	2.07	754.4	$ 53,519	Dry Flood Proof
537715674	212 Cedar St	$ 131,980	-0.04	743.4	$ -	No Reccomendation
537723765	212 Main St	$ 693,824	3.95	753.1	$ 97,062	Dry Flood Proof*
537694959	212 S 3rd St	$ 36,503	0.32	762.7	$ 78,409	Dry Flood Proof
537694967	213 W Euclid St	$ 109,227	1.29	762.8	$ 54,210	Dry Flood Proof
537723706	214 W Euclid St	$ 165,554	0.40	764.7	$ 346,037	Dry Flood Proof
537723769	215 3rd St	$ 422,152	0.69	757.6	$ 45,900	Dry Flood Proof
537723771	215B 3rd St	$ 264,795	0.69	757.6	$ 38,220	Dry Flood Proof
537723770	215C 3rd St	$ 1,271,017	0.69	757.6	$ 57,676	Dry Flood Proof
537731158	217 EUCLID ST	$ 113,520	0.12	768.9	$ 50,484	Dry Flood Proof

537694983	217 W Euclid St	$ 197,441	2.03	763.0	$ 357,312	Dry Flood Proof
537715678	218 Cedar St	$ 119,763	-0.09	741.1	$ 22,775	Fill Crawlspace
537731161	218B CEDAR ST	$ 50,592	0.70	871.8	$ 281,150	Dry Flood Proof
537723677	219 Main St	$ 999,750	2.04	756.4	$ 68,436	Dry Flood Proof
537704902	220 N 4th St	$ 137,196	0.36	758.0	$ 62,892	Dry Flood Proof
537694985	223 W Euclid St	$ 135,974	2.04	763.3	$ 310,377	Dry Flood Proof
537715666	224 Cedar St	$ 112,370	1.33	740.3	$ 45,201	Dry Flood Proof
537715659	226 Cedar Dr	$ 172,646	4.67	737.1	$ 253,560	Buyout
537715669	226 Cedar St	$ 139,936	2.53	739.7	$ 55,889	Dry Flood Proof
537723672	227a Main St	$ 202,726	2.80	756.6	$ 49,806	Dry Flood Proof
537694479	228A Cedar Dr	$ 109,786	3.61	812.5	$ 206,370	Buyout
537701288	228B Cedar Dr	$ 142,077	3.52	778.4	$ 287,490	Buyout
537715683	228C Cedar Dr	$ 148,698	3.72	761.5	$ 259,020	Buyout
537731185	228D Cedar Dr	$ 50,592	3.60	819.2	$ 248,100	Buyout
537731184	228E Cedar Dr	$ 102,927	3.84	780.4	$ 216,120	Buyout
537727222	228F Cedar Dr	$ 141,991	3.88	769.0	$ 244,590	Buyout
537715663	228G Cedar Dr	$ 109,786	3.46	738.5	$ 253,560	Buyout
537715662	228H Cedar Dr	$ 109,786	3.92	738.4	$ 253,560	Buyout
537715671	228I Cedar Dr	$ 113,242	3.45	747.2	$ 190,380	Buyout
537715661	228J Cedar Dr	$ 109,786	3.37	738.4	$ 253,560	Buyout
537694507	228K Cedar Dr	$ 146,096	3.17	807.8	$ 253,560	Buyout
537715660	228L Cedar Dr	$ 109,786	3.71	738.1	$ 253,560	Buyout
537715658	228M Cedar Dr	$ 109,786	3.23	738.0	$ 253,560	Buyout
537715657	228N Cedar Dr	$ 109,786	4.53	737.1	$ 253,560	Buyout
537694495	228O Cedar Dr	$ 115,129	3.84	811.3	$ 253,560	Buyout
537694485	228P Cedar Dr	$ 105,573	3.78	775.2	$ 222,360	Buyout
537704898	230 S Spring St	$ 262,107	-0.89	773.2	$ 22,368	Fill Crawlspace
537694965	231 W Euclid St	$ 102,304	2.01	763.4	$ 43,318	Dry Flood Proof
537704904	232 N 4th St	$ 143,961	-0.90	758.9	$ -	No Reccomendation
537700946	25 E MO-8	$ 1,875,722	1.69	748.1	$ 164,350	Dry Flood Proof
537700952	25 MO-8	$ 380,804	2.74	744.5	$ 46,243	Dry Flood Proof
537705106	26 Mo-8	$ 6,915,673	0.41	765.9	$ 148,363	Dry Flood Proof
537694979	271 W Euclid St	$ 49,053	1.73	768.3	$ 50,750	Dry Flood Proof
537694975	283 W Euclid St	$ 126,466	-0.22	769.5	$ -	No Reccomendation
537694987	285 W Euclid St	$ 151,389	-0.09	769.9	$ -	No Reccomendation
537700944	29 MO-8	$ 1,184,571	2.14	743.4	$ 105,996	Dry Flood Proof
537694542	300 S 1st St	$ 149,565	-1.83	767.3	$ -	No Reccomendation
537716473	301 Frisco St	$ 191,160	0.96	748.3	$ 431,093	Dry Flood Proof
537730809	302 Water St	$ 170,580	3.71	755.7	$ 30,125	Dry flood proof*

537716469	303 Frisco St	$ 153,338	-0.01	749.4	$ 260,738	Fill Basement
537701596	303 Pine St	$ 492,693	0.84	756.6	$ 56,793	Dry Flood Proof
537729990	303 S 1st St	$ 170,637	-1.89	758.7	$ -	No Reccomendation
537694955	303 W Euclid	$ 203,047	-0.05	770.4	$ -	No Reccomendation
537701602	303B Pine St	$ 2,248,864	1.02	755.2	$ 156,850	Dry Flood Proof
537704881	304 S 3rd St	$ 152,210	0.23	758.6	$ 67,888	Dry Flood Proof
537715695	304 Water St	$ 157,103	2.90	754.3	$ 61,417	Dry Flood Proof
537716470	305 Frisco St	$ 153,361	-0.61	748.8	$ 319,295	Fill Basement
537701604	305 Pine St	$ 283,540	-0.01	758.6	$ -	No Reccomendation
537715698	306 Water St	$ 184,403	1.81	754.2	$ 63,874	Dry Flood Proof
537701567	307 Pine St	$ 175,764	-1.92	758.7	$ 309,461	Fill Basement
537694957	308 Main St	$ 43,804	0.78	762.7	$ 56,795	Dry Flood Proof
537715693	308 Water St	$ 103,665	1.35	754.5	$ 46,184	Dry Flood Proof
537701560	309 Pine St	$ 193,633	-1.21	759.2	$ 292,028	Fill Basement
537727877	31 MO-8	$ 175,951	0.88	752.9	$ 24,500	Dry Flood Proof
537715703	310 Main St	$ 135,796	-1.72	756.8	$ 260,738	Fill Basement
537729986	310 S 1st St	$ 449,012	-1.12	757.6	$ 45,128	Fill Crawlspace
537715696	310 Water St	$ 151,753	1.28	755.6	$ 372,121	Dry Flood Proof
537715700	310B Main St	$ 112,624	2.27	776.5	$ 50,115	Dry Flood Proof
537725245	311 Main St	$ 225,319	0.57	756.6	$ 649,059	Dry Flood Proof
537701579	311 Pine St	$ 117,227	-1.44	761.1	$ 20,390	Fill Crawlspace
537701591	313 Pine St	$ 179,319	-1.95	761.1	$ 331,141	Fill Basement
537701556	313B Pine St	$ 117,381	0.48	759.6	$ 221,147	Dry Flood Proof
537729989	314 Pine St	$ 767,201	0.09	762.6	$ 75,686	Dry Flood Proof
537701571	315 Pine St	$ 140,920	-1.71	762.5	$ 277,724	Fill Basement
537701589	317 Pine St	$ 160,929	-1.70	763.9	$ 281,300	Fill Basement
537701540	319 Pine St	$ 132,216	-1.28	764.5	$ -	No Reccomendation
537723677	321 Main St	$ 999,750	2.47	756.4	$ 77,372	Dry Flood Proof
537701575	323 Pine St	$ 121,524	-1.16	765.1	$ -	No Reccomendation
537701598	323 Pine St	$ 121,524	-0.38	765.5	$ 23,018	Fill Crawlspace
537701608	325 Pine St	$ 132,583	-0.97	766.4	$ 250,904	Fill Basement
537701577	327 Pine St	$ 128,730	-0.02	767.6	$ -	No Reccomendation
537716456	329 Pine St	$ 728,362	-0.24	776.9	$ -	No Reccomendation
537717712	333 Pine St	$ 177,923	-0.13	842.1	$ -	No Reccomendation
537704906	352 N 4th St	$ 133,329	-0.83	759.8	$ -	No Reccomendation
537715702	388 Main St	$ 783,780	-0.12	757.1	$ -	No Reccomendation
537716472	401 Frisco St	$ 166,494	0.43	747.0	$ 90,738	Dry Flood Proof
537729915	401 Main St	$ 78,332	1.02	758.7	$ 54,610	Dry Flood Proof
537729914	403 W Main St	$ 239,148	-0.51	758.7	$ -	No Reccomendation

537726246	404 Main St	$ 1,366,054	1.19	760.9	$ 66,850	Dry Flood Proof
537729907	404 W Main St	$ 181,536	-0.86	758.8	$ -	No Reccomendation
537727161	405 Frisco St	$ 660,546	-0.76	746.5	$ -	No Reccomendation
537704920	405 Main St	$ 114,815	0.69	758.9	$ 58,387	Dry Flood Proof
537727165	407 Frisco St	$ 264,932	-0.10	746.1	$ 25,264	Fill Crawlspace
537704928	407 Main St	$ 45,534	1.39	759.9	$ 45,085	Dry Flood Proof
537704924	407A Main St	$ 75,131	1.57	759.9	$ 42,988	Dry Flood Proof
537727163	407B Frisco St	$ 342,426	-1.10	746.4	$ 365,532	Fill Basement
537704932	407B Main St	$ 330,254	1.04	759.9	$ 43,886	Dry Flood Proof
537704926	407C Main St	$ 109,281	1.98	759.9	$ 47,482	Dry Flood Proof
537729905	408 Main St	$ 358,364	1.57	758.6	$ 51,833	Dry Flood Proof
537701194	451 Industrial Dr	$ 390,641	0.52	727.8	$ 86,464	Dry Flood Proof
537700940	47 E MO-8	$ 4,554,524	-0.15	743.2	$ -	No Reccomendation
537727862	501 Frisco St	$ 209,960	-0.11	744.5	$ -	No Reccomendation
537727866	501B Frisco St	$ 255,753	-0.09	744.8	$ 530,185	Fill Basement
537726251	502 Main St	$ 434,234	1.38	760.4	$ 53,540	Dry Flood Proof
537727860	503 Frisco St	$ 151,849	-1.40	743.3	$ 256,939	Fill Basement
537729927	503 Main St	$ 487,828	2.78	760.9	$ 73,832	Dry Flood Proof
537729928	503 Main St	$ 549,723	1.83	760.2	$ 59,841	Dry Flood Proof
537727859	504 E High St	$ 104,592	-0.15	743.6	$ -	No Reccomendation
537727864	504 Frisco St	$ 111,011	-0.01	742.9	$ 191,900	Fill Basement
537729913	504 Main St	$ 195,830	2.15	758.7	$ 43,117	Dry Flood Proof
537727865	505 Frisco St	$ 108,124	1.62	742.7	$ 61,655	Dry Flood Proof/Fill crawlspace
537727858	506 E High St	$ 119,563	-1.29	742.8	$ 22,748	Fill Crawlspace
537717740	510 Main St	$ 390,110	1.91	773.6	$ 54,887	Dry Flood Proof
537726250	510B Main St	$ 1,564,488	0.76	763.6	$ 146,950	Dry Flood Proof
537726247	510C Main St	$ 533,256	0.46	762.3	$ 78,629	Dry Flood Proof
537729912	510D Main St	$ 209,985	1.73	758.7	$ 44,119	Dry Flood Proof
537701192	522 Industrial Dr	$ 756,252	0.99	722.4	$ 136,409	Dry Flood Proof
537701216	552 Industrial Dr	$ 468,434	1.38	721.7	$ 91,523	Dry Flood Proof
537701180	552B Industrial Dr	$ 532,176	1.24	722.6	$ 101,347	Dry Flood Proof
537727868	597 Industrial Dr	$ 600,683	2.61	723.9	$ 46,020	Dry Flood Proof
537727867	597B Industrial Dr	$ 1,382,251	3.59	726.1	$ 167,000	Wet Flood Proof
537701258	601 Frisco St	$ 155,225	0.38	742.5	$ 315,529	Dry Flood Proof
537729828	601 W Main St	$ 1,461,130	2.42	761.1	$ 110,756	Dry Flood Proof
537701304	602 Industrial Dr	$ 391,388	0.74	721.2	$ 79,844	Dry Flood Proof
537694971	602 Main St	$ 258,661	2.93	761.4	$ 47,546	Dry Flood Proof
537694961	604 Main St	$ 255,523	1.61	762.7	$ 64,713	Dry Flood Proof
537701312	605 Frisco St	$ 133,539	1.22	742.0	$ 69,771	Dry Flood Proof

537723797	606 Main St	$ 2,437,366	2.19	831.8	$ 111,850	Dry Flood Proof
537701210	607 Frisco St	$ 111,435	0.48	740.9	$ 44,833	Dry Flood Proof
537701232	609 Frisco St	$ 100,558	0.98	739.8	$ 44,833	Dry Flood Proof
537701240	609 Frisco St	$ 100,558	0.22	741.4	$ 44,833	Dry Flood Proof
537701274	609 Frisco St	$ 100,558	1.14	740.7	$ 44,833	Dry Flood Proof
537729904	61 B MO-8	$ 314,050	2.31	758.5	$ 38,229	Dry Flood Proof
537723662	61 MO-8	$ 1,202,677	2.54	752.0	$ 127,644	Dry Flood Proof
537701204	613 Frisco St	$ 131,980	2.37	738.2	$ 59,943	Dry Flood Proof
537701224	615 Frisco St	$ 145,376	2.04	738.0	$ 346,734	Dry Flood Proof
537701200	619 Frisco St	$ 170,637	1.66	738.1	$ 364,187	Dry Flood Proof
537700964	61C MO-8	$ 837,013	2.12	735.6	$ 67,588	Dry Flood Proof
537701286	621 Frisco St	$ 87,773	3.00	737.4	$ 148,484	Dry Flood Proof
537701266	623 Frisco St	$ 147,220	2.76	736.7	$ 291,728	Dry Flood Proof
537701280	625 Frisco St	$ 108,403	2.61	736.9	$ 53,719	Dry Flood Proof
537701186	627 Frisco St	$ 154,544	1.80	736.7	$ 62,646	Dry Flood Proof
537700938	63 MO-8	$ 7,035,926	2.86	735.6	$ 56,189	Dry Flood Proof
537701222	631 Frisco St	$ 163,752	2.63	736.2	$ 342,502	Dry Flood Proof
537723668	63B MO-8	$ 143,341	3.68	750.5	$ 78,800	Wet Flood Proof (open walls)
537700956	63C MO-8	$ 3,595,574	1.00	736.9	$ 305,694	Dry Flood Proof
537730808	69 MO-8	$ 175,406	0.32	737.4	$ 42,550	Dry Flood Proof
537715672	700 Frisco St	$ 1,240,897	5.10	735.0	$ 133,780	Wet Flood Proof
537701612	73 MO-8	$ 154,296	1.70	812.0	$ 98,463	Dry Flood Proof
537700962	75 MO-8	$ 1,722,486	0.06	734.5	$ 170,784	Dry Flood Proof
537700936	77 MO-8	$ 707,933	2.19	731.8	$ 75,423	Dry Flood Proof
537729906	810 Main St	$ 7,624,508	1.99	758.8	$ 208,176	Dry Flood Proof
537729903	810B Main St	$ 9,406,832	2.13	758.5	$ 252,491	Dry Flood Proof
537723655	8185 MO-8	$ 354,692	2.85	752.7	$ 101,725	Dry Flood Proof
537729926	868 Main St	$ 48,222	1.56	760.9	$ 44,414	Dry Flood Proof

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Flood Hazard Analysis and Mitigation Plan
City of Steelville, MO

Appendix E: USACE Nonstructural Flood Risk Management Matrix

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Table E1. USACE Nonstructural Flood Risk Management Matrix

NONSTRUCTURAL FLOOD RISK MANAGEMENT MATRIX May 2019		PHYSICAL NONSTRUCTURAL MITIGATION MEASURES									
		Elevation									
		Extended Foundation	Piers	Posts	Columns	Piles	Fill (compacted)	Relocation	Acquisition	Dry Flood Proofing	Wet Flood Proofing
Flood Characteristics	**Flood Depth**										
	Shallow (<3 feet)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Deep (6 to 12 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Very Deep (>12 feet)	N	N	N	N	N	N	Y	Y	N	N
	Flood Velocity										
	Low (less than 3 feet per second)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet per second)	N	Y	Y	Y	Y	Y	Y	Y	N	N
	High (greater than 6 feet per second)	N	Y	N	N	Y	N	Y	Y	N	N
	Flash Flooding										
	Yes (less than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	No (more than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Debris /Ice Flow										
	Yes	N	Y	N	N	Y	Y	Y	Y	N	N
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**										
	Coastal Beach Front	N	N	N	N	Y	N	Y	Y	N	N
	Coastal Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Riverine Floodplain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Soil Type										
	Permeable	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Structure Characteristics	**Structure Foundation**										
	Slab on Grade (reinforced)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Crawlspace	N	N	N	N	N	Y	Y	Y	N	Y
	Basement	N	N	N	N	N	Y	Y	Y	N	Y
	Abandonment of Crawlspace/Basement	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Structure Envelope/Exterior										
	Concrete, Stone, or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Overall Structure Condition										
	Excellent to Fair	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fair to Poor	N	N	N	N	N	N	N	Y	N	N