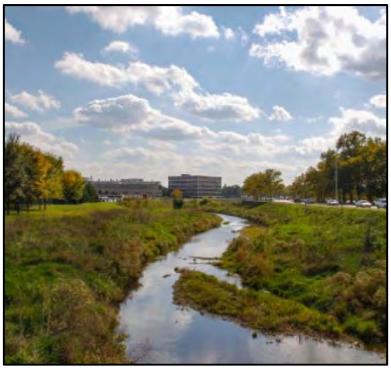
Columbus, Indiana
Flood Risk Management Plan

Completed: June, 2013





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City of Columbus – Bartholomew County Planning Department
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EXECUTIVE SUMMARY

While the City of Columbus covers 28 square miles and the extended Columbus planning jurisdiction includes approximately 110 square miles, rainfall from an area of over 2,000 square miles flows through Columbus. This overall drainage area is 18 times the size of the Columbus planning jurisdiction. As a result, 36 square miles of land along streams within the Columbus planning jurisdiction (about 1/3 of the 110 square miles) have a 1% chance of flooding in any given year as identified by the National Flood Insurance Program. Because of this extent of potential flooding, this document was developed to provide the City with a road map to manage flood risks.

A respected planning model that guides communities through emergency planning is the "Emergency Life Cycle", which consists of "Respond", "Recover", "Mitigate" and "Prepare" phases. This process is grounded in the belief that emergency planning in a community can and should constantly improve. Protocols can be established such that after each emergency event, real-time data is captured and the data is analyzed to determine how to reduce risk for the next emergency.

"Emergency Life Cycle"

The City of Columbus Flood Risk Management Plan is organized around the Respond-Recover-Mitigate-Prepare framework. Organized within this framework, the Plan describes current flood risks, identifies flood forecasting resources, presents a Flood Response and Evacuation Plan, establishes protocols for post flood damage assessment and data collection, notes information sources for educating the public about flood safety, and uses multiple-component screening criteria to screen over 350 Considered Solutions for mitigation of identified existing floodprone areas down to almost 100 Possible Solutions, then 52 Promising Solutions and finally several Most Promising Solutions.

These Most Promising solutions include levees along select reaches of Haw Creek, Clifty Creek, Flatrock River, and Sloan Branch. Floodproofing and/or voluntary buyouts of structures in other areas were also among the Most Promising Solutions.

The report also provides a road map of action steps for all phases of the Respond-Recover-Mitigate-Prepare Emergency Life Cycle including road replacements for the creation of flood-free routes, enhancement of flood forecasting tools, updating of hydrologic and hydraulic computer modeling, policy revisions to address

future condition flood potential, and updates of the Plan. A summary listing of all recommendations from the Plan is included in Chapter 6 along with implementation steps when applicable.

While all of the plan recommendations should be considered for implementation, the following is a list of the overall top recommended actions to be taken by the City in the order listed:

1. Identify responsible party within the City for implementing each of the Plan recommendations.
2. Take immediate steps to prevent escalation of the existing extent of flooding problems and/or creation of additional flooding problems by addressing policy recommendations.
3. Identify appropriate funding source(s) for each recommendation using the funding considerations listed in Section 6.3. (Creation of a Stormwater Utility appears to be the most versatile and reliable funding source to implement or cost-share the implementation of this Plan's recommendations.)
4. Take the necessary steps to ensure preservation of current forecast tools (NWS tools, USGS gages).
5. Start the process of updating/expanding hydrologic and hydraulic studies to better identify risks and needs.
6. Prioritize buyout areas and work with Indiana Department of Homeland Security to secure available funding.
7. Prioritize levee projects and fund the Preliminary Engineering for the selected projects to evaluate the feasibility at each site. Proceed with funding, design, and construction of levee segments found feasible and preferable as compared to other options.
8. Set up systems for tracking Plan changes and update needs.

Implementation of these recommended actions will lead to a reduction in flood risk and constantly improving preparedness for the next emergency.

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CHAPTER 1 PLAN OVERVIEW

1.1 INTRODUCTION

The City of Columbus is located at the confluence of several streams. Flatrock River flows to Columbus from the northeast joining Driftwood River flowing from the north. Together these streams form the East Fork White River which flows to the south through the center of the Columbus planning jurisdiction. Haw Creek and Clifty Creek are two of the streams that join the East Fork White River within the Columbus planning jurisdiction. Combined, these five streams drain the water that falls on almost 2,000 square miles of land. These watersheds are shown in **Figure 1-1**. These streams as they flow through the Columbus jurisdictional area are shown in **Figure 1-2**. It is these streams and their associated floodplains that are the focus of this Flood Risk Management Plan. (Flooding from groundwater sources is not addressed.)

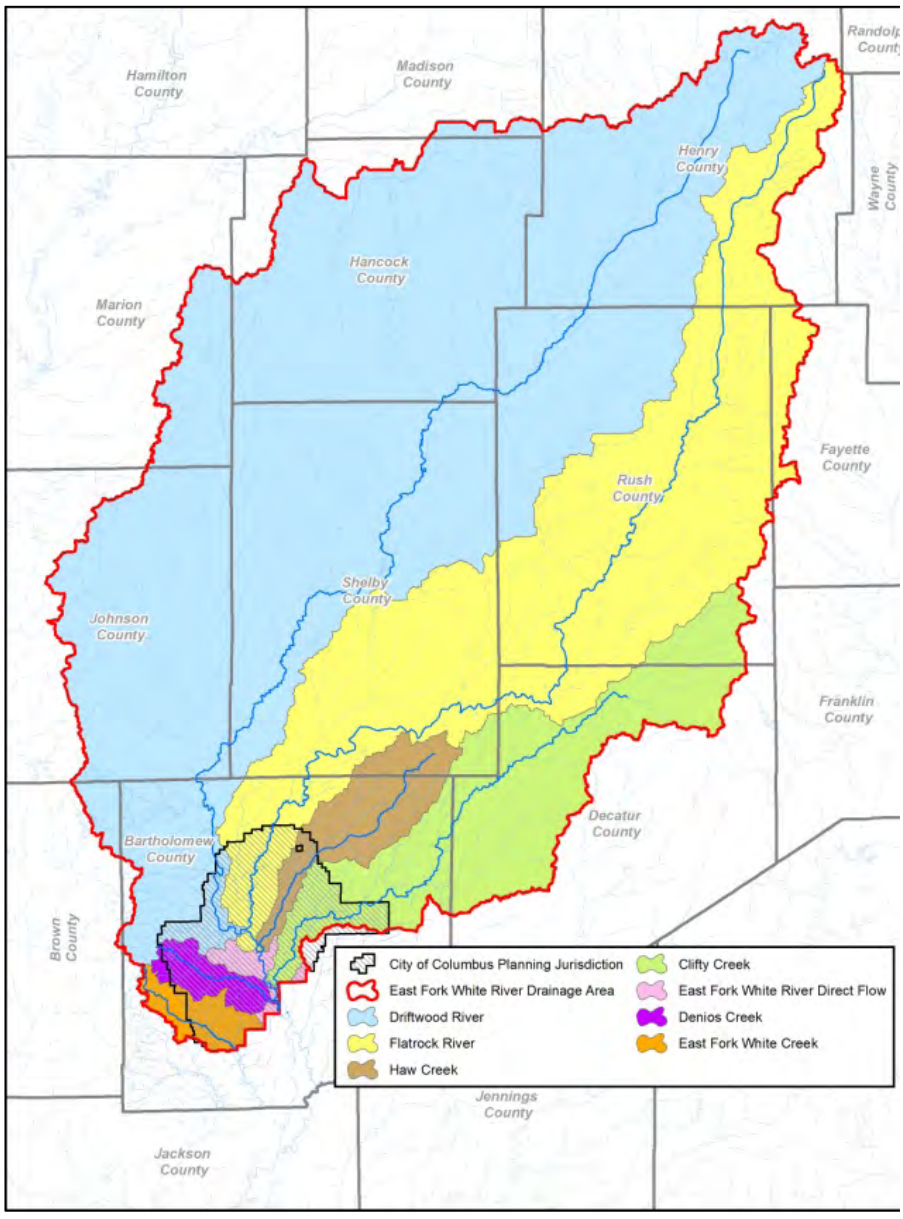


Figure 1-1 Watersheds of Streams Draining through Columbus

Currently, 36 square miles (23,300 acres) of land along these streams within the Columbus planning jurisdiction have been identified by the National Flood

Insurance Program (NFIP) as having a 1% chance of flooding in any given year. That's one third of the approximately 110 square miles of Columbus planning jurisdiction determined to have a 1 in 4 chance of being flooded in a given 30-year time period! **Figure 1-3** shows the currently identified floodplain areas.

The NFIP floodplains are those areas with a 1% chance of flooding within any given year. In Columbus, areas beyond the floodplains identified by the NFIP have also flooded. In June 2008, the residents, businesses, and municipal assets along Haw Creek and other stream reaches in the City sustained enormous economic damage as a result of rainfall and the subsequent flooding that extended beyond the identified flood hazard areas.

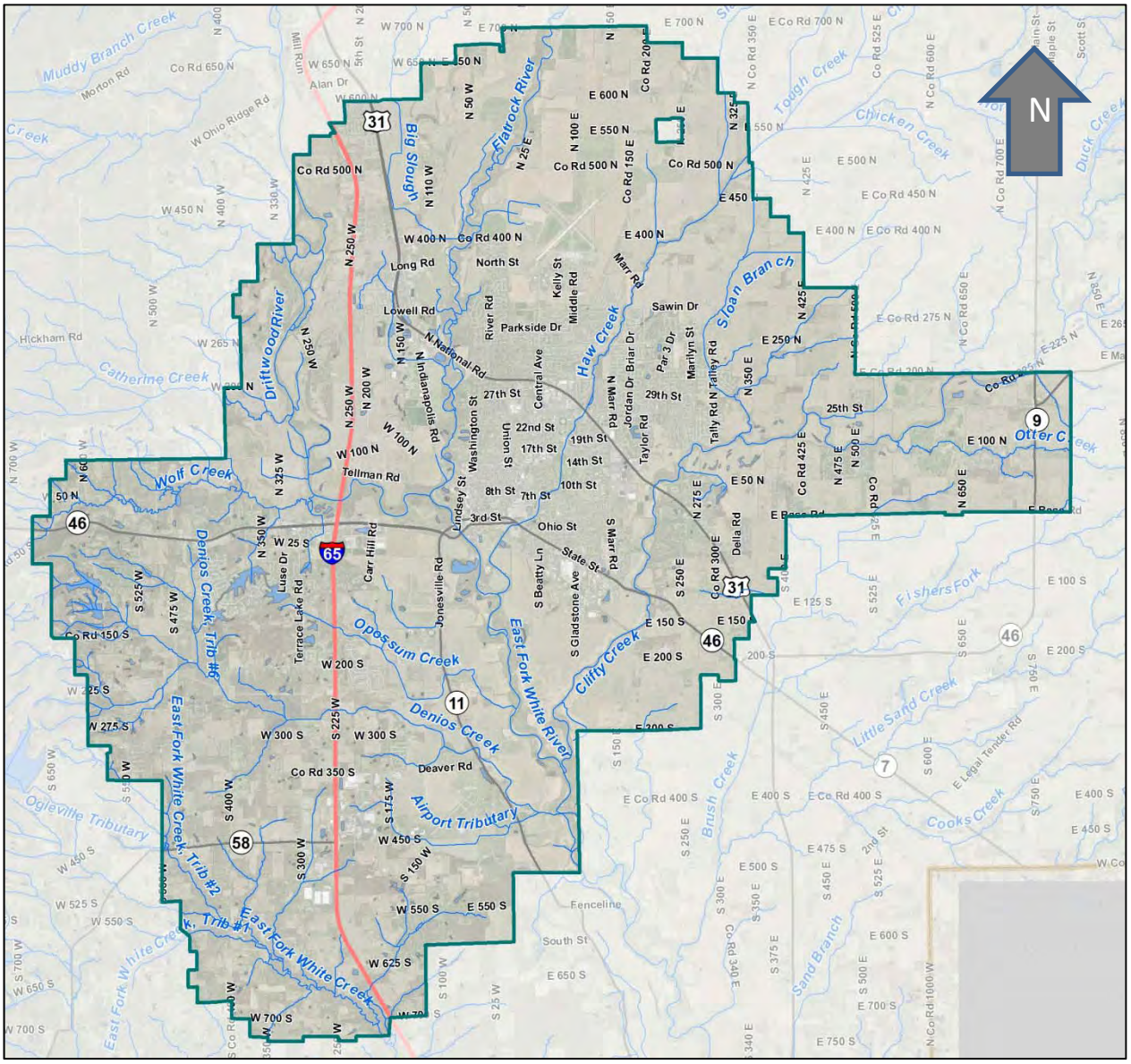


Figure 1-2 Streams within the Columbus Planning Jurisdiction

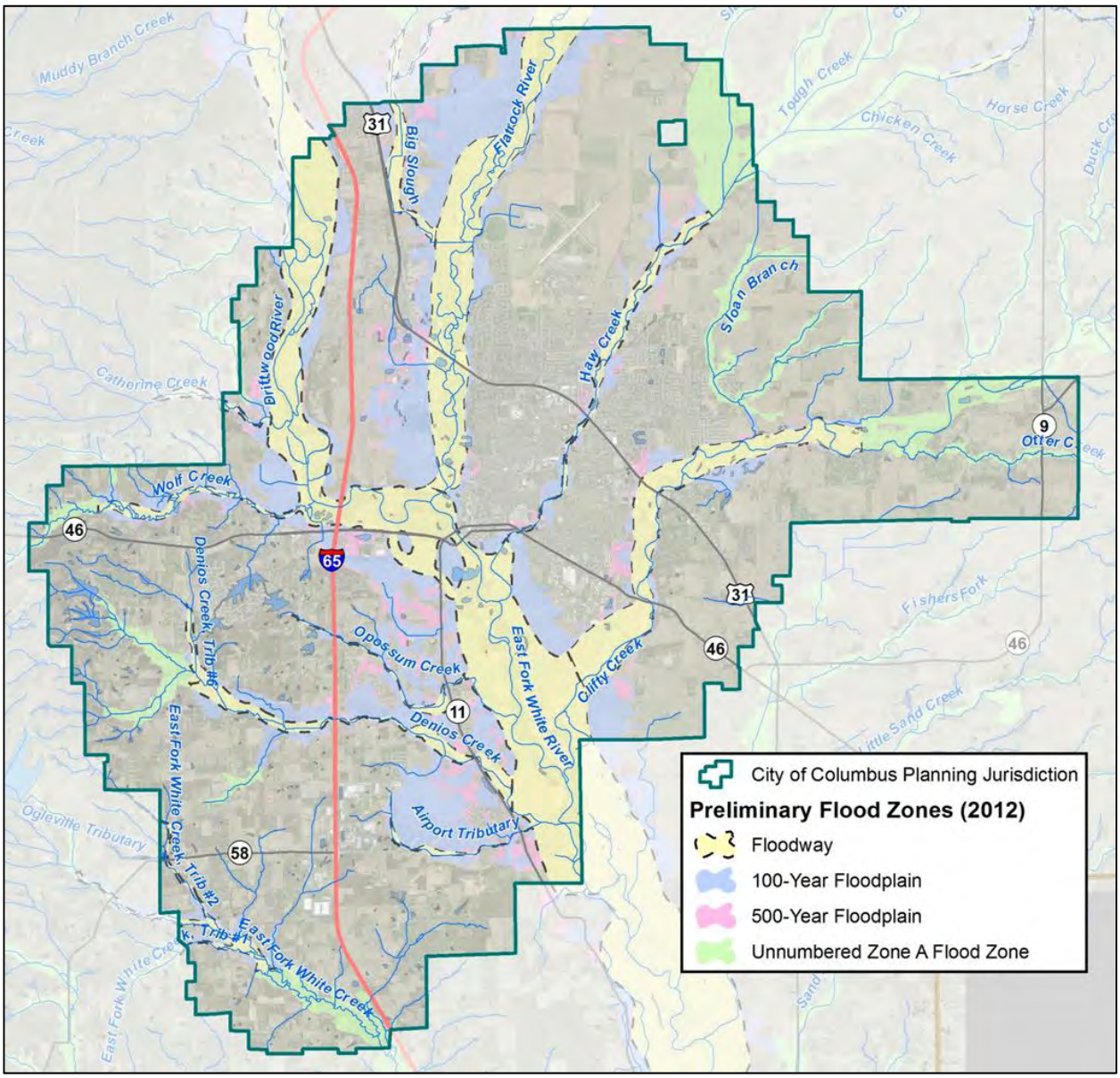


Figure 1-3 Current NFIP Identified Floodplains

1.2 PURPOSE & SCOPE

In order to improve the understanding of the flood risks within the Columbus planning jurisdiction and prepare for future flooding, Columbus officials hired Christopher B. Burke Engineering, LLC (CBBEL) to assist in creating a Flood Risk Management Plan for the City and areas under its jurisdiction. The Plan provides a road map to help the community function more efficiently through the emergency life cycle shown in the graphic to the left. The phases of this cycle are:

- Respond to flooding when it occurs,
- Recover from flood events,
- Pursue avenues to mitigate the community's vulnerability to present and future condition flood risks, and
- Improve overall preparedness for flood events

To do this, the Plan includes:

- ✓ Evaluation of the accuracy of current flood risk data,
- ✓ Flood depth mapping for selected stream reaches and frequency floods,
- ✓ Examination of current flood forecasting tools available for use,
- ✓ Development of a Flood Response and Evacuation Plan,
- ✓ Development of a protocol for post flood damage assessment and data collection,
- ✓ Review of current and proposed ordinance language,
- ✓ Identification of flood prone areas,
- ✓ Evaluation of potential projects to reduce the flood risk, and
- ✓ Evaluation of available flood related educational material.

1.3 ORGANIZATION OF DOCUMENT

The components of the City of Columbus Flood Risk Management Plan are organized by the four phases of the emergency life cycle: Respond, Recover, Mitigate, and Prepare. A brief summary of the contents of each chapter is presented below. Back-up data for information in each of the chapters is provided in an Appendix.

Chapter 1: Plan Overview – presents the project purpose, scope, and organization of the Plan document.

Chapter 2: Flood Response – Identification of Flood Risks and Creation of a Flood Response and Evacuation Plan – describes the current flood risks on streams in the planning jurisdiction, provides flood depth mapping for selected areas, describes existing and potential flood forecasting resources, and presents a Flood Response and Evacuation Plan.

Chapter 3: Flood Recovery – Post Flood Damage Assessment and Data Collection Protocol – establishes a protocol for damage assessment and data collection following a flood event.

Chapter 4: Flood Mitigation – Reduction of the Existing and Future Levels of Flood Vulnerability – summarizes the flood prone areas for which an investigation of potential mitigation projects was done. Potential solutions to the flooding issues along with evaluation of the benefits of each proposed solution and screening of the alternatives are presented along with the recommended mitigation projects. Recommendations for preventing flood levels from increasing due to future conditions are also discussed.

Chapter 5: Flood Preparedness – Educational and Outreach Materials, Watershed Studies & Master Plans, and other Flood Preparedness Plans –information for educating the public about what to do before, during, and after a flood are reviewed and noted. Discussion of watershed studies that have been done and master plans that would provide helpful information is also provided.

Chapter 6: Summary and Conclusions - This Chapter presents a brief summary of activities performed as part of this Flood Risk Management Plan and presents a consolidated list of recommendations made throughout the report along with implementation steps necessary to implement each of the recommendations.

Each of these chapters may contain references to and example screen shots from internet sources. An effort has been made to provide the title of the information so that if web addresses change, the information can still likely be located by searching for

the product/article name. The layout of web pages can also change. The screen shots provided are the layouts at the time of the writing of the associated portion of the Plan.

CHAPTER 2 FLOOD RESPONSE – IDENTIFICATION OF FLOOD RISKS AND CREATION OF A FLOOD RESPONSE AND EVACUATION PLAN

2.1 INTRODUCTION

Once a flood event occurs in a community, the first order of business is to respond and limit the impact of the event. The presence of an effective, accurate, and updated Flood Response and Evacuation Plan is crucial in guiding the community's response efforts. Accurately identifying the extent of the flood risks in the community is an important step in the development of an appropriate flood response and evacuation plan. Accurate risk identification is also necessary for determining actions that will mitigate the risk. The following tasks were done in support of these goals and are described in this chapter:

1. Provide an evaluation of the validity of the current flood risk data included in the effective Flood Insurance Study modeling.
2. Provide flood depth mapping for selected stream reaches in the community.
3. Identify the flood prone areas in the planning jurisdiction.
4. Provide flood forecast information that is currently available and describe potential future forecast tools.
5. Develop a Flood Response and Evacuation Plan for Columbus based on the information described above.
6. Make recommendations for future improvements to flood response capabilities.

2.2 EVALUATION OF FLOOD RISK DATA ACCURACY

CBBEL evaluated each of the existing Flood Insurance Study (FIS) hydraulic computer models within the Columbus planning jurisdiction for evidences of errors or outdated information that would lead to predicted flood depth inaccuracies. Streams included in the evaluation are shown below.

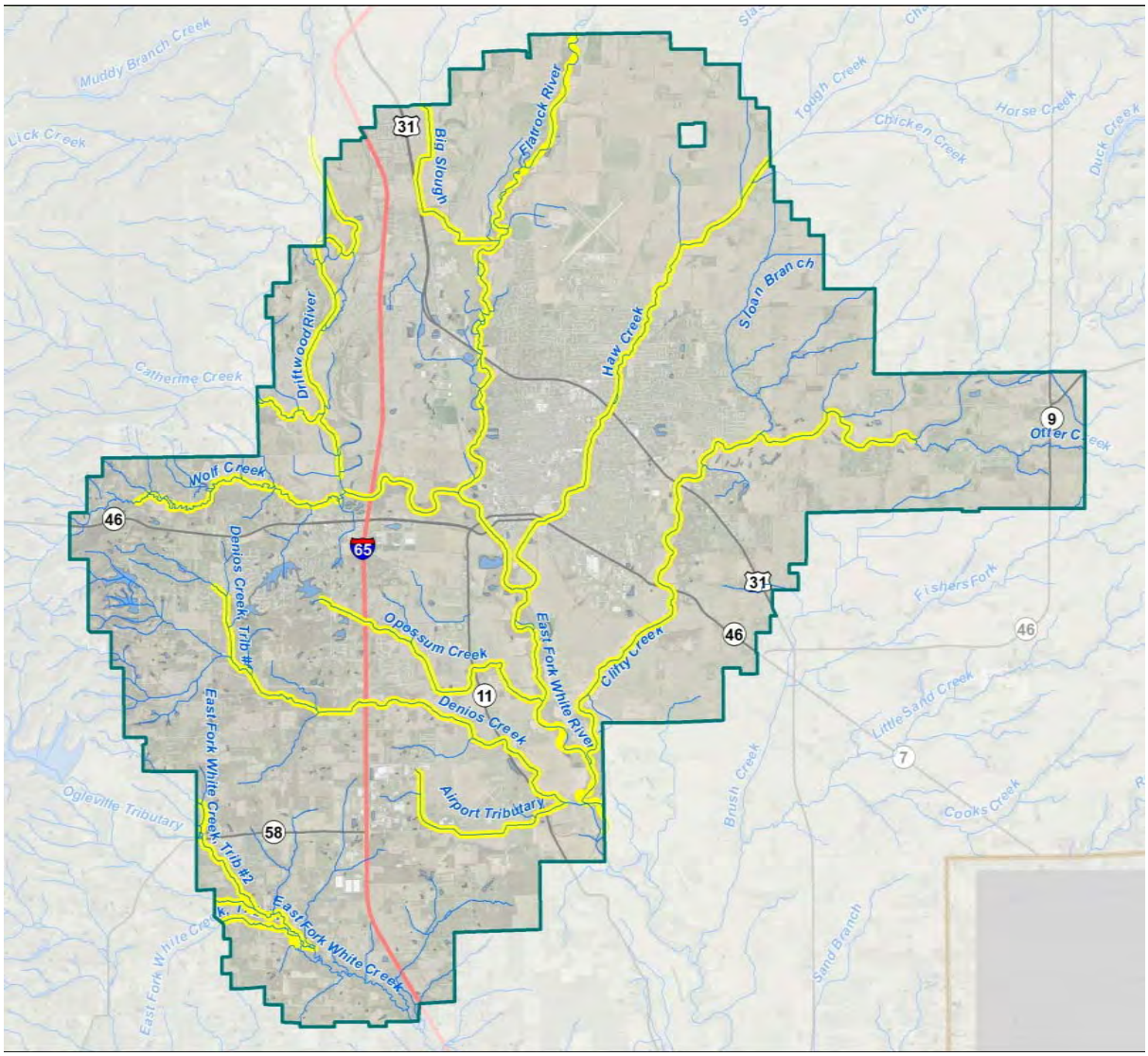


Figure 2-1 Stream Reach Models Investigated for Accuracy

The analysis on these streams consisted of:

- ✓ comparison with historic flood elevation and discharge information
- ✓ review of the model input data compared to available topography and bridge/culvert data, and
- ✓ estimation of the extent of the impact of a correction on regulatory decisions.

Based on the findings of this evaluation, CBBEL identified the recommended priorities and estimated costs associated with correcting each of the stream reaches determined to have modeling errors. A detailed description of the evaluation is provided in Appendix 1.

A scoring system was developed to aid in the prioritization of updating the stream models. This scoring system was based on the sum of the score in each of 3 areas:

- potential area impacted
- change in regulatory outcome, and
- model changes

The assigned score in each area was based on the descriptions noted in **Table 2-1**.

Table 2-1 Criteria for Scores in Evaluation System for Prioritization of FIS Model Revisions

Score	Potential Area Impacted	Change in Regulatory Outcome	Model Changes
0	The edge of the effective floodplain is along steep terrain so increased BFE would not likely add area to the floodplain	A change in the model would not impact regulatory decisions	Model revisions would not likely change the BFE or floodway
1	A small corridor would be added to the floodplain if BFE increased	A change in the model may impact regulatory decisions in isolated areas and/or completed updated modeling is not reflected on FEMA regulatory maps	Model revisions may make localized changes to the BFE or floodway
2	BFE increases could potentially add large areas to the floodplain designation	If the model is not corrected, regulations may allow building in places and at elevations that would not provide adequate protection against flooding	Significant changes in BFE &/or floodway are expected with model corrections

A score for each of the 3 areas was assigned to each stream based on the findings from the investigation of the existing models. The three scores for each stream were then totaled for an overall score for each stream. Those streams with the maximum value of 6 are the streams for which an update to the modeling would have the most impact. Any stream with the minimum value of 0 could be restudied but would likely result in outcomes no different than those based on the existing study. A map showing the score of each stream is shown in **Figure 2-2**. A description of each of the streams and the score they received is provided in the following subsections.

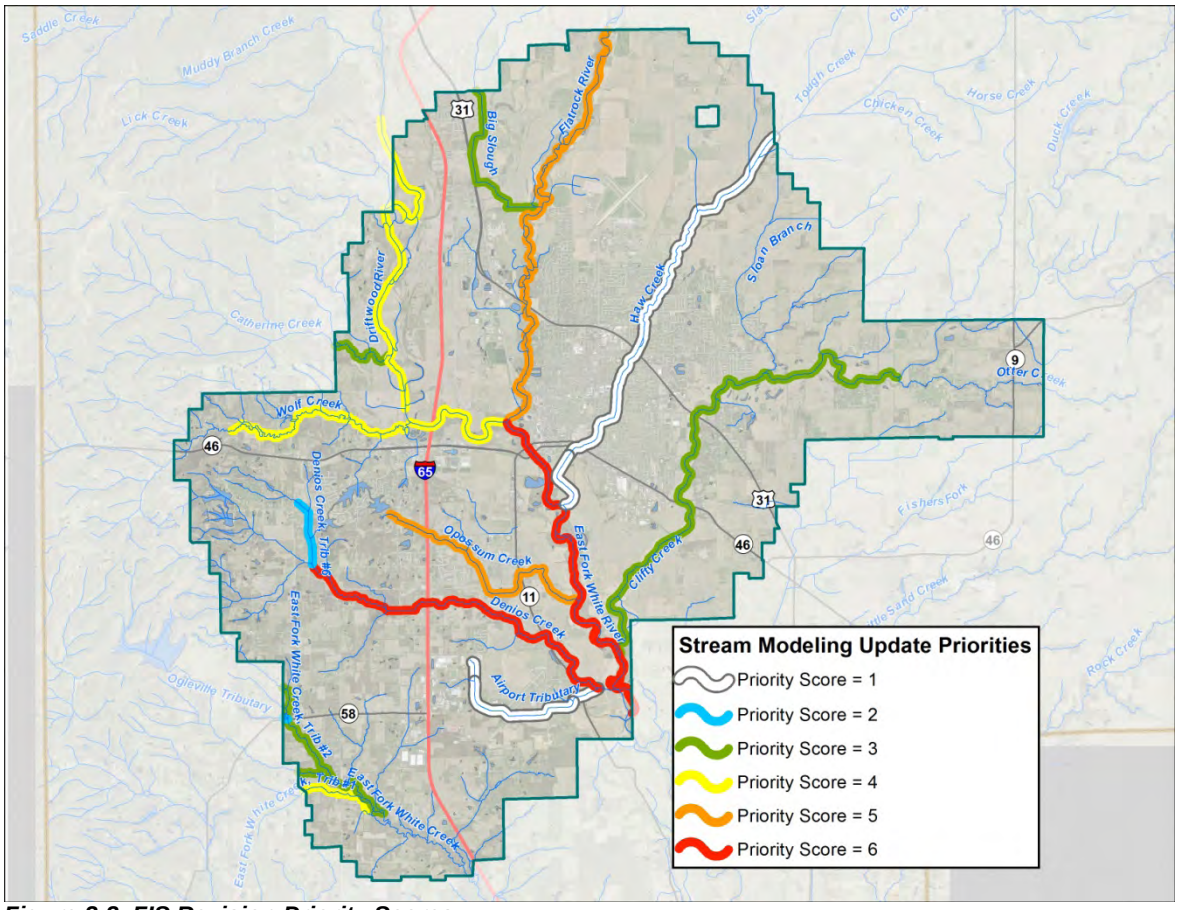


Figure 2-2 FIS Revision Priority Scores

Streams with Priority Score 6

East Fork White River and Denios Creek scored the highest with the most potential for impacts to existing and potential development due to probable erroneous identification of floodplain and floodway areas. Significant areas of land may be omitted

from the flood hazard area designation with the current modeling and several residential structures may not have correctly identified flood elevations determined.

A step toward correcting the East Fork White River model has been taken with the recent creation of a new hydraulic model for a reach of the stream by the United States Geological Survey (USGS) for use in creating inundation map libraries. This model has been calibrated to the USGS gaging station records at the Columbus gage. This model does not determine the floodway and needs some additional modeling revision to accurately model the 100- and 500-year flood elevations. If this additional work were to be done, it could be submitted to the Indiana Department of Natural Resources for use as the regulatory and FIS model. The revision would also have implications for revisions to the downstream reaches of Driftwood and Flatrock Rivers.

Streams with Priority Score 5

Flatrock River and Opossum Creek both scored the next highest value. These models were done with minimal data similar to East Fork White River and Denios Creek. Similar to the previous category, several residential structures may not have correctly identified flood elevations determined and regulatory decisions for future construction may be made incorrectly due to erroneous BFE and floodway information. However, unlike the previous category, the potential change in floodplain area is small due to steeper ground slopes at the edge of the floodplain. An updated, calibrated model for Flatrock River is also being developed by the USGS for use in creating inundation map libraries similar to those for East Fork White River. Therefore, similar to the new USGS model for East Fork White River, the Flatrock River model could be used as a starting point for a revised Flood Insurance Study (FIS) model.

Streams with Priority Score 4

The next highest score was given to Driftwood River, East Fork White Creek Tributary #1, and Wolf Creek. Corrections of these stream models would improve the accuracy of floodway delineations and may show that some additional area is in the floodplain.

Streams with Priority Score 3

Big Slough, Catherine Creek, Clifty Creek, East Fork White Creek, and East Fork White Creek Tributary #2 all scored 3 in the analysis. Corrections to modeling of these streams would improve the accuracy of the Base Flood Elevation (BFE) and may show that some additional area is in the floodplain.

Streams with Priority Score 2

A re-analysis of Denios Creek Tributary and North Ogleville Tributary would not be expected to result in significant changes to the BFE or floodway.

Streams with Priority Score 1

A correction of the Airport Tributary modeling is currently underway by the City as part of the preliminary FIS appeal process. The City also is already using the updated modeling created for Haw Creek after the June 2008 flood for their regulations. This model should, however, also be incorporated into the FIS.

Summary of FIS Restudy Priorities

A summary of the priority level and very approximate level cost for restudy of each stream is shown in **Table 2-2**.

Table 2-2 FIS Stream Restudy Priorities

Restudy Priority Score	Stream	Approximate Cost of Restudy*
6	Denios Creek	$54,000
6	East Fork White River	$50,000**
5	Flatrock River	$50,000**
5	Opossum Creek	$30,000
4	Driftwood River	$50,000**
4	East Fork White Creek Tributary #1	$13,000
4	Wolf Creek	$39,000
3	Big Slough	$24,000
3	Catherine Creek	$9,000
3	Clifty Creek	$75,000
3	East Fork White Creek	$30,000
3	East Fork White Creek Tributary #2	$16,000

Restudy Priority Score	Stream	Approximate Cost of Restudy*
2	Denios Creek Tributary #6	$12,000
2	North Ogleville Tributary	$9,000
1	Airport Tributary	FIS map revision in process
1	Haw Creek	Model revision completed for Community regulations but not incorporated into FIS mapping

**does not include cost of inclusion in FIS mapping*

***use USGS calibrated model as starting point. Cost will vary depending on how well it satisfies FIS modeling criteria*

For the depth mapping and subsequent Flood Response and Evacuation Plan, the current FIS model results will be used with the exception of East Fork White River. Since the USGS model of this stream reach is complete and has been calibrated, it will be used in order to provide the most accurate, currently available predicted flood elevations. Because flood elevations based on uncalibrated models with errors that may impact computed water surface elevations are used for the other streams, depth mapping may show slightly lower or higher flood depths in some locations than would actually be expected to occur but the depth mapping will still be adequate for the development of the Flood Response and Evacuation Plan. The Flood Response and Evacuation Plan is organized in such a way that updates can be made as modeling is corrected.

In addition to the streams discussed above that have been studied by detailed methods, there are about 25 miles of additional streams within the City jurisdiction which have flood areas determined by approximate methods or not at all. For the approximate method reaches, this means the flood extents were only done for the 100-year flood level and do not take into account the influence of road crossings or the higher discharges for the 500-year event which is used for City regulations. Proposed development in any of the areas with over one square mile drainage area must obtain engineering studies that identify the floodway or they must not develop in these areas.

Following is a list of stream reaches that do not have detailed studies but have a drainage area greater than 1 square mile and thus need Construction in a Floodway Permits from the Indiana Department of Natural Resources for any development in the floodway. These stream reaches are shown in **Figure 2-3**.

1) Slash-Loesch Ditch - from confluence with Haw Creek to jurisdiction limit (1.5 miles)
2) Sloan Branch - from completed study upstream to jurisdiction limit (1.1 miles)
3) Unnamed Tributary (UNT) Sloan Branch (2.3 mile)
4) UNT UNT Sloan Branch (1.0 mile)
5) Otter Creek - from the confluence with Clifty Creek to the planning jurisdiction limit (3.1 miles)
6) Clifty Creek - from existing study limit upstream to planning jurisdiction limit (3.3 miles)
7) East Fork White Creek - from existing study limit downstream to planning jurisdiction limit (2.7 miles)
8) UNT East Fork White Creek - from confluence with East Fork White Creek to point of 1 square mile drainage area (1.5 miles)
9) Another UNT East Fork White Creek - from confluence with East Fork White Creek to point of 1 square mile drainage area (1.5 miles)
10) Another UNT East Fork White Creek - from confluence with East Fork White Creek to point of 1 square mile drainage area (0.7 miles)
11) UNT Denios Creek (1.2 miles)
12) Another UNT Denios Creek (1.5 miles)
13) Denios Creek - from current study limits upstream to jurisdiction limits (1.3 miles)
14) Wolf Creek - from CR 580 West to CR 675 West (1.4 miles)
15) North Branch Wolf Creek (0.1 mile)
16) UNT Catherine Creek (0.6 miles)

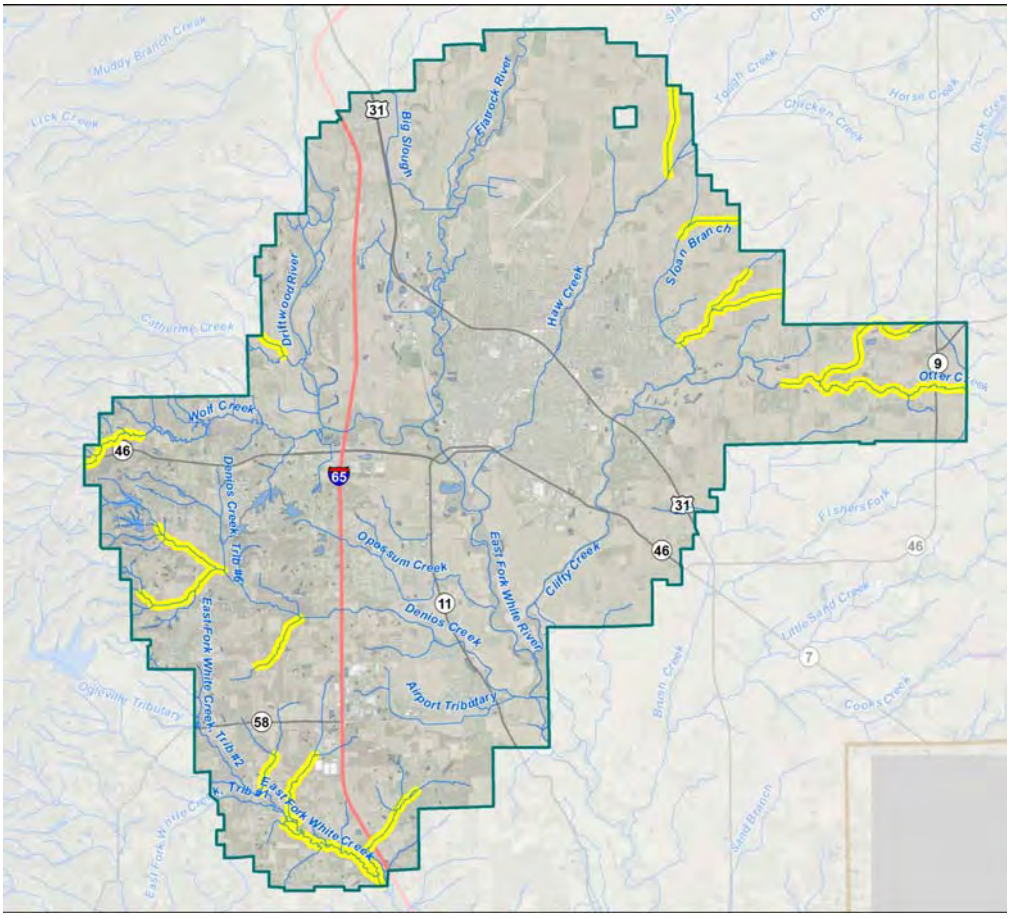


Figure 2-3 Unstudied Stream Reaches With Greater Than One Square Mile Drainage

2.3 FLOOD DEPTH MAPPING

Flood depth mapping was created by comparing expected water surface elevations with ground elevations to determine the anticipated flood depth at any given point. These depths were then mapped using different colors to represent areas within given ranges of depth. Due to the accuracy limits of the 2011 LiDAR mapping elevations and the predicted water surface elevations, the resulting maps are not exact representations of flood depths at every point. In addition, there are flooded areas, usually areas where flow is bypassing the main channel, that are not directly included in the modeling. For those areas, educated assumptions had to be made in the application of modeled water surface elevations. Even though the depth mapping in these areas carries a higher degree of uncertainty, it does provide a picture of potential areas of shallow or deeper flooding in order to guide regulatory decisions as well as flood response preparations and actions.

The Flood Response and Evacuation Plan will correlate each of the depth maps to an indicator that would reflect various action levels. Appropriate actions can then be determined based on the visual representation of flood depths at roads, residential areas, business areas, etc. that are depicted by the flood depth maps.

An effort to make flood depth mapping available for use with USGS stream gages as the indicator of the flood potential is currently underway in the form of Inundation Map Libraries. Such libraries are currently being developed by USGS for approximately 9 miles of Haw Creek, 5 miles of East Fork White River, and 5 miles of Flatrock River. An Inundation Map Library has recently been completed by USGS for approximately 5 of the 9.5 miles of Driftwood River affecting the City of Columbus jurisdictional area.

The inundation map libraries will provide the estimated depth of flooding and the extent of area expected to be inundated for various stream gage stage readings. These maps are to be provided for 0.5 to 1.0 foot increments of stage from Flood Stage to the highest stage of record. The inundation map library for Driftwood River is complete and has been placed on the USGS web site. As each inundation map library is set up on the web, they can be viewed at the USGS web page associated with the

Flood Inundation Mapper. The current web address for this product is wim.usgs.gov/FIMI/.
Following is a summary of the type of depth mapping available for the selected stream reaches in the Columbus planning jurisdiction.

1) Flood depth and inundated area for given stages at a USGS gage is currently available via the USGS Inundation Map Library on the internet for:

   - Driftwood River upstream of CR 200 N

2) Based on water surface elevations from the preliminary FIS data and ground elevations from the 2011 Light Detection and Ranging (LiDAR) data, CBBEL interim depth maps were created for stream reaches for which USGS Inundation Map Libraries are in process but are not yet completed. These stream reaches include:

   - Flatrock River
   - East Fork White River (using elevations from the USGS model that will be used for the USGS inundation mapping plus CBBEL revisions to include the 100- and 500- year flood discharges)
   - Haw Creek (based on CBBEL modeling for Haw Creek done prior to the City's October 2011 ordinance that has elevations close enough to those from subsequent model revisions to be useable for depth mapping purposes)

3) CBBEL created depth mapping based on water surface elevations from the preliminary FIS data and ground elevations from the 2011 LiDAR data for:

   - Driftwood River downstream of Wolf Creek (including the revised backwater elevations from the USGS model of East Fork White River)
   - Opossum Creek
   - Denios Creek
   - Airport Tributary (based on revised modeling done under a separate task for the City)
   - Clifty Creek
   - Sloan Branch (based on hydrologic and hydraulic modeling created by CBBEL)

It should be noted that a reach of Clifty Creek on the east side of the City could be added to the USGS list for inundation map libraries if a local sponsor to fund the USGS stream gage in this reach could be obtained. Without this gage, there is no stream gage elevation information to tie depths maps to. There also is no data to use to calibrate modeling of the stream to assure that correct elevations are being determined by the modeling. Because it provides information that is useful to the City, it is recommended that the City pursue avenues to fund this gage every year

Error! Reference source not found. shows the stream reaches listed above for which CBBEL depth maps or USGS inundation map libraries have been created. Where a USGS gage is available, the stage at the gage for the 10-, 50-, 100-, and 500-year floods is provided in **Table 2-3**. If the USGS gage reaches the stage noted, then the corresponding depth map is an approximation of the area that is likely flooded and the depth of the flooding. Depending on the distance of the gage from the point of interest, the flood depth may not be reached at the same time that the gage reaches the noted stage. In addition, factors along the stream between the gage and the point of interest (such as a tributary that receives more or less rain than the watershed above the gage, or the rainfall distribution that is different from that assumed in the modeling for the stream flood elevations) may change the relationship.

Table 2-3 USGS Gage Height (Stage) and Associated Frequency Depth Map

Associated Flood Frequency Depth Map	USGS Stream Gage Height (Stage), feet				
	Clifty Creek near Columbus	East Fork White River at Columbus	Flatrock River at Columbus	Driftwood River near Edinburgh	Haw Creek near Clifford
10-Year	19.2	15.4	15.6	15.7	14.6
50-Year	21.1	18.7	17.4	17.3	15.8
100-Year	21.5	19.9	18.0	17.9	16.0
500-Year	23.1	22.0	19.3	19.4	16.5

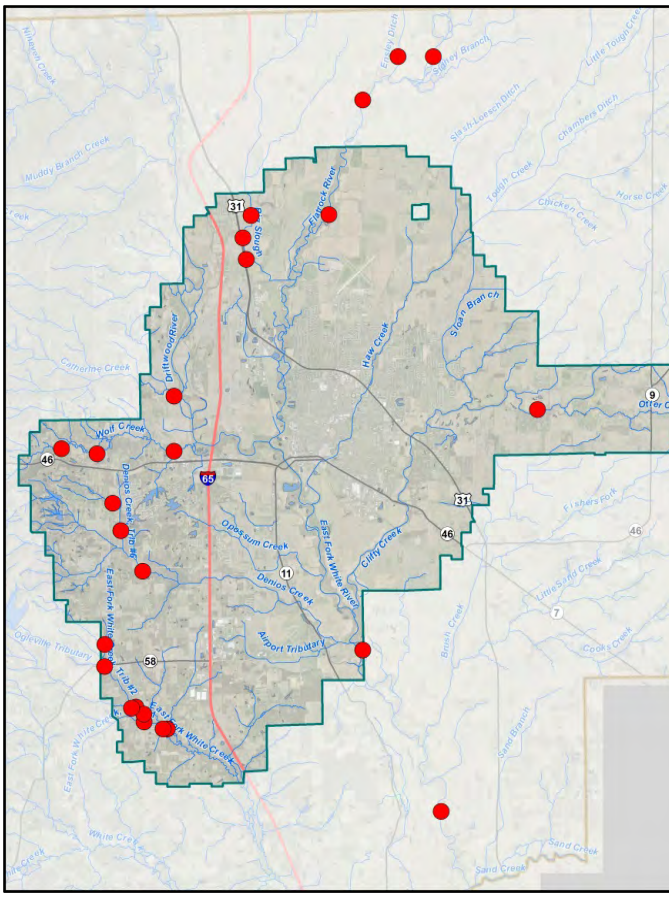


Figure 2-4 Roads with Depth Mapping

Figure 2-4 shows the additional road crossings for which flood depths have been mapped. The depths were based on water surface elevations from the FIS at the upstream side of the road and road profile elevations from the 2011 LiDAR data.

The actual flood depth maps for each noted stream reach and road crossing are provided as **Exhibits 1** through **38**. **Table** 2-4 outlines which streams are covered on which exhibits.

Table 2-4 Depth Map Exhibit Numbers

Stream	Depth Map Exhibit
East Fork White River, Driftwood River, & Flatrock River	#1-9
Haw Creek	#10-13
Clifty Creek & Sloan Branch	#14-18
Denios Creek, Opossum Creek, & Airport Tributary	#19-25
East Fork White Creek & tributaries	#26-30
Miscellaneous Roads	#31-38

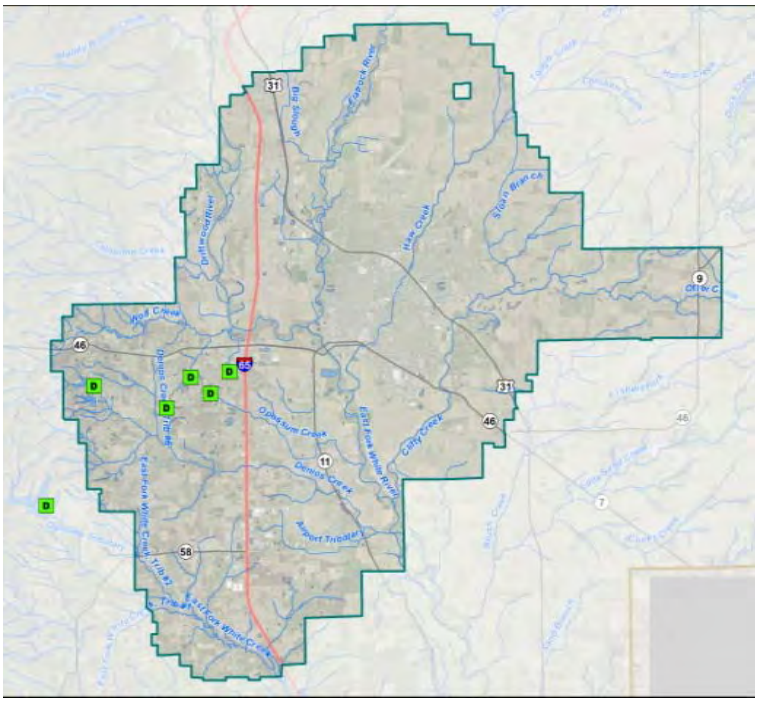


Figure 2-5 Dams with Dam Breach Inundation Mapping

In addition to stream flooding from excess rainfall, flooding may also be caused by the failure of an upstream dam. Several dams exist in the jurisdiction that, given the right circumstances, could fail. Inundation maps showing the approximate area that would be flooded by the breach of each dam in a worst-case scenario were developed for the December 2008 Bartholomew County Multi-Hazard Mitigation Plan are provided as **Exhibit 39** for the failure of the dams shown in **Figure 2-5**.

These maps were not turned into depth maps because the suddenness and velocity of the flood wave is enough to make any depth a danger. In addition, these maps were developed by approximate methods without the benefit of the more detailed 2011 LiDAR terrain data.

2.4 IDENTIFICATION OF FLOODPRONE AREAS

The flood depth maps discussed in Section 2.3 provide data on what areas are generally expected to be flooded and the depth and frequency of that flooding. As such, they provide a visual representation of areas that are prone to flooding and could benefit from some type of mitigation effort. Using the depth mapping along with the FIS floodplains in areas where depth mapping was not done and City provided repetitive loss information, historical data, and information about past flood issues, CBBEL identified and cataloged flood prone areas. Areas identified generally include road segments that are overtopped as shown on depth mapping provided in Section 2.3 and riverine flooded areas identified in the sources above where there are multiple structures flooded and a public road is involved to access those structures. For each of the 125 areas identified, the following is generally provided:

- a description of the maximum flood depths along roads and at structures,
- an approximate number of impacted structures (based on an older GIS structure data file from the City and 2011 aerial photography),
- the highest flood-free frequency (10-, 50-, 100-, or 500-year) for structures and roads, and
- a description of flood impacts on access to structures,
- the types of critical facilities, if any, that are located in the flood prone area (based on a partial update of the critical facilities file provided by the City), and
- an indication of the order of magnitude of the duration of flooding (based on unsteady flow modeling of Haw Creek and on drainage area of the other streams).

It should be noted that these descriptions are based on a desktop level survey of the riverine flood potential based on a generalized determination of stream flow and associated frequency and unobstructed flow, and do not account for variations in rainfall distribution, accumulation of debris at a road crossing, or localized factors (such as elevated structures, landscaping or curbing, connection between areas via pipe networks, etc.) that may add to or prevent actual flooding of particular structure(s).

A table of the floodprone areas identified along each stream is provided with descriptions of the flooding in each area in **Tables 2-5 through 2-16**. Some numbers are out of sequence or skipped due to reorganization after initial labeling was done. A map of the floodprone areas with labeling of the areas to match that shown in the Table is provided as **Exhibit 40**.

Table 2-5 Description of Floodprone Areas During 500-Year Flood - AIRPORT TRIBUTARY*

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Walesboro Airfield (1)	AT2	CR450 South between CR 125 West and SR 11	Up to over 2' flood depths on a reach of CR 450 South. Prevents access to at least 4 businesses. Shallow flooding begins at the 10-year flood level	
	AT3	CR 400 South just east of CR 50 West	Up to over 1' of flooding of a reach of CR 400 South. Prevents access to at least 3 sets of structures. Flooding begins above the 100-year flood event	
	AT4	former airport property bounded by Deaver Road, CR 50 West, CR 400 South, and CR 175 West	Significant flooding of potential development area. Average flood depths of 2'. Flooding of the area begins below the 10-year flood event	
	AT5	business in the northwest corner of the CR 50 West and CR 450 South intersection	Shallow flooding of entrance road, potentially up to 3' flood depths in parking areas as well as potential flooding of business. Flooding begins below the 10-year flood level	1 hazardous material facility
	AT6	business north of Airport Tributary in the northeast corner of the CR 175 W and CR 450 South intersection	Potential for over 4' of flooding of business buildings and parking as well as some flooding of road leading to business. Flooding begins below the 10-year flood level	1 hazardous material facility
	AT7	CR 175 West between CR 350 South and CF 450 South	Up to 3' flood depths on a reach of CR 175 West. Does not currently impact direct access to structures. Flood depths of up to a foot are still possible on the 10-year flood	
Walesboro (2)	AT1	area bounded by Airport Tributary, railroad, and CR 450 South	4 structures with flood depths less than 2', 17 structures with flood depths over 2', flooding of access roads to over 6' as well as over 3' on CR 450 South leading to the entrance, one structure may be above flood elevations but would be surrounded by water. Some access road and potentially structure flooding is beginning at the 10-year flood level	

***** *Descriptions are based on depth mapping using FIS water surface elevation data. Due to limitations in methodology and study detail for the FIS, FIS flood depths for Airport Tributary are much larger than actual depths are expected to be. Flooding may start at the levels noted but are expected to be shallow except where flood water collects in low areas.*

Table 2-6 Description of Floodprone Areas During 500-Year Flood - BIG SLOUGH

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
CR 450 N	BS1	CR 450 N just east of US 31	Flooding from Big Slough of over 5' with flooding beginning below the 10-year level, no direct impact to access to structures	
CR 500 N	BS2	CR 500 north east of US 31	Flooding by more than 1' of water with overtopping beginning below the 10-year flood level of Big Slough, direct access to one farmstead is prevented by flood waters	
CR 550 N	BS3	North side of CR 550 North just east of US 31	Small portion of parking area in 500-year floodplain, one building and grain elevators located in Big Slough floodway	1 hazardous material facility

Table 2-7 Description of Floodprone Areas During 500-Year Flood - CLIFTY CREEK

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Wehmeier/Columbus East (24)	CC1	Businesses along Repp Drive south of State Street (SR46)	Flooding up to 3 feet deep may occur at one building with flooding starting above the 50-year flood level. Parking lots may experience shallow flooding. Access roads may be flooded by over 1 foot of water (once flooding exceeds 100-year flood levels) preventing access to 9 businesses.	1 fire station
	CC2	Wehmeier Addition north and east of Marr Road and State Street (SR 46)	Flooding of 45 structures to depths less than 2' and 69 structures over 2', neighborhood roads are also flooded to depths up to 3', approximately 5 structures would be above flood waters but without access to and from the neighborhood, flooding begins below the 50-year level, 16 structures located in the floodway	
	CC3	Marr Road and Indiana Avenue north of State Street	Flooding of Indiana Avenue north of the softball diamonds begins below the 100-year event. Flooding of Marr Road begins above the 100-year event and reaches depths up to about 1'. Depths on Indiana Avenue reach 1 1/2 feet and prevent access to the buildings on Salzburg Boulevard. Flooding of Marr Road prevents access to the Columbus East High School from Marr Road but access from the north is still available.	
	CC4	A portion of the building complex on Salzburg Boulevard north of Indiana Avenue (Steinhurst Manor)	The northeast most parking lot is flooded by about a foot of water, access to the northwest parking is prevented by water up to almost 2' deep, access to the northwest parking is impacted above the 10 year flood, access to the northeast parking begins to be impacted at the 50-year flood	
	CC13	Columbus East High School	Flooding of a portion of the high school & parking areas with up to 3' flood depths is possible. Flooding begins above the 100-year flood as long as there are no culverts under Marr Road to transfer flood water from the east to the west side. Access to the flood-free portions of the school is only available from the north, protection has been constructed to above the 100-year flood	1 school
Mckinley Ave	CC5	McKinley Ave between Marr Road and Clifty Creek	A portion of this road is flooded up to over 3 feet between Marr Road and the set of 3 buildings that use this as the only access. Flooding begins above the 10-year flood level for both the road and the structures.	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Sandy Hook/Clifty Crossing (25)	CC6	Businesses just south of National Road between Clifty Creek and just west of 10th Street	Parking lots are flooded by up to approximately 1 1/2 feet but buildings appear to be elevated above flood elevations. Parking lot flooding begins at about the 50-year flood level. Open ground between the businesses east of Taylor Road appears to be an important auxiliary path for flood waters to pass under National Road	
	CC7	National Road west of Taylor Road	About 1200' of the road just west of the intersection is flooded at depths up to about 2 1/2 feet preventing access to at least one business. Flooding begins above the 100-year flood level	
	CC8	Sandy Hook neighborhood bounded by Taylor Road, National Road, and Waycross Drive	Potential shallow depth flooding of about a dozen homes, significant street flooding depths up to 3' preventing access to and from about 50 homes, road flooding blocks one of the accesses to an assisted living facility, flooding of at least one business. Water overtops Taylor Road and begins flooding the area above the 100-year level flood, structure flooding is beginning at the 500-year flood level	1 child care facility
Regency Drive (28)	CC9	Hartford Place neighborhood bounded by Dawnshire Drive, Tally Road, Clifty Creek, and 25th Street	Up to 2' of flood depths possible in some streets limiting access to and from up to 50 homes. Flooding begins above the 50-year flood level of Clifty Creek, 1 or 2 homes may experience minor flooding	
CR 50 N	CC10	CR 50 North between CR 275 East and N Dellasburg Road	Flood depths over 4' on portions of the road. Flooding starts below the 10-year flood level. Access to a private drive for 3 residences is cut off starting above the 10-year flood level	
	CC11	Between Clifty Creek and 25th Street west of CR 500 East	2 structures are located in the floodway. An additional 4 are in the 100-year floodplain. Only 1 structure appears to be flooded by the 10-year flood.	
CR 500 E	CC12	CR 500 East between Clifty Creek and 25th Street	CR 500 East is flooded by up to 3 feet deep water, flooding begins above the 10-year flood level, no direct impact to access to structures	

Table 2-8 Description of Floodprone Areas During 500-Year Flood - DENIOS CREEK

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Bethel Village (4)	DC1	Bethel Village neighborhood northwest of Deaver Road and SR 11	Over 100 structures with flood depths less than 2', 60 structures with flood depths over 2', flooding of almost all streets by up to approximately 4', flooding of several structures and inundation of the access into and out of the neighborhood occurs below the 10-year flood elevation,6 structures in the floodway, various projects are being or have been considered/constructed to attempt to reduce flooding of the neighborhood. (This description applies to flooding from Denios Creek only. See WR8 for description of impacts when flooding source is White River)	
	DC2	Deaver Road west of SR 11	Overtopped by over 5 feet cutting off access to and from the neighborhood and a farmhouse to the north, flooding starts below the 10-year flood elevation, prevents as much access to surrounding properties as the flooding of the properties themselves (This description applies to flooding from Denios Creek only. See WR6 for description of impacts when flooding source is White River)	
SR 11 South (5)	DC3	Neighborhood along Dawson Street west of SR 11	Approximately 10 structures are located in the floodway, 18 structures are flooded by depths up to 2', 19 structures are flooded by water over 2' deep. Access to about all of the structures is prevented by road flooding up to almost 3', flooding begins at less than 10-year levels (This description applies to flooding from Denios Creek only. See WR11 for description of impacts when flooding source is White River)	
Shadow Creek Farms (6)	DC4 (also identified as OC2)	CR 150 West between CR 200 South and CR 300 South	Overtopped by over 1' of water cutting off access to 2 residences and potentially the east access to the subdivision north of Denios Creek (Shadow Creek Farms), shallow flooding occurs near the creek at the 10-year flood elevation. EFK White River flood waters come near to the road but do not appear to overtop it.	
	DC5 (also identified as OC3)	Shadow Creek Farms subdivision southwest of CR 200 South and CR 150 West along Shadow Creek Blvd	Existing structures appear to be built above the flood elevations. However, a short portion of Rolling Knoll Lane and portions of what looks like the early stages of construction for another street show flood depths of more than a foot. This, in combination with flooding of CR 150 West, would isolate about 25 existing homes and potentially more as the subdivision is developed. Flooding of the street does not start until levels greater than the 100-year.	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Access Roads	DC6	Access roads along I-65 between CR 200 South and CR 300 South	West side access road flooded by less than about 1' of water, flood-free to flood levels above the 100-year. East side access road flooded by up to more than 3' of water, minimal flooding occurs for the 10-year flood level alternative route exists	
CR 400 W	DC7	CR 400 West north of CR 250 South	Overtopped by up to about 2', does not prevent access to any structures, flooding starts below the 10-year flood elevation	
Carr Hill Road	DC8	Carr Hill Road east of CR 475 West	Overtopped by up to about 2' cutting off access from the west to one residence. Road overtopping starts below the 10-year flood elevation	
Goeller Road	DC9	Goeller Road just east of CR 475 West	Road is overtopped by about 1/2 foot of water but does not cut off direct access to any structures. Overtopping starts above the 50- year flood levels.	

Table 2-9 Description of Floodprone Areas During 500-Year Flood - DRIFTWOOD RIVER

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Front Door East/ Jonathan Moore Pike (10)	DW1	SR46 (Jonathan Moore Pike) east of I-65 to EFK White River	The road is overtopped by up to 6' of water, blocks access to 5 or more businesses and other structures east of I-65, prevents access to 3 hazardous material facilities, flooding of the edge of SR 46 begins at about the 10-year flood level.	
	DW3	Along Jonathan Moore Pike and Merchants Mile east of I-65	Approximately 17 structures are flooded to depths less than 2' and 5 greater than 2'. Jonathan Moore Pike floods to over 5' of depth. Parking lots are flooded to depths of around 2'. Flooding of Jonathan Moore Pike starts below the 10-year flood levels as does access road and potentially some structure flooding, 5 structures are in the floodway	3 hazardous material facilities
Front Door West/ Westhill (11)	DW4	North and south of Jonathan Moore Pike west of I-65	Approximately 15 structures are flooded to depths of less than 2' while 6 are greater than 2'. Jonathan Moore Pike floods to about 3' of depth and access road flooding occurs and may cause 2-5 buildings to be isolated by flood waters. Access to buildings further south is flooded but other flood free access exists from Jonathan Moore Pike to the west. Flooding of Jonathan Moore Pike starts below the 10-year flood levels as does access road and some structure flooding.	3 hazardous material facilities
	DW5	Carlos Folger Drive between CR 315 West and Jonathan Moore Pike	Shallow flooding begins below the 10-year flood elevation reaching almost 5' of depth during the 50-year flood. Alternative access to structures along the road exists.	
	DW6	Between Jonathan Moore Pike and Carlos Folger Drive along CR 325 West	Approximately 2 structures are flooded up to more than 1', Carlos Folger Drive and CR 325 West are flooded by up to 4' of water cutting off access to SR 46 from the north, flooding of the road begins at less than the 10-year flood level while flooding of the structures may begin at the 10-year level, alternate access to structures exists	water treatment plant office
	DW7	Not used		
CR 325 W (12)	DW8	CR 325 West between Lowell Road and Carlos Folger Drive	Portions of this stretch of road are flooded by more than 4' of water cutting off direct access to over 10 structures along the road. Flooding of portions of the road begin below the 10-year flood level, 4 properties with structures have been bought out	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Lowell Road (13)	DW9	Vicinity of the Lowell Road and CR 250 West intersection	At a stage of 17 feet (approximately the 50-year flood) portions of both roads are flooded to over 1' deep cutting off access to a few structures north of Lowell Road and others west of CR 250 West and preventing access to the west side of Driftwood River along Lowell Road. Flooding begins between the stages of 15 and 16' (approximately the 10-year) as measured at the Driftwood at Edinburg USGS gage.	
Tellman Camp Road (15)	DW2	Along Tellman Road between CR 250 West and Indianapolis Road	Approximately 30 structures are inundated to levels greater than 2', approximately 4 structures are inundated to levels less than 2'. Tellman Road is flooded by over 10 feet of water cutting off access to approximately 50 structures, flooding of most of the structures and access to the structures begins below the 10-year flood level, 17 structures in the floodway	
	DW10	Not used		
CR 330 W	DW11	Along CR 330 West from approximately 2,000 to 3,000 feet south of CR 450 North	Flooding of the road begins at about stage16 as recorded at the USGS gage on Driftwood River at Edinburg cutting off access from the south to 5 structures on the east side of the road. Access to the north remains open at a stage of 17 feet (approximate 50-year flood level)	
CR 250 W	DW12	Along CR 250 West north of CR 500 North	Flooding up to about 1' deep of a short section of road begins above stage 16 (over the 10-year) as recorded at the USGS gage at Edinburg, no direct access to structures is impacted	

Table 2-10 Description of Floodprone Areas During 500-Year Flood - EAST FORK WHITE CREEK

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
CR 600 S	EFKWC1	CR 600 South just east of CR 400 West	Up to approximately 1 1/2' foot of flooding, flooding begins near the 10-year flood level, does not impact direct access to structures	
CR 400 W	EFKWC2	CR 400W between CR 550 South & CR 600 S	Up to approximately 1/2' of flooding, flooding begins at near 50-year flood levels, does not impact direct access to structures	
CR 550 S	EFKWC3	CR 550 South just west of CR 400 West	Up to approximately 3' of flooding beginning below the 10-year flood level. Impacts access to 3-4 structures	
SR 58	EFKWC4	SR 58 east of CR 500 West	Flood depths over 2' beginning below the 10-year level, preventing access to at least one structure	
CR 350 S	EFKWC5	CR 350 South (Deaver Road) east of CR 500 West	About 2' of flooding, beginning below the 10-year level, prevents direct access to 1 structure	

Table 2-11 Description of Floodprone Areas During 500-Year Flood - EAST FORK WHITE RIVER

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Walesboro (2)	WR2	West of SR 11 between CR 400 South and Southern Crossing	Approximately 13 structures in the 500-year floodplain of EFK White River, flooding may limit access to some of the structures	
	WR3	East of SR 11 north of CR 400 South for 600 feet	Approximately 1 structure in the floodway, 5 more in the 100-year floodplain and 3 more in the 500-year floodplain, access to these structures may be prevented by floodwaters	
Southern Crossing (3)	WR1	Southern Crossing of White River	Approximately 3' deep flooding beginning below the 10-year flood level, flooding of the road approaches does not appear to directly impact the entrance to structures	
Bethel Village (4)	WR6	Deaver Road west of SR 11	Inundated by up to almost 6' but flooding does not start until over the 10-year flood event, prevents as much access to surrounding properties as the flooding of the properties themselves. (This description applies to flooding from East Fork White River only. See DC2 for description of impacts when flooding source is Denios Creek.)	
	WR8	Bethel Village neighborhood northwest of Deaver Road and SR 11	80 structures with flood depths less than 2', 60 structures with flood depths over 2', flooding of almost all streets by up to approximately 4', flooding of several structures and inundation of the access into and out of the neighborhood occurs above the 10-year flood elevation. (This description applies to flooding from East Fork White River only. See DC1 for description of impacts when flooding source is Denios Creek.)	
	WR5	Not used		
SR 11 South (5)	WR4	East of SR 11 near Deaver Road	Approximately 9 structures flooded to depths >2' and 0 structures flooded to depths <2', access is prevented by flooding of SR 11, flooding begins at less than 10-year levels, 6 structures are in the floodway	
	WR7	SR 11 approximately 1500 feet north and south of Deaver Road	Flood depths of over 3' beginning near the 50-year level, prevents direct access to 2 farmsteads	
	WR9	East of SR 11 near SR11 crossing of Denois Creek	Approximately 2 structures flooded to depths <2', access is prevented by flooding of SR 11, flooding of structures begins at about the 10 year level, road flooding begins above the 10 year levels	
	WR10	Blessing Road east of SR 11	Flood depths of about 6' prevent access to approximately 6 structures starting at below 10-year levels	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
SR 11 South (5) Cont.	WR11	Neighborhood along Dawson Street west of SR 11	About 20 structures are flooded to depths of about 2', another almost 12 structures are isolated due to flood waters on Dawson Street up to almost 2' deep, flooding begins above the 50-year level. (This description applies to flooding from East Fork White River only. See DC3 for description of impacts when flooding source is Denios Creek.)	
Huffman Drive/ WWTP (8)	WR15	SR11, Huffman Drive, & WWTP access road just north and south of Denois Creek under SR 11	Flooding of a portion of SR 11 (2' deep), Huffman Drive (5' deep) and WWTP access road (1' deep), flooding begins on each road below the 10-year flood level, access to a few structures that are above flood levels is prevented, minor flooding of about 5 structures	Waste water treatment plant, Southside Elementary School access from the south
	WR16	Not used		
Garden City (9)	WR17	Kenmill Street area east of RR between Garden Street and CR 200 South	Approximately 38 structures flooded to depths less than 2' and 53 structures flooded to depths over 2', although some structures are also above the 500-year flood elevations, access to most of these structures is prevented by flooding of SR 11, minor flooding begins at about the 10 year level, 2 structures are located in the floodway	1 hazardous material facility, mobile home park
	WR18	Garden City east of RR between SR 46 and Garden Street	Approximately 13 structures flooded to depths less than 2' and 8 structures flooded to depths over 2', although some structures are also above the 500-year flood elevations, access to most of these structures is prevented by flooding of SR 11, flooding of the road and a few structures begins below the 10-year level, 4 structures are in the floodway	
	WR19	Garden Street west of SR 11	While structures in this reach appear to be above the 500-year flood levels, flooding of Garden Street up to about 4' begins below the 10-year flood level preventing access to and from approximately 16 structures	
	WR20	Not used		
Gladstone Avenue (23)	WR12	Gladstone Avenue south of Clifty Creek	Over 6' flood depths preventing access to approximately 3 sets of structures, up to 3' depths for Clifty Creek flooding, flooding from EFK White River or from Clifty Creek begins at less than 10-year flood levels	
	WR13	Gladstone Avenue between the RR and Clifty Creek	Road overtops by up to about 7', prevents access to a couple sets of structures when White River floods, a few additional structures are cut off when Clifty Creek floods, flooding begins at less than 10-year levels	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Water Street (29)	WR23	South of 1st Street between Lafayette Avenue & Brown Street	Access roads flooded by up to over 7' of water preventing access to 1 or 2 businesses, structures appear to be near or above flood elevations, road flooding begins at less than 10-year flood levels	
Mariah/ Reo St (30)	WR21	Commercial and residential area east of Haw Creek, south of State Street and north of the RR	Approximately 12 structures flooded to depths less than 2' and 10 structures flooded to depths over 2', flooding may occur from water backing up Haw Creek and overtopping the berm along the commercial property or EFK White River water flooding over the RR, overtopping of these features occurs around the 50-year flood level of EFK White River. (This description applies to flooding from East Fork White River only. See HC13 for description of impacts when flooding source is Haw Creek.)	1 hazardous material facility
Beatty Lane	WR14	Beatty Lane south of RR	Flood depths over 7 feet preventing entrance to one farmstead	
	WR22	Not used		

Table 2-12 Description of Floodprone Areas During 500-Year Flood - FLATROCK RIVER

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Mill Race Park (14)	FR1	Between 5th and 11th Streets and Flatrock River and Jackson Street	1 or 2 structures flooded by less than 2' of water with access blocked for those structures and potentially 5 additional structures, road and minor structure flooding begins at about the 50-year level. Potential for flooding of Cummins COB loading dock at 500-year level.	1 hazardous material facility
Indianapolis Road (16)	FR3	Along Indianapolis Road from about 3000' north to 2000' south of CR 100 N	Flood depths along Indianapolis Road are over 3', 1 structure along this reach of the road is flooded by less than 2' of water while 23 are flooded by over 2', road and structure flooding begins below the 50-year flood level, direct access to more than 10 businesses is blocked by flood waters, 17 structures are located in the floodway	
	FR4	CR 100 North from Indianapolis Road to CR 200 West	Flood depths along this road segment are over 6', cutting off access to at least one set of buildings, flooding starts below the 10-year flood level	
	FR7	West of Indianapolis Road roughly between Brian Drive and Arcadia Drive	Road flooding at over 3' depth preventing access to several businesses that appear to be above the 500-year flood level, road flooding (including Indianapolis Road) begins around the 10-year level	1 hazardous material facility
Washington St (17)	FR2a	Area from Washington Street to Flatrock River and between 12th Street and Newsome Avenue	45 structures with flood depths less than 2', 90 structures with flood depths over 2', flooding of streets to 3' or more of water, flooding of several structures and inundation of the access into and out of the neighborhood begins below the 50 year flood elevation, RR embankment provides some protection between the 10- and 50-year floods for the southern portion of the area	
Noblitt Falls (18)	FR2b	Noblitt Falls neighborhood west of Washington Street and Newsome Avenue to 23rd Street	20 structures with flood depths less than 2', 35 structures with flood depths over 2', flooding of streets to 3' or more of water, flooding of several structures and inundation of the access into and out of the neighborhood begins at about the 50-year flood elevation when the lagoon berm is overtopped or water flows over a low point in Newsome Avenue near its intersection with Lawton Avenue, 40 structures located in the floodway	
Riverside Drive South (19)	FR6	Riverside Drive between 23rd and 28th Streets	Flooding of auxiliary access to some structures may occur at less than the 10-year flood level, all structures appear to be above 500-year flood levels and have access to the east	
US 31 (20)	FR10	Along National Road between Washington Street and 2000' east of Indianapolis Road	Minor flooding possible at the 500-year flood level, access to adjoining properties becomes flood free before internal access within those properties, impacts access to 2 hazardous material facilities	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Long Road (22), Commerce Park (21)	FR8	Northeast, southeast, and southwest quadrant of National Road and Indianapolis Road intersection	Potential flooding less than 2' deep on 5 structures with street flooding over 3' deep preventing access, some flooding begins around the 50-year level, 20 structures in the floodway	2 hazardous material facilities
Long Road (22)	FR12	North and east of Long Road and Lowell Road intersection	3 structures with flood depths less than 2', parking lot flooding begins at 50-year level with potential flooding of structures at 100-year level, at 500-year access to another group of structures is flooded	
	FR13	Along east side of Indianapolis Road for 1800' south of Long Road	Parking lot and access road flooding up to about 1' which may block access to 2 businesses starting above the 100-year flood level	
Riverside Drive North (45)	FR11	Riverside Drive between Rocky Ford Road and Washington Street	3 structures flooded by less than 2', 3 structures flooded by more than 2', flooding begins above the 10-year flood level, auxiliary access is available for all but 2 structures via alley east of the structures	
CR 200 W	FR5	CR 200 West from CR 100 North to approximately 3,500 feet north	Flooding of road up to about 2' blocks access for 2 sets of structures, flooding begins at less than the 500-year level	
Princeton Park Drive	FR9	Along Princeton Park Drive south of Heathrow Drive	Some road flooding less than 1/2' except for in front of one residence where flood depths are over 3', structure may or may not be above the 500-year flood elevation, access to that one structure may be blocked at less than 50-year flood levels	
Riverside Drive	FR14	Riverside Drive north of North Street	Road flood depths up to about 1' blocking access to 5 or 6 residences beginning above 100-year flood levels	
CR 400 N	FR15	CR 400 North between US 31 & River Road	Flood depths of over 4' beginning below the 10-year level, no direct impact to access to structures	
CR 550 N	FR16	CR 550 North between Flatrock River and US 31	Flood depths on road over 7' preventing direct access to about 3 parcels beginning below the 10-year flood elevation	

Table 2-13 Description of Floodprone Areas During 500-Year Flood - HAW CREEK

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Mariah/ Reo St (30)	HC13	Commercial and residential area east of Haw Creek, south of State Street and north of the RR	Approximately 17 structures flooded to depths less than 2' and 9 structures flooded to depths over2', flooding may occur from Haw Creek water overtopping the berm along the commercial property or EFK White River water flooding over the RR, overtopping of these features can occur around the 50-year flood level of EFK White River or the 10-year level of Haw Creek	1 hazardous material facility
CEP/ 2nd St (31)	HC3	Central Avenue between 3rd Street and 7th Street	Depths of over 1' with flooding beginning above the 100-year level, flooding eliminates one access route for the business	
	HC4	Cummins Engine Plant north of 3rd Street and Central Avenue	Flooding of parking and building begins at levels near the 100 year, floodwall is under construction to protect structure from flooding	1 hazardous material facility
	HC8	West side of Haw Creek between 3rd Street and the RR	Fill has been placed south of 2nd St so depths in this portion are unknown. North of 2nd Street flood depths are up to 6 feet, 5 buildings are flooded to depths over 2', 2 buildings are flooded to depths less than 2', 3rd Street flood depths are over 4' while 2nd Street depths are a little over 1', flooding of the area north of 2nd St begins above the 100-year flood	1 hazardous material facility
Tech Center/ Pleasant Grove (32)	HC1	Cummins, Inc property	levee/floodwall system has been built to protect Cummins Technology Center structures from flooding, Child Care Center begins flooding just below the 100-year flood level	1 hazardous material facility (protected), 1 child care facility
	HC2	Pleasant Grove neighborhood between State Street and 7th Street between Pleasant Grove and Cherry Street	Flood depths up to over 7' for structures and streets, flooding begins below the 50-year flood level, alternate flood-free access is available, several structures have been bought out	
10th / Central (33)	HC5	Neighborhood between Haw Creek and Cottage Avenue and between 7th and 12th Streets	68 structures with flood depths less than 2', 104 structures with flood depths over 2', structure flooding may begin below 10-year level, significant street flooding with depths over 6', some street flooding at the 10-year level, access is cut off to approximately 12 structures that appear to be flood-free , 2 structures have been bought out	
	HC6	8th Street between Haw Creek and Central Avenue	Over 3' depth, flooding begins below the 50-year flood level, access is prevented to already flooded areas	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
(33) Cont.	HC7	10th Street between Haw Creek and Hutchins Avenue	Street flooding up to 6', flooding begins below the 10-year level, access is prevented to already flooded areas	
17th/ Keller (34)	HC12	Neighborhood between 17th and 20th Streets and Keller Avenue to Haw Creek Avenue	Approximately 36 structures with less than 2' flood depths, 12 structures with more than 2' flood depths, street flooding up to over 4' of water, street flooding begins at about the 50-year level	
CRH (35)	HC10	Columbus Regional Hospital east of Haw Creek along 17th Street	Flooding of parking areas near the creek with over 2' of water along with building flooding, parking lot flooding begins below the 50-year level, building flooding via the loading dock would begin about the 100-year level, hospital has constructed flood control measures to protect against structure flooding	medical facility
Midway (36)	HC11	North of Columbus Regional Hospital to 24th Street between Haw Creek and Midway Street	Flooding of parking lots to depths over 5', 19 structures with flood depths less than 2', 10 structures with flood depths over 2', street flooding generally about 2' deep, flooding of parking lots starts below the 10-year event, structure flooding begins below the 100-year level, alternate access to non- flooded structures (except 2) is maintained, impacts to Columbus Health and Rehabilitation Center begin about the 100-year event level	assisted living facility, school
Everroad Park East (37)	HC17	Everroad Park East along Griffa Avenue north of 25th Street	In the southern portion of the area, flooding of structures begins at about the 100-year level, shallow flooding of about 10 residential structures and over 2' for a business along with street flooding of up to 1' preventing direct access to about 16 residences. In the northern part of the area, flooding begins just above the 10-year flood level, 30 structures are flooded to depths over 2' and about 15 are flooded to depths less than 2', access to about 3 structures is prevented by flood waters	
Everroad Park West/ Eastbrook (38)	HC14	Southwest corner of the 25th Street and National Road intersection (Eastbrook Plaza)	Approximately 2' deep flood waters in strip mall structures and parking areas beginning around the 50-year flood level	
	HC15	National Road west of Haw Creek to Herman Darlage Drive	Flood depths of up to about 3', flooding begins below the 100-year flood level, flooding limits access to neighborhood to the north and a few businesses along the road	
	HC16	Everroad Park West neighborhood west of Haw Creek between National Road and 31st Street	Street flooding begins below the 50-year level making about 10 structures inaccessible, structure flooding beginnings at or above 50-year level, 112 structures flooded by less than 2', 67 structures flooded by depths over 2', streets flooded by over 2' of water	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Cedar Ridge (39)	HC19	Between Middle road and Trestle Drive between Cedar Crest Drive and Cedar Ridge Drive	Street flooding of over 1' prevents access to about 25 structures, flooding begins above the 100-year flood	
	HC20	Trestle Drive south of Rocky Ford Road	Flood depths over 1' prevent access to one structure and cut off 1 of the accesses to a neighborhood on its west south of Rocky Ford Road, flooding begins above the 100-year level	
Windsor Place/ Hillcrest (40)	HC18	Windsor Place/Hillcrest neighborhood east of Haw Creek between 30th Street and Rocky Ford Road	Over 70 structures flooded by less than 2' of water, 15 structures flooded by over 2', streets flooded by over 2' of water, access prevented to even more structures, structure and street flooding begins at the 50-year flood level	
Northbrook/ Candlelight (41)	HC22	Candlelight/Northbrook neighborhood between Candlelight Drive and Haw Creek and Northbrook Drive and Rocky Ford Road	138 houses and 154 mobile homes flooded by less than 2', 1 house and 80 mobile homes flooded by over 2', flooding begins below the 50-year flood level	mobile home park
	HC23	Not used		
Sycamore Bend/Arrowood (42)	HC24	Arrowood/Willowwood neighborhood north of Rocky Ford Road and west of Indianwood Drive	Minor street flooding begins below the 50-year flood level, approximately 20 structures are flooded by less than 2' of water, streets are flooded by approximately 2' of water making over 50 structures inaccessible even though some are above flood waters	
	HC25	Marr Road and Sawin Drive near their intersection	Flood depths over 2' beginning below the 50-year level, no impact on direct access to structures	
	HC26	Not used		
Marr Road (43)	HC27	Along Marr Road from CR400 North to about Sawin Drive	Depths over 4' preventing direct access to one or two farmsteads, flooding begins east of Haw Creek at less than the 10-year level	
	HC28	Not used		
	HC29	Not used		
North Haw Creek (44)	HC30	CR 400 North east of Marr Road	Flood depths up to 5' preventing direct access to 2 farmsteads, flooding begins below the 10-year level	
	HC31	Marr Road between CR 550 North and CR450 North	Flood depths over 2' with minor flooding starting at the 10-year level, direct access prevented to 2 farmsteads	
	HC32	Along Talley Road south of CR 450 North	Flood depths over 1' beginning below the 50-year level, does not impact direct access to structures	

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
North Haw Creek (44) Cont.	HC33	CR 450 North east of Marr Road	Flood depths over 4' preventing direct access to 3 farmsteads, flooding begins below the 10-year level	
	HC34	CR 250 East north of CR 450 North	Flood depths over 3' preventing direct access to 2-3 farmsteads, flooding begins below the 10-year level	
	HC35	CR 500 North east of CR 150 East	Flood depths over 5' with flooding starting below the 10-year level, direct access prevented to 1 farmstead	
Ravens-wood Drive	HC9	Along Ravenswood Drive between 15th and 17th Streets	Minor flooding possible for 3 structures, potential street flooding up to almost 1' would block access to about 7 residences, flooding begins at depths over the 100-year flood level	
Rocky Ford	HC21	Rocky Ford Road between Candlelight Drive and Taylor Road	Flooding east of Haw Creek to 1' depth of water preventing access to about 15 structures, flooding west of Haw Creek to depths of over 4' cutting off 1 of the accesses to the mobile home park on the north and the neighborhood to the south, prevents access to one business, shallow flooding begins at the 10-year level	

Table 2-14 Description of Floodprone Areas During 500-Year Flood - OPOSSUM CREEK

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
	OC1	North of CR 230 South & east of CR 150 West	Flooding of 2 structures and their access with over 2' of water, flooding begins below the 10-year level of Opossum Creek and the 50-year level of EFK White River (access flooding from EFK White River begins at slightly lower level)	
Shadow Creek Farms (6)	OC2 (also identified as DC4)	CR 150 West between CR 200 South and CR 300 South	Overtopped by over 1' of water cutting off access to 2 residences and potentially the east access to the subdivision north of Denios Creek (Shadow Creek Farms), shallow flooding occurs near the creek at the 10-year flood elevation. EFK White River flood waters come near to the road but do not appear to overtop it.	
	OC3 (also identified as DC5)	Shadow Creek Farms subdivision southwest of CR 200 South and CR 150 West along Shadow Creek Blvd	Existing structures appear to be built above the flood elevations. However, a short portion of Rolling Knoll Lane and portions of what looks like the early stages of construction for another street show flood depths of more than a foot. This, in combination with flooding of CR 150 West, would isolate about 25 existing homes and potentially more as the subdivision is developed. Flooding of the street does not start until levels greater than the 100-year.	
CR 200 S (7)	OC4	CR 200 South and CR150 West south and west of their intersection	CR 150 West is flooded up to 3' from Opossum Creek and up to about 2' from EFK White River, CR 200 South is flooded by up to 1/2' water from Opossum Creek and no flooding from EFK White River, flooding of CR 150 West here in combination with further south prevents access to about 10 residences, flooding along CR 200 South prevents access to 1 residence and to Southside Elementary School from the west, flooding of CR 150 West begins from EFK White River at the 50-year level and from Opossum Creek below the 10-year level, flooding of CR 200 South begins at the 50-year level	Southside Elementary School access

Table 2-15 Description of Floodprone Areas During 500-Year Flood - SLOAN BRANCH

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
Madison/ Grant/ Flintwood (26)	SB2	Talley Road and Valley Forge Avenue north of 25th Street	Street flood depths over 1' preventing access to approximately 20 residences along these road segments, flooding begins at about the 10-year level	
	SB3	Neighborhood north of 25th Street between Flintwood Drive and Talley Road	Approximately 64 structures flooded to depths less than 2', 2 structures flooded by over 2' of water, street flooding up to 2' in the neighborhood and up to almost 1 foot along 25th Street preventing access to over 230 structures , flooding of 1-2 structures may begin at the 10-year level, additional structure and street flooding begins below the 50-year level, significant areas plus 25th Street are affected by the 100-year level, access to the Lutheran Home is impacted above the 50-year flood level	1 hazardous material facility, medical facility, school, Lutheran Home
Eastridge Manor (27)	SB4	Eastridge Manor neighborhood south of Rocky Ford Road between Talley Road and Virginia Street	Approximately 26 structures flooded to depths less than 2', 5 structures flooded to depths over 2', access is prevented to most structures along Elizabeth Street, Rocky Ford Road is flooded by up to 2', minor flooding of structures, Elizabeth Street, and Rocky Ford Road occurs at the 10-year level	
25th St & CR 350 E	SB1	North and east of intersection of 25th Street and Bonnell Road	Flooding of about 1/2' on 25th Street and up to 2' on Bonnell Road, minor flooding of Bonnell Road begins near the 10-year level, flooding of 25th Street begins above the 100 year, alternate access to structures is available	
Talley Road	SB5	Talley Road south of Sawin Drive	6 structures flooded to depths less than 2', 2 structures flooded to depths over 2', Talley Road flood depths near 4' prevent access to flooded structures, minor flooding begins near the 10-year level	
CR 350 N	SB6	CR 350 North east of Talley Road	Road flooding over 1' deep, does not impact direct access to any structures, minor flooding begins at 10-year level	

Table 2-16 Description of Floodprone Areas During 500-Year Flood - WOLF CREEK

Neighbor-hood Reference	Map Identifier	General Location	Description of Flood Impacts at 500-Year Flood Levels and Frequency at Which Impacts Begin	Critical Facilities
CR 500 W	WC1	CR 500 West north of SR 46	Road flood depths over 1', does not block direct access to any structures, minor flooding begins at the 10-year level	
CR 580 W	WC2	CR 580 West between Old Nashville Road and CR 50 North	Road flood depths up to 1/2', does not prevent direct access to any structures, flooding begins above the 100-year level	

2.5 FLOOD FORECASTING

Advance warning of flood levels and associated impacted areas that are possible from an approaching storm greatly enhances the ability of individuals and communities to respond in appropriate ways to protect life and property. These responses include such things as evacuation while roads are still passable, sand bagging around areas before the water reaches a structure, and selection of areas requiring flood response assistance.

Existing Flood Forecast Products

The National Weather Service (NWS) has the responsibility of weather forecasting and warning and has developed several related products on the internet for use by the public. The United States Geological Survey (USGS) and others have also developed products that complement the NWS products and enhance the information that can be obtained. Those products that are pertinent to communicating or developing flood forecast information for the Columbus area are described in this section. These products can be accessed from multiple web pages. Only one of the possible addresses to access a given product is provided. Currently, these products provide the following types of information:

- spatial distribution of forecasted rainfall depths or snowfall water equivalent
- the rainfall that would be generally required in an area to create flooding based on the ground moisture conditions

- forecasted river stages at USGS stream gages
- expected extent and depth of flood inundation along select stream reaches at various stages recorded or forecasted at associated USGS stream gages

Table 2-17 shows which of these products are currently available for each stream. Streams with similar products are placed together in a Forecast Product Category as shown on the table. Because each category of products contains different data, different methods and confidence levels of flood forecasts are available for the stream in each of the different categories.

The Forecast Product Category for each stream is also shown in **Figure** 2-6. A discussion of potential applications for flood forecasting using each category of products is provided. A detailed description of how to currently access these products is provided in **Appendix 2**. Steps for use in Columbus flood forecast efforts are provided in the City of Columbus Flood Response and Evacuation Plan. Work is under way by various entities to expand these capabilities in the future.

Table 2-17 Flood Forecast Product Availability

Stream	USGS gage is NWS river forecast point	Forecast Uncertainty Information	USGS inundation map library	CBBEL depth maps tied to USGS stream gage stages	CBBEL depth maps	USGS gage measuring real time stages	Precipitation forecast for the watershed	Flash flood guidance
Category A – USGS Gage and NWS Forecast Point Available								
EFK White R	√	√	√	√		√	√	√
Driftwood R, North	√		√			√	√	√
Category B – USGS Inundation Map used with Real Time USGS Stream Gage is Best Available Information								
Flatrock R, South			√	√		√	√	√
Haw Ck			√	√		√	√	√
Category C – CBBEL Depth Map used with Real Time USGS Stream Gage is Best Available Information								
Clifty CK, Downstream of Sloan Br				√		√	√	√
Clifty Ck, Upstream of Sloan Br				*		√	√	√
Driftwood R, South				√		√	√	√
Driftwood R, Middle				*		√	√	√
Flatrock R, North				*		√	√	√
Category D – CBBEL Depth Map is Best Available Information (No stream gage available)								
Airport Tributary					√		√	√
Denios Ck, Downstream of I-65					√		√	√
Opossum Ck					√		√	√
Sloan Branch					√		√	√
Category E - No Depth Mapping or Stream Gage Available								
Big Slough							√	√
Catherine Ck							√	√
Denios Ck, Upstream of I-65							√	√
Denios Ck Trib							√	√
EFK White Ck							√	√
EFK White Ck Trib 1							√	√
EFK White Ck Trib 2							√	√
North Ogleville Trib							√	√
Wolf Ck							√	√

**Development of depth maps for these reaches was out of the project scope but data does exist for development in the future.*

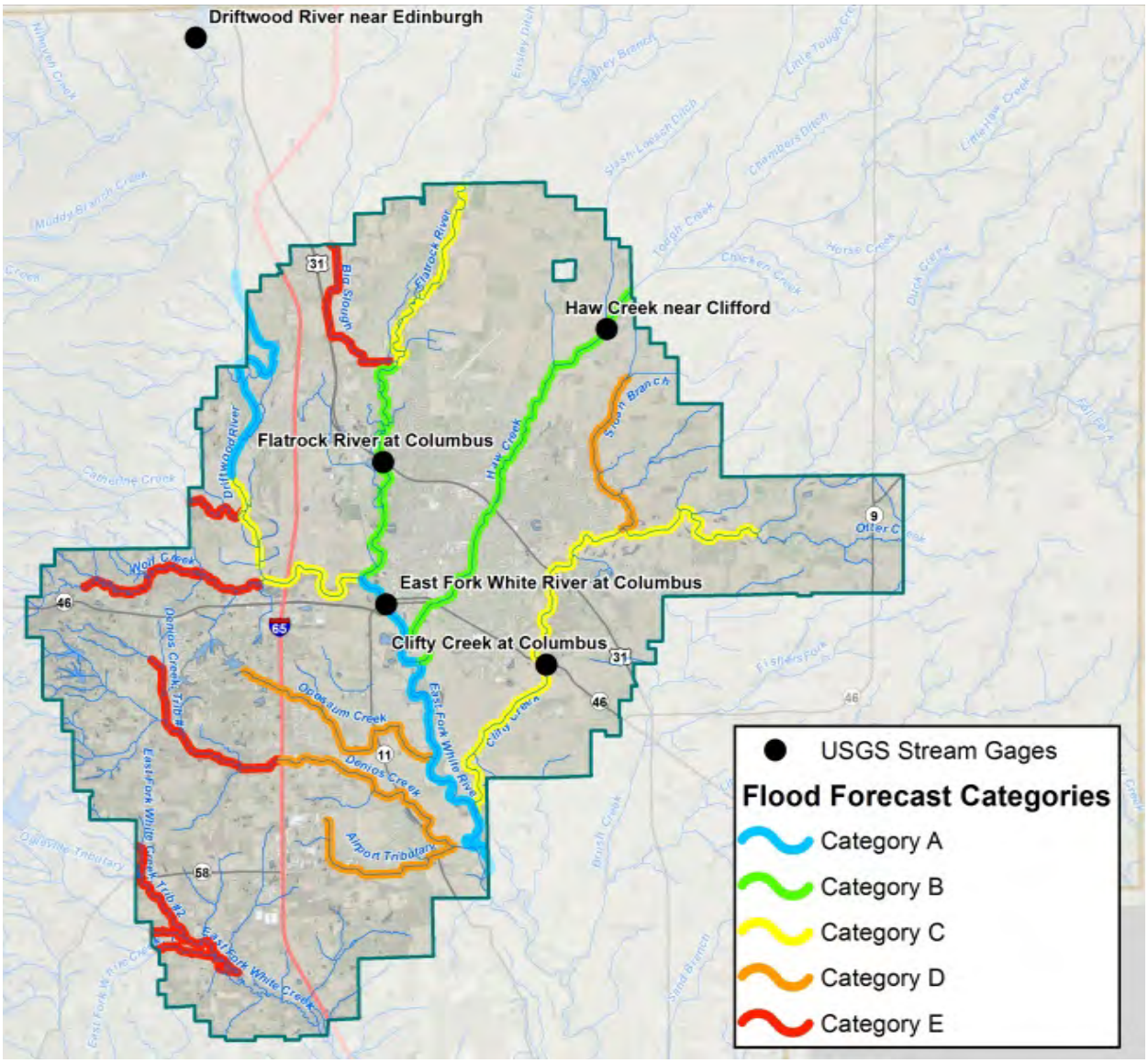


Figure 2-6 Flood Forecast Product Category for Each Stream Reach

Forecast Product Category A – Driftwood River (upstream of CR 200 N) and East Fork White River - As soon as the inundation map library currently under way for East Fork White River is completed by USGS and the forecast uncertainty products for the Driftwood River near Edinburgh USGS gage are completed by NWS, the reaches of the East Fork White River and Driftwood River will have the ideal set of tools for flood forecasting. This is because the East Fork White River at Columbus and

Driftwood River near Edinburgh gages are included as river forecast points by the NWS and an inundation map library has or is being developed by USGS.

Every day, the NWS is using their methodology to make precipitation forecasts for subsequent days. Additional staff at the NWS then use other models to turn those precipitation forecasts into forecasted stages at select NWS forecast points, such as the East Fork White River USGS gaging station located just downstream of SR46 West and Driftwood River near Edinburgh. As precipitation forecasts and ground moisture conditions change and river stages are observed in response to rainfall, the forecasted river stages are revised. These forecasted river stages in conjunction with flood inundation mapping can be found on the internet in the Flood Inundation Mapper currently accessible at wim.usgs.gov/FIMI/.

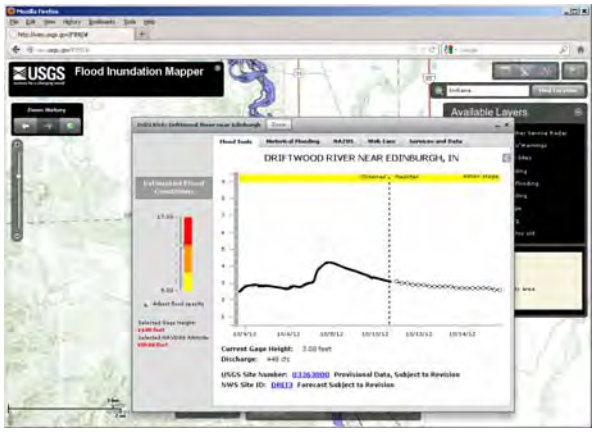


Figure 2-7 Web Site Observed Stage Data

Using the tools on this web page (an example of which is shown at left), forecasted river stages can be turned into approximate flood area and depth mapping. This data can be used by the public as well as emergency responders for determining the level of preparedness that is needed if conditions proceed as forecasted. Many factors influence the forecasts at any given time. Sometimes, meteorological conditions have more potential for change than at other times. Therefore, the NWS has developed an experimental product that provides the forecast along with information regarding the associated uncertainty in that forecast.

In summary, the following information is or will soon be available for the Driftwood River north of CR 200 North and the East Fork White River in Columbus:

- observed stages at the USGS gage
- forecasted stages at the USGS gage
- range of uncertainty associated with the forecasted stages, and
- map of expected inundated areas at various USGS gage stages.

With this information, emergency management personnel, local citizens, and others can see the impact of expected flooding and respond as needed.

Forecast Product Category B - Flatrock River (downstream of CR 400 N) and Haw Creek - Flatrock River downstream of CR 400 N and Haw Creek will soon have available most of the same tools as East Fork White River. Currently, inundation mapping is in process for the Flatrock River at Columbus and Haw Creek near Clifford gages. However, these gages are not currently slated to become NWS river forecast points.

Until such time as river stage forecast information is available for these 2 streams, only observed stages and inundation mapping is available. The process for obtaining this data is the same as that for Category A streams. The graph of the river stages shown in
Figure *2-7* just will not have the forecasted stage portion and no forecast uncertainty information is available.

In lieu of NWS forecast data, the graph of the observed stages at the gage can provide an indication of whether the stream is still rising or has begun to recede. Educated guesses as to the amount it will continue to rise based on NWS rainfall forecasts for the area can be made in order to make emergency preparedness decisions. Up to date rainfall forecasts for several time increments can be accessed on the web at the NWS Indianapolis Weather Forecast Office web page currently located at http://www.crh.noaa.gov/ind/. The forecasted rainfall for the duration that is critical for a given stream per the table in **Appendix 3** can then be compared with the graph of rainfall versus duration that is also provided in Appendix 3 to determine if there is the potential for flooding.

There is currently no NWS product that provides the range of uncertainty for a given precipitation forecast on watersheds not associated with river forecast points. However, due to the fact that the Driftwood River and Flatrock River combine to create the East Fork White River, the probability information provided for the East Fork White River gage described in the previous section is likely

also an indication of the range predicted rainfall would be in for these two stream's watersheds.

In summary, the following information is or will soon be available for Flatrock River (downstream of CR 400 North), and Haw Creek:

- observed stages at USGS gages
- range of forecasted precipitation uncertainty based on the East Fork White River gage forecast information
- map of expected inundation area at various USGS gage stages, and
- precipitation forecast data for the watersheds.

With this information, emergency management personnel, local citizens, and other can see the impact of expected flooding and respond as needed. This information will be incorporated into the Flood Response and Evacuation Plan.

Forecast Product Category C - Clifty Creek, Flatrock River (Upstream of CR 400 N), and Driftwood River Middle and South (Downstream of CR 200 N) - Data for Clifty Creek downstream of Sloan Branch and for Driftwood River between the mouth and Wolf Creek is similar to that described above for the Category B streams with the exception that no inundation map library is in process. Other Category C stream reaches include Clifty Creek upstream of Sloan Branch, Flatrock River upstream of CR 400 N and Driftwood River between CR 200 N and Wolf Creek which were not included in the scope for depth map creation as part of the CBBEL study. Because the data exists for creation of the depth mapping, these reaches are also included as Category C streams for the purpose of this report.

There is currently a USGS gage on Clifty Creek which could serve as the basis for future creation of an inundation map library but this gage will soon be discontinued if no local sponsor can be found to contribute yearly to the gage maintenance.

For the time being, depth mapping for Clifty Creek downstream of Sloan Branch, Flatrock River downstream of CR 400 N, and Driftwood River downstream of Wolf Creek has been created as described in Section 2.3 and has been linked to stages at the USGS gages. This in essence provides depth mapping for 4 stages of the gage ranging from the 10-year to 500-year flood stages.

Observed gage stages can be found at the NWS Indianapolis Weather Forecast Office page at http://www.crh.noaa.gov/ind/. From this page, a graph of the observed gage stages can be accessed. This graph can be an indication of whether the stream is still rising or has begun to recede. Educated guesses based on whether additional rainfall is forecasted can be made as to the amount it will continue to rise. Up to date rainfall forecasts can be accessed on the web at the NWS Indianapolis Weather Forecast Office page currently located at http://www.crh.noaa.gov/ind/. That forecasted rainfall can then be compared with the graph of rainfall versus duration that is provided in Appendix 3 to roughly determine the forecasted rainfall frequency. That frequency can then be used with the frequency flood depth maps developed and described in Section 2.3 to make rough predictions of flood inundation areas for use in the Flood Response and Evacuation Plan.

In summary, the following information is available for Clifty Creek and for Driftwood River from its mouth to just upstream of the confluence of Wolf Creek:

- Observed stage at USGS gages
- Depth mapping and associated stage at USGS gage
- Forecast precipitation data for the watersheds

The same information could also be made available for Driftwood River between Wolf Creek and CR 200 N and Flatrock River upstream of CR 400N if depth mapping were done for these reaches and related to the respective USGS gages.

With this information, emergency management personnel, local citizens, and other can see the impact of expected flooding and respond as needed.

Forecast Product Category D - Airport Tributary, Denios Creek (Downstream of I-65), Opossum Creek, and Sloan Branch - Airport Tributary, Denios Creek downstream of I-65, Opossum Creek, and Sloan Branch do not have USGS stream gages to use for forecasting or estimating flood stages. Flood depth mapping has however been developed by CBBEL. Currently, forecasted rainfall depths and flash flood guidance are the only forecast products that are available for these watersheds. The NWS Ohio River Forecast Center Flash Flood Guidance product is available for indicating how much rainfall in a given period would be expected to produce flooding. The NWS forecasted rainfall can also be compared with the graph of rainfall versus duration that is provided in Appendix 3 to determine the approximate frequency of the forecasted rainfall. That frequency can then be used with the frequency flood depth maps developed and described in Section 2.3 to make rough predictions of flood inundation areas for use in the Flood Response and Evacuation Plan.

Forecast Product Category E - Big Slough, Catherine Creek, Denios Creek Upstream of I-65, Denios Creek Tributary, East Fork White Creek, East Fork White Creek Tributaries 1 and 2, North Ogleville Tributary and Wolf Creek - These streams do not have inundation map libraries, depth mapping, USGS stream gage observations, or river forecasts available for use in determining flood response needs. The NWS Flash Flood Guidance product is the most useful product for these streams. This product shows the rainfall depths in the subsequent 1-, 3-, 6-, 12-, and 24-hours that would potentially create flooding.

Potential Future Flood Forecast Input Data and Products

In an ideal world, all stream reaches in Columbus would have the same products as the East Fork White River thus providing the capability of knowing the forecasted flood stages and having an associated map of what areas would be expected to be inundated

if the flood happened as forecasted. In reality, flood levels are dependent on so many variables that accurate predictions are not always possible. Efforts to better understand the variables and their impact are a part of the NWS tasks. Rainfall gages, USGS stream gages, NWS forecast points, the USGS inundation map libraries, and potential products that could be developed by other entities are all components of the efforts to create the ideal flood prediction/warning process. Items that would assist the NWS in providing better forecasts and increasing Columbus abilities to know what flood scenario to prepare to respond to are as follows.

Rainfall gages – Rainfall gages used by the NWS to calibrate their modeling and make predictions of rainfall are scattered around the Columbus area. Based on conversation with the NWS personnel, the following would help them improve their forecasts:

- hourly rainfall gage generally located half way between Indianapolis and the Indiana/Ohio state line,
- hourly rainfall gage generally located south of Brookville Lake between Columbus and Cincinnati
- conversion of the USGS stream gage rainfall recording instrumentation from 24-hour to hourly reporting gages (particularly at the Driftwood River at Edinburgh and Sugar Creek at Shelbyville gages)

In addition, rainfall gages in each of the watersheds for the smaller streams that flow through the City would give flood responders additional data on which to base flood response decisions. There are a variety of avenues that could be used for this network but the maximum benefit could probably be achieved by soliciting volunteers to become a part of the existing Community Collaborative Rain, Hail, & Snow Network (CoCoRaHS). This network is used by NWS personnel and is also currently available for access through the internet at http://www.cocorahs.org/viewdata/listdailyprecipreports.aspx.

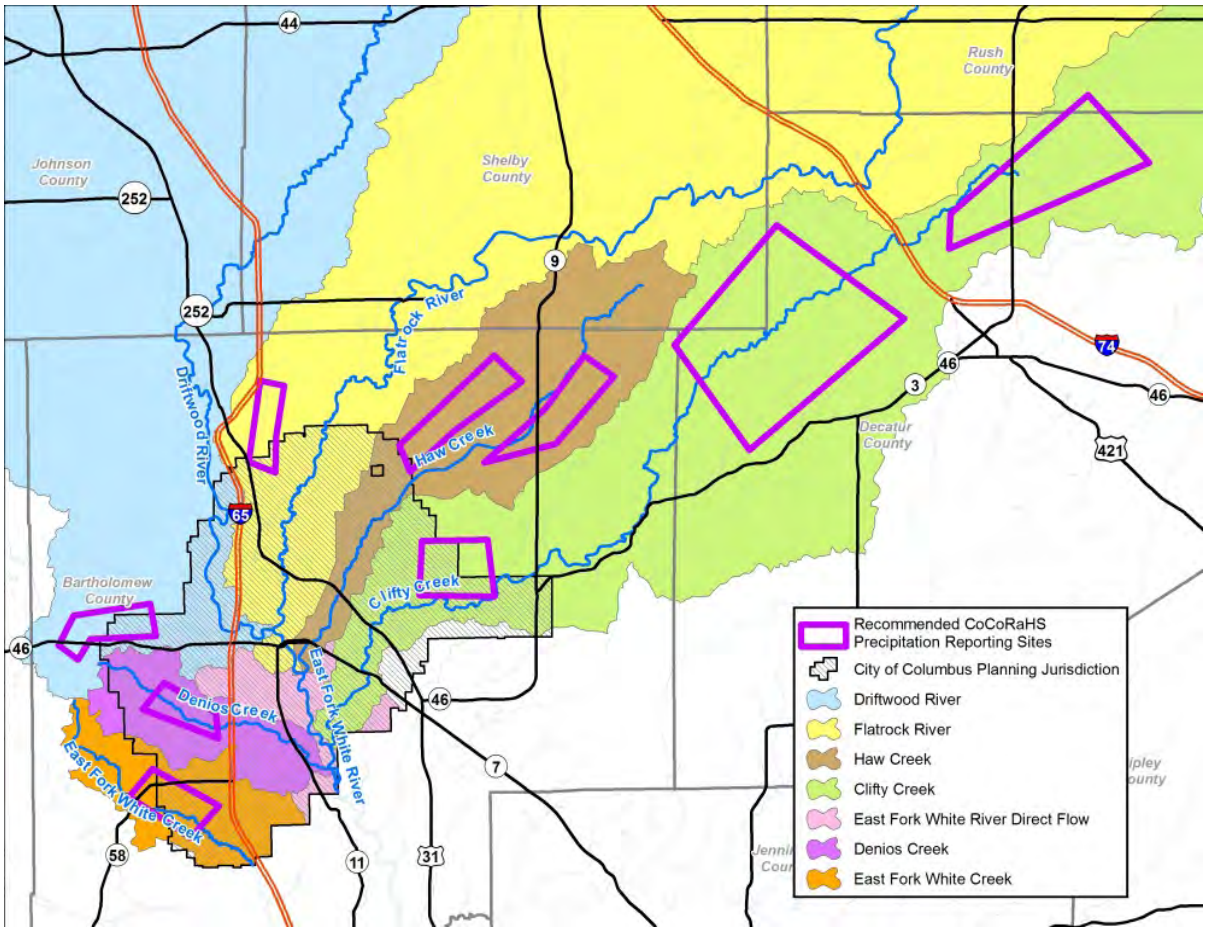


Figure 2-8 Recommended CoCoRaHS Precipitation Reporting Sites

Besides benefitting NWS forecast efforts, the network also provides data for use in future model calibration and for up to date, actual precipitation information for use in flood response decisions. The general locations of areas where this additional precipitation information would be helpful are shown in

Figure 2-8 and listed below. A gage located at any convenient location that would be appropriate for recording rainfall within these areas would be helpful. These areas are generally located:

- Clifty Creek watershed north of Greensburg
- Clifty Creek watershed west of Greensburg
- Haw Creek watershed in the lower reaches of the Little Haw Creek watershed portion

- Haw Creek watershed in the lower reaches of the Tough Creek watershed portion
- Flatrock River watershed north of Columbus
- Wolf Creek watershed
- Middle to upper portion of Opossum Creek watershed
- Middle to upper portion of East Fork White Creek watershed

NWS forecast points – The City would benefit from the addition of more stream forecast points besides the current East Fork White River at Columbus and Driftwood River near Edinburgh sites. This possibility was discussed by CBBEL with NWS officials. NWS has strict criteria for being able to add gages to their forecast network. Per CBBEL request, NWS is investigating the data nodes that they have in their current modeling to determine whether there is the possibility of adding any of the other existing USGS gage sites to the network of forecast points. The City should follow up with the NWS regarding the results of their investigation on the addition of the following gages to the river forecast network:

- Flatrock River at Columbus,
- Haw Creek near Clifford, and
- Clifty Creek near Columbus

Additional USGS gages that are important to these forecasts (and therefore should be maintained) but do not need to be NWS forecast points for the benefit of Columbus are:

- Buck Creek at Acton
- Flatrock River at St. Paul
- Haw Creek at Hope
- Clifty Creek at Hartsville
- Blue River at Shelbyville

Non-NWS forecast points – Because of the strict requirements that the NWS has for adding forecast points to their system and the large area that they must provide forecasts for, it is not likely that the NWS will add forecast points along every Columbus stream to their network. However, a discussion has been started by CBBEL

through the USGS about using models similar to the NWS forecast models but that have been at least partially developed for use on a smaller scale. These models could use the NWS NEXRAD radar data and precipitation forecasts along with real time soil moisture data to potentially predict flood elevations at key points along streams in Columbus. A pilot project on Haw Creek is currently being investigated by the USGS to test these capabilities.

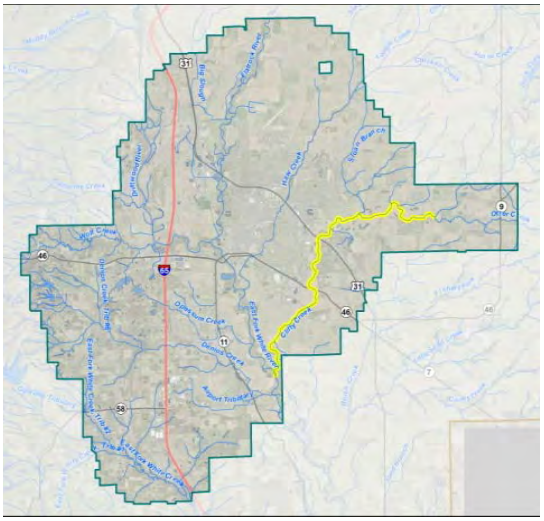


Figure 2-9 Potential Reach of Flood Inundation Mapping if Clifty Creek USGS Gage is Continued

USGS Gages And Associated Inundation Map Libraries – There are currently 5 USGS stream gages that are within or very close to the Columbus planning jurisdictional area. These stream gages are the most important for the City in terms of flood forecasting information and response decisions. Inundation map libraries are currently underway for 4 of these stream gage reaches. The fifth USGS gage, Clifty Creek at Columbus, has no cooperating partner for providing funding and will soon be dropped from the USGS network if no funding partner is found. If a funding partner is found, it is expected that the Clifty Creek near Columbus inundation map library would also eventually be created for the approximate reach shown in yellow in Figure 2-9.

If additional USGS stream gages were installed along remaining streams, additional inundation map libraries could also be created and tied to those gages. Establishing these gages would also provide valuable data for calibration of hydrologic and hydraulic modeling of the streams. Suggested locations for additional USGS gages are listed below and shown in
Figure 2-10 along with existing gages. (Upgrading of the existing gages noted above to NWS forecast points should take precedence to adding these gages to the USGS network, however.)

1. Wolf Creek near CR 500 West
2. Opossum Creek near CR 200 South
3. Denios Creek near I -65
4. East Fork White Creek near CR 250 West
5. Sloan Branch upstream of SR 46

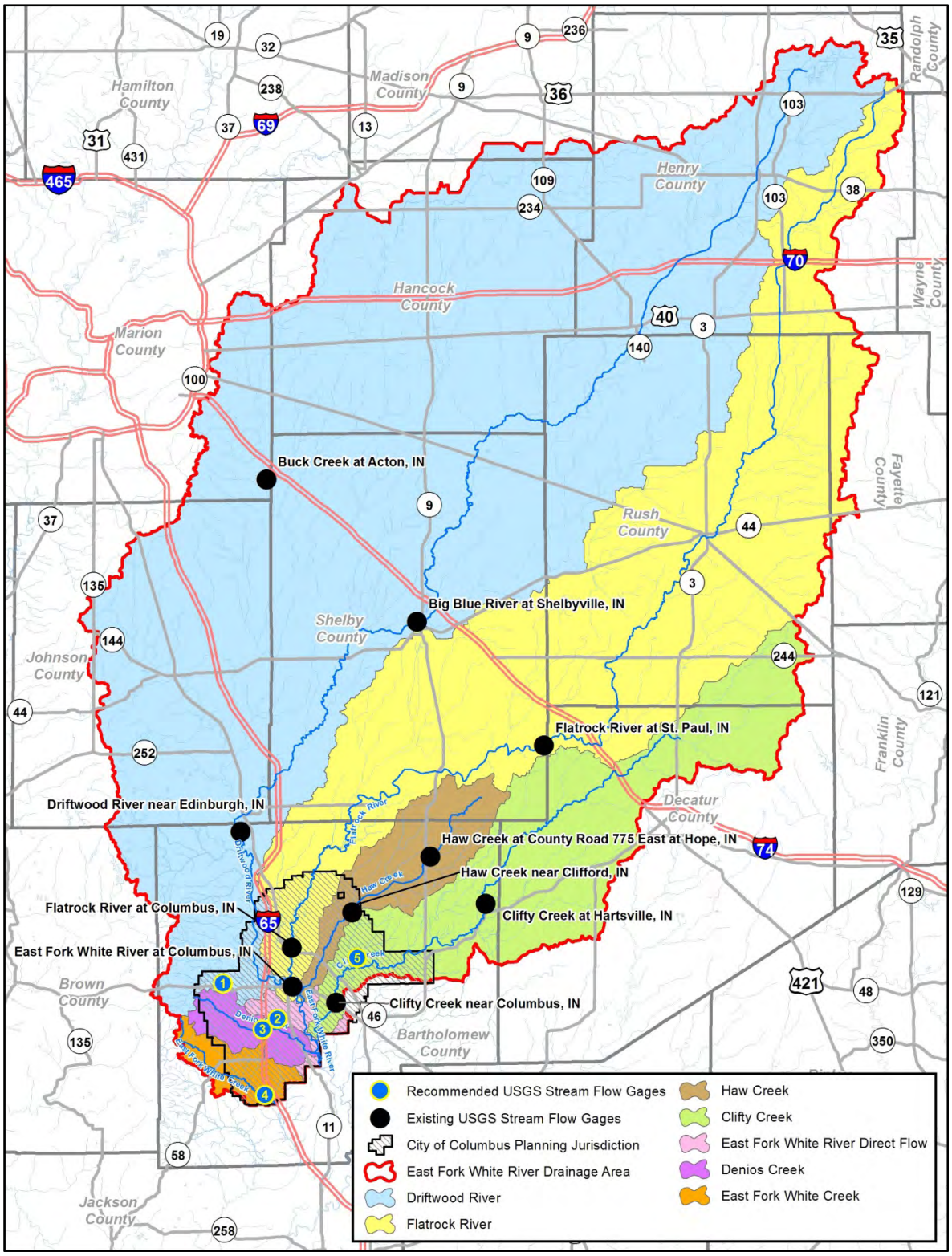


Figure 2-10 Recommended and Existing USGS Stream Gage Sites

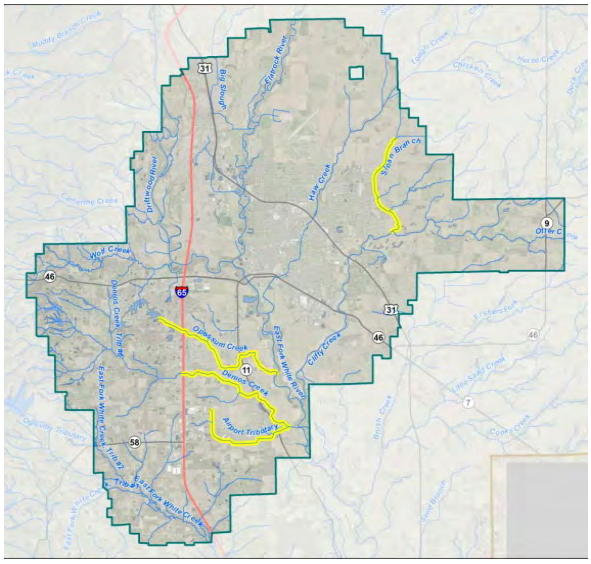


Figure 2-11 Depth Map Reaches without Stream Gages for Correlation

Library of Additional Inundation (Flood Depth) Maps – As part of this Flood Risk Management Plan, flood depth maps were created by CBBEL for the 10%, 2%, 1%, and 0.2% annual chance floods (based on the effective Flood Insurance Study data) for the ungaged streams shown in **Figure** 2-11 and discussed in Section 2.3. There is, however, currently no USGS stream gage to connect these Airport Tributary, Sloan Branch, Denios Creek, or Opossum Creek depth maps to. If USGS stream gages were added to these streams, they would move to Forecast Product Category D and have a connection between anticipated rainfall and associated depth maps.

Even with the availability of all of these products, it must be remembered that the forecasts are only estimates based on as much data as possible. Flood levels, however, may vary from predicted elevations in response to localized conditions such as debris blocking culverts, changes in localized drainage patterns, or isolated rainfall anomalies among other possibilities. Forecast tools cannot take every condition into account but they can improve individual and community ability to prepare for a flood and reduce damages.

2.6 FLOOD RESPONSE AND EVACUATION PLAN

The purpose of the Flood Response and Evacuation Plan (FREP) is to reduce the risk of human life loss, injury, and damage to property during a flood event. The scope of the FREP is limited to the actions that the FREP Coordinators will need to make decisions and accurately inform others of the likely extent of flooding. Although tools and guidance are provided to assist in determining the likely extent and depth of flooding in each neighborhood, location of impassible roads and flood-safe routes, and type of actions needed for response and evacuations, the response and evacuation Standard Operating Procedures (SOPs) for emergency managers and first responders (EMA, E911, Fire, Police, and Red Cross) are not included in the FREP.

The Plan outlines four steps that must be followed anytime a flood event is detected in the City of Columbus. The steps are:

Step 1: Event Detection and Level Determination
Step 2: Notification and Communication
Step 3: Expected Actions
Step 4: Termination and Follow-up

The actions required for each step of the FREP are summarized below.

Step 1 - Event Detection and Level Determination
In this step, a flood event is detected and classified by the FREP Coordinators into one of the following flood event levels:

- Action Stage Flood Event
- Flood Stage (Minor Flood) Event
- Moderate Stage Flood Event
- Major Stage Flood Event

Step 2 - Notification and Communication
After the event level has been determined, notifications are made in accordance with the appropriate notification flow chart provided in the FREP.

Step 3 - Expected Actions
After the initial notifications are made, processes are outlined for the FREP Coordinators to take actions, assess the status of the situations, and keep others informed through communication channels established during the initial notifications.

Step 4 - Termination and Follow-up
Recovery, termination, and follow-up procedures are outlined to take once the event has ended or been resolved.

Recommendations for periodic testing and annual review and update are provided in order for the document to stay current. Due to its intended use during a flood emergency, the full FREP has been created as a stand-alone document.

2.7 RECOMMENDATIONS – IDENTIFICATION OF FLOOD RISKS AND CREATION OF FLOOD RESPONSE AND EVACUATION PLAN

Based on the discussions above regarding flood response tools and plans, the following recommendations are made. These recommendations will be prioritized in the final chapter of this Plan.

1) <u>Correct and Extend FIS Hydrologic and Hydraulic Modeling</u>

a) The hydraulic modeling for the FIS mapping in the City planning jurisdiction was evaluated and found to have varying levels of potential errors. Based on the findings, it is recommended that the streams that received the highest score be placed as high priority for a restudy. The Indiana Department of Natural Resources (IDNR) can be contacted about adding these streams reaches to their ongoing study update list or the City can fund the restudy and supply the data to IDNR for inclusion in the FIS study. Available gage data and high water marks should be used for calibration of the models. It is recommended that the high priority streams be restudied in the next two years and the medium priority streams studies be initiated within the next 5 years. The low priority streams could be initiated in between 5 and 10 years from now if funding is not available before that time. Following is a list of which streams are in each priority level:

High Priority:

- Denios Creek
- East Fork White River (plus overflow portion of Driftwood River)

Medium Priority

- Flatrock River
- Opossum Creek
- Driftwood River
- East Fork White Creek Tributary #1
- Wolf Creek

Low Priority

- Big Slough

- Catherine Creek
- Clifty Creek
- East Fork White Creek
- East Fork White Creek Tributary #2
- Denios Creek Tributary #6 (very low priority)
- North Ogleville Tributary (very low priority)

b) There are still approximately 25 miles of stream reaches within the City planning jurisdiction that do not have detailed studies. As such, proposed development in these areas must obtain engineering studies that identify the floodway or not develop these areas. The FIS "Zone A"s shown in these reaches are based on 100-year flood levels. The City ordinance regulates to the 500-year level so the current delineations do not provide enough data. It is recommended that the City request that these stream reaches be added to IDNR's list of needed future studies or fund the studies and submit them to IDNR for inclusion in future FIS revisions. The stream reaches are:

- Slash-Loesch Ditch from confluence upstream to jurisdiction limit (1.5 miles)
- Sloan Branch from completed study upstream to jurisdiction limit (1.1 miles)
- Unnamed Tributary (UNT) Sloan Branch (2.3 mile)
- UNT Sloan Branch (1.0 mile)
- Otter Creek from the confluence with Clifty Creek to the planning jurisdiction (3.1 miles)
- Clifty Creek from existing study limit upstream to planning jurisdiction limit (3.3 miles)
- East Fork White Creek from existing study limit downstream to planning jurisdiction limit (2.7 miles)
- UNT East Fork White Creek from confluence with East Fork White Creek to 1 square mile drainage area (1.5 miles)
- Another UNT East Fork White Creek from confluence with East Fork White Creek to 1 square mile drainage area (1.5 miles)
- Another UNT East Fork White Creek from confluence with East Fork White Creek to 1 square mile drainage area (0.7 miles)
- UNT Denios Creek (1.2 miles)
- Another UNT Denios Creek (1.5 miles)

- Denios Creek from current study limits upstream to jurisdiction limits (1.3 miles)
- Wolf Creek from CR 580 West to CR 675 West (1.4 miles)
- North Branch Wolf Creek (0.1 mile)
- UNT Catherine Creek (0.6 miles)

c) As additional or revised hydraulic modeling is generated, consideration should be given to generating new depth mapping and seeing that the information is accounted for in the Flood Response and Evacuation Plan.

2) <u>Coordinate with NWS to Improve Forecast Ability</u>

a) Discussions with NWS staff have identified additional rainfall gage locations or data that would be beneficial to them in their river forecasting duties. It is recommended that the City work with the Indianapolis Office of the NWS to provide assistance in making these additions to the NWS network:

- hourly rainfall gage located half way between Indianapolis and the Indiana/Ohio state line,
- hourly rainfall gage located south of Brookville Lake between Columbus and Cincinnati
- conversion of the USGS stream gage rainfall recording instrumentation from 24-hour to hourly reporting gages (particularly at the Driftwood River at Edinburgh and Sugar Creek at Shelbyville gages)

b) Besides additional data for the NWS to use in creating their forecasts, the City could benefit by the addition of river forecast points to the NWS forecast network. Upgrading of existing gages to become NWS forecast points should take precedence over adding any USGS stream gages to the network if it is found that resources required to do both are limited. The following USGS gage sites are currently being investigated by NWS for inclusion in their forecast system. It is recommended that the Planning Department Floodplain Administrator coordinate further with the Indianapolis Office of the NWS to add these points if possible:

- Flatrock River at Columbus
- Haw Creek near Clifford
- Clifty Creek near Columbus

c) If these points cannot be added to the NWS system, then it is recommended that avenues be pursued with USGS and the City for developing non-NWS forecast points using enhanced modeling and NWS NEXRAD radar data, precipitation forecasts, and real time soil moisture data.

3) <u>Coordinate with USGS to Improve Stream Gage Network</u>

a) Designate a position within the City to be responsible for coordination with USGS and City (or alternative) funding of the gages, especially the two recently re-established Haw Creek stream gages, for which no other local cost-share funding currently exists.

b) Inundation mapping tied to USGS stream gage stages is a helpful tool in flood mitigation and flood response efforts. Clifty Creek at Columbus is the one existing USGS gage within the planning jurisdiction that is not scheduled to have inundation mapping created. Part of the reason is that there is currently no local sponsor to fund the maintenance of the gage. It is recommended that the City sponsor this gage and seek local entities that could benefit from the stream gage data and would assist in the funding. Once the gage is funded, then the City should request that USGS develop the inundation mapping.

c) It is recommended that the Clifty Creek near Columbus gage be relocated upstream to US 31 since under low flow conditions on Clifty Creek and very high flow on East Fork White River, the East Fork White River could be influencing gage heights and discharges in its current location.

d) The City of Columbus benefits from good coverage of USGS stream gages on the major streams impacting the City. These gages are East Fork White River at Columbus, Flatrock River at Columbus, Driftwood River near Edinburgh, Haw Creek near Clifford, and Clifty Creek near Columbus. They also provide information on flooded areas when tied to inundation or depth mapping. It is

therefore recommended that the City encourage or participate in the funding of these gages. The City could encourage financial participation by other local businesses or groups that may also have an interest in these gages and may be willing to assist in the funding.

e) Besides the USGS gages that can be used with flood inundation or depth mapping, additional gages are beneficial to Columbus for forecasting use by the NWS. At a minimum, these include Buck Creek at Acton, Big Blue River at Shelbyville, Flatrock River at St. Paul, Clifty Creek at Hartsville, and, to a lesser extent, Haw Creek at Hope (due to its small drainage area in comparison to the drainage area in Columbus). The City coordinate with USGS to receive notification if any of these gages will be losing funding so that they can assist in some way in reinstating that funding.

f) Additional USGS stream gages are recommended at the following locations for use in hydrologic and hydraulic model calibration and correlation to inundation or depth mapping: Sloan Branch upstream of SR 46, Opossum Creek near CR 200 South, East Fork White Creek near CR 250 West, Denios Creek upstream of I-65, and Wolf Creek near CR 500 West. The City should seek funding cooperation for these gages from businesses or other entities that could benefit from the availability of the stream gage data, both in terms of water quantity and water quality information.

4) <u>City Data Collection</u>

a) The City should create access to additional local rainfall data for use in model calibration, NWS rainfall forecasting, and City flood response efforts by soliciting volunteers in each of the areas shown in

b) **Figure** 2-8 for participation in the CoCoRaHS network. These areas are:

- Clifty Creek watershed north of Greensburg
- Clifty Creek watershed west of Greensburg
- Haw Creek watershed in the lower reaches of the Little Haw Creek watershed portion

- Haw Creek watershed in the lower reaches of the Tough Creek watershed portion
- Flatrock River watershed north of Columbus
- Wolf Creek watershed
- Middle to upper portion of Opossum Creek watershed
- Middle to upper portion of East Fork White Creek watershed

c) As USGS Inundation Maps become available, the City should download the files to their computer system so that the files are available should the internet be down when the information is needed.

d) The City should devise a system for tracking and storing GIS files as data provided with this plan is updated or additional data becomes available.

e) The City should continue to update its critical facilities GIS layer for use in correctly identifying areas that need assistance in preparation for or during a flood event.

f) The City should develop a system for and note when stream crossings or approaches are raised or larger openings are constructed in order to trigger a decision regarding the need to revise hydraulic modeling of flood elevations and/or the available flood-safe routes for the Flood Response and Evacuation Plan.

5) <u>Flood Response and Evacuation Plan</u>

a) The Fire Department should purchase a boat and complete the necessary training for water rescues. This is meant to supplement, not replace, the Sheriff Water Rescue team.

b) Flood Response and Evacuation Plan (FREP) Coordinator (EMA Director) should keep abreast of NWS and USGS flood forecast tools as they evolve.

c) Update the FREP annually and conduct tests of the plan as outlined in the FREP.

d) Incorporate the results of additional stream hydraulic studies or road overtopping elevation changes in the FREP actions as warranted.

e) The Planning Department Floodplain Administrator should replace paper maps and forms used in post flood damage assessment with digital resources (handheld Global Positioning System (GPS) data loggers or laptops) and automatic updates to Excel-based tracking system.

f) The Planning Department Floodplain Administrator should work with USGS to expand the current limited depth mapping developed by CBBEL or others for the 10-, 50-, 100-, and 500-year flood profiles into a library of static maps and/or a dynamic inundation map that would change automatically as the forecast stage height would change.

g) The Street Department should supplement the County Highway sand bag supply with an adequate supply at the City garage. The City should consider purchasing sand and a sand bag machine to expedite filling bags as part of the flood fight effort.

CHAPTER 3 FLOOD RECOVERY – POST FLOOD DAMAGE ASSESSMENT AND DATA COLLECTION PROTOCOLS

3.1 INTRODUCTION

After flood waters subside and response efforts are substantially completed, the recovery process begins. Citizens need to understand how to safely reenter their homes. Business and residents may also need to know how to safely rebuild. Damages must be documented for insurance purposes, grants, or other assistance applications. A coordinated effort to accomplish these and other post flood damage assessment and data collection activities is outlined in a post-flood damage assessment protocol and a post-flood data collection protocol.

3.2 POST-FLOOD DAMAGE ASSESSMENT AND DATA COLLECTION PROTOCOL

A post-flood damage assessment protocol gives the community a defined plan to make sure community ordinance requirements are met and damage is properly assessed. Also, a post-flood data collection protocol provides a way to take advantage of the opportunity to gather data that will improve the tools for evaluating future flood risks and possible alternatives to reduce those risks. Columbus has a procedure that has been used in the past but it was not documented. In order to document the procedures and to provide enhancements of existing functions and additions to better accomplish City goals, meetings were held between the City Planning Department and Code Enforcement Departments to create written protocols for both post-flood damage assessment and post-flood data collection protocols. These protocols outline specific tasks and associated responsible parties to complete the post-flood damage assessments and data gathering. Following is an outline of each of the protocols.

Post-Flood Damage Assessment Protocol

1. Evaluate Damage to Structures – the Emergency Management Agency (EMA) is responsible for conducting the initial damage assessment and coordinating with the Red Cross, the Indiana Department of Homeland Security

(IDHS) and the Federal Emergency Management Agency (FEMA) regarding damage assessments during larger flood events. The EMA leaves a door hanger on each structure assessed and creates a database for the City.

2. Identify Damage Areas in the Special Flood Hazard Area (SFHA) – the City Planning Department uses flood maps to identify damaged structures (as evaluated by the EMA) in the SFHA.

3. Distribute Outreach Materials – City Planning and Code Enforcement distribute information to the public and media.

4. Review Permit Application and Verify SFHA Status – the owner obtains an estimate to repair the flood-related damage to their structure. On a case-by-case basis, City Planning will review SFHA status. If the structure is not in the SFHA, then the application proceeds to Step 6 of this protocol.

5. Cost Estimate to Repair Damage to Structures in the SFHA – City Code Enforcement determines the assessed value of the damaged structure and determines if there is cumulative damage from previous floods.

6. Issue Local Permits – City Code Enforcement issues local permits for repairs.

7. Inspect Repairs and Document Damage – City Code Enforcement conducts an inspection of the repairs and updates the database with a list of permits obtained and work completed. City Planning updates the database to document any repetitive loss structures.

8. Documentation – City Planning maintains all flood-related records, depth of flooding documentation, and repetitive loss information.

Post-Flood Data Collection Protocol

- Coordinate collection of aerial photography of the flooded areas

- Coordinate collection of high water marks along the streams and in flooded areas

- Coordinate collection and capture of data on observed rainfall depths and patterns

- Coordinate collection and capture of Advanced Hydrologic Prediction Service (AHPS) observed and forecast flood stages

- Compare the extent of observed flooded areas to Flood Insurance Rate Maps (FIRMs)

A more in-depth description of the resources available for post-flood data collection is included in **Appendix 4**. Because the flood data collection and damage assessment activities are a part of or are closely tied to flood response, a copy of the post-flood damage assessment protocol and the post-flood data collection protocol are integrated into the Flood Response and Evacuation Plan which was created as a stand-alone document.

3.3 RECOMMENDATIONS – POST FLOOD PROTOCOL

Based on the discussions above regarding flood response tools and plans, the following recommendations are made:

a) Update the appropriate section of the Flood Response and Evacuation Plan (FREP) as City permit processes or regulations change, or as use of the protocol show the need for revisions/additions.

b) Add information about permitting requirements and processes to the materials that will be distributed immediately after a flood event.

c) Develop task checklists that can be provided to owners of damaged structures.

d) Develop post flood data collection record keeping procedure.

e) Inform the Indianapolis NWS office of areas/roads flooded in a given event so they can add the information to their web site .

CHAPTER 4 FLOOD MITIGATION – REDUCTION OF THE EXISTING AND FUTURE LEVELS OF FLOOD VULNERABILITY

4.1 INTRODUCTION

This chapter discusses the process of identifying and evaluating possible mitigation actions to reduce or eliminate the flooding in the floodprone areas identified in Section 2.4 and prevent increased vulnerability to flooding in the future. Mitigation is aimed at permanent solutions to flooding so options using temporary features such as sand bag levees are not addressed in this chapter. The use of such temporary flood fighting measures is discussed in the City's Flood Response and Evacuation Plan (FREP).

To aid in the evaluation of appropriate options to reduce flooding in existing floodprone areas, a set of screening criteria was selected. The screening of mitigation options was done based on the depth mapping, select gage data, and some additional conceptual level modeling using the effective FIS modeling, previously developed Haw Creek modeling, and the Sloan Branch model developed as part of this Plan.

This chapter is organized as follows:

a) Floodprone area mitigation goals and project criteria
b) Description of solutions considered to address existing condition flood risks
c) Initial screening of considered solutions to determine possible solutions
d) Further screening of possible solutions to determine promising solutions
e) Detailed evaluation and screening of promising solutions to provide data to aid decision makers in comparing solutions, prioritizing implementation, and determining most promising solutions
f) Description of solutions considered to reduce future condition flood vulnerability
g) Summary of flood mitigation recommendations

4.2 FLOODPRONE AREA MITIGATION GOALS AND PROJECT CRITERIA

The City selected the following overall criteria to use for evaluating potential mitigation options. Not all of the criteria were used at each level of screening but all options that continued through the screening process and are noted as promising solutions appear to meet all of the criteria based on the level of analysis completed for this Plan.

- *Technical Feasibility*: The mitigation option can be implemented and will provide consequential flood damage reduction with a desired goal of 500-year flood protection.

- *Legality*: The mitigation option does not violate any laws and would be approvable by regulatory permit agencies under existing local, state, and federal regulations.

- *Social Appropriateness*: The mitigation option will reduce flood losses, will not create more problems than it solves, will not simply shift a problem from one location to another, and/or will provide substantial non-tangible benefits. Non-tangible benefits would include the protection of an iconic or significant component of the City (a historic district or structure, an architecturally significant building, an important social service provider, or a key employment source). Further, the mitigation option will be acceptable and beneficial to the community as a whole, rather than providing a benefit to a few individuals at the expense of the larger community.

- *Economic Feasibility*: The mitigation option will likely have a favorable cost-to-benefit ratio or economic advantage over other available alternatives.

Additional aspects of each mitigation option that were noted in order to aid in the selection/prioritization of promising solutions are as follows:

- *Reduction in Flooding of Major City Transportation Routes (as identified in the Flood Response and Evacuation Plan):* The creation of additional flood-free transportation routes for City residents is desirable.

- *Protection of At-Risk Population:* Based on current at-risk facilities such as apartment complexes, childcare centers, nursing homes, schools, and other similar facilities identified by the City in the floodprone areas, it was noted whether or not a given mitigation option would provide protection to population in that facility.

- *Multi-purpose Benefit:* The mitigation option is compatible with and contributes to another City priority, such as park plans, long-term growth and development strategy, etc.

- *Administrative Efficiency*: The mitigation option will minimize the amount of City resources necessary for initial implementation and long-term maintenance of the mitigation option. Resources include primarily staff time, emergency response resources, and funding.

4.3 DESCRIPTION OF SOLUTIONS CONSIDERED TO ADDRESS EXISTING CONDITION FLOOD VULNERABILITY

The following structural and non-structural options were evaluated to address the existing condition flood concerns:

- Flood Reduction Measures: These are projects that either 1) store a portion of the flow until the peak has passed and release it when the flood recedes, or 2) increase the capacity of the stream so that more water can be conveyed at lower water surface elevations. The types of projects considered in this category are:

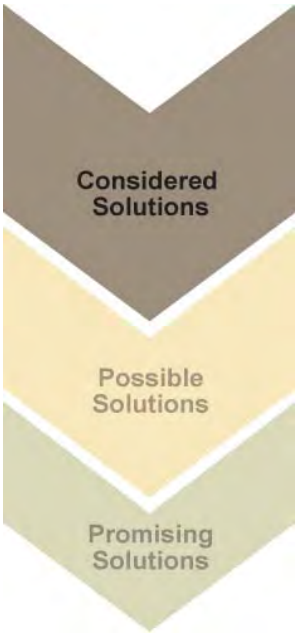
    - Upstream on-line flood control reservoir
    - Off-line detention (diverting flows above a selected level to an off-line detention area for slow release after the flood peak has passed)
    - Clearing vegetation and other obstructions from the channel
    - Enlarging the channel with a 2-stage ditch concept that allows low flows to continue in the existing channel but then adds flow area by creating a wider shelf above the low flow channel
    - Creation of a bypass channel for a portion of the flood waters

- Bridge/culvert replacements that reduce upstream flood elevations without significant downstream increases in discharge

- Flood Protection Measures: These actions do not change the height of flood waters but do increase the protection of structures to those flood heights. Among these options are:

  - Voluntary buyouts/acquisition of floodprone structures
  - Floodproofing
  - Levee/ floodwall including:
    - major levee/berms/floodwalls that are certifiable under the FEMA process and would remove areas from the Special Flood Hazard Area (SFHA) or reduce the cost of flood insurance
    - Smaller levee/berm/floodwalls to provide protection without meeting the stricter FEMA criteria for removal of protected areas from the SFHA

4.4 INITIAL SCREENING OF CONSIDERED SOLUTIONS



An initial screening of each of the options listed above for each of the identified floodprone areas was done using the technical feasibility, legality, social appropriateness, and economic benefit criteria along with approximate calculations to determine storage volumes, excavation volumes, etc. required for a given solution to be effective. Once it was found that one essential criterion was not met for a given solution, no additional investigation was done for that solution. The calculations used in this screening were done in such a way that if the results did not show that an alternative met the required criteria at this level of analysis, it would not meet it at a more detailed level of analysis later in the screening process.

Tables describing the findings for each of the floodprone areas and information to substantiate why the solution does or does not meet the criteria at this cursory level are provided in **Appendix 5**. An example table is provided below **Table 4-1**. Options that did not meet all of the criteria (shown as shaded in the tables) were

not carried forward for further evaluation. Options that did pass the screening were carried forward as "possible solutions". Floodproofing and voluntary buyouts in the tables were evaluated as stand-alone options. In most cases, they were carried forward as one option together if one or the other was not feasible for the whole area.

FLOOD SOURCE: Haw Creek
AREA: Haw Creek North (44)

CONSIDERED SOLUTIONS

	Considered Solution	Satisfies Criteria For Selection as Possible Solution (Yes/No)					Findings/ Comments
		Technical			Social	Economic	
		Technically Feasible	Legal & Permitable	Provides Consequential* Flood Damage Reduction	Flood Damage is Reduced Without an Increase or Shift of Risk to Other Areas	Project Costs Do Not Significantly Exceed Benefits & are Potentially Fundable	
Flood Prevention/ Reduction	Upstream Reservoir	N					No good location
	Off-line Detention	Y	Y	Y	Y	N	Selection of alternative more likely based on results for other areas; chosen location of detention would impact results here
	Channel Clearing	Y	Y	N			Computer modeling shows this would lower flood elevations by no more than 3/4 ft which is not enough to provide protection
	Bypass/ Diversion	N					No good location for localized diversion
	Bridge Replacement	Y	Y	Y	Y	Y	Roads could potentially be raised to provide flood free access and opening increased to make up for the lost road overflow area & to maintain connection with storage areas
	2-Stage Ditch Channel Improvement	Y	Y	N			Significant amount of flow outside the channel means that a 2-stage channel would have to be very large to reduce flood elevations.
Flood Protection	Voluntary Buyouts	N/A					No flooded structures
	Floodproofing	N/A					No flooded structures
	Levee/ Floodwall	Y	N				Would increase flood stages significantly

* Consequential flood damage reduction is defined as more than 1/2 foot of reduction in the 10- and 500-year flood elevations or the ability of the protection measure to protect at least some structures from at least the 100-year flood.

** Recommendation is based on costs noted in the Findings/Comments column for permanent, earthen levees and floodwall segments. Temporary levees, such as may be constructed from sand bags or dirt piles, may be used if measures to compensate negative impacts, if any, are addressed and until such time as another alternative is constructed.

Note: *Sand bags or construction of a levee/floodwall close to individual structures may be options in lieu of a project to protect the entire area.*

Table 4-1 Example of Summary of Initial Screening of Considered Solutions

4.5 FURTHER SCREENING OF POSSIBLE SOLUTIONS

The alternatives that passed the first screening described above were summarized by stream as "possible solutions" for further evaluation. This further evaluation included additional computer modeling of specific alternatives, conceptual cost estimates, and more investigation of the benefits of each alternative. Results of this evaluation were summarized in a table for each stream. The tables, provided in **Appendix 6** include data on:

- Storm frequency that structure or vehicular access road flooding begins and the approximate number of structures that are flooded or inaccessible by vehicle at the 500-year flood levels. (This data was obtained from the Floodprone area descriptions in Section 2.4),
- Results of the conceptual calculations for the number of structures expected to be protected,
- Estimated costs,
- Whether there is a reduction in major transportation route flooding (routes identified for the Flood Response and Evacuation Plan),
- Whether an at-risk population (apartment complexes, childcare centers, nursing homes, schools, and other similar facilities identified by the City) would be protected, or,
- Benefits to another City priority noted by the City.

An example of these tables is provided as **Table 4-2**. The alternatives that did not meet the criteria after this additional evaluation are shaded in the tables. Options that did pass the screening were carried forward as "promising solutions".

OPOSSUM CREEK POSSIBLE SOLUTIONS

Floodprone Area (#)	Possible Solutions	Current Condition Flood Potential at 500 Year Levels: Structure — Frequency at Which Structure Flooding Begins	Current Condition Flood Potential at 500 Year Levels: Structure — Approximate Number of Flooded Structures	Current Condition Flood Potential at 500 Year Levels: Inaccessibility — Frequency at Which Roads Start to Flood and Prevent Access to Residences	Current Condition Flood Potential at 500 Year Levels: Inaccessibility — Approximate Number of Structures Inaccessible During 500 Year Flood	Cost & Benefits of Possible Solution — Estimated Construction Cost	Cost & Benefits of Possible Solution — Approximate Number of Flooded Structures Protected (floodproof/ buyout/ commercial floodproof)	Cost & Benefits of Possible Solution — Approximate Number of Inaccessible Structures that Would become Accessible during 500 Year Flood	Cost & Benefits of Possible Solution — Reduction in Flooding of Major City Transportation Route (Yes/No)	Cost & Benefits of Possible Solution — Protects At-Risk Population **** (Yes/No/ Maybe)	Cost & Benefits of Possible Solution — Compatibility With/ Contribution to Other City Priorities	Comments
Opossum Creek	[illegible]	500	2	<10	35	>>$2.5 M***	2	35	N	Y	-	Would allow access from west to Southside Elementary School during flood event; cost is excessive for the benefit
CR 200 South (7)	[illegible]	500	2	<10	10	NC	0	access allowed to additional areas	N	Y	-	Raise west approach to CR 200 S bridge, increase flow capacity under the road to provide flood free access to Southside Elementary School
	[illegible]	500	2	<10	10	NC	2	access allowed to additional areas	N	Y	-	300' wide shelf reduced flood elevations at the bridge negligibly so the road still overtops below the 50 year flood level
	[illegible]	500	2	<10	10	$20 K**	2/ 0	0	N	Y	-	Protection of structures from rare flooding is not a high priority
	[illegible]	500	2	<10	10	$550 K*	2	access allowed to additional areas	N	Y	-	Construct east of CR 130 W to prevent backwater from entering subdivision and flooding CR 150 W
Shadow Creek Farms (6)	[illegible]	>500	0	>100	35	NC	0	access allowed to additional areas	N	-	-	Replace SR 13 & RR to reduce backwater; then CR 150 W may or may not also need additional capacity in order to allow flood free access. To be addressed with a separate roads discussion, rather than floodprone areas.

Solution did not meet the criteria for selection as a Promising Solution.

NC Cost not calculated.

* [illegible] costs for mitigation of negative impacts to flood elevations [illegible] channel improvements, compensatory flood plain storage, culvert im[illegible] that may be needed.

** Estimate for commercial structures based on $20,000 City cost share for each floodproofed structure only. Estimate for residential structures based on $100,000 City cost share for each floodproofed structure plus 25% City cost share of 120% of assumed average structure value of $100,000 for each buyout structure assuming FEMA grant programs are used.

*** Estimate for only the excavation portion of the construction costs

**** Includes government complexes, childcare centers, nursing homes, schools, and other similar facilities.

Notes: [illegible] for alternatives are for 500 year protection. Comments regarding benefits of alternatives at other frequencies are noted where applicable.

Table 4-2 Example of Table of Summary of Screening of Possible Solutions

The promising solutions are summarized in **Table 4-3**. To aid in further references to each promising solution, names were assigned to each alternative based on the stream initials, the floodprone area number, and the solution type where:

a = floodproofing/ voluntary buyouts
b = levee/floodwall
c = miscellaneous alternative (bridge replacement or 2-stage channel improvement

Table 4-3 Promising Solutions

STREAM	PROMISING SOLUTION	FLOODPRONE AREAS POTENTIALLY ADDRESSED BY SOLUTION*	RESPECTIVE ASSIGNMENT OF REFERENCE NAMES FOR ALTERNATIVES**
Clifty Creek	Floodproofing/Voluntary Buyouts	24	CC24a
	Levee/ floodwall/ temporary levees	24, 25, 28	CC24b, CC25b, CC28b
	Replacement of SR 46 (State Street)	24	CC24c
Denios Creek	Floodproofing/Voluntary Buyouts	4, 5	Included as EFK4a and EFK5a
	Levee/ floodwall/ temporary levees	4, 5	Included as EFK4b and EFK5b
Driftwood River	Floodproofing/Voluntary Buyouts	10, 11, 15	DR10a, DR11a, DR15a
	Levee/ floodwall/ temporary levees	10, 11	DR10b, DR11b
East Fork White River	Floodproofing/Voluntary Buyouts	4, 5, 8, 9, 30	EFK4a, EFK5a, EFK8a, EFK9a, EFK30a
	Levee/ floodwall/ temporary levees	4, 5, 30	EFK4b, EFK5b, EFK30b
Flatrock River	Floodproofing/Voluntary Buyouts	17, 18, 22, 45	FR14a, FR17a, FR18a, FR21a, FR22a, FR45a
	Levee/ floodwall/ temporary levees	16, 17, 18, 21, 22, 45	FR14b, FR16b, FR17b, FR18b, FR21b, FR22b, FR45b
	Increase capacity of US31 crossing	45	FR45c
Haw Creek	Floodproofing/Voluntary Buyouts	30, 31, 32, 33, 34, 35, 36, 38, 40, 41, 42	EFK30a, HC31a, HC32a, HC33a, HC34a, HC35a, HC36a, HC38a, HC40a, HC41a, HC42a
	Levee/ floodwall/ temporary levees	30, 34, 36, 37, 38, 40, 41, 42	EFK30b, HC34b, HC36b, HC37b, HC38b, HC40b, HC41b, HC42b
Opossum Creek	Levee/ floodwall/ temporary levees	7	OC7b
Sloan Branch	Floodproofing/Voluntary Buyouts	26, 27	SB26a, SB27a
	Levee/ floodwall/ temporary levees	26	SB26b
	2-stage channel improvement	26	SB26c

*see Exhibit 40 for floodprone area location

** Alternatives described in Section 4.6

4.6 DESCRIPTION AND SCREENING OF PROMISING SOLUTIONS

Based on the results of the efforts discussed in Sections 4.4 and 4.5, the following four basic types of projects passed the screenings and appear to have promise for reducing flood damages in the floodprone areas:

1. floodproofing/voluntary buyouts,
2. levee/floodwall,
3. bridge replacements
4. 2-stage channel improvements

These 4 project types are described in general terms in Section 4.6.1. The location, cost, and expected benefits for each promising alternative for each floodprone area are then described in subsequent sections. Cost estimates are conceptual in nature and are meant to assist in comparing alternatives. Actual project costs may be significantly larger. Copies of the cost estimate calculation sheets are provided in **Appendix 7**.

4.6.1 General Descriptions of Promising Solutions

Floodproofing/Voluntary Buyouts

Floodproofing involves altering the building or property to eliminate or reduce exposure to floodwater or reduce damage caused by the entry of floodwater. Floodproofing will not reduce the frequency of adjacent street and open property flooding nor does it eliminate the requirement for flood insurance. It does, however, provide real protection up to the design level. For this analysis, the structures shown on the depth mapping as having 2 feet or less flood depths in the 500-year flood were noted as floodproofing candidates. The following web sites provide more specific information on floodproofing:

- www.fema.gov/library/viewRecord.do?id=1420
- www.msdlouky.org/programs/crssite/fpfloodproof.html
- www.wvdhsem.gov/WVDisaster_Library/Library/Tech%20Manuals/Floodproofing%20NonResidential%20Structures.html

General approaches to floodproofing range from low cost solutions such as moving or elevating valuables from the area subject to flooding to more expensive solutions including:

- Implementing measures that prevent basement flooding and sewer backups;
- Wet floodproofing – modifying the building and relocating the contents to allow floodwaters inside the structure with little or no damage;
- Dry floodproofing – preventing water from entering the structure by making the building floor and walls watertight;
- Floodwalls – preventing floodwaters to come near the building by constructing barriers around the building or at the lower elevations on the property; and
- Elevation – preventing the floodwaters to enter the building by raising the building in place.

Selecting the appropriate floodproofing measure for a structure will depend on the nature of the flood hazard, the physical condition of the site, the function and use of the building, and its structural characteristics.

Depending on the structure and mitigation needs, floodproofing or retrofitting structures for flood protection may range from $20,000 to $70,000 per structure. For the purposes of this Plan, it was assumed that the City and property owners would share the cost of floodproofing so that the property owners have a significant stake in the project. It was assumed that the City's contribution to each property owner would be only 50% of the total actual project costs, with the City's share not to exceed $20,000 for each commercial building or $10,000 for each residential building.

Floodproofing is generally better suited to structures with no more than 2 or 3 feet of flooding. When flood depths exceed this, voluntary buyouts are proposed. Voluntary buyouts of residential structures using FEMA funds have already been successfully completed by the City in select areas along Haw Creek. In a property acquisition or buyout project, the community identifies and purchases private property, acquires the title to it, and then removes the structure(s). By law, that property, which is now public property, must forever remain as open space. The community can use it to create public parks, wildlife refuges, etc. but it cannot sell it to private individuals nor develop it. The acquired properties will also serve as floodplain storage.

Therefore no fill is to be placed on any acquired property located in the floodplain. Property acquisitions work the same way as any other real estate transactions. Land and buildings are appraised at their fair market value. Buyouts are strictly voluntary and no homeowners are ever forced to relinquish their property. Listed below are some of the advantages and disadvantages of a voluntary acquisition (buyout) program:

Advantages of Voluntary Acquisition (Buyout):

- Saves money in long-term since it breaks the disaster-response-recovery cycle
- Permanently removes structures from flood-prone areas
- Serves multiple objectives for community planning
- Enhances natural flood protection
- Respects private property rights

Disadvantages of Voluntary Acquisition (Buyout):

- High upfront cost of purchasing properties
- Loss of local tax base of purchased properties
- Can disrupt established neighborhoods
- Higher housing costs for those relocating
- Incomplete participation limits effectiveness

For the purposes of this Plan, the cost for the voluntary buyout was calculated as 25% City cost share (75% typically paid by FEMA grant) of 120% of an assumed average residential structure assessed value of $100,000 for buildings with 2 feet or more of flooding during the 500-year event ($200,000 for structures in floodprone area 18 (Noblitt Falls)). 120% of the value was used in order to account for auxiliary costs such as closing costs and demolition. A copy of the computations for the buyout/floodproofing cost of each alternative is provided in Appendix 7.

A combination of floodproofing and voluntary buyouts could be an option for every floodprone area in the City, although other options may be preferable in some cases. The numbers of structures that are recommended for floodproofing or buyouts in this plan are based on depths per the 2011 DEM and preliminary FIS profile elevations. This data does not indicate low areas such as basements where water could enter a building, nor does it necessarily indicate if a building is on a raised footprint such that

water would not enter the building. Therefore, additional data should be collected for structures in an area selected for floodproofing or buyouts to provide a more accurate identification of the structures suited for each option based on grades that are determined through actual field survey. A method for categorizing and prioritizing structures for buyout or floodproofing is provided in **Appendix 8**.

The following floodprone areas were identified as appropriate for considering a combination of floodproofing and voluntary buyouts:

- floodprone area 24 along Clifty Creek,
- floodprone areas 4 and 5 along Denios Creek (same area as # 4 and 5 along East Fork White River),
- floodprone areas 10, 11, and 15 along Driftwood River,
- floodprone areas 4, 5, 8, 9, and 30 along East Fork White River (area 30 is also along Haw Creek),
- floodprone areas 17, 18, 22, and 45 along Flatrock River,
- floodprone areas 30-34, 36, 38, 40, 41, and 42 along Haw Creek, and
- floodprone areas 26 and 27 along Sloan Branch.

Levees/floodwalls

This alternative category includes construction of permanent, earthen levees and floodwall segments to protect a cluster of buildings and roads from overbank flooding. The potential for levees/floodwalls to encroach on conveyance paths or remove floodplain storage resulting in increased flood stage and flow velocity along neighboring properties must be considered carefully. To provide protection from flooding without causing additional flooding elsewhere, levees and floodwalls must:

- tie in to existing ground at elevations at least as high as the levee or floodwall,
- address internal drainage issues
- be designed to prevent adverse impact on other properties as a result of loss of flow conveyance or significant floodplain storage. Mitigation of these impacts can be accomplished in a variety of ways depending on the stream and degree of impact:
    - compensation of lost floodplain storage by excavation or detention,

- increasing channel or overbank flow conveyance capacity through compensatory excavation,
- purchase of flood easements on impacted properties

Potential negative impacts of levees on flood elevations or flood velocities were not determined as a part of this Plan. If a levee option is selected, further analysis of the above noted requirements will need to be made. Estimated project costs assume permanent, earthen embankments (or floodwalls where space is limited) built to the 500-year flood elevation and are conceptual in nature based on limited available information. In some cases where floodways have been calculated, the levee is shown along the stream but the cost of acquiring the structures in the floodway was included to address the need to change the levee alignment to a location further landward and outside of the regulatory floodway in order to prevent increased flood stages upstream.

The purpose of the conceptual level cost estimates is to allow comparison with other potential projects. Actual project costs could vary significantly depending on a number of variables. Estimated costs do not include the associated costs of professional services, land acquisition, permitting, or environmental mitigation, each of which could be significant.

The sites for which this alternative has been identified as a promising solution (not necessarily the only promising solution) are:

- floodprone areas 24, 25, and 28 along Clifty Creek,
- floodprone areas 4 and 5 along Denios Creek (same as areas 4 and 5 along East Fork White River),
- floodprone areas 10 and 11 along Driftwood River,
- floodprone areas 4, 5, and 30 along East Fork White River (area 30 is also along Haw Creek),
- floodprone areas 16, 17, 18, 21, 22, and 45 along Flatrock River,
- floodprone areas 30, 34, 36, 37, 38, 40, 41, and 42 along Haw Creek, and
- floodprone area 26 along Sloan Branch.

Bridge Replacement

Many streets and roads in and around Columbus are flooded during the 500-year flood or smaller flood events. This flooding could be reduced in many cases by providing larger bridge openings and raising the road approaches. Additionally, bridge replacement could reduce flood levels for several buildings located upstream of the bridges such as was determined for:

- the US 31 crossing of Flatrock River (benefitting Floodprone Areas 22 and 45) and
- the SR 46 (State Street) crossing of Clifty Creek (benefitting Floodprone Area 24).

Costs for bridge replacement and raising of road approaches were not determined as such construction work will likely be combined with other road improvement needs and quite difficult to reliably estimate at such a conceptual level appropriate for this plan.

2-Stage Ditch Channel Improvement

2-stage ditch improvements provide an excavated "shelf" a few feet above the channel bottom and along one or both sides of the ditch. This option provides increased flow capacity with minimal disruption of habitat. Estimated costs for this alternative were based on a conceptual location for overbank shelf excavation and excavation quantities computed using the available FIS hydraulic model data. Costs only reflect excavation costs and do not include professional services, land acquisition, permitting, or environmental mitigation costs, each of which could be significant. A copy of the hydraulic modeling results for each stream analyzed is provided in **Appendix 9**.

The site for which this alternative has been identified as a promising solution (not necessarily the only promising solution) is:

- floodprone area 26 along Sloan Branch

4.6.2 Detailed Evaluation of Promising Solutions in Each Floodprone Area

This section summarizes the results of detailed evaluation performed for each promising solution identified in **Table 4-3**. For each promising solution, a description is provided of the location of the solution components, the extent of protection provided, and the estimated cost. All of the promising solutions for a given floodprone area are presented together. While these promising solutions were able to provide benefit to the floodprone areas, none of them reduced the flooding of any of the major City transportation routes identified in the Flood Response and Evacuation Plan.

Clifty Creek Levee/Floodwall (Alternative CC28b)

Construction of a levee/floodwall along each of the conceptual alignments (blue lines in **Figure 4-1**) would protect the 2 flooded structures and allow access to all 50 of the inaccessible structures in the outlined floodprone area during the 500-year event. The estimated construction cost is $510 K.

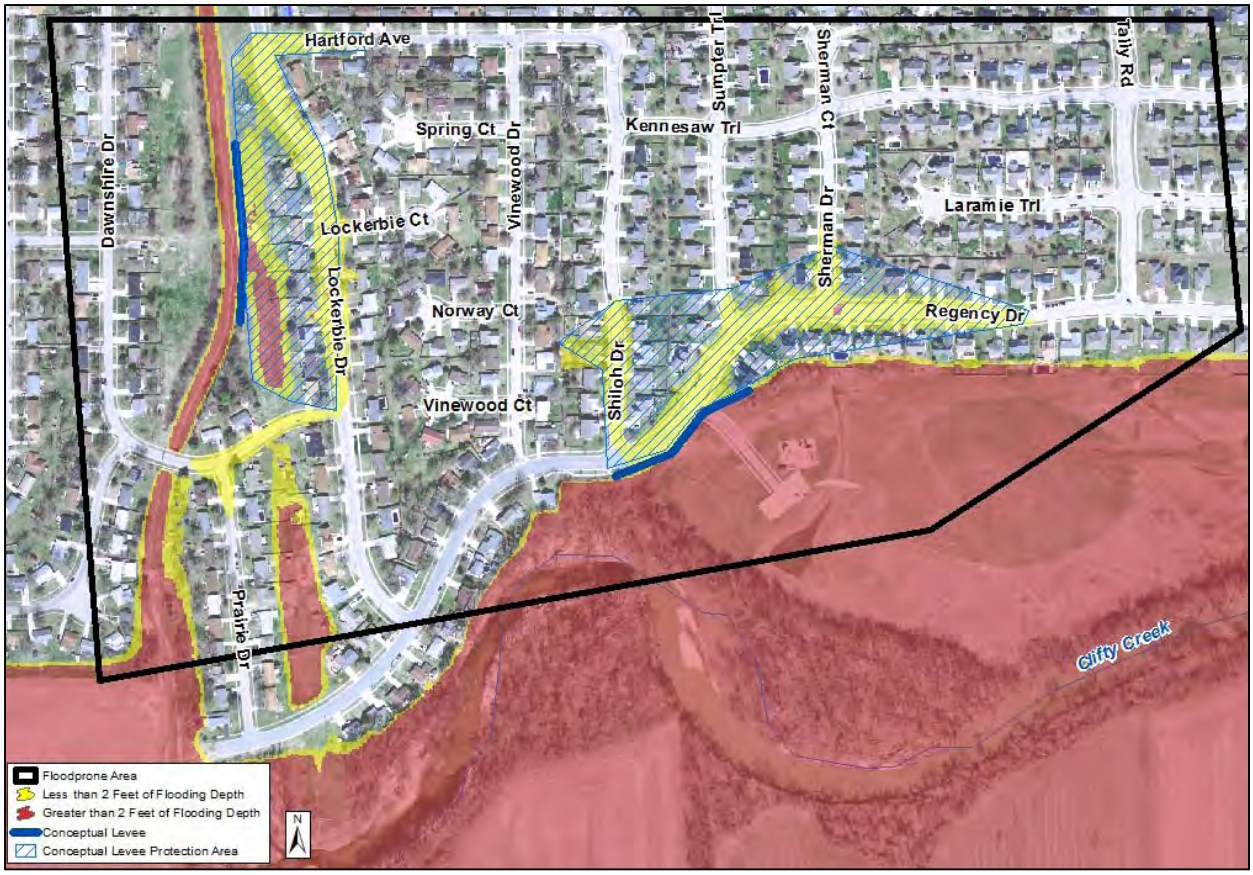


Figure 4-1 Clifty Creek Levee/Floodwall Alternative CC28b – Regency Drive

Clifty Creek Levee/Floodwall (Alternative CC25b)

A levee/floodwall constructed along the conceptual alignment shown as a blue line in **Figure 4-2** would protect all 10 of the flooded structures and allow access to all 60 of the structures in the outlined floodprone area during the 500-year event. This alternative allows access to the Sandy Hook United Methodist Church day care located in the area. The estimated construction cost is $1.4 M.

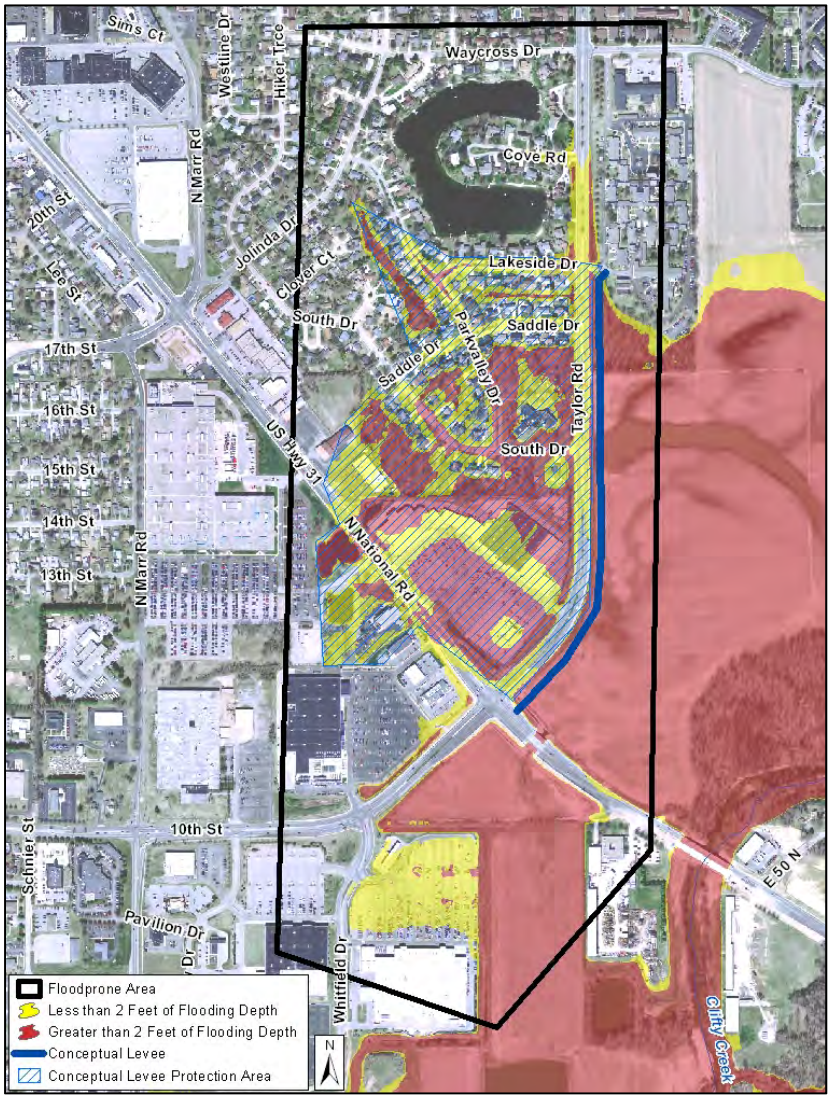


Figure 4-2 Clifty Creek Levee/Floodwall Alternative CC25b – Sandy Hook/Clifty Crossing

Clifty Creek Floodproofing/Voluntary Buyout (Alternative CC24a)

Floodproofing of approximately 45 residential structures located in the area shown in yellow in Error! Reference source not found. and additional floodproofing of Columbus East High School along with voluntary buyouts of the remaining 64 residential structures would make all of the structures in the outlined area flood-free in the 500-year flood (Floodproofing of the Columbus East high School already provides protection to at least the 100-year flood level but may not be quite sufficient for the 500-year flood.) All structures remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $2.4 Million.

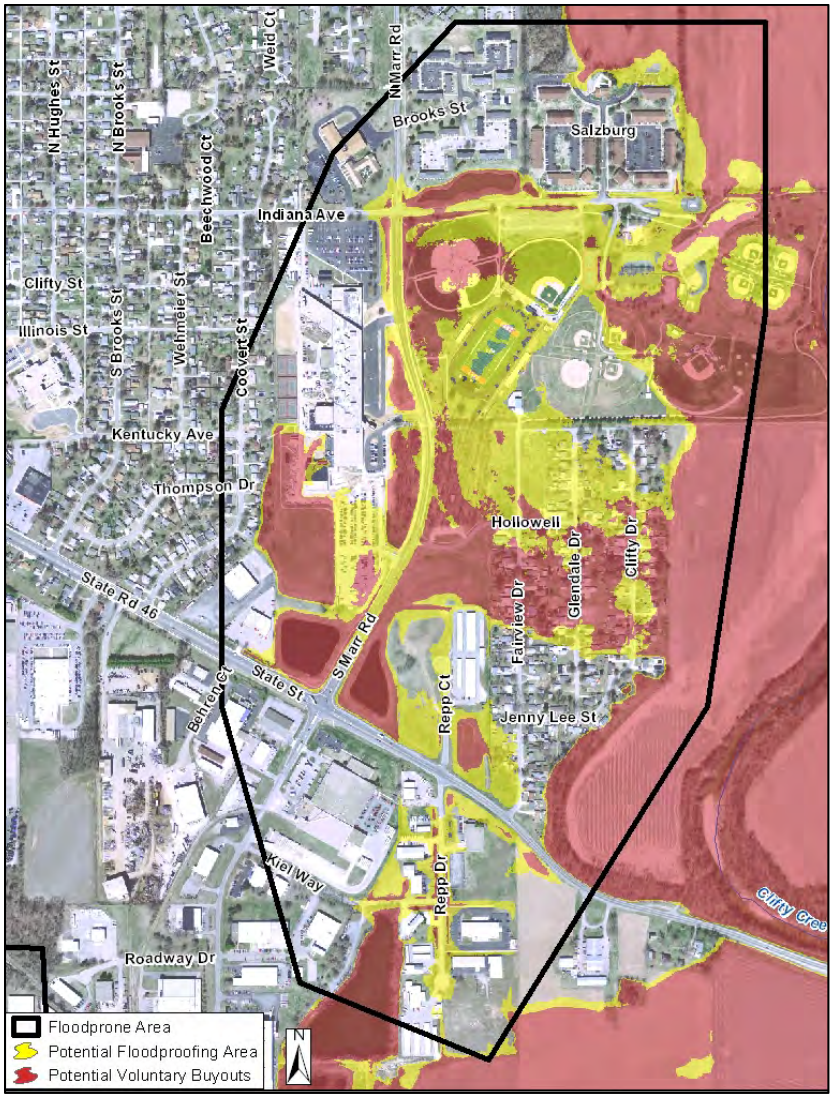


Figure 4-3 Clifty Creek Floodproofing/Buyout Alternative CC24a – Wehmeier / Columbus East

Clifty Creek Levee/Floodwall (Alternative CC24b)

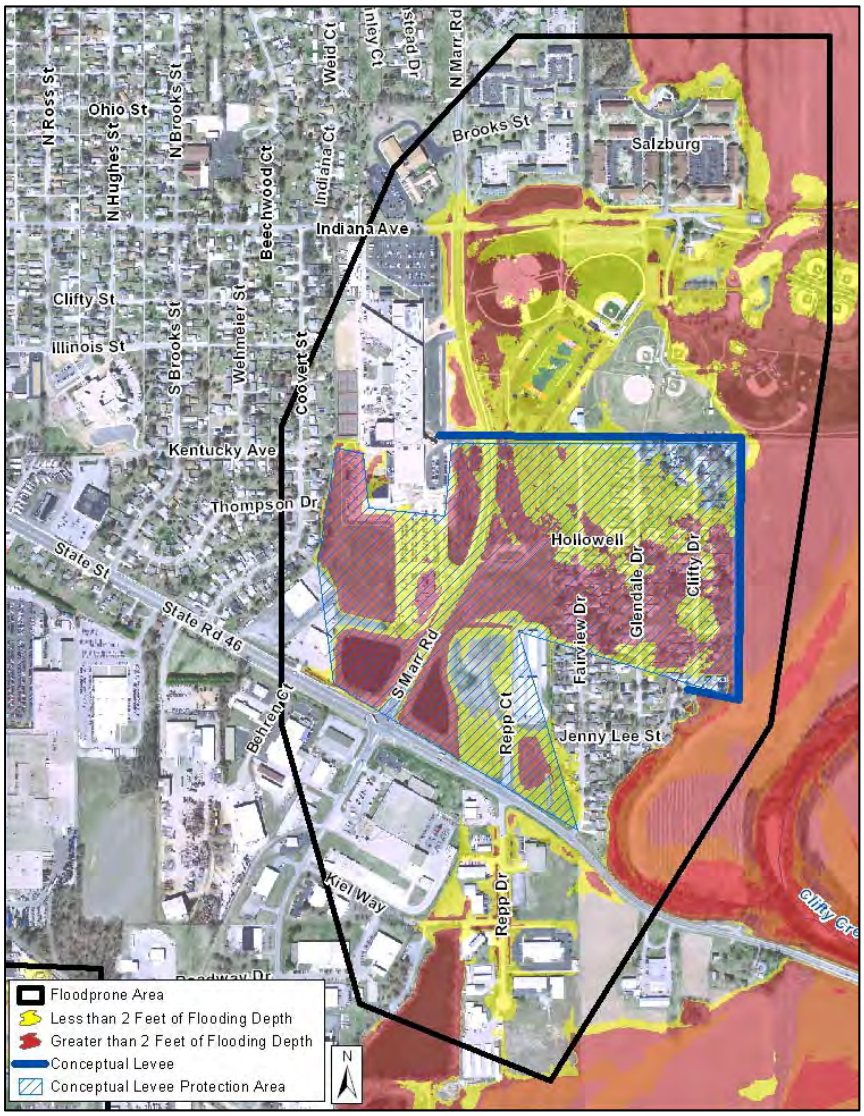


Figure 4-3 Clifty Creek Levee/Floodwall Alternative CC24b – Wehmeier / Columbus East

Construction of a levee along the conceptual alignment shown as a blue line in **Figure 4-3** would protect and allow access to 110 flooded structures of the 120 structures in the outlined area that are flooded or inaccessible during the 500-year event. This alternative would provide additional protection of the Columbus East High School located in the area. The estimated construction cost is $1.0M.

Clifty Creek Bridge Replacement (Alternative CC24c)

SR 46 (State Street) over Clifty Creek is already flood-free in the 500-year event but additional capacity for flood flows could lower the upstream flood elevations enough to remove approximately 35 structures from the 500-year flooplain and reduce the frequency of flooding on the remaining structures. Only approximately 5 structures would become accessible with this reduction in flood elevations, however.

Driftwood River Floodproofing/Voluntary Buyout (Alternative DW15a)

Floodproofing of 5 structures in the area shown in yellow and voluntary buyout of 30 structures located in the area shown in red in **Figure** 4-4 would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any structures remaining after buyouts, and an additional 15 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $950 K.

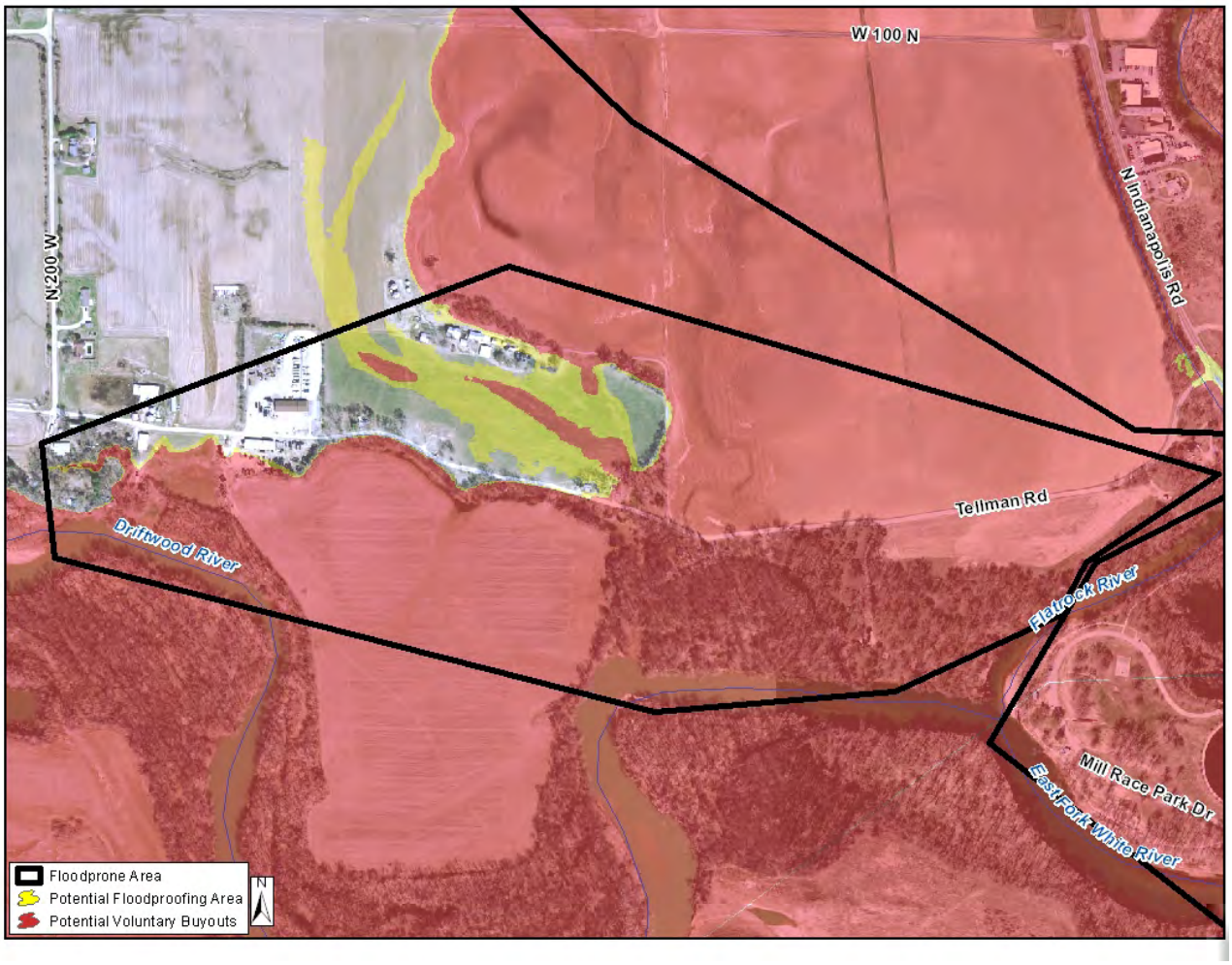


Figure 4-4 Driftwood River Floodproofing/Voluntary Buyout Alternative DW15a - Tellman Camp Road

Driftwood River Floodproofing (Alternative DW11a)

Floodproofing of approximately 20 commercial structures located in the outlined flooded area shown in **Figure 4-5** would make the area structures flood-free in the 500-year flood. All structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $400 K.

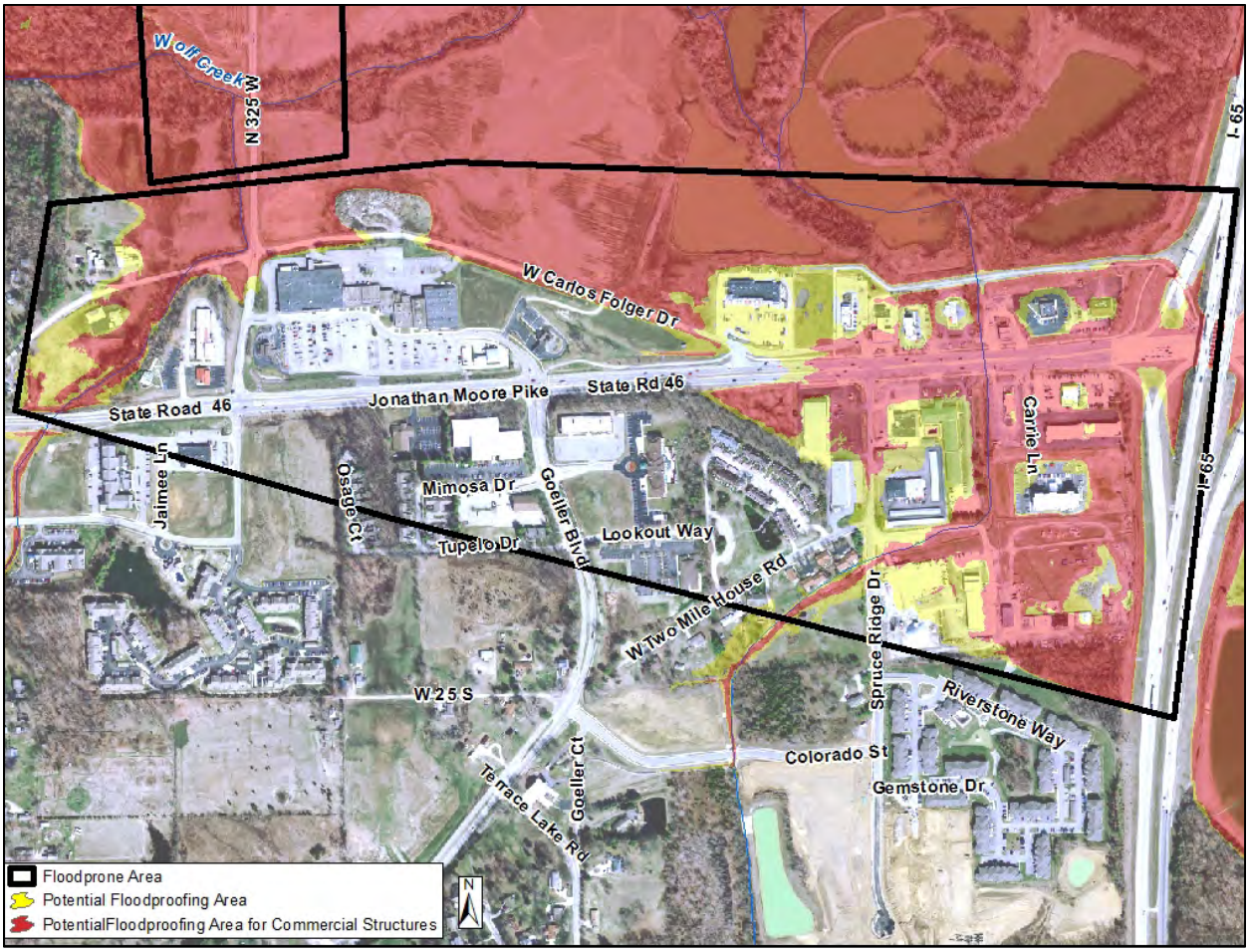


Figure 4-5 Driftwood River Floodproofing Alternative DW11a - Front Door West / Westhill

Driftwood River Levee/Floodwall (Alternative DW11b)

Combined with the existing high ground apparently provided by the I-65/ SR 46 ramps on the east side of I-65, a levee/floodwall constructed along the conceptual alignment shown as a blue line in **Figure 4-6** would protect all 20 of the flooded structures in the outlined area and allow access to and from all 25 of the flooded/inaccessible structures along SR 46 from the west and I-65 north or southbound during the 500-year event. The estimated construction cost is $650 K.

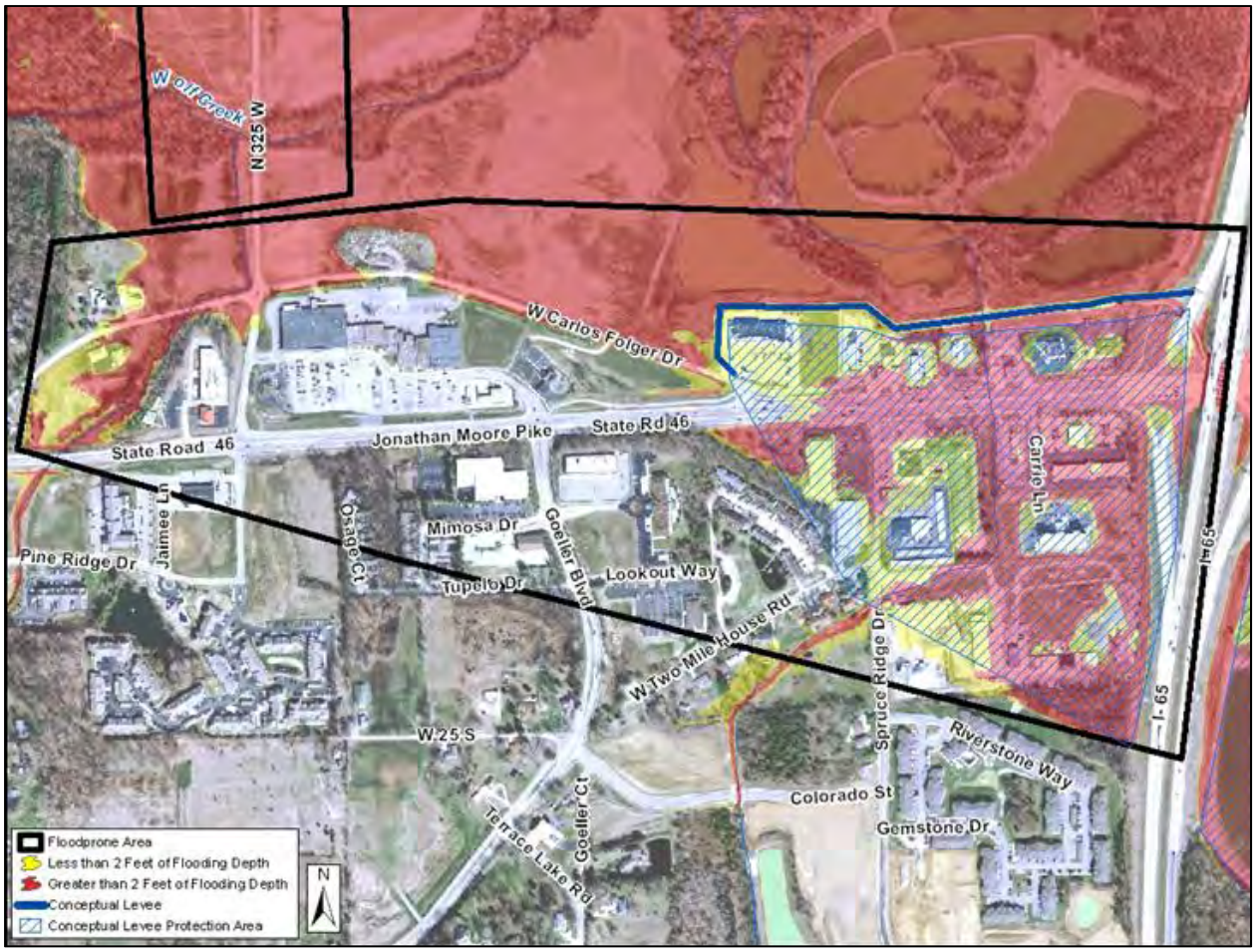


Figure 4-6 Driftwood River Levee/Floodwall Alternative DW11b - Front Door West / Westhill

Driftwood River Floodproofing (Alternative DW10a)

Floodproofing of approximately 25 commercial structures located in the area shown in the outlined flooded area in **Figure** 4-7 would make the area structures flood-free in the 500-year flood. All structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $500 K.

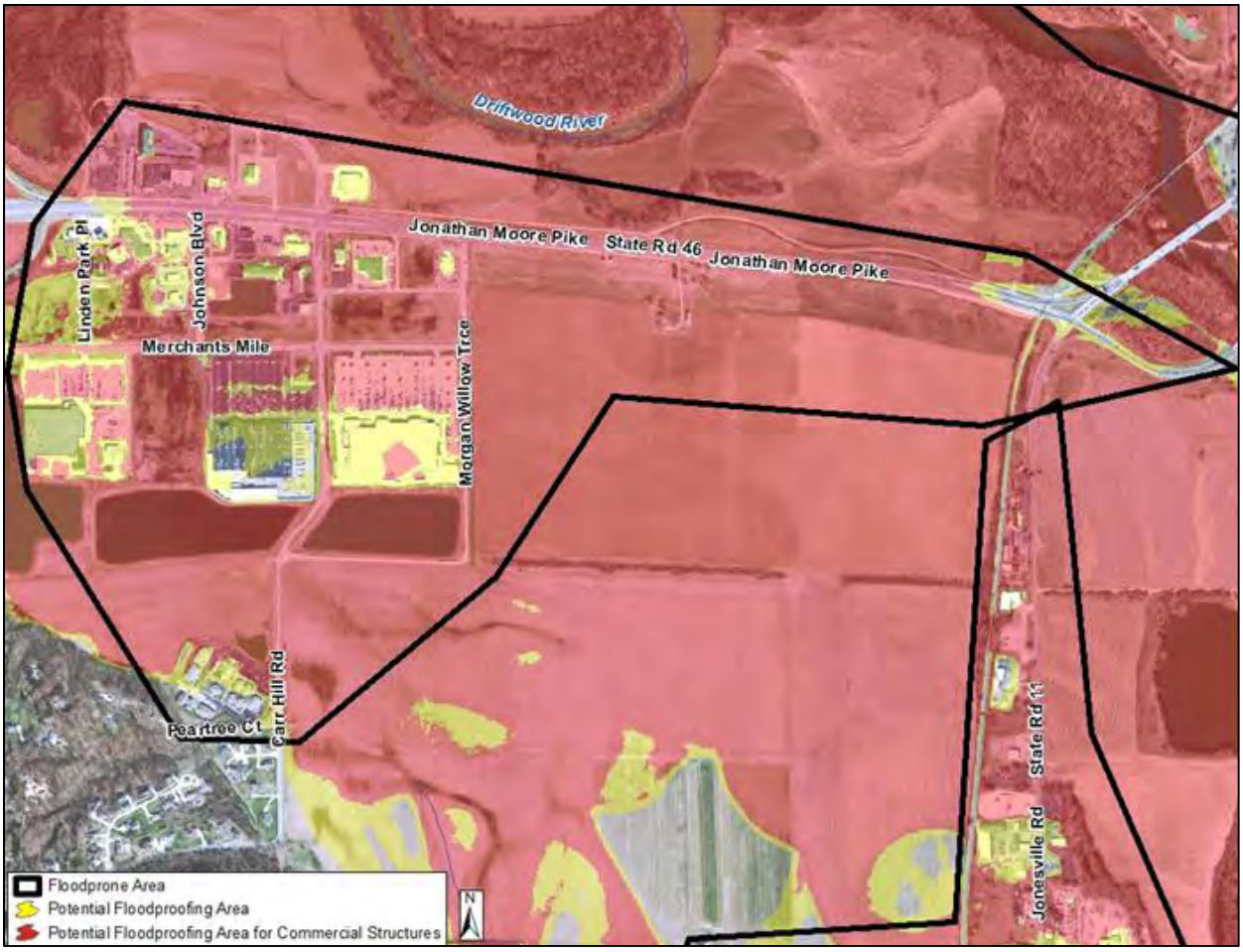


Figure 4-7 Driftwood River Floodproofing Alternative DW10a - Front Door East / Jonathan Moore Pike

Driftwood River Levee/Floodwall (Alternative DW10b)

A levee/floodwall constructed along the conceptual alignment shown as a blue line in **Figure 4-8** would protect all 25 of the flooded structures and allow access to and from I-65 Northbound for all 30 of the flooded/inaccessible structures during the 500-year event. The estimated construction cost is $4.1 M. In order for access to be created from I-65 southbound, SR46 eastbound, and to I-65 southbound and SR 46 westbound, this alternative would have to be constructed in conjunction with alternative DW11b.

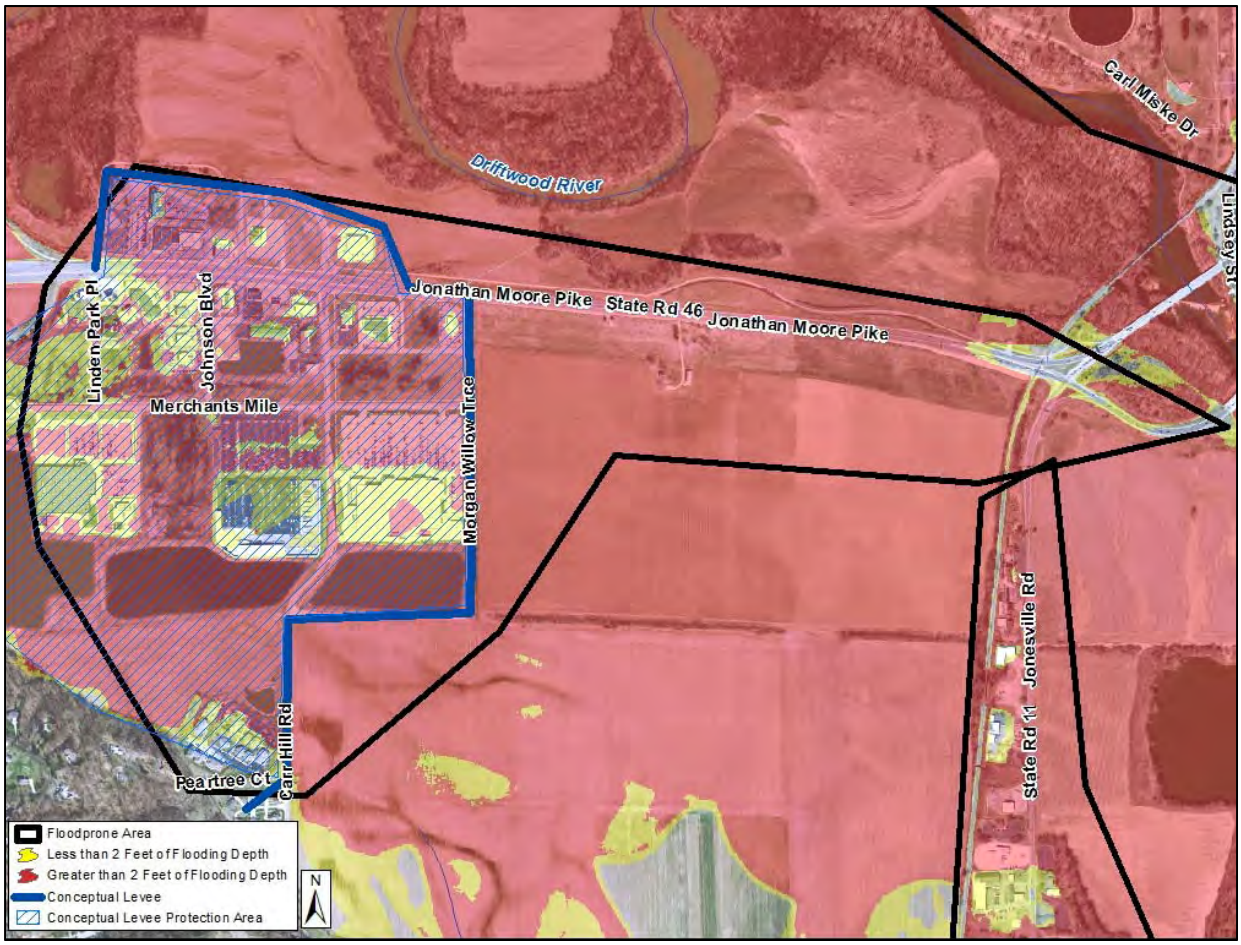


Figure 4-8 Driftwood River Levee/Floodwall Alternative DW10b - Front Door East/ Jonathan Moore Pike

East Fork White River Floodproofing/Voluntary Buyout (Alternative EFK30a)

Floodproofing of approximately 1 commercial structure and voluntary buyout of the 24 residential structures shown in **Figure 4-9** would make the structures in the outlined area flood-free in the 500-year flood on East Fork White River or Haw Creek. The floodproofed structure and any structures remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $740 K.

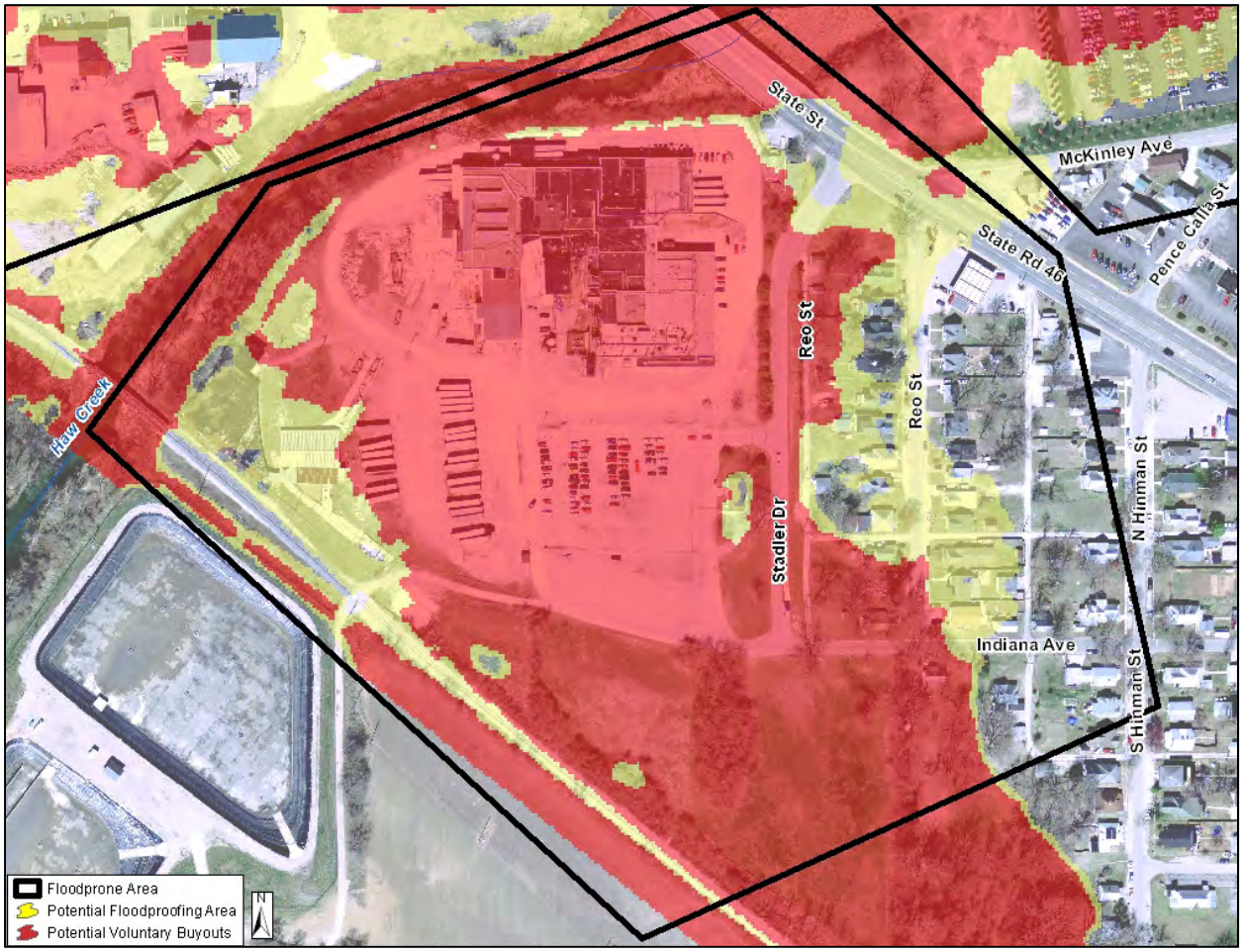


Figure 4-9 East Fork White River Floodproofing/Voluntary Buyout Alternative EFK30a - Mariah/Reo Street

East Fork White River Levee/Floodwall (Alternative EFK30b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-10** would protect and allow access to about 24 of the 25 flooded structures during the 500-year flood event on East Fork White River or Haw Creek. The estimated construction cost is $2.3 M.

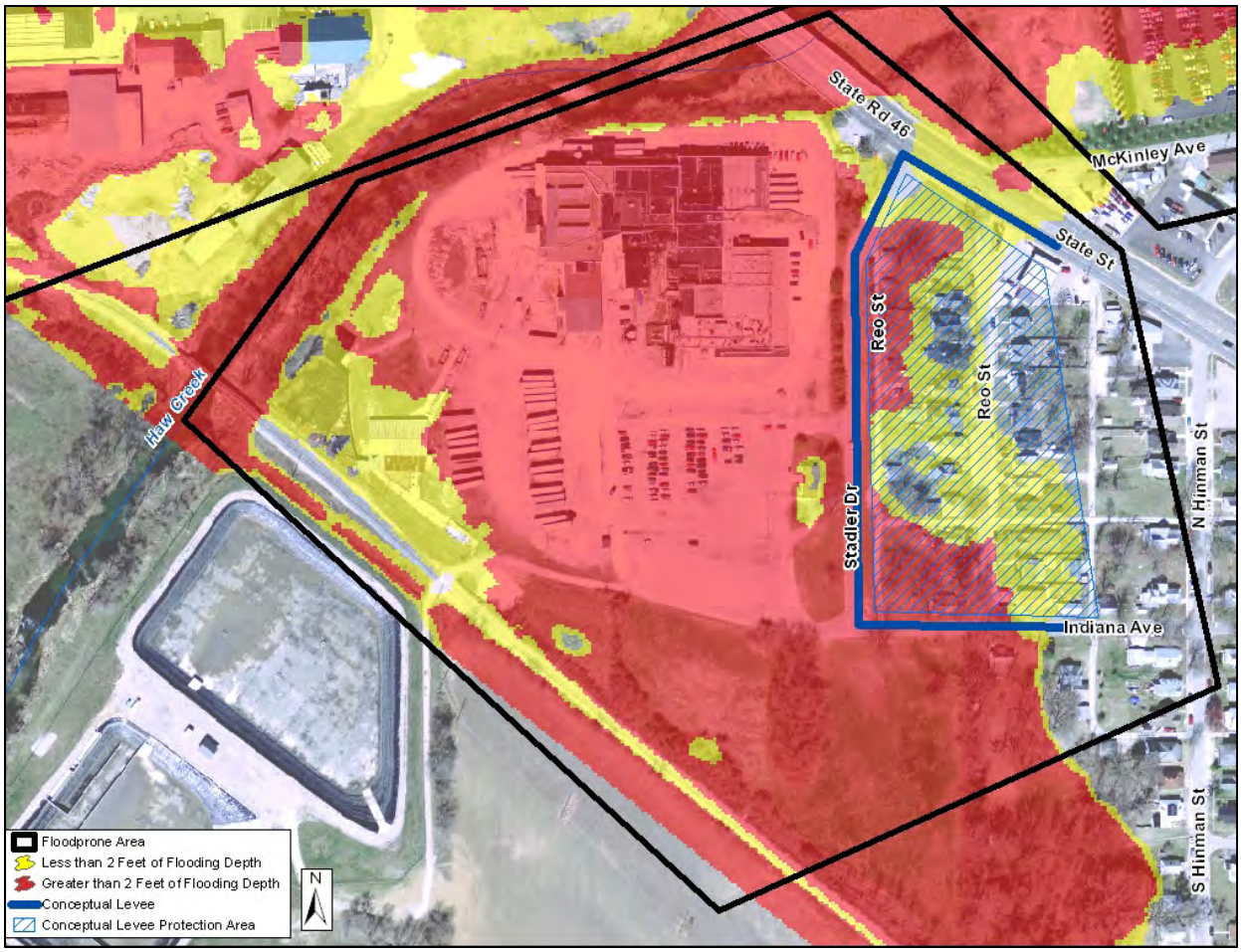


Figure 4-10 East Fork White River Levee/Floodwall Alternative EFK30b – Mariah / Reo Street

East Fork White River Floodproofing/Voluntary Buyout (Alternative EFK9a)

Floodproofing of approximately 50 structures located in the area shown in yellow in **Figure 4-11** along with voluntary buyouts of the remaining 60 structures shown in the red area would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any remaining after the voluntary buyouts, and an additional few flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $2.3 M.

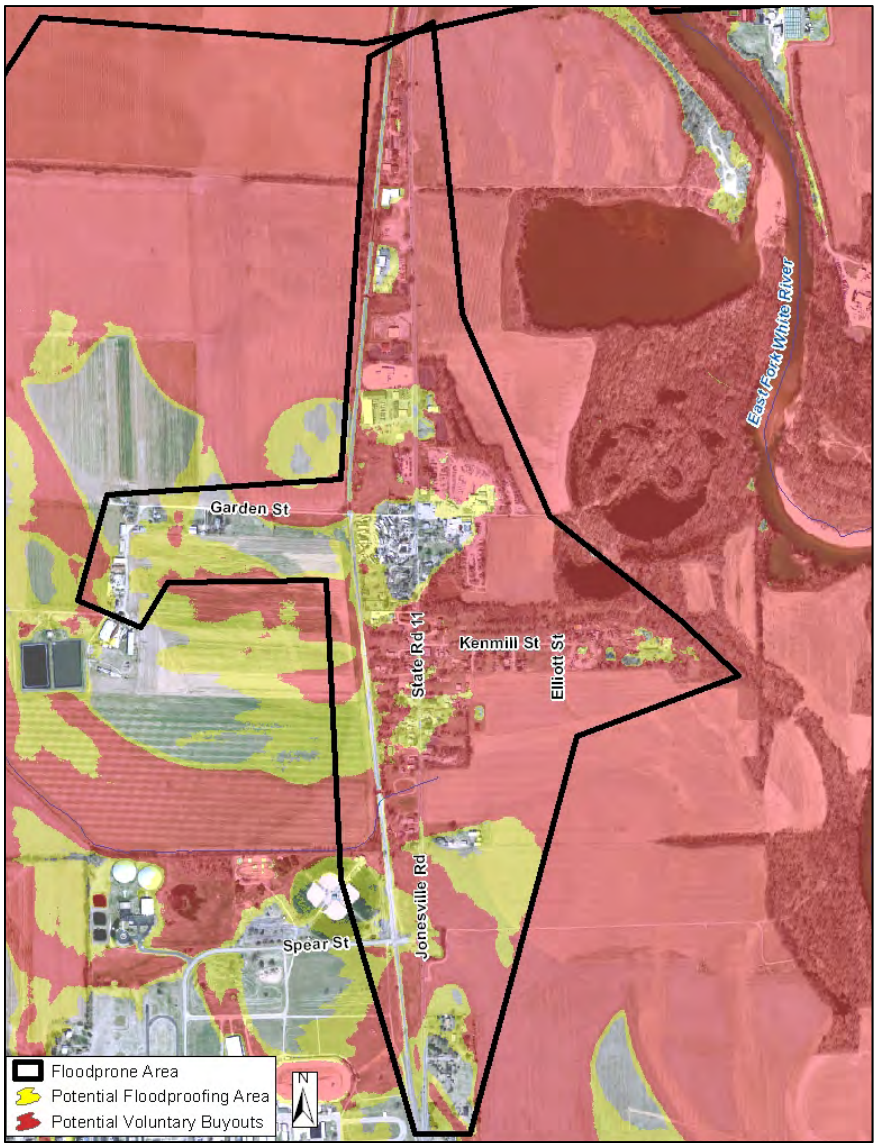


Figure 4-11 East Fork White River Floodproofing/Voluntary Buyout Alternative EFK9a – Garden City

East Fork White River Floodproofing (Alternative EFK8a)

Floodproofing of approximately 5 structures located in the area shown in yellow in **Figure 4-12** would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and an additional 5 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $50 K.

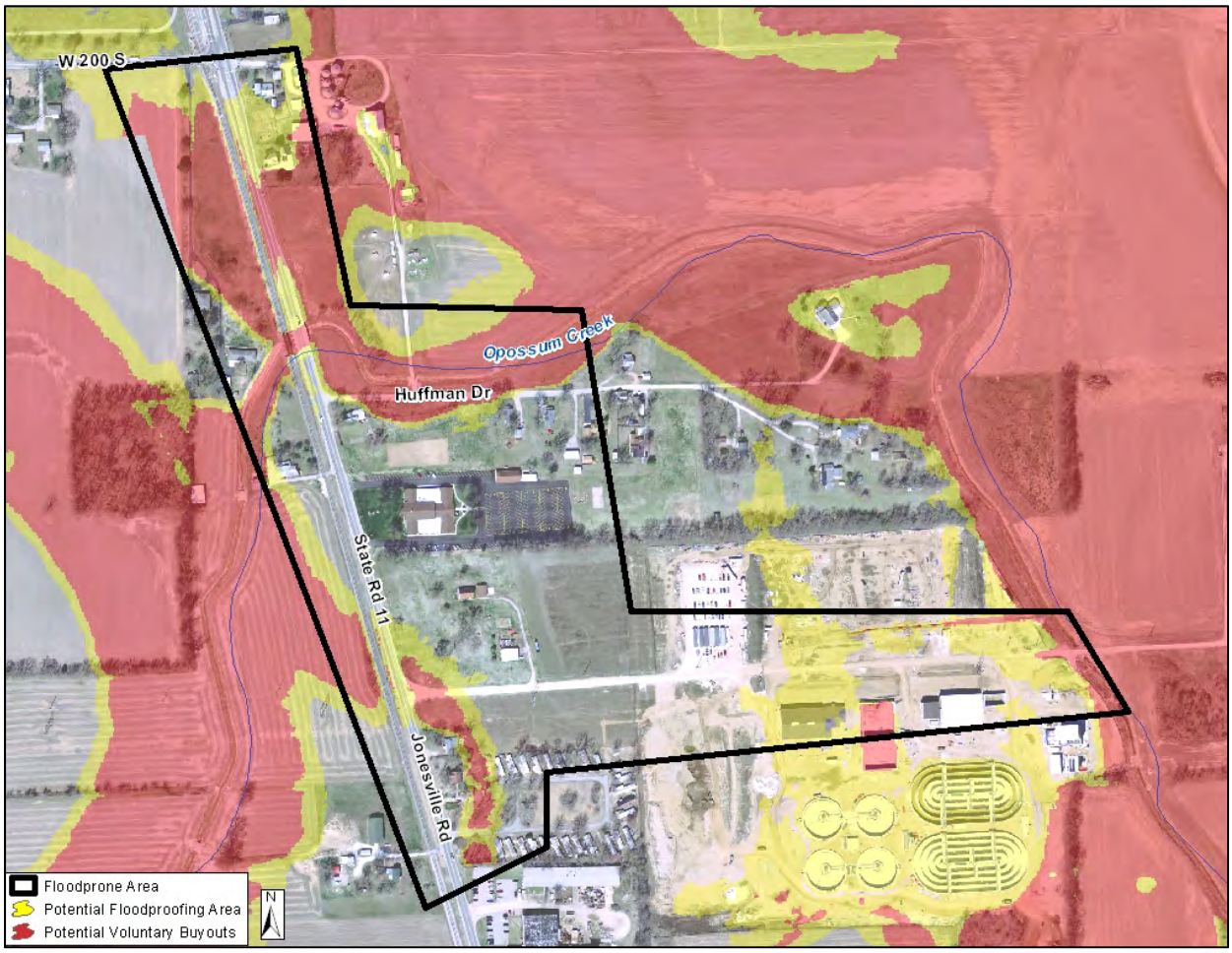


Figure 4-12 East Fork White River Floodproofing Alternative EFK8a - Huffman Drive/WWTP

East Fork White River Floodproofing/Voluntary Buyout (Alternative EFK5a)

Floodproofing of approximately 20 structures located in the area shown in yellow in **Figure 4-13** along with voluntary buyouts of the remaining 25 structures located in the area shown in red or orange (colors are slightly different from other maps due to showing flood depth information for both the East Fork White River and Denios Creek floodplains overlaid on each other) would make the structures in the outlined area flood-free in the 500-year flood on East Fork White River or Denios Creek. All of the floodproofed structures, any remaining after the voluntary buyouts, and an additional 10 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $950 K.

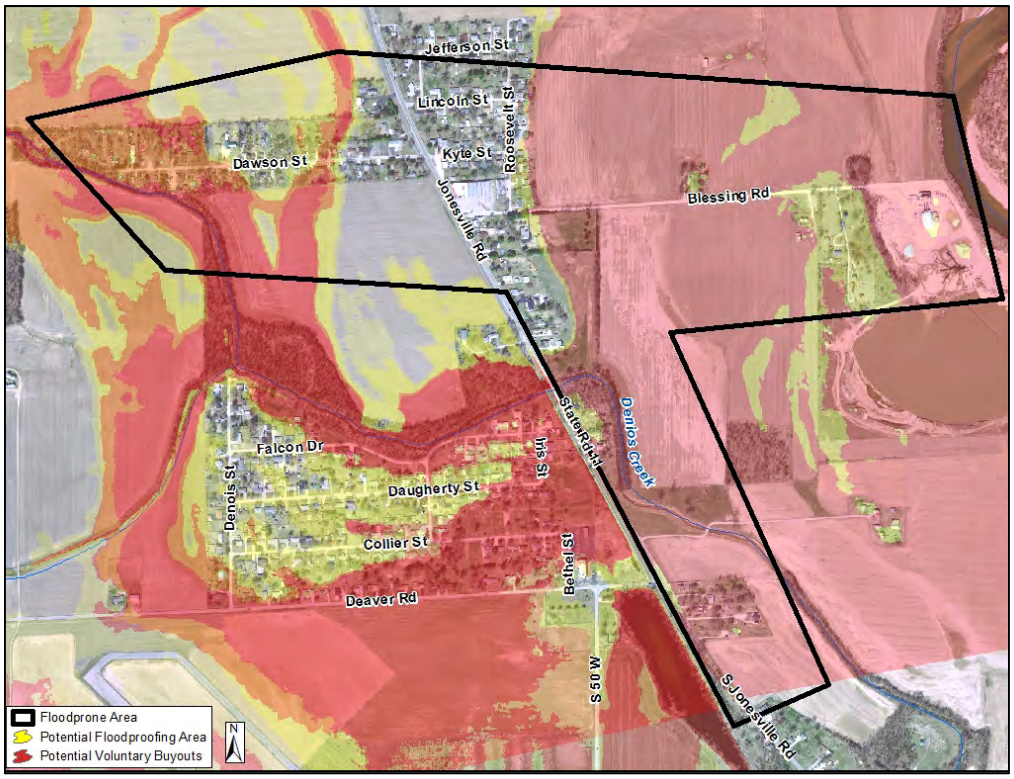


Figure 4-13 East Fork White River Floodproofing/ Voluntary Buyout Alternative EFK5a - SR 11 South

East Fork White River Voluntary Buyout (Alternative EFK5aa)

Voluntary buyout of all 55 structures located in the outlined flooded area shown in **Figure 4-13** or made inaccessible during a flood would eliminate 500-year flood damage and inaccessibility issues due to East Fork White River or Denios Creek flooding. The estimated local cost share is $1.7M.

East Fork White River Levee/Floodwall (Alternative EFK5b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-14** and buyout of the structures between the levee and Denios Creek would protect all 45 of the flooded structures along Dawson Street but would not create access to any of the 55 structures within the levee during the 500-year event on East Fork White River or Denios Creek due to flooding of SR 11. (Only the Denios Creek floodplain is shown since it has the higher flood depths in the area of the levee.) The estimated construction cost is $ 1.9 M.

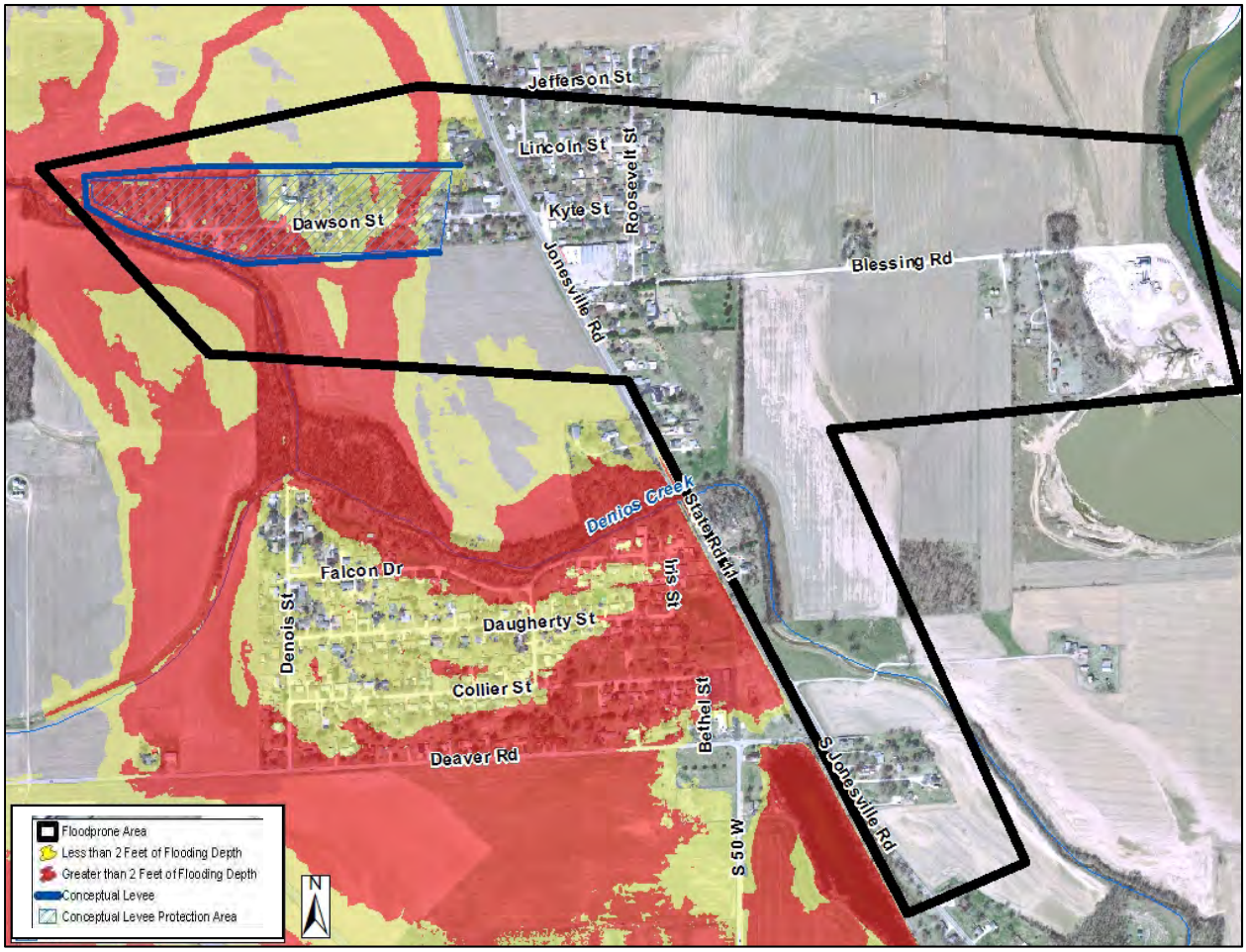


Figure 4-14 East Fork White River Levee/Floodwall Alternative EFK5b - SR 11 South

East Fork White River Floodproofing/Voluntary Buyout (Alternative EFK4a)

Floodproofing of approximately 100 structures located in the area shown in yellow in **Figure 4-15** along with voluntary buyout of the remaining 60 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood on either East Fork White River or Denios Creek. All of the floodproofed structures, any structures remaining after the voluntary buyouts, and an additional 40 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $2.8 M.

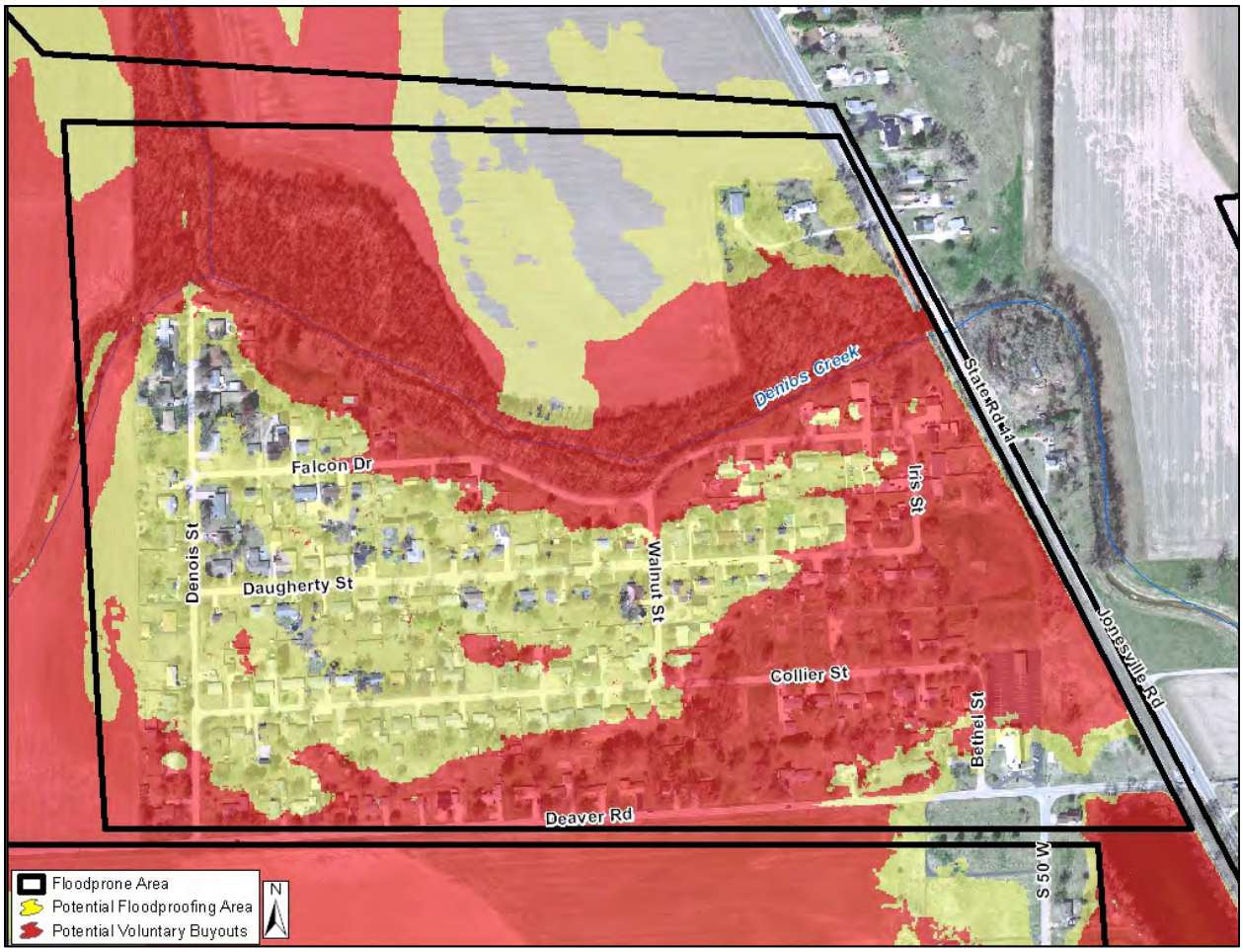


Figure 4-15 East Fork White River Floodproofing/Voluntary Buyout Alternative EFK4a - Bethel Village

East Fork White River Voluntary Buyout (Alternative EFK4aa)

Voluntary buyout of all 200 structures shown in the outlined flooded area shown in **Figure 4-15** or made inaccessible by flooding would eliminate 500-year flood damage and inaccessibility issues due to flooding of East Fork White River or Denios Creek. The estimated local cost share is $6.0 M.

East Fork White River Levee/Floodwall (Alternative EFK4b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-16** would protect all 160 of the flooded structures and allow access to all 200 structures within the levee during the 500-year event on East Fork White River or Denios Creek as long as the RR continues to act as a levee. The estimated construction cost is $3.3 M.

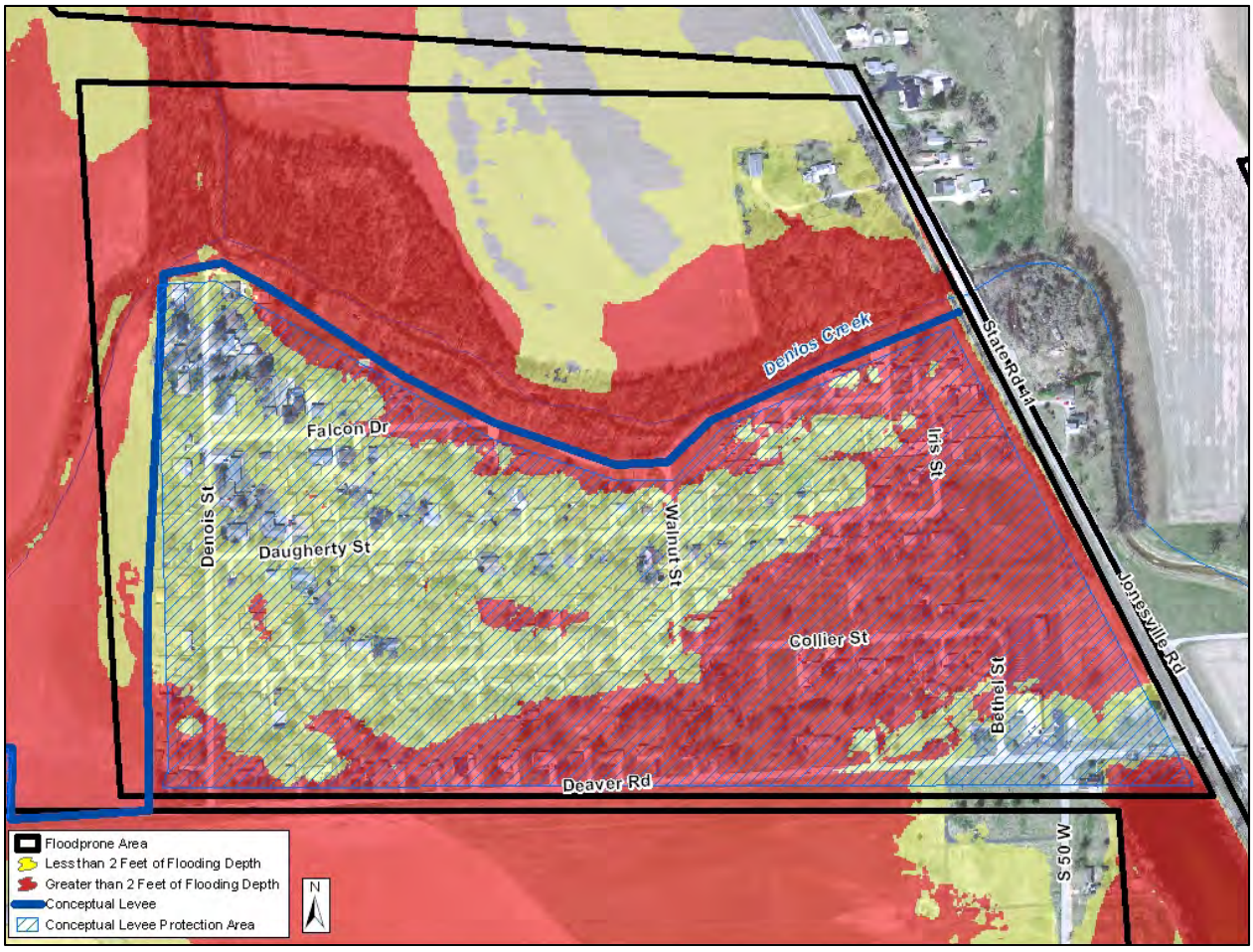


Figure 4-16 East Fork White River Levee/Floodwall Alternative EFK4b - Bethel Village

Flatrock River Floodproofing/Voluntary Buyout (Alternative FR45a)

Floodproofing of approximately 3 structures in the area shown in yellow and voluntary buyout of the remaining 2 structures located in the area shown in red in **Figure 4-17** would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and any remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $90 K.

Figure 4-17 Flatrock River Floodproofing/Voluntary Buyout Alternative FR45a - 45 Riverside Drive North

Flatrock River Levee/Floodwall (Alternative FR45b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-18** would protect all 5 of the flooded structures during the 500-year event. The estimated construction cost is $1.4 M.

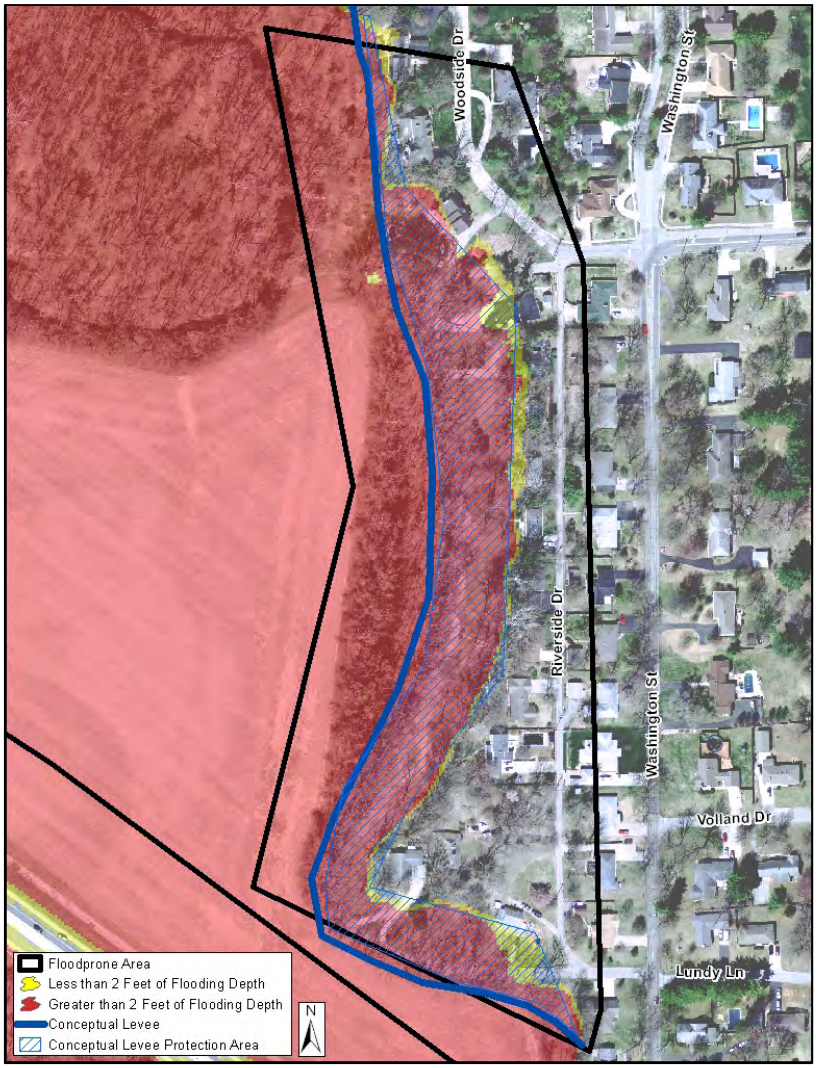


Figure 4-18 Flatrock River Levee/Floodwall Alternative FR45b - 45 Riverside Drive North

Flatrock River Bridge Replacement (Alternative FR45c)

The US 31 approaches to the bridge over Flatrock River are flooded in the 500-year flood based on the effective FIS elevations. However, the bridge has been replaced and may have been replaced with a large enough opening to be flood-free during the 500-year event. Additional capacity would reduce upstream flood levels more and could make 3 of the 5 structures flood-free in the 500-year flood.

Flatrock River Floodproofing (Alternative FR22a)

Floodproofing of approximately 3 commercial structures located in the flooded area shown in **Figure 4-19** would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and an additional 7+ flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $60 K.

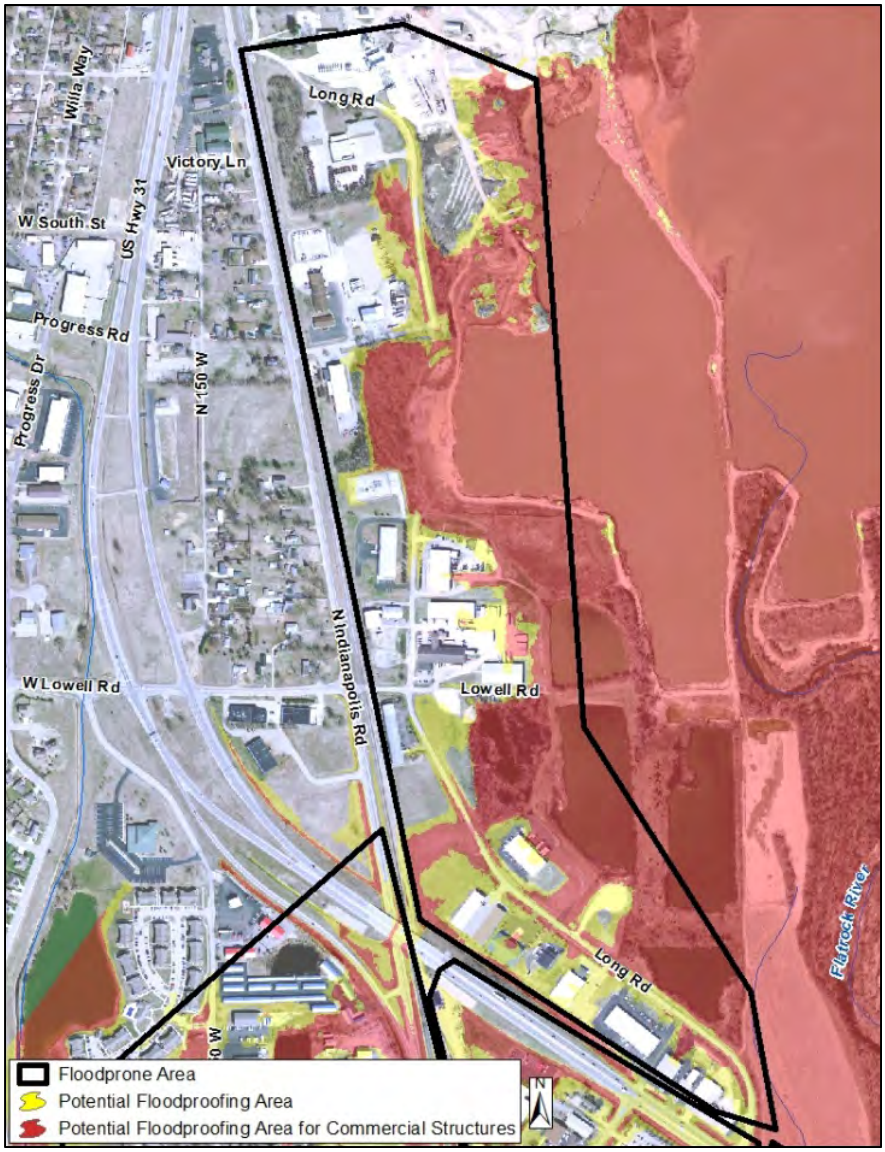


Figure 4-19 Flatrock River Floodproofing Alternative FR22a - Long Road

Flatrock River Levee/Floodwall (Alternative FR22b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-20** would protect all 3 of the flooded structures and allow access to over 7 more inaccessible structures during the 500-year event. The estimated construction cost is $2.5 M.

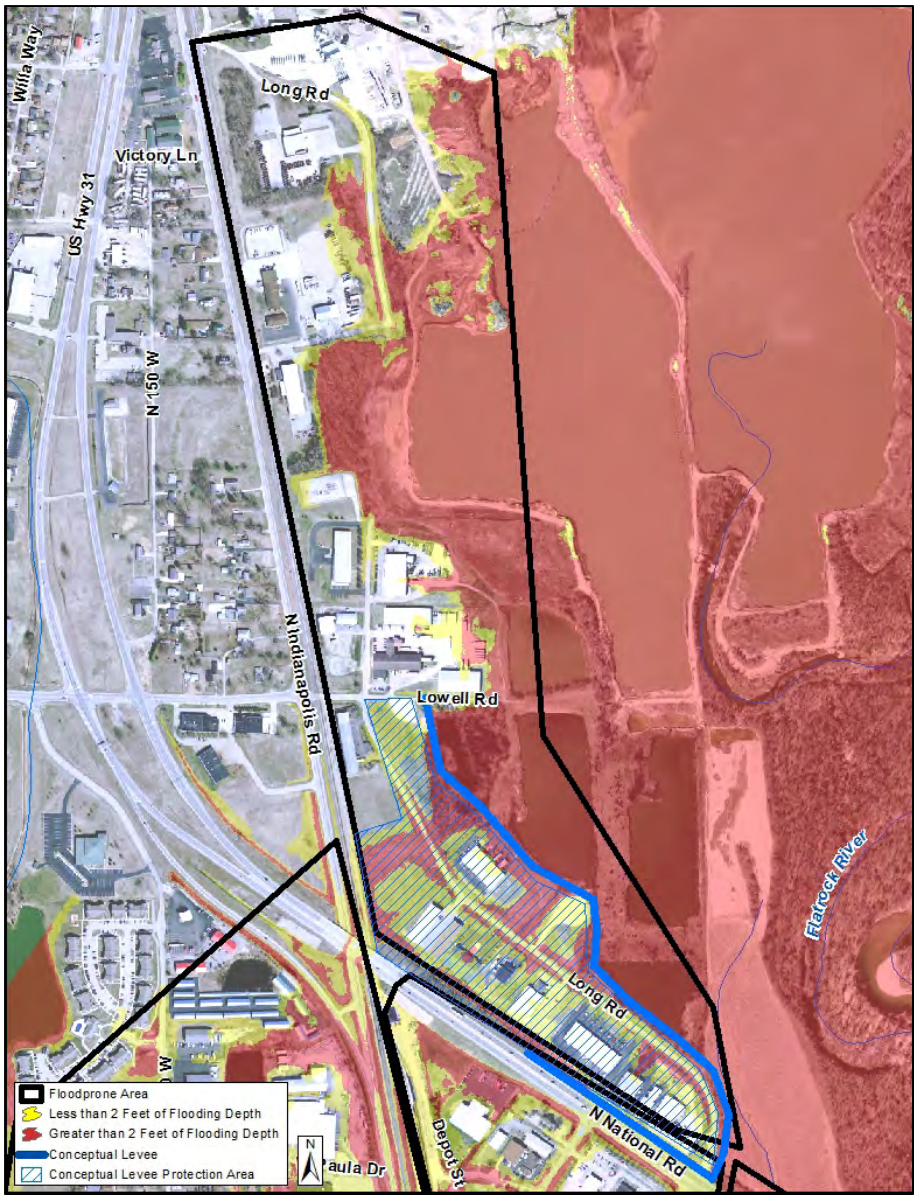


Figure 4-20 Flatrock River Levee/Floodwall Alternative FR22b - Long Road

Flatrock River Levee/Floodwall (Alternative FR21b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-21** would protect all 5 of the flooded structures and allow access to the other 10 inaccessible structures during the 500-year event. The estimated construction cost is $1.1 M.

Figure 4-21 Flatrock River Levee/Floodwall Alternative FR21b - Commerce Park

Flatrock River Floodproofing/Voluntary Buyout (Alternative FR18a)

Floodproofing of approximately 35 structures located in the area shown in yellow in **Figure 4-22** along with voluntary buyout of the remaining 20 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and any remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $1.8 M.

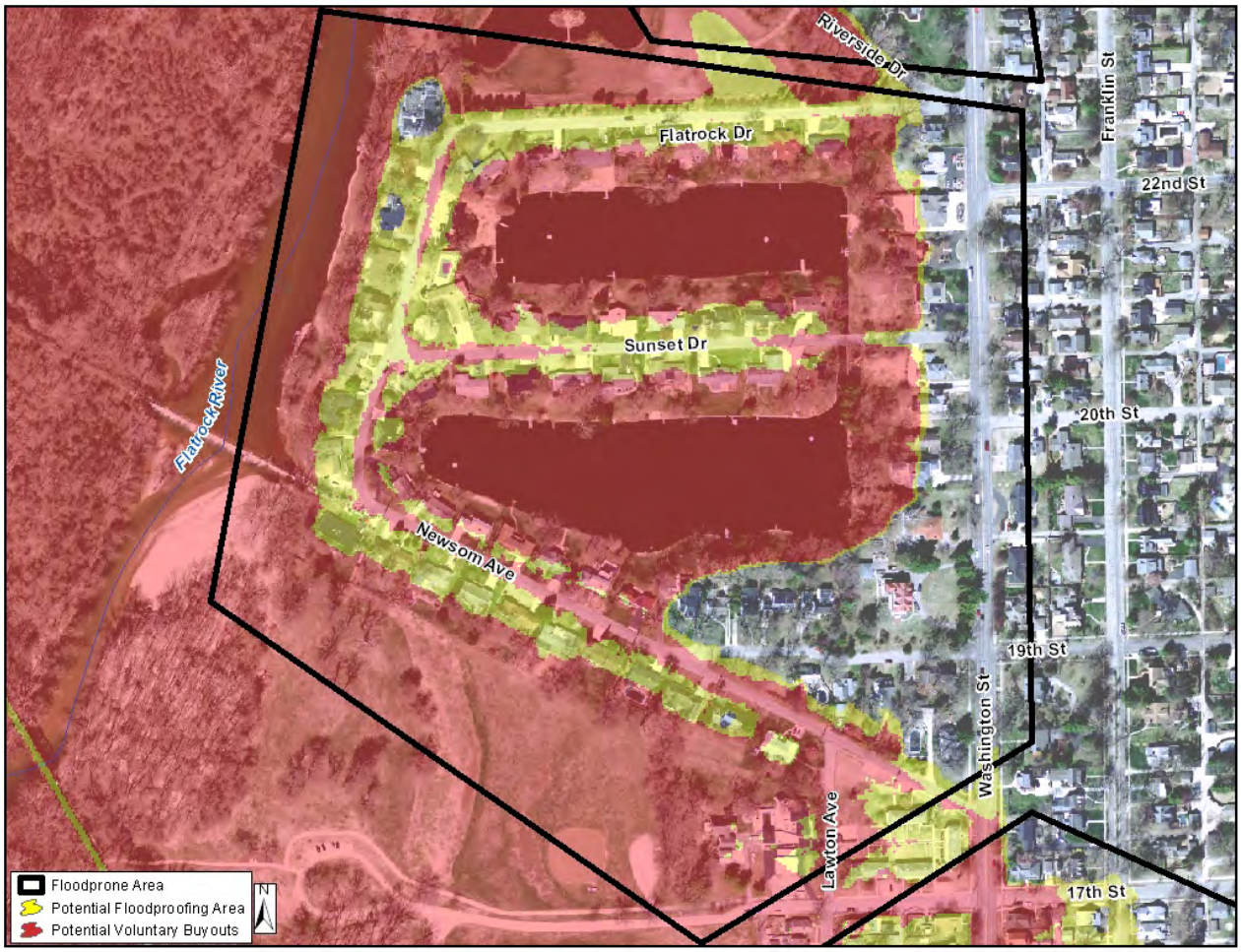


Figure 4-22 Flatrock River Floodproofing/Voluntary Buyout Alternative FR18a - Noblitt Falls

Flatrock River Levee/Floodwall (Alternative FR18b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-23** would protect all 55 of the flooded structures during the 500-year event. The estimated construction cost is $3.0 M. If this levee were to be constructed in conjunction with the levee/ floodwall alternative FR17b for the Washington Street area to the south, approximately one third of the southern portion of this FR18b levee would not be needed.

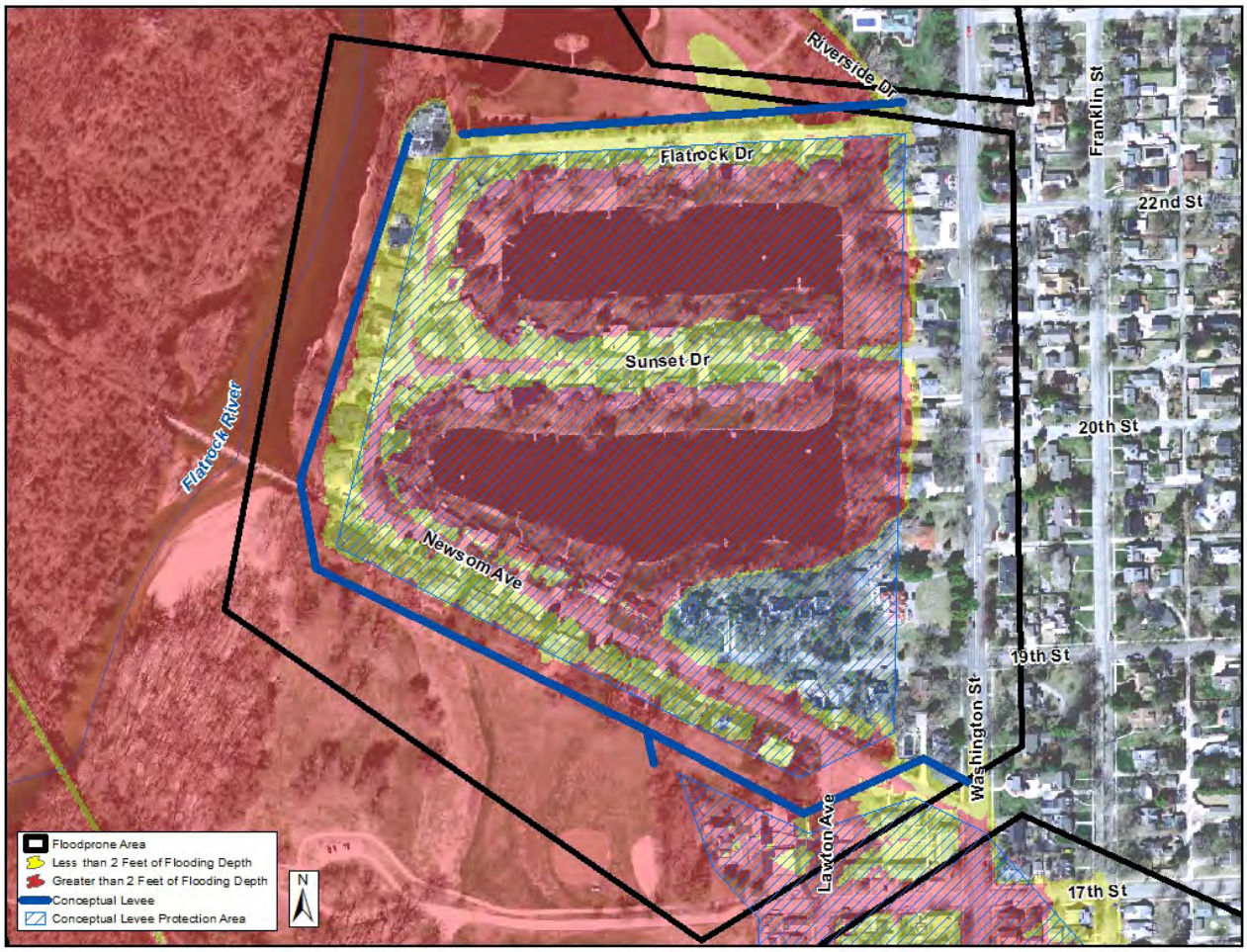


Figure 4-23 Flatrock River Levee/Floodwall Alternative FR18b - Noblitt Falls

Flatrock River Floodproofing/Voluntary Buyout (Alternative FR17a)

Floodproofing of approximately 45 structures located in the area shown in yellow in **Figure 4-24** along with voluntary buyouts of the remaining 90 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and any structures remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $3.2 M.

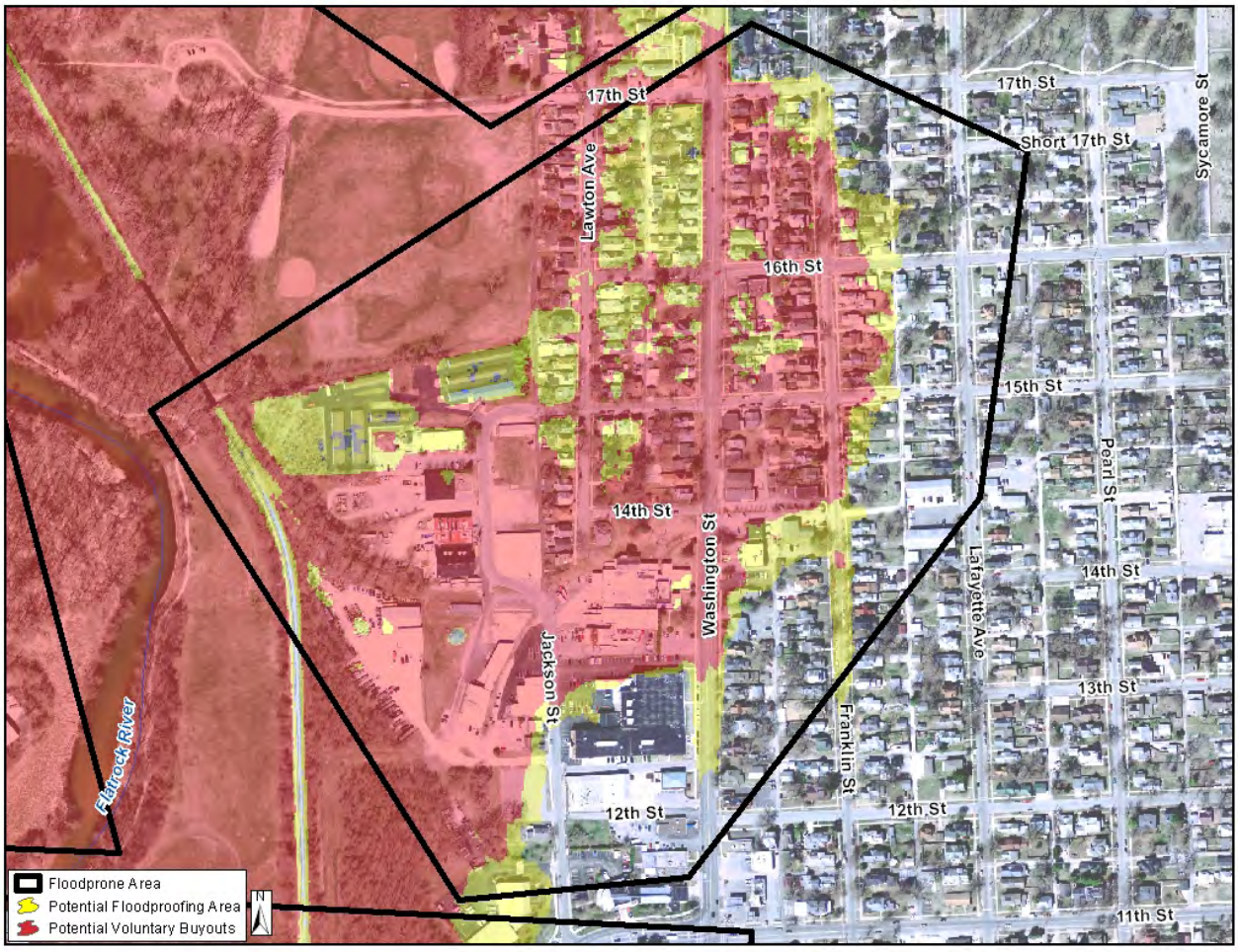


Figure 4-24 Flatrock River Floodproofing/Voluntary Buyout Alternative FR17a - Washington Street

Flatrock River Levee/Floodwall (Alternative FR17b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-25** would protect all 135 of the structures flooded during the 500-year event. The estimated construction cost is $1.5 M. This alternative is dependent on the railroad extending the levee to the south being of sufficient height and stability to function as a part of the levee protection system. If this alternative were constructed in conjunction with alternative FR18b, it would eliminate the need for a part of that alternative's levee.

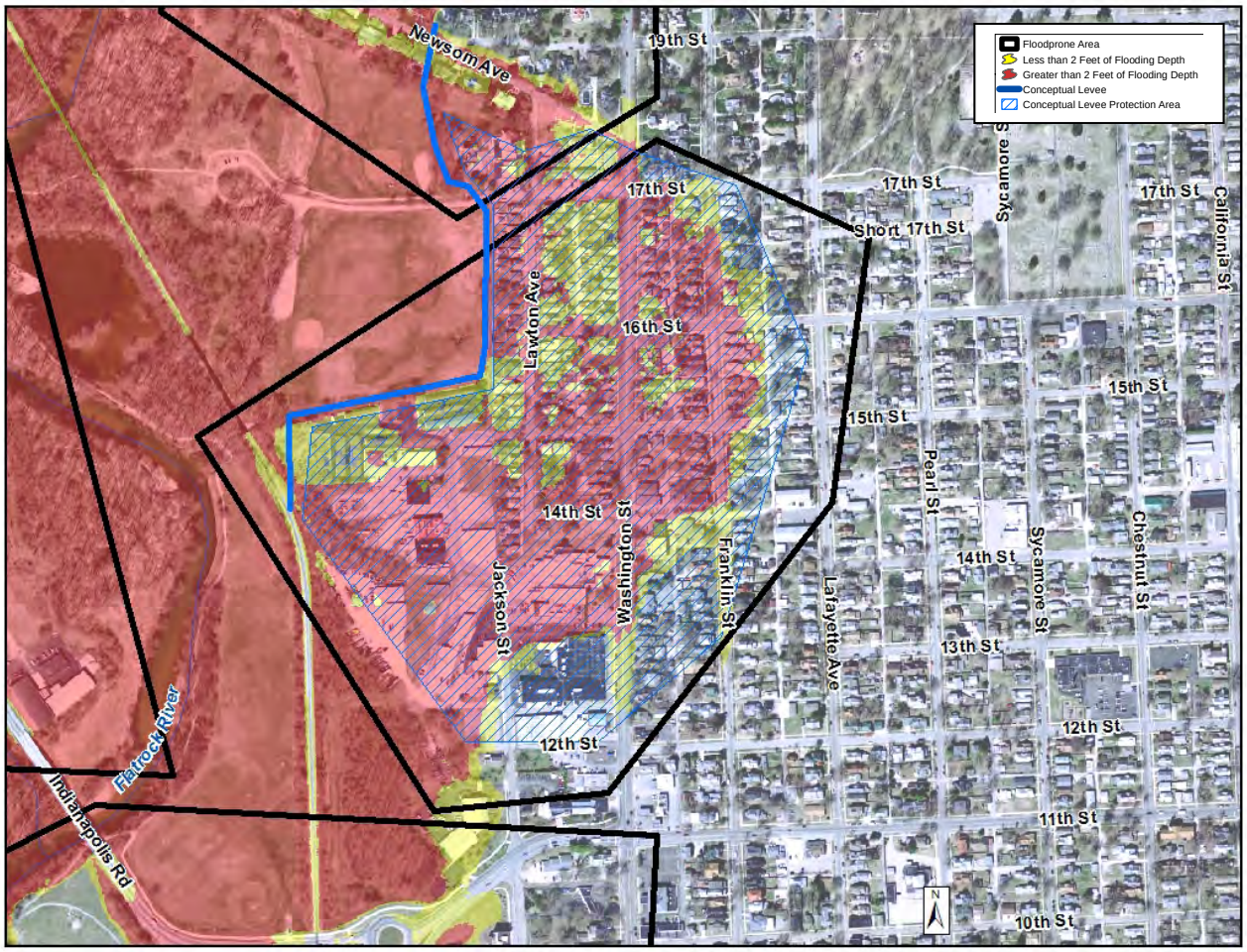


Figure 4-25 Flatrock River Levee/Floodwall Alternative FR17b - Washington Street

Flatrock River Levee/Floodwall (Alternative FR16b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-26** would protect about 20 of the 25 flooded structures and allow access to the other 20 inaccessible structures during the 500-year event. The estimated construction cost is $6.9 M. Mitigation required for lost floodplain storage behind the levee is likely to be significant. The levee could be shortened to slightly reduce the impacts.

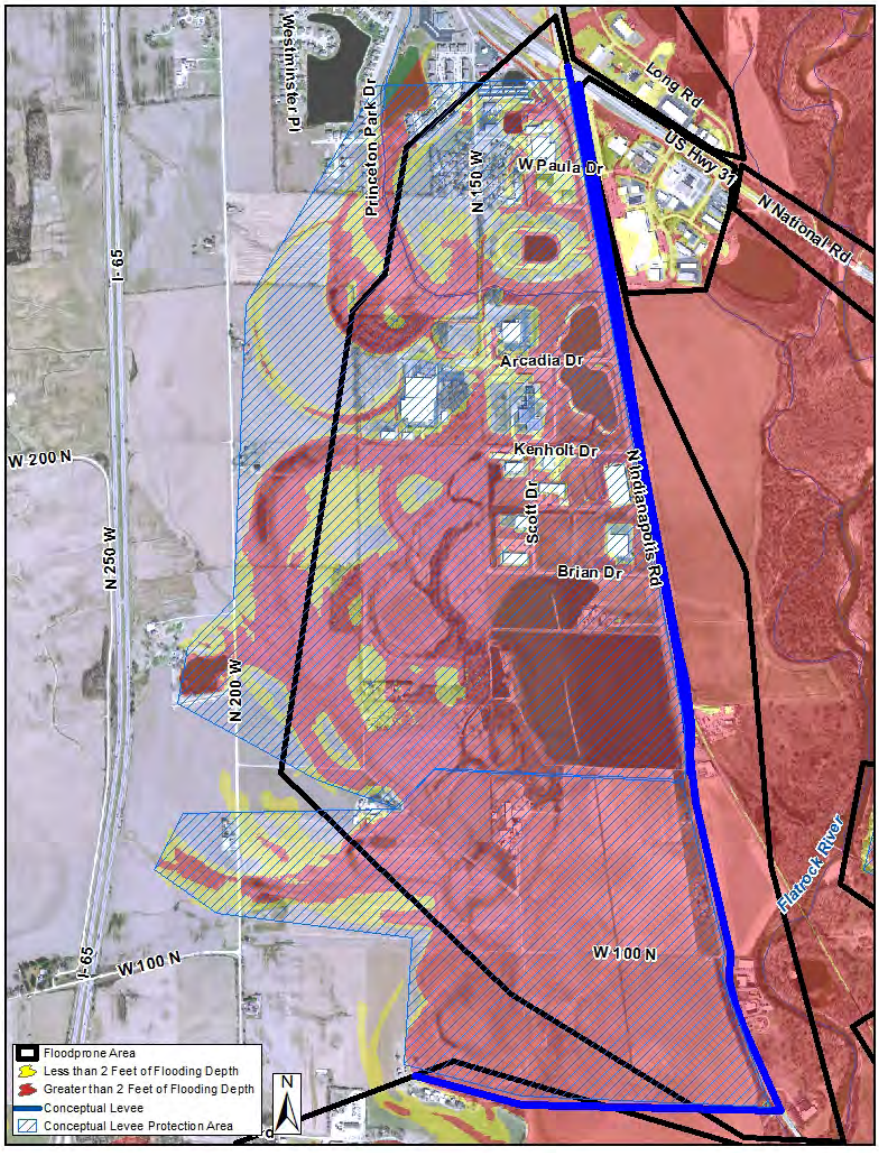


Figure 4-26 Flatrock River Levee/Floodwall Alternative FR16b - Indianapolis Road

At the time of the Haw Creek modeling, limited data was available to model the flood depths in this area in detail. Therefore, flood depths and extent are estimates based on assumptions of how water would flow through the area. In order to provide more definitive recommendations, more detailed data should be collected in this area and added to the Haw Creek modeling.

Haw Creek Floodproofing (Alternative HC42a)

Floodproofing of approximately 15 structures located in the area shown in yellow in **Figure 4-27** would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and an additional 10 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $150 K.

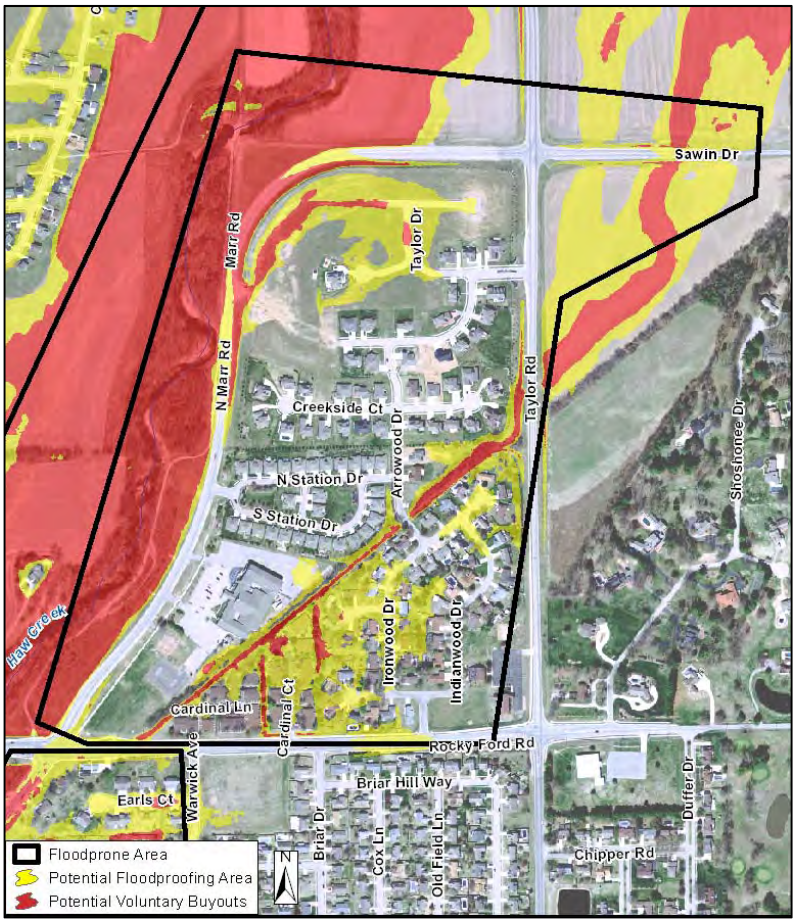


Figure 4-27 Haw Creek Floodproofing Alternative HC42a - Sycamore Bend / Arrowood

Haw Creek Levee/Floodwall (Alternative HC42b)

Construction of a levee/floodwall along the conceptual alignment shown as 2 blue lines in **Figure 4-28** would protect all 15 of the flooded structures, allow access to the other 10 inaccessible structures, and protect the future construction residences in the subdivision during the 500-year event. The estimated construction cost is $1.0 M assuming that the short levee segment along the western limits is built separately in the form of raising the street when the entrance is constructed. Structures are above the water surface elevation that would back up into the tributary from Haw Creek at Rocky Ford Road so backflow protection would not be required. The existing tributary is likely large enough to handle the flow from its drainage area if the levee were constructed.

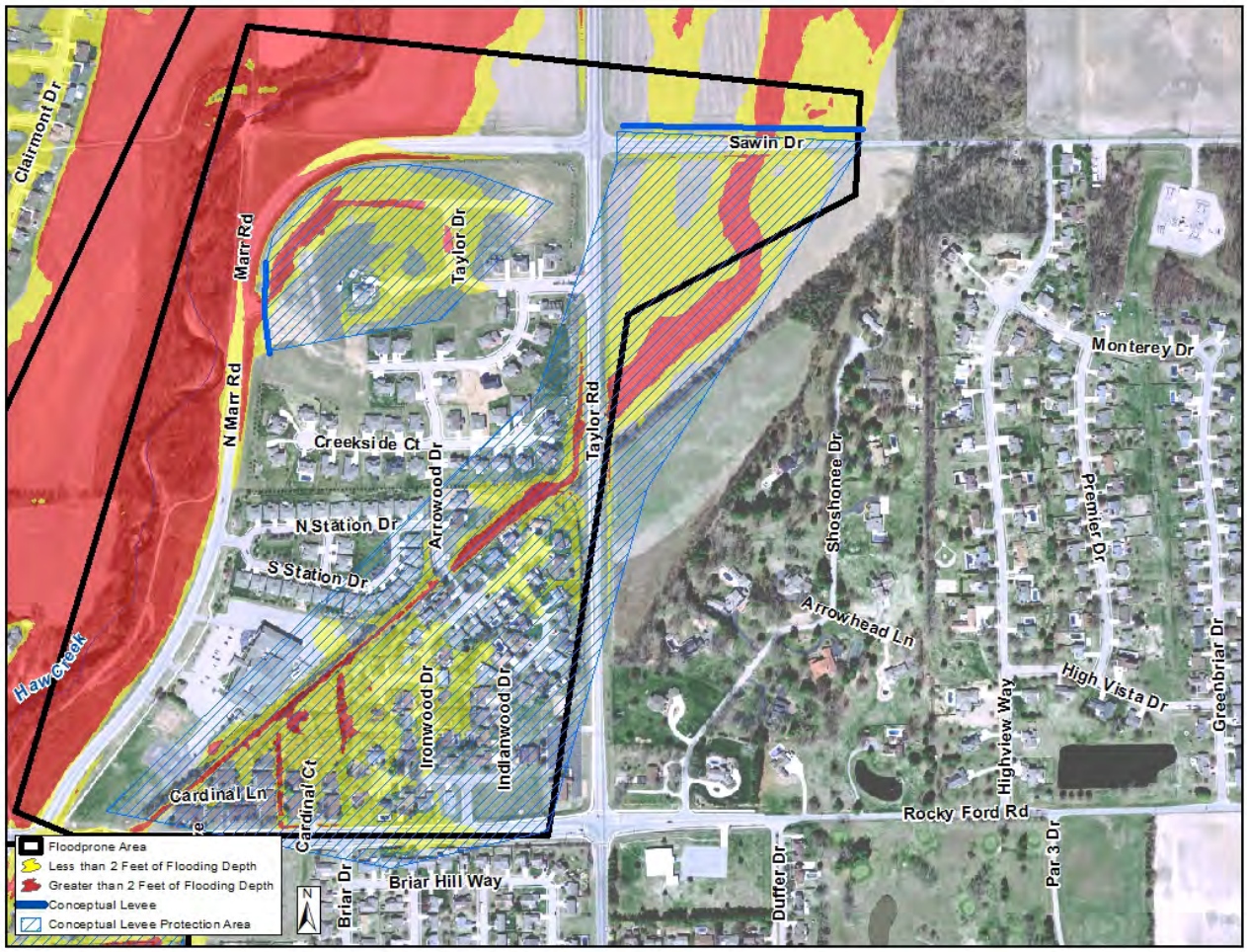


Figure 4-28 Haw Creek Levee/Floodwall Alternative HC42b - Sycamore Bend / Arrowood

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC41a)

Floodproofing of approximately 290 structures located in the area shown in yellow in **Figure 4-29** along with voluntary buyouts of the remaining 80 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any structures remaining after the voluntary buyouts, and an additional 30+ flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $5.3 M.

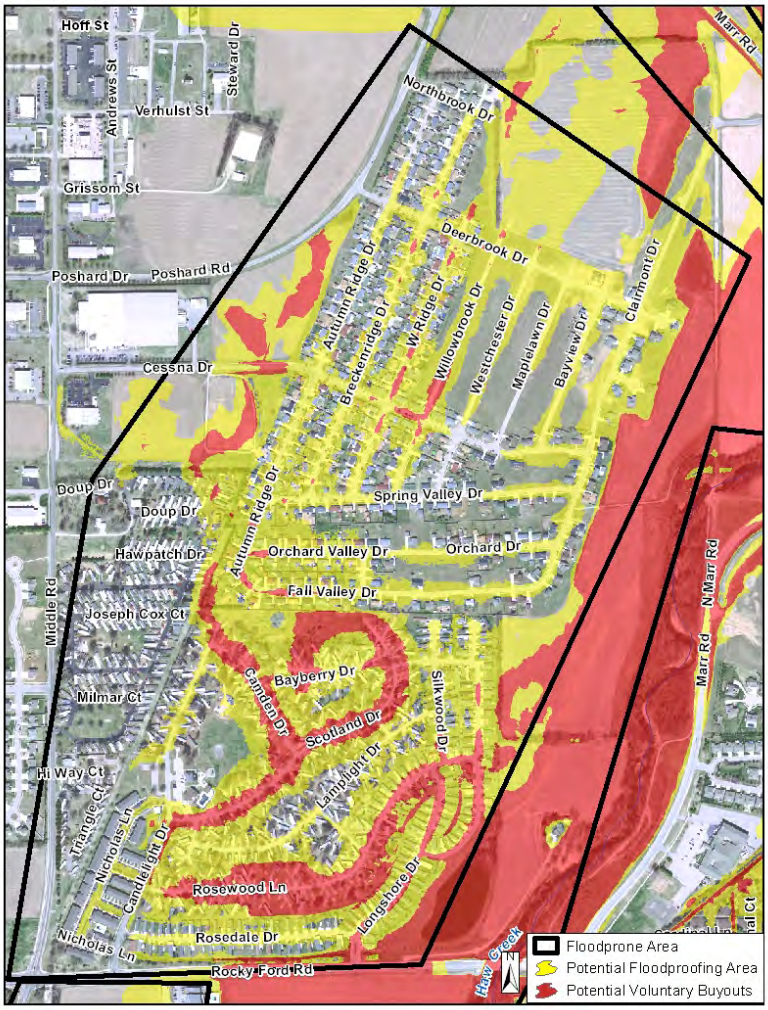


Figure 4-29 Haw Creek Floodproofing/Voluntary Buyout Alternative HC41a – Northbrook / Candlelight

Haw Creek Levee/Floodwall (Alternative HC41b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-30** would protect all 370 of the flooded structures and allow access to the other 30 or more inaccessible structures during the 500-year event. The estimated construction cost is $1.9 M

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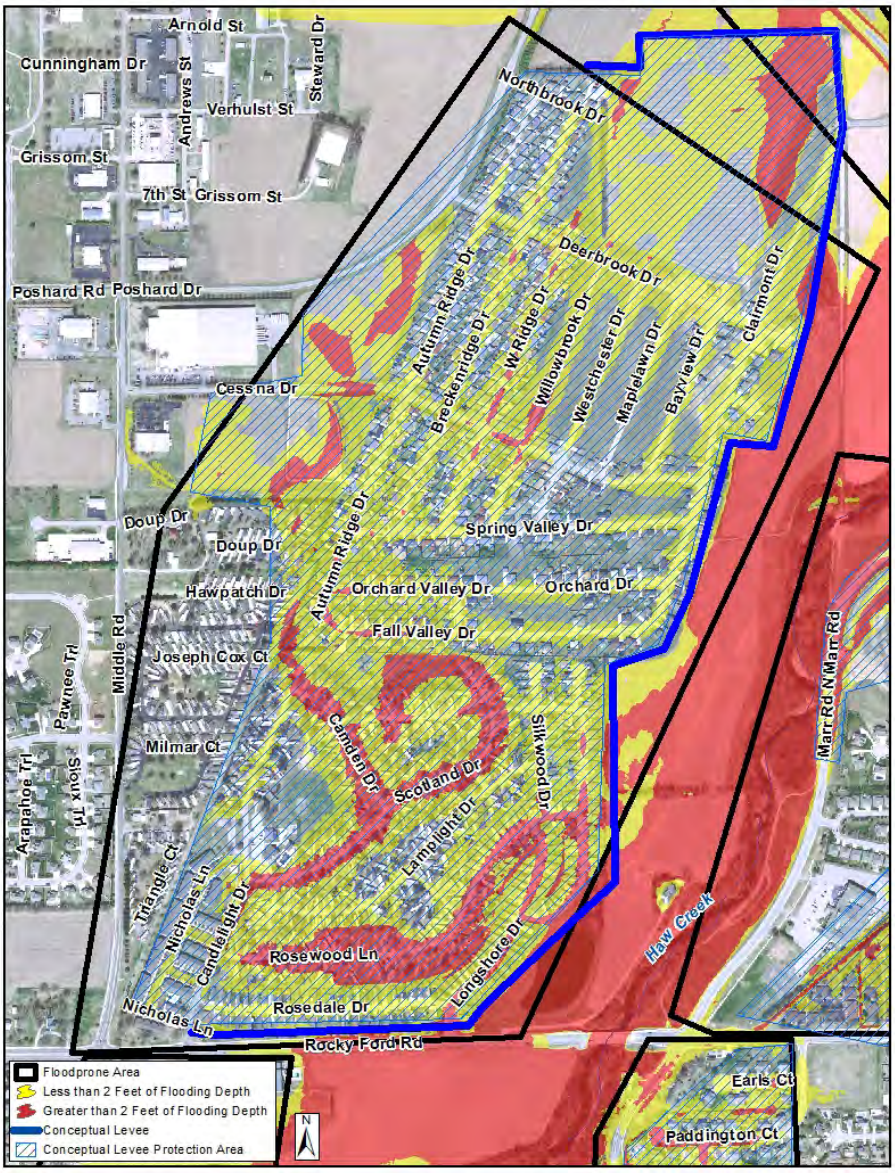

Figure 4-30 Haw Creek Levee/Floodwall Alternative HC41b – Northbrook / Candlelight

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC40a)

Floodproofing of approximately 70 structures located in the area shown in yellow in **Figure 4-31** along with voluntary buyouts of the remaining 15 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any structures remaining after the voluntary buyouts, and an additional few flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $1.2 M.

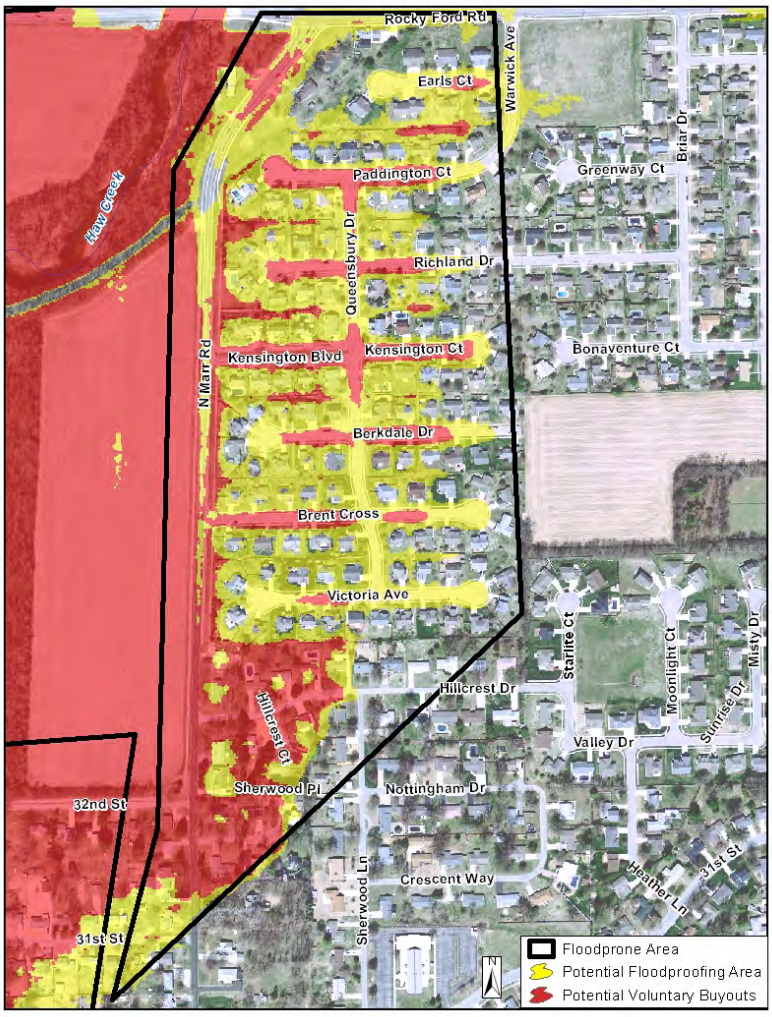

Figure 4-31 Haw Creek Floodproofing/Voluntary Buyout Alternative HC40a - Windsor Place / Hillcrest

Haw Creek Levee/Floodwall (Alternative HC40b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-32** would protect all 85 of the flooded structures and allow access to the few additional inaccessible structures during the 500-year event. The estimated construction cost is $1.6 M. There may still be flooding from overflow of the tributary north of Rocky Ford if Alternative HC42b is not constructed.

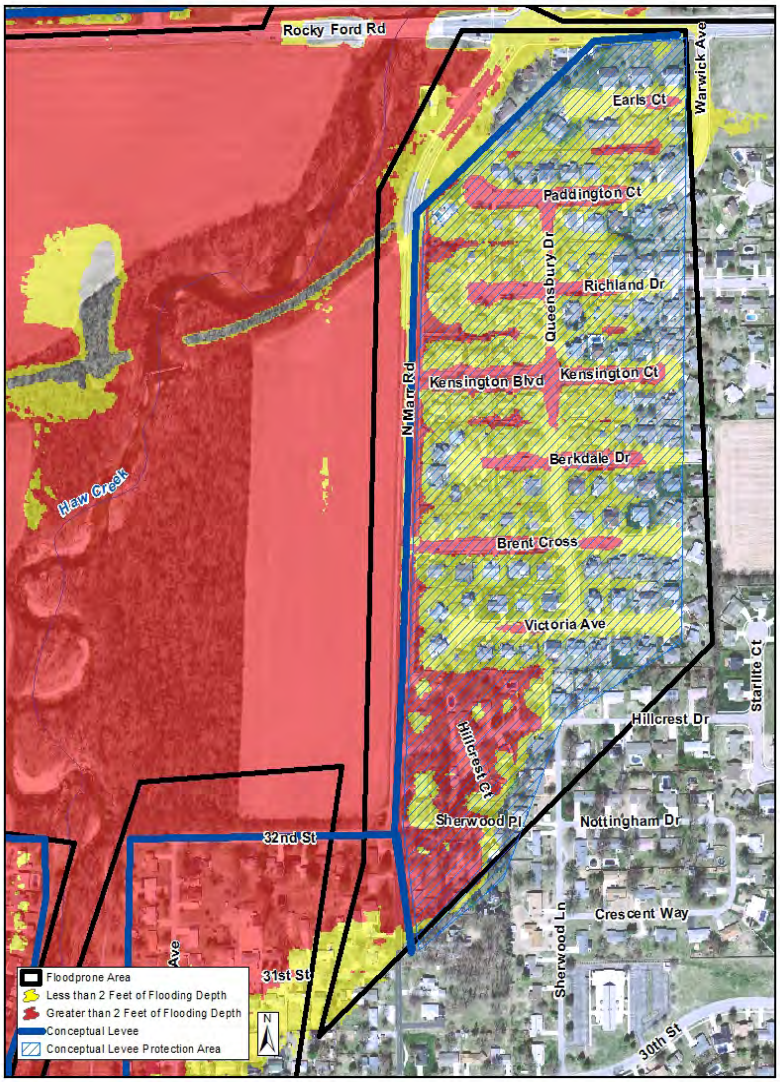

Figure 4-32 Haw Creek Levee/Floodwall Alternative HC40b - Windsor Place / Hillcrest

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC38a)

Floodproofing of approximately 110 structures in the area shown in yellow in **Figure 4-33** along with voluntary buyouts of the remaining 70 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any structures remaining after the voluntary buyouts, and an additional 10+ flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $3.2 M.

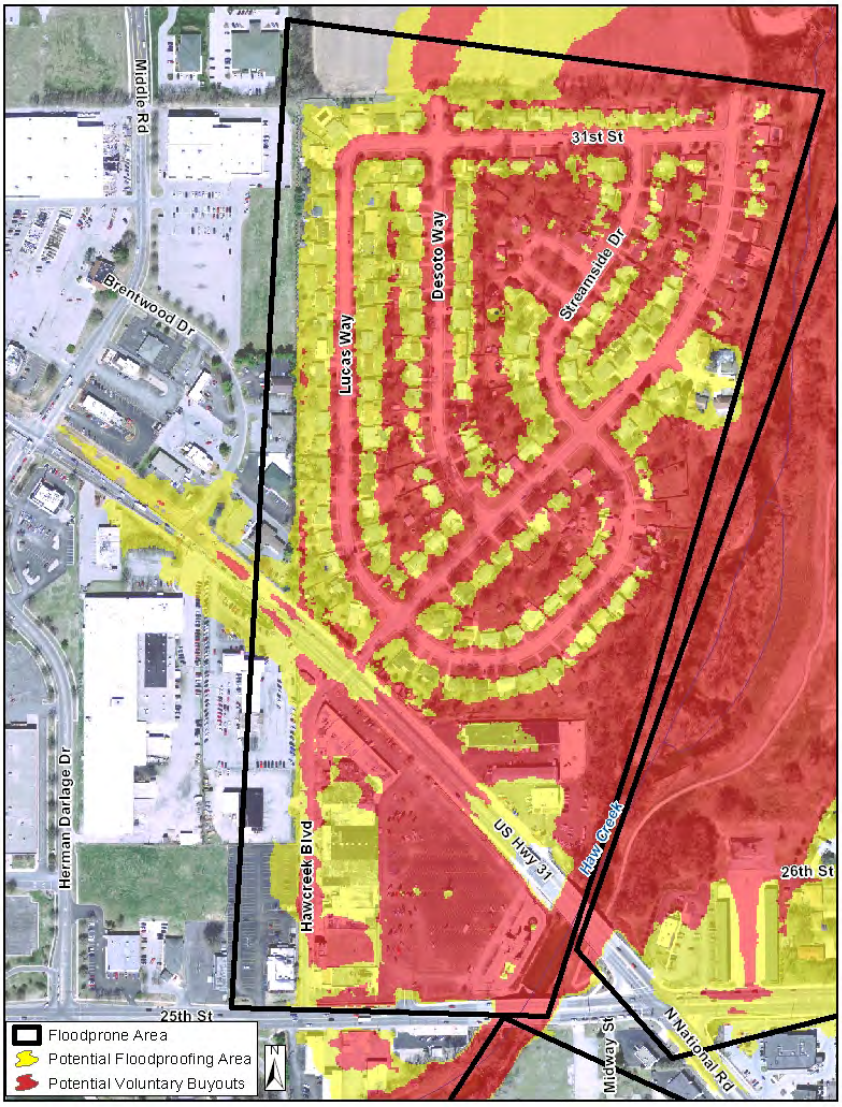

Figure 4-33 Haw Creek Floodproofing/Voluntary Buyout Alternative HC38a - Everoad Park West/Eastbrook

Haw Creek Levee/Floodwall (Alternative HC38b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-34** would protect all 180 of the flooded structures and allow access to the additional inaccessible structures during the 500-year event. The estimated construction cost is $4.3 M.

Figure 4-34 Haw Creek Levee/Floodwall Alternative HC38b - Everoad Park West/Eastbrook

Haw Creek Levee/Floodwall (Alternative HC37b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-35** would protect all 55 of the flooded structures and allow access to the other 20 inaccessible structures during the 500-year event. The estimated construction cost is $1.8 M.

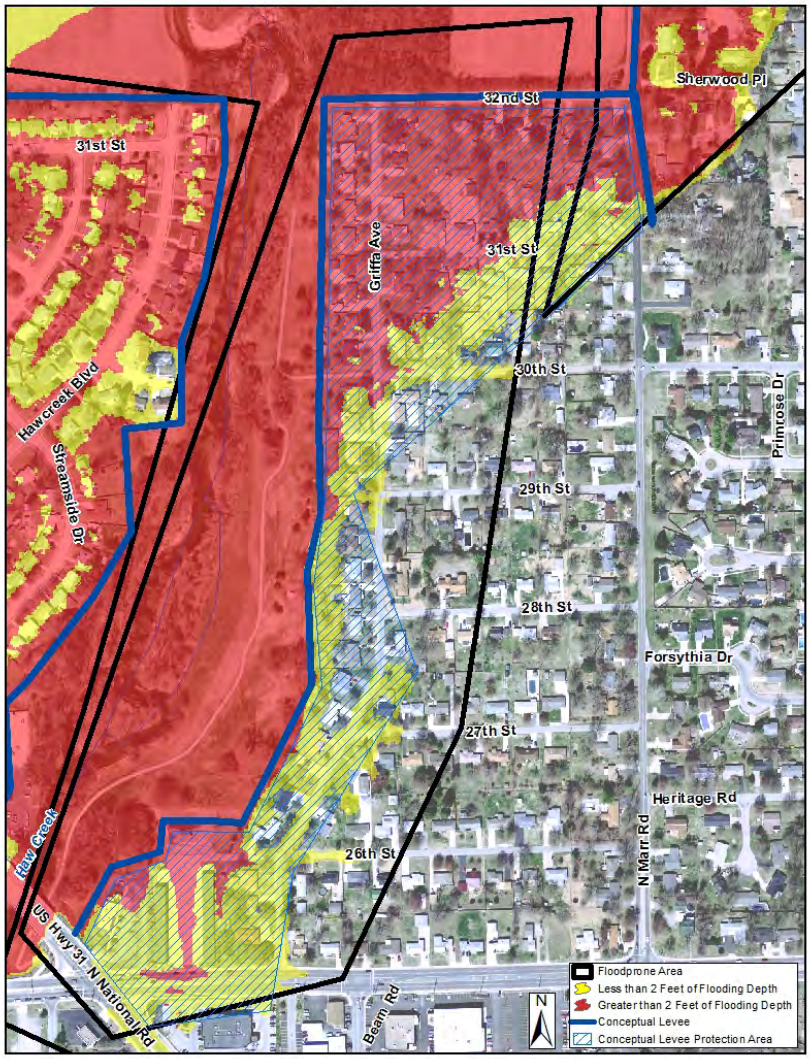

Figure 4-35 Haw Creek Levee/Floodwall Alternative HC37b - Everoad Park East

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC36a)

Floodproofing of approximately 20 residential structures and 2 commercial structures (including Columbus Health and Rehabilitation) in the area shown in yellow in **Figure 4-36** along with voluntary buyouts of the remaining 8 structures located in the area shown in red would the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any structures remaining after the voluntary buyouts, and an additional 2 flood-free structures would, however, still be inaccessible during the peak of the flood event. This alternative would provide additional protection of the Columbus Health and Rehabilitation facility but the facility would still be inaccessible. The estimated local cost share is $480 K.

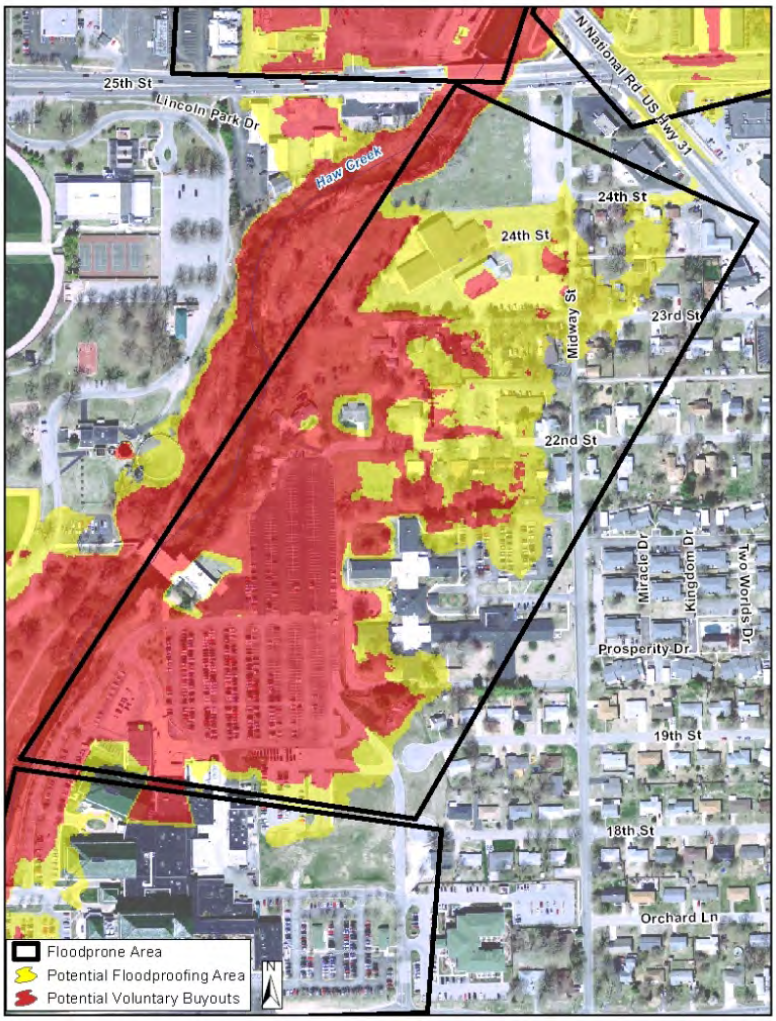

Figure 4-36 Haw Creek Floodproofing/Voluntary Buyout Alternative HC36a - Midway

Haw Creek Levee/Floodwall (Alternative HC36b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-37** would protect all 30 of the flooded structures and allow access to the couple other inaccessible structures during the 500-year event. This alternative would provide protection for the Columbus Health and Rehabilitation facility located in the area. The estimated construction cost is $1.3 M.

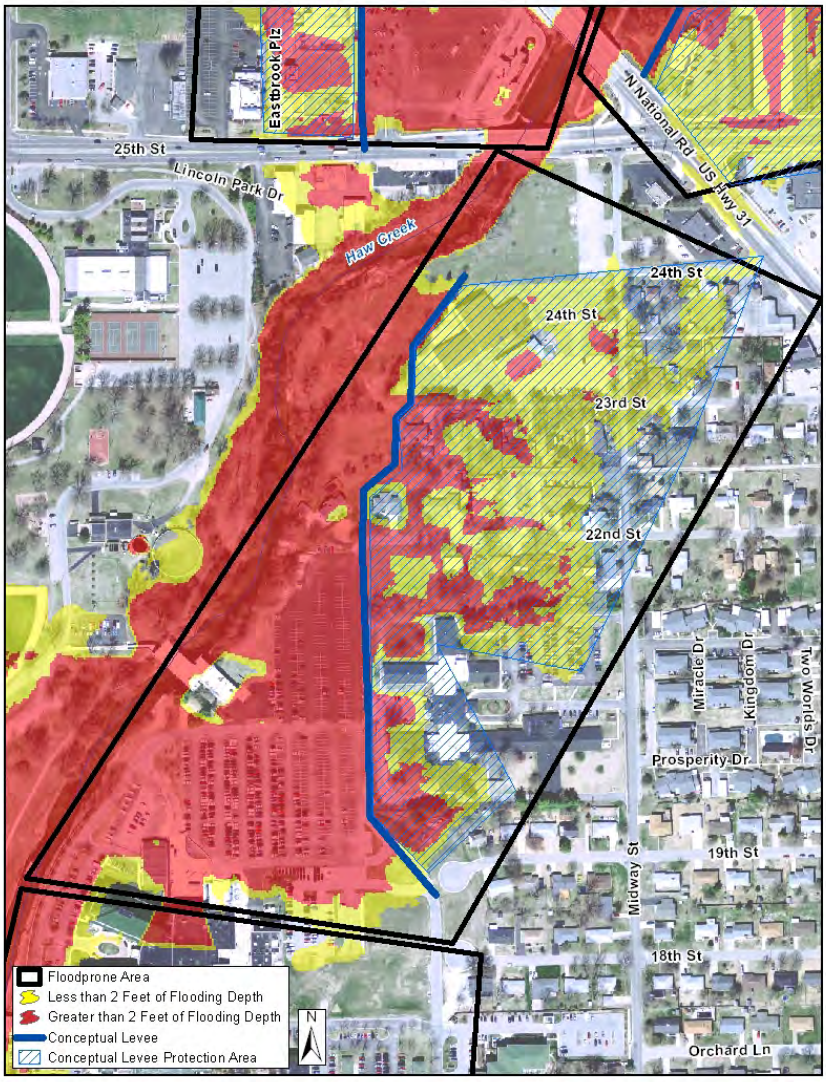

Figure 4-37 Haw Creek Levee/Floodwall Alternative HC36b - Midway

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC34a)

Floodproofing of approximately 35 residential structures and 2 commercial structures in the area shown in yellow in **Figure 4-38** along with voluntary buyouts of the remaining 13 residential structures shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and any structures remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $780 K.

Figure 4-38 Haw Creek Floodproofing/Voluntary Buyout Alternative HC34a - 17th/Keller

Haw Creek Levee/Floodwall (Alternative HC34b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-39** would protect and allow access to all 50 of the structures flooded during the 500-year event. A levee closure structure at 18th Street would, however, limit access to the Columbus Regional Hospital from this direction. The estimated construction cost is $900 K.

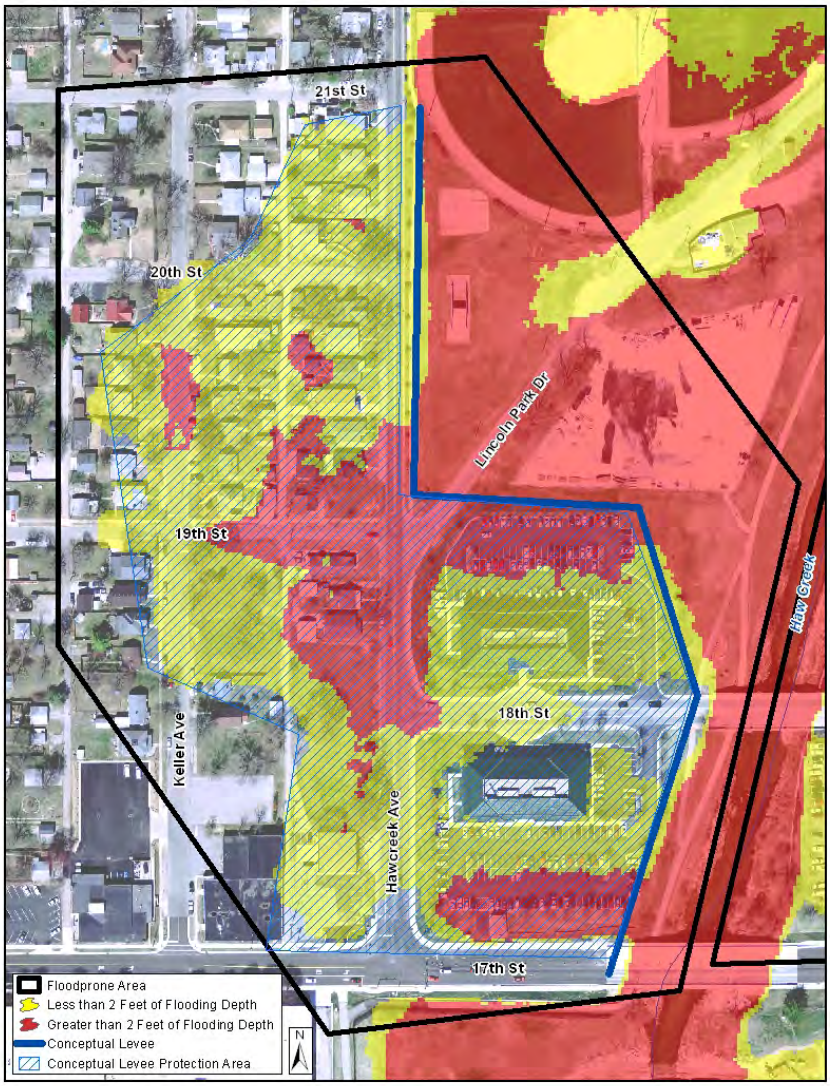

Figure 4-39 Haw Creek Levee/Floodwall Alternative HC34b - 17th/Keller

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC33a)

Floodproofing of approximately 70 structures in the area shown in yellow in **Figure 4-40** along with voluntary buyouts of the remaining 100 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures, any structures remaining after the voluntary buyouts, and an additional 15 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $3.7 M.

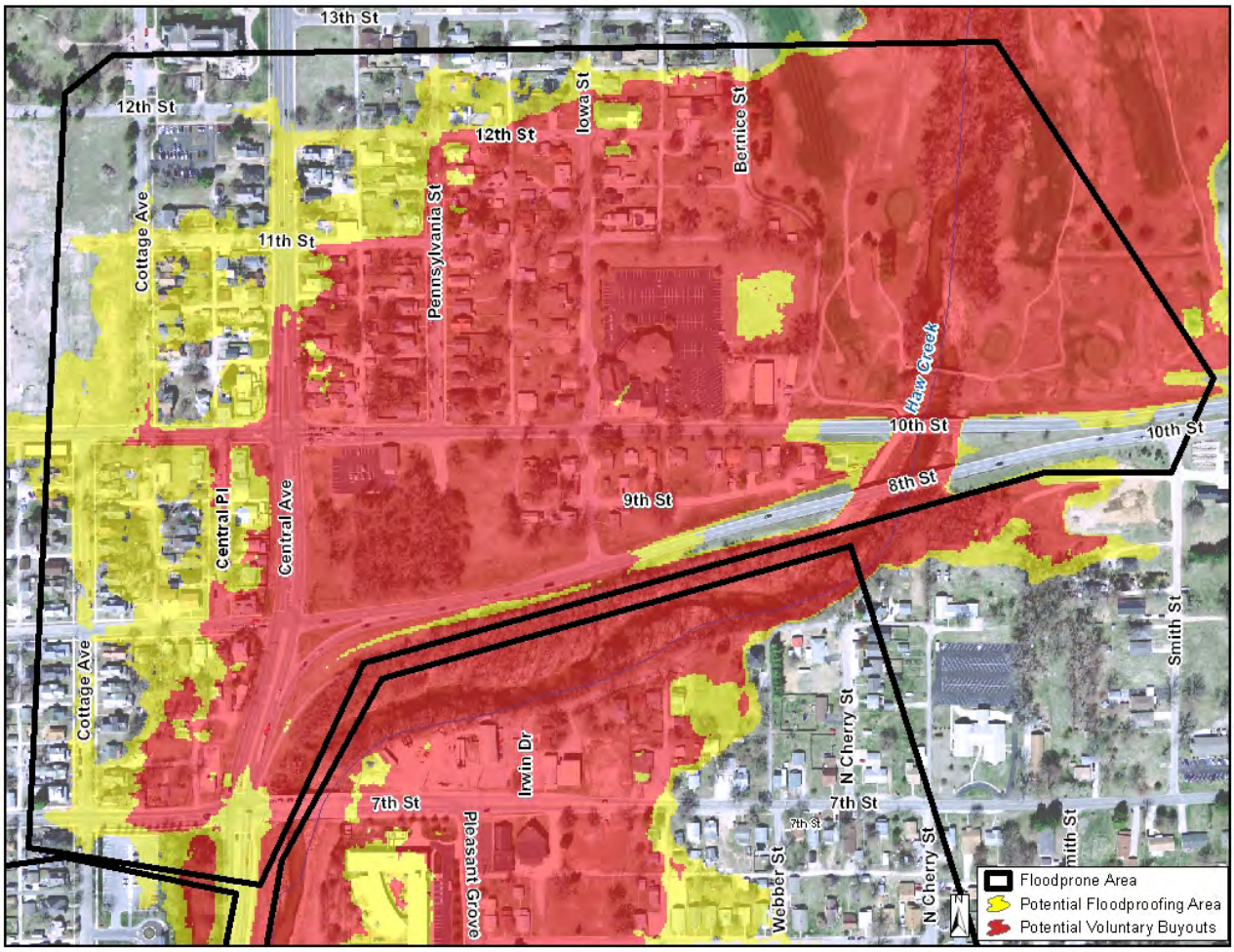

Figure 4-40 Haw Creek Floodproofing/Voluntary Buyout Alternative HC33a - 10th/Central

Haw Creek Floodproofing/Voluntary Buyout (Alternative HC32a)

Floodproofing of approximately 25 residential structures located in the area shown in yellow in **Figure 4-41** and 4 commercial structures shown in the red area along with voluntary buyouts of the remaining 21 residential structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and any structures remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $1.0 M. Many other structures were already purchased in this area after the 2008 flood.

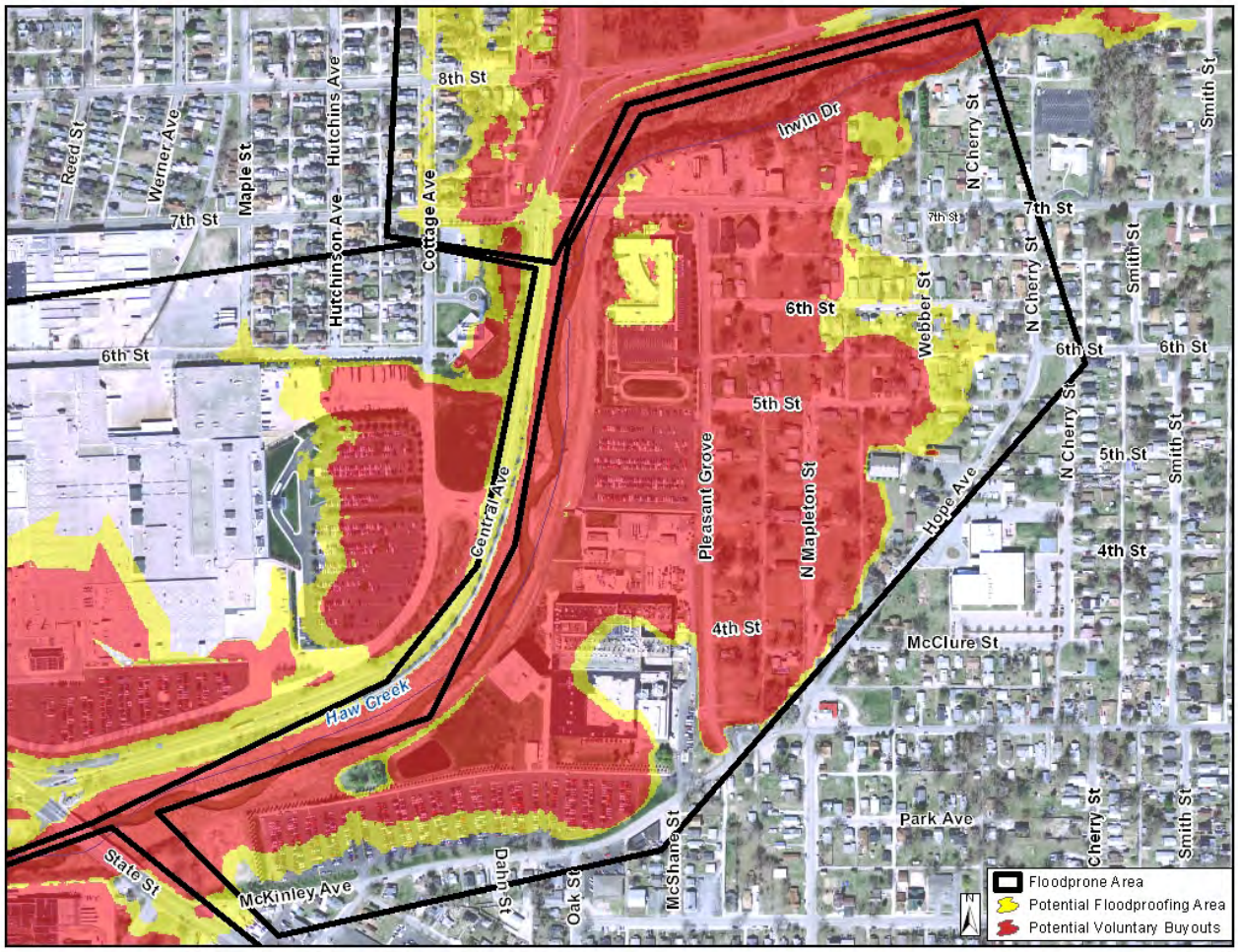

Figure 4-41 Haw Creek Floodproofing/Voluntary Buyout Alternative HC32a - Tech Center/ Pleasant Grove

Haw Creek Floodproofing (Alternative HC31a)

Floodproofing of approximately 7 commercial structures (not including Cummins Engine Plant where a floodwall has been recently constructed) located in the flooded area shown in **Figure 4-42** would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $140 K.

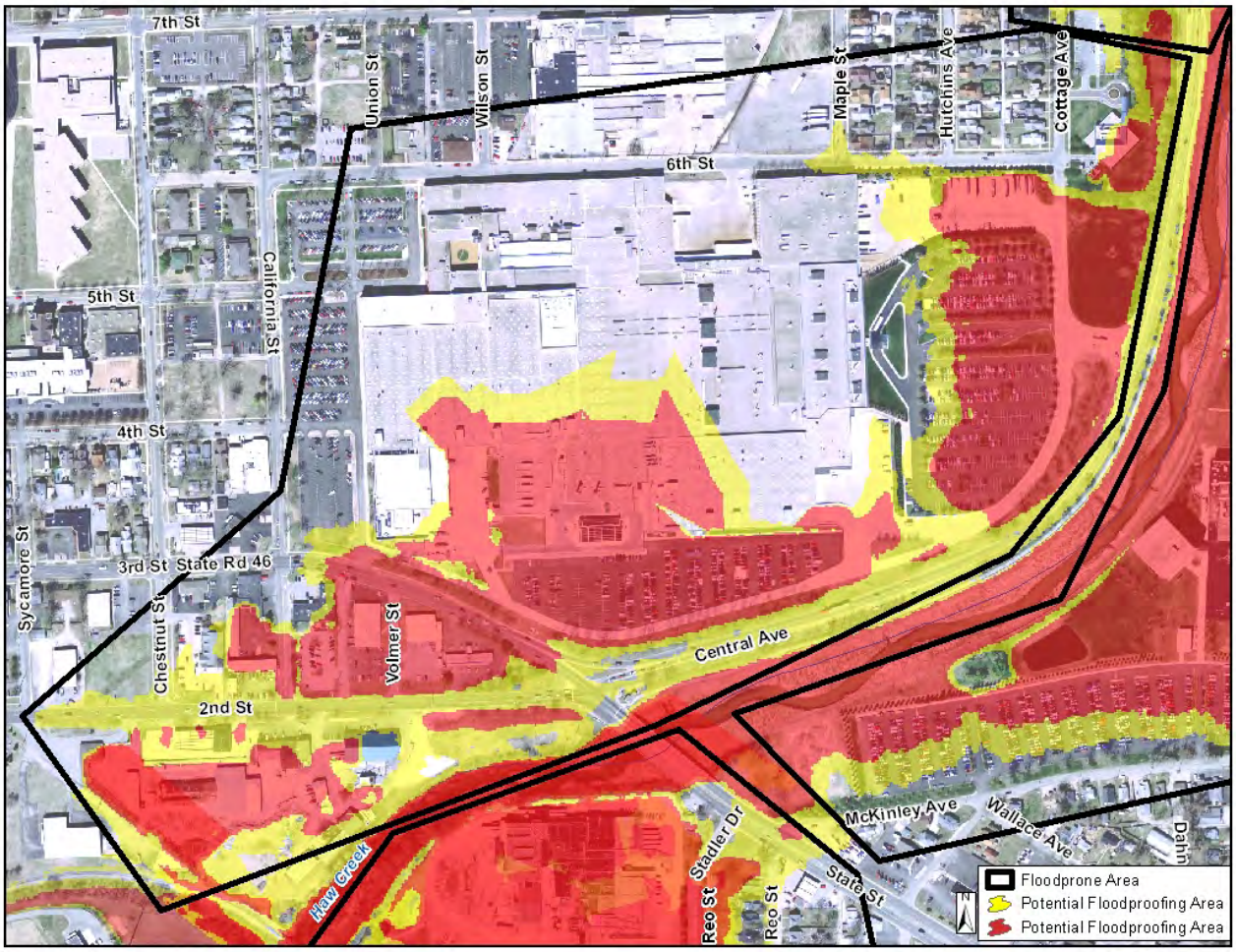

Figure 4-42 Haw Creek Floodproofing Alternative HC31a - CEP/2nd Street

Opossum Creek Levee/Floodwall (Alternative OC7b)

Construction of a levee/floodwall along the conceptual alignment shown as a blue line in **Figure 4-43** (outside the floodprone area) would protect the 2 structures flooded by Opossum Creek outside the floodprone area and improve access along CR 150 West (within the floodprone area) to nearby subdivisions during the 500-year and more frequent flood events. Elimination of the flooding of CR 200 South and further south on CR 150 West would be needed to achieve flood-free access. The estimated construction cost of the levee to protect CR 150 West is $550 K.

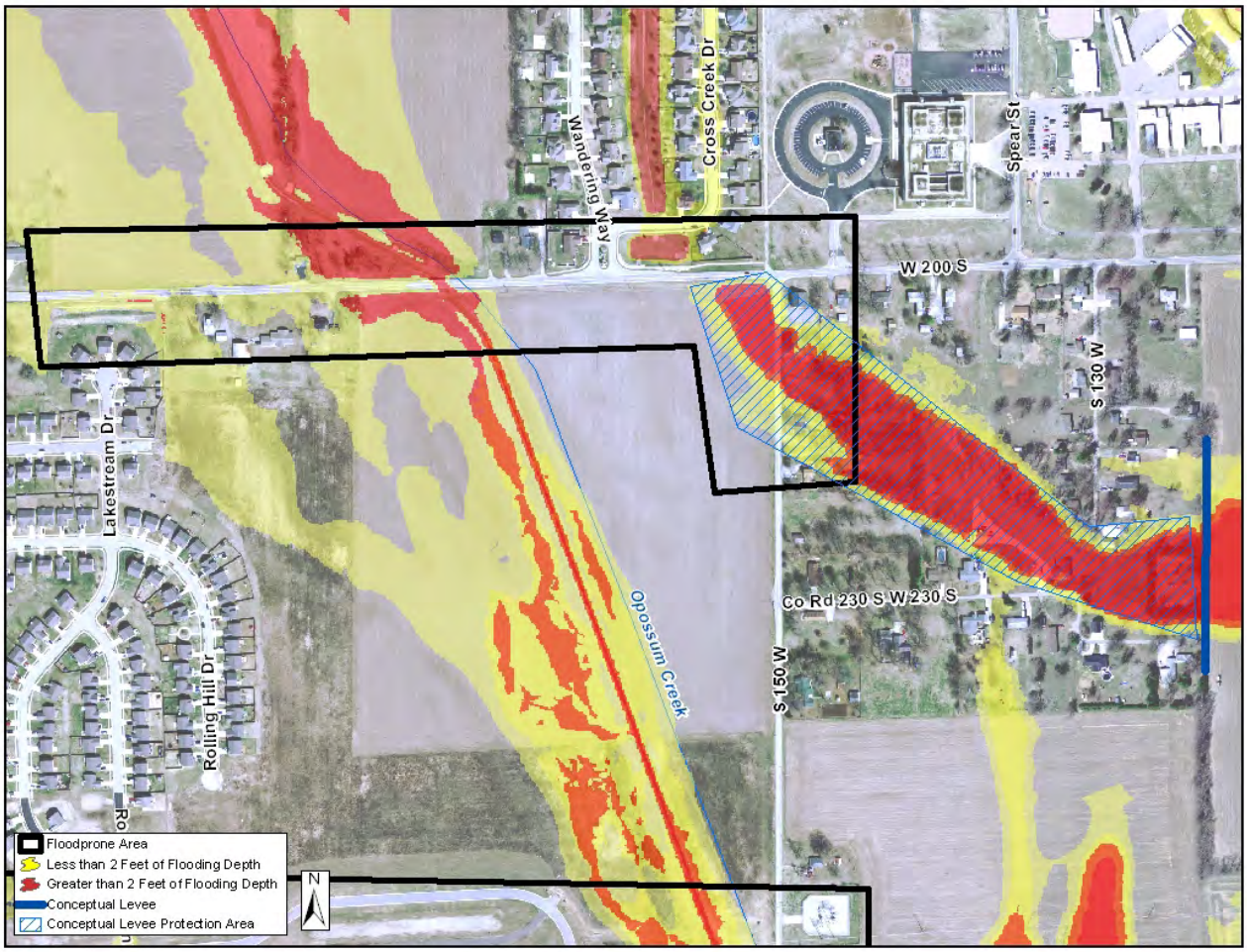

Figure 4-43 Opossum Creek Levee/Floodwall Alternative OC7b - CR 200 South

Sloan Branch Floodproofing (Alternative SB26a)

Floodproofing of approximately 58 residential structures and 7 commercial structures located in the flooded area shown in **Figure 4-44** would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and an additional 185 flood-free structures would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $720 K.

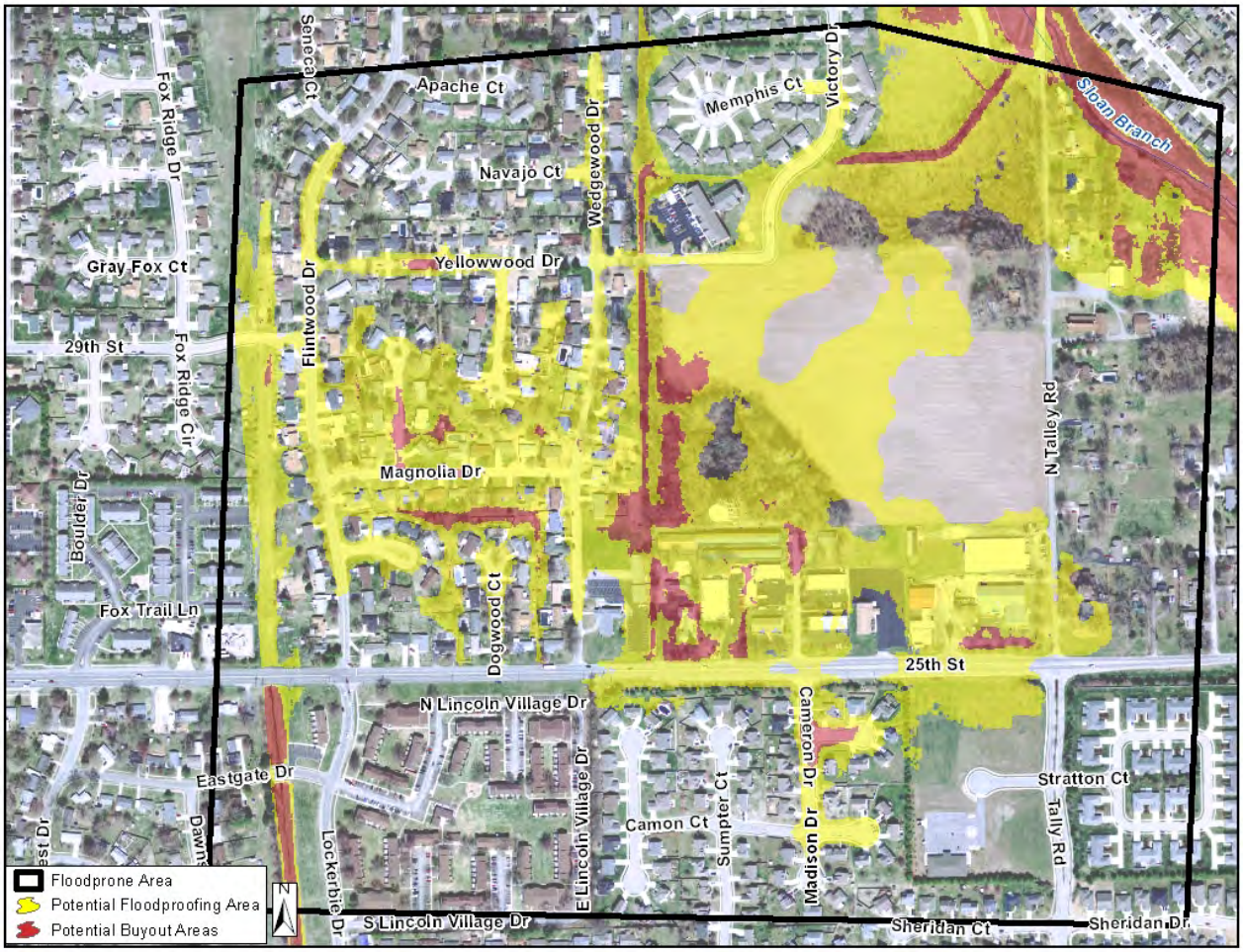

Figure 4-44 Sloan Branch Floodproofing Alternative SB26a – Madison / Grant / Flintwood

Sloan Branch Levee/Floodwall (Alternative SB26b)

Construction of two short levee/floodwalls along the conceptual alignments shown as the two blue lines in **Figure 4-45** would protect about 60 of the 65 flooded structures and allow access to another 130 of the other 185 inaccessible structures during the 500-year event. The estimated construction cost is $350 K.

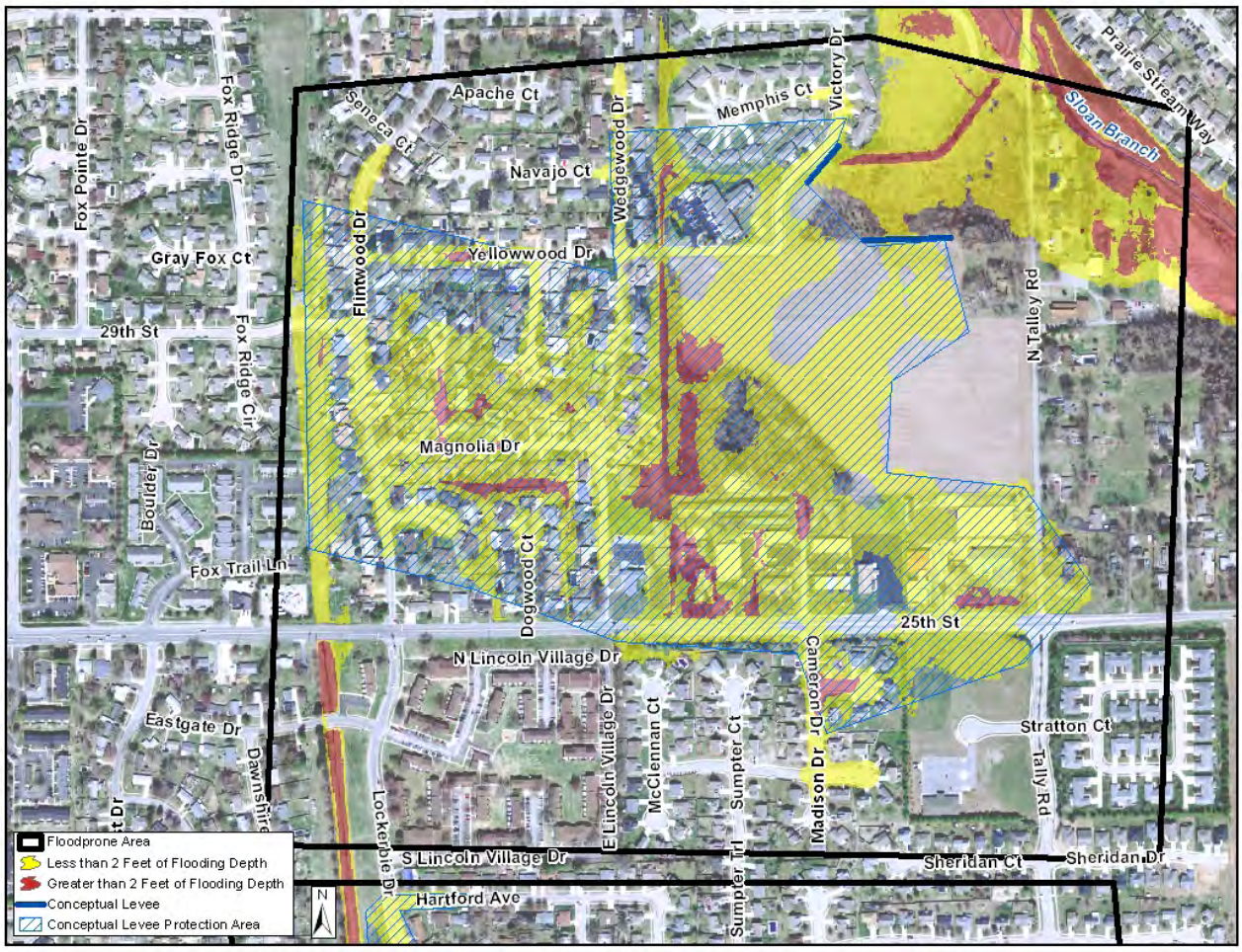

Figure 4-45 Sloan Branch Levee/Floodwall Alternative SB26b – Madison / Grant/ Flintwood

Sloan Branch 2-Stage Ditch Channel Improvement (Alternative SB26C)

Construction of a 2-stage ditch in the area shown in **Figure 4-46** would protect about 30 of the 65 flooded structures and allow access to an additional 5 of the 185 flood-free structures during the 500-year event. This alternative would open up access to the Lutheran Home located in the area. The estimated construction cost is $1.5 M.

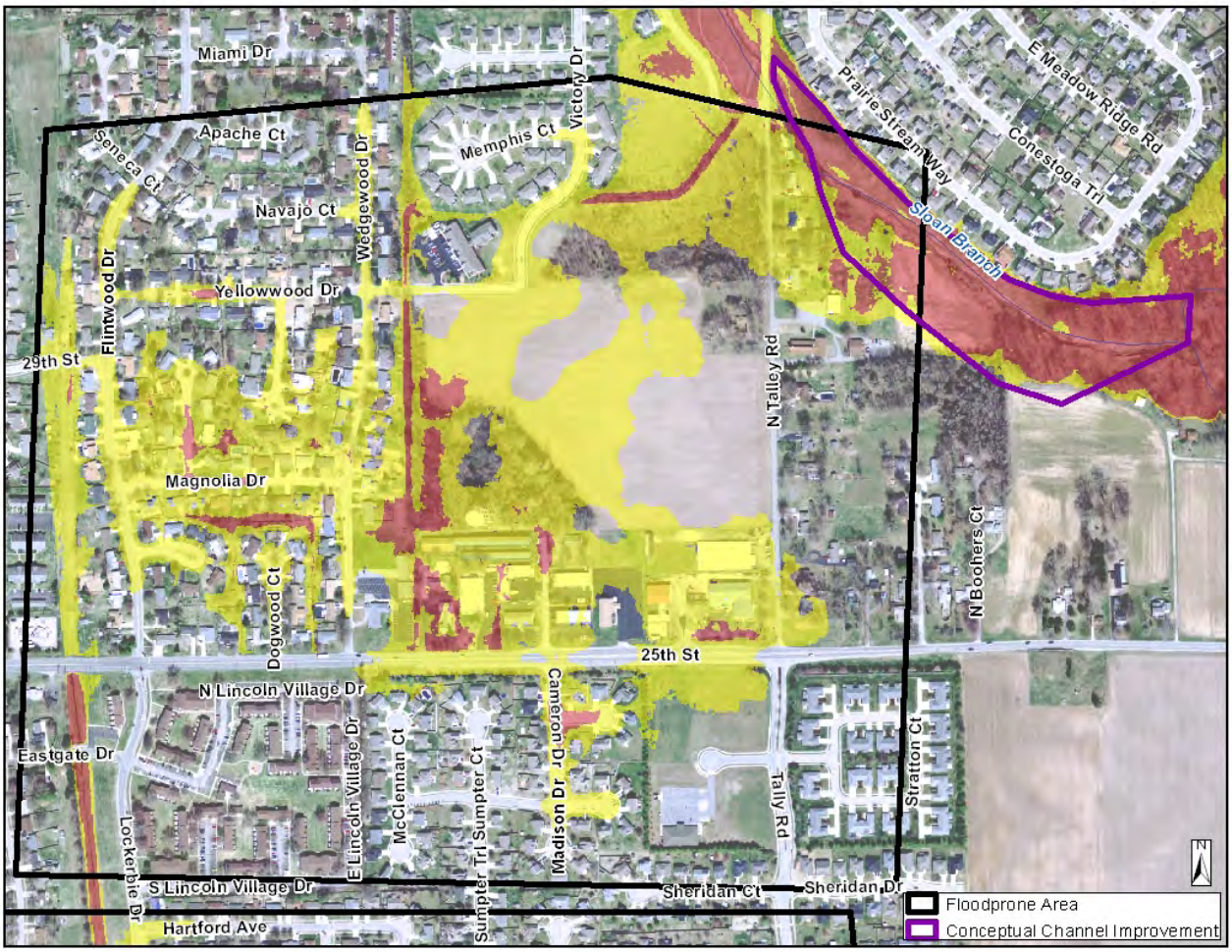

Figure 4-46 2-Sloan Branch Stage Ditch Channel Improvement Alternative SB26C – Madison / Grant / Flintwood

Sloan Branch Floodproofing/Voluntary Buyout (Alternative SB27a)

Floodproofing of approximately 25 structures in the area shown in yellow in **Figure 4-47** along with voluntary buyout of the remaining 5 structures located in the area shown in red would make the structures in the outlined area flood-free in the 500-year flood. All of the floodproofed structures and any structures remaining after the voluntary buyouts would, however, still be inaccessible during the peak of the flood event. The estimated local cost share is $400 K.

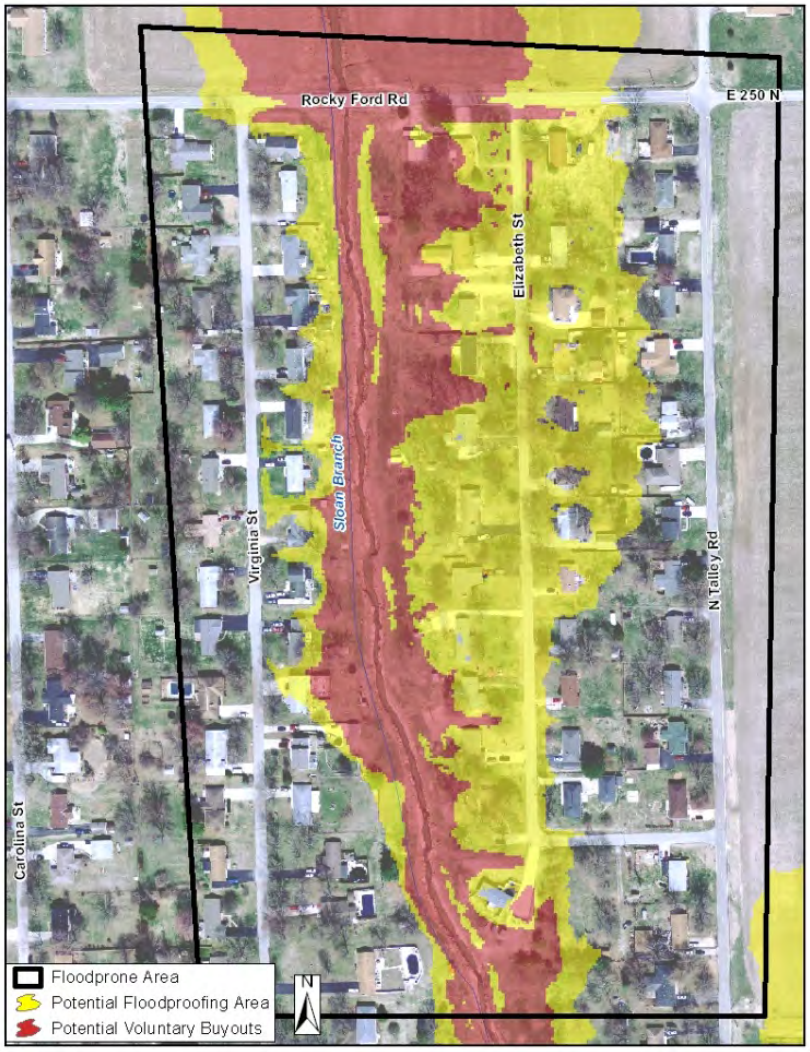

Figure 4-47 Sloan Branch Floodproofing/Voluntary Buyout Alternative SB27a - Eastridge Manor

4.7 PROMISING SOLUTIONS PERFORMANCE SUMMARY

Information regarding each of the promising solutions described above was summarized into tables. Each of these solutions satisfied the initial project performance criteria and goals described at the beginning of this chapter. To assist in the selection and prioritization of these solutions for implementation, a method of color coding the information gathered for each alternative based on factors important to City decision making was developed as indicated in **Table 4-4.** **Table 4-5** provides the summary of gathered information and appropriate color coding on the promising solutions that are within City limits.
Table 4-6 provides similar information for those promising solutions outside the City limits.

Table 4-4 Explanation of Color Coding Used in Summary Table

Selection Factors	Ranking of Selection Factor Values			
	High	Medium	Low	NA/ For Information Only
Return Interval At Which Flooding Begins	<10-50-year	50-100-year	100-500-year	-
Approximate Number of Flooded Structures Protected	50+	10-50	0-10	-
Cost Per Protected Structure	< $30,000	$30,000-$50,000	> $50,000	NC
Approximate Number of Inaccessible Structures that become Accessible	50+	10-50	0-10	-
Protects Critical At-risk Population	yes		no	none in existing 500-yr floodplain
Reduction in Flood Depths that Affect Human Safety	depths reduced to <1 ft	depths reduced to 1-3 ft	depths remain over 3 ft	-
Level of on-going City Administrative, Technical, and/or Financial Resources Required	low	med	High	-
Compensation Required for Potential Impacts	None to low	minor	Significant	-

Table 4-5 Summary of Promising Solutions – Within City Limits

Stream	Floodprone Area	Promising Solution ID	Promising Solutions	Estimated Construction Cost	Return Interval at Which Structure Flooding Begins	Summary of Benefits of Promising Solutions							Comments
						Approximate Number of Flooded Structures Protected (floodproof/ buyout/ commercial floodproof)	Cost per Protected Structure	Approx.# of Inaccessible Structures (not Including Buyouts) That Would Become Accessible During 500-Year Flood	Protects Critical At-Risk Population **** (Yes/No)	Reduction in Flood Depths That Affect Human Safety	Level of On-going City Administrative, Technical, and/or Financial Resource Required	Compensation Required for Potential Impacts	
Clifty Creek	**28 Regency Drive**	CC28b	Levee/ Floodwall	$510 K*	100-500-year	2	$255,000	50	-			Y	
	25 Sandy Hook/ Clifty Crossing	CC25b	Levee/ Floodwall	$1.4 M*	500-year	10	$140,000	60	Y			Y	allows access to Sandy Hook United Methodist Church day care
	24 Wehmeier/ Columbus East	CC24a	Floodproofing/ Voluntary Buyout of Structures	$2.4 M**	50-year	(45/64/1)	$21,818	0	Y			N	would not address accessibility issues
		CC24b	Levee/ Floodwall	$1 M*	50-year	110	$9,091	90	Y			Y	
		CC24c	SR 46 Bridge Replacement	NC	50-year	35	NC	5	Y				Road is already flood free during 500-year event but adding capacity sufficient to remove surcharge created by the bridge could provide protection for the approximately 50 structures upstream of SR 46 flooded during the 100-year event
Driftwood River	**11 Front Door West/ Westhill**	DW11a	Floodproofing	$400 K**	<10-year	(0/0/20)	$20,000	0	-			N	non residential structures
		DW11b	Levee/ Floodwall	$650 K*	<10-year	20	$32,500	25	-			Y	Could allow access to I-65 from the west along SR 46
	10 Front Door East/ Jonathan Moore Pike	DW10a	Floodproofing	$500 K**	<10-year	(0/0/25)	$20,000	0	-			N	non residential structures
		DW10b	Levee/ Floodwall	$4.1 M*	<10-year	25	$164,000	30	-			Y	non residential structures
East Fork White River	**30 Mariah/ Reo Street (X)**	EFK30a	Floodproofing/ Voluntary Buyout of Structures	$740 K**	50-year	(0/24/1)	$29,600	24	-			N	
		EFK30b	Levee/ Floodwall	$2.3 M*	50-year	24	$95,833	24	-			Y	additional levee required around Mariah for its protection
Flatrock River	**45 Riverside Drive North**	FR45a	Floodproofing/ Voluntary Buyout of Structures	$90 K**	10 - 50-year	(3/2/0)	$18,000	0	-			N	
		FR45b	Levee/ Floodwall	$1.4 M*	10 - 50-year	5	$280,000	5	-			Y	
		FR45c	US 31 Bridge Replacement	NC	10 - 50-year	3	NC	2	-				US31 appears to have been replaced since the FIS, based on plans the 100 year water surface is lowered by 0.6' with the new bridge, additional capacity would reduce flood levels more
	22 Long Road	FR22a	Floodproofing	$60 K**	100-year	(0/0/3)	$20,000	0	-			N	structures are not residential
		FR22b	Levee/ Floodwall	$2.5 M*	100-year	3	$833,333	10+	-			Y	requires compensatory measures
	21 Commerce Park	FR21b	Levee/ Floodwall	$1.1 M*	500-year	5	$220,000	15	-			Y	requires compensatory measures
	18 Noblitt Falls	FR18a	Floodproofing/ Voluntary Buyout of Structures	$1.6 M**	50-year	(35/20/0)	$29,091	0	-			N	
		FR18b	Levee/ Floodwall	$3.0 M*	50-year	55	$54,545	55	-			Y	
	17 Washington Street	FR17a	Floodproofing/ Voluntary Buyout of Structures	$3.2 M**	10 - 50-year	(45/90/0)	$23,704	0	-			N	
		FR17b	Levee/ Floodwall	$1.5 M*	10 - 50-year	135	$11,111	135	-			Y	
	16 Indianapolis Road	FR16b	Levee/ Floodwall	$6.9 M*	50-year	20	$345,000	40	-			Y	significant mitigation for lost floodplain storage may be required to negate adverse impacts on flood elevations, large scale economic development area
Haw Creek	**42 Sycamore Bend/ Arrowood**	HC42a	Floodproofing/ Voluntary Buyout of Structures	$150 K**	50 - 100-year	15	$10,000	0	-			N	more detailed modeling required to determine more accurate flood depths in the area
		HC42b	Levee/ Floodwall	$ 1 M	50 - 100-year	15	$66,667	25	-			Y	more detailed modeling required to determine more accurate flood depths in the area and extent of mitigation needed

Stream	Floodprone Area	Promising Solution ID	Promising Solutions	Estimated Construction Cost	Return Interval at Which Structure Flooding Begins	Summary of Benefits of Promising Solutions							Comments
						Approximate Number of Flooded Structures Protected (floodproof/ buyout/ commercial floodproof)	Cost per Protected Structure	Approx.# of Inaccessible Structures (not Including Buyouts) That Would Become Accessible During 500-Year Flood	Protects Critical At-Risk Population **** (Yes/No)	Reduction in Flood Depths That Affect Human Safety	Level of On-going City Administrative, Technical, and/or Financial Resource Required	Compensation Required for Potential Impacts	
Haw Creek	**41 Northbrook/ Candlelight**	HC41a	Floodproofing/ Voluntary Buyout of Structures	$5.3 M**	10 - 50-year	(290/80/0)	$14,324	0	-			N	
		HC41b	Levee/ Floodwall	$1.9 M*	10 - 50-year	370	$5,135	400+	-			Y	
	40 Windsor Place/ Hillcrest	HC40a	Floodproofing/ Voluntary Buyout of Structures	$1.2 M**	10 - 50-year	(70/15/0)	$14,118	0	-			N	
		HC40b	Levee/ Floodwall	$1.6 M*	10 - 50-year	85	$18,824	85+	-			Y	may still be flooding from overflow of the tributary north of Rocky Ford Road
	38 Everoad Park West/ Eastbrook	HC38a	Floodproofing/ Voluntary Buyout of Structures	$3.2 M**	50-year	(110/70/0)	$17,778	0	-			N	
		HC38b	Levee/ Floodwall	$4.3 M*	50-year	180	$23,889	190+	-			Y	
	37 Everoad Park East	HC37b	Levee/ Floodwall	$1.8 M*	10 - 50-year	55	$32,727	75	-			Y	
	36 Midway	HC36a	Floodproofing/ Voluntary Buyout of Structures	$480 K**	50 - 100-year	(20/8/2)	$16,000	0	Y			N	Columbus Health & Rehabilitation located in this area
		HC36b	Levee/ Floodwall	$1.3 M*	50 - 100-year	30	$43,333	32	Y			Y	Columbus Health & Rehabilitation located in this area
	34 17th/ Keller	HC34a	Floodproofing/ Voluntary Buyout of Structures	$780 K**	50 - 100-year	(35/13/2)	$15,600	0	-			N	
		HC34b	Levee/ Floodwall	$900 K*	50 - 100-year	50	$18,000	50	-			Y	
	33 10th/ Central	HC33a	Floodproofing/ Voluntary Buyout of Structures	$3.7 M**	<10-year	(70/100/0)	$21,765	0	-			N	
	32 Tech Center/ Pleasant Grove	HC32a	Floodproofing/ Voluntary Buyout of Structures	$1.0 M	10 - 50-year	(25/21/4)	$20,000	0	-			N	Reasonable area to buyout since several homes have already been bought out after 2008 flooding, Cummins Childcare Center could be individually floodproofed, a floodwall has been constructed to protect CTC.
	31 CEP/ 2nd Street	HC31a	Floodproofing	$140 K**	100-year	(0/0/7)	$20,000	0	-			N	CEP has constructed floodwall for flood protection
Opossum Creek	**7 CR 200 South**	OC7b	Levee/ Floodwall	$550 K*	500-year	2	$275,000	access allowed to additional areas	-			Y	construct east of CR 130 W to prevent backwater from entering subdivision and flooding CR 150 W
Sloan Branch	**26 Madison/ Grant/ Flintwood**	SB26a	Floodproofing	$720 K**	<10-year	(58/0/7)	$11,077	0	N				access to structures would still be an issue
		SB26b	Levee/ Floodwall	$350 K*	50 - 100-year	60	$5,833	190	Y			Y	Lutheran Home access would be protected by this alternative, flood frequency is noted for the area of the structures this alternative addresses
		SB26c	2-Stage Ditch Channel Improvement	$1.5 M	<10-year	30	$50,000	35	Y			Y	Lutheran Home is in this area, combining this alternative with a small berm may make this alternative have the same benefits as the bypass alternative (very close to 100 year protection is provided without the extra berm)
	27 Eastridge Manor	SB27a	Floodproofing/ Voluntary Buyout of Structures	$400 K**	10-year	(25/5/0)	$13,333	0	-			N	

(X) also experiences flooding from tributary - data provided is for protection of flooding from both East Fork White River and the tributary

NC cost not calculated

* Does not include costs for mitigation of negative impacts to flood elevations (such as channel improvements, compensatory floodplain storage, detention,...) that may be needed

** Estimate for commercial structures based on $20,000 City cost share for each floodproofed structure only. Estimate for residential structures based on $10,000 City cost share for each floodproofed structure plus 25% City cost share of 120% of assumed average structure value of $100,000 ($200,000 for area 18) for each buyout structure assuming FEMA grant programs are used

*** Estimate is for only the excavation portion of the construction costs

**** Includes apartment complexes, childcare centers, nursing homes, schools, and other similar facilities

Notes: Results for alternatives are for 500 year protection. Comments regarding impacts of alternative at other frequencies are noted where applicable.

Table 4-6 Summary of Promising Solutions – Outside City Limits

Stream	Floodprone Area	Promising Solution ID	Promising Solutions	Estimated Construction Cost	Return Interval at Which Structure Flooding Begins	Summary of Benefits of Promising Solutions							Comments
						Approximate Number of Flooded Structures Protected (floodproof/ buyout/ commercial floodproof)	Cost per Protected Structure	Approximate Number of Inaccessible Structures (not Including Buyouts) That Would Become Accessible During 500-Year Flood	Protects Critical At-Risk Population **** (Yes/No)	Reduction in Flood Depths That Affect Human Safety	Level of On-going City Administrative, Technical, and/or Financial Resources Required	Compensation Required for Potential Impacts	
Driftwood River	**15 Tellman Camp Road**	DW15a	Floodproofing/ Voluntary Buyout of Structures	$950 K**	<10-year	(5/30/0)	$27,143	0	-			N	
East Fork White River	**9 Garden City**	EFK9a	Floodproofing/ Voluntary Buyout of Structures	$2.3 M**	<10-year	(50/60/0)	$20,909	0	-			N	
	8 Huffman Drive/ WWTP	EFK8a	Floodproofing	$50 K**	100 - 500-year	(5/0/0)	$10,000	0	-			N	
	5 SR 11 South (X)	EFK5a	Floodproofing/ Voluntary Buyout of Structures	$950 K**	<10-year	(20/25/0)	$21,111	0	-			N	remaining structures would still be inaccessible during flood events on Denios Creek and East Fork White River due to flooding of SR 11 and Dawson Street
		EFK5aa	Voluntary Buyouts of all Flooded & Inaccesible Structures	$1.7 M**	<10-year	(0/55/0)	$30,909	55	-			N	
		EFK5b	Combination: levee and mitigation (channel improvement or buyouts)	$1.9 M*	<10-year	45	$42,222	0	-			Y	levee and buyout of 5 parcels in the floodway, still inaccessibility issues due to major flooding of SR 11 from East Fork White River
East Fork White River	**4 Bethel Village (X)**	EFK4a	Floodproofing/ Voluntary Buyout of Structures	$2.8 M**	<10-year	(100/60/0)	$17,500	0	-			N	remaining structures would still be inaccessible during flood events on Denios Creek and East Fork White River due to SR 11 flooding
		EFK4aa	Voluntary Buyouts of all Flooded & Inaccesible Structures	$6.0 M**	<10-year	(0/200/0)	$30,000	200	-			N	
		EFK4b	Combination: levee and mitigation (channel improvement or buyouts)	$3.3 M*	<10-year	160	$16,500	200	-			Y	levee & buyout of 10 structures in floodway (assumed permitable location), requires continuation of RR as levee

(X) also experiences flooding from tributary - data provided is for protection of flooding from both East Fork White River and the tributary

NC cost not calculated

* Does not include costs for mitigation of negative impacts to flood elevations (such as channel improvements, compensatory floodplain storage, detention,...) that may be needed

** Estimate for commercial structures based on $20,000 City cost share for each floodproofed structure only. Estimate for residential structures based on $10,000 City cost share for each floodproofed structure plus 25% City cost share of 120% of assumed average structure value of $100,000 ($200,000 for area 18) for each buyout structure assuming FEMA grant programs are used

*** Estimate is for only the excavation portion of the construction costs

**** Includes apartment complexes, childcare centers, nursing homes, schools, and other similar facilities

Notes: Results for alternatives are for 500 year protection. Comments regarding impacts of alternative at other frequencies are noted where applicable.

Based on comparison of the data shown in Table 4-5, the following solutions appear to provide the most flood protection benefit for the money for the floodprone areas within the City limits. The locations of these solutions are shown on **Exhibit 41**.

- CC24b – levee/floodwall in Wehmeier/Columbus East area ($1 M)
- DW11b – levee/floodwall in the Front Door West/ Westhill area ($650 K)
- DW10a – floodproofing of structures in Front Door East/ Jonathan Moore Pike area ($500 K)
- EFK30a – floodproofing/ voluntary buyout of structures in the Mariah/ Reo Street area ($740 K)
- FR45a – floodproofing/ voluntary buyout of structures in the Riverside Drive North area ($90 K)
- FR18b – levee/floodwall in the Noblitt Falls area ($3.0 M) (could be done in conjunction with FR17b levee)
- FR17b – levee/floodwall in Washington Street area ($1.5 M) (could be done in conjunction with FR18b levee)
- HC41b – levee/floodwall in Northbrook/Candlelight area ($1.9 M)
- HC40b – levee/floodwall in Windsor Place/ Hillcrest area ($1.6 M)
- HC38b – levee/floodwall in the Everoad Park West/ Eastbrook area ($4.3 M)
- HC37b – levee/ floodwall in the Everoad Park East area ($1.8 M)
- HC36b – levee/ floodwall in the Midway area ($1.3 M)
- HC34b – levee/ floodwall in the 17th/ Keller area ($780 K)
- HC33a – floodproofing/voluntary buyout of structures in 10th/ Central area ($3.7 M)
- HC32a – floodproofing/voluntary buyout of structures in the Tech Center/Pleasant Grove area ($1.0 M)
- SB26b – levee/ floodwall for a portion of the Madison/ Grant/ Flintwood area ($350 K)
- SB27a – floodproofing/voluntary buyout of structures in Eastridge Manor area ($400 K)

  (Note that HC 41b, 40b, 38b, 37b, 36b, and 34b are all in relatively close proximity to each other and, combined, may eliminate significant floodplain conveyance and storage. Therefore it is recommended that the initial engineering for these areas be done at the same time in

order to efficiently identify any measures necessary to offset negative impacts. Floodproofing and voluntary buyouts would be left as alternatives for the areas that would not be able to be protected by levees.)

These are the most promising solutions at this point in time. Other selection factors may change the priorities as funding options are investigated and additional data is gathered in the process of implementing Plan recommendations.

Since no one project was found to significantly benefit at least most of the neighborhoods along Haw Creek and because of the interest generated after the 2008 flooding in various options for reducing flooding, additional analysis was done of potential solutions along Haw Creek and their impact on lesser floods. The potential solutions of interest were:

- Replace all bridges such that they do not increase upstream flood elevations,
- Widen the RR bridge opening (an increase in 50 feet, the probable maximum available increase, was selected for analysis) and create a longer transition upstream and downstream between the existing channel and wider opening,
- Channel clearing, that is clearing the channel and channel slopes of woody debris and woody vegetation from the RR upstream to Rocky Ford, and
- Channel dredging (assumed 2 foot lower channel bottom and 50 foot wide from 8th Street upstream to Marr Road and flat bottom at existing invert between the floodwalls from RR to 8th Street, in-line dams would also be removed). Maneuverability and access issues for machinery to accomplish the dredging exist as well as many permitting issues to overcome. There is also a good chance that the dredged area will fill back in and require the project to be done again to maintain the flow capacity.

Table 4-7 summarizes the findings of this additional analysis. **Figure 4-48**, **Figure 4-49**, and **Figure 4-50** show the 100-year floodplain differences between the existing condition and each potential solution. The floodplain difference for widening the RR bridge opening is the same as that for replacing all bridges except that the differences shown upstream of 7th Street do not occur. Floodplain differences just upstream of the railroad are shown

only for Haw Creek as the flooding source. The regulatory floodplain in this area is controlled by White River flood elevations which will not be altered by enlarging the railroad bridge opening.

Table 4-7 Summary of Benefits for Additional Potential Solutions for Haw Creek

Potential Solution	Estimated Construc- tion Cost	Summary of Benefits		
		Frequency	Street Flooding	Structure Flooding
Replace all bridges	Millions of dollars per bridge	10- & 50- year	Slight reduction in extent in 10th Street area	Slight reduction in number of flooded structures in 10th St area
		100-year	Eliminated for Everoad Park West/ Eastbrook	Some reduction in number of flooded structures in Windsor Place/ Hillcrest
		500-year	-	Eliminates flooding of a few of the many flooded structures in the Windsor Place/ Hillcrest, 17th & Keller, Everoad West/ Eastbrook, & Everoad East areas
Widen RR Bridge Opening	$600 K	10- to 500-year	~ 1 ½ foot reduction in Haw Creek flood stages at the RR transitioning to no reduction upstream of 7th Street. White River flood elevations are still higher than Haw Creek flood elevations for at least 500 feet upstream of the RR so the area will remain vulnerable to floods.	
		100- & 500-year	Would reduce flooding over the RR tracks due to Haw Creek but still would flood from White River	Eliminates flooding of a few structures in the Reo Street area
Channel Clearing	$500 K - $750 K (repeated cost to maintain)	10-year	Eliminate most street flooding in 10th Street area	Eliminates flooding of most of the structures in 10th Street area
		50- year	-	Eliminates flooding of the few flooded structures in Everoad Park West/ Eastbrook and Northbrook/ Candlelight areas
		100- year	Eliminated in Everoad Park West/ Eastbrook, Everoad Park East, and much of Windsor Place/ Hillcrest and Northbrook/ Candlelight areas	Eliminates flooding of some structures in Northbrook/ Candlelight and Windsor Place/ Hillcrest areas
		500- year	-	Eliminates flooding of a few of the several flooded structures in the Windsor Place/ Hillcrest area and several structures in the Northbrook/ Candlelight areas
Channel Widening/ Dredging	$6 M based on extrapolation of recent contractor estimate	100-year	Eliminate some in Northbrook/ Candlelight and 10th Street areas, eliminate in Everoad Park West/ Eastbrook and Winsor Place/ Hillcrest areas	Eliminates flooding of some structures in Northbrook/ Candlelight and 10th Street areas, eliminates flooding of all structures in Everoad Park East and Windsor Place/ Hillcrest areas

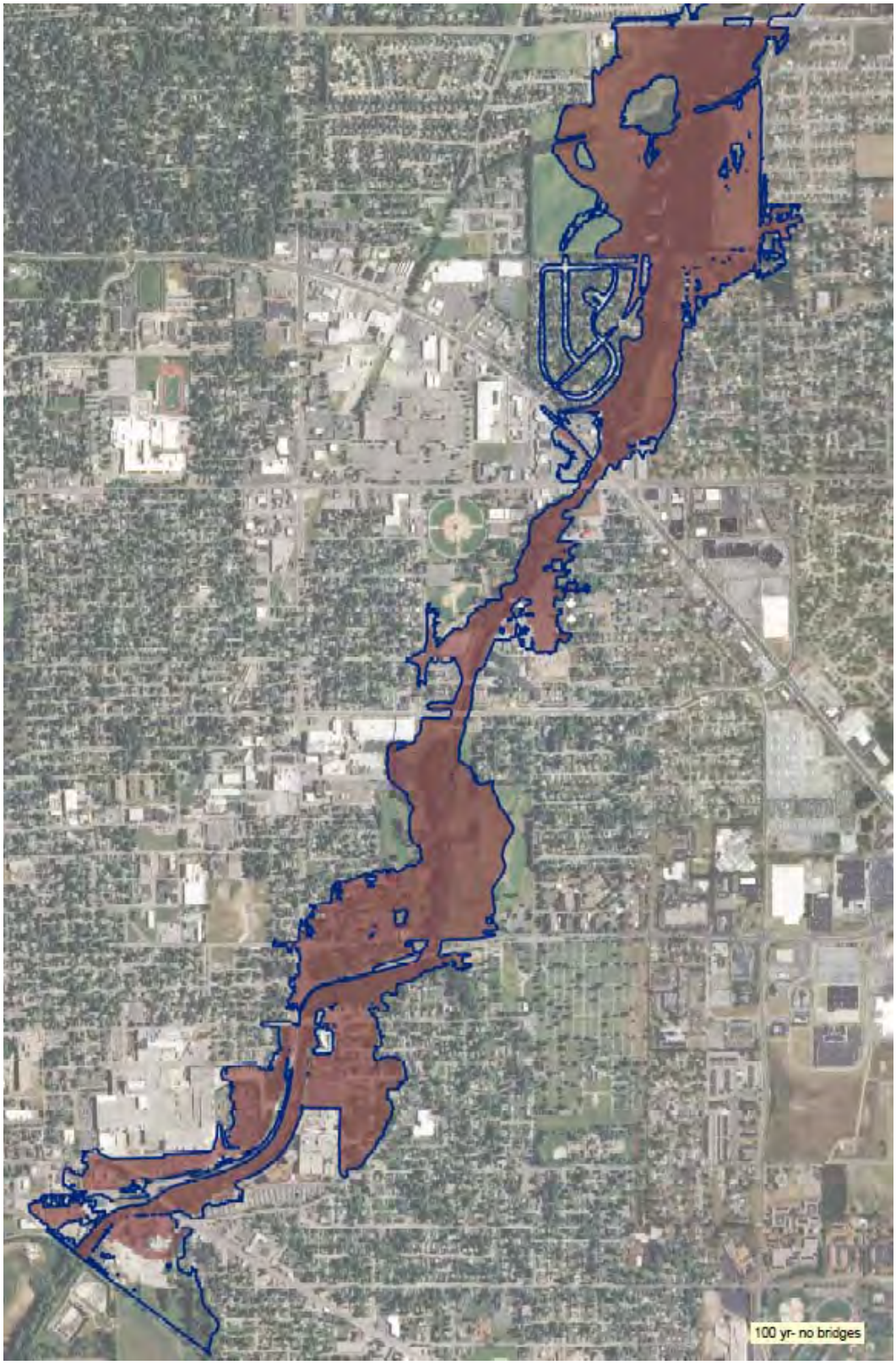

Figure 4-48 Existing Condition 100-Year Floodplain (blue outline) Compared to Floodplain if No Bridge Restrictions (solid brown)

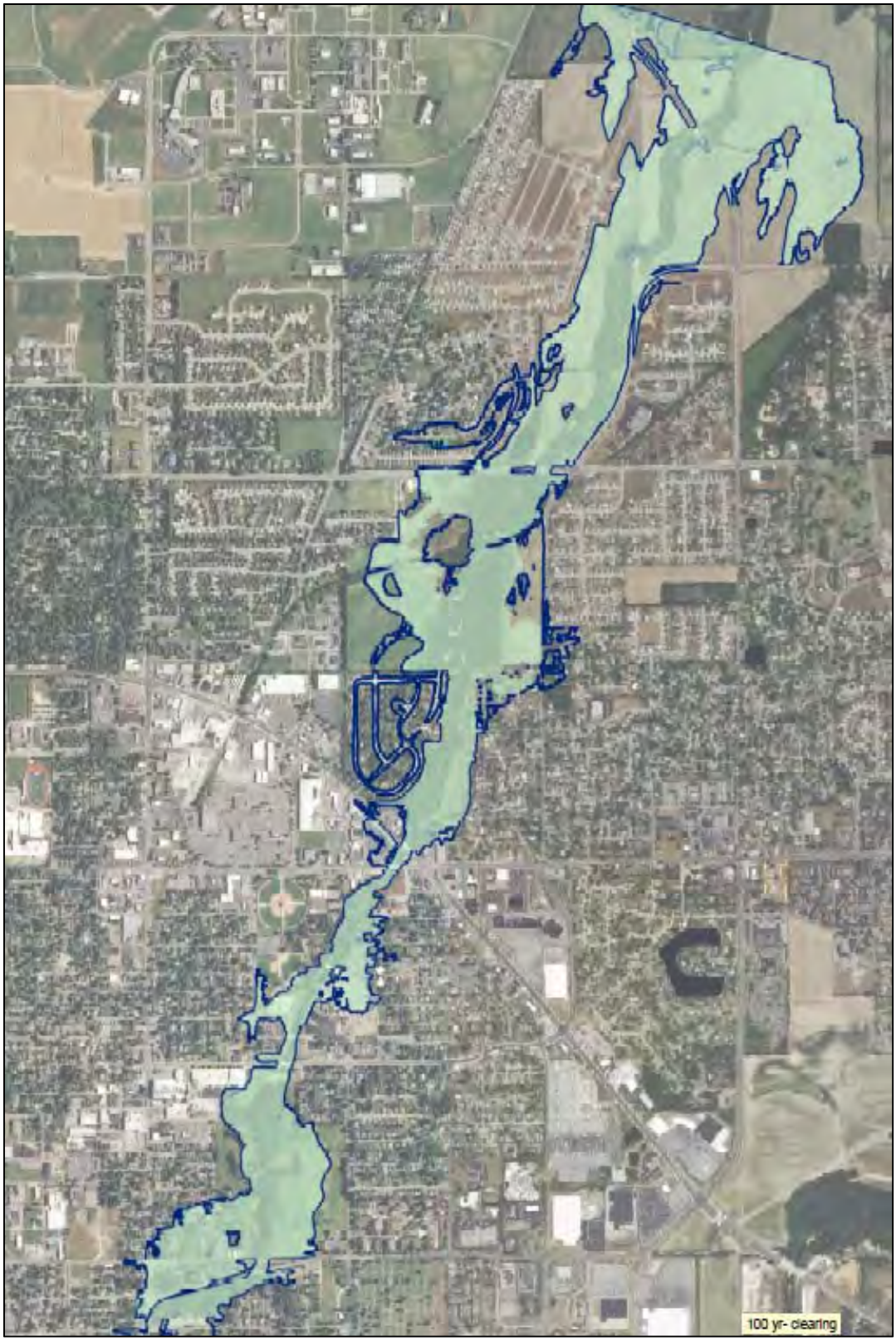

Figure 4-49 Existing Condition 100-Year Floodplain (blue outline) Compared to Channel Clearing Option Floodplain (solid green)

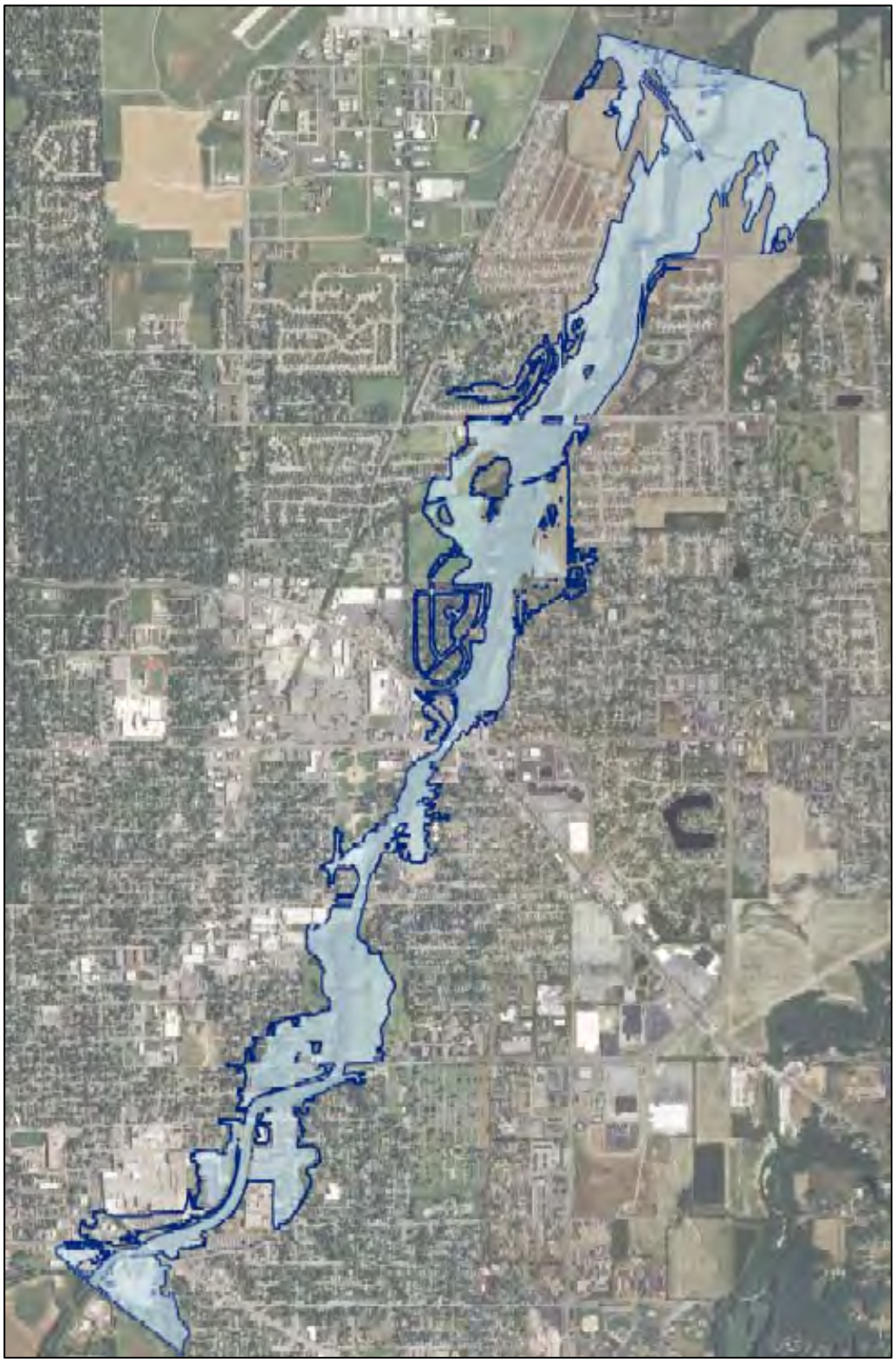

Figure 4-50 Existing Condition 100-Year Floodplain (blue outline) Compared to Channel Widening/Dredging Option (solid blue)

"Complete and permanent" 500-year protection of structures along Haw Creek cannot be achieved by these solutions. Subdivision/individual level protection as previously noted is required. However, channel clearing can provide up to 1 foot of reduction in flood elevations and provide a slight reduction in flood impacts or, in combination with the subdivision/ individual level protection, may reduce the required elevations of the protection measures. Periodic channel cleaning is also a preventive maintenance activity that keeps the channel from losing its carrying capacity causing increased stages during flooding. Replacement of bridges and approaches is described in Section 4.8.

4.8 TRANSPORTATION ROUTES

In addition to the floodprone areas discussed above, there are major transportation routes (as identified in the FREP) that are floodprone. Additional routes, although not identified as major, are also floodprone and impact movement around the city. In order to assist the City in decision making regarding road/bridge reconstruction needs and priorities, the following data was collected on the noted roads:

- streams and the road segments they potentially flood
- whether the road crosses the stream or is just along it in the floodplain
- whether designated as a major transportation route in the FREP
- 500-year flood-free status for road segments
- Whether the road segment is in the City limits
- promising solutions that will benefit road segments

Based on the available information, 17th Street over Haw Creek and SR 46 (State Street) and US 31 over Clifty Creek are the only flood-free stream crossings along a major cross-town thoroughfare during a major event such as the 500-year storm event. These alone do not allow sufficient access within or into and out of the City. Since none of the promising solutions for the floodprone areas reduce the major road flooding, bridge capacities will need to be increased and approaches or other road segments will need to be raised (with appropriate mitigation of any resulting flood elevation increases) in order to create the needed flood-free routes.

To visually aid in the prioritization of bridge/road replacements to create flood-free routes, the color coding shown in **Table 4-8**was used in **Table 4-9**. Based on this color coding scheme, the more green shown for a bridge/road, the greater the need for replacement of that bridge/road.

Table 4-8 Color Codes for Transportation Routes

Factor	Ranking of the Need For Replacement		
	High	Medium	Low
FREP Identified Major Transportation Route	Yes		No
Flood-free at 500-Year flood	No		Yes
Within City Limits	Yes		No
Bridge Replacement is Promising Solution for Floodprone Area	Yes	No	

Table 4-9 Summary of Road Flood Reduction Consideration

Stream	Road	Crosses Stream	In Floodplain but Doesn't Cross Stream	Major Transportation Route Identified in FREP	Road Segment is Flood-free at 500-Year Flood	Within City Limits	Flooprone Areas for Which Bridge Replace-ment is a Promising Solution	Promising Solution would Benefit Road
East Fork White River	Southern Crossing	X		Y	N	N		
	Gladstone Avenue		X	Y	N	N		
	CR 800 S	X		Y	N	N		
	SR 11		X**	Y	N	Y		
	SR 46	X		Y	N	Y		
Denios Creek	SR 11	X		Y	N	Y		
	Railroad	X		N	N	N		
	CR 150 W	X		N	N	N	6	
Sloan Branch	25th Street	X		Y	N	Y		SB26c - slight
Opossum Creek	CR 150 W	X		N	N	Y	6	
	CR 200 S	X		N	N	N		
	SR 11	X		Y	N	Y		
	Railroad	X		N	N	N		

Stream	Road	Crosses Stream	In Floodplain but Doesn't Cross Stream	Major Transportation Route Identified in FREP	Road Segment is Flood-free at 500-Year Flood	Within City Limits	Flooprone Areas for Which Bridge Replace-ment is a Promising Solution	Promising Solution would Benefit Road
Flatrock River	US 31	X		Y	N	Y	45, 22	
	CR 400 N	X		Y	N	N		
	Indianapolis Road	X		Y	N	Y		
	CR 550 N	X		Y	N	N		
Clifty Creek	US 31	X		Y	Y	Y		
	SR 46	X		Y	Y	N	24	
	Gladstone Avenue	X		Y	N	N		
Haw Creek	Marr Road	X		Y	N	N		
	10th Street	X		Y	N	Y		
	SR 46 (State Street)	X		Y	N	Y		
	CR 450 N	X		Y	N	N		
	Rocky Ford	X		Y	N	Y		
	US 31	X		y	N	Y		
	25th Street	X		Y	N	Y		
	17th Street	X		Y	Y	Y		
Driftwood River	Lowell Road	X		Y	N	N		
	Jonathan Moore Pike		X	Y	N	Y		DW11b
	CR 325 W		X	N	N	N		

* replaced since FIS and now bridge is flood-free but approaches still flood and bridge still impacts upstream flooding

** high traffic volumes and frequent flooding

Based on the information above, a list of recommended priorities is provided below for creating additional flood-free access routes when the opportunity arises in conjunction with the City Thoroughfare Plan.

Critical Transportation Routes – High Priority

US 31 is a critical route through the City. SR 11 is a high traffic volume road that floods often and prevents access to significant areas. SR 46 (State Street) serves as a good secondary route thru the City with access to I-65. Therefore, these roads have been selected as the most critical to make flood-free at all crossings through the City. This includes bridges themselves as well as approaches and other road segments in the floodplain.

Following is a list of all of the stream crossings or floodplain road segments on these 3 routes through the City and their current floodprone status and impact on surrounding flooding, if applicable. Those stream crossings or road segments noted as "floodprone" will need to be upgraded to create a continuous flood-free route. The numbered segments are shown on **Figure 4-51**.

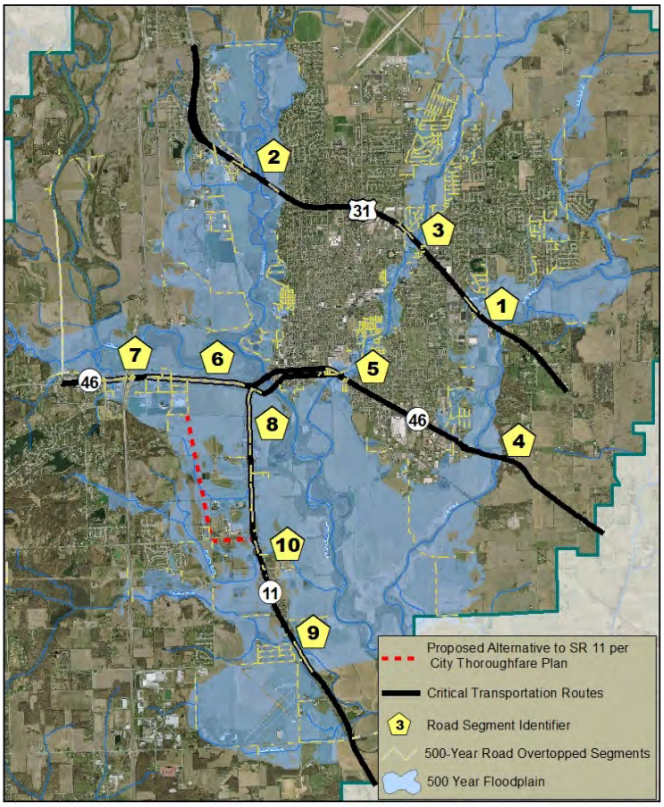

Figure 4-51 High Priority Flood-Free Transportation Routes

US 31

1) Clifty Creek bridge – already flood-free
2) Flatrock River bridge – floodprone approaches, bridge capacity increases may also benefit floodprone areas 45 and 22
3) Haw Creek bridge/ approaches – floodprone

SR 46

4) Clifty Creek bridge – already flood-free but additional capacity may benefit floodprone area 24
5) Haw Creek approaches – floodprone, adjoining site constraints west of the bridge impact the ability to accomplish this so replacement should be done in coordination with any selected mitigation solution for Floodprone Area HC31
6) East Fork White River to I-65 (to allow access to I-65 from the east) – floodprone, additional constraints impact this reach due to floodway needs, also should be coordinated with any selected mitigation solution for Floodprone Area DW10
7) I-65 interchange (to allow access from east to west of I-65) – floodprone, the levee promising solution DW11b may also address this floodprone interchange

SR 11

8) along East Fork White River south of SR 46 - floodprone
9) Denios Creek bridge/ approaches – floodprone, bridge capacity increase could also benefit Floodprone Areas 4 and 5
10) Opossum Creek bridge/ approaches – floodprone, bridge capacity increases could also benefit Floodprone Area 7

Because options to make these locations flood-free are so limited due to the need to allow significant flow area from Driftwood River overflow to the East Fork White River, as well as other considerations, a parallel road to the west between CR 200 S and SR 46 is being considered as part of the Columbus Thoroughfare Plan. This proposed alternate road along with the high priority US 31 and SR 46 flood-free routes are shown in Figure 4-51.

Major Transportation Routes – Medium Priority

Indianapolis Road serves as access to a major development area. It is therefore noted as a major transportation route for the City. Following is a list of the Indianapolis Road segments in the City that are impacted by floodplains and will therefore need to be upgraded to create a continuous flood-free route.

Indianapolis Road

- Flatrock River bridge/ approaches – floodprone
- along Flatrock River to the north of the stream crossing - floodprone

Additional Transportation Routes within the City – Low Priority

Following are additional floodprone roads and the streams they cross within the City that should be considered for improvements to reduce flooding of the bridge and/or bridge approaches:

- 10th St at Haw Creek
- 25th Street at Clifty Creek and Haw Creek
- Rocky Ford at Haw Creek

Additional Routes Near or Outside of the City Limits – Lowest Priority

Following are additional floodprone stream/floodplain crossings that are near enough to the City limits to have some importance for flood-free access to and from the City and should eventually be considered for improvements to reduce flooding of the bridge and/or bridge approaches:

- Southern Crossing at East Fork White River
- Gladstone Avenue at Clifty Creek and along East Fork White River
- CR 400 N over Flatrock River and Big Slough
- CR 550 N over Flatrock River and Big Slough
- CR 450 N over Haw Creek
- Marr Road over Haw Creek
- CR 800 S over East Fork White River

For the stream crossings noted above, the bridge itself and/or approaches can be raised and additional flow capacity under the road can be added to prevent increases in flood stages. For road segments noted above that do not cross the stream, the road can be raised and sufficient openings added under the road to maintain connection to the floodplain storage area. Efforts to increase the number of flood-free routes should be made according to the priorities listed above. Other road/bridge improvements should also be considered when can be done as part of another project. The City should maintain an awareness of these priorities as it receives notice of proposed road replacements by others as well as improvements it pursues on its own.

4.9 DESCRIPTION OF SOLUTIONS CONSIDERED TO REDUCE FUTURE CONDITION FLOOD VULNERABILITY

It is often said that “an ounce of prevention is worth a pound of cure”. Preventing an increase in flood vulnerability within the planning jurisdiction of the City of Columbus is an important component of the long-term vision for a flood-sustainable Columbus.

One such prevention tool is a maintenance program of checking for and removing debris in the stream channels (especially at bridges) before it accumulates to the point of increasing flood stages. There are several other major factors that can contribute to potential increases in flood stages as well. Based on an

extensive body of research, previous studies, and observation of gaged streams these are:

1. Uncompensated encroachment to flow conveyance paths along the stream corridor;
2. Uncompensated loss of floodplain storage along the stream corridor;
3. Uncompensated increase in runoff volumes and peaks due to new development and redevelopment in the watershed; and
4. Climate change.

An earlier detailed study of the Haw Creek watershed by CBBEL supported these items as factors by showing that the extent and magnitude of flooding along Haw Creek would likely become worse without the implementation of strict measures to ensure that the peak discharge, velocity, and volume of runoff are not increased as further modifications and developments occur within the watershed. This finding is consistent with studies done in other watersheds throughout the nation and is equally applicable to other watersheds affecting the City. To address some of the most urgent concerns identified in the noted study, the City amended their ordinance to add controls on development in the flow paths of Haw Creek that were identified outside of the FIS floodway (and floodplain in some instances).

The City has also been working on improving these efforts to limit increased flooding with the establishment of a Floodplain Regulation Study Committee. This committee reviewed the existing Floodplain ordinance and floodplain policies of the City and made several recommendations for revisions. With the incorporation and implementation of the committee recommendations, the City will have a comprehensive floodplain ordinance to prevent increased flood vulnerability due to future development to the extent reasonably possible.

One item that was considered by the study committee but was not recommended for inclusion at this time was the requirement for compensatory floodplain storage. The idea behind this requirement is the replacement of floodplain storage that is lost due to fill, etc. from developments so that downstream flows and associated elevations are not increased over time by the loss of areas for water to be stored and passed downstream after the peak flow has passed.

Based on the earlier modeling of Haw Creek used for the ordinance revision, loss of all floodway fringe storage in the study reach of Haw Creek could create as much as ½ to 1 ½ foot increase in the 100-year flood and even larger amounts in the 500-year flood event. Because the study committee determined that a requirement for compensatory storage in the floodway fringe was not recommended at this time, it is instead recommended that the City add a factor of safety, above and beyond the normally required freeboard, anytime the regulatory flood elevation is used (such as when determining the flood protection grade for new structures to be placed in the floodplain, determining bridge low chords or deck elevation, determining flood-free elevations, floodproofing elevations, or design elevations for mitigation efforts such as levees) to account for the potential increases in flood elevations and floodplain extent as floodplain storage is reduced. Based on the results of previous CBBEL analysis, a safety factor of 1.0 foot for the 100-year flood elevation and 2.0 feet for the 500-year elevation (above and beyond any normally considered freeboard) is recommended.

Since the floodplain committee's focus was evaluation of the floodplain ordinance and not the stormwater requirements that also affect flooding within the City, the City's June 17, 2008 Stormwater Management ordinance and its companion June 24, 2008 Stormwater Design Manual were reviewed by CBBEL as part of this Flood Risk Management Plan for their adequacy in terms of preventing an increase in vulnerability to flooding in future. Based on the noted review, the following observations and recommendations for improvements are made:

a) While, overall the Ordinance and Design Manual appear to be relatively comprehensive and appear to cover most typical significant stormwater requirements, the material seems to have been presented in a generally unorganized fashion, with several discrepancies (mostly minor) noted between the provisions of the Ordinance and the provisions contained within the Design Manual. This general lack of cohesiveness may make it difficult for the applicants to clearly understand the requirements and for the City review personnel to clearly know what to check for.

   A reorganization of the design manual is recommended to improve the effectiveness of the document.

b) Based on the provisions contained in the Design Manual, it appears that detention would only be required if a proposed development results in an increased peak discharge. Based on experience with several Indiana entities, this policy may result in a situation where the applicant can show, based on numbers, that detention is not needed. An example of this is when the land use is changed from row crops to a low intensity subdivision that would appear to result in a reduction of Curve Number (due to lack of adequate provisions in the current Manual) when in reality it is needed if the calculations are done more meticulously. This situation is exacerbated by the observation contained under Item c (below).

   It is recommended that the design manual state that a peak flow control measure is needed for any proposed development meeting the appropriate threshold described in the Ordinance.

c) The Design Manual does not contain any guidance regarding the impact of soil disturbance on the Hydrologic Soil Group of the underlying soil layers. The normal development process often times involves stripping the top soil and compaction of the underlying soil layers, either intentionally or unintentionally, resulting in the reduction of the upper soil layers' infiltration capacity.

   For this reason, it is recommended that the Design Manual specify that for determining Curve Numbers for post-development conditions, the next less-infiltrating soil group be assumed so that the impact of the construction activities on the underlying soil layers is somewhat considered.

d) When detention is required, the Maximum Allowable Release Rate for the post-development 100-year peak discharge has been set to the pre-developed 10-year peak discharge. While this is a common criterion that has been widely used in Indiana in the past, experience with other entities has shown that a haphazard or sometimes biased calculation of an inflated pre-developed 10-year peak discharge by the applicants has resulted in smaller than needed detention ponds.

   In addition, this policy has resulted in an unchecked increase of peak discharges for the more frequent flood events (2-year to 10-year). This not only has implications for frequent

downstream flooding but also for increased downstream channel bank erosion.

The newer, recommended thinking on this is to set default Unit Maximum Allowable Release Rates in cfs/acre units based on available watershed-wide hydrologic modeling for both the 100-year post-development and 10-year post-development peak discharges. The noted default Unit Maximum Allowable Release Rates set in the ordinance would be based on the "typical" (or the actual calculated value for each specific watershed when it becomes available) existing-condition 10-year and 2-year peak discharges, respectively.

e) The Design Manual requires the use of Huff rainfall distributions for determining flow hydrographs. The use of such distributions has to include accurate pairing of various Huff distributions with compatible rainfall durations and performing detailed critical duration analysis. The required procedures create a lot of chances for error due to the need for performing and recording numerous calculation iterations.

   Another difficulty with use of the Huff rainfall distributions is that the need to determine critical durations may allow the critical duration associated with the calculated peak discharge for post-development conditions to be different from that calculated for pre-development conditions. As a result, the detention pond may actually release a higher peak flow for the pre-development critical duration rainfall because it is based on a different hydrograph duration and cannot make use of all of the storage that is designed for controlling the post-development critical duration hydrograph. Thus, the increased runoff due to the development is not fully controlled.

   Past experience with other entities has shown that, when using this methodology, many applicants submit calculations that may be inaccurate or result in a smaller detention pond than needed. It is recommended that the City adopt the simpler, more straightforward utilization of the SCS Type 2, 24-hour rainfall distribution for post-development flow hydrograph generation, combined with the use of Unit Maximum Allowable Release rates discussed in Item d.

f) The required size of emergency overflow spillway associated with detention ponds as stated in the Design Manual will likely

result in a smaller than prudent emergency overflow facility that can threaten the structures around the lake in an event of a major, larger than design flood event.

It is recommended that the minimum size of the emergency spillway of ponds is set at 1.25 times the peak inflow to the pond with no consideration given to pond storage.

g) The Ordinance and Design Manual are silent on steps needed to minimize acceleration in channel bank erosion that typically results from upstream development regardless of whether detention is provided or not. Such acceleration in channel bank erosion occurs as a result of an increase in frequent (2-year to 5-year) flood discharges and runoff volumes. This increase is typically not addressed by an upstream detention pond and in fact is exacerbated due to elongation of flood hydrographs as a result of the controlled pond releases.

   It is recommended that the City adopt the requirement that the Channel Protection Volume (1-year, 24-hour flow hydrograph) be fully "retained" or, if that is not possible, be subject to "extended detention".

h) The Design Manual encourages the use of "better site design practices". However, it lacks the necessary integration and incentivizing of these concepts into the ordinance requirements.

   It is recommended that standards for LID and green infrastructure be included within the Design Manual in an integrated fashion and be incentivized through Curve Number reduction credit/recognition. (See Tippecanoe County or City of Lafayette/West Lafayette integrated Stormwater Ordinance and Standards as examples.)

4.10 RECOMMENDATIONS – FLOOD MITIGATION

Based on the discussions above, the flood mitigation recommendations are summarized below.

1) Floodprone Area Most Promising Solutions

For each floodprone area identified in the Columbus planning jurisdiction, several options for mitigating for flood losses were considered. Based on technical feasibility, legality, ability to provide flood damage reduction, impacts to other areas, cost, number of structures benefitted, protection of identified at-risk populations, frequency of flooding, and location within the City limits, the most promising solutions were identified. The City should initially consider these alternatives based on expected available funding and the costs and benefits noted for each alternative. Selected alternatives should then be implemented as funding allows:

- CC24b – levee/floodwall in Wehmeier/Columbus East area ($1 M)
- DW11b – levee/floodwall in the Front Door West/ Westhill area ($650 K)
- DW10a – floodproofing of structures in Front door East/ Jonathan Moore Pike area ($500 K)
- EFK30a – floodproofing/ voluntary buyout of structures in the Mariah/ Reo Street area ($740 K)
- FR45a – floodproofing/ voluntary buyout of structures in the Riverside Drive North area ($90 K)
- FR18b – levee/floodwall in the Noblitt Falls area ($3.0 M) (could be done in conjunction with FR17b levee)
- FR17b – levee/floodwall in Washington Street area ($1.5 M) (could be done in conjunction with FR18b levee)
- HC41b – levee/floodwall in Northbrook/Candlelight area ($1.9 M)
- HC40b – levee/floodwall in Windsor Place/ Hillcrest area ($1.6 M)
- HC38b – levee/floodwall in the Everoad Park West/ Eastbrook area ($4.3 M)
- HC37b – levee/ floodwall in the Everoad Park East area ($1.8 M)
- HC36b – levee/ floodwall in the Midway area ($1.3 M)
- HC34b – levee/ floodwall in the 17th/ Keller area ($780 K)
- HC33a – floodproofing/voluntary buyout of structures in 10th/ Central area ($3.7 M)

- HC32a – floodproofing/voluntary buyout of structures in the Tech Center/Pleasant Grove area ($1.0 M)
- SB26b – levee/ floodwall for a portion of the Madison/ Grant/ Flintwood area ($350 K)
- SB27a – floodproofing/voluntary buyout of structures in Eastridge Manor area ($400 K)

(Note that HC 41b, 40b, 38b, 37b, 36b, and 34b are all in relatively close proximity to each other and, combined, may eliminate significant floodplain conveyance and storage. Therefore it is recommended that the initial engineering for these areas be done at the same time in order to efficiently identify any measures necessary to offset negative impacts. Floodproofing and voluntary buyouts would be left as alternatives for the areas that would not be able to be protected by levees.)

2) Transportation and Flood-free Routes
   a) Create additional flood-free routes, starting with the identified critical routes of US 31, SR 46, and SR 11.
   b) Efforts to create additional flood-free routes should be made as opportunities arise and according to the listed priorities in conjunction with the City Thoroughfare Plan.

3) Policy Recommendations
   a) Make updates to the Stormwater Ordinance and Design Standards:
      - Reorganize the Ordinance and Design Manual to improve effectiveness of the document
      - Amend Design Manual to require a peak flow control measure for any proposed development meeting the appropriate threshold described in the Ordinance
      - Amend the Design Manual to specify that determination of Curve numbers for post-development conditions should assume the next less-infiltration soil group
      - Amend the Ordinance to include Unit Maximum Allowable Release Rates
      - Adopt the use of the SCS Type 2, 24-hour rainfall distribution for post-development flow hydrograph generation instead of the Huff rainfall distributions
      - Amend the Design Manual to require that the minimum size of the emergency spillway of ponds

be set at 1.25 times the peak inflow to the pond with no consideration given to pond storage.

- Adopt the requirement that the channel Protection Volume (1-year, 24-hour hydrograph) be fully retained or subject to extended detention.
- Include standards for Low Impact Design (LID) and green infrastructure in an integrated fashion and incentivized through Cure Number reduction credit/recognition.

b) In lieu of the preferred policy of establishing a requirement for compensatory floodplain storage when the floodplain storage is lost, it is recommended that the City add a factor of safety of 1.0 foot for the 100-year flood elevation and 2.0 feet for the 500-year elevation, above and beyond the normally required freeboard, anytime the regulatory flood elevation is used (such as determining the flood protection grade for new structures to be placed in floodplain, determining bridge low chords or deck elevation, determining flood-free elevations, floodproofing elevations, or design elevations for mitigation efforts such as levees) to account for the potential increases in flood elevations and floodplain extent as floodplain storage is reduced.

4) Channel Maintenance
   a) Establish a maintenance program of checking for and removing debris in the stream channels (especially at bridges) before it accumulates to the point of increasing flood stages.

5) Additional Analysis
   a) Additional data should be collected and added to the Haw Creek modeling in order to better define the flood depths and risk in the Sycamore Bend/Arrowood floodprone area (FR 42).

CHAPTER 5

FLOOD PREPAREDNESS – EDUCATION & OUTREACH MATERIALS, WATERSHED STUDIES & MASTER PLANS, AND OTHER FLOOD PREPAREDNESS PLANS

5.1 INTRODUCTION

This chapter includes a description of education and outreach materials that are currently available for information about various levels of flood preparedness. Also included is a description of the watershed studies, watershed master plans, and flood preparedness plans that have been developed for the community.

5.2 EDUCATION AND OUTREACH MATERIALS

In each phase of the disaster cycle, there are questions on the part of homeowners, renters, businesses, local officials, and insurance professionals. A myriad of articles/publications to answer these questions have been developed and are available on the internet or through various agencies. A summary of helpful information that was located during a review of available information is provided in **Table 5-1**.

The table is divided into the 4 phases of the disaster cycle: response, recovery, mitigation, and preparedness. Each of these phases is then divided by the audience that the material is directed towards: homeowners and renters, business owners, City officials, or insurance professionals. Each of these categories is then broken down into a list of potential questions or issues of interest followed by the reference letter for the document if a copy is provided in **Appendix 10** and/or the Resource Number to link to the appropriate reference provided in **Table 5-2**. Those resource numbers that are a number plus text are the title of the article or section of the reference that is applicable to the issue. Most of the resources are web sites.

Because web sites are revised with varying degrees of frequency, an attempt has been made to provide titles of documents (if applicable) for use in searching for the document if the link changes or a copy of the information is provided in the Appendix 10.

Table 5-1 Summary of Educational Resources

Phase	*Audience*	Issue	Educational Resources Appendix Reference	Resource Number
RESPONSE	*homeowners & renters*	initial preparations if flood is likely	A	1*
		evacuation preparation	A	1*
		turning off utilities	A	1*
		additional information	O	2*,3
RECOVERY	*homeowners & renters*	hazards to be aware of	B,C	3- After the Flood*, 4*
		filing insurance claims	B,D	3- After the Flood*
		clean up	B, C, D	3- After the Flood*, 4*
		documenting damages	B, C, D	3- After the Flood*, 4*
		physical health protection precautions	C	4*
		mental health information	C	4*
		Rebuilding	E	3-Managing Your Flood Insurance Claim*
		appealing flood insurance claims	F	3- Appealing your Flood Insurance Claim*
		additional information	O, N	5,2*, 3 - Answers to Tough Questions*, 6
	City Officials	DNR's guide for officials		16
	claims adjusters, insurance professionals	claim guidance & forms, damage assessments, policy eligibility & extensions		7
		additional information	O	2*

Phase	*Audience*	Issue	Educational Resources Appendix Reference	Resource Number
MITIGATION	*homeowners & renters*	elevating floodprone structures		8, 9
		retrofitting residential structures		10
		local requirements for floodplain development		14
		additional information	O, N	11,12, 2*, 3 - Answers to Tough Questions*
	business owners	floodproofing nonresidential structures		13
		local requirements for floodplain development		14
	City Officials	Increased Cost of Compliance Option	H	3- Increased Cost of Compliance*
		grant programs for repetitive loss mitigation activities	G	3-Repetitive Loss*
PREPAREDNESS	*homeowners & renters*	identification of flood hazard areas		14
		National Flood Insurance Program	M	5*
		how to buy flood insurance	L, M	15*, 5*
		finding an insurance agent	L, M	15*, 5*
		understanding flood insurance policy coverage	J	3-Understanding Your Flood Insurance Policy*
		Protection of Building Utilities	I	5* "Preparation & Recovery"
		household inventory	I	5* "Preparation & Recovery"
		developing family emergency plan & kit	I	5* "Preparation & Recovery"
		how to be prepared before a flood	I, K, L	3- Flood Preparation and Safety* , 15*
		additional information	O, N	7, 2*, 3 - Answers to Tough Questions*
	City Officials	certification, workshops, & available training		7
		answering public questions about NFIP	N	3 - Answers to Tough Questions*
	claims adjusters, insurance professionals	understanding increased cost of compliance coverage	H	3- Increased Cost of Compliance*
		coverage summaries, forms, flood zone determination companies, summary of coverage		7
		certification, workshops, & available training		7
		additional information	O	2*

*hard copy provided in Appendix 10

Table 5-2 Education Resource References

Resource Number	Resource Reference
1	www.ready.gov/floods - "during" tab
2	www.fema.gov/frequently-asked-questions-0
3	www.floodsmart.gov/toolkits/flood
4	www.ready.gov/floods - "after" tab
5	www.floodsmart.gov
6	"Repairing Your Flooded Home", Red Cross
7	www.fema.gov/national-flood-insurance-program
8	FEMA Publication # 347 Above the Flood: Elevating your Floodprone House (fema.gov/library - search by pub #)
9	FEMA Publication 54 Elevated Residential Structures (fema.gov/library - search by pub # FEMA 54)
10	FEMA Publication 312 Homeowner's Guide to Retrofit (fema.gov/library - search by pub #)
11	FEMA Publication # 114 Design Manual for Retrofitting Flood-prone Residentail Structures(fema.gov/library - search by pub #)
12	FEMA Publication # 259 Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings(fema.gov/library - search by pub #)
13	FEMA Publication # 102 Floodproofing for Non-Residential Structures (fema.gov/library - search by pub #)
14	www.columbus.in.gov/planning/flood
15	www.ready.gov/floods - "before" tab
16	http://www.in.gov/dnr/water/files/FloodAdmGuide.pdf, "Local Floodplain Administrator's Guide"

Additional resources could be developed to answer questions that would be specific to the City of Columbus. A recommended resource would be one that describes the permit process that must be followed in order to rebuild after a flood. Portions of the post flood damage assessment protocol developed as part of the FREP could be used for that purpose.

5.3 WATERSHED STUDIES AND MASTER PLANS

The community has benefitted by additional watershed studies that have been completed. After the June 2008 flood new hydrologic and hydraulic modeling of Haw Creek went beyond the

normal scope of the FIS studies to account for actual observed flow paths beyond the main channel floodplain. As a result, decisions makers were provided with crucial data to better understand the extent of vulnerabilities and evaluate specific mitigation recommendations within the watershed.

In the process of preparing this Plan, additional areas were noted that may also benefit from analysis beyond the normal FIS level study modeling. For example, depth mapping shows that Opossum Creek, Denios Creek, and Airport Tributary may exchange water between them via paths that are not currently understood or included in floodway regulations. Development in these areas may impact flood elevations on each of the streams.

Driftwood River, Flatrock River, and Clifty Creek each have a considerable amount of their watershed that is outside of the Columbus planning jurisdiction. Development is occurring in not only the Columbus area, but other areas of these watersheds which Columbus does not have control of. Cumulative losses of floodplain storage or flow area inside or outside of the Columbus area will impact Columbus. The City should consider coordinating with the other jurisdictions in the watersheds to establish regulations that will reduce the potential impacts or to at least be prepared for the results of the policies and actions of other jurisdictions in the watersheds. Additional detailed hydrologic and hydraulic studies would provide additional insight into making these decisions for these watersheds.

Watershed studies and plans also provide modeling that can more accurately allow the investigation of what-if scenarios in the watershed as well as be a guide to the selection of maximum allowable release rates so that detention facilities are sized based more closely on actual watershed conditions.

5.4 FLOOD PREPAREDNESS PLANS

As part of the development of this Flood Risk Management Plan, a comprehensive Flood Response and Evacuation Plan (FREP) was developed and presented as a stand-alone document. The FREP is a very significant and crucial step to reduce the impacts of flooding on lives and properties when floods occur.

The development of this Flood Risk Management Plan and FREP is in itself the City's most important step in preparation for a flood

event. A summary of the recommendations identified in this Plan and FREP for improving flood preparedness along with a prioritized list of implementation steps to carry out community efforts to reduce the current and future vulnerability to flood risks is provided in Chapter 6 of this report.

5.5 RECOMMENDATIONS – EDUCATIONAL MATERIALS, WATERSHED STUDIES, AND MASTER PLANS

Based on the discussions above regarding educational materials, watershed studies, and Master Plans, the following recommendations are made:

a) The City should develop a resource to describe the City permit process for rebuilding after a flood. Portions of the post flood damage assessment protocol developed as part of the FREP could be used for that purpose.

b) The City should pursue a more detailed study of Opossum Creek, Denios Creek, and Airport Tributary to determine the interaction of flood waters between the streams in order to understand the potential impacts of development in the area and regulations that may be needed to prevent adverse impacts.

c) The City should coordinate with other jurisdictions in the watersheds of Driftwood River, Flatrock River, and Clifty Creek to establish regulations that will reduce the potential impacts or to allow the City to be aware of and prepare for the results of the policies and actions of other jurisdictions in the watersheds. Decisions on regulations may require additional hydraulic and hydrologic modeling to allow the investigation of what-if scenarios or to be the guide in establishing maximum allowable release rates for sizing detention facilities.

CHAPTER 6 SUMMARY AND CONCLUSIONS

6.1 INTRODUCTION

This Chapter presents a brief summary of activities performed as part of this Flood Risk Management Plan and presents a consolidated list of recommendations made throughout the report along with implementation steps necessary to implement the recommendations.

6.2 SUMMARY

The City of Columbus is located at the confluence of several streams. As such, the rainfall on 2,000 square miles drains through the City and, based on available data, creates a 1% annual chance of flooding on over 36 square miles of land, or one third, of the Columbus planning jurisdiction. Because of this extent of potential flooding, this Plan was developed to provide the City with a road map to manage flood risks.

A respected planning model that guides communities through emergency planning is the “Emergency Life Cycle”, which consists of “Respond”, “Recover”, “Mitigate” and “Prepare” phases. This process is grounded in the belief that emergency planning in a community can and should constantly improve. Protocols can be established such that after each emergency event, real-time data is captured and the data is analyzed to determine how to reduce risk for the next emergency.

The City of Columbus Flood Risk Management Plan is organized around the Respond-Recover-Mitigate-Prepare framework. Organized within this framework, the Plan describes current flood risks, identifies flood forecasting resources, presents a Flood Response and Evacuation Plan, establishes protocols for post flood damage assessment and data collection, notes information sources for educating the public about flood safety, and uses multiple-component screening criteria to screen over 350 Considered Solutions for mitigation of identified existing floodprone areas down to almost 100 Possible Solutions, then 52 Promising Solutions and finally several Most Promising Solutions. These Most Promising solutions include levees along select

reaches of Haw Creek, Clifty Creek, Flatrock River, and Sloan Branch. Floodproofing and/or voluntary buyouts of structures in other areas were also among the Most Promising Solutions. The report also provides a road map of action steps for all phases of the Respond-Recover-Mitigate-Prepare Emergency Life Cycle including road replacements for the creation of flood-free routes, enhancement of flood forecasting tools, updating of hydrologic and hydraulic computer modeling, policy revisions to address future condition flood potential, and updates of the Plan. Implementation of these recommended actions will lead to a reduction in flood risk and constantly improving preparedness for the next emergency. Potential funding sources are described in Section 6.3. All of the recommendations noted in this Plan are summarized in Section 6.4.

6.3 FUNDING CONSIDERATIONS

This section provides a brief discussion of the funding sources that may potentially be utilized to assist in implementation of the promising mitigation solutions as well as other recommendations within this plan. It is important to note that the implementation of the recommendations is expected to be undertaken over several years as interest and urgency is generated and funding is obtained. Many of the potential funding sources listed below are experiencing a reduction in available funds and, as a result, funding has become increasingly competitive in nature. Therefore, when applying for funds it is important to show a diverse group of partners and funding sources with the ability to utilize one funding source to either leverage additional funds or to complement those funds for the same project. It is also greatly beneficial to show several enhancements with one action or objective. For example, funding for the completion of floodplain or watershed studies is shown to result in several benefits such as a more detailed identification of the risk area, a greater awareness of the risk to appropriate landowners, and more accurate information to be used to prevent future losses within those areas.

The list of potential funding sources below is not meant to be exhaustive; funding availability and priorities may change as agency priorities and funding changes.

Federal:

FEMA Cooperating Technical Partner (CTP) – a main objective and benefit of the CTP Program is leveraging available funding and local data to get more updated flood hazard maps out of limited resources. National mapping needs and partnering opportunities determine FEMA funding priorities. Federal funding is managed by the FEMA Regional Offices and provided through a cooperative agreement.

FEMA Flood Mitigation Assistance (FMA) Grant Program – provide funding to communities with approved Flood Mitigation Plans to implement measures to reduce flood losses. This program requires a 25% non-Federal cost share.

FEMA Hazard Mitigation Grant Program (HMGP) – provides grants to States and local governments to implement long-term hazard mitigation measures after a major disaster declaration. Funds may be used to protect either public or private property or to purchase property that has been subjected to, or is in danger of, repetitive damage. This program requires a 25% non-Federal cost share.

FEMA Pre-Disaster Mitigation Program (PDMP) – provides funds for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. This program requires a 25% non-Federal cost share.

FEMA Repetitive Flood Claims (RFC) – these funds can be used to reduce flood damages to insured properties that have had one or more claims to the National Flood Insurance Program (NFIP). This program requires a 25% non-Federal cost share.

FEMA Severe Repetitive Loss Program (SRL) – provides funding to reduce or eliminate the long-term risk of flood damage to sever repetitive loss structures insured under the NFIP. This program requires a 25% non-Federal cost share.

HUD Sustainable Communities Regional Planning (SCRP) Grants – supports metropolitan and multi-jurisdictional planning efforts to integrate housing, land use, economic and workforce development, transportation and infrastructure investment to meet the challenges of economic competitiveness and revitalization,

social equity and access to opportunity, energy use and climate change, and public health and environmental impact.

Land and Water Conservation Fund (LWCF) – provides matching grants to State and local governments for the acquisition and development of public outdoor recreation areas and facilities. Funds have been widely used for land acquisition, open space/green space development, and similar projects that can reduce the impacts of flooding. The fund is administered through the National Park Service.

NOAA-NWS – National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service (NWS) has awarded integrated Automated Flood Warning System (AFWS) grants to reduce the loss of life, property damage, and disruption of commerce from floods. Automated Flood Warning Systems are in use in numerous American communities to alert officials about flood threats, and for environmental monitoring, water resource management, fire risk assessment as well as homeland security. Each year, NOAA awards AFWS grants through a nationally competitive process.

US Army Corps of Engineers (USACE) Section 22 – Planning assistance from the USACE to States for studies and projects related to flood damage reduction, water supply, water conservation, environmental restoration, water quality, hydropower, erosion, navigation, fish and wildlife, cultural resources, and environmental resources. The federal allotment to each state is $500,000 annually to fund projects that are generally $20,000 to $150,000 each, but could be more. The cost-share is 50% federal and 50% non-federal.

State:

Community Development Block Grant (CDBG) – funds provided from the US Department of Housing and Urban Development (HUD) to States for a wide range of unique community development activities including but not limited to property acquisition, public services, planning activities, and development projects. These projects may include flood-related projects such as stream studies, floodplain management, infrastructure, and ordinance development. Federal funds are administered through the Indiana Office of Community and Rural Affairs (OCRA) and Indiana Housing and Community Development Authority (HCDA).

IDNR Division of Water: Water Resource Development Funds – these funds can be accessed if specifically included in the IDNR biennial budget and approved by the Indiana Legislature

Indiana Heritage Trust (IHT) – The purpose of the IHT is to acquire state interests in real property that are examples of outstanding natural resources and habitats or provide areas for conservation, recreation, protection or restoration of native biological diversity within the state of Indiana. IHT could serve as a cash or in-kind match for areas slated for acquisition that also provide a benefit to the goals of the IHT.

Indiana Transportation Enhancement (TE) Program – funds for transportation-related activities that are designed to strengthen the cultural, aesthetic, and environmental aspects of the transportation system. Funds are available for the implementation of a variety of non-traditional projects with examples ranging from acquisition of scenic easements, landscaping and scenic beautification, to the mitigation of water pollution from highway runoff.

USGS Indiana – can provide limited matching funds for operation and maintenance of stream gages as well as provide gage equipment as available

Local:

County Commissioners/City Council – can provide local cost-share match (in-kind and/or cash) required by many State and Federal grant programs. General operating funds would provide the resources necessary to sustain the day-to-day activities and pay for all administrative and operating expenses.

County Emergency Management Agency – can provide local cost-share match (in-kind and/or cash) required by many State and Federal grant programs

Developers – provide funding necessary to complete studies of downstream areas to ensure that new development will not adversely impact the stream or floodplain

Local Land Trusts – may provide funding or technical assistance with acquired lands in environmentally sensitive areas where water quality and natural resource protection will be enhanced.

Local Watershed Groups – can provide local cost-share match (in-kind and/or cash) required by many State and Federal grant programs

Soil and Water Conservation Districts (SWCDs) – can provide local cost-share match (in-kind and/or cash) required by many State and Federal grant programs

Stormwater Utility – A stormwater utility can be formed and user fees established to provide funds for drainage maintenance, capital improvements, and implementation of stormwater management permit programs. Of all of the available funding sources, this is the most flexible option while still allowing for the use of additional funding when applicable.

Other:

esri Grants – sponsors programs that help organizations serve society and better the environment using Geographic Information System (GIS) technology. esri-sponsored grants offer free software, hardware, and/or training programs

6.4 RECOMMENDATIONS AND IMPLEMENTATION STEPS

Recommendations from each of the chapters are summarized here along with prioritized implementation steps and some additional recommendations based on the Plan as a whole. The recommendations/ implementation steps have been organized into 7 categories: **Data** (NWS, USGS, City, and hydraulic modeling data needs), **Equipment, Projects-Structures** (mitigation projects for protecting structures), **Projects-Roadways** (projects for creating flood-free transportation corridors through the City), **Policy**, **Updates** (listing of personnel and data that will need to be updated as information changes), and **General** (recommendations that apply to the Plan as a whole). When applicable, a reference has been added at the end of each recommendation to indicate the location in the Plan of additional details regarding the recommendation.

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL
PRIORITY	RECOMMENDATION and IMPLEMENTATION STEPS					REFERENCE
	NWS Forecast Tools					
1	Coordinate with the Indianapolis Office of the National Weather Service (NWS) to request the addition of river forecast points and to provide assistance in making helpful additions to the NWS rainfall and river forecasting network by funding additional rainfall observers					Section 2.7, Recomm. 2a, 2b, 2c
2	Solicit volunteers in 8 specific areas for participation in the CoCoRaHs network of rainfall data collection					Section 2.7, Recomm. 4a
3	Inform the Indianapolis NWS office of areas/roads flooded in a given event so they can add the information to their web site identifying flooded areas expected at noted USGS gage heights					Section 3.3 Recomm. e
	USGS Gages					
1	Maintain current funding of current USGS stream gages					Section 2.7 Recomm. 3a
2	Investigate additional local resources for the funding of USGS stream gages					Section 2.7, Recomm. 3d
3	Contact the USGS to discuss City sponsorship of the Clifty Creek at Columbus stream gage and its relocation upstream to US 31, the addition of 5 new gages, and receiving notification if significant regional gage stations are losing funding					Section 2.7, Recomm. 3b, 3c, 3e, 3f
4	Download USGS inundation mapping to City computers as they become available					Section 2.7, Recomm. 4b
5	Work with USGS to investigate the possibility of expanding the limited depth mapping done by CBBEL or other future mapping into a library of static maps correlated to stream gages or creating additional inundation mapping					Section 2.7, Recomm. 5f
	City Post-Flood Education					
1	Add information about permitting requirements and processes to the materials that will be distributed immediately after a flood event					Section 3.3, Recomm b
2	Develop task checklists that can be provided to owners of damaged structures after a flood and other resources to describe the City permit process for rebuilding					Section 3.3, Recomm c, Section 5.5, Recomm a
3	Develop form letters and post flood data collection record keeping procedures for use as outlined by the post flood damage assessment and data collection protocol					Section 3.3, Recomm d, e
	Data Management					
1	Determine an appropriate repository for the Plan GIS files					
2	Develop a process for tracking and triggering changes to GIS files, FREP mapping, FREP procedures, and other elements of the Plan					Section 2.7, Recomm. 4c
	Update or Expand Available Hydraulic/Hydrologic Modeling					

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION STEPS	REFERENCE
1	Pursue more detailed hydraulic modeling of the interaction of Opossum Creek, Denios Creek, & Airport Tributary to assess potential impacts of development in the area & regulations that may be needed to prevent adverse impacts • Obtain needed engineering service • Add new or revised flood elevation data to the regulatory processes used for planning and building permits • Revise mapping, etc in the FREP or Plan if needed based on the model findings	Section 5.5 Recomm. B, Section 2.7, Recomm 1d, 5d
2	Pursue determination of flood elevations along the streams in the planning jurisdiction that do not yet have Base Flood Elevations determined • Prioritize stream reaches for analysis • Obtain needed engineering service • Add new or revised flood elevation data to the regulatory processes used for planning and building permits • Revise mapping, etc in the FREP or Plan if needed based on the model findings	Section 2.7 Recomm. 1b, Section 2.7, Recomm 1d, 5d
3	Update/correct the existing FIS modeling according to the priorities outlined in the Plan • Prioritize stream reaches for analysis • Obtain needed engineering services • Add new or revised flood elevation data to the regulatory processes used for planning and building permits • Revise mapping, etc in the FREP or Plan if needed based on the modeling results	Section 2.7 Recomm. 1a, Section 2.7, Recomm 1d, 5d
4	Pursue adding more detail data to the Haw Creek model in order to better define flood risks in the Sycamore Bend/Arrowood floodprone area	Section 4.10 Recomm. 5a

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS	REFERENCE
1	The Fire Department should obtain funding, purchase a boat, and compete the necessary training for water rescues	Section 2.7, Recomm. 5a
2	Investigate, select, and implement the use of digital resources such as handheld GPS data loggers or laptops for use in automatic updates to an Excel-based tracking system to replace paper maps and forms used in post flood damage assessments	Section 2.7, Recomm. 5e
3	The Street Department should supplement the County Highway sand bag supply with an adequate supply at the City garage and consider purchasing a sand bag machine and sand to expedite filling bags as part of the flood fight effort	Section 2.7, Recomm. 5g

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS	REFERENCE
	Projects - Levee	
1	Prioritize the following identified most promising solutions based on expected available funding and noted costs and benefits • proposed levee/floodwall along Clifty Creek to protect the Wehmeier subdivision ($1 M) • proposed levee/floodwall along Flatrock River to protect the Noblitt Falls subdivision and the Washington Street area between 12th & 18th Streets ($3.0 M & $1.5 M) • proposed levee/floodwalls along portions of Haw Creek to protect the Northbrook/Candlelight, Windsor Place/ Hilcrest, Everoad Park West/ Eastbrook, Everoad Park East, Midway, and 17th/ Keller areas, substituting floodproofing and voluntary buyouts for areas that must remain accessible to flood waters to prevent adverse impacts (Total of all segments = $ 11.7 M) • proposed levee/floodwall along Sloan branch to protect a portion of the Madison/ Grant/ Flintwood area ($350 K)	Section 4.10 Recomm. 1
2	For each selected solution: • Obtain necessary funding • Complete preliminary engineering report • Review benefits compared to potential cost of construction, permitting, and mitigation to determine whether the option should be pursued • Add a factor of safety of 1.0 foot to the 100-year flood elevation and 2.0 feet to the 500-year flood elevation as the basis for design of mitigation projects (above and beyond normal freeboard considerations) to account for increase in flood elevation due to expected future loss of floodplain storage along stream corridors in the upstream watershed unless floodplain storage compensation requirements are enacted for the entire watershed upstream of the project • Complete design and construction documents • Construct the project and maintain as directed in the operation and maintenance documents • Pursue revision of the FIRM to reflect levee if constructed and maintained per FEMA requirements	Section 4.10 Recomm 3b
	Projects - Floodproofing/Voluntary Buyouts	
1	Investigate funding options	
2	Select and prioritize areas from the Most Promising Solutions list for which floodproofing or voluntary buyout assistance will be provided by the City based on the Plan findings for • Front Door East and West (Driftwood River), • Mariah/ Reo Street, 10th & Central, Pleasant Grove (Haw Creek), • Riverside Drive North (Flatrock River), and • Eastridge Manor (Sloan Branch)	Section 4.10 Recomm. 1
3	Complete a prioritization plan for a voluntary buyout and/or floodproofing program to determine what type of mitigation action is the most appropriate for a given building (Note that the prioritization plan, the decision to floodproof versus buyout, and floodproofing design should be based on flood elevations with the added factor of safety noted under Recommendation 3b in Section 4.10 unless floodplain storage compensation requirements are enacted for the entire watershed upstream of the project)	N/A

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS	REFERENCE
4	Create outreach materials (such as floodproofing program guide and application form, voluntary buyout program guide and application form, etc) and conduct meetings or use other methods to inform homeowners in targeted areas of the potential options and requirements	N/A
5	Assemble supporting materials for funding grant application including elevations, past flood-related losses, acquisition and/or floodproofing costs	N/A
6	Secure mitigation funding from FEMA to acquire and/or floodproof buildings as listed in the prioritization plan	N/A
7	Use other identified funding sources to acquire and/or floodproof prioritized buildings	N/A
	Channel Maintenance	
1	Establish a maintenance program of checking for and removing debris in the stream channels (especially at bridges) before it accumulates to the point of increasing flood stages	Section 4.10 Recomm. 4a

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS	REFERENCE
1	Pursue road/bridge projects that will provide for flood-free access along the identified critical transportation routes US 31, SR 11, and SR 46. This includes: • US 31 crossing of Flatrock River, • US 31 and SR 46/ State Street crossings/approaches of Haw Creek, • SR 11 relocated between CR 200 S and SR 46 per City Thoroughfare Plan, and • SR 46 from the East Fork White River bridge through the I-65 interchange	Section 4.10 Recomm. 2a
2	Add a factor of safety of 1.0 foot to the 100-year flood elevation and 2.0 feet to the 500-year flood elevation as the basis for design of bridge/road replacement design (above and beyond normal freeboard considerations) to account for increase in flood elevation due to expected future loss of floodplain storage along stream corridors in the upstream watershed unless floodplain storage compensation requirements are enacted for the entire watershed upstream of the project	Section 4.10 Recomm 3b
3	Pursue creation of additional flood-free routes as opportunities arise and according to the priorities listed in the Plan and in conjunction with the City Thoroughfare Plan	Section 4.10, Recomm. 2b
4	Whenever a road/bridge project is considered, maximize the opportunity to create flood-free access or a reduction in flood elevations using the priorities listed in this Plan	Section 4.10, Recomm. 2b
5	Develop a system for tracking when stream crossings/approaches are replaced or raised	N/A
6	Provide data on changes to stream crossings/approaches to designated party with decision making responsibility regarding the need to revise affected Plan components	Section 2.7, Reomm. 4e
7	Revise modeling and/or depth mapping for the Plan and FREP as appropriate	Section 2.7, Reomm. 5d

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS	REFERENCE
1	Update and reorganize the Ordinance and Design Manual, using outside assistance if necessary, to improve effectiveness of the document and include revisions to require peak flow control measures, specify Curve numbers for post-development conditions, provide Unit Maximum Allowable Release Rates, adopt the SCS Type 2, 24-hour rainfall distribution for post-development flow hydrograph generation, require minimum pond emergency spillway sizes, adopt Channel Protection Volume retention, and include standards for Low Impact Design and green infrastructures	Section 4.10 Recomm. 3a
2	Update the applicable ordinances and policy statements throughout the City to add a factor of safety of 1.0 foot for the 100-year flood elevation and 2.0 feet for the 500-year elevation, above and beyond the normally required freeboard, anytime the regulatory flood elevation is used (such as for determining the flood protection grade for new structures to be placed in floodplain, determining bridge low chords or deck elevation, determining flood-free elevations, floodproofing elevations, or mitigation efforts such as levees) to account for the potential increases in flood elevations and floodplain extent as floodplain storage is reduced unless floodplain storage compensation requirements are enacted for the entire watershed upstream of any proposed project or building.	Section 4.10 Recomm 3b
3	Coordinate with other jurisdictions in the watersheds of Driftwood River, Flatrock River, Haw Creek, and Clifty Creek to establish regulations that will reduce the potential impacts of those jurisdictional policies on runoff through Columbus	Section 5.5 Recomm. c

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL

PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS	REFERENCE
1	Revisit the calculation of Community Rating System (CRS) points to see if any of the actions taken as a result of this Plan can change the community's classification and further reduce the flood insurance premiums for City property owners	N/A
2	As additional or revised hydraulic modeling is generated, consider generating new depth mapping for use in the Flood Response and Evacuation Plan	Section 2.7 Recomm. 1c
3	Develop a system for identifying changes in the data used in the Plan and any associated information in the FREP such as: FIS hydraulic models and associated depth mapping, completed mitigation projects, raised approaches or larger bridge openings impacting flood-free transport, and critical facilities data	Section 2.7, Recomm. 4d, 4e
4	Procure the needed services to make the Plan revisions when needed	N/A
5	Update the responsible parties for Plan components as changes occur	N/A
6	When Plan updates are completed, revisit the calculation of Community Rating System (CRS) points to determine if a change in classification is warranted and submit the necessary documentation for a change if warranted	N/A
7	The FREP Coordinator (EMA Director) should keep abreast of NWS and USGS flood forecast tools as they evolve	Section 2.7, Recomm. 5b
8	The Planning Department Floodplain Administrator should make sure the FREP is tested and updated to reflect changes in city permit processes or regulations or as use of the FREP and associated protocols shows the need for revisions/additions	Section 2.7, Recomm. 5c, Section 3.3 Recomm. A

DATA	EQUIPMENT	PROJECTS - STRUCTURES	PROJECTS - ROADWAYS	POLICY	UPDATES	GENERAL
PRIORITY	RECOMMENDATION and IMPLEMENTATION ITEMS					REFERENCE
1	Identify and assign the appropriate positions within the City that will be responsible for carrying out each of the Plan recommendations					N/A
2	Maintain coordination with the selected responsible positions within the following City Departments and other agencies regarding at least the items noted in parenthesis • USGS (stream gage network, inundation mapping) • NWS (forecast network data and tools) • EMA (FREP) • Funding sources • Indiana Department of Natural Resources – Division of Water (FIS study updates/additions) • FREP participants (revisions to the FREP) Building Department (code requirements for rebuilding after a flood) • Floodplain Administrator • Planning Department • Street Department (changes in flood-free routes or flood elevations as road elevations or bridge openings are changed) • Indiana Department of Transportation (changes in flood-free routes or flood elevations as road elevations or bridge openings are changed) • County Highway (changes in flood-free routes or flood elevations as road elevations or bridge openings are changed)					N/A

Recommendations above are listed in order of priority within each category or subcategory. Implementation of these recommendations can proceed as outlined and as selected priorities and available funding dictate. While all of the plan recommendations noted above in various categories should be considered for implementation, the following is a list of the overall top recommended actions to be taken by the City in the order listed:

1. Identify responsible party within the City for implementing each of the Plan recommendations.
2. Take immediate steps to prevent escalation of the existing extent of flooding problems and/or creation of additional flooding problems by addressing policy recommendations.
3. Identify appropriate funding source(s) for each recommendation using the funding considerations listed in Section 6.3. (Creation of a Stormwater Utility appears to be the most versatile and reliable funding source to implement or cost-share the implementation of this Plan's recommendations.)
4. Take the necessary steps to ensure preservation of current forecast tools (NWS tools, USGS gages).

5. Start the process of updating/expanding hydrologic and hydraulic studies to better identify risks and needs.
6. Prioritize buyout areas and work with Indiana Department of Homeland Security to secure available funding.
7. Prioritize levee projects and fund the Preliminary Engineering for the selected projects to evaluate the feasibility at each site. Proceed with funding, design, and construction of levee segments found feasible and preferable as compared to other options.
8. Set up systems for tracking Plan changes and update needs.