State of Illinois
Illinois Department of Natural Resources

Jacksonville Town Brook Strategic Planning Study Report

Illinois Department of Natural Resources

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I. PURPOSE AND AUTHORITY

This report summarizes the results of a strategic flood study conducted to investigate the causes and extent of flooding along Town Brook and Mauvaise Terre Creek in the City of Jacksonville, Illinois. This study proposes and analyzes alternatives to reduce flooding and decrease erosion in key areas. This study was prepared for the City of Jacksonville, Illinois under the authorization granted to the Illinois Department of Natural Resources/Office of Water Resources (OWR) under the Flood Control Act of 1945.

Previous Study

A Flood Insurance Study (FIS) was completed by the Federal Insurance Administration in 2009 to better determine floodplain and floodway limits throughout Morgan County. Data from the FIS was utilized in modeling efforts completed in this report.

Flood Insurance Study, Morgan County, Illinois and Incorporated Areas, U.S. Federal Emergency Management Agency, Federal Insurance Administration, August 18, 2009.

II. WATERSHED DESCRIPTION

The City of Jacksonville is located along the north side of Interstate 72, through the center of Morgan County. Jacksonville is approximately 30 miles west of Springfield and surrounded by unincorporated areas of Morgan County. According to the 2010 U.S. Census, the population of Jacksonville is 19,446 people.

The Mauvaise Terre watershed is a combination of rural and urban areas as shown in **Figure 1**. The headwaters of Mauvaise Terre Creek are predominately rural and drain northwest into Lake Mauvaise Terre. Mauvaise Terre Creek then flows north along the east side of the City of Jacksonville before turning west and flowing along the north side of the City. Thus, the watershed area along the west side and south side of Mauvaise Terre Creek, which encompasses the City, is urban. Town Brook is a tributary to Mauvaise Terre Creek and flows from the west into Jacksonville and continues east and through the City and its watershed area is a combination of rural farmland and urban areas. The watershed area east and north of Mauvaise Terre Creek, including tributaries, is mostly rural farmland. After leaving Jacksonville, Mauvaise Terre Creek continues west through rolling hills, wooded areas and farmland before flowing into the Illinois River just south of Naples.

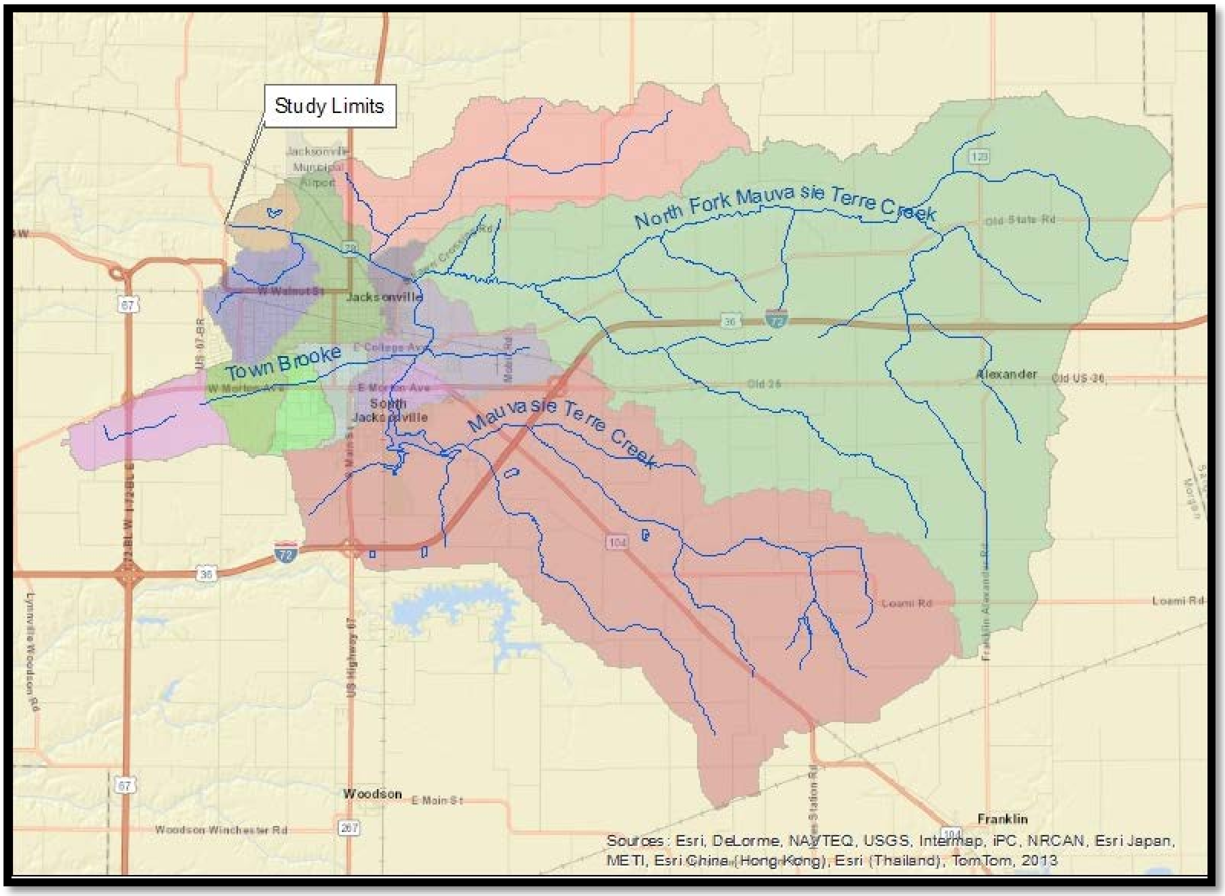

Figure 1 – Mauvaise Terre Watershed Site Map

The study area limits are located along Mauvaise Terre Creek downstream of Jacksonville.

Town Brook has a drainage area of 6.4 square miles and is a small tributary to Mauvaise Terre Creek. The upper portions of Town Brook are rural farmland sloping **northeast** into detention basins west of Jacksonville. From there most of the watershed becomes urban as Town Brook winds its way along Morton Ave and eventually past MacMurray College before joining Mauvaise Terre Creek.

Due to a combination of channel slope and channelization, the upper reaches Town Brook currently have high velocities causing erosion. The lower portion due to more gradual slopes and backwater effects from Mauvaise Terre Creek has lower velocities and therefore a more stable channel. The lower portion of Town Brook flows through two different railroad crossings. The upstream crossing is a stone arch way 14 feet across and 13 feet tall. The downstream crossing is a combination of three culverts. Two corrugated metal pipes with a 5-foot diameter pipe, as well as a 12 ft. x 10 ft. box culvert.

III. HYDROLOGY

HEC-HMS Model

Discharges were developed from rainfall runoff from sub basins using the HEC-HMS model. For this modeling the entire Jacksonville watershed was divided into 14 different basin areas. Town Brook was divided into five different basin areas which allows for more detailed and better refinement of flows along the critical area of Town Brook. Watershed boundaries and statistical information were determined from the USGS Streamstats website. The time of concentrations were calculated by use of the USGS 82-22 method.

The SCS Curve Number method was chosen to analyze the watersheds. These curve numbers were generated by analyzing soil types and land use in Geographic Information System (GIS) mapping. Curve numbers varied from a low of 82 to a high of 90.9. These high values are due to soil types C&D being found over most of the area. These soil types have very poor infiltration rates. Please refer to sub-basin parameters shown in **Table 1** below.

Subbasin	Basin Area (ac)	Basin Area (mi^2)	SCS CN	CN-Rounded	TC (hr)	R (hr)
TB_Outside of Town	1,536	2.4	90.2	90	5.9	3.9
TB_TJHS	896	1.4	90.2	90	2.4	1.6
TB_Diamond St	704	1.1	90.2	90	1.4	1
TB_Clay Ave	576	0.9	90.9	91	2.3	1.6
TB_Confluence	448	0.7	90.4	90	2.5	1.7
M_Dam Crest	21,184	33.1	90.3	90	10.4	6.9
M_Confluence	448	0.7	90.1	90	2.4	1.6
M_Trib East_Confluence	1,600	2.5	82.8	83	4.5	3
M_Trib West_Confluence	448	0.7	82.7	83	1.8	1.2
M_Trib Town	1,408	2.2	82.9	83	2.7	1.8
Mauve_Limits	448	0.7	82	82	1.5	1
Trib_East	32,896	51.4	90.3	90	20.1	13.4
Trib_West	5,760	9.0	90.3	90	10.6	7.1
Trib_Town	1,472	2.3	90.5	91	2.9	2

Table 1 – Sub-Basin Parameters

Meteorological models were made for seven different storm frequencies (1-,2-,5-,10-,25-,50-,and100-year events) for both 12-hour and 24-hour duration; the 2-, 3-, 6-, 12-, and 24-hour duration events for 100-year frequency were also modeled. By modeling the various 100-year durations, the critical duration was determined to be the 24-hour duration. This is because the 24-hour duration creates the highest flows on Mauvaise Terre Creek which causes the largest backwater effect through the critical area along Town Brook. Please refer to **Appendix A** for more detailed information.

Finally, eight point cross sections were used for the junctions between various watersheds. These cross sections were taken from representative cross sections in the HEC-RAS model. Please see **Table 2** below for the 100-year frequency discharges at specific locations.

	Drainage Area	100-YR Discharge
Location	SQ. MI.	CFS
Study Limit	109.1	12,242
N. Fork Junction	64.2	12,641
Town Brook	6.5	2,382
Mauvaise Terre CR.	33.1	7,124

Table 2 – Junction 100-Year Discharges

IV. HYDRAULICS

HEC-RAS Model

The Hydraulic Engineering Center's River Analysis System (HEC-RAS), created by the US Army Corps of Engineers, was used to develop existing condition flood profiles on Town Brook and Mauvaise Terre Creek. The watershed was modeled as five different reaches:

- Mauvaise Terre Creek Upper
- Mauvaise Terre Creek Middle
- Mauvaise Terre Creek Lower
- Town Brook
- Town Tributary

Mauvaise Terre Creek is divided into an upper portion which extends from the outflow of Lake Mauvaise Terre to the confluence of Town Brook. The middle portion extends from the Town Brook confluence to the confluence with the Town Tributary. The lower portion extends from the Town Tributary confluence down to Poor Farm Road. Town Brook encompasses its own reach extending from the detention basins near Walmart all the way to the confluence with Mauvaise Terre Creek. The Town Tributary extends from culverts underneath Founders Lane to the confluence with Mauvaise Terre Creek. The HEC-RAS model for the study area contains over 145 cross sections and 31 bridges and culverts, covering almost 56,000 feet of channel being created by over 5,000 individual surveyed points. Cross section locations for the study area are shown in **Figure 2** below.

Manning's N-Values

Manning roughness coefficients (N-values) fluctuate across the model area based on varying land use. Values used in the hydraulic model were based on field inspections and comparisons to values in the HEC-RAS manual published by the U.S. Army Corps of Engineers.

HEC-RAS Unsteady State Model

There are two types of HEC-RAS modeling methodologies that were considered for the City of Jacksonville study: Steady-State and Unsteady-State modeling. Steady-state modeling uses the maximum inflows at various locations to create the maximum water surface profiles throughout the watershed. Unsteady-state modeling uses a hydrograph of inflows and combines these at various locations through the watershed to show how the water surface profiles change over time.

Use of both steady and unsteady state modeling was considered and evaluated for this study. It was determined that the unsteady state model would be the most accurate to use for this study. These models use the normal depth boundary conditions for the starting water surface elevations with a slope of 0.0005 ft/ft, based on surveyed Cross-Sections.

A hydrograph is a component of timing for flow events that gets included in unsteady modeling. This is critical when time of concentrations of these hydrographs vary across different watersheds. When you compare some of the Mauvaise Terre watersheds to Town Brook's watersheds, the time of concentrations are not simultaneous. When plotting the various watershed hydrographs, the peak flow occurs during varying time periods (**Figure 3**). This indicates that the unsteady state modeling methodology will be more accurate for this watershed. The unsteady model was used to calculate the 100-, 50-, 25-, 10-, 5-, 2-, and 1-year frequency event water surface elevations. These Existing Conditions profiles are shown in **Figure 4** below. For more HEC-RAS model details please refer to **Appendix B**.

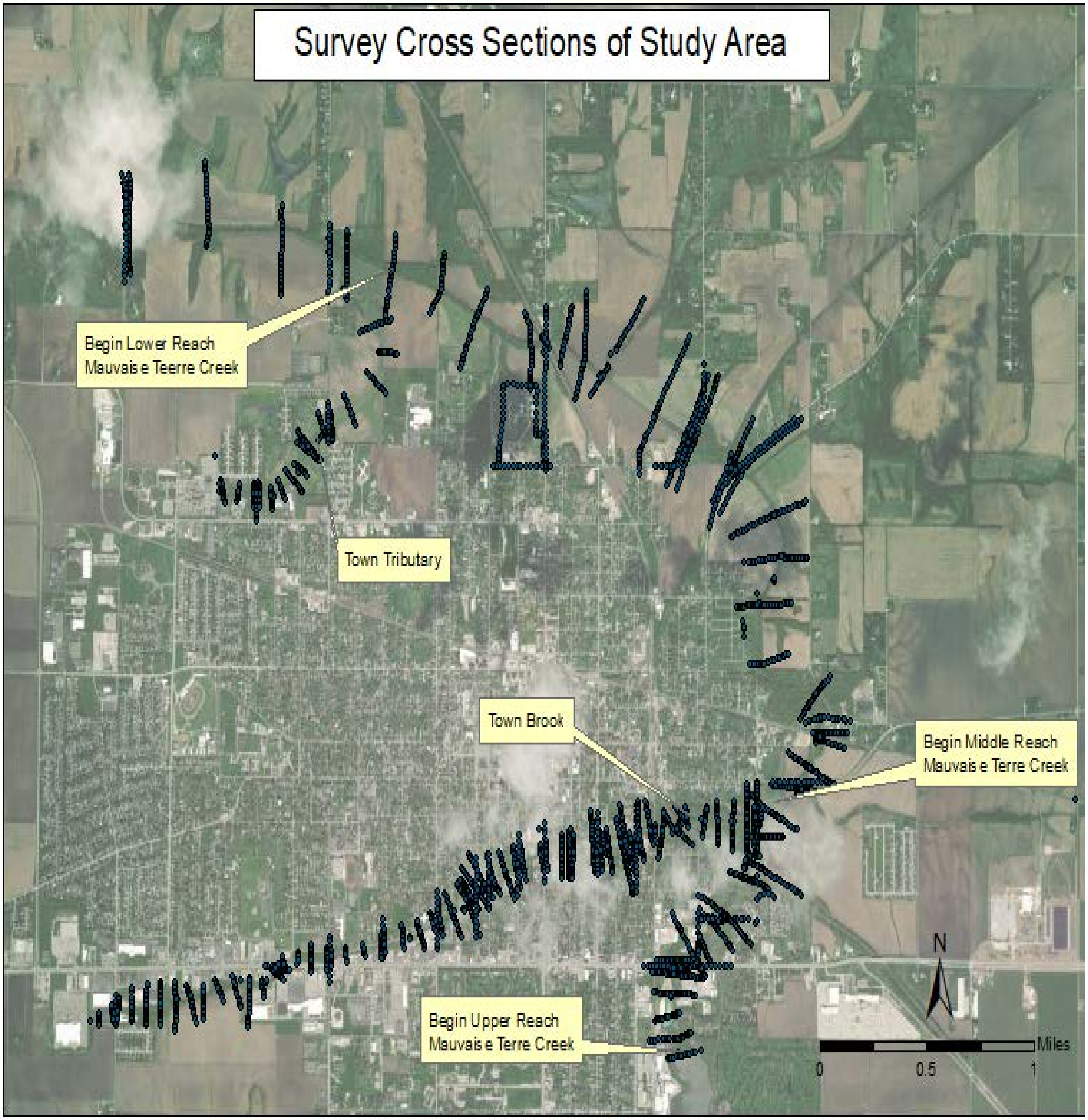

Figure 2 – Cross Section Layout

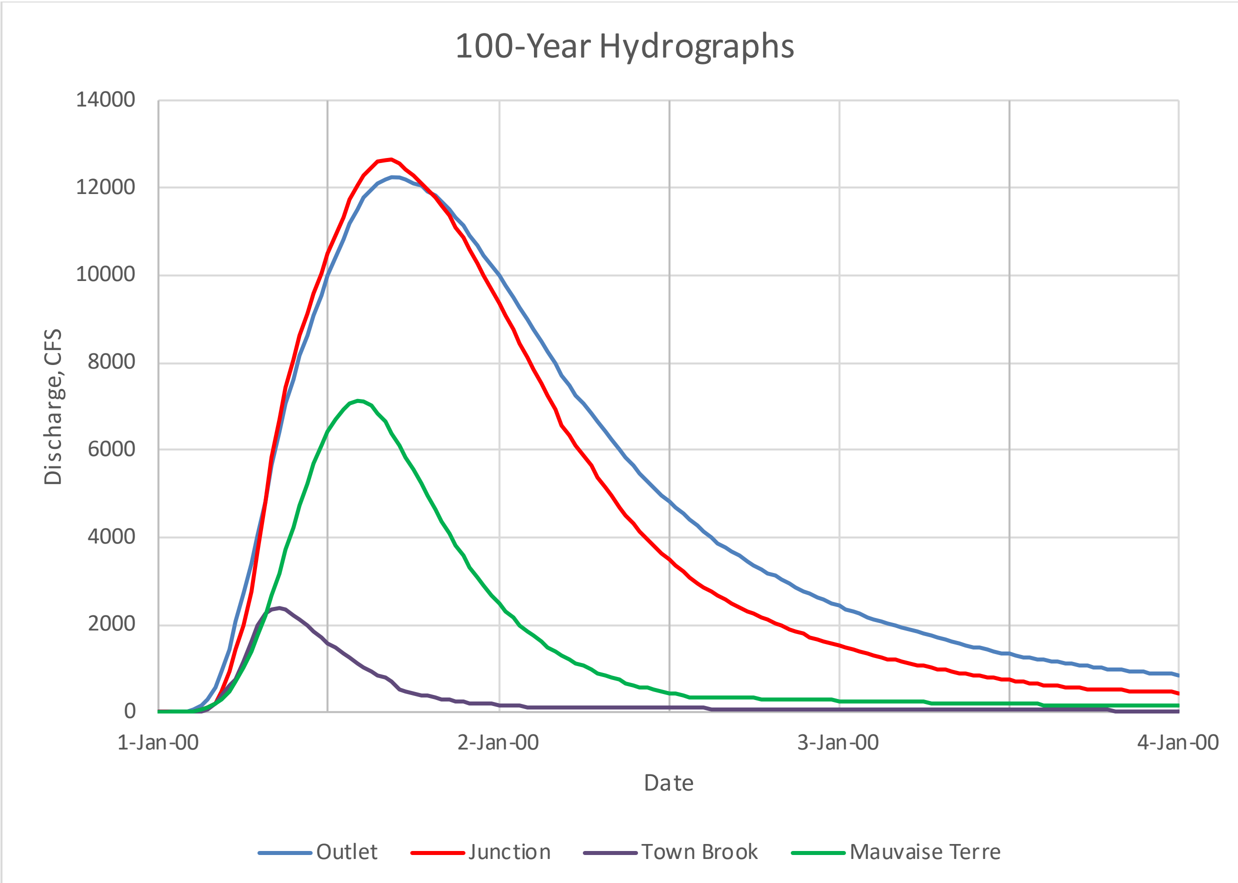

Figure 3 - 100-Year Hydrograph Comparison

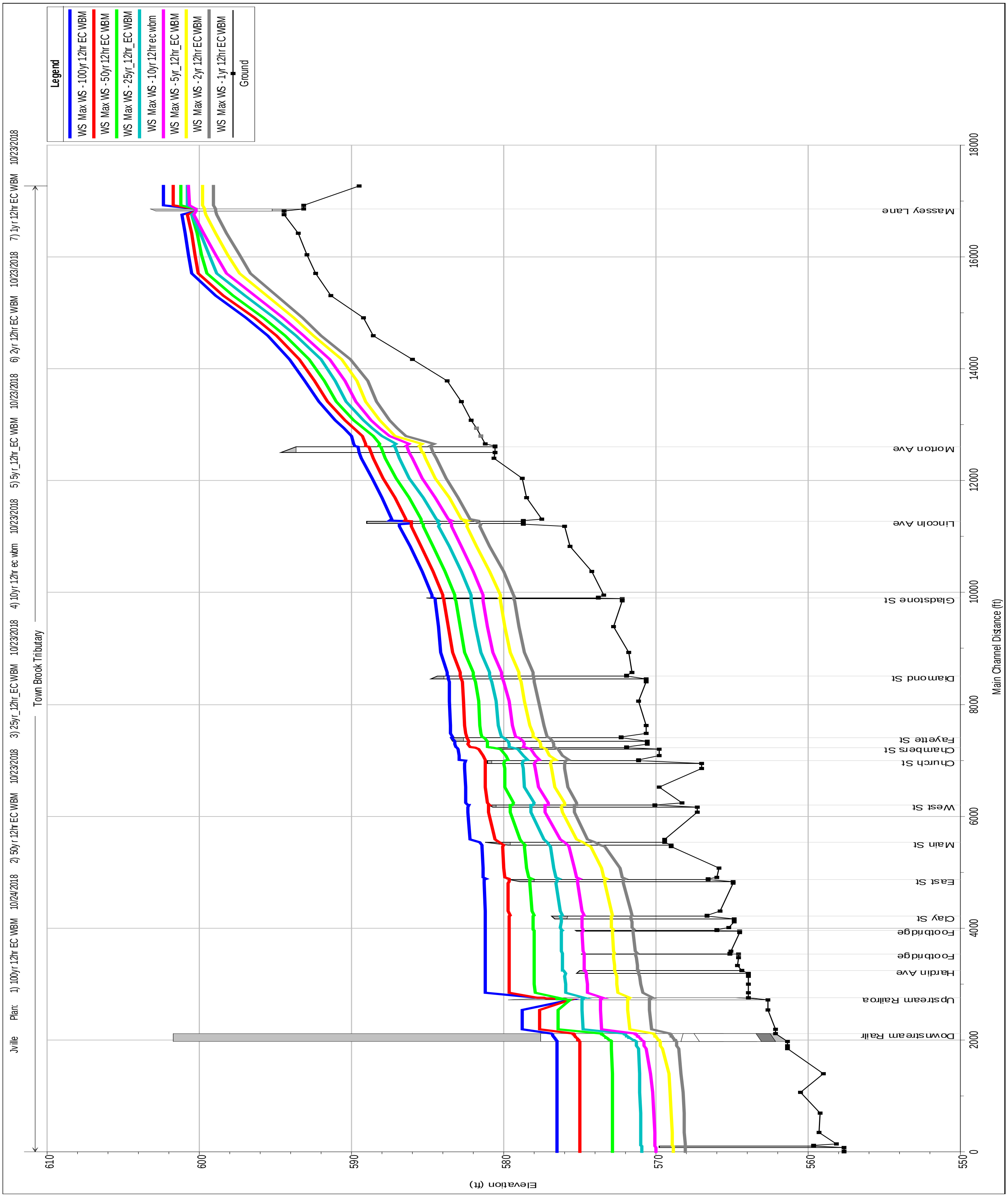

Figure 4 – Water Surface Profiles for Varying Flow Frequencies

V. CALIBRATION

Since no gages are located within the study location, attempts were made to set high-water marks for two different storm events which occurred on June 6, 2014 and December 26, 2015. Unfortunately, these storms proved to be incredibly flashy and made it difficult to obtain accurate high-water marks for calibration of the HEC-RAS model**.** Therefore, the model cannot be calibrated with field data at this time.

VI. DAMAGES MODEL

The damage model was created using a damage calculator developed by the IDNR-OWR (Damages Calculator 4.3). Structures for the model were selected using a visual survey with the FIS Map as a reference and selecting all the structures located in or near the 500/100-yr floodplain. The number of these structures totaled 325 individual structures. During the surveying process, 39 structures were eliminated because they were either clearly too high or because they had been demolished/abandoned. This damage model uses the remaining 286 surveyed structures around Jacksonville. First floor or low water entries were surveyed for all of these structures and basic information about building type and structure design were collected. This information was combined with tax assessor structure value information obtained from Morgan County's Mobile Parcel Viewer GIS website. The values of several business structures and the MacMurray College structures were determined by using replacement costs that were depreciated based on age of the structures.

FEMA's damage curves for various building types were used as input for the model. Water surface profiles were exported for the various HEC-RAS models and represent the flood frequency at 100-, 50-, 25-, 10-, 5-, 2-, and 1-year events. The various rivers incorporated in the HEC-RAS models stationing has been laid out as follows; Mauvaise Terre Creek is the same as the HEC-RAS model, Town Brook has the same stationing except 100,000 has been added to all stations (ex: cross section 17,549.81 becomes 117,549.81), and 200,000 has been added to the Town Tributary cross sections.

The unsteady-state existing conditions damage modeling showed 99 structures being flooded in the100-year event. The lowest structure incurs damages at the 5-year frequency event. Flooding of structures along Town Brook occur east of Diamond Street to the confluence with Mauvaise Terre Creek. **Figure 5** shows the structures that sustain damages and those that are not damaged for the 100-year flood. The existing conditions average annual damage (AAD) is $216,453. These are the average amount of damages to structures and contents that would occur each year. This damage total was adjusted based on the Consumer Price Index (CPI) to bring this value to current (2020) dollars. The current value of AAD is $230,306 (**Table 3**) which correlates to $6,068,975 in capitalized damages. The capitalized damages are computed by

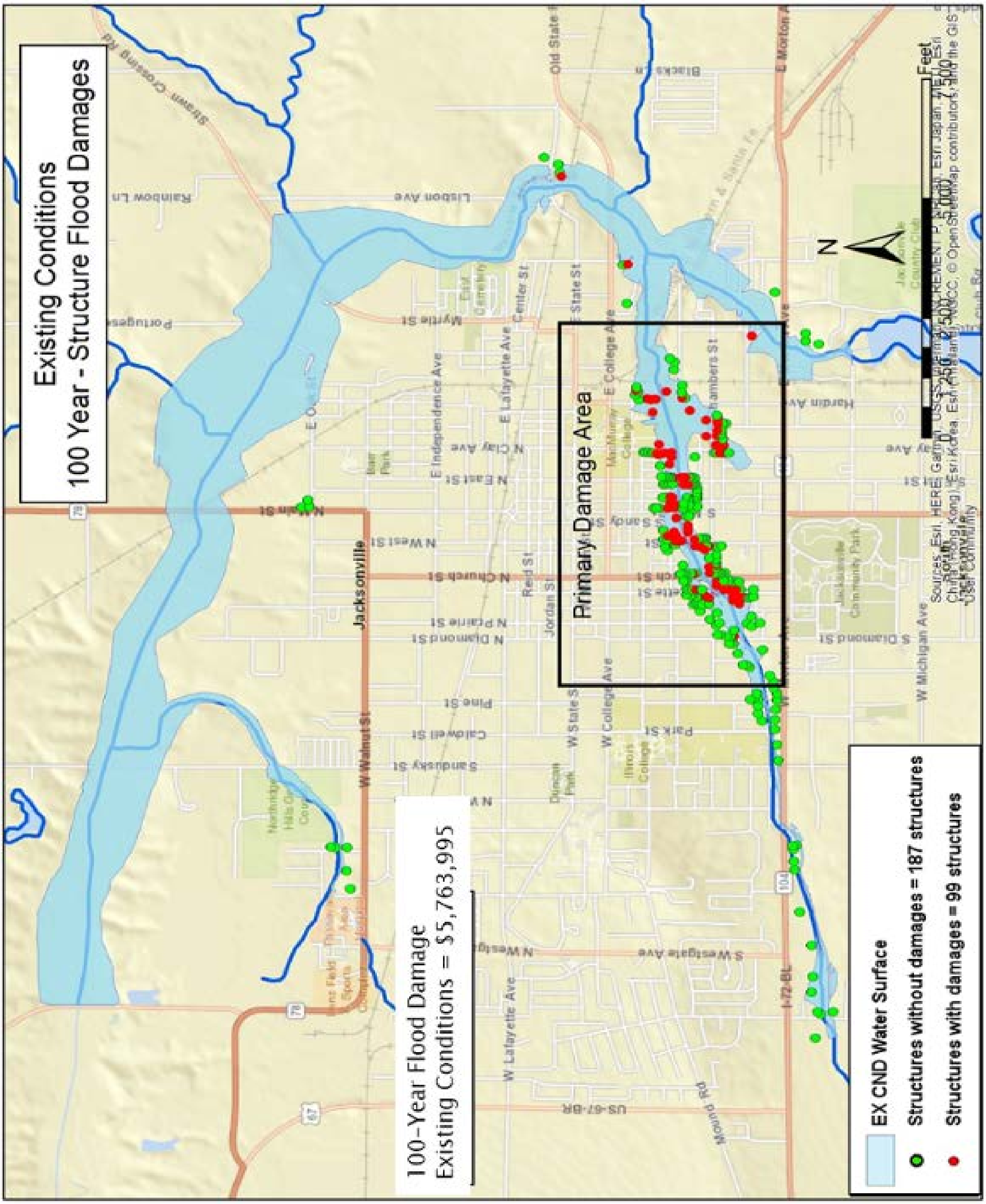

Figure 5 – Existing Conditions 100-Year Floodplain Structure Damages

Frequency (Years)	Number of Structures	Damages
100	99	$5,763,995
50	34	$3,432,503
25	15	$1,733,240
10	2	$56,095
5	1	$637
2	0	$0
1	0	$0
		$200,266
	Indirect Damages	**$30,040**
	Total AAD	**$230,306**

Table 3 – Frequency Damages (2020$)

multiplying the AAD by 26.35185 which is the reciprocal of the Capital Recovery Factor (CRF). The CRF is calculated using the U.S. Army Corps of Engineers interest rate of 2.875% for Fiscal Year 2021. This interest rate is applied based on a project life of 50 years to yield the CRF. For more detailed information and damages calculations please refer to **Appendix C**

VII. FLOOD PROBLEM

Flooding from Mauvaise Terre Creek generates high tailwater conditions on Town Brook which reduce conveyance in the channel reach upstream. In addition, the western railroad bridge and the eastern railroad bridge near the downstream end of Town Brook are very restrictive. These railroad bridges cause an increase in water surface elevation of 6.5 feet at the 100-year frequency event upstream of both the railroad bridges. The existing culverts through the eastern railroad embankment are two 5-foot diameter pipe culverts and a 12’x10’ box culvert. The eastern railroad bridge opening area is significantly less than the other bridges on Town Brook. The combined restrictions of both of the railroad bridges cause flows to overtop the banks of Town Brook which results in flooding of 99 structures along the channel.

The OWR Existing Conditions Damages Model was used to calculate damages in the City of Jacksonville. Based on this model, there are 99 structures damaged and over 99 percent of the damages that occur in the City, are in an area along a 1-mile reach of Town Brook. This damage reach begins about 105 feet upstream of the western railroad bridge on Town Brook. This area encompasses a portion of the campus of MacMurray College. Six of the structures on MacMurray's campus make up 78 percent of the total damages in the City of Jacksonville. However, there are many other structures all along this one-mile reach of Town Brook that were modeled which also sustain damages.

VIII. ALTERNATIVES

Once the model is developed, it can be used to evaluate various improvement alternatives. The following alternatives were investigated to determine the amount of reduction in flood damages that could be provided with implementation of each alternative.

- **Alternative 1** – Add Culverts at Upstream Railroad
- **Alternative 2** – Add Culverts at the Downstream Railroad
- **Alternative 3** – Add Culverts at the Upstream and Downstream Railroad
- **Alternative 4** – Construct Two Offline Reservoirs
- **Alternative 5** – Construct Only the Morton Ave. Offline Reservoir
- **Alternative 6** – Construct Only the Walmart Offline Reservoir
- **Alternative 7** – Construct a Benched Channel Enlargement
- **Alternative 8** – Buyout Ten Structures
- **Alternative 9** – Floodproof MacMurray College Structures
- **Alternative 10** – Combined MacMurray Floodproofed Structures and Buyouts

The alternatives consist of varying levels of improvements either to the capacity of the floodway or protection of the structures. Capacity was proposed by either adding culverts to railroad crossings or constructing offline reservoirs for flood water storage. Additional culverts allow increased flow to pass through the crossings and prevents back flooding. Offline storage provides a location for increased flow to be retained during the flood event to divert flooding away from the structures. Another method to increase channel flow capacity was to enlarge the floodway channel. A final method for reducing costs associated with damaged structures was to completely remove them from the floodplain. All alternatives have costs associated with construction but also have cost savings related to the improvements. Those costs are compared for all the proposed alternatives to help determine the optimal solution.

Alternative 1 - Add Culverts at Upstream Railroad

This alternative consists of adding two 10-foot diameter reinforced concrete (RC) pipe culverts under the upstream railroad spur track, adjacent to the existing 14 feet wide by 13 feet tall stone arch culvert. The new culverts would have a length of 40 feet and would be jacked into place. This would eliminate the need to open cut the railroad embankment. To transition back to the existing channel, minor re-shaping of the channel at 4 to 1 side slopes would be required. **Figure 6** shows a cross section view of the two proposed culverts and the existing arch culvert. Riprap (gradation R4) would be used to line the channel at the ends of the culverts for a distance of 50 feet. **Figure 7** shows a plan view of the culverts, riprap, and channel transition.

Adding two downstream culverts would reduce the 100-year water surface elevation by 1.2 feet just upstream of the railroad and the reduction would gradually decrease to 0.5 feet moving upstream until the reduction ends between S. Diamond Street and Gladstone Street. A total of 45 structures are removed from the 100-year floodplain. While, 54 structures will remain in the 100-Year floodplain, all but two will experience less damage due to lower flood elevations. **Figure 8** shows the revised 100-year floodplain, structures removed from the floodplain, and structures that are still damaged.

Overall structural damages are decreased by $1,977,593. This alternative would have a total first cost of $1,068,289 and a total annual cost of $40,945. The total annual benefits would be $104,947 which yields a benefit to cost ratio of 2.56. Thus, OWR could fund the total construction cost of this alternative since the benefit to cost ratio is greater than 1.0. Refer to **Appendix D** which shows the detailed cost analysis.

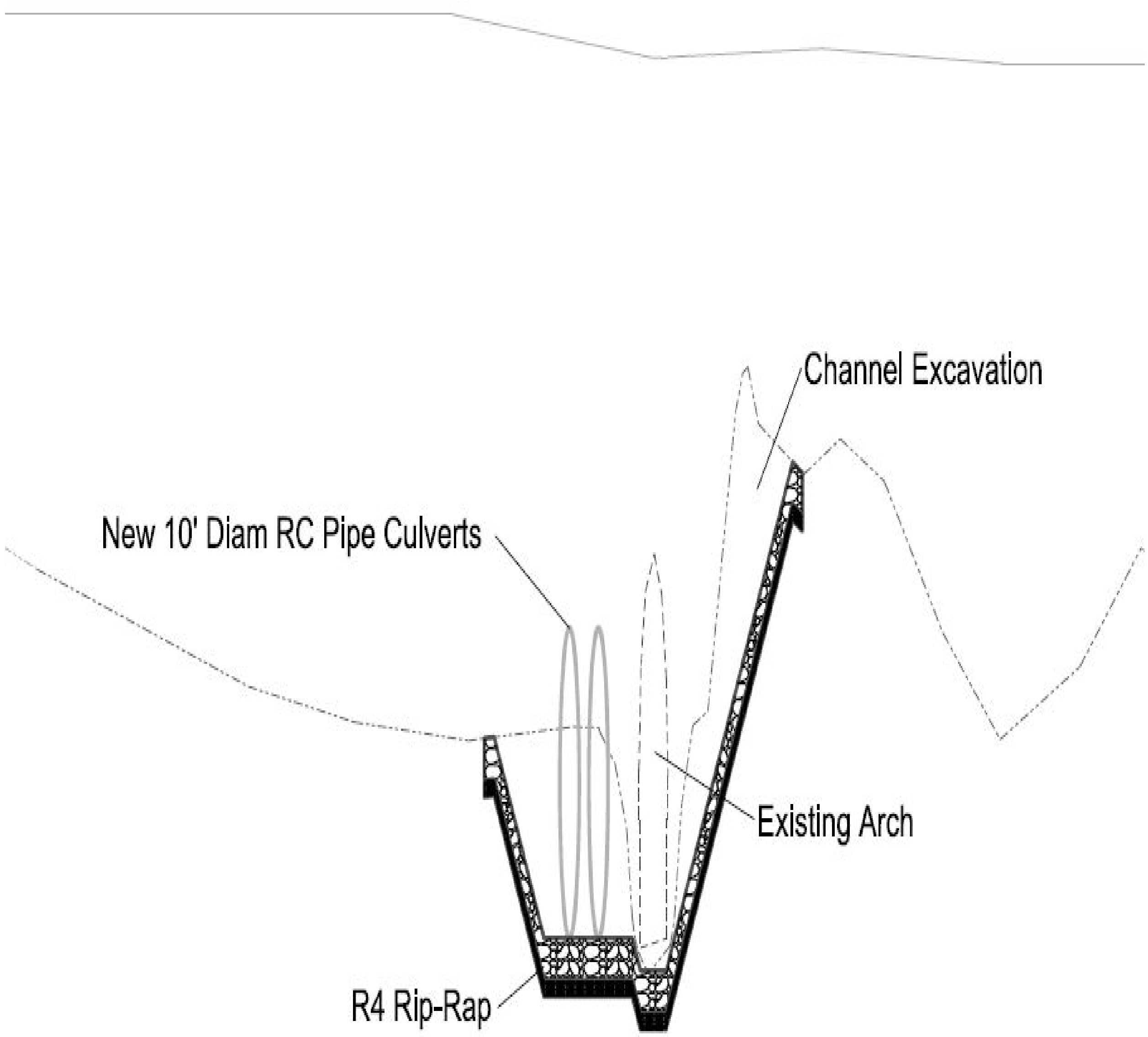

Figure 6 – Alternative 1 – Cross-Section View of Two New Upstream Culverts

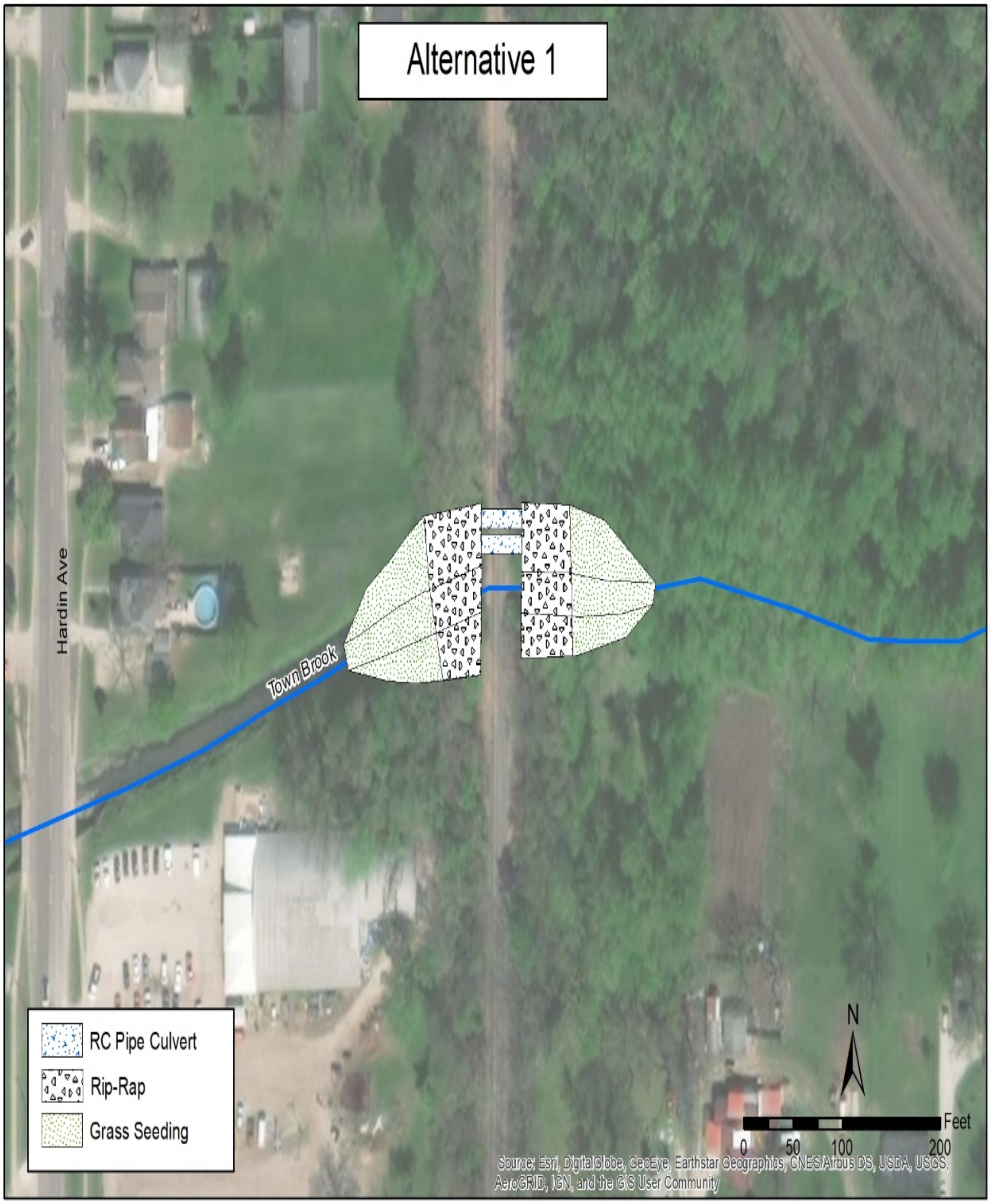

Figure 7 - Alternative 1 – Plan View of Two New Upstream Culverts

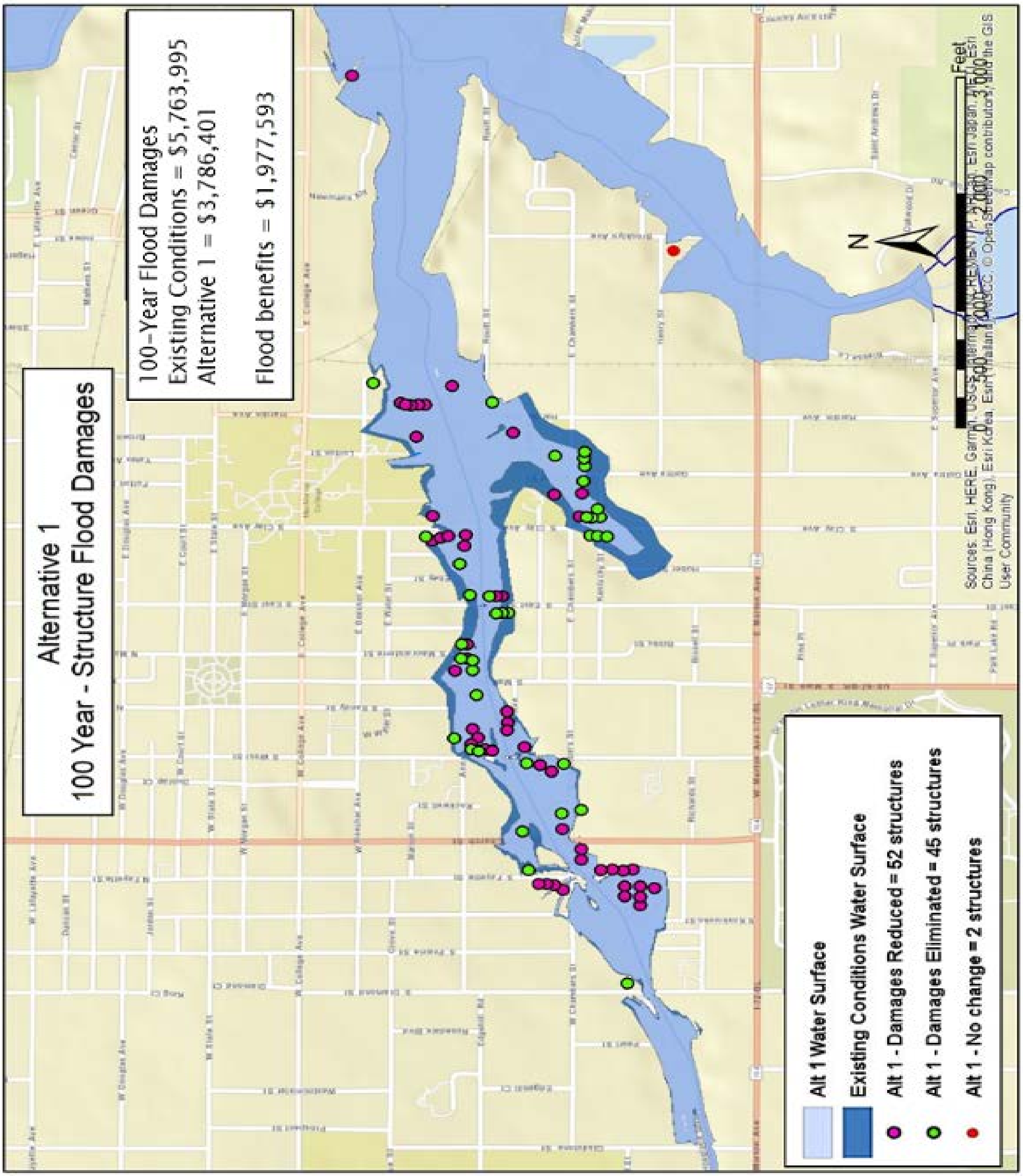

Figure 8 - Alternative 1-100 Year Floodplain Structure Damages

Alternative 2 - Add Culverts at the Downstream Railroad

This alternative consists of adding two 10-foot diameter RC pipe culverts at the downstream railroad to replace the two existing 5-foot diameter pipe culverts. The culverts would be 140 feet in length and jacked into place. This would eliminate the need to open cut the railroad embankment for installation. The existing box culvert would remain. See **Figure 9** shows a cross section view of the two proposed culverts and the existing culvert. Riprap would be used at the ends of the culverts for a distance of 50 feet and minor re-shaping of the channel at 4 to 1 side slopes to transition back to the existing channel would be completed. **Figure 10** shows a plan view of the two proposed culverts with the existing culvert, riprap, and proposed channel transition.

Adding two upstream culverts would reduce the 100-year water surface elevation by 2.6 feet to 1.1 feet upstream until the elevation reduction ceases at Gladstone Street. A total of 57 structures are removed from the 100-year floodplain. While 42 structures will remain in the 100-year floodplain, all but two of those structures will experience reduced damages. **Figure 11** shows the revised 100-year floodplain, structures removed from the floodplain, and structures that are still damaged.

Overall structural damages are decreased by $3,464,898. This alternative would have a total first cost of $1,728,206 and a total annual cost of $66,238. The total annual benefits would be $173,145 which yields a benefit to cost ratio of 2.61. Thus, OWR could fund the total construction cost of this alternative since the benefit to cost ratio is greater than 1.0. Please refer to **Appendix D** which shows the detailed cost analysis for this Alternative.

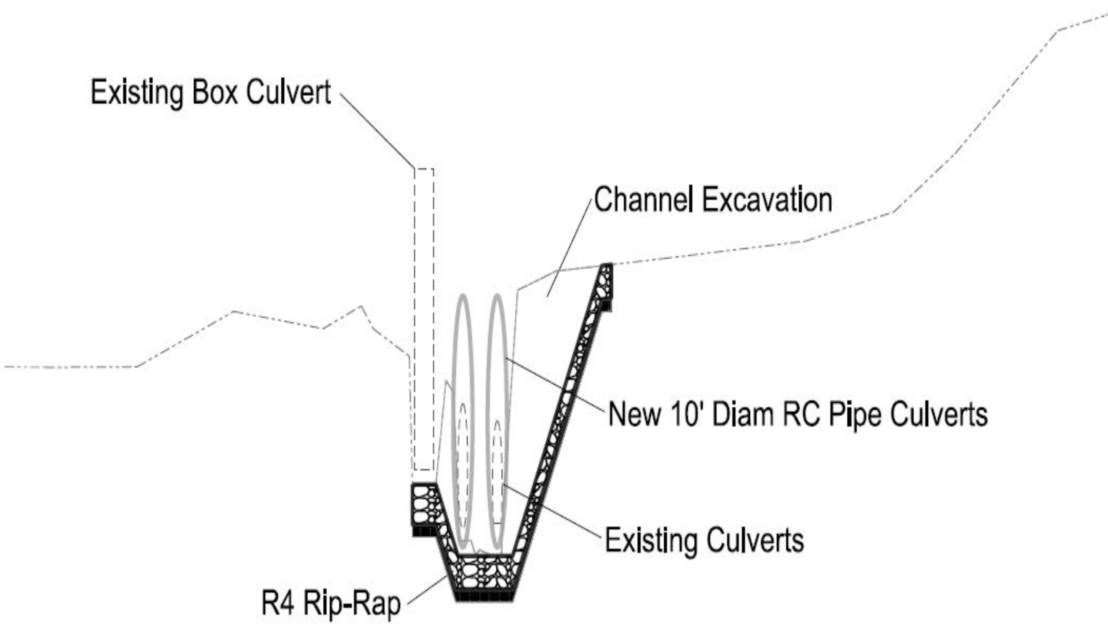

Figure 9 - Alternative 2 – Cross-Section View of Two New Downstream Culverts

Figure 10 - Alternative 2 – Plan View of Two New Downstream Culverts

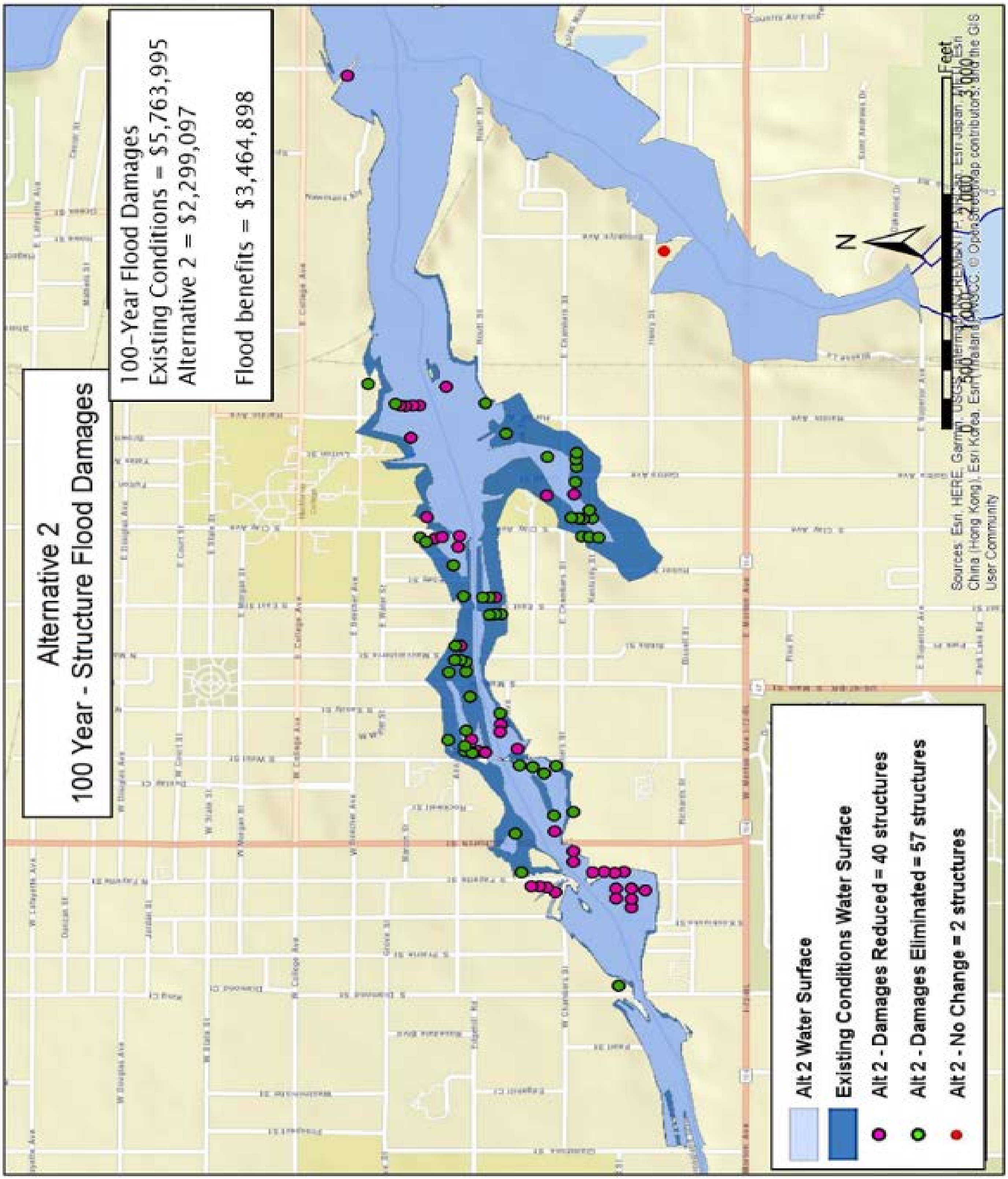

Figure 11 - Alternative 2 - 100 Year Floodplain Structure Damages

Alternative 3 - Add Culverts at the Upstream and Downstream Railroad

This alternative would combine Alternatives 1 and 2 which were described above. Specifically, two 10-foot diameter RC pipe culverts would be added under the upstream railroad spur track and adjacent to the existing 14 feet wide by 13 feet tall stone arch culvert. The culverts would have a length of 40 feet and would be jacked into place. Secondly, two 10-foot diameter RC pipe culverts would be added at the downstream railroad to replace the two existing 5-foot diameter pipe culverts. The culverts would be 140 feet in length and jacked into place. Riprap would be used at the ends of the culverts for a distance of 50 feet and minor re-shaping of the channel at 4 to 1 side slopes to transition back to the existing channel would be done at both culvert locations. **Figure 12** shows a plan view of all the culverts, riprap, and channel transition.

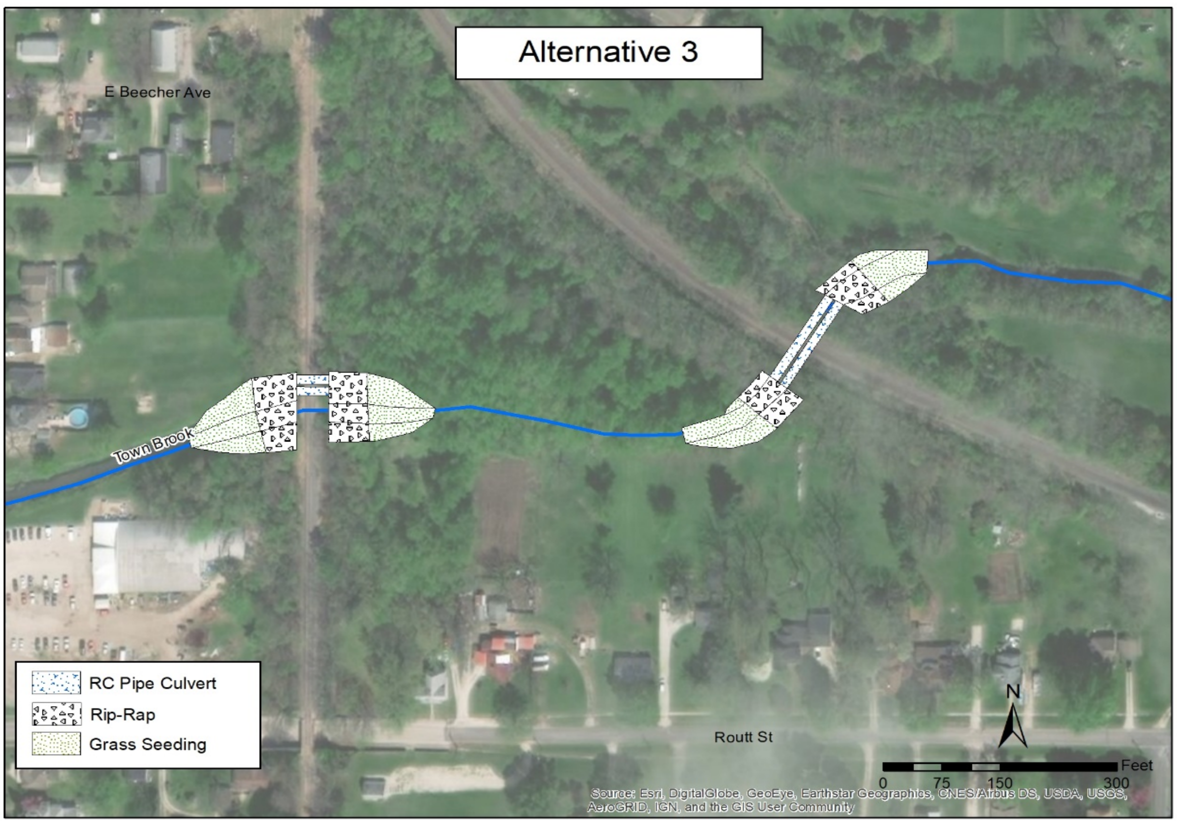

Figure 12- Alternative 3 – Plan View of New Upstream and Downstream Culverts

This alternative which includes new culverts at both the downstream and downstream railroads would reduce the 100-year water surface elevation by 4.7 feet to 1.7 feet upstream until the reduction ends at Gladstone Street. A total of 73 structures are removed from the 100-year floodplain. While 26 structures will remain in the 100-year floodplain, all but two of those structures will experience reduced damages. Please see **Figure 13** which shows the revised 100-year floodplain, structures removed from the floodplain, and structures that are still damaged.

Overall structural damages are decreased by $5,197,395. This alternative would have a total first cost of $2,796,495 and a total annual cost of $107,183. The total annual benefits would be $219,825 which yields a benefit to cost ratio of 2.05. Thus, OWR could fund the total construction cost of this alternative since the benefit to cost ratio is greater than 1.0. Refer to **Appendix D** which shows the detailed cost analysis.

Alternative 4 - Construct Two Offline Reservoirs

This alternative would consist of constructing two dry bottom offline storage reservoirs which would store runoff while releasing the flow over a longer period of time. This would reduce flows in Town Brook which would lower the existing conditions water surface elevations in Town Brook and reduce flood damages.

One reservoir would be constructed in an open field area along the southern edge of Town Brook behind the business along Morton Avenue and west of the Home Depot. This reservoir would have a surface area of 21.5 acres, storage volume of 205 acre-feet, and a depth of 13.0 feet. The 100-year water surface elevation would be 608.0 ft. and the side slopes would be 4' horizontal to 1' vertical. The outlet would consist of two 24-inch diameter reinforced concrete pipe (RCP) culverts and the spillway would be constructed with articulated concrete blocks.

The second reservoir would be constructed behind the Walmart and would have a surface area of 26.7 acres, storage volume of 165.4 acre-feet, and a depth of 11.0 feet. The 100-year water surface elevation would be 606.0 ft. and the side slopes would be 4' horizontal to 1' vertical. The outlet would consist of two 24-inch diameter RCP culverts. **Figure 14** below shows a plan view of the two proposed reservoir locations.

This alternative would reduce the 100-year water surface elevation by 2.5 feet to 2.3 feet upstream until the reduction ends at Massey Lane. A total of 77 structures are removed from the 100-year floodplain. While 22 structures will remain in the 100-year floodplain, all of those structures will experience reduced damages. **Figure 15** shows the new 100-year floodplain, the structures removed from the floodplain, and the structures that are still damaged.

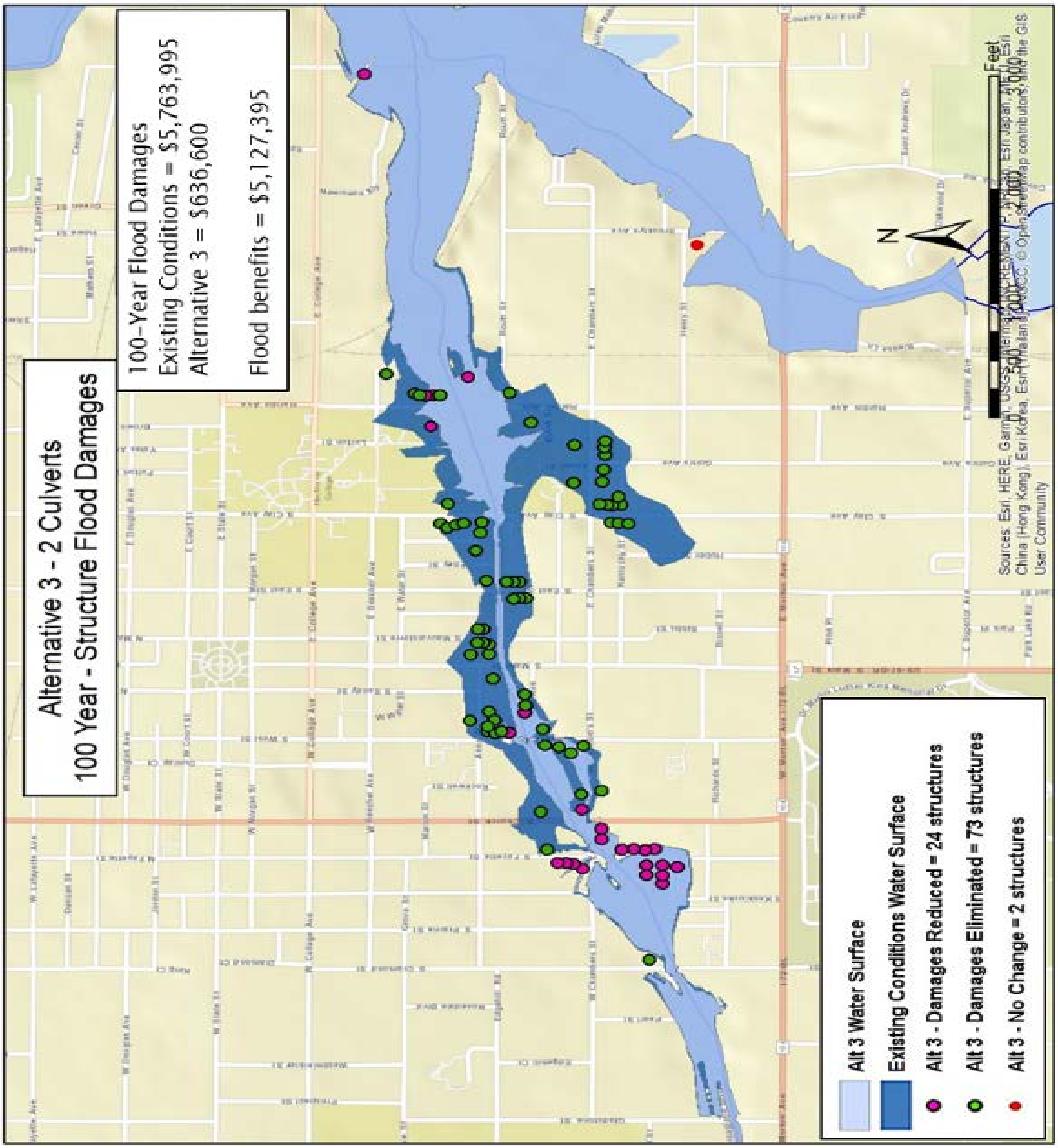

Figure 13 - Alternative 3 – 100-Year Floodplain Structure Damages

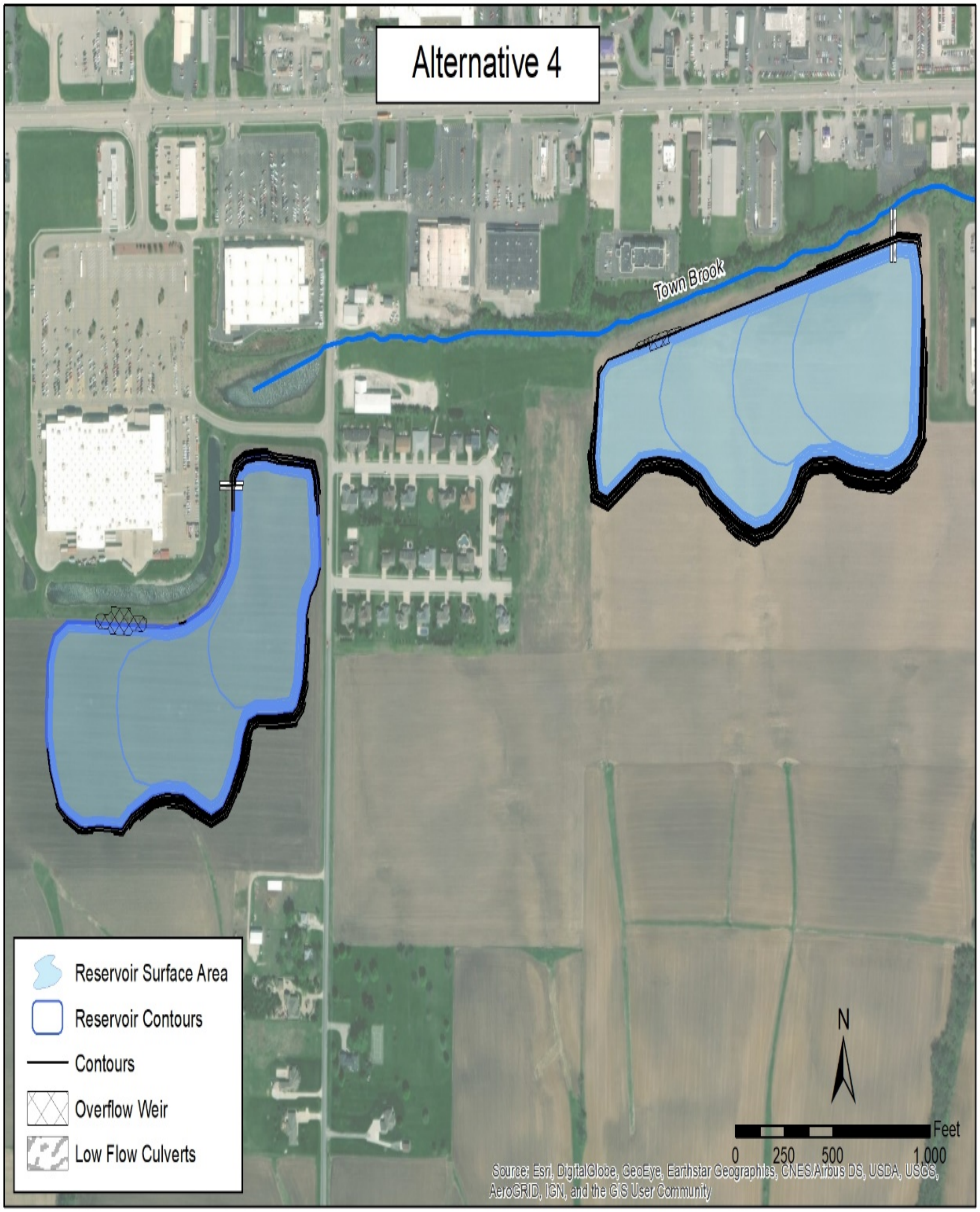

Figure 14- Alternative 4 – Plan View of Adding Two Offline Reservoirs

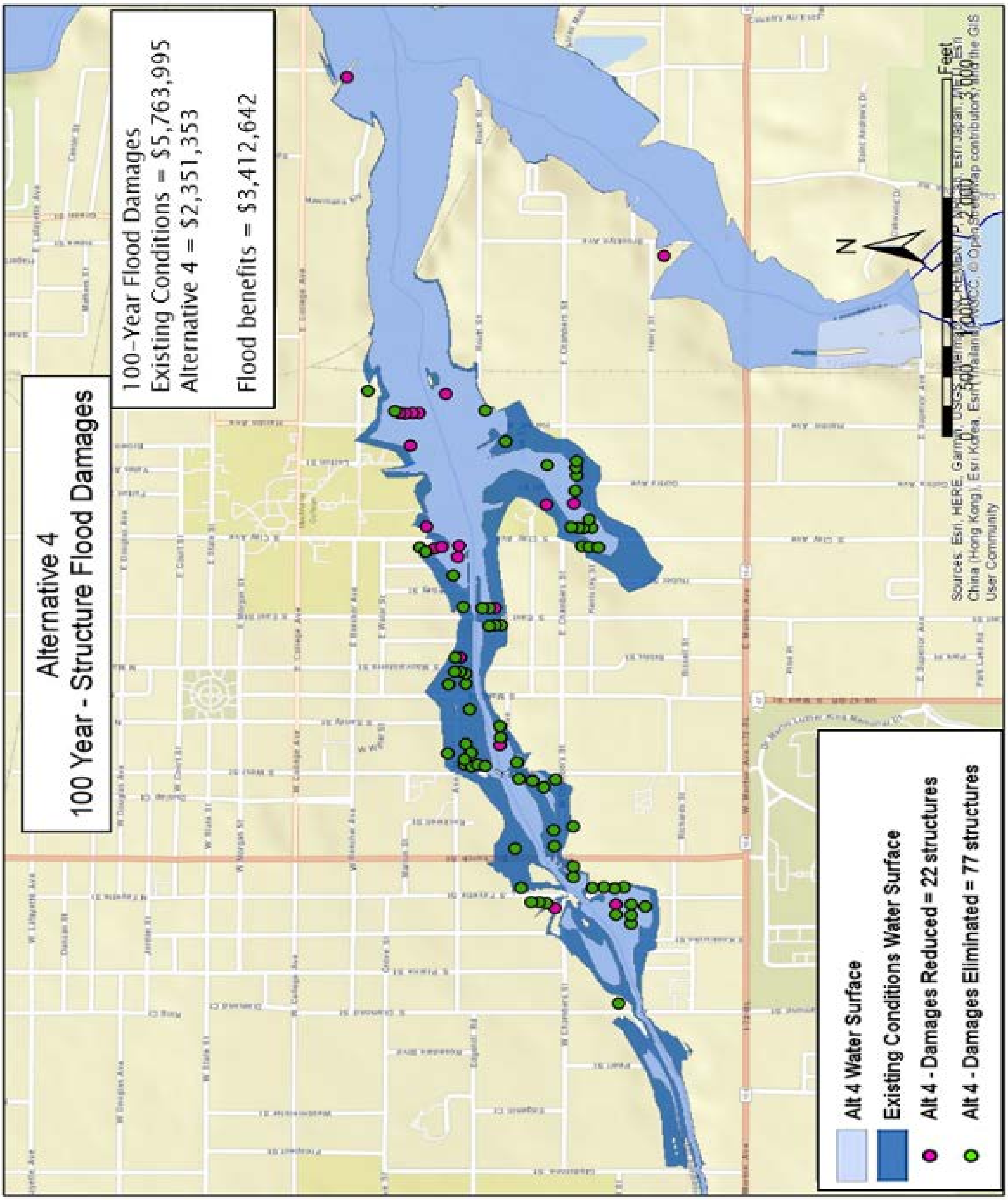

Figure 15 - Alternative 4 – 100 Year Floodplain Structure Damages

Overall structural damages are decreased by $3,412,642. This alternative would have a total first cost of $14,367,262 and a total annual cost of $593,496. The total annual benefits would be $169,333 which yields a benefit to cost ratio of 0.31. The amount of the capitalized benefits based on the amount of benefits generated is $4,462,237. OWR could fund the construction costs up to the capitalized amount. The City would be required to fund the remaining construction costs of $9,913,411. Refer to **Appendix D** which shows the detailed cost analysis.

Alternative 5 - Construct Only the Morton Ave. Offline Reservoir

This alternative would consist of constructing just the Morton Avenue reservoir from Alternative 4. This reservoir would be located in an open field area and remains an offline storage reservoir to retain runoff which would reduce flows in Town Brook. This reduction in flow lowers the existing conditions water surface elevations in Town Brook and reduces flood damages.

The reservoir would have a surface area of 21.5 acres, storage volume of 205 acre-feet, and a depth of 13.0 feet. The water surface elevation would be 608.0 ft. and the side slopes would be 4' horizontal to 1' vertical. The outlet would consist of two 24-inch diameter RCP culverts and the spillway would be constructed with articulated concrete blocks. **Figure 16** shows a plan view of the reservoir location.

This Morton Avenue Offline Reservoir would reduce the 100-year water surface elevation ranging from 2.0 feet to 1.8 feet further upstream until the reduction ends at Massey Ln. A total of 69 structures are removed from the 100-year floodplain. While 30 structures will remain in the 100-year floodplain, all but two of those structures will experience reduced damages. **Figure 17** shows the new floodplain, structures removed from the floodplain, and structures still damaged.

Overall structural damages are decreased by $2,932,338. This alternative would have a total first cost of $8,033,116 and a total annual cost of $307,889. By eliminating the reservoir behind the Walmart, the project costs are reduced. However, the benefits are also reduced because there is less storage and less reduction of flow in Town Brook. The total annual benefits would be $140,036 which yields a benefit to cost ratio of 0.45. The amount of the capitalized benefits based on the amount of benefits generated is $3,690,200. OWR could fund the construction costs up to this capitalized amount. The City would be required to fund the remaining construction costs of $4,418,214. Refer to **Appendix D** to see the detailed cost analysis.

Figure 16- Alternative 5 – Plan View of Adding Morton Ave. Offline Reservoir

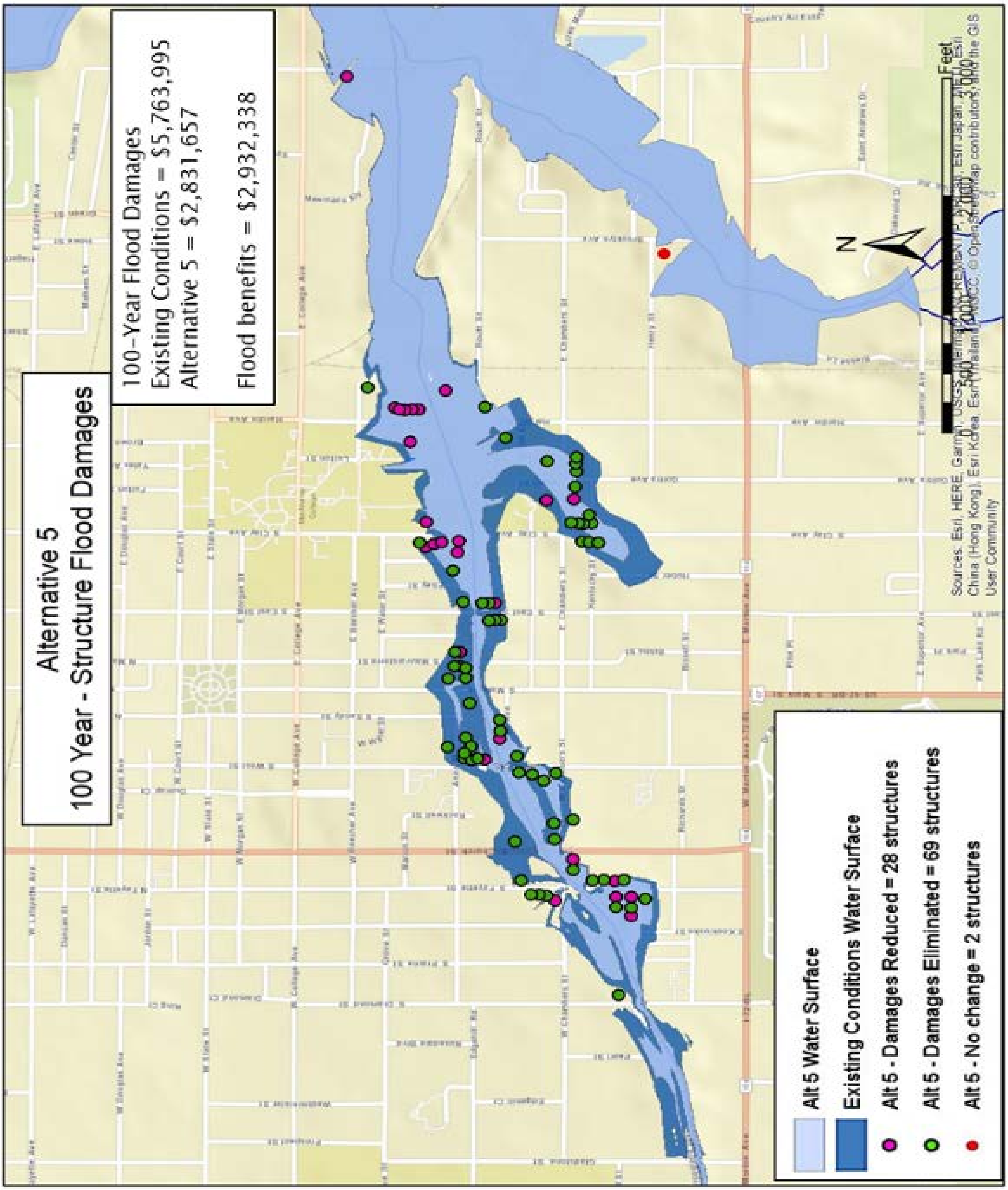

Figure 17- Alternative 5 – 100 Year Floodplain Structure Damages

Alternative 6 - Construct Only the Walmart Offline Reservoir

This alternative would consist of constructing only the reservoir behind Walmart in the open area as proposed in Alternative 4. It remains an offline storage reservoir to retain runoff which would reduce flows in Town Brook. This reduction in flow lowers the water surface elevations in Town Brook and reduces flood damages.

The reservoir would have a surface area of 26.7 acres, storage volume of 165.4 acre-feet, and a depth of 11.0 feet. The water surface elevation would be 606.0 ft. and the side slopes would be 4' horizontal to 1' vertical. The outlet would consist of two 24-inch diameter RCP culverts and the spillway would be constructed with articulated concrete blocks. **Figure 18** shows a plan view of the location of the reservoir location.

This would reduce the 100-year water surface elevation by 1.4 feet upstream until the reduction ends about 1,400 feet downstream of Massey Lane. By eliminating the reservoir along Morton Ave., the project costs are reduced. However, the benefits are also reduced because there is less storage and less reduction of flow in Town Brook. A total of 56 structures are removed from the 100-year floodplain. While 43 structures will remain in the 100-year floodplain, all but two of those structures will experience reduced damages. **Figure 19** shows the new floodplain, structures removed from the floodplain, and structures still damaged.

Overall, the Walmart Offline Reservoir alternative structural damages are decreased by $2,363,859. This alternative would have a total first cost of $6,334,146 and an average annual cost of $242,772. The total annual benefits would be $127,789 which yields a benefit to cost ratio of 0.53. The amount of the capitalized benefits based on the amount of benefits generated is $3,367,457. OWR could fund the construction costs up to this capitalized amount. The City would be required to fund the remaining construction costs of $2,977,049. Refer to **Appendix D** for the detailed cost analysis.

Alternative 7: Construct a Benched Channel Enlargement

Another way to increase capacity of the channel is to enlarge the channel. This can be accomplished by excavating material from the channel and creating a "bench" where possible along Town Brook. The design of the bench is at half the height of the channel, 15' to 20' width, a depth of 4' to 7' and has a back slope of 3:1. The channel bench excavation has been added at the following cross section locations: 17045.29 to 14067, 12682 to 11562, and 8691 to 271.0722. These are reaches where the overbanks have open room without impacting structures. The total length of the bench excavation is about 9,351 lineal feet to increase capacity by 50,632 cubic yards. This proposal has the added benefit of reducing erosion because side slopes of

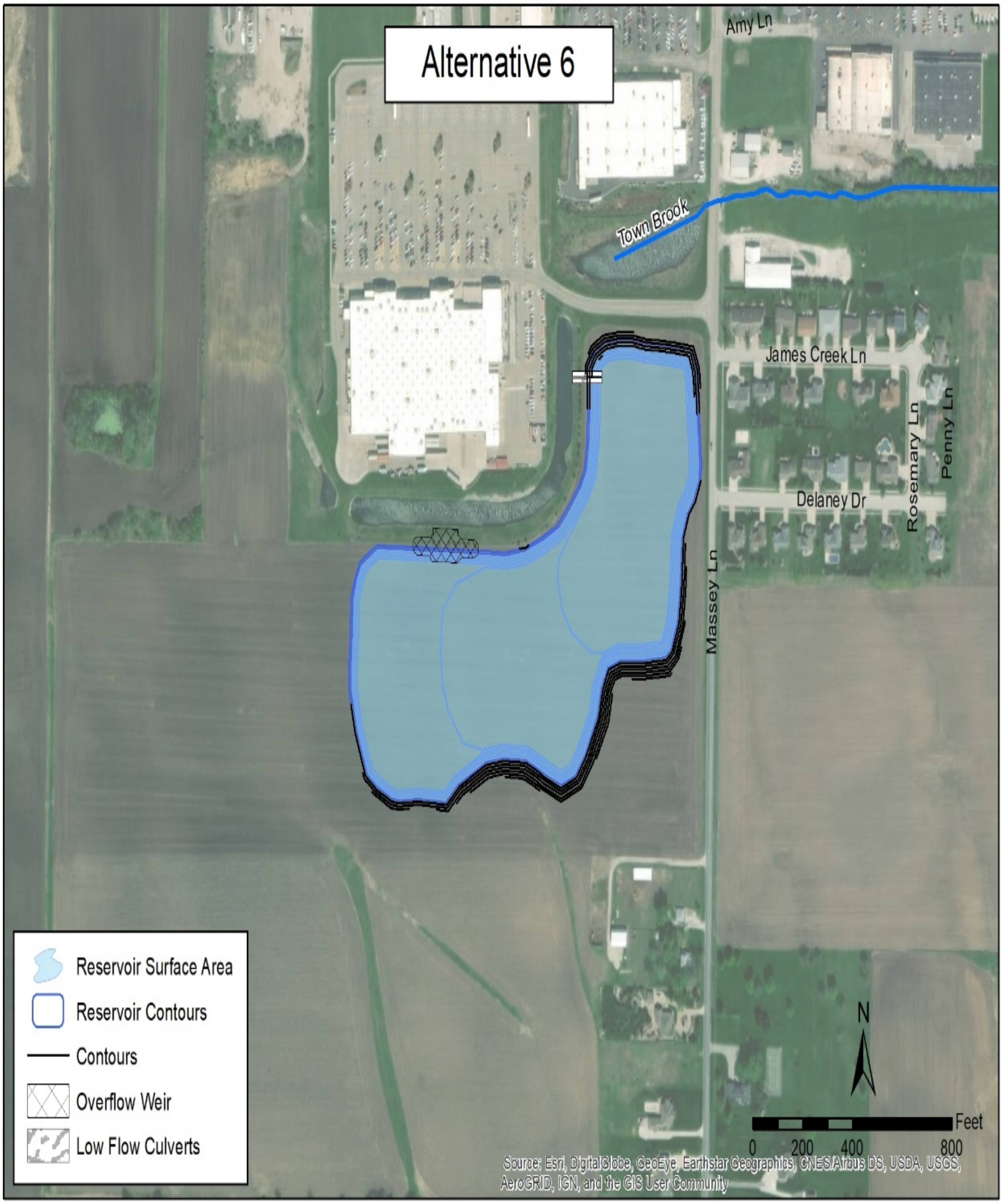

Figure18 - Alternative 6 – Plan View of Adding Walmart Offline Reservoir

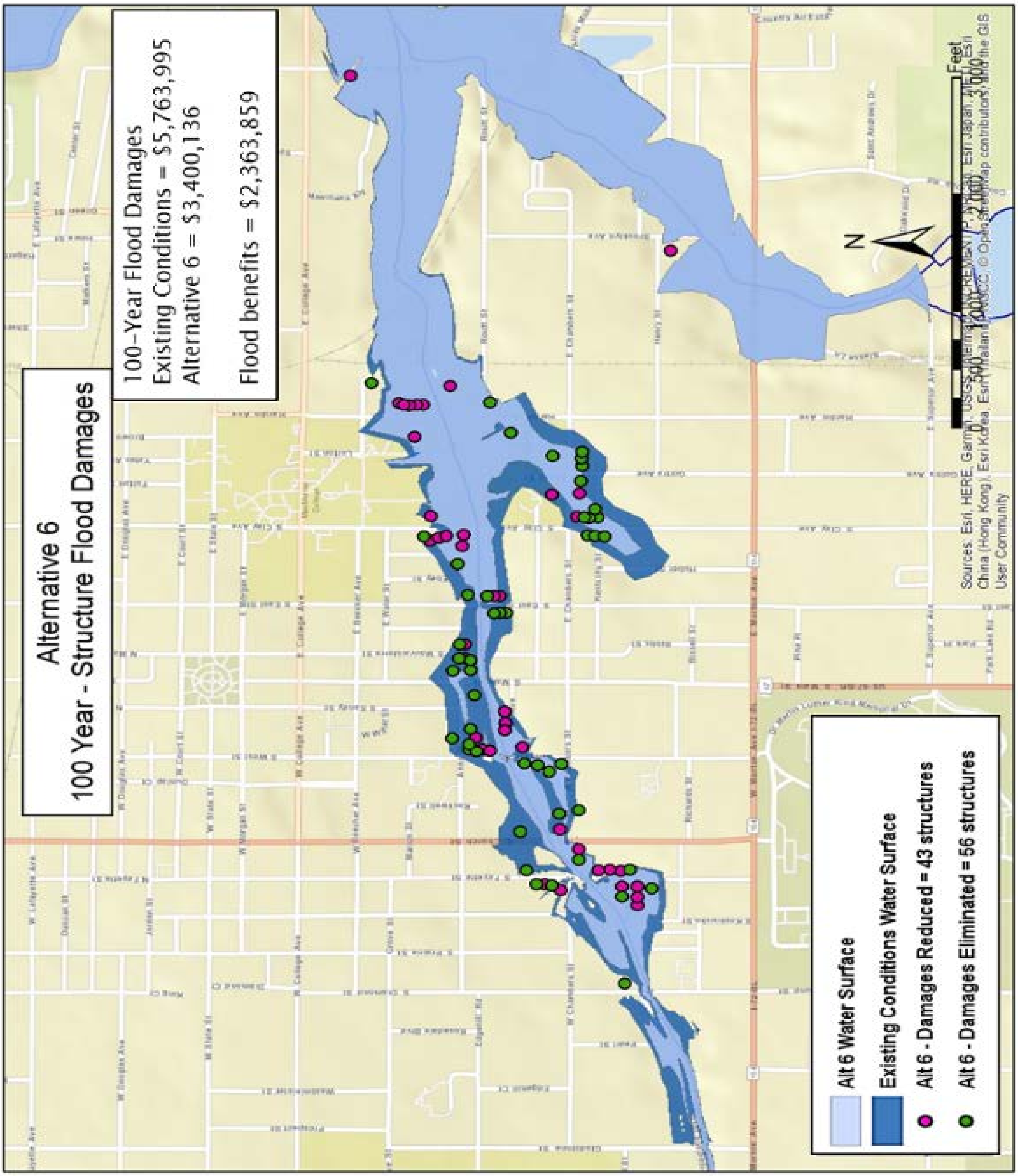

Figure 19 - Alternative 6 - 100 Year Floodplain Structure Damages

benches are set at 3:1 which is less steep than the existing conditions. **Figure 20** shows a cross section view of the typical channel cross section for this alternative.

The proposed 100-yr 12-hr water surface reduction is almost negligible. There are two reasons that this has happened. During resulting high flows, a large portion of the flow is now in the channel which changes the ratio of in channel and out of channel flow. The out of channel or overbank flow resulted in greater conveyance capacity due to a larger flow area. Although there is now more flow area in the channel with the excavated benches than existed without them, that conveyance area is less than the overbank conveyance area without the benches. This results in the benched channel impacts being less effective to reduce stages. The other reason the water surface reduction was minimal is because of Town Brook's relationship with Mauvaise Terre Creek. The benches reduced the flow velocities which increased the time for Town Brook peak flows to reach the junction with Mauvaise Terre Creek. This allowed higher flows to occur on Mauvaise Terre Creek which raises the tailwater elevation on Town Brook. This results in a larger backwater effect on Town Brook, which limits the reduction in water surface elevations with this improvement. Only one structure is removed from the 100-year floodplain. Therefore, 98 structures will remain in the 100-year floodplain. **Figure 21** shows the new 100-year floodplain, structures removed from the floodplain, and structures still damaged.

Overall structural damages are decreased by $737,512. The Benched Channel Enlargement alternative would have a total first cost of $1,318,693 and a total annual cost of $50,542. The total annual benefits would be $37,539 which yields a benefit to cost ratio of 0.74. Since the benefit to cost ratio is less than 1.0, OWR could only fund the construction costs up to the capitalized benefit amount of $989,218. The remaining costs for this alternative or $342,860 would need to be provided by the City. However, this alternative only protects one structure from the 100-year frequency flood event. There would be 89 structures that would still be damaged and would sustain $155,228 of AAD. Refer to **Appendix D** for the detailed cost analysis.

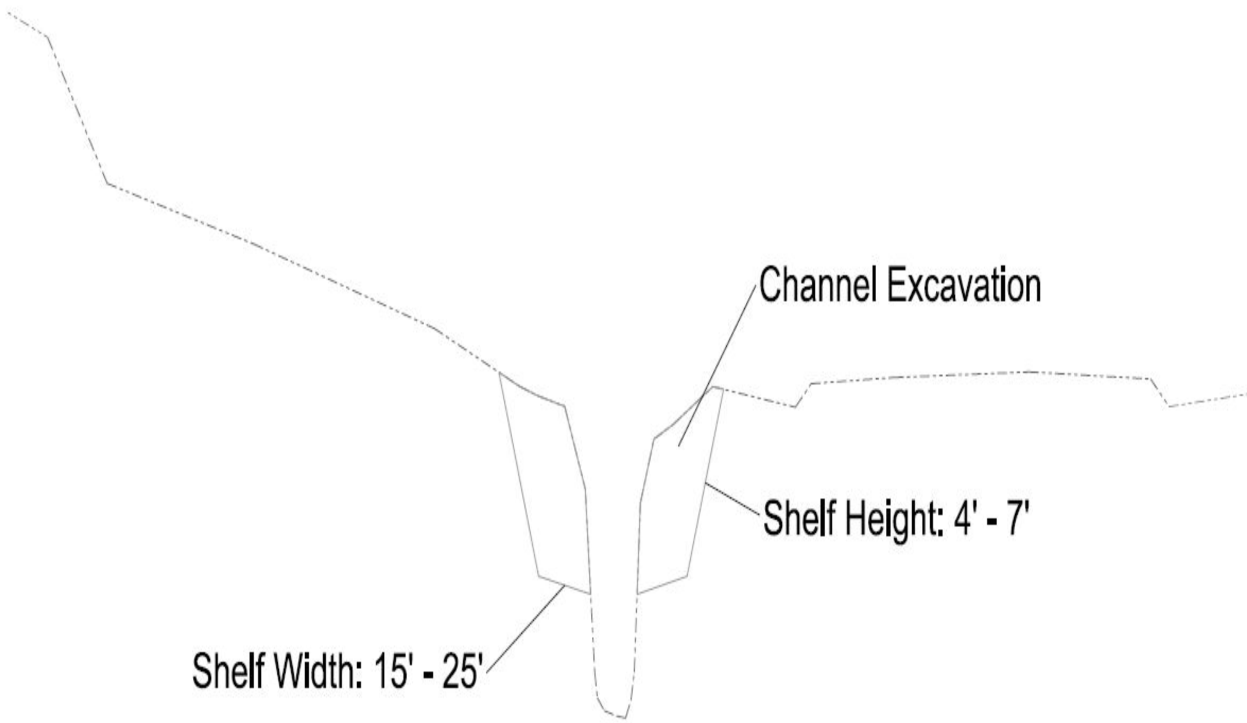

Figure 20 - Alternative 7 – Cross-Section View of Benched Channel Enlargement

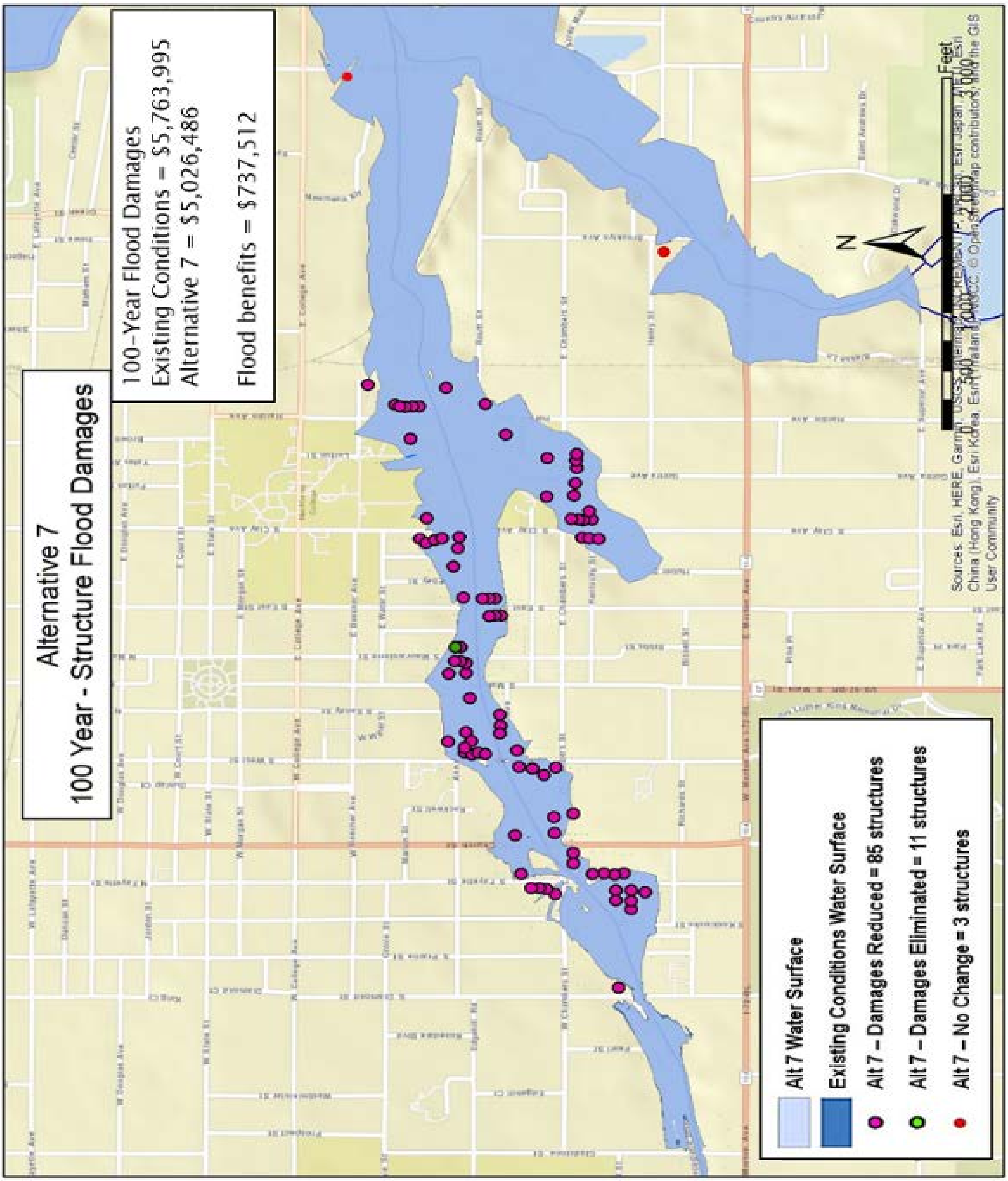

Figure 21 - Alternative 7 - 100-Year Floodplain Structure Damages

Alternative 8 - Buyout Ten Structures

This alternative would consist of buying out all (ten) structures that flood at the 25-year event except for four of the MacMurray College buildings. Removing structures permanently removes them from the possibility of any future flooding. This would include a total of 10 structures that would be purchased which would include the Gordon Facilities Management Facility. The structures would be demolished and the land maintained by the City as open space. The costs to purchase the structures including demolition costs is detailed below in **Table 4**.

Structure #	Address	Morgan County Assessor PIN	Land Value	Building Value	Total Value	Total Value Includes Demolition	B/C Ratio
216	455 S Clay Ave	09-21-311-019	$12,690	$2,640	$15,330	$30,330	0.03
215	469 S Clay Ave	09-21-311-018	$10,950	$19,050	$30,000	$45,000	0.18
213/214	475 S Clay Ave	09-21-311-051	$17,000	$219,880	$236,880	$266,880	0.35
267	406 Hardin Ave	09-21-323-002	$13,830	$53010	$66,840	$81,840	0.35
266	408 Hardin Ave	09-21-323-003	$13,830	$40,470	$54,300	$69,300	0.33
265	410 Hardin Ave	09-21-323-004	$10,440	$34,560	$45,000	$60,000	0.32
264	450 Hardin Ave/MacMurray College	09-21-323-006		$526,181	$561,181	$561,181	1.19
85	675 Fayette St.	09-20-410-014	$1,900	$19,100	$21,000	$63,000	0.19
150	218 Capps St.	09-20-422-014	$1,950	$3,060	$5,010	$15,010	0.10
Total						**$1,207541**	**0.70**

Table 4 – Proposed Buyout Structure Summaries

Overall structural damages are decreased by $514,944. This alternative would have a total first cost of $1,207,541 and a total annual cost of $46,282. The total annual benefits would be $32,448 which yields a benefit to cost ratio of 0.70. Since the benefit to cost ratio is less than 1.0, OWR could only fund the construction costs up to the capitalized benefit amount of $855,063. The remaining costs for this alternative or $362,262 would need to be provided by the City. However, this alternative only protects 10 structures from the 100-year frequency flood event. There would be 89 structures that would still be damaged and would sustain $165,410 of AAD. Refer to **Appendix D** for the detailed cost analysis.

Alternative 9. Floodproof MacMurray College Structures

As noted previously, six of the structures on MacMurray's campus make up 78 percent of the total damages in the City of Jacksonville. Therefore, it makes sense to target protection of some of these structures. This alternative involves floodproofing four MacMurray College structures by constructing a levee or floodwall around each structure to prevent flooding. These structures are: Julian Hall, Jenkins Education Complex/Wall Gymnasium, Michalson House, and Norris Hall. The Gordan Facilities Management structure was not included for protection because any levee or floodwall would need to be constructed in the regulated floodway and would not be permittable. The sixth structure was Kendall house but the benefits to be derived from floodproofing were too low when compared to the cost so it was also eliminated.

Earthen levees would be used for all structures except the Jenkins Education Complex/Wall Gymnasium. A concrete floodwall would be required for this structure because there is not sufficient area to construct a levee. **Figure 22** shows the locations for the proposed levees and floodwall.

The levees would provide 100-year flood protection. The levees would be constructed with 3 to 1 side slopes and a 5-foot top width. The levees for Julian Hall and Norris Hall would be constructed to a height to allow 2 feet of freeboard above the 100-year elevation. Michalson House would be constructed to a height with 1 foot of freeboard above the 100-year frequency due to right-of-way availability. Levee heights for the structures would range from to 5.1 feet to 8.1 feet.

The height of the floodwall is limited to 4 feet due to structural stability of the wall from static pressure from the water. Therefore, the floodwall would only provide 25-year frequency protection so it will still flood during larger storm events. The Jenkins Education Complex/Wall Gymnasium would have 0.9 feet of freeboard above the 25-year elevation.

There will be openings in the levees and floodwall at strategic locations such as driveways to parking lots and sidewalks for access to the buildings. These openings would require removable or hinged closure structures that would be used during flood conditions.

Overall structural damages are decreased by $104,602. This alternative would have a total first cost of $1,103,448 and a total annual cost of $42,292. The total annual benefits would be $111,297 which yields a benefit to cost ratio of 2.63. Since the benefit to cost ratio is greater than 1.0, OWR could fund the construction costs of this alternative. However, this alternative only protects three structures from the 100-year

Figure 22 - Alternative 7 – Plan View of Floodproofed MacMurray Structures

flood and one structure from the 25-year flood. There would be 95 structures that would still be damaged and $119,009 AAD remaining. **Table 5** shows much of the cost analysis discussed above. Please refer to **Appendix D** for additional details of the cost analysis.

Structure #	Address	Total Cost	Existing AAD	Project AAD	Project AAB	Total Annual Cost	Capitalized Benefits	B/C Ratio
224	440 S Clay Ave	$129,310				$6,200		3.88
228	400 E. Chambers St.	$285,511				$13,690		2.04
227	504 E. Chambers St.	$392,231				$18,807		0.63
225	409 Hardin Ave	$296,397				$14,212		3.34
Total			**$175,709**	**$64,413**	**$111,297**	**$42,292**	**$2,932,887**	**2.63**

Table 5 – Summary of Floodproof Costs for MacMurray Buildings

Alternative 10. Combined MacMurray Floodproofed Structures and Buyouts

Alternative 10 combines the Alternative 8 Buyouts with Alternative 9 MacMurray College Floodproofed Structures levees and floodwall. This alternative would protect more structures and eliminate more damages than each individual alternative.

Overall structural damages are decreased by $135,098. This alternative would have a total first cost of $2,310,989 and a total annual cost of $88,574. The total annual benefits would be $143,745 which yields a benefit to cost ratio of 1.62. Since the benefit to cost ratio is greater than 1.0, OWR could fund the construction costs of this alternative. However, this alternative only protects 13 structures from the 100-year frequency flood and 1 structure from the 25-year flood. There would be 86 structures that would still be damaged and would sustain $86,561 of AAD. Please see **Table 6** below which shows many of the details of the cost analysis discussed above. Also see **Appendix D** for all details of the cost analysis.

Structure #	Address	Morgan County Assessor PIN	Land Value	Building Value	Total Value	Total Value Include Demolition	Average Annual Benefits	Average Annual Cost	B/C Ratio
216	455 S Clay Ave	09-21-311-019	$12,690	$2,640	$15,330	$30,330		$1,151	0.03
215	469 S Clay Ave	09-21-311-018	$10,950	$19,050	$30,000	$45,000		$1,708	0.18
213/214	475 S Clay Ave	09-21-311-051	$17,000	$219,880	$236,880	$266,880		$10,128	0.35
267	406 Hardin Ave	09-21-323-002	$13,830	$53010	$66,840	$81,840		$3,106	0.35
266	408 Hardin Ave	09-21-323-003	$13,830	$40,470	$54,300	$69,300		$26,030	0.33
265	410 Hardin Ave	09-21-323-004	$10,440	$34,560	$45,000	$60,000		$2,277	0.32
264	450 Hardin Ave/MacMurray College	09-21-323-006		$526,181	$561,181	$561,181		$21,296	1.19
85	675 Fayette St.	09-20-410-014	$1,900	$19,100	$21,000	$63,000		$12,158	0.19
150	218 Capps St.	09-20-422-014	$1,950	$3,060	$5,010	$15,010		$570	0.10
224	440 S. Clay St.	Flood Proof			$129,310			$6,200	3.88
228	400 E. Chambers St.	Flood Proof			$285,511			$13,690	2.04
227	504 E. Chambers St.	Flood Proof			$392,231			$18,807	0.63
225	409 Hardin St.	Flood Proof			$296,397			$14,212	3.34
Total						**$2,310,989**	**$143,574**	**$88,574**	**1.62**

Table 6 – Summary of Buyout Structures and Floodproofed MacMurray Structures

IX. Recommendations

All Alternatives provided a lower 100-year floodplain and reduced associated structural damages. Some solutions provided costs savings by removing structures from the floodplain. Others focused on reducing flood impacts for the highest value structures. **Table 7** provides a comparison matrix of benefits and costs for all ten alternatives that were investigated in the Study. When evaluating options, the City might look at the annual cost savings, the numbers of protected structures and the Benefit to Cost (B/C) ratio. Higher B/C ratios indicate higher value for money spent on improvements. In addition, Alternatives with B/C ratios greater than 1.0 allow OWR to fund the construction cost, thereby further reducing the costs to the City.

Alternative 4 provides flood protection for the largest number of structures. This option is the offline storage reservoir along Morton Ave. and the offline storage reservoir near Walmart. The total storage volume provided is 370 acre-feet. This alternative removes a total of 77 structures from the100-year floodplain which is more than any of the other alternatives. However, this alternative has a cost of $14,367,262, which is the highest cost of all the other alternatives, and it has a benefit to cost (B/C) ratio of only 0.31.

Since the B/C ratio is less than 1.0, OWR funding for this project would be limited to the amount of the capitalized benefits. The capitalized benefits are computed by multiplying the Average Annual Benefits by 26.35185 which is the reciprocal of the Capital Recovery Factor (CRF). The CRF is calculated using the U.S. Army Corps of Engineers interest rate of 2.875% for Fiscal Year 2021. This interest rate is applied based on a project life of 50 years to yield the CRF. So multiplying the AAB amount of $169,333.35 by 26.35185 would total $4,462,237 of capitalized benefits. This is the amount of funding OWR can provide for the project leaving a balance of $9,913,411 which the City would have to provide to implement this alternative.

The highest average annual benefits are provided by Alternative 3 which adds two new culverts at both downstream and upstream railroads. This Alternative removes a total of 73 structures from the100-year floodplain and has a B/C ratio of 2.05. This Alternative removes only 4 fewer structures from the 100-year floodplain than Alternative 4 for a cost that is $11,570,767 less. It also provides the highest total reduction of damages. Since the B/C ratio is greater than 1.0, OWR can provide all the construction costs for this project. The total cost of this alternative is $2,796,495. The City of Jacksonville would be required to pay the cost for all land rights (est. $3,700) and utility relocation required for construction. Since Alternative 3 provides the highest average annual benefits while also protecting more structures than most of the other alternatives, OWR would recommend that Alternative 3 be implemented. Typically, the City would select the project that is to be constructed. However, OWR must agree with that project’s selection.

Alternative	Description	Structures Removed from 100 YR Floodplain	Average Annual Benefits	Total Project Costs	B/C Ratio	Total Reduction of Damages
1	New Culverts @ Upstream Railroad	45	$104,947	$1,068,289	2.56	$1,997,593
2	New Culverts @ Downstream Railroad	57	$173,145	$1,728,206	2.61	$3,464,898
3	New Culverts @ Both Railroads	73	$219,825	$2,796,495	2.05	$5,127,395
4	Both Storage Reservoirs	77	$169,333	$14,367,262	0.31	$3,412,642
5	Morton Ave. Reservoir	69	$140,036	$8,033,116	0.45	$2,932,338
6	Walmart Reservoir	56	$127,789	$6,334,146	0.53	$2,363,859
7	Channel Modifications	11	$37,538	$1,318,693	0.74	$737,512
8	Buyouts	10	$32,448	$1,207,541	0.70	$514,944
9	Floodproofed MacMurray College Structures (4)	3	$111,297	$1,051,475	2.76	$104,602
10	Buyouts Combined with MacMurray Floodproofed Structures	13	$143,745	$2,259,016	1.66	$135,099

Table 7 - Alternative Comparison Matrix

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