

**City of West University Place
City-Wide Drainage Study**

Drainage Report

*Prepared for:
City of West University Place*

F-14087



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1. Executive Summary

This report presents the drainage study and assessments made for the City of West University Place by HT&J, LLC. The efforts made in this study were made in conjunction with feedback from the City. The results and recommendations made after evaluating the existing drainage system are included in this report.

The existing conditions of the drainage system were modeled and analyzed. The results showed that the majority of the City has limited drainage capacity, with some areas having a less than 2-year capacity. The inundation maps provided show the extent of the flooding within the City for different storm events.

In the previous studies from the former City engineer, the main trunk line on Buffalo Speedway was improved and modeled to increase the capacity and reduce ponding around the Buffalo Speedway drainage system. These improvements were included in our proposed conditions models to reflect how the drainage system will function with all of the improvements accounted for.

To increase the capacity of the overall system, improvements to various parts of the system are recommended. This includes a new storm sewer trunk line along Community Drive. Storm sewer lines around the City were increased in size in modeling the proposed system to reduce surface and home flooding. After modeling these proposed improvements, inundation maps show a visual effect of how ponding is reduced around the City. This can primarily be seen for the 2-, 10-, and 50-year rainfall events. This proposed system provides a 50-year Level of Service, which means that storm sewers and street are capable of conveying storm water while eliminating structural damage for the 2-, 10-, and 50-year events. During the 2-year event, the hydraulic grade line (HGL) is maintained below the gutter elevation.

The total cost from the proposed recommendations to the drainage system, and street reconstruction projects, is approximately \$61,530,000. This includes the cost escalator factor for future years.

2. Introduction

Definitions

- **Hydrology & Hydraulics (H&H):** Hydrology is the scientific study of the movement, distribution, and management of water. Hydraulics involves the conveyance of liquids through pipes and channels.
- **Level of Service (LOS):** The least frequent rain event at which the storm water is conveyed in the underground sewer system and the roads without resulting any structural flooding.
- **Hydraulic Grade Line (HGL):** Water surface elevation in a pipe or open channel.
- **2-Year Event:** An amount of rain having a 50% chance of being equaled or exceeded in any given year.
- **10-Year Event:** An amount of rain having a 10% chance of being equaled or exceeded in any given year.
- **50-Year Event:** An amount of rain having a 2% chance of being equaled or exceeded in any given year.
- **100-Year Event:** An amount of rain having a 1% chance of being equaled or exceeded in any given year.
- **100-Year Floodplain:** The area of land that has a 1% chance of being inundated by flood waters from a bayou, stream or creek in a given year.
- **500-Year Floodplain:** The area of land that has a 0.2% chance of being inundated by flood waters from a bayou, stream or creek in a given year.
- **Public right-of-way (ROW):** An area in which the City has acquired right-of-way interest. This includes streets, roads, sidewalks, and alleys.
- **Tailwater:** The elevation of water at the downstream end of a pipe.
- **Sheet flow:** Refers to water flow or drainage over surfaces, rather than being diverted into channels, culverts, or pipes.
- **LiDAR:** Stands for **L**ight **D**etection and **R**anging. Involves remote sensing that can be used to map structure height, density, and other characteristics across a region.
- **Delineated Drainage Areas:** Land area where precipitation collects and drains into an outlet such as a drainage inlet.

Purpose

The purpose of this study is to perform a Hydrology & Hydraulic (H&H) analysis of the existing drainage conditions in the City of West University Place, and determine the efficacy of possible improvement projects to be able to select ones ultimately that would optimize both level-of-service and cost. The community historically has experienced significant street ponding and flooding during extreme events due to rainfall and undersized drainage infrastructure.

Location

The City of West University Place is located in Harris County, Texas. It is located inside of the Interstate 610 loop, near the western intersection of Interstate 610 and Interstate 69. The City is approximately 2 square miles in area and falls within the Brays Bayou watershed. Figure 1 below shows the vicinity map of the city.

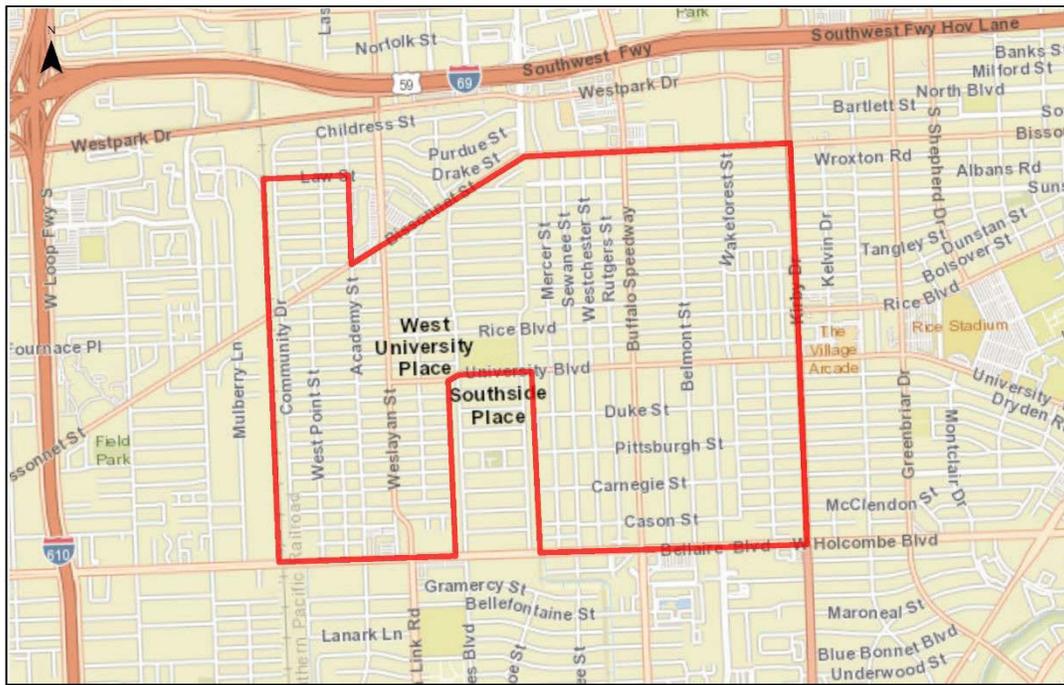


Figure 1 - West University Place Vicinity Map

Basic Design Standards

The design standards for the type of drainage system in the City of West University Place are held by two main metrics. The first is that during a 2-year storm event, the HGL should not exceed the gutter elevation in the street. Anything above that does not meet the design standard. Figure 2 represents a graphic showing the maximum allowed HGL for a 2-year storm event.

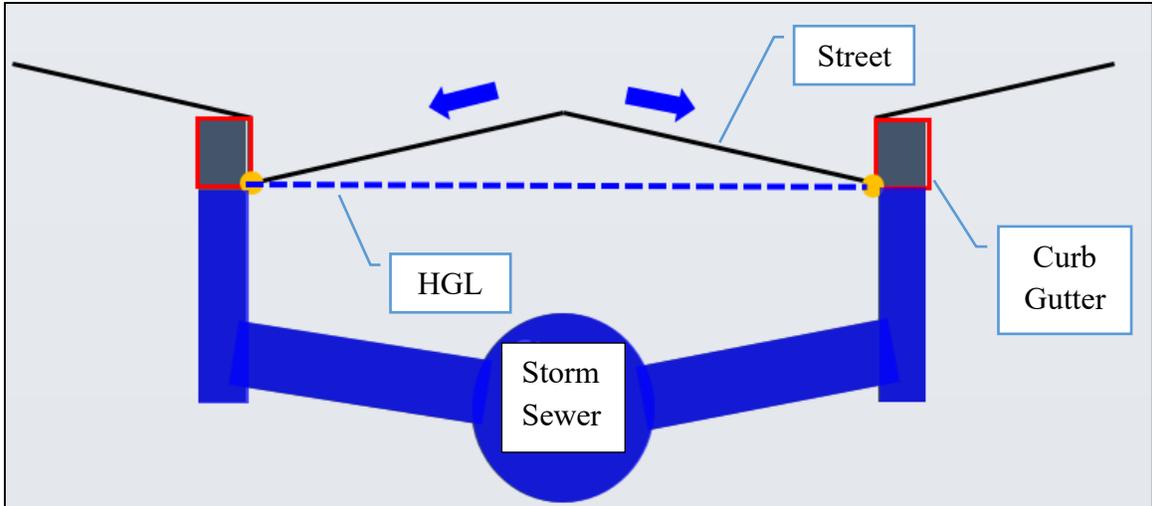


Figure 2 - 2-year Design Standard

The second metric is that during a 100-year storm event, the HGL should not pond beyond the right-of-way (ROW). This means the water cannot extend onto any homeowners' properties. Figure 3 presents a graphic showing the maximum allowed HGL for a 100-year storm event.

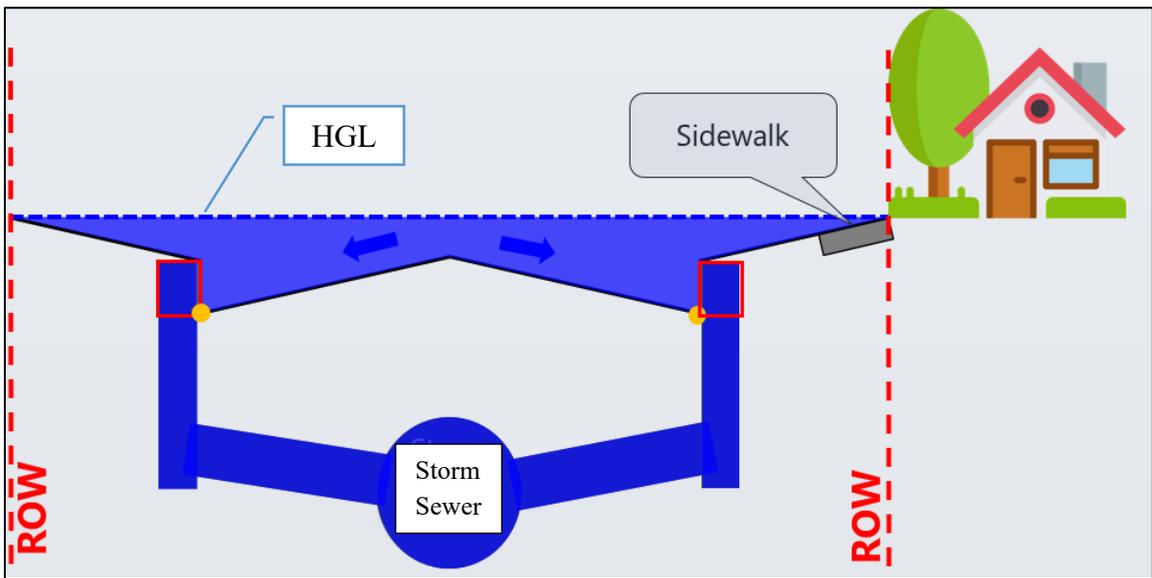


Figure 3 - 100-year Design Standard

Existing Drainage Conditions

The inlets, which allow storm flows to enter the storm sewer system, are open curb inlets and are located along the roadways. Storm runoff flows along the street gutter to these curb inlets, during heavy rainfall events storm runoff ponds in the streets, draining down into the curb inlets. The surface flow typically follows the topography of the City. The surface flow from higher elevations

at the northern side of the city flows south towards the lower elevations. This is shown by the arrows in Figure 4.

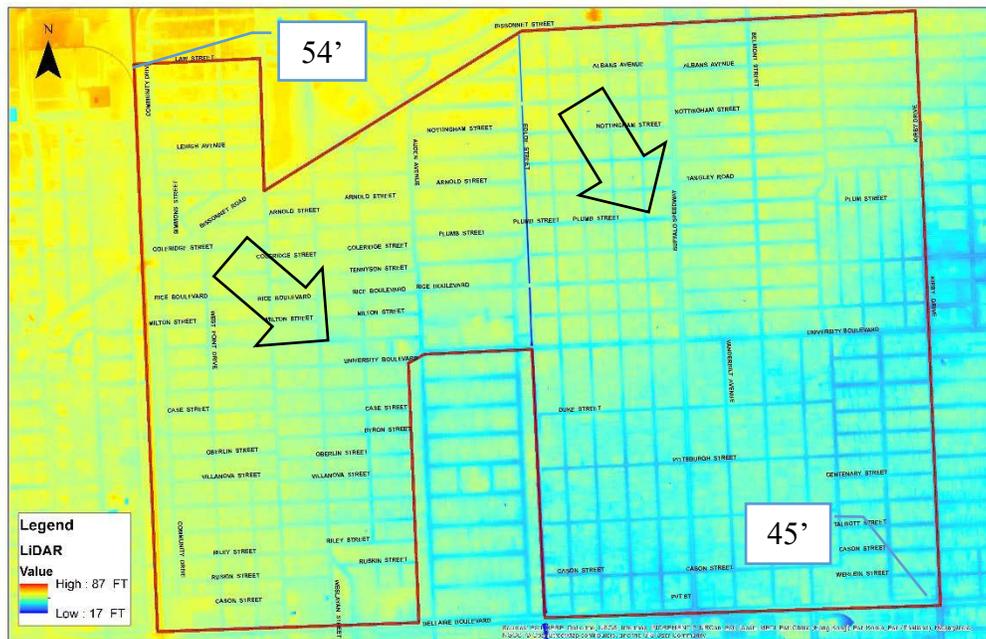


Figure 4 - Topographic Map

As seen in Figure 4, sheet flow occurs from northwest to southeast. It does not follow the North-South layout of the roads throughout the City, which can cause issues of water flowing through properties. The elevations of the City range from approximately 54 feet at the highest point to 45 feet at the lowest point.

On the northern edge of the City, some areas within the City of Houston, during major storm events, drain into the City through sheet flow. This is taken into account in this drainage study.

The existing drainage systems for the City are the Academy Street System, College Street System, Poor Farm Ditch System, Buffalo Speedway System, and the Kirby Drive System. The details on the individual drainage systems are found in Section 4 of this report. The storm water collected from these systems flow south towards Brays Bayou.

Rain events that are used and modeled in this analysis are the 2-, 10-, 50-, and 100-year events. A good portion of the City lies within the 100-year FEMA flood plain while the large majority of the City lies within the 500-year flood plain as shown in Figure 5. This means that there is an existing risk of the City flooding during these rain events due to its location, terrain, and proximity to Brays Bayou.

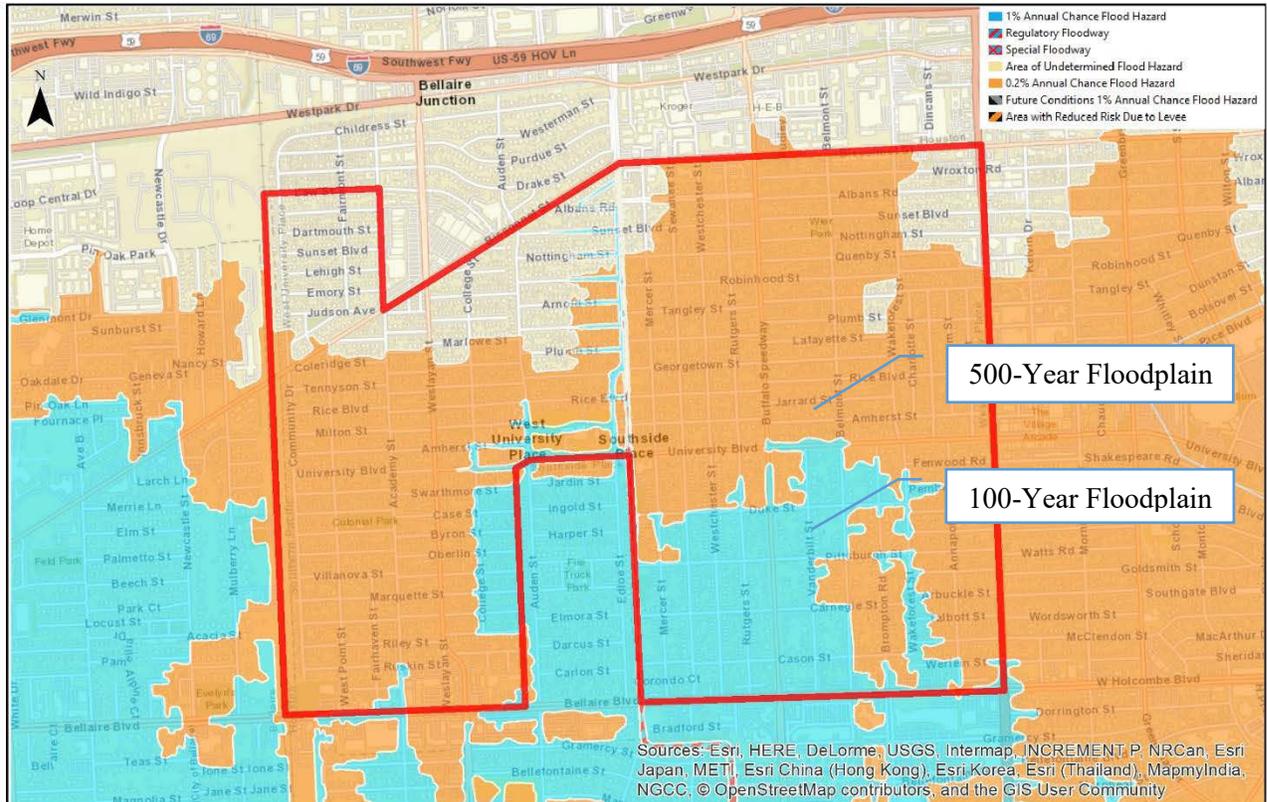


Figure 5 - FEMA Floodplain Map

In the previous city-wide drainage study, performed by HDR, Inc. in 2019, the existing drainage conditions do not match the proposed improvements and results found in this report. The reason for this is because the study made by HDR did not use the rainfall data from The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation Frequency Estimates, which was published in 2019. The proposed trunk line along Buffalo Speedway from the HDR study is included in our proposed conditions models to reflect how the drainage system will function with all of the improvements accounted for. As a note, the previous analysis on Buffalo Speedway used pre-Atlas 14 rainfall data.

Assumptions and Constraints

This analysis made assumptions where necessary based on limitations in available information. The tailwater values for outfalls in the studied system had to be interpolated from known water surface elevations in Brays Bayou, since the model was not extended to the ultimate outfall into the bayou. The flooding records received from the City were not verified, and the available FEMA claims data did not provide a depth of flooding to use for model calibration. Additionally, building finished floor elevations were available for only a very limited amount of homes compared to overall number of homes in the City.

3. Workshops/City Council Meetings

On June 15, 2020, HT&J presented the draft findings and recommendations to the City Council in a workshop format. This included an overview of the City’s historical rainfall events, the existing drainage conditions, and an overview of the different layouts of proposed improvement to the existing system. The City Council gave direction to proceed with modeling with the layout that had a new trunk line on Community Drive.

On the presentation given on July 20, 2020, the items presented were more specific and detailed. This includes an exhibit on comparing the finished floor elevation of certain homes/structures with the ground elevation and water surface elevation during a 100-year flood. This comparison was made to show how the finished floor elevation of these homes are higher than the resulting 100-year water surface elevation. In addition, it showed the location of homes that made claims to either FEMA, or reported as flooded to the City after Hurricane Harvey. The presentation provided inundation maps of the layout with the new trunk line on Community Dr., as well as an estimated cost of the improvements. This presentation also included cross-sections that were made across the City to compare water surface elevations and to see the impact that the proposed improvements have on the system.

The final presentation was given on July 27, 2020. This presentation was made to assist the City Council to make a final decision on whether or not to proceed forward with the preliminary engineering and design for this project. Information provided include the summary of average drop in water surface elevation, the breakdown of the estimated cost between road reconstruction and drainage improvements, and the design phase services and estimated schedule of the project.

(Attachment 1 presents the June 22, July 20, and July 27 presentations that were given to the City.)

4. Methodology

Hydrology and Hydraulics

Individual drainage areas within the system were delineated using the layout of the existing storm sewer system and available Light Detection and Ranging (LiDAR) data. The peak discharge rates for each delineated drainage area were computed using the Rational Method as presented in equations 1, 2, and 3, where:

Q is the peak discharge rate in cubic feet per second,

C is the runoff coefficient based on land use,
i is the rainfall intensity in inches per hour, and
A is the area of the drainage areas.

$$Q = CiA \text{ -----Eq. 1}$$

The rainfall intensity is calculated using the equation below. T_c is the time of concentration, and the b, d, e coefficients depend on the rainfall event.

$$i = \frac{b}{(T_c+d)^e} \text{-----Eq. 2}$$

The time of concentration equation used is shown below.

$$T_c = 10A^{0.1761} + 15 \text{-----Eq. 3}$$

The software program, XP-SWMM (2019 version), was used to model the current drainage system of the City. XP-SWMM is a dynamic model capable of analyzing the hydrology and hydraulics (H&H) at the same time. The drainage system is represented by nodes and links within the model. The nodes represent the drainage structures (inlets and pipe junctions) and the links represent the conveyance system (streets and pipes) in Hydraulic mode. Additionally, the nodes represent the traits of a drainage catchment area in hydrology module.

Within the model, there are nodes that represent each delineated drainage area. Most of the nodes represent a junction or manhole where storm water meets. The properties and parameters such as area, time of concentration, and storage coefficient are input into these nodes. The results of these inputs include the peak discharge. The storage coefficient, R, was then calculated using XP-SWMM by calibrating against the Rational Method. The 100-year storm event was used for this calculation. Attachment 2 presents the Rational Method inputs and results, the TC and R values, and the XP-SWMM peak flows for comparison.

After the necessary inputs were made and the appropriate parameters were optimized, the drainage system was modeled. Links that connect nodes were made to represent the existing storm sewers and overland sheet flow. This was done using the provided as-built drawings and available LiDAR data.

Exhibit 1 shows the delineated drainage areas in the City.

Exhibit 2 shows the existing drainage system as modeled on XP-SWMM.

The 2-, 10-, 50-, and 100-year storm events were analyzed for all scenarios. The rainfall from the NOAA Atlas 14 Precipitation Frequency Estimates, with the exceptions noted previously, was used in this study. Table 1 presents the Atlas 14 rainfall totals.

Table 1 - Harris County Hydrologic Region 3 Atlas 14 Rainfall (inches)

Annual Exceedance Probability Rainfall Data for Harris County (Partial Duration)									
Duration	50% AEP 2-Year	20% AEP 5-Year	10% AEP 10-Year	4% AEP 25-Year	2% AEP 50-Year	1% AEP 100-Year	0.5% AEP 200-Year	0.2% AEP 500-Year	0.1% AEP 1000-Year
5-min	0.60	0.75	0.88	1.07	1.21	1.37	1.53	1.76	1.94
10-min	0.94	1.19	1.40	1.70	1.94	2.18	2.43	2.76	3.02
15-min	1.20	1.50	1.76	2.13	2.42	2.72	3.04	3.48	3.83
30-min	1.72	2.14	2.50	3.01	3.40	3.81	4.28	4.95	5.50
60-min	2.29	2.88	3.38	4.09	4.65	5.25	5.94	6.98	7.84
2-hr	2.87	3.72	4.49	5.63	6.58	7.64	8.84	10.60	12.10
3-hr	3.23	4.26	5.23	6.71	7.98	9.42	11.00	13.40	15.40
6-hr	3.87	5.22	6.55	8.59	10.40	12.50	14.80	18.20	21.10
12-hr	4.56	6.24	7.88	10.40	12.60	15.20	18.20	22.80	26.70
24-hr	5.30	7.33	9.30	12.30	15.00	18.00	21.70	27.20	32.00

Runoff volume was based on HCFCD standard values for infiltration losses and land use.

Additionally, in the XP-SWMM model, different areas were assigned different land use parameters. The land use categories used were buildings, roads, and default. Default refers to all open area not paved over or covered by a building. Each land use category is assigned a Manning’s (n) roughness value. The Manning’s (n) values were set to 1.0 for buildings, 0.02 for roads, and 0.05 for default. Buildings were set to 1.0 so that they would act as an obstruction and not allow flow to pass through them. This is used during the 2D analysis to calculate the flow and infiltration across different types of land. For example, water will flow faster and infiltrate less on a paved street than it will on a front lawn.

Calibration of the XP-SWMM model was performed to validate ability to forecast ponding depths based on the detailed assumptions and constraints. Calibration was based upon known flooding depths during Hurricane Harvey. The Hurricane Harvey storm event was run through the model, and parameters such as Manning’s roughness value and tailwater elevations were adjusted so that the ponding depths matched those reported during the actual storm.

The way that the proposed improvements were created involve the evaluation of the existing 2-year capacity of the system, which is further discussed in the following section. The 2-year design standard maintains the hydraulic grade line at or below gutter elevation. This means that there should be no street ponding during a 2-year event. Implementing increased line sizes to the proposed scenario model is an iterative process as it involves reviewing the results of these changes and finalizing the best solution. An important aspect of this process includes the location of the change in pipe size. For example, the line size that is chosen for the most upstream end of a trunk line is preferred to be smaller than the pipe at the downstream end. This is because it is not necessary to include a larger pipe where it is not needed.

In order to account for the surface flow that causes roads and homes to flood, 2D modeling on XP-SWMM was used with 2018 LiDAR data to define the surface elevations within the City. The way the model differentiates between 1D and 2D flow is that if the HGL is below the ground surface elevation (still within the storm sewer pipes only), it is analyzed as 1-dimensional. Once

the HGL exceeds the ground elevations provided by the LiDAR data, the overland flow is analyzed as 2-dimensional. This is done using the elevation data and a grid that calculates values within each individual cell. The results from the 1D and 2D modeling are shown in the inundation maps for each storm scenario.

5. Existing Conditions

The existing drainage system was modeled as explained in the previous section. This was done carefully to reflect the current conditions and provide a visual of how the system can be improved.

Exhibits 3 through 6 show the inundation maps under the existing drainage conditions for each storm event (2-, 10-, 50-, and 100-year events). The areas shown in these exhibits that have risk for flooding are shown covered by the black-to-white gradient. The gradient represents the peak water depth for a given storm event. If there is none, then that area is not seen as at risk for that storm. Using the legend it is possible to see the maximum calculated depth at a location based on the color of the shading.

Drainage System Areas

The city currently has five major drainage systems that drain to Brays Bayou: Academy Street System, College Street System, Poor Farm Ditch System, Buffalo Speedway System, and the Kirby Drive system. These systems were delineated based on the major trunk lines that are fed by collector storm sewer lines. Figure 6 shows the major drainage systems.

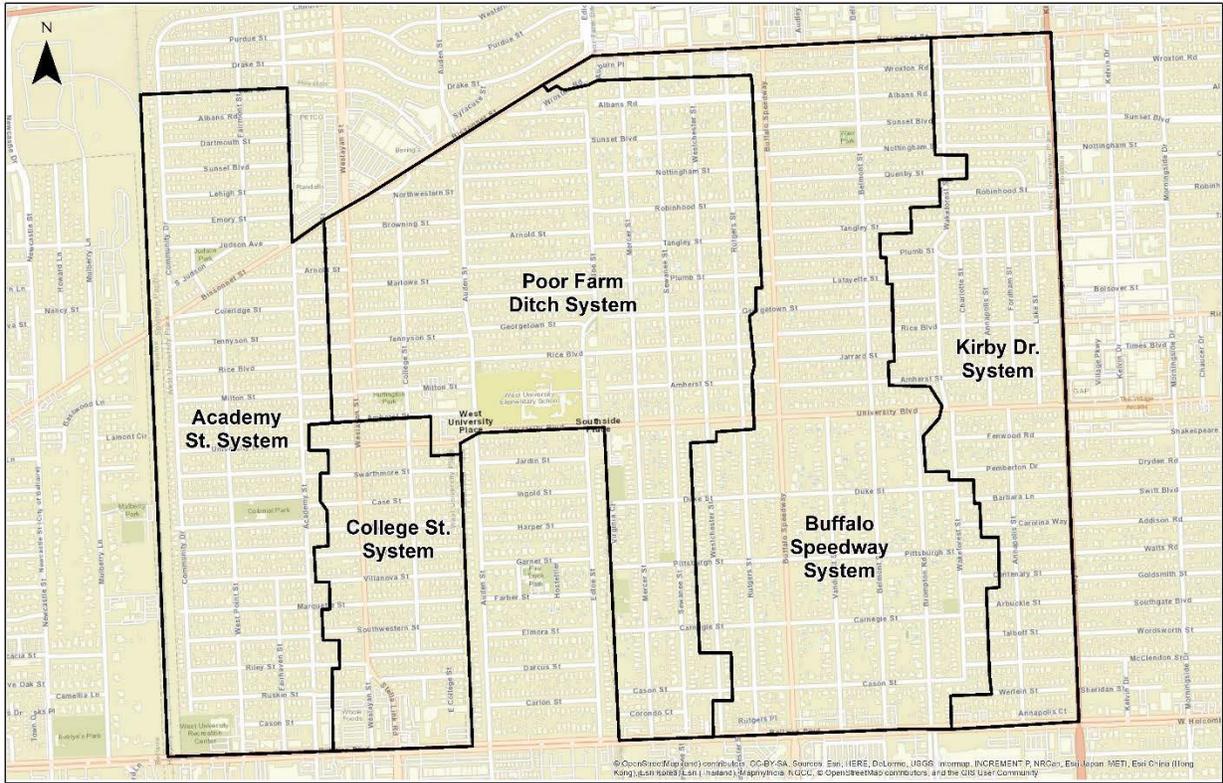


Figure 6 - Major Drainage Systems

Academy Street System

The Academy Street system accounts for approximately 260 acres. The main trunk line runs below Academy Street. The size of the system's storm sewers ranges from 18" pipes to 72" pipes. Street and property flooding are an issue for the 2-year event and above. (Refer to the existing conditions inundation maps in Exhibits 3 through 6.) Figure 7 shows the existing line sizes of the storm sewers and the lines with 2-year capacity. The vast majority of this system is incapable of conveying storm runoff during a 2-year event. This was taken into account when modeling the proposed recommendations to the system.

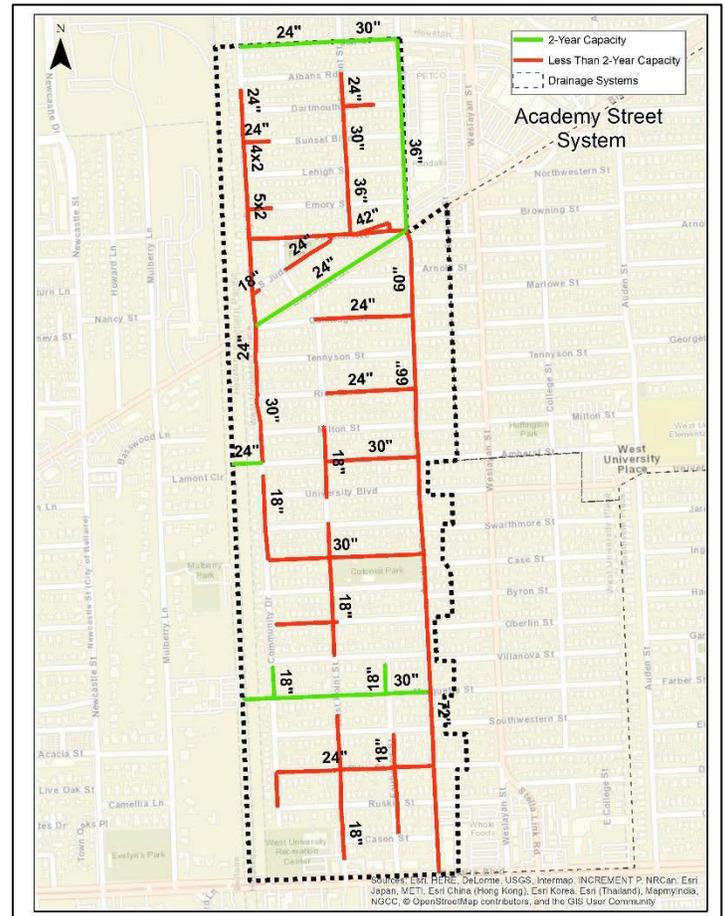


Figure 7 - Existing Academy St. System Capacity

College Street System

The College Street system accounts for 107 acres. The main trunk line in this system is a shared line between the City and Southside Place. The size of the system's storm sewers ranges from 12" pipes to 8'x4' boxes. Street and property flooding are an issue for the 10-year event and above. (Refer to the existing conditions inundation maps in exhibits 3 through 6.) Figure 8 shows the existing line sizes of the storm sewers and the lines with 2-year capacity. This entire system is capable of conveying storm runoff during a 2-year event. This was taken into account when modeling the proposed recommendations to the system.



Figure 8 - Existing College St. System Capacity

Poor Farm Ditch System

The Poor Farm Ditch System accounts for 361 acres. Poor Farm Ditch is the major drainage channel of the system. The size of the system's storm sewers ranges from 18" pipes to 6'x3' boxes. Street and property flooding are an issue for the 10-year event and above. (Refer to the existing conditions inundation maps in exhibits 3 through 6.) Figure 9 shows the existing line sizes of the storm sewers and the lines with 2-year capacity. The vast majority of this system is capable of conveying storm runoff during a 2-year event, although some areas that are undersized. This was taken into account when modeling the proposed recommendations to the system.

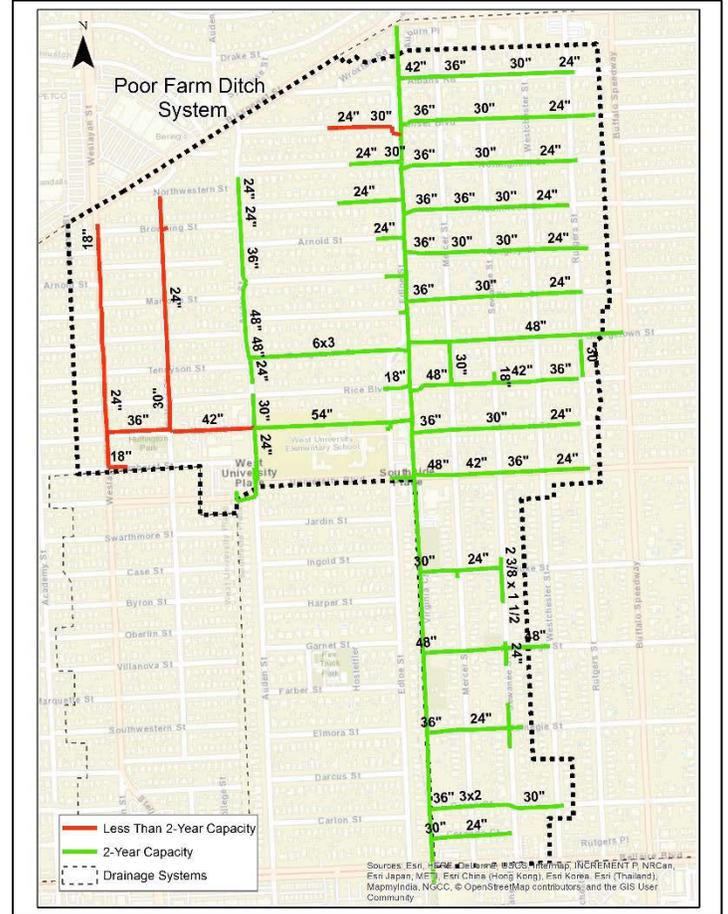


Figure 9 - Poor Farm Ditch System Existing Line Size

Buffalo Speedway System

The Buffalo Speedway system accounts for 356 acres. The main trunk line in this system runs below Buffalo Speedway. The size of the system's storm sewers ranges from 18" pipes to 72" pipes. Street and property flooding are an issue for the 2-year Event and above. (Refer to the existing conditions inundation maps in exhibits 3 through 6.) Figure 10 shows the existing line sizes of the storm sewers and the lines with 2-year capacity. Half of this system is incapable of conveying storm runoff during a 2-year event. This was taken into account when modeling the proposed recommendations to the system. As a note, the previous analysis on Buffalo Speedway used pre-Atlas 14 rainfall data. The recommendations made in this analysis, separate from the previously approved Buffalo Speedway storm sewer improvements, includes the line size recommendations along University Boulevard and Duke Street.

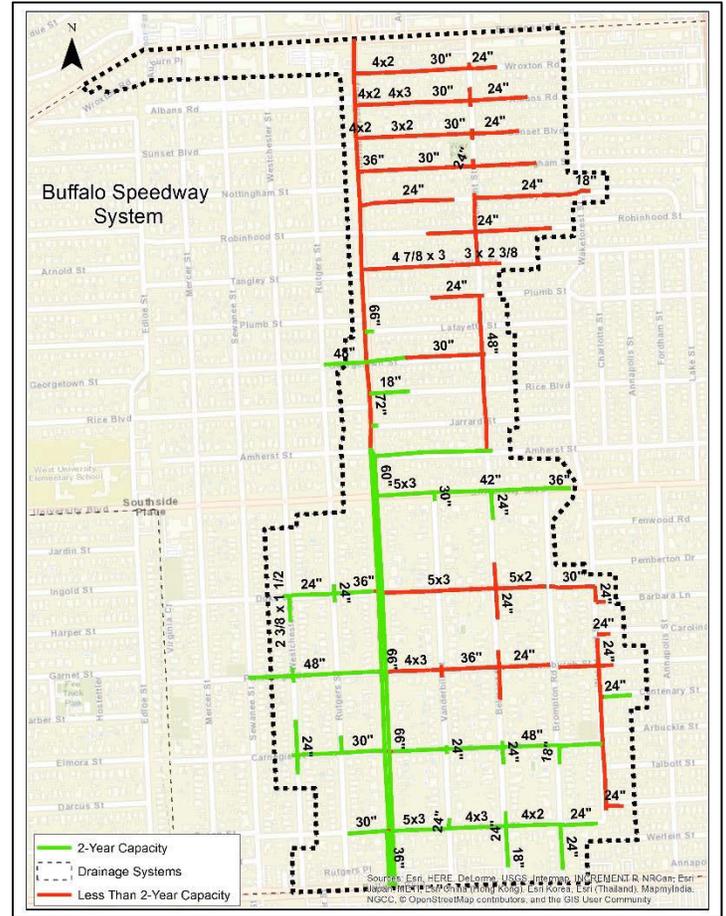


Figure 10 - Existing Buffalo Speedway Capacity

Kirby Drive System

The Kirby Drive system accounts for 202 acres. The main trunk line in this system runs below Kirby Drive and is part of the City of Houston. The size of the system's storm sewers ranges from 18" pipes to 14'x12' boxes. Street and property flooding are an issue for the 10-year Event and above. (Refer to the existing conditions inundation maps in exhibits 3 through 6.) Figure 11 shows the existing line sizes of the storm sewers and the lines with 2-year capacity. The vast majority of this system is capable of conveying storm runoff during a 2-year event, with only one area that is undersized. This was taken into account when modeling the proposed recommendations to the system.

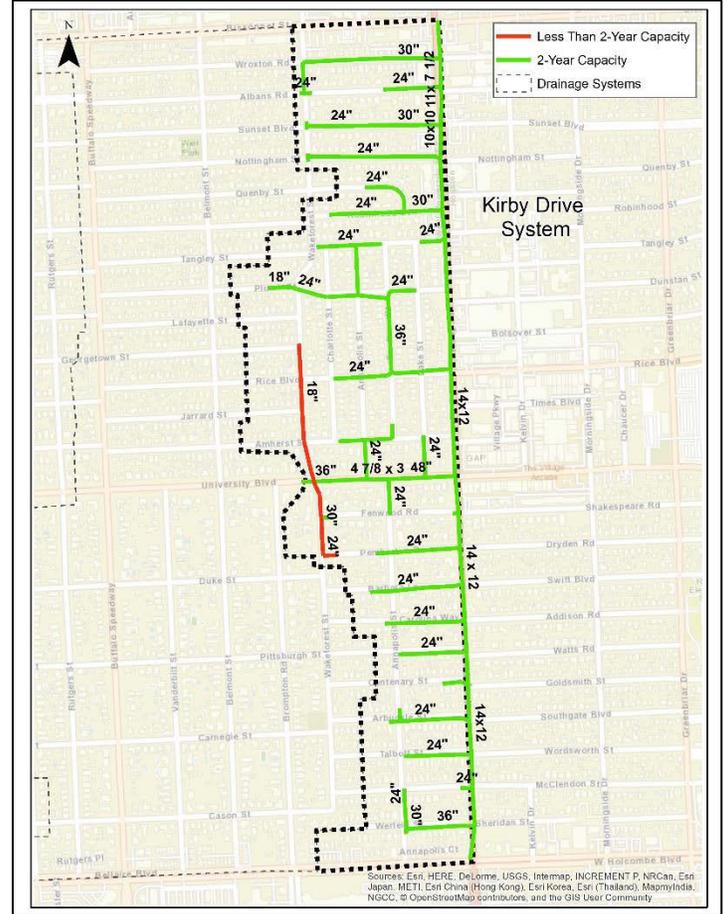


Figure 11 - Existing Kirby Dr. Capacity

The previous assessment reported that the dead-end streets within the College Street system (such as Swarthmore Street and Case Street) did not have capacity for the 2-year storm event. This analysis shows that the areas do in fact have capacity for the 2-year storm, however the capacity is far exceeded during the 10-year storm event. Due to the low-lying nature of these dead-end streets, once water begins flooding into the streets it becomes one of the more susceptible areas to flooding in the City.

6. Proposed Conditions

Proposed Drainage Improvements without Restrictors

Based on the results and evaluation from the existing conditions, the proposed drainage system and proposed storm sewers were evaluated using XP-SWMM. As stated previously, the proposed analysis was an iterative process. Several different scenarios were modeled in order to find the proposed system sizing which worked best for the City. To clarify, the proposed improvements scenario without restrictors would require detention. 260 acre-feet of detention is recommended, as discussed in the Detention/Mitigation portion of this report.

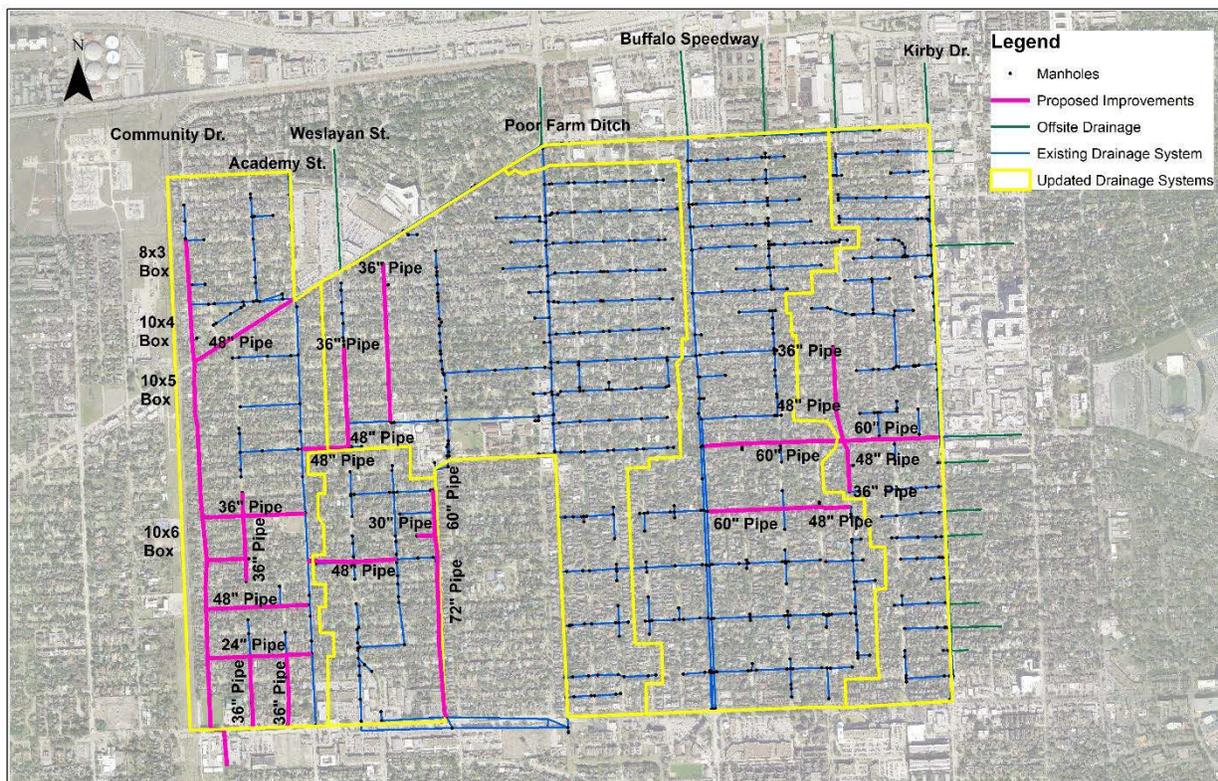


Figure 12 - Proposed Drainage Improvements

Figure 12 shows the recommended improvements across the City. The pink lines represent the storm sewers that are recommended to be replaced or added, depending on their locations. The

proposed line sizes are labeled along their respective storm sewers. The significant addition that was implemented in the proposed model is the Community Drive trunk line. This addition was made to allow more surface flow to be captured within the drainage system and reduce street ponding.

The proposed improvements made in the Academy Street system include the addition of a new trunk line and an increase of collector line sizes. These changes affect the overall drainage of the area by increasing the amount of capacity within the storm sewers.

In the College Street system, the improvements made are the increase in size of the shared trunk line between West University Place and Southside Place and other collector lines. The recommended improvements along the shared trunk line are meant to reduce surface ponding along the dead-end roads that are just west of this trunk line.

Changes in the Poor Farm Ditch system consist of the increase in line sizes along College Street and Wesleyan Street.

In the Buffalo Speedway system, increase in line sizes affect the system by reducing the amount of ponding along University Boulevard and other areas within the eastern side of the City. The changes within the Kirby Drive system have the same effects. No changes were proposed for the Kirby Drive trunk line since it is a part of the City of Houston.

In the area where improvements are proposed along University Drive, the existing system already has capacity for the 2-year storm event. The improvements are proposed because this is a major thoroughfare through the City, and increases to the pipe sizes can help reduce street flooding during larger storm events (such as the 50-year event).

Table 2 below presents the existing and proposed line sizes of the sewers that are recommended to be changed. The diameter of the pipe is reported as inches and the span and rise of the box-shaped sewers are reported in feet.

Table 2 - Altered Storm Sewers

Street/Location	Existing Storm Sewer		Proposed Storm Sewer	
	Diameter (in) /Span (ft)	Rise (ft)	Diameter (in) /Span (ft)	Rise (ft)
Community Dr.	5	2	8	3
Community Dr.	24	-	10	4
Community Dr.	30	-	10	5
Community Dr.	-	-	10	6
Bissonnet St.	24	-	48	-
Case St.	30	-	36	-
Oberlin St.	18	-	36	-
West Point Dr.	18	-	36	-
Marquette St.	30	-	48	-
Riley St.	24	-	24	-
Fairhaven St.	24	-	36	-
West Point Dr.	18	-	36	-
College St.	24	-	36	-
Weslayan St.	24	-	36	-
Weslayan St.	24	-	48	-
Amherst St.	-	-	48	-
Byron St.	15	-	30	-
Oberlin St.	30	-	48	-
Shared Line	48	-	60	-
Shared Line	60	-	72	-
Wakeforest Ave.	18	-	36	-
Wakeforest Ave.	18	-	48	-
Wakeforest Ave.	30	-	48	-
Wakeforest Ave.	30	-	36	-
University Blvd.	42	-	60	-
University Blvd.	48	-	60	-
Duke St.	5	2	48	-
Duke St.	5	3	60	-

Exhibits 7 through 10 present the inundation maps showing the effect that these improvements have on the system for all analyzed storm events.

As shown in the exhibits, there is significant reduction in ponding across the City for the 2-, 10-, and 50-year events. There is still substantial ponding under the 100-year event, especially towards the west side of the city.

The 2-year capacity of the proposed system without restrictors is shown below in Figure 13. As shown in the figure, the entire system has capacity to convey a 2-year event.

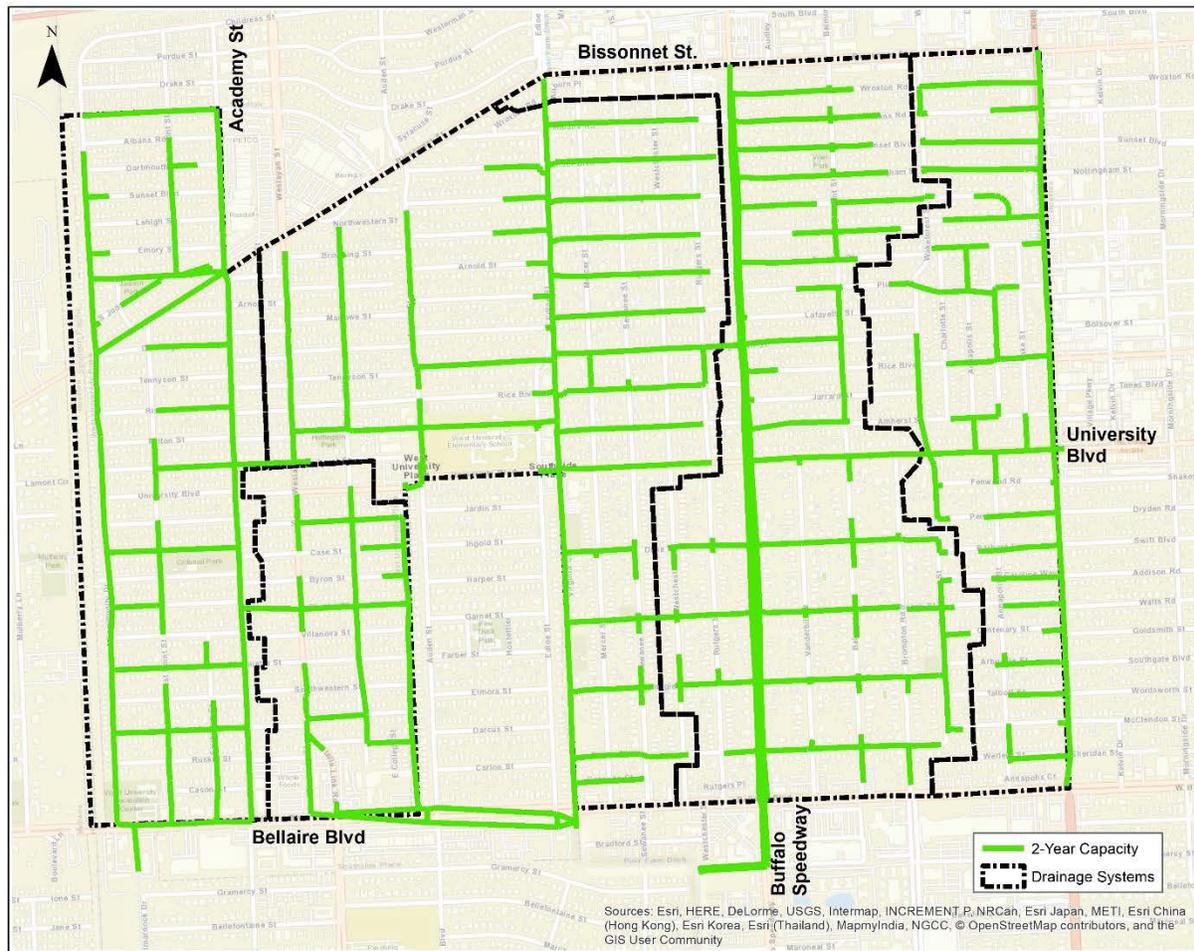


Figure 13 - Overall System 2-Year Capacity After Improvements

Proposed Improvements with Restrictors

This portion of the analysis was based on evaluation of various storm events for conditions that discharge from the respective drainage system. The discharge (outflows) of the recommended improvements are limited to discharge rates which do not exceed current discharge rates of the respective systems. The proposed improvements do not include restrictors to maintain the existing flow conditions downstream of the City. To have an option that allows for flow regulation under the proposed scenario, restrictors were included in the system as a separate proposed conditions scenario. Restrictors were included at the outfall of the proposed trunk line on Community Drive and that of the shared trunk line between the City of West University Place and the City of Southside Place. To clarify, the proposed improvements scenario with restrictors would not require detention. Figure 14 shows the proposed improvements with the restrictors.

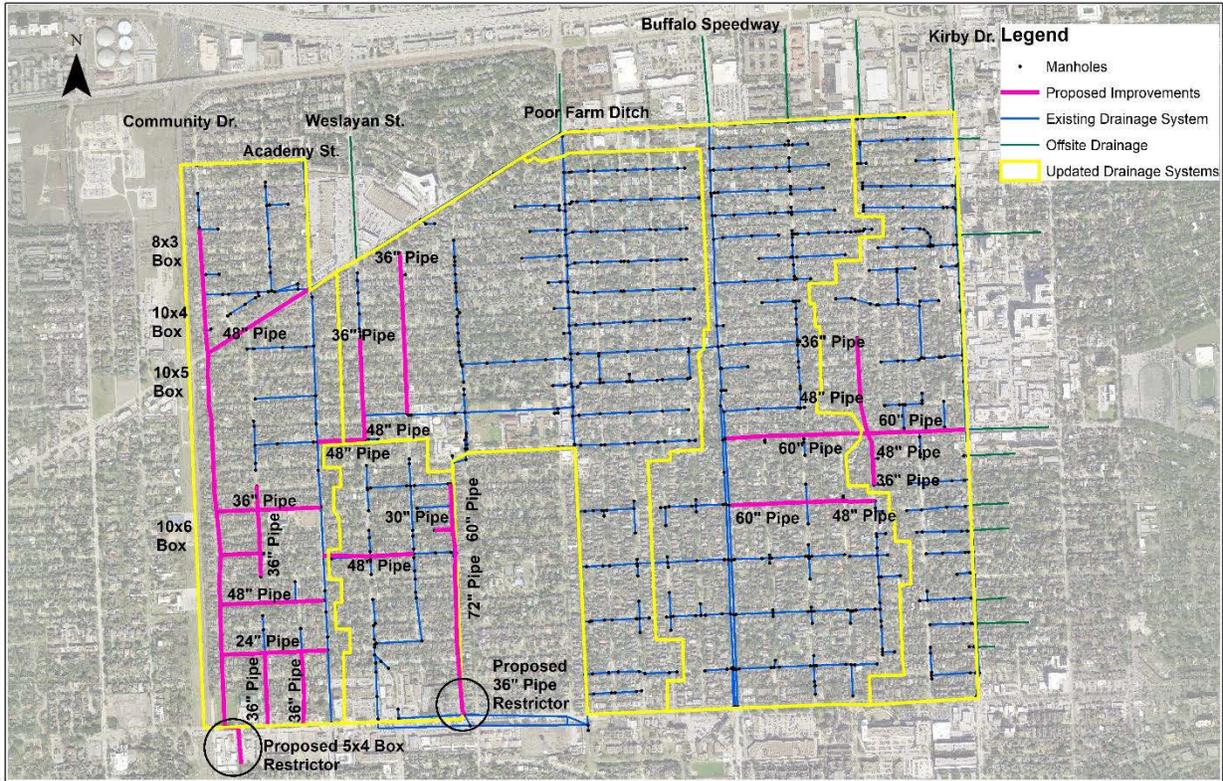


Figure 14 - Proposed Improvements with Restrictors

Exhibits 11 through 14 presents the resulting inundation maps from the addition of the restrictors. Refer to Attachment 3 for the HGL comparison between the existing conditions, proposed conditions with restrictor, and proposed conditions without restrictors.

Based on the results, the addition of restrictors to the proposed system is not recommended. This is due to the fact that the system with restrictors does not provide significant benefits to the system (compared to the benefits without the restrictors).

The 2-year capacity of the proposed system with restrictors is shown below in Figure 15. As shown in the figure, the vast majority of the system with restrictors is able to convey storm water from a 2-year event. During larger storm events such as the 10-year event, the improvements to the drainage system are far less effective with the restrictors. This can be seen in the comparison inundation maps in exhibits 11 through 14.

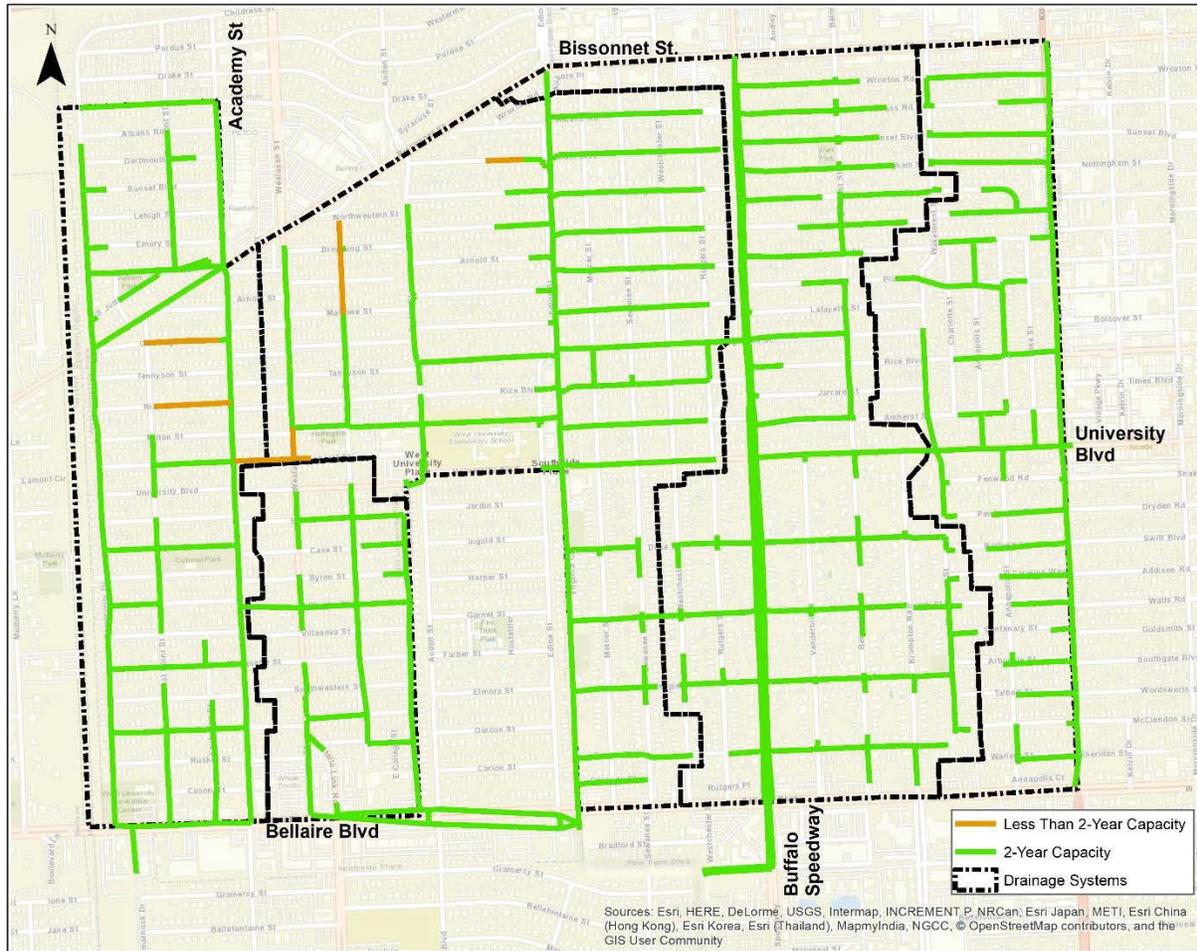


Figure 15 – Overall System (With Restrictor) 2-Year Capacity

Detention / Mitigation

Given that the proposed improvements without restrictors increase the flow discharging out of the system, it is recommended that a detention pond be added to the system to regulate the flow. The estimated amount of detention required to compensate the increase in discharge for the 100-year event is 260 acre-feet. Presently, there is no space available for the detention pond within the City limits. It is recommended that the detention pond be constructed outside of the City. Storm water from outside the City’s system could be detained depending on the detention location and routing. Additional evaluation on possible solutions to this problem have been made by modeling a Low-Impact Development (LID) scenario. There is a separate report on the results and details of the LID study. To reap full benefits of construction, 260 acre-feet of detention is recommended.

Buffalo Speedway Trunk Line Improvements

The previous study for the City’s drainage system by HDR has led to the design of an improved Buffalo Speedway trunk line system. The system has been evaluated and the design has been submitted for construction after the XP-SWMM model. In this report, the existing conditions are based on the current drainage system. HT&J, LLC modeled the proposed Buffalo Speedway trunk line system from the model prepared by HDR, without the improvements proposed in this report. This was done to show a visual of the effect of these improvements. The inundation maps from this scenario compared to the existing conditions are presented in Exhibits 15 through 18.

Results

The benefits from specific locations within the City’s drainage systems were evaluated to see the real impact the proposed improvements would have on each system. Cross-sections were made at various locations to inspect how the water surface elevations differ between the existing and proposed conditions. Table 3 shows the average drop in water surface elevation between the existing condition results and proposed conditions results without restrictors. This is based on four locations within each system. The cross sections for a sample of three of these locations are shown in Attachment 3 to present the typical drop in water surface elevation for the 2-, 10-, 50-, and 100-year storm events.

Table 3 – Water Surface Elevation Level Difference Between Existing and Proposed Conditions

System	Average Difference in WSEL (in)			
	2-Year	10-Year	50-Year	100-Year
Academy	6.6	5.1	2.3	1.8
College	7.0	4.8	1.8	1.2
Poor Farm Ditch	4.8	3.4	1.5	1.0
Buffalo Speedway	7.2	4.5	3.0	1.7
Kirby	4.2	3.0	1.6	1.0

After improvements were made within the drainage model, it was found that the level of service for the proposed system was up to the 50-year event. This means that the drainage system has the capacity to carry the runoff from a 50-year rainfall event without causing any structural flooding.

Street Reconstruction

In addition to the Drainage Improvements, the city has a planned street reconstruction priority for certain areas. The priority area¹ 1 is located on the eastern side of the city while areas 2 and 3 are located on the southwest portion of the city. Storm sewers that are located in these areas are set to be replaced by new ones. If there are no proposed changes to the line sizes from the drainage study, the existing line sizes will be maintained.

Exhibit 19 presents the locations of where the street reconstruction will be with regards to proposed improvements.

Exhibit 20 presents all of the proposed improvements with the street reconstruction locations.

7. Cost Estimate

In evaluating the cost estimate of this proposed project, HT&J took into account the cost of all the streets that will be reconstructed due to the replacement of storm sewers. Table 4 shows the cost estimate per drainage system.

Table 4 – Estimated Probable Cost per Drainage System

Drainage System	Improvements Cost
Academy	\$30,430,000
College	\$15,300,000
PFD	\$3,000,000
Buffalo & Kirby	\$12,800,000
TOTAL:	\$61,530,000

Items included in this estimate are the paving-related items, drainage items, traffic control, sediment control, and utility adjustments. Thirty percent of the estimated cost of these items was also included as contingency. The design engineering services, bid phase services, construction administration services, surveying services, geotechnical & environmental services, and urban forester services were taken into account as well. The total estimate takes into account the 5-year inflation rate of 4% to better estimate how much the project will cost if the drainage and road improvements were implemented five years from now. The breakdown of the total estimated cost is shown in Attachment 4.

¹ For the overall drainage study, the analysis and recommendations were presented at drainage sub-basin level. The priority areas were developed by the city for their infrastructure planning purpose.

8. Recommendations

Based on the above discussion and the H&H analysis, it is recommended that the City takes into account the proposed recommendations made in our analysis. The majority of the existing drainage system does not meet the 2-year storm criteria. Additional detention is required to maximize the benefits of the proposed improvements.

EXHIBITS



Legend

-  City Boundary
-  Drainage Areas

Community Dr.

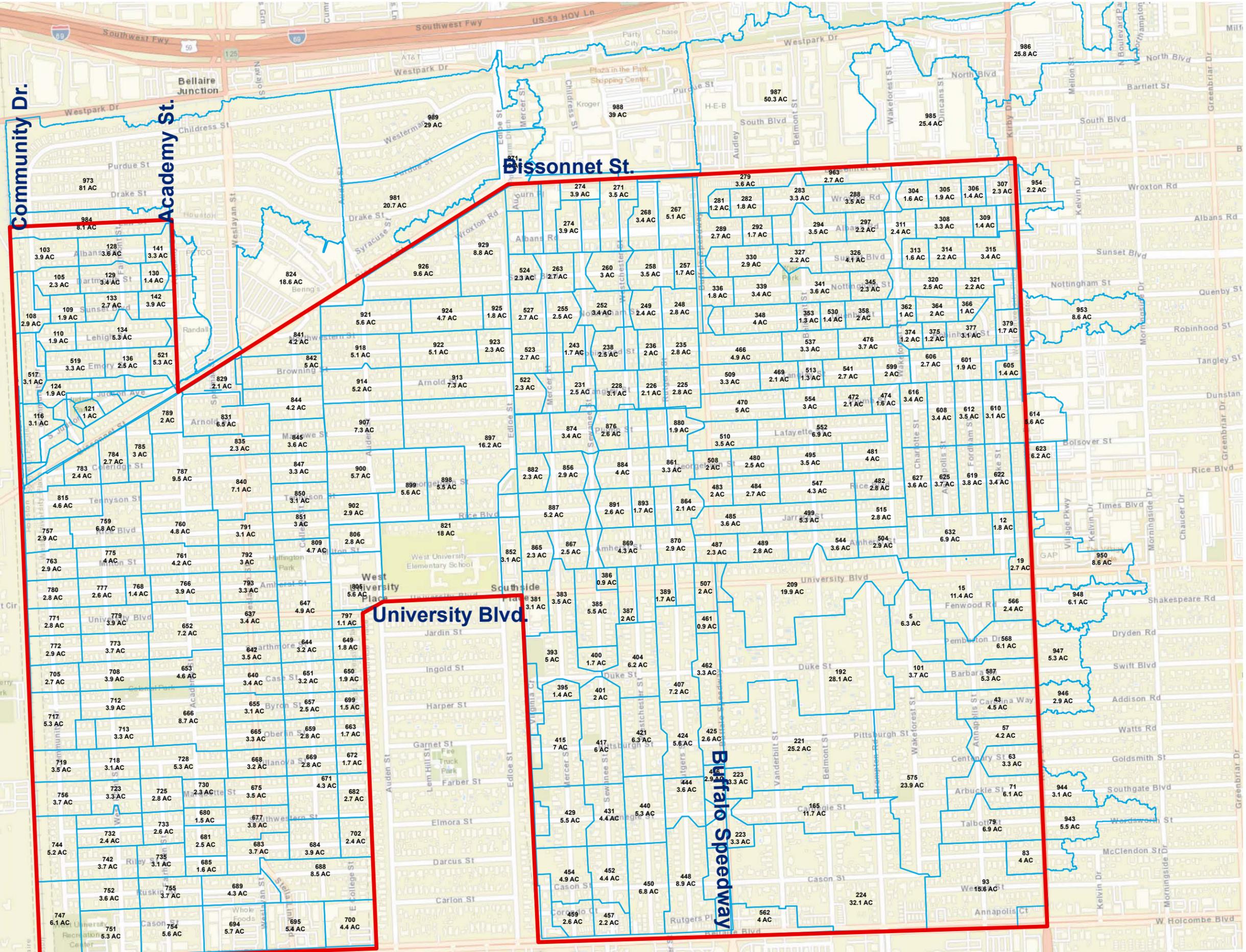
Academy St.

Bissonnet St.

University Blvd.

Buffalo Speedway

Bellaire Blvd.



Drainage Areas

Exhibit 1



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Legend

- Existing Drainage
- - - City Boundary

Community Dr.

Academy St.

Bissonnet St. 36"

University Blvd.

Bellaire Blvd.

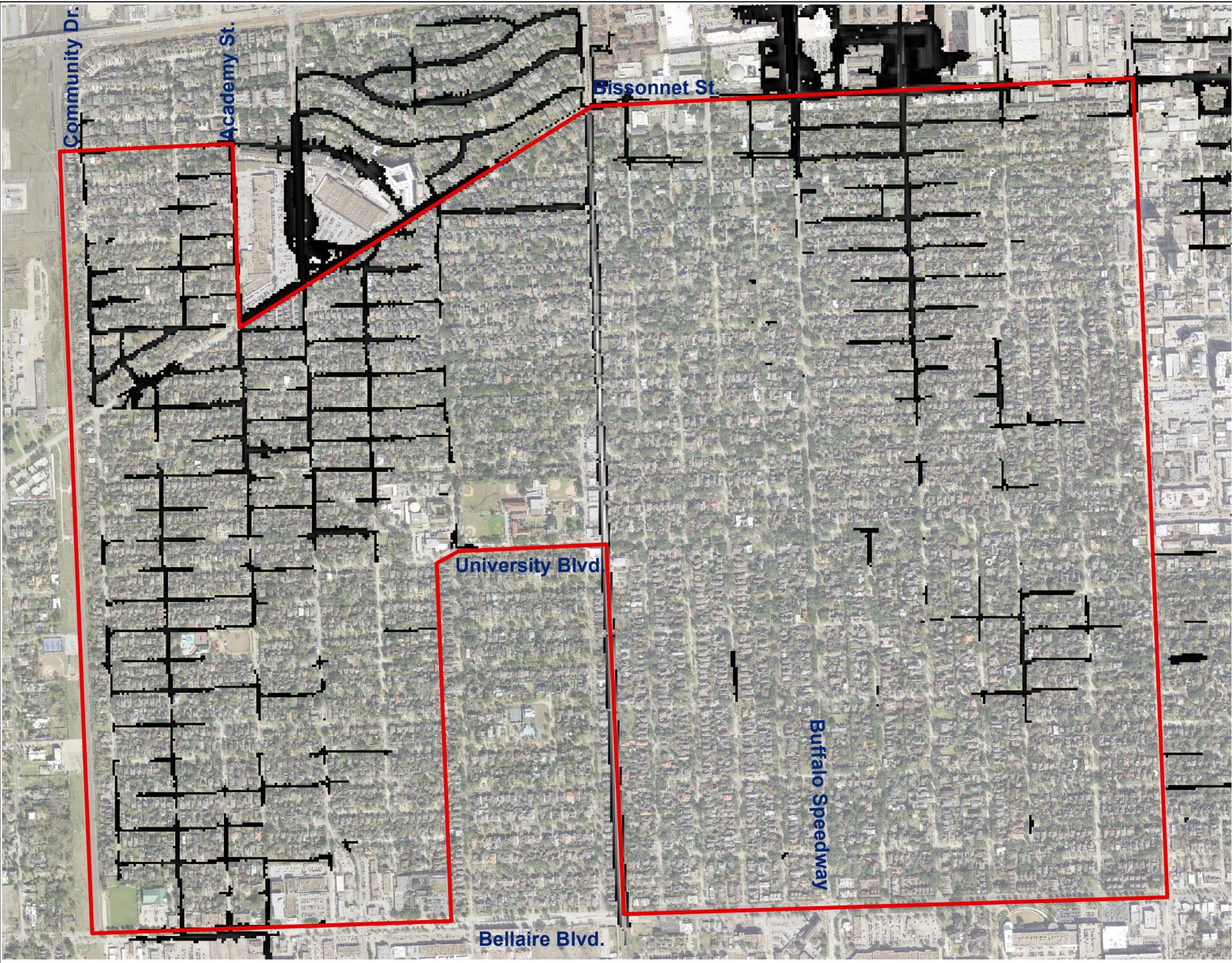
Buffalo Speedway

Existing Drainage System

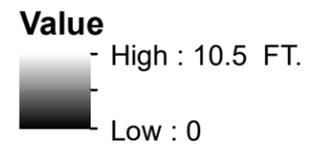
Exhibit 2



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

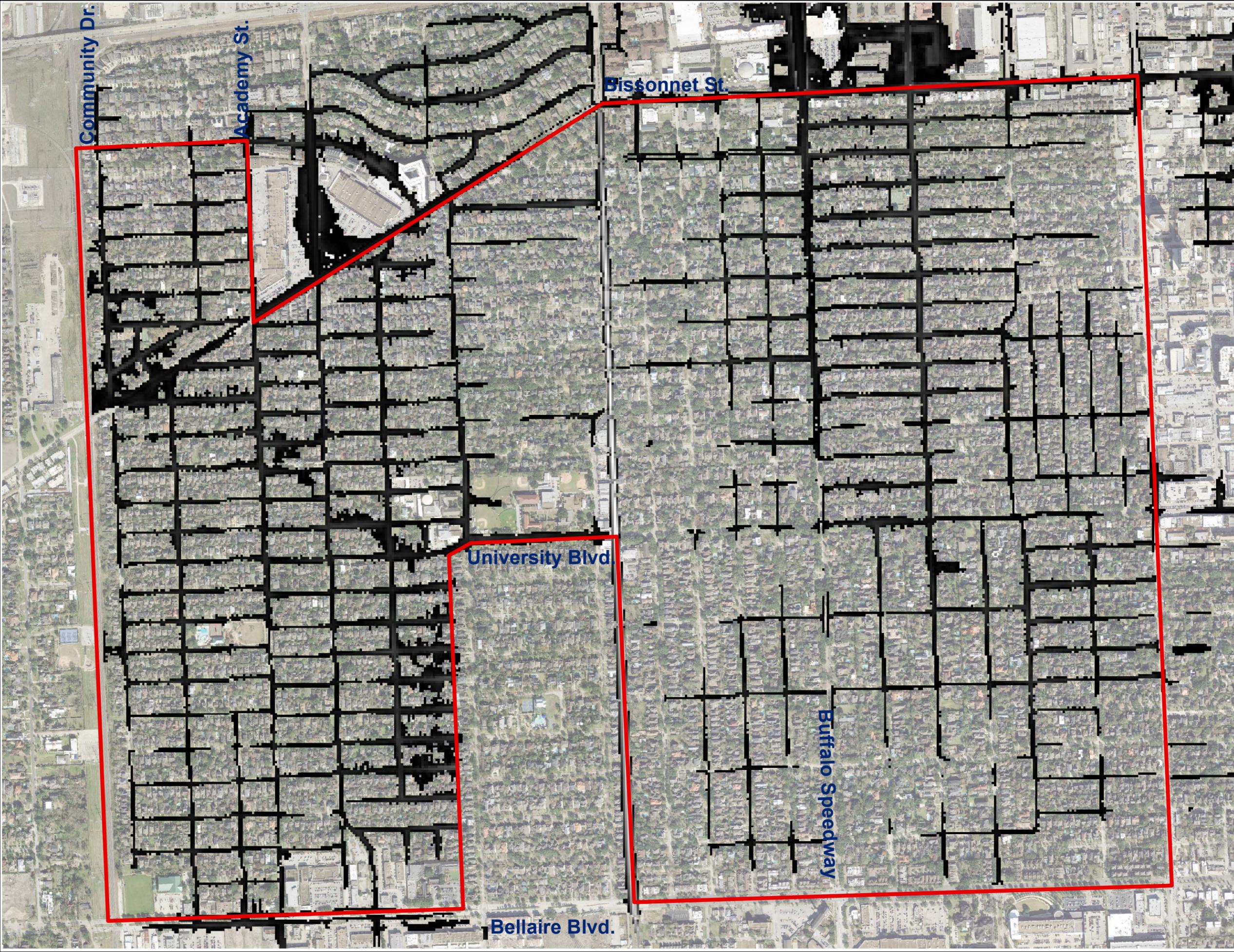


Existing 2-Year Scenario



**2-Year
Existing Conditions
Inundation Map**

Exhibit 3



Existing 10-Year Scenario

Value
- High : 8.5 FT.
- Low : 0

**10-Year
Existing Conditions
Inundation Map**

Exhibit 4





Existing 50-Year Scenario

Value
- High : 10 FT.
- Low : 0

**50-Year
Existing Conditions
Inundation Map**

Exhibit 5



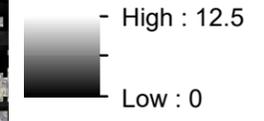


N



Existing 100-Year Scenario

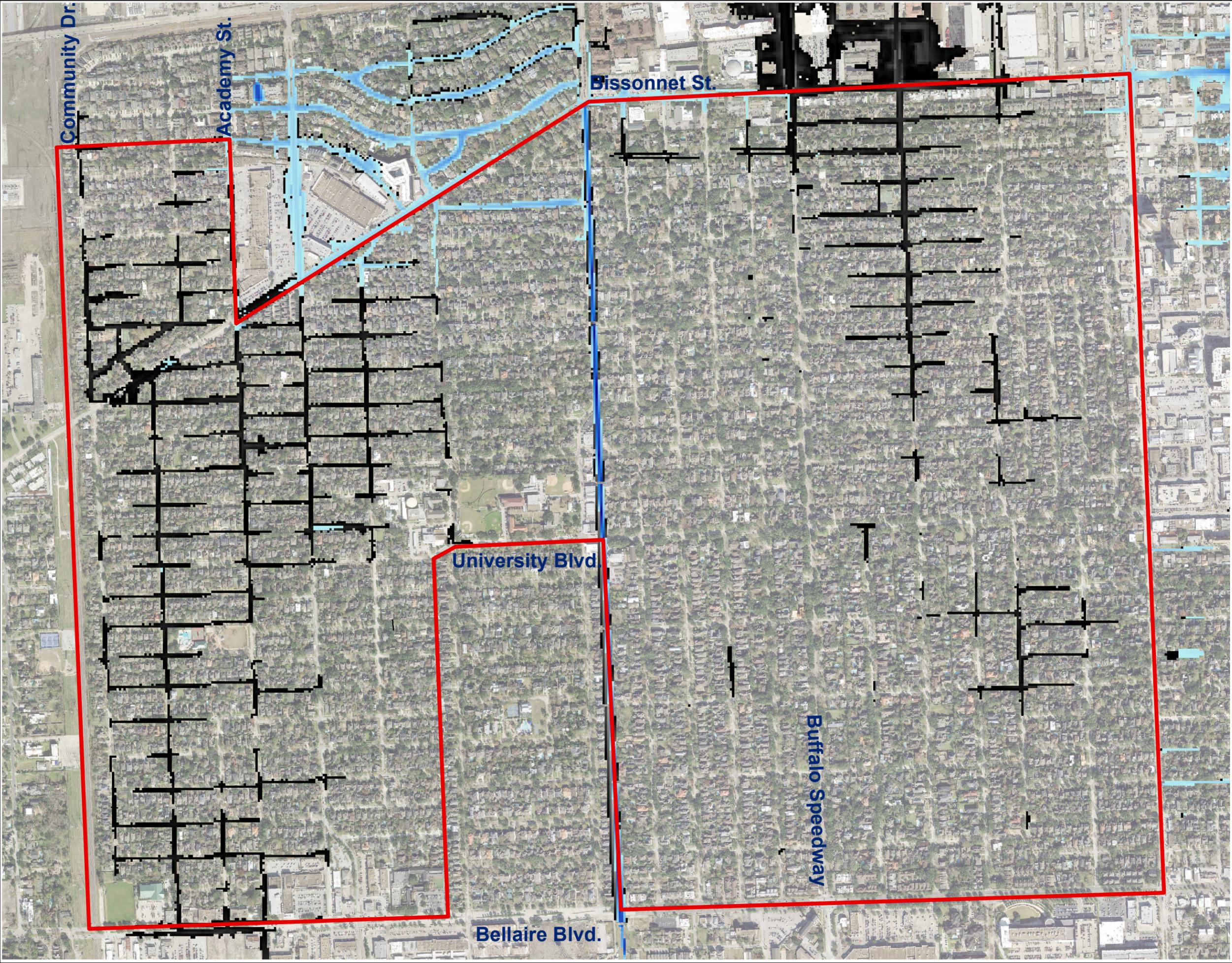
Value



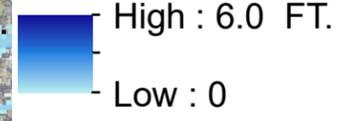
**100-Year
Existing Conditions
Inundation Map**

Exhibit 6

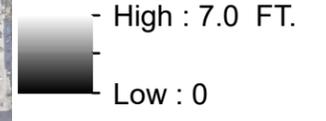




2-Year Proposed Imp. Scenario Value



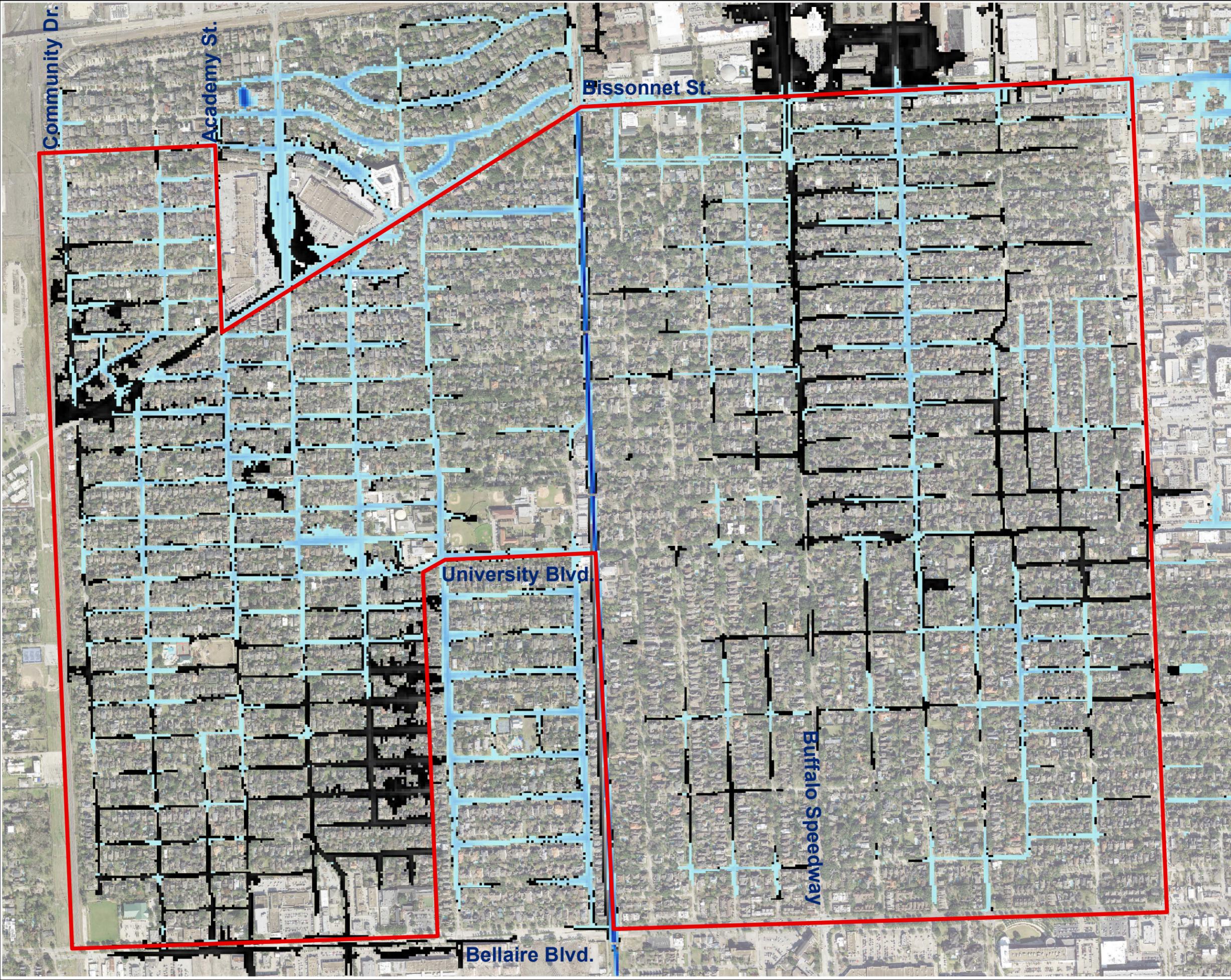
2-Year Existing Scenario Value



Inundation Comparison Map Without Restrictors

Exhibit 7





10-Year Proposed Imp. Scenario

Value

High : 9.0 FT.

Low : 0

10-Year Existing Scenario

Value

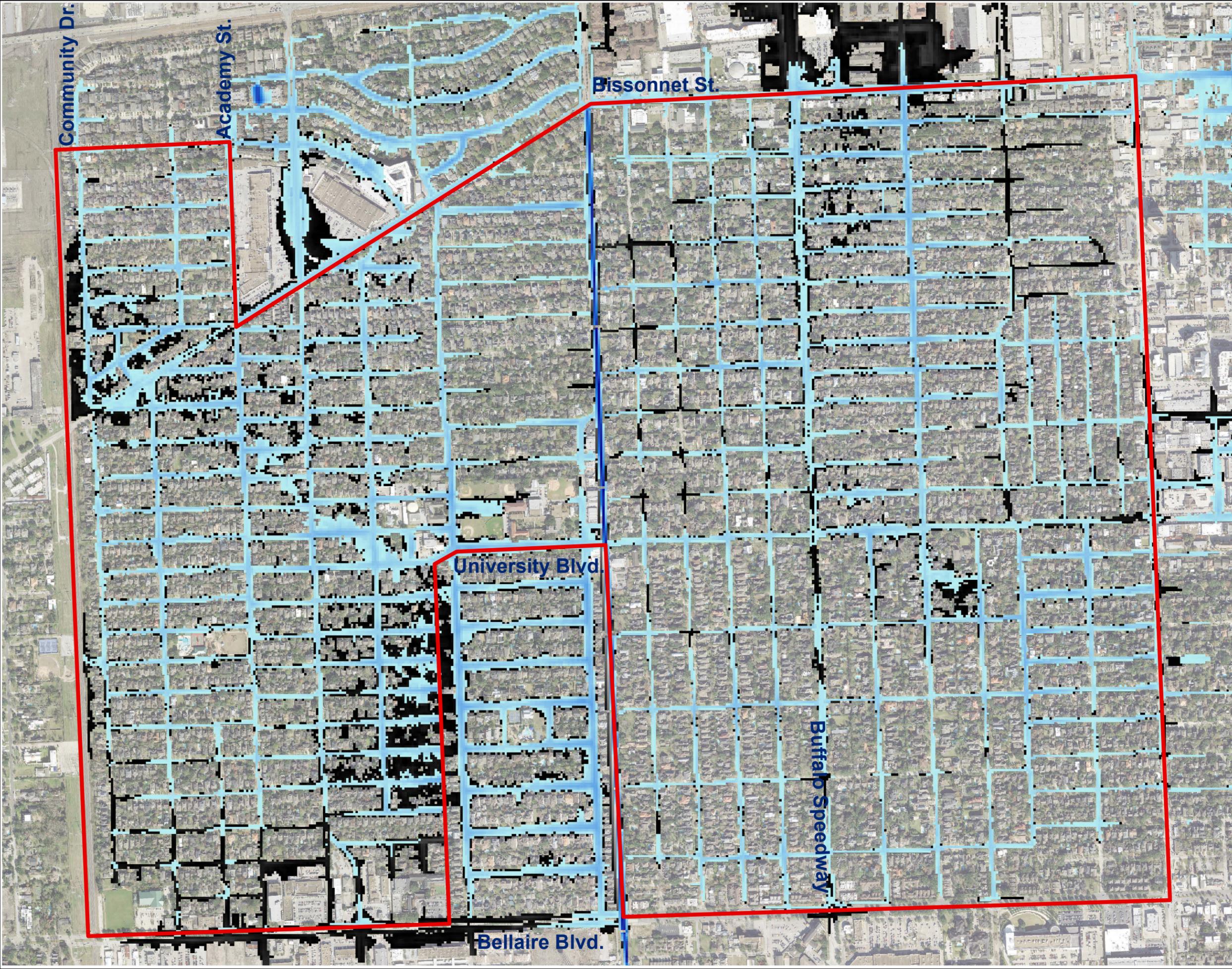
High : 8.5 Ft.

Low : 0

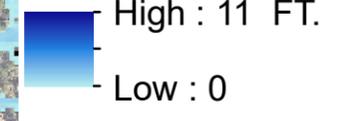
**Inundation
Comparison Map
Without Restrictors**

Exhibit 8

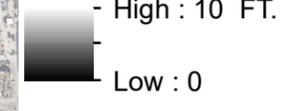




50-Year Proposed Imp. Scenario Value



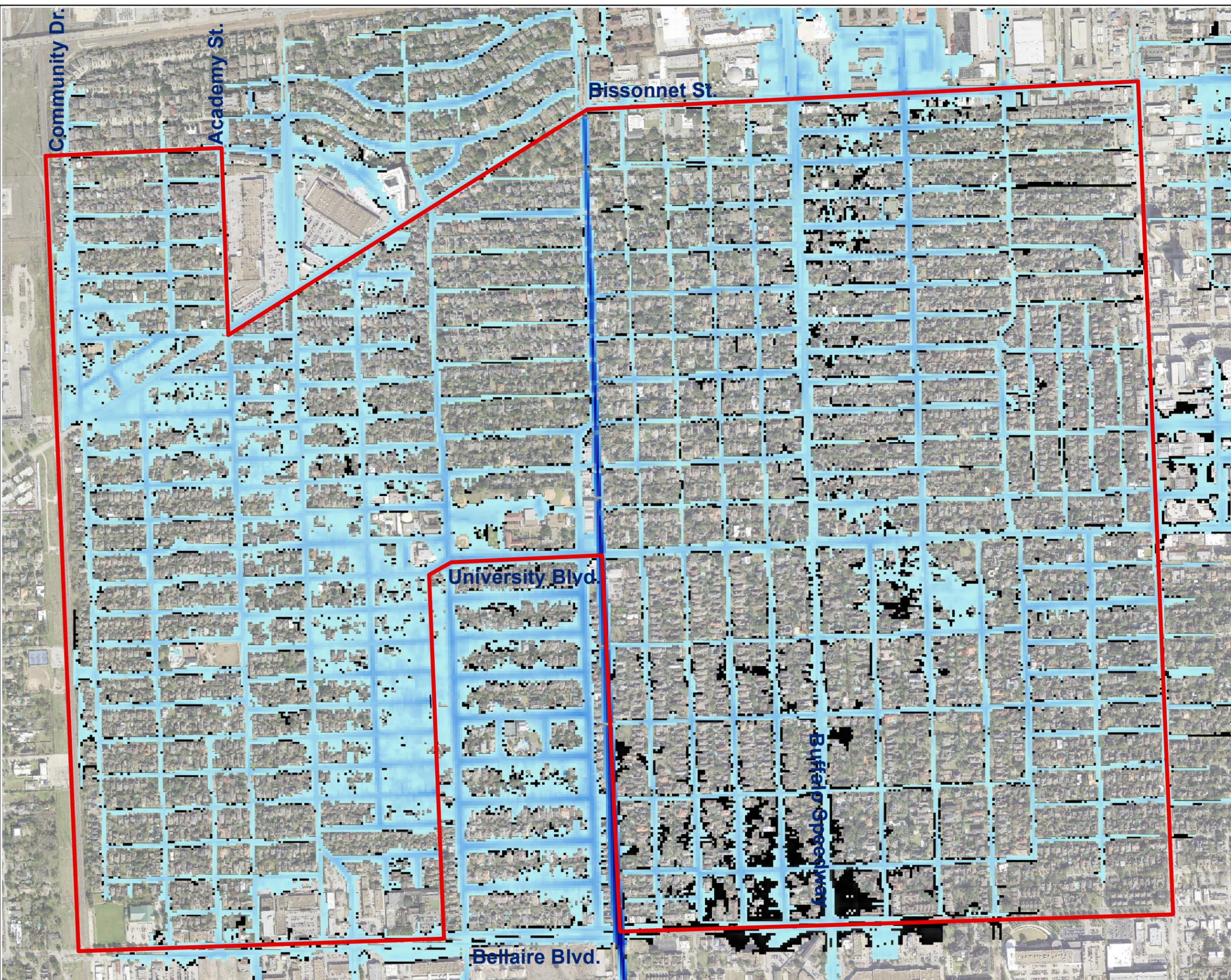
50-Year Existing Scenario Value



Inundation Comparison Map Without Restrictors

Exhibit 9

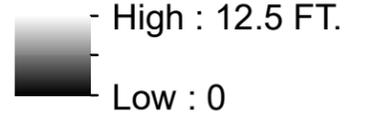




100-Year Proposed Imp. Scenario Value



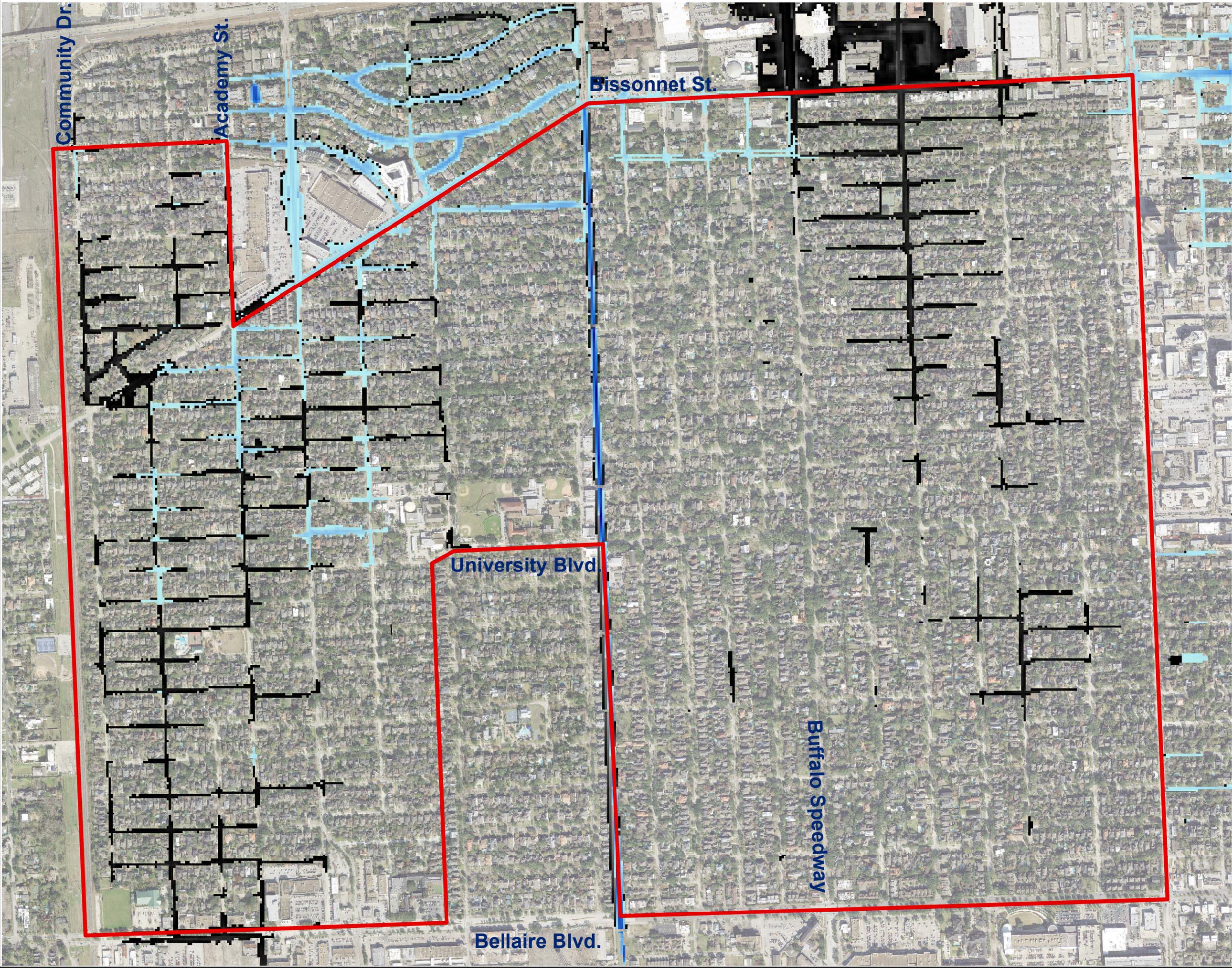
100-Year Proposed Imp. Scenario Value



**Inundation
Comparison Map
Without Restrictor**

Exhibit 10





2-Year Proposed Imp. Scenario

Value

High : 6.0 FT.



Low : 0

2-Year Existing Scenario

Value

High : 7.0 FT.

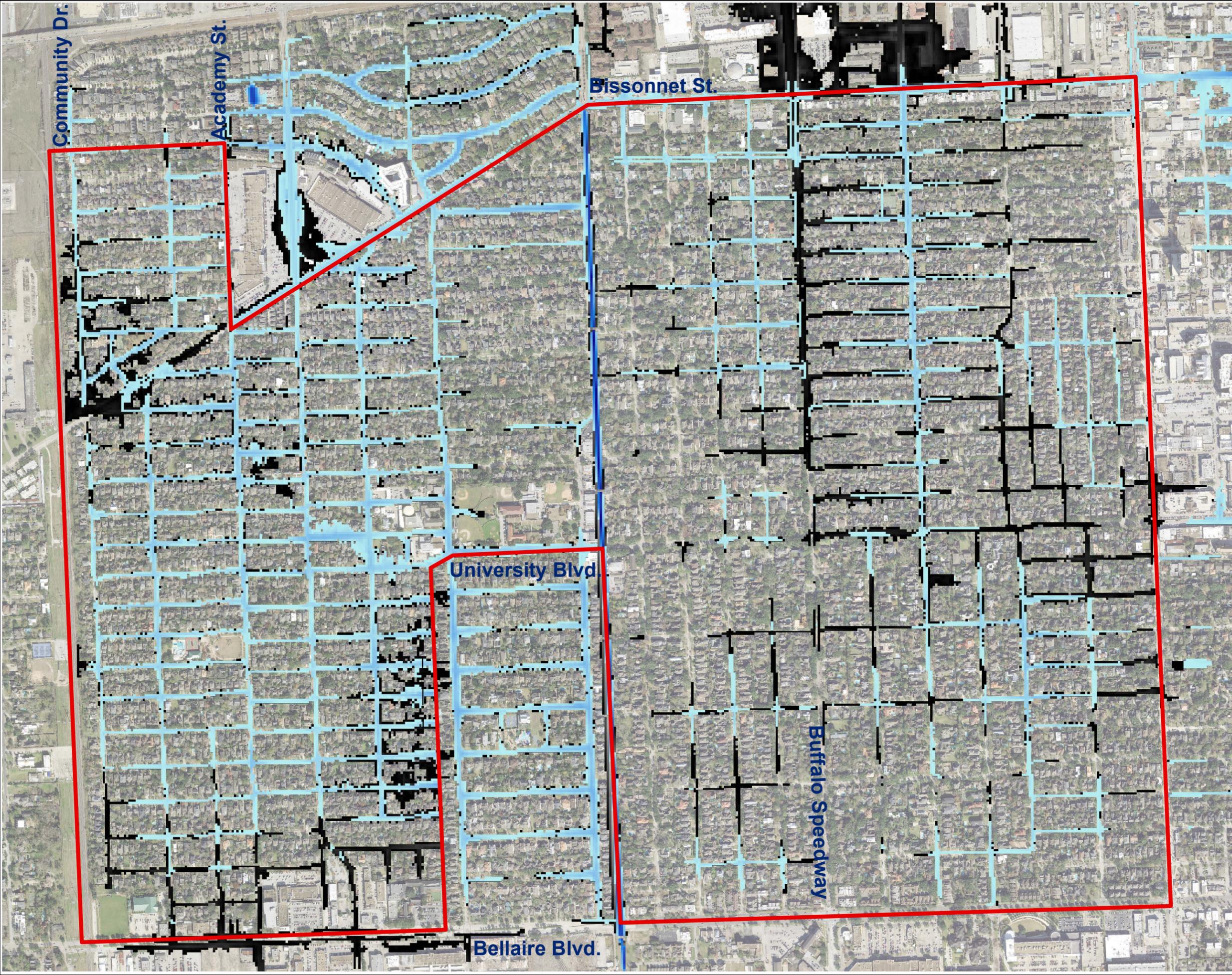


Low : 0

**Inundation
Comparison Map
With Restrictor**

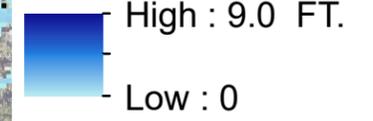
Exhibit 11





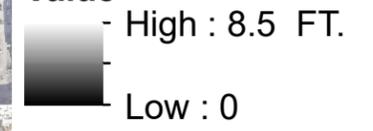
10-Year Proposed Imp. Scenario

Value



10-Year Existing Scenario

Value



**Inundation
Comparison Map
With Restrictor**

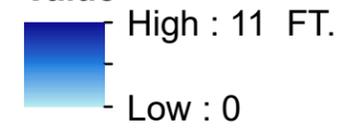
Exhibit 12





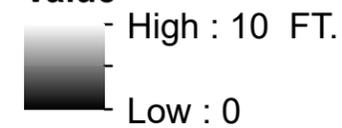
50-Year Proposed Imp. Scenario

Value



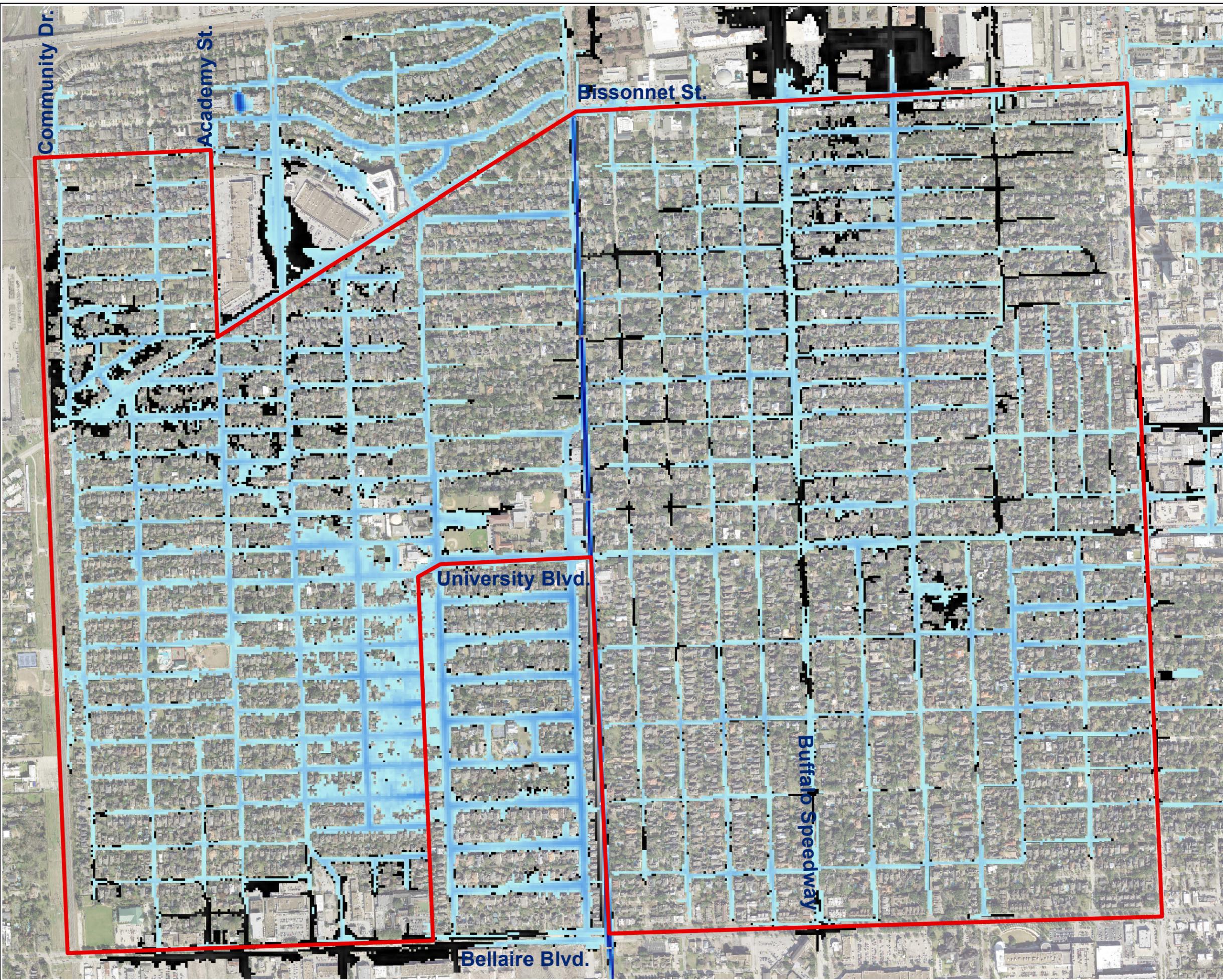
50-Year Existing Scenario

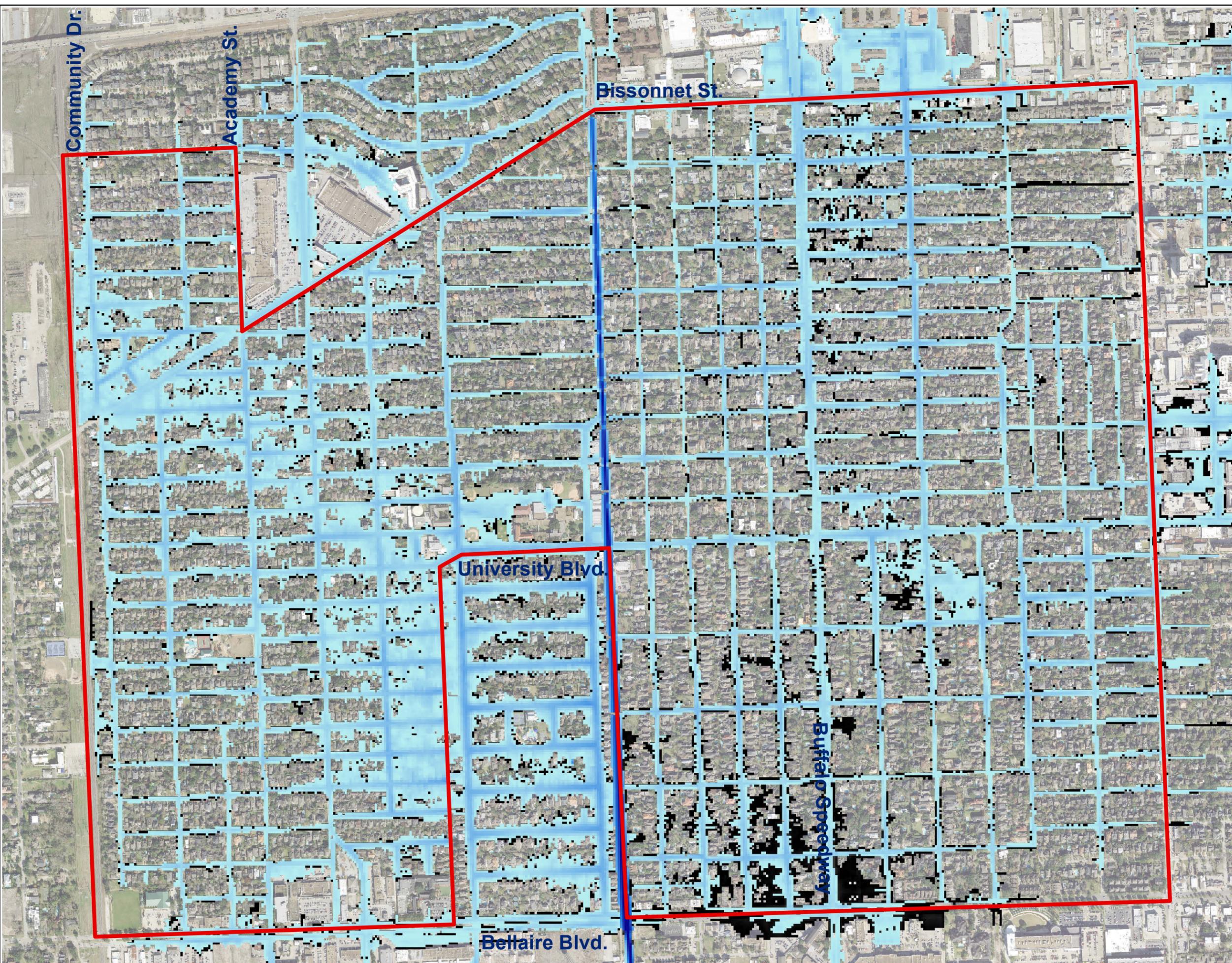
Value



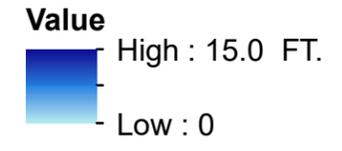
**Inundation
Comparison Map
With Restrictor**

Exhibit 13

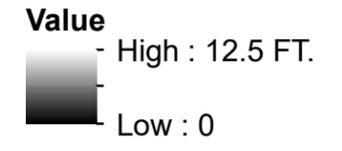




100-Year Proposed Imp. Scenario



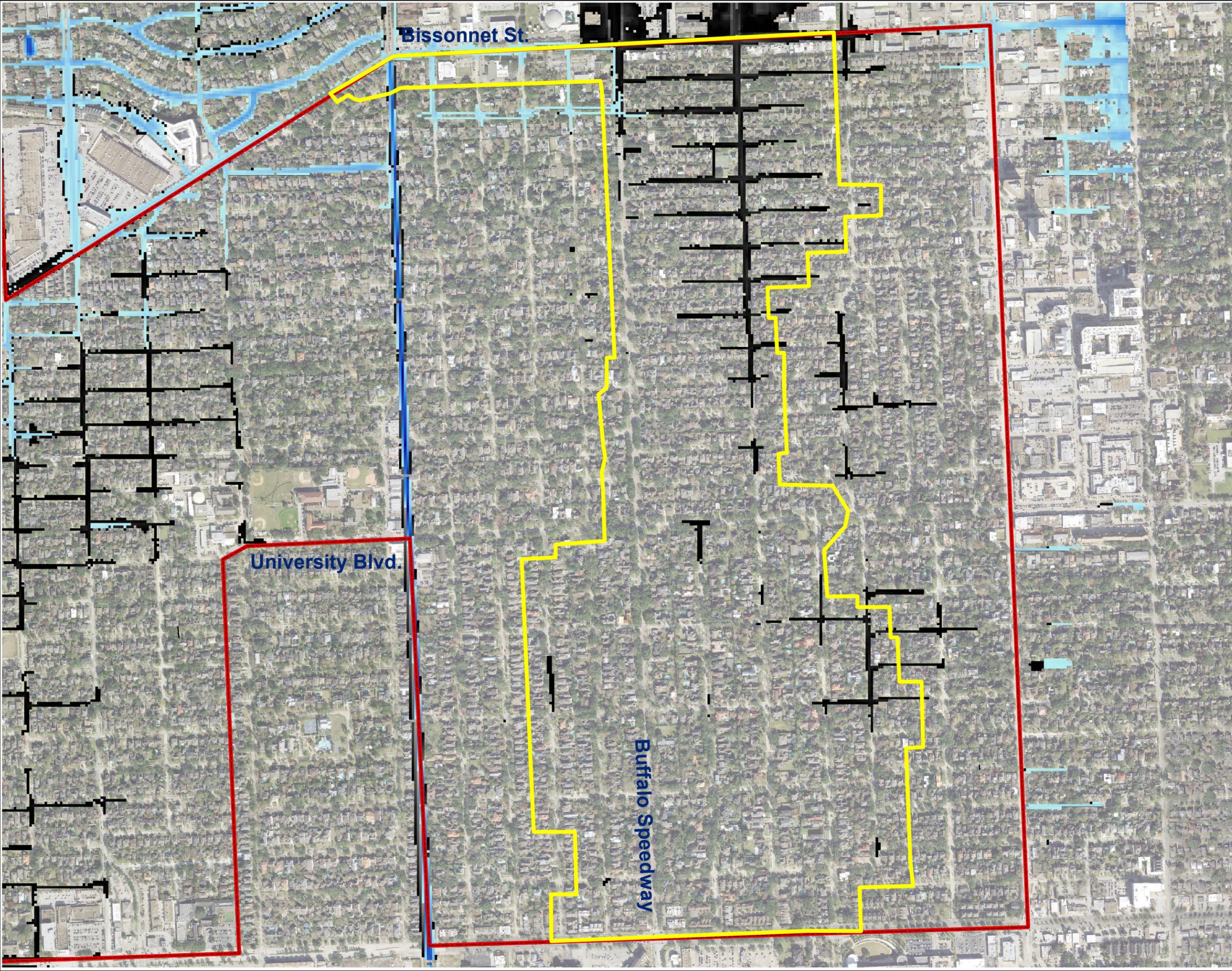
100-Year Existing Scenario



**Inundation
Comparison Map
With Restrictor**

Exhibit 14



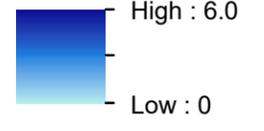


Legend

 Buffalo Speedway Drainage Area

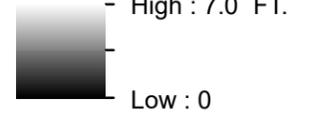
2-Year Buffalo Spdwy Imp. Value

Value



2-Year Existing Scenario Value

Value



2-Year Inundation Comparison Map

Buffalo Speedway Improvements

Exhibit 15



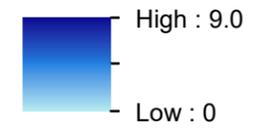


Legend

 Buffalo Speedway Drainage Area

10-Year Buffalo Spdwy Imp.

Value



10-Year Existing Scenario

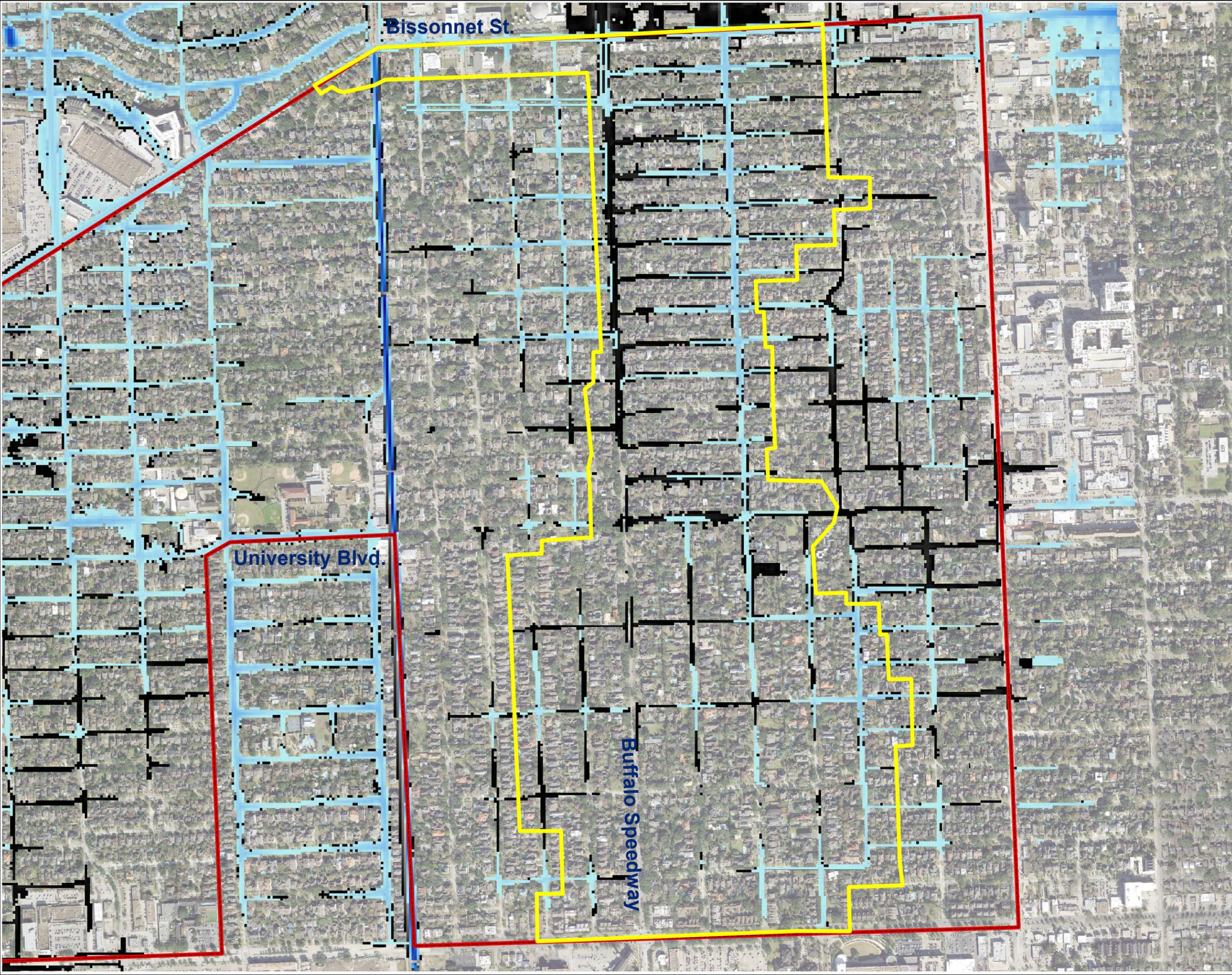
Value



10-Year Inundation Comparison Map

Buffalo Speedway Improvements

Exhibit 16





Legend

 Buffalo Speedway Drainage Area

50-Year Buffalo Spdwy Imp.

Value
 High : 11.5 FT.
Low : 0

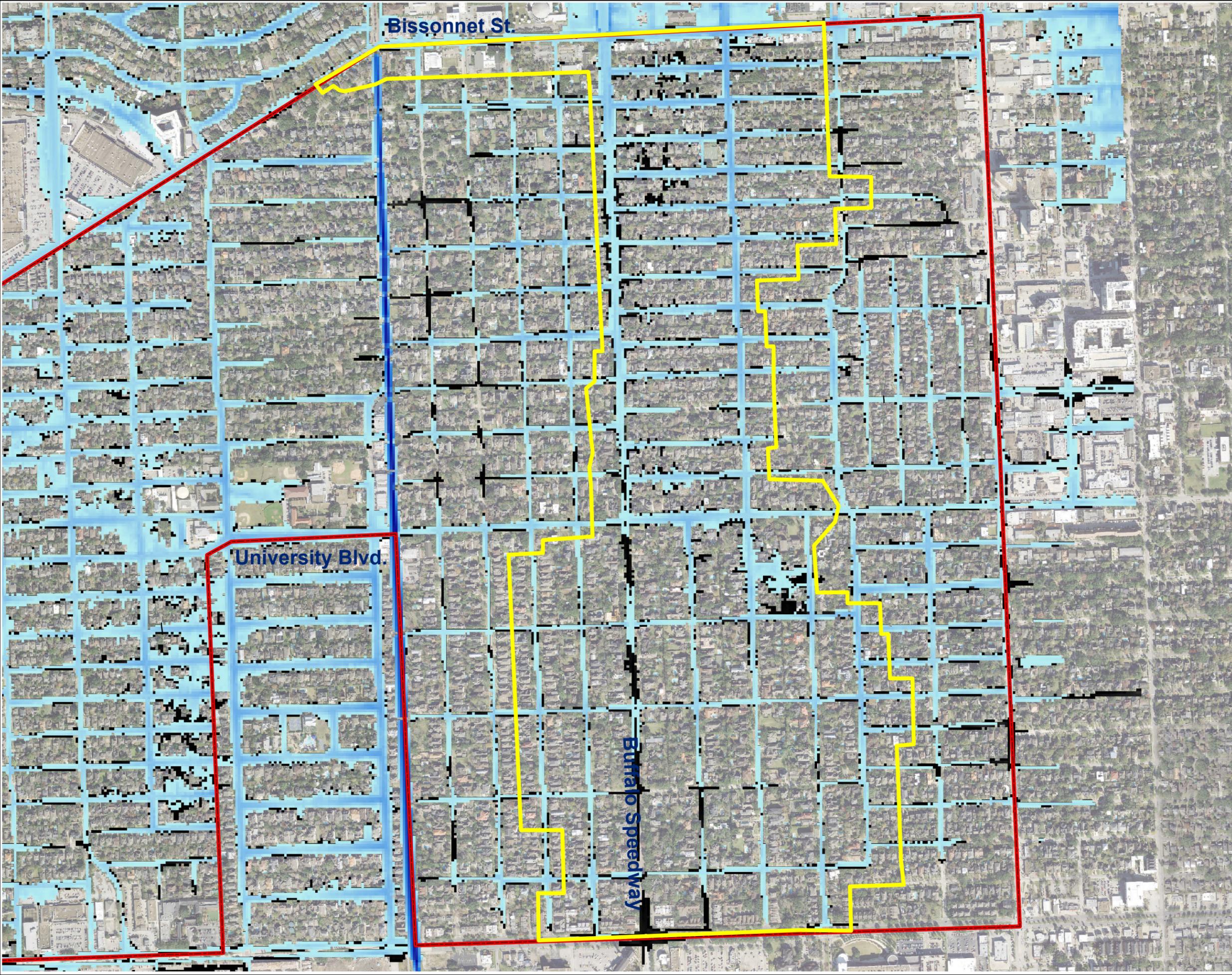
50-Year Existing Scenario

Value
 High : 9.5 FT.
Low : 0

50-Year Inundation Comparison Map

Buffalo Speedway Improvements

Exhibit 17





Legend

 Buffalo Speedway Drainage Area

100-Year Buffalo Spdwy Imp.

Value
 High : 15.0 FT.
Low : 0

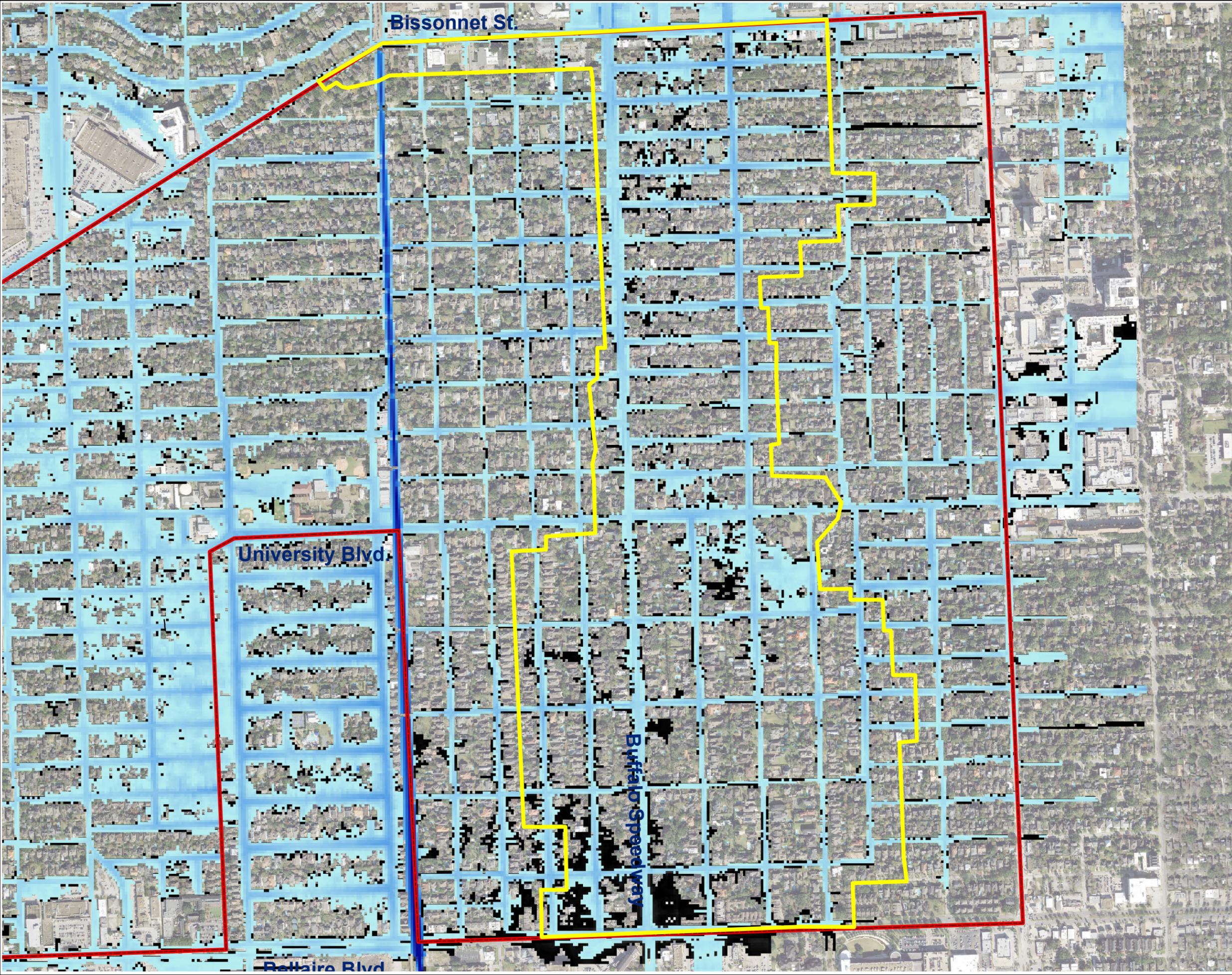
Existing 100-Year Scenario

Value
 High : 12.5 FT.
Low : 0

100-Year Inundation Comparison Map

Buffalo Speedway Improvements

Exhibit 18



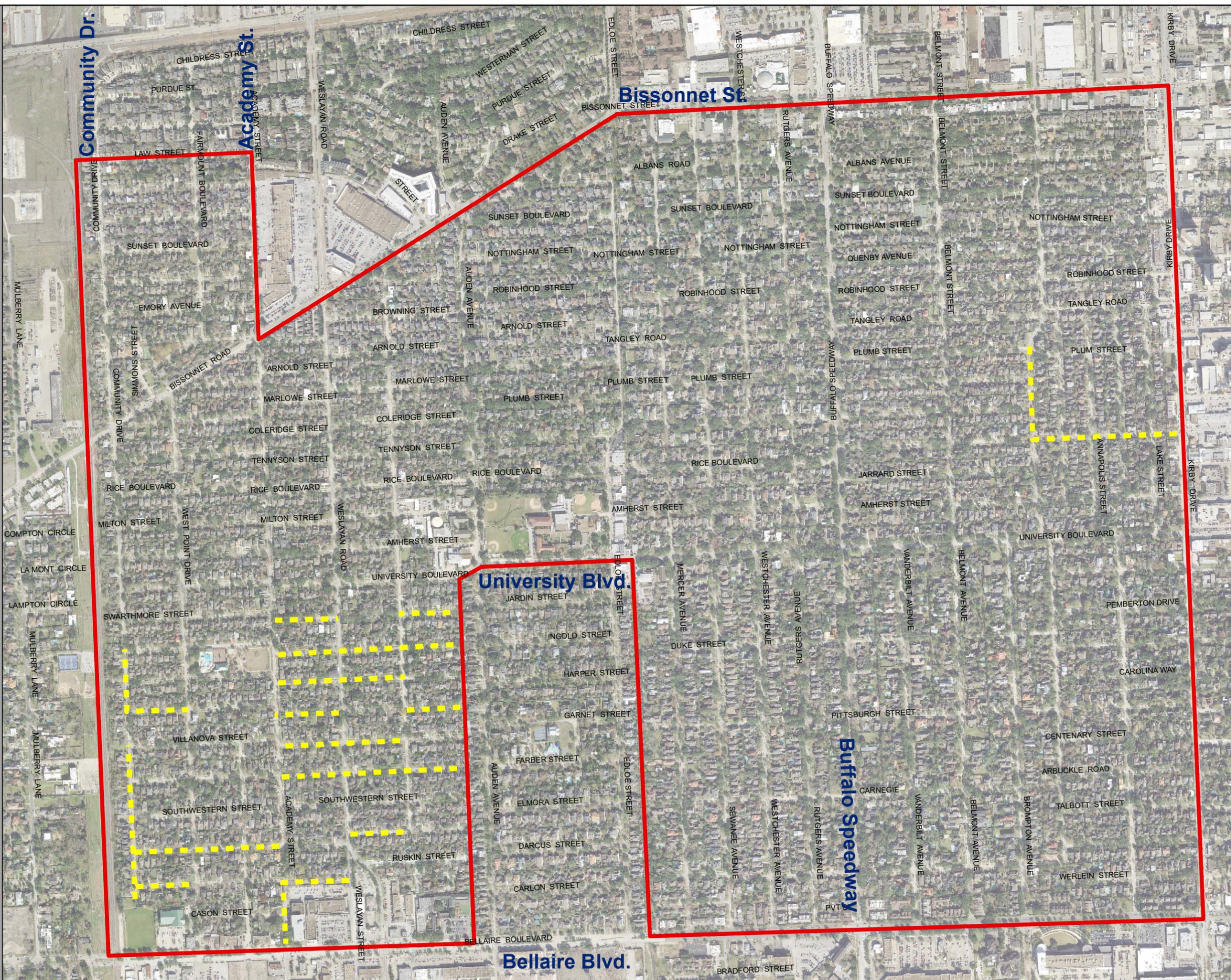


Legend

■ ■ ■ Proposed Street Rehabilitation

Street Rehabilitation

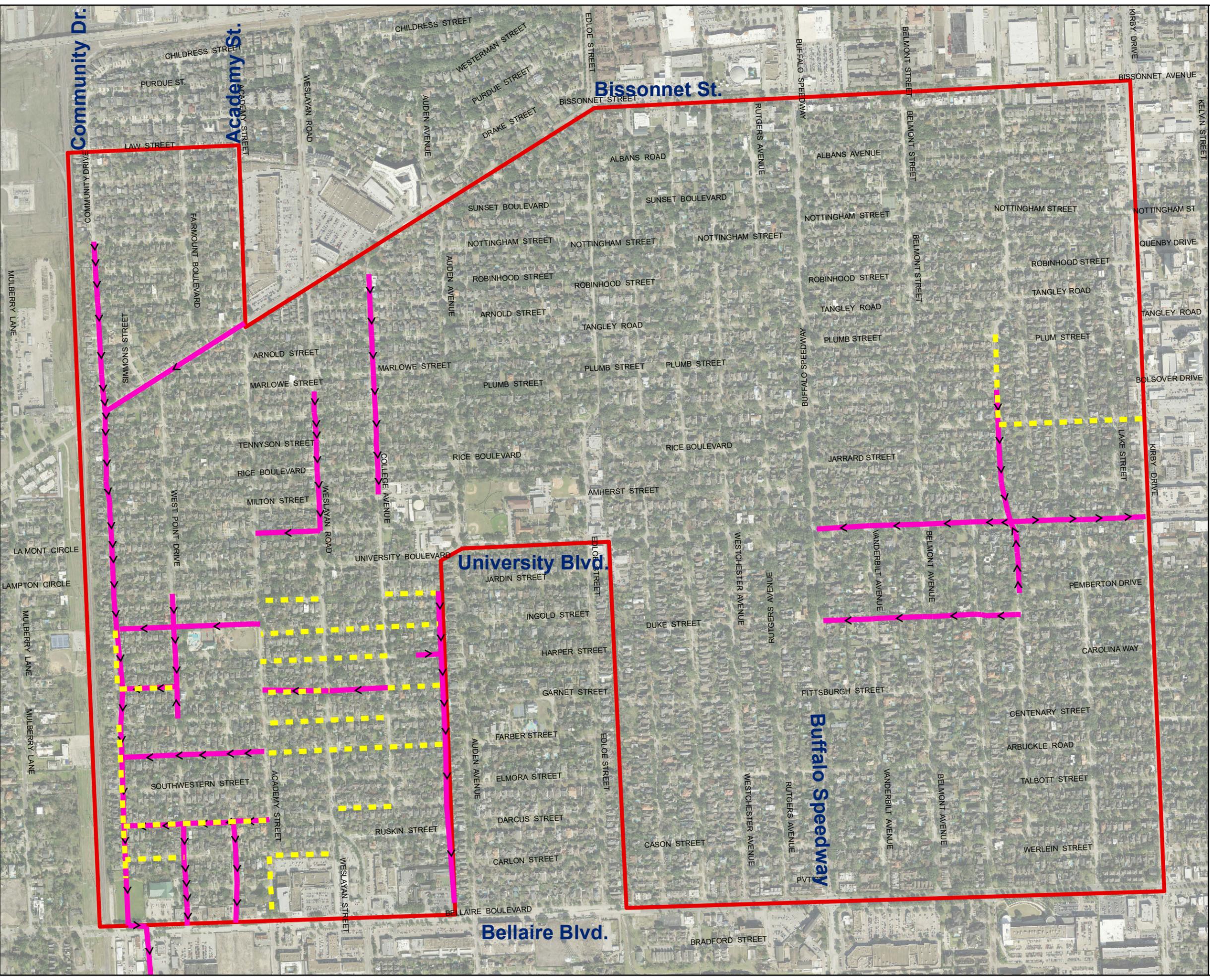
Exhibit 19





Legend

-  Proposed Improvements
-  Proposed Street Rehabilitation



Proposed Improvements

Exhibit 20



ATTACHMENT 1A

Council Workshop Presentation

6/22/2020

City of West University Place Citywide Storm Sewer Analysis

June 22, 2020

Prepared for:



Prepared by:



Agenda

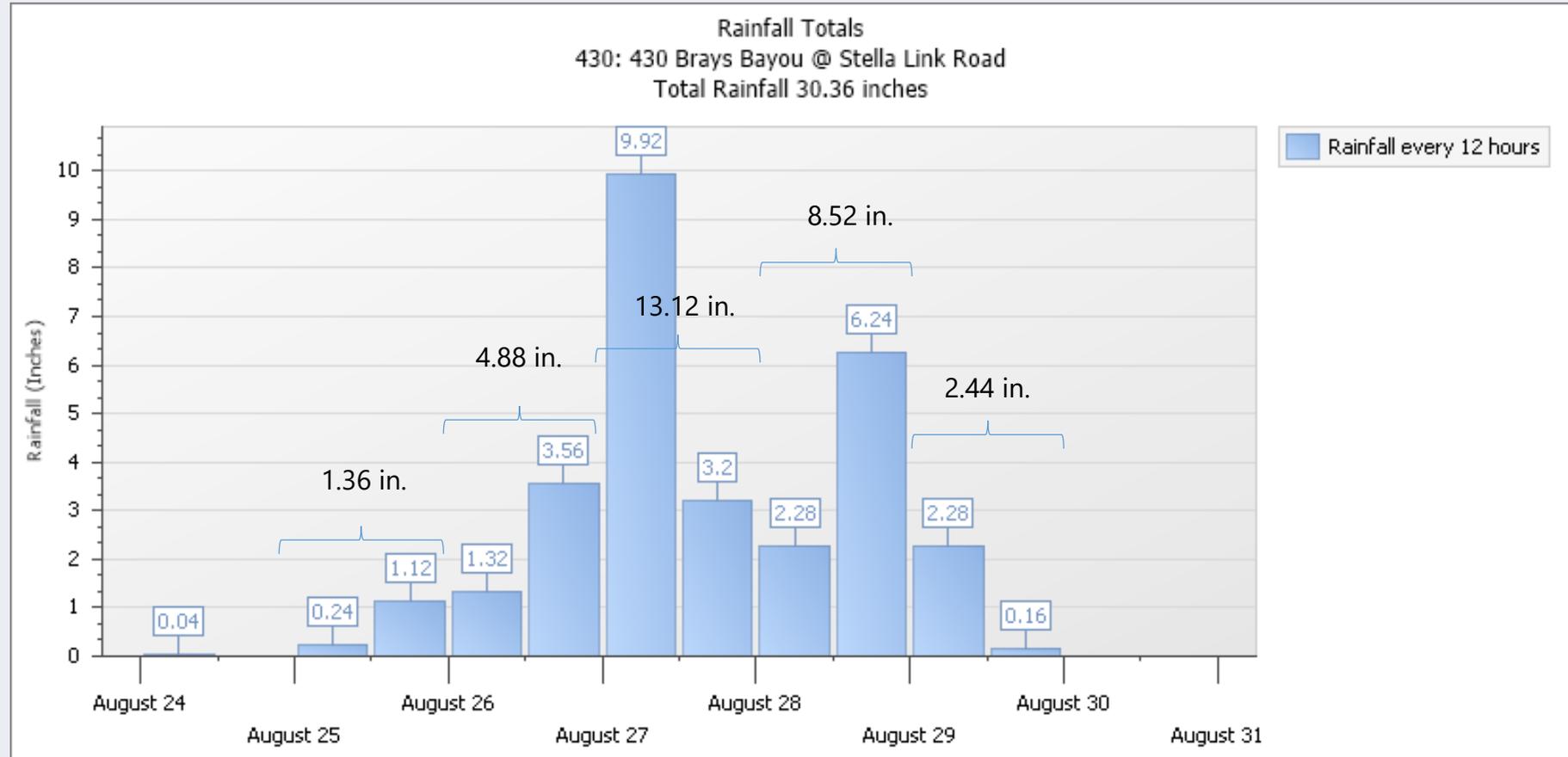
- **Background Introduction**
- **Drainage Design Criteria**
- **Hydrology & Hydraulic Modeling**
- **Alternatives**

Basic H&H Information

Rainfall Total and Annual Exceedance

Duration	50% AEP	20%AEP	10% AEP	4% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	0.1% AEP
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year	1000-Year
5-min	0.58	0.73	0.85	1.01	1.13	1.26	1.39	1.58	1.72
10-min	0.92	1.16	1.35	1.61	1.81	2.01	2.21	2.48	2.68
15-min	1.17	1.46	1.69	2.01	2.25	2.49	2.76	3.12	3.40
30-min	1.67	2.07	2.39	2.83	3.15	3.48	3.87	4.42	4.87
60-min	2.22	2.77	3.22	3.84	4.29	4.78	5.36	6.23	6.96
2-hr	2.79	3.56	4.25	5.24	6.02	6.89	7.95	9.56	10.90
3-hr	3.13	4.07	4.94	6.21	7.27	8.48	9.93	12.20	14.10
6-hr	3.75	4.98	6.15	7.94	9.48	11.30	13.40	16.70	19.50
12-hr	4.40	5.91	7.39	9.66	11.70	14.00	16.70	20.90	24.40
24-hr	5.11	6.92	8.71	11.50	14.00	16.90	20.10	25.00	29.10
2-day	5.90	8.05	10.20	13.70	16.80	20.40	24.10	29.20	33.30
3-day	6.43	8.78	11.10	14.90	18.30	22.10	26.00	31.20	35.20
4-day	6.82	9.29	11.70	15.60	19.10	22.90	26.80	32.10	36.20
7-day	7.69	10.30	12.90	16.80	20.30	24.10	28.00	33.40	37.60

Hurricane Harvey Rain Total



Historical Information

Historical Storm

Date	Event	Elevation *
6/18/1973		45.10'
8/31/1981		46.10'
8/18/1983	Alicia	42.70'
3/4/1992		45.00'
10/18/1994		46.00'
9/11/1998	Frances	44.30'
6/9/2001	Allison #2	48.40'
11/17/2003		46.30'
9/13/2008	Ike (10-Year)	45.90'
4/28/2009		43.00'
1/9/2012		45.70'
5/26/2015	Memorial Day (50-Year)	48.30'
4/18/2016	Tax Day (10-Year)	46.50'
1/18/2017		45.70'
8/27/2017	Harvey (100-Year)	49.70'

High water mark elevations are approximate.

Top of the Bank = 48.4 ft.

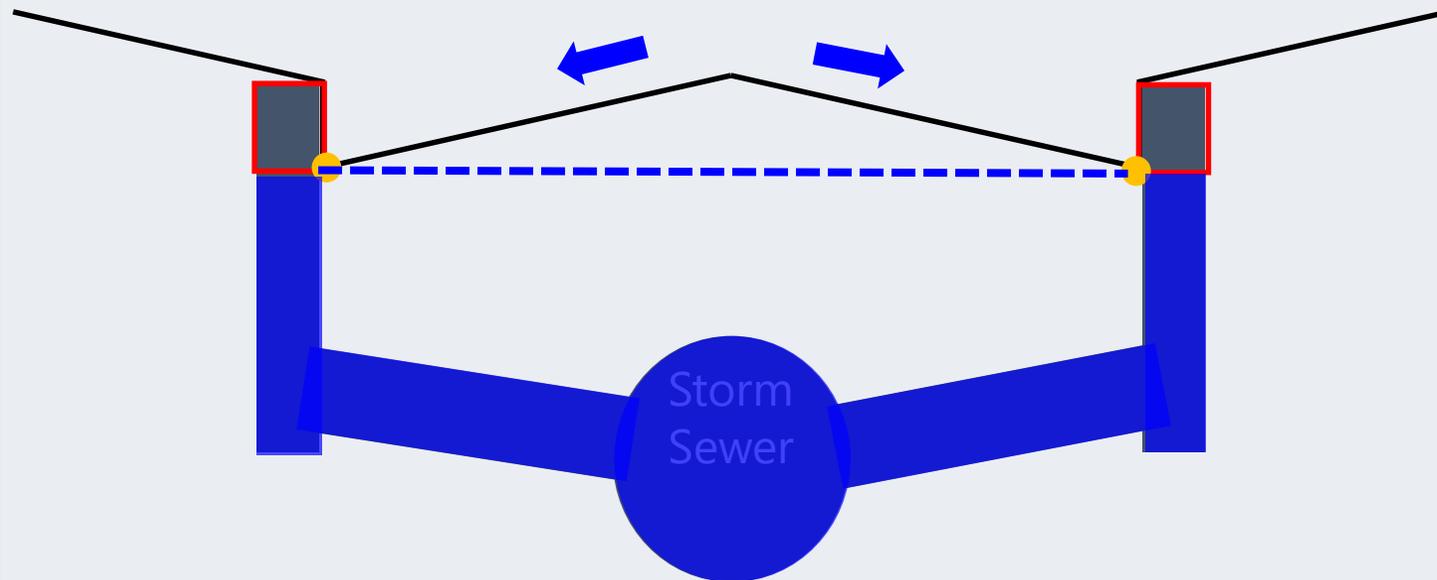
Flood Frequency	Elevation
10% (10-year)	45.50'
2% (50-year)	47.50'
1% (100-year)	49.60'
.2% (500-year)	51.80'

Flood frequency based on 24-hour duration

Design Criteria

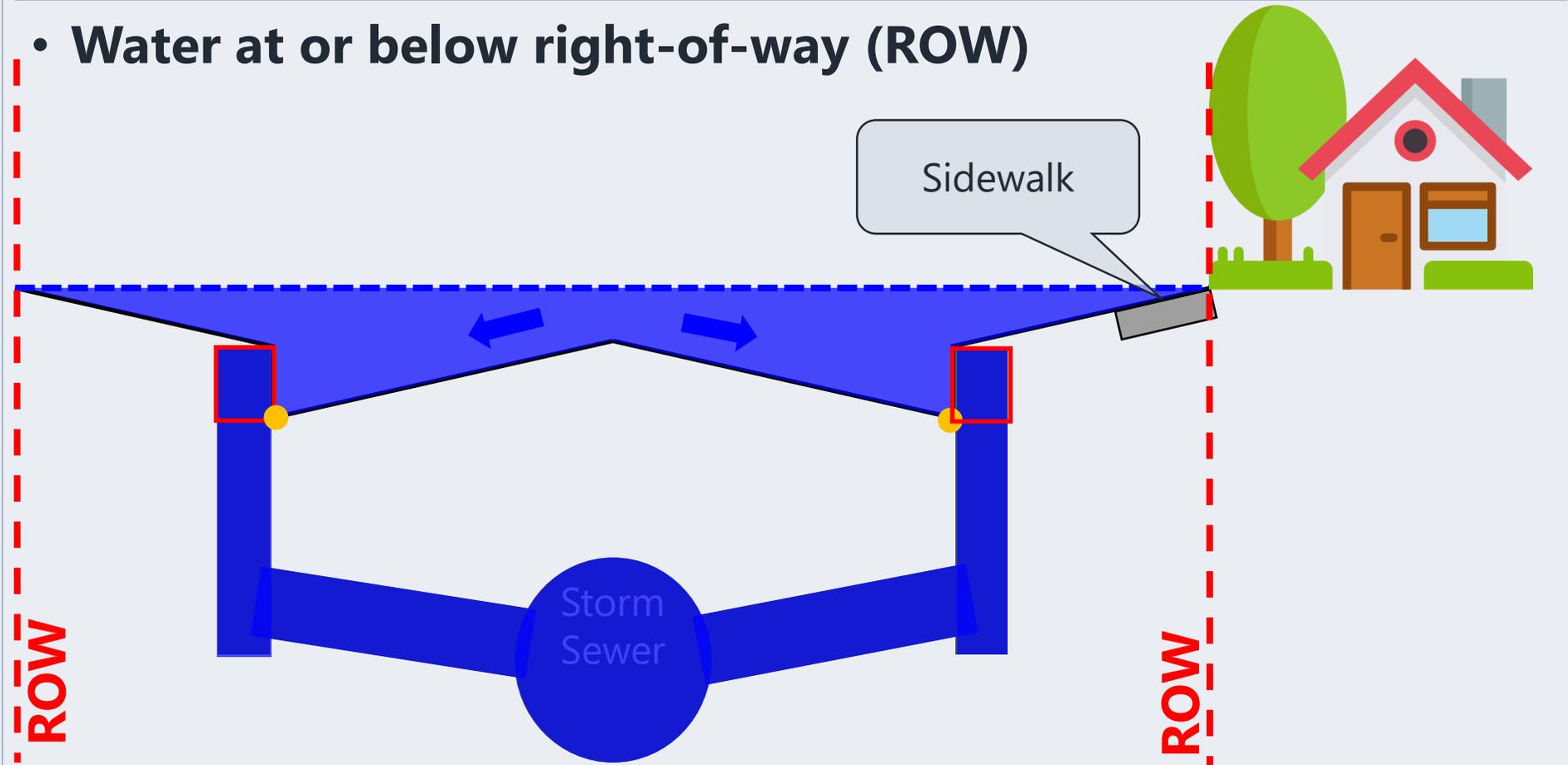
Drainage Design Criteria – 2-year

- **Hydraulic Grade Line (HGL) at or below the gutter**

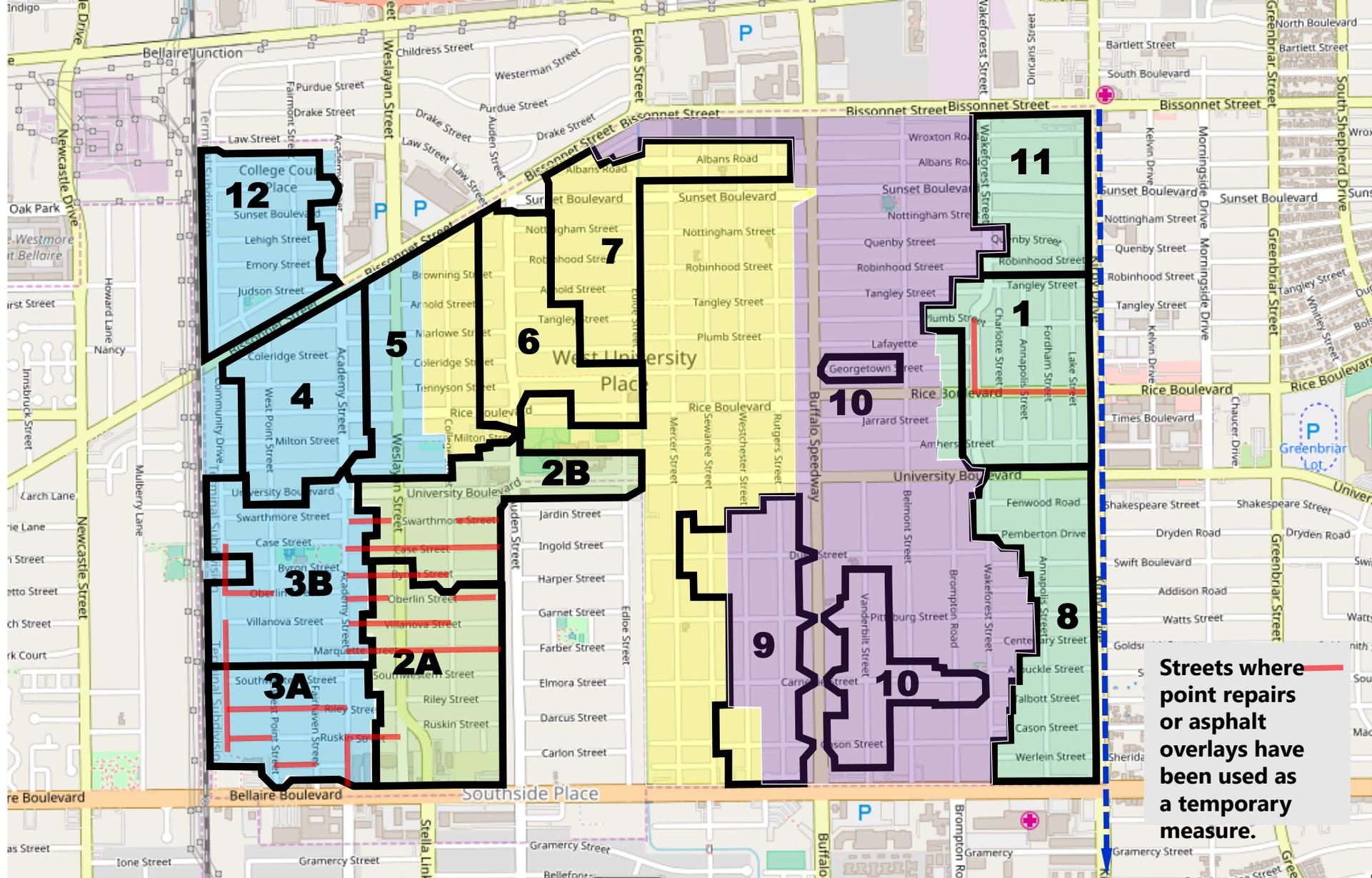


Drainage Design Criteria – 100-year

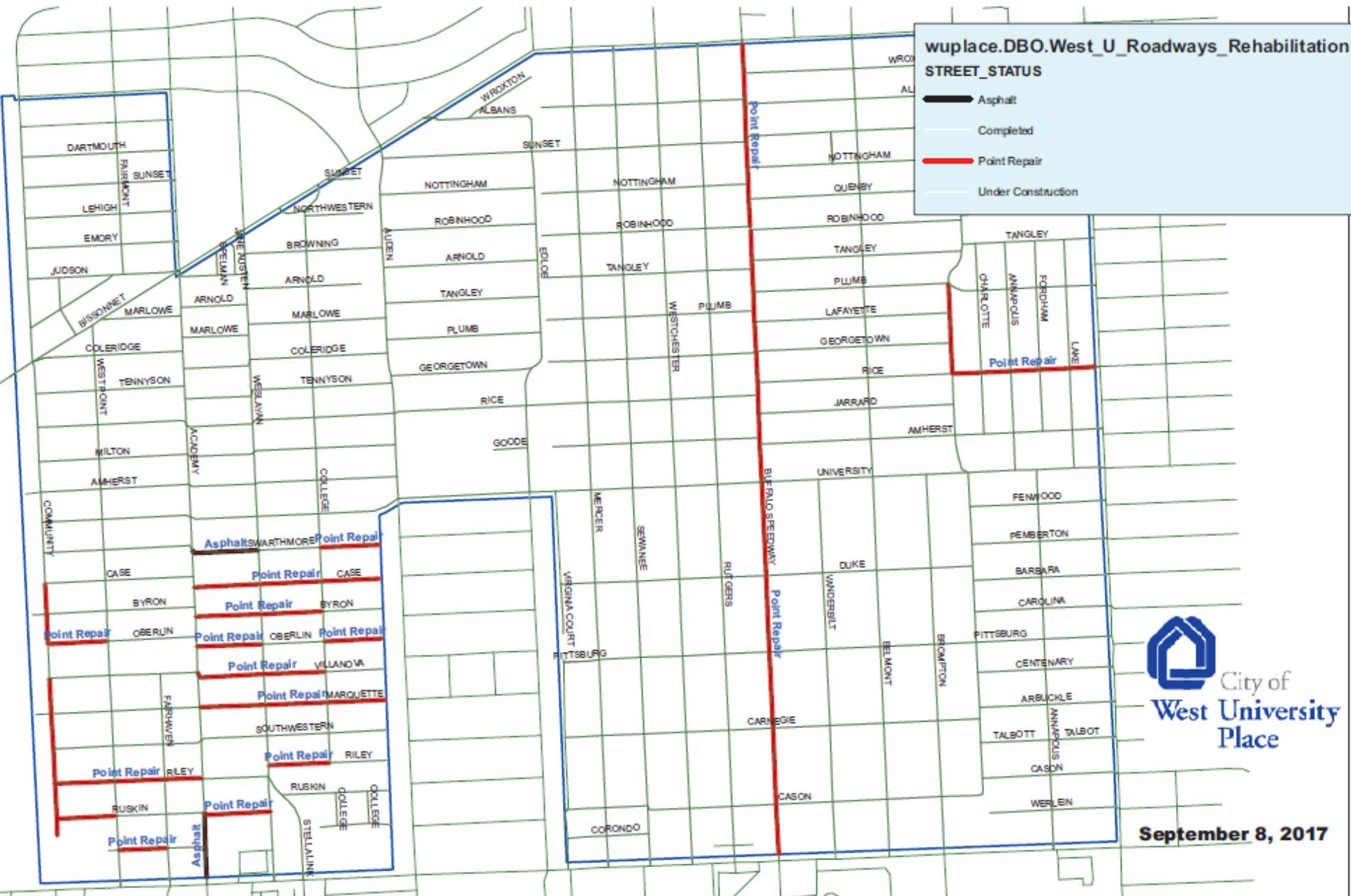
- Water at or below right-of-way (ROW)



Existing Conditions



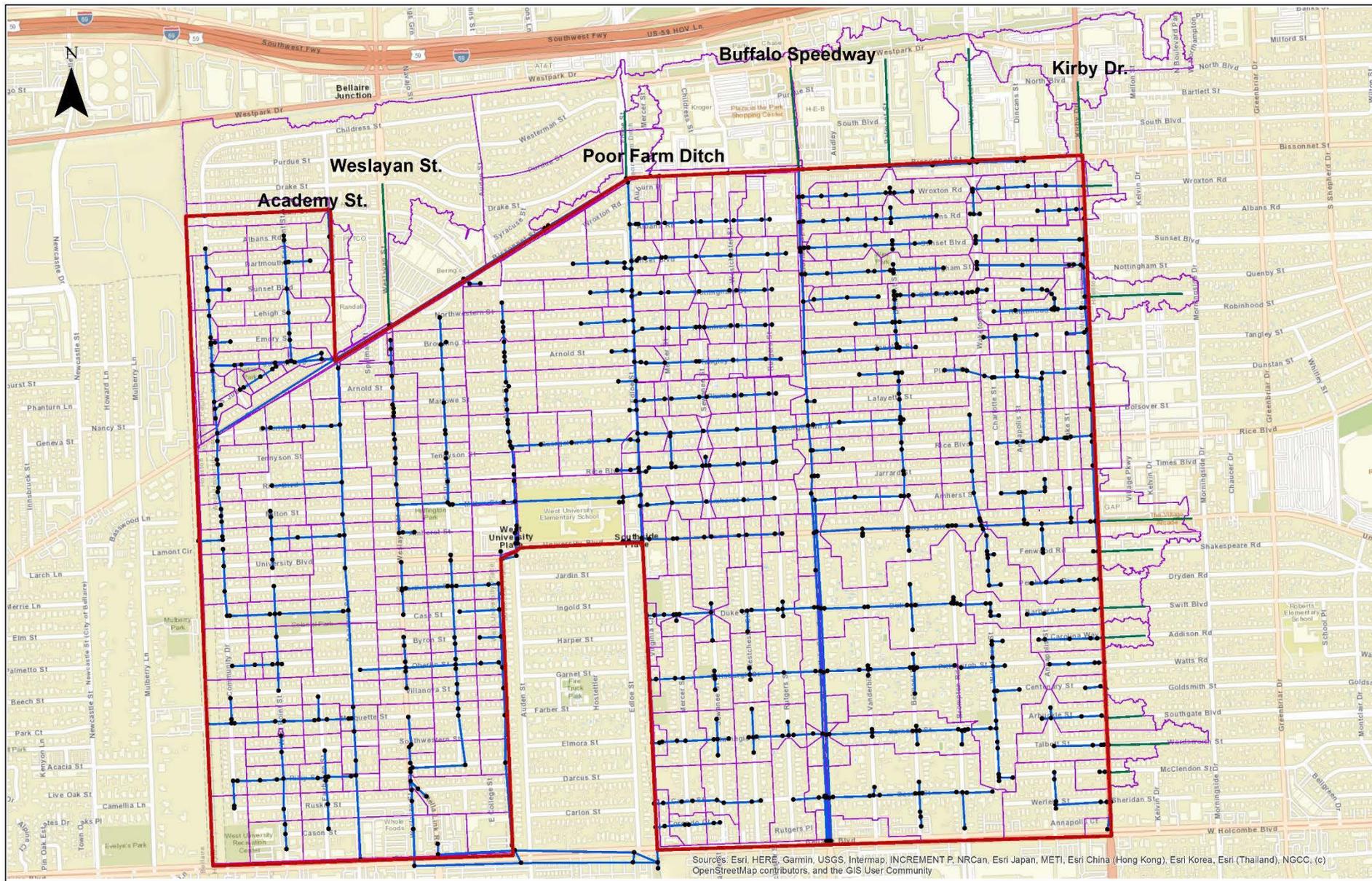
Planning Zones



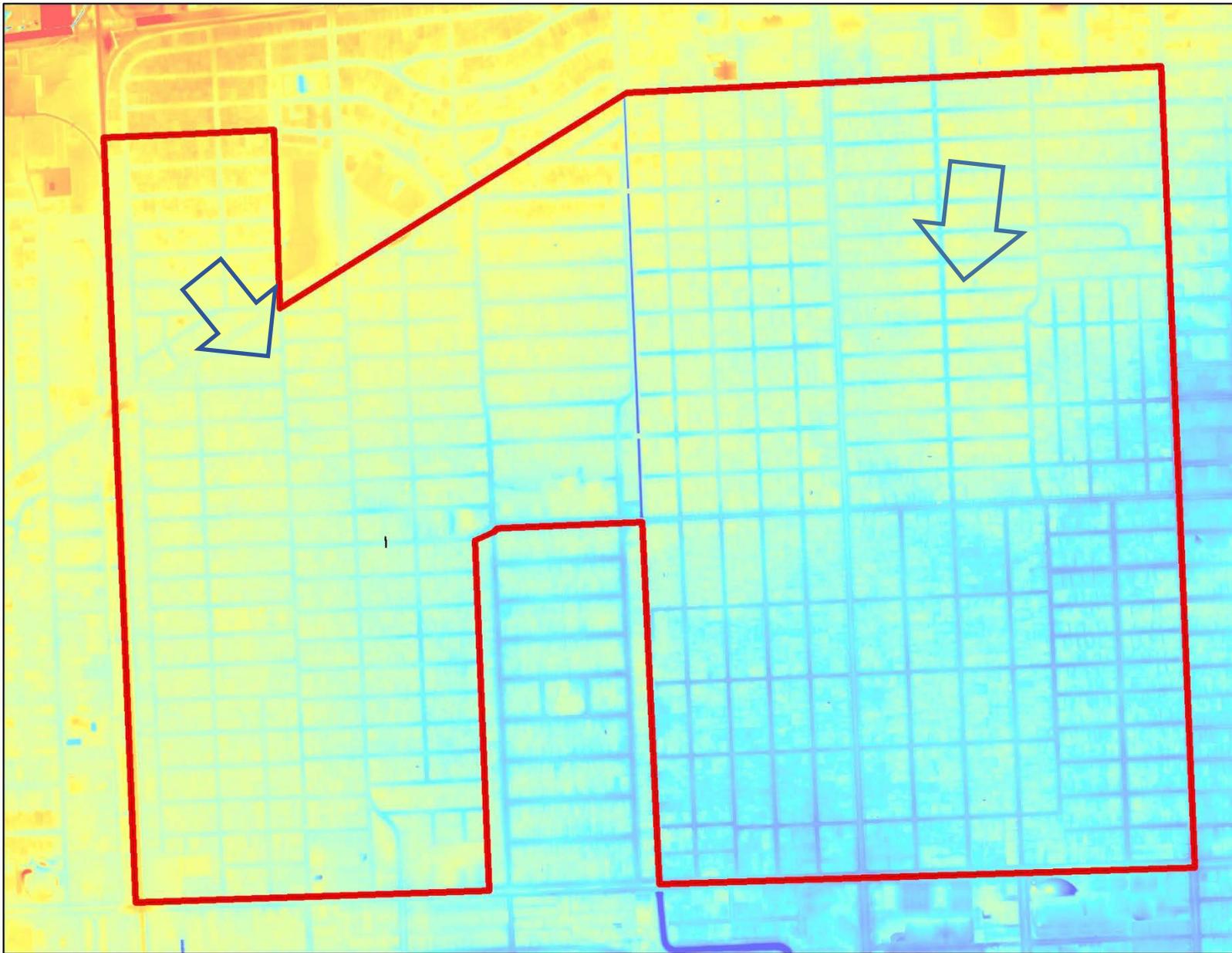
Road Reconstruction



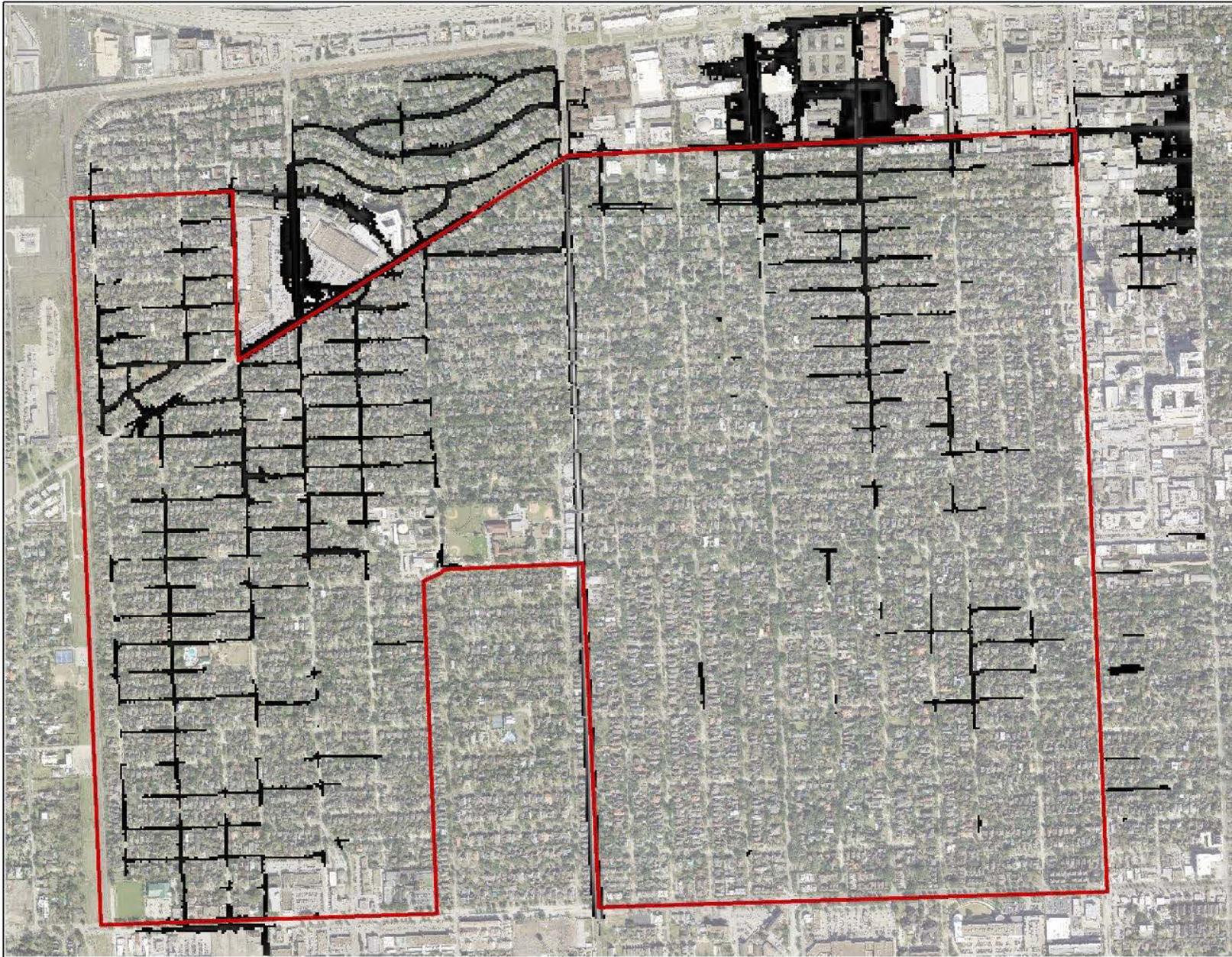
September 8, 2017



Existing Drainage System



Existing Topography 2018 LiDAR



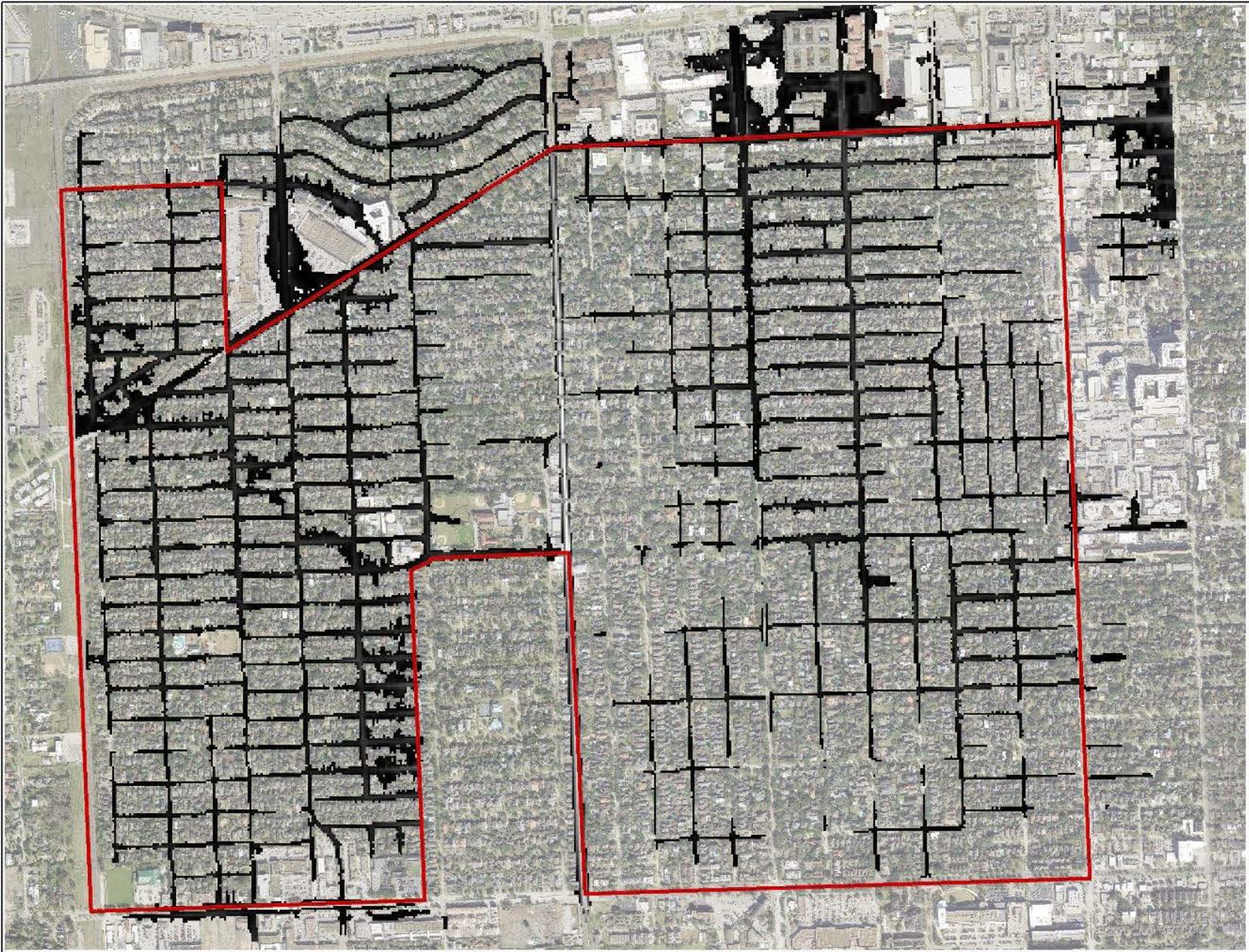
Legend

Existing 2-Year Scenario



Existing 2-Year Event
Inundation Map

Without Buffalo
Speedway
Improvements



Legend

Existing 10-Year Scenario

Value
High : 8.5 FT.
Low : 0

Existing 10-Year Event
Inundation Map
Without Buffalo
Speedway
Improvements



Legend

Existing 50-Year Scenario



Existing 50-Year Event
Inundation Map

Without Buffalo
Speedway
Improvements



Legend

Existing 100-year Scenario

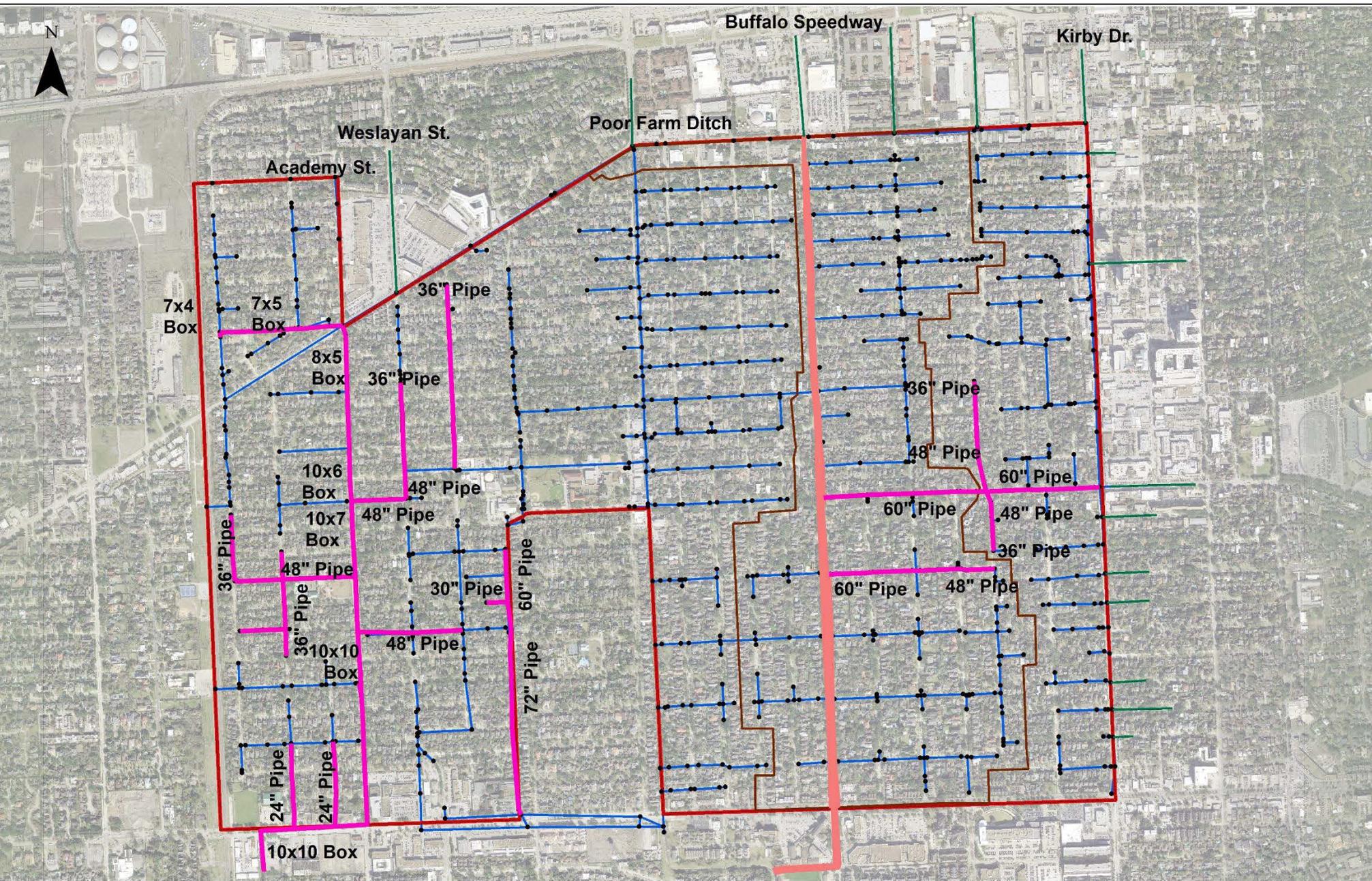
Value
High : 10.6 FT.
Low : 0

Existing 100-Year Event
Inundation Map

Without Buffalo
Speedway
Improvements

Proposed Conditions

1. **Academy Street + Shared Line**
2. **Community Street + Shared Line**
3. **West Side Along Rail-Road + Shared Line**
4. **West Point + Shared Line**

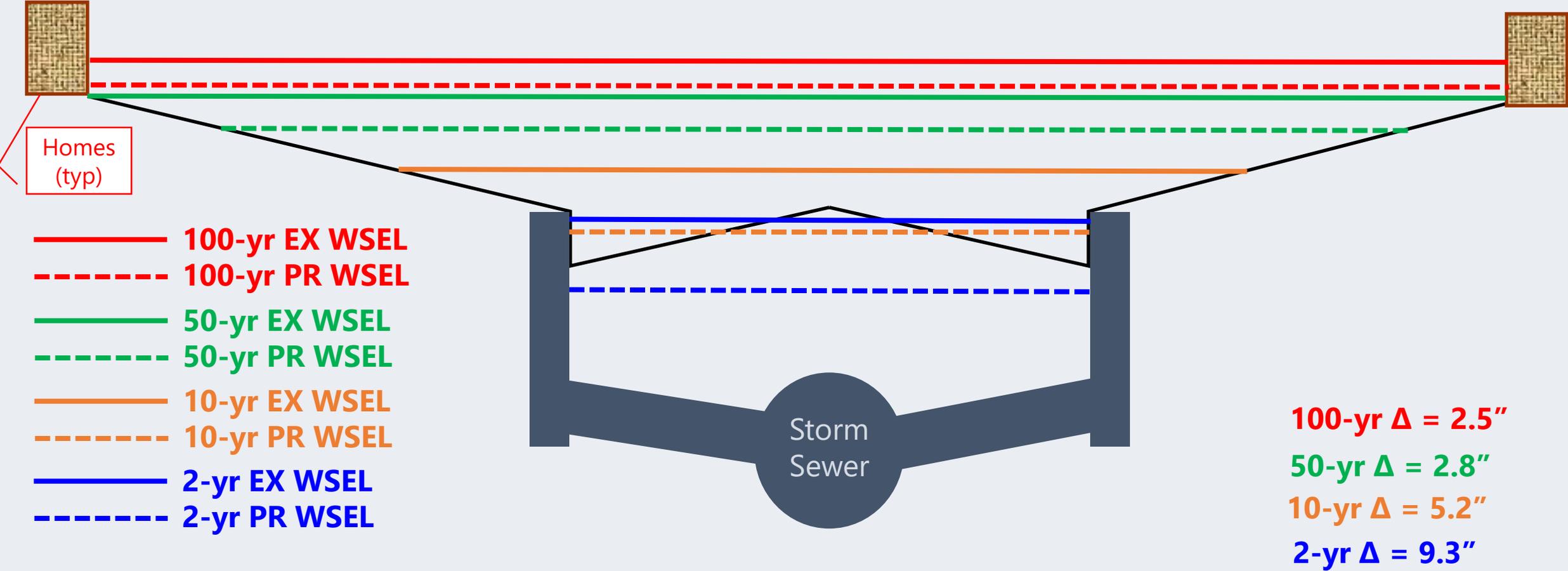


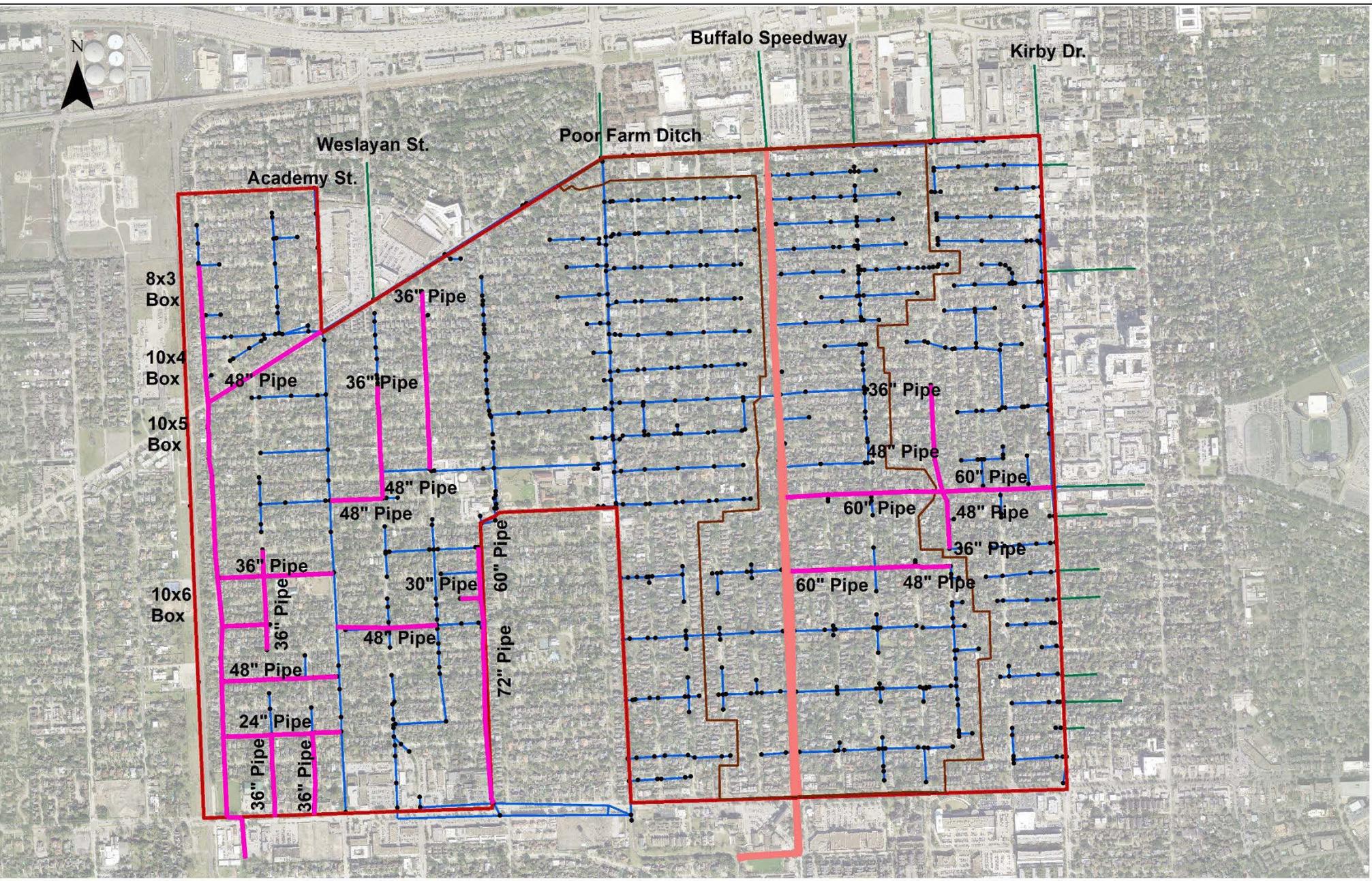
Approx.
\$67M

Along Academy Street and shared line at city limit

Option 1

Average Drop in Water Surface Elevation

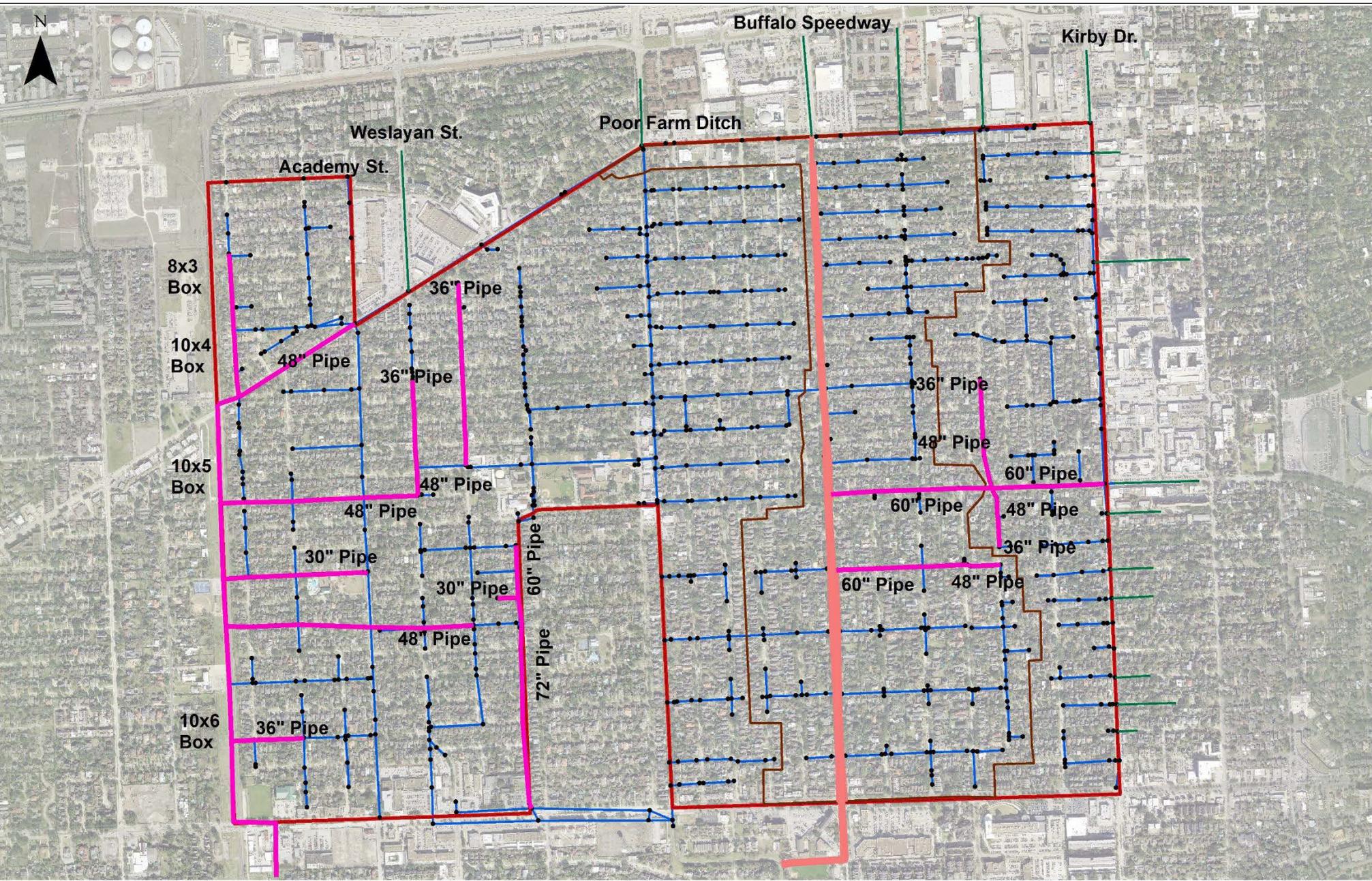




Approx.
\$60M

Along Community Drive and shared line at city limit

Option 2

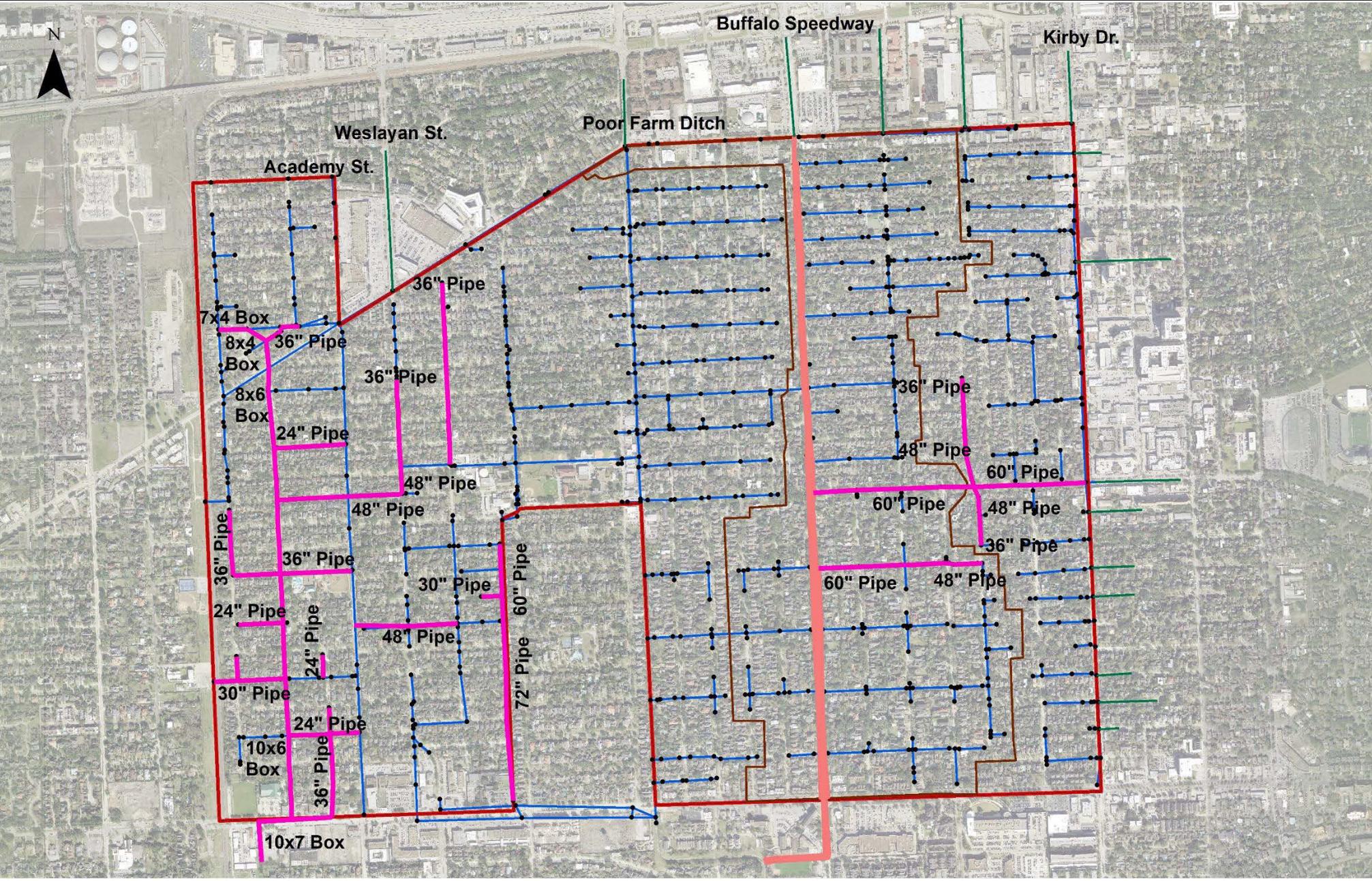


Approx.
\$59M

+
ROW

Along Railroad
and shared line at
city limit

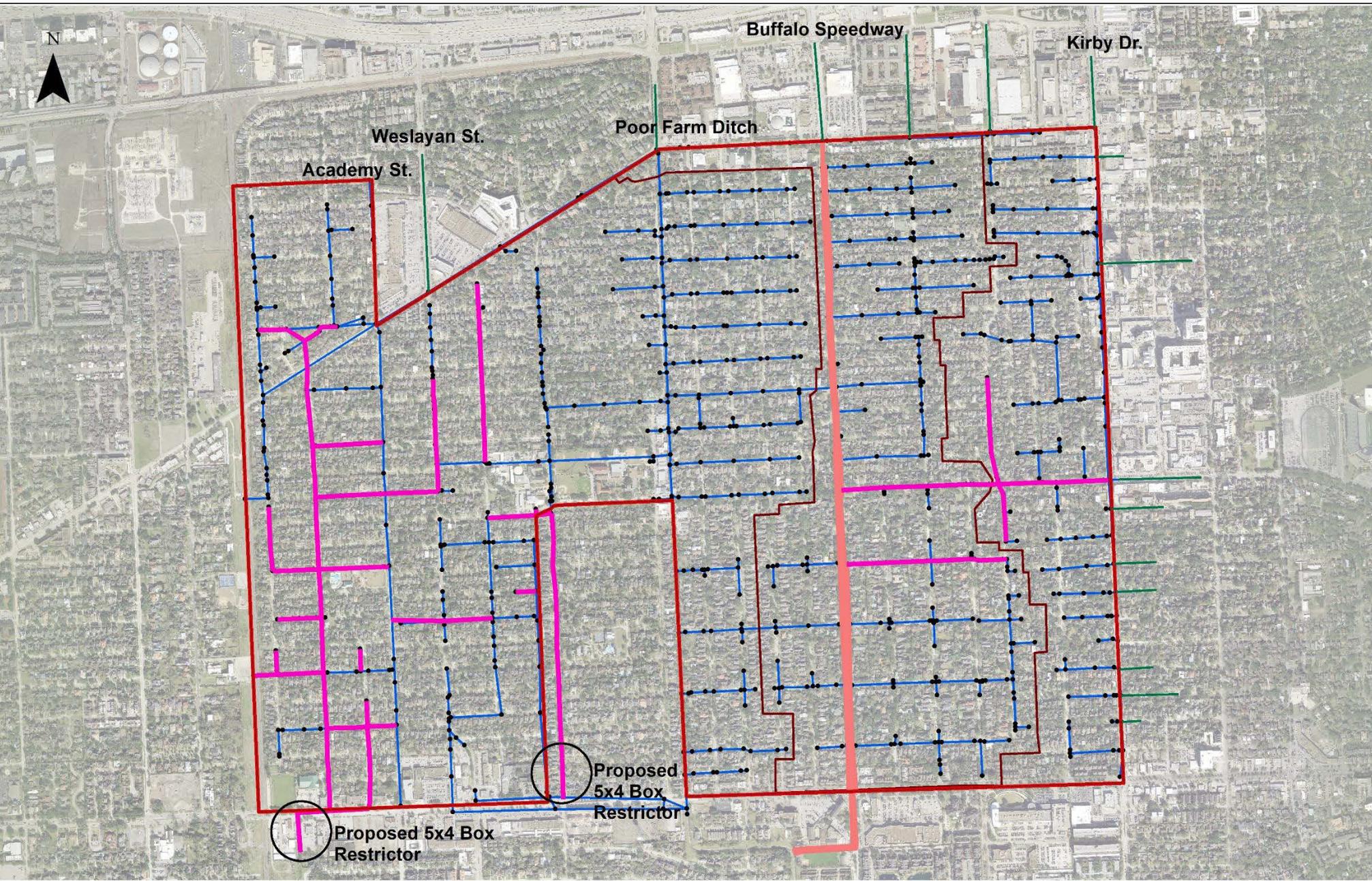
Option 3



Approx.
\$66M

Along West Point
and shared line at
city limit

Option 4



Inline Detention

Inline Detention will increase the cost by \$50M - \$60M

Summary of Average Drop in Water Surface Elevation, Inches

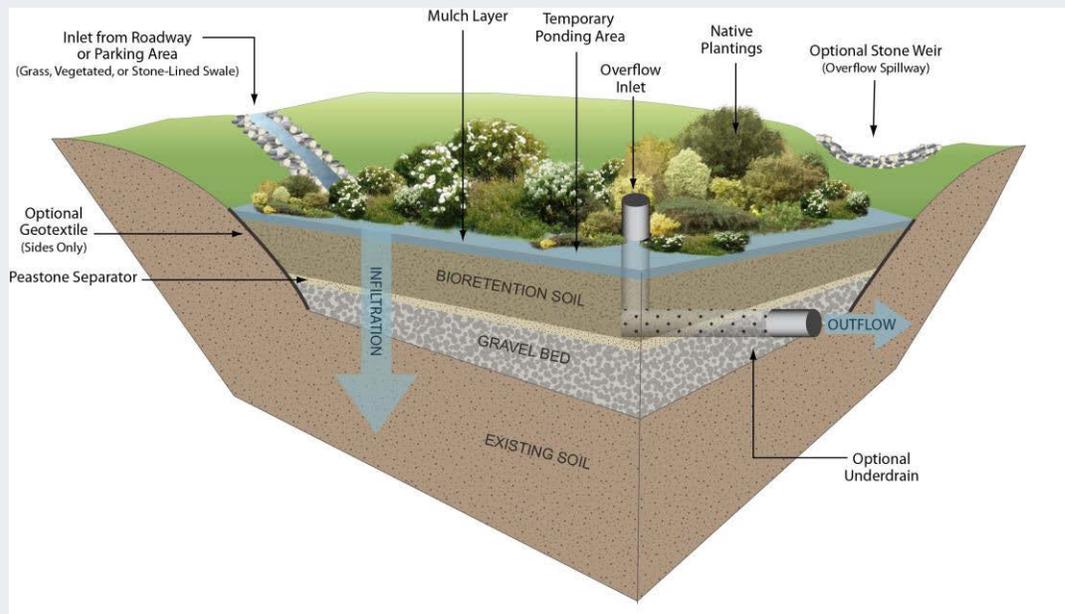
Option	Est. Cost	W/O Restrictor				W/ Restrictor			
		2-Year	10-Year	50-Year	100-Year	2-Year	10-Year	50-Year	100-Year
1- Academy	\$67M	9.3	9.2	2.5	2.1	9.3	5.1	1.7	1.1
2- Community	\$60M	9.3	7.1	3.5	3.0	9.3	5.1	1.7	1.1
3- Rail Road	\$59M	9.3	7.1	3.6	3.0	9.3	5.1	1.7	1.1
4- WestPoint	\$66M	9.3	5.2	2.8	2.5	9.3	5.1	1.7	1.1
5- Inline	\$114M	9.3	14.4	6.9	5.9	9.3	8.6	4.3	3.2

Cost Estimate Assumption

Exclusions

- Buffalo Speedway
- Any ROW Acquisition
- Cost of Future Detention Volume
- Except where full reconstruction was identified, pavement replacement includes single panel replacement

LOW IMPACT DEVELOPMENT (LID) Concept



**Bio Retention Basin /
Raingarden**

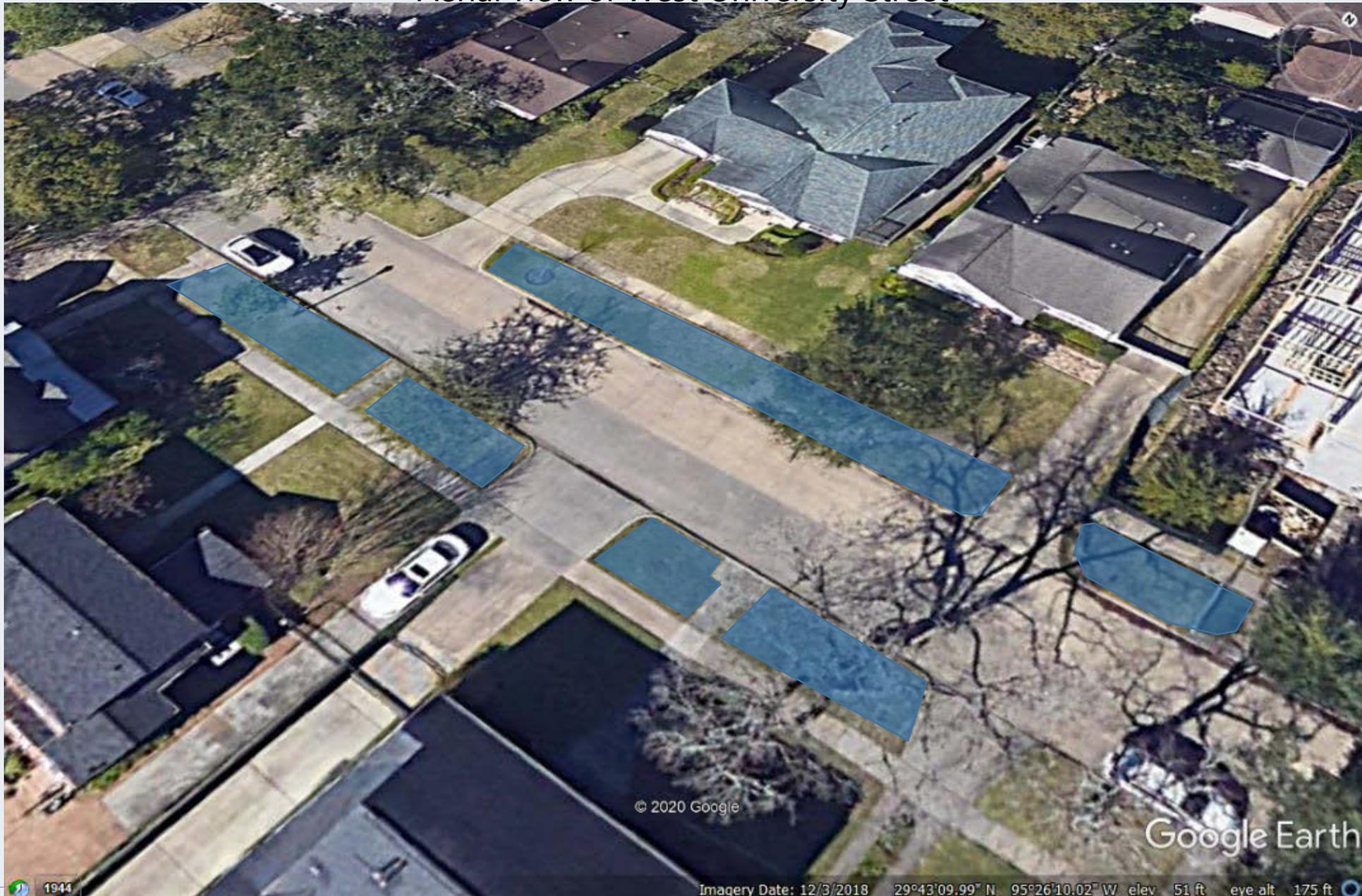


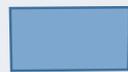
Rain Barrel

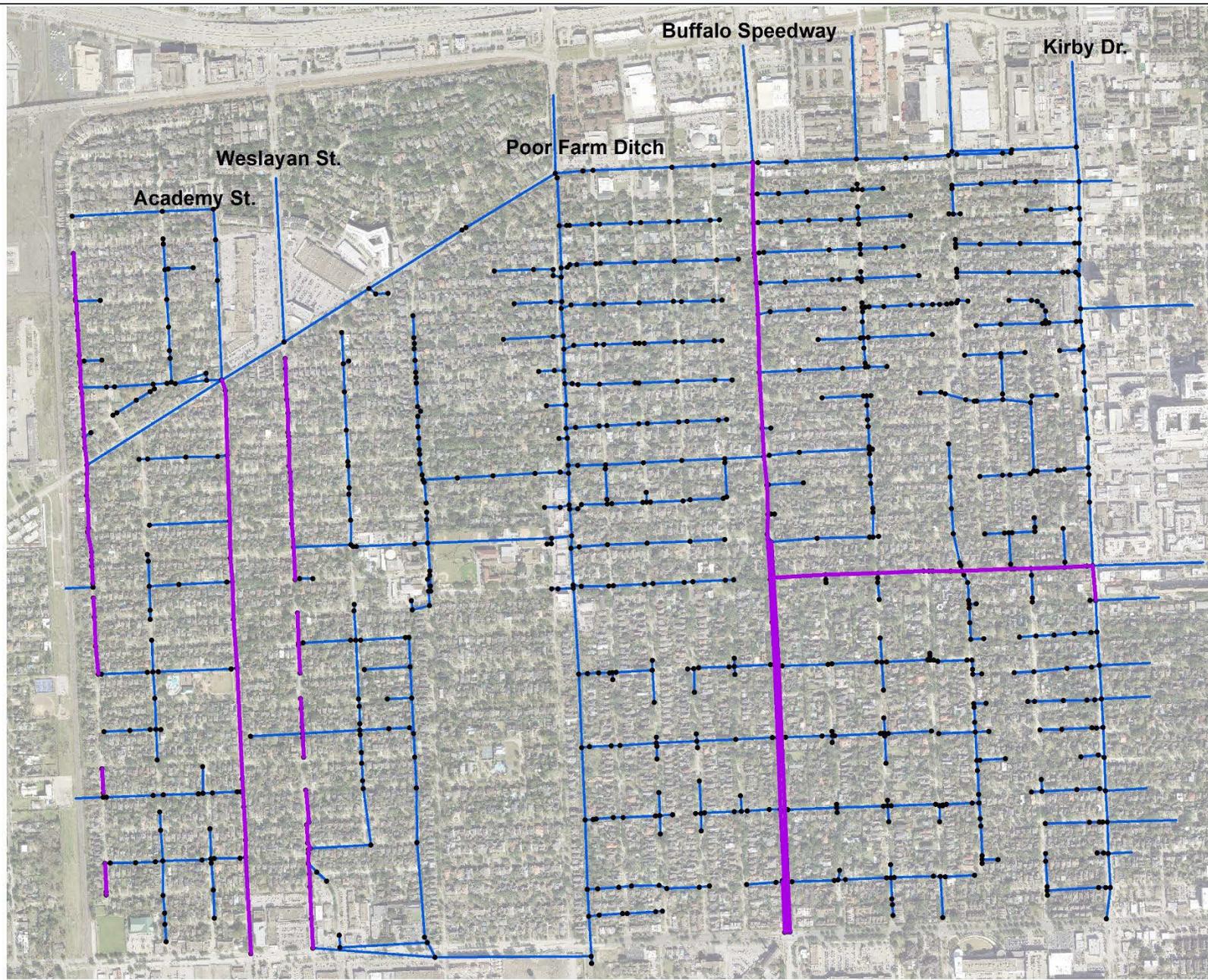


Bio-Swales

Aerial view of West University Street



 Bioswale



Legend

- Proposed Low Impact Development
- Manholes
- Existing Drainage
- West University Boundary

Additional Items

Detention Pond at Coca-Cola Site

Results / Findings

**Detention Requirements for the Proposed
Improvements without Restrictor**

230 acre-feet

Conclusion

- Proposed storm Sewer Improvements provide nearly 50-year Level-of-Service (LOS)
- Low Impact Development (LID) improvements can provide LOS up to 10-year
- Inline Detention help for smaller rain events
- Coca Cola site is not helping the system in a meaningful manner after Buffalo Speedway improvements

Questions & Answers
Thank You

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Houston, Texas 77025

www.ht-j.com
hfc@ht-j.com

(O) 832-767-0090
(F) 832-767-0141

ATTACHMENT 1B

Council Workshop Presentation

7/20/2020

City of West University Place

Citywide Storm Sewer Analysis

July 20, 2020

Prepared for:



Prepared by:

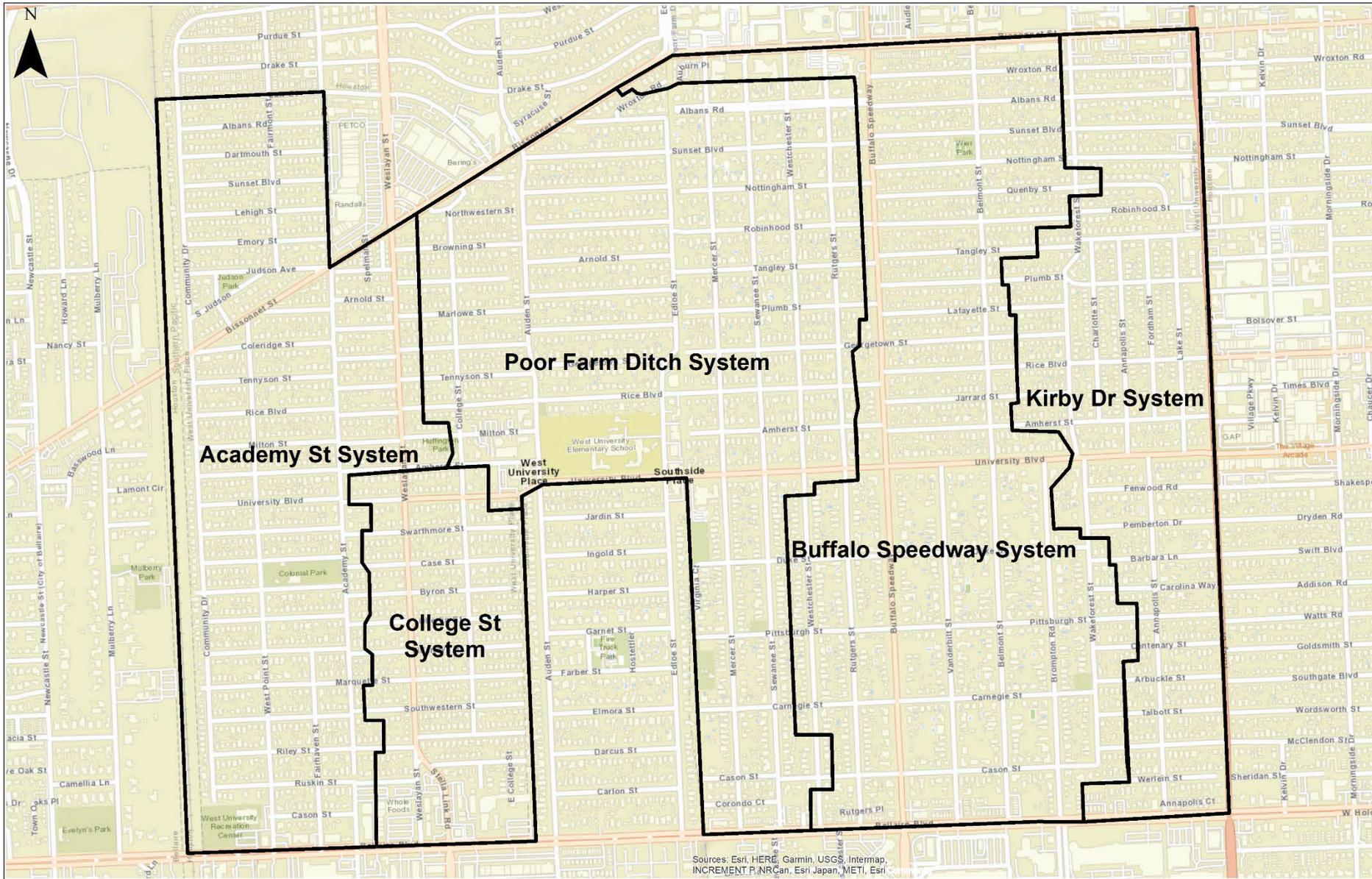


Agenda

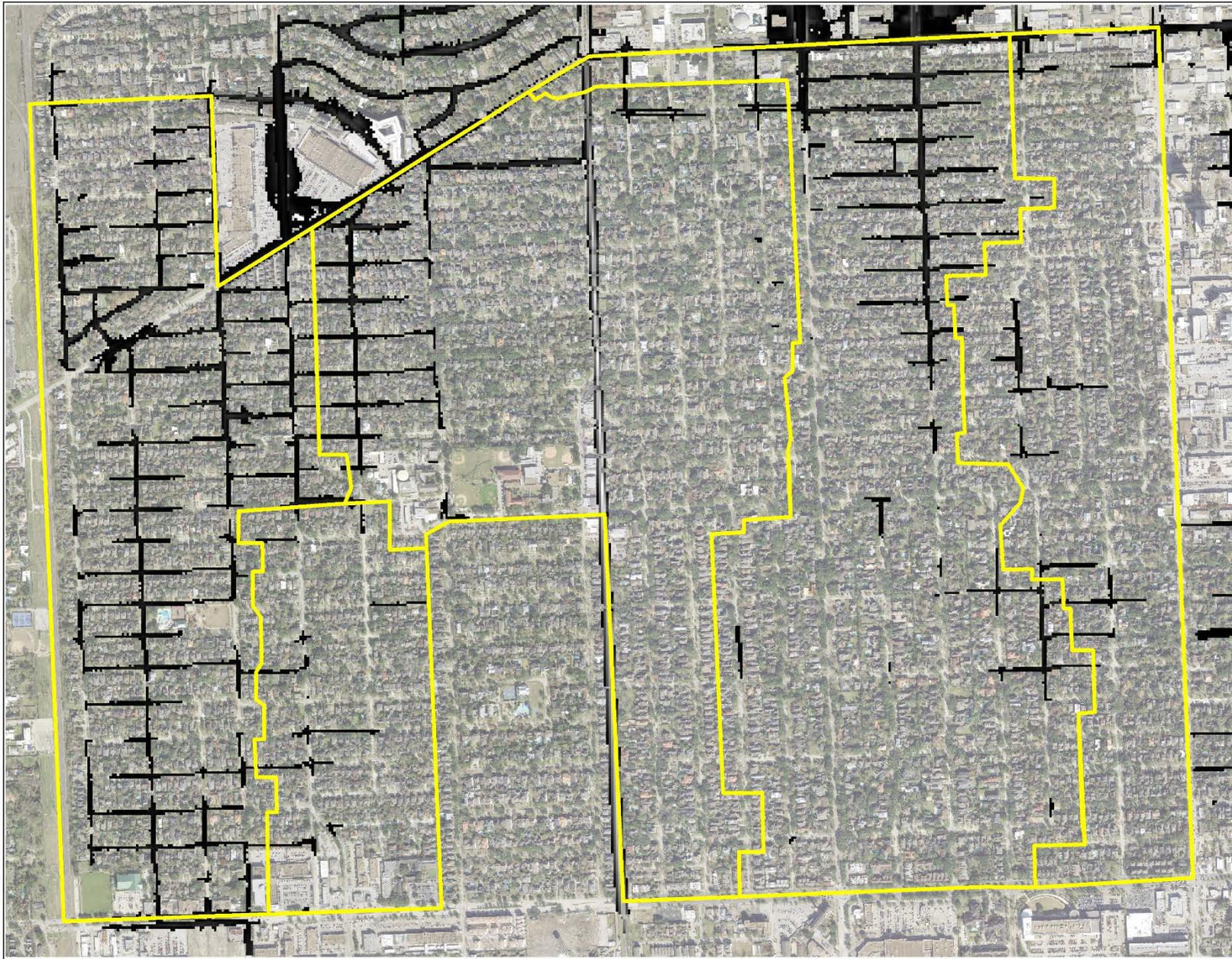
Additional Results Discussion

Existing Conditions

Flooding Conditions for Different Rain Events

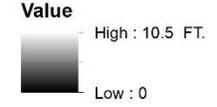


Major Drainage Systems

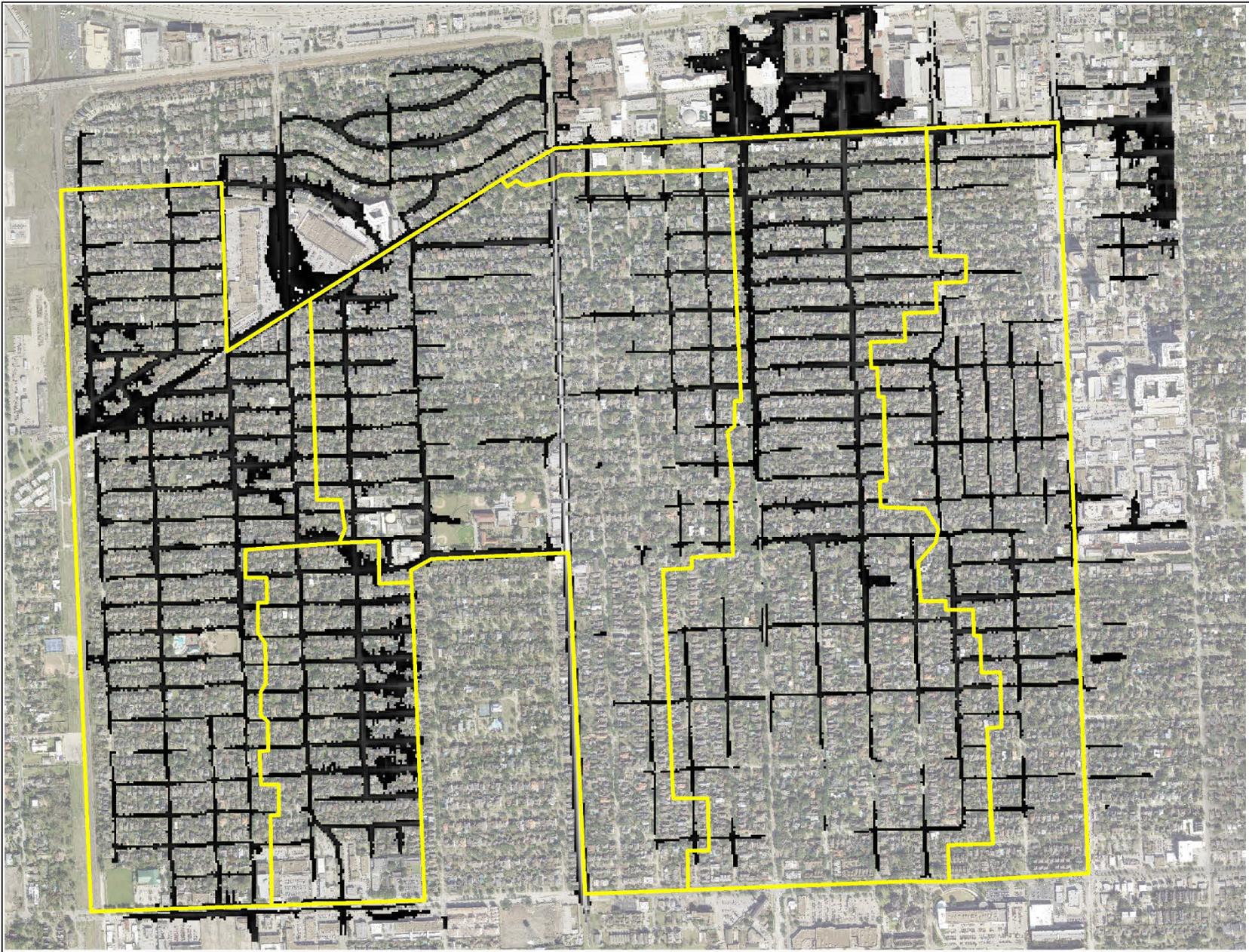


Legend

Existing 2-Year Scenario



Existing 2-Year Event
Inundation Map



Legend

Existing 10-Year Scenario

Value
High : 8.5 FT.
Low : 0

Existing 10-Year Event
Inundation Map



Legend

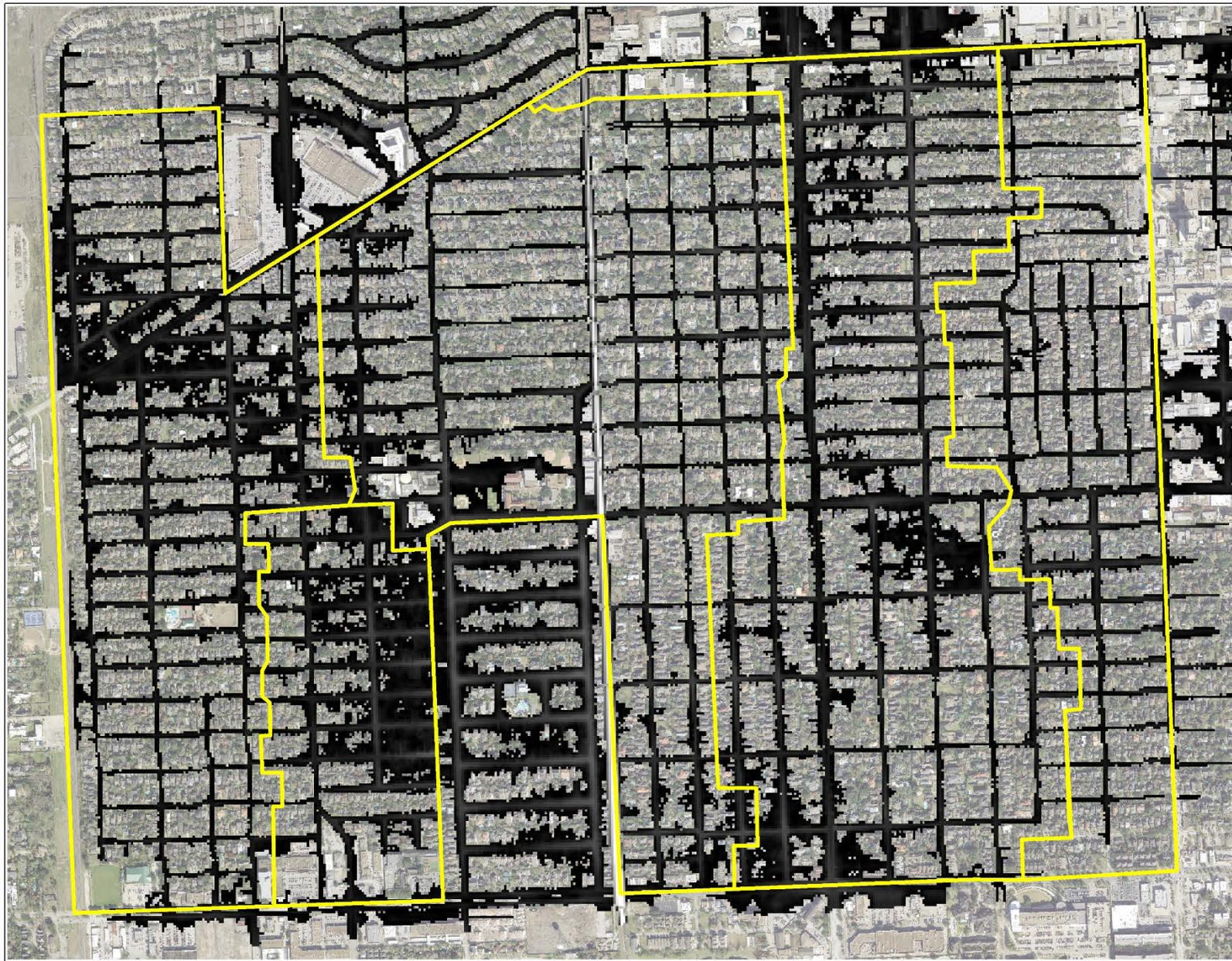
Existing 50-Year Scenario

Value

High : 9.7 FT.

Low : 0

Existing 50-Year Event
Inundation Map



Legend

100-Year Existing Scenario

Value

High : 12.5 FT.

Low : 0

Existing 100-Year Event
Inundation Map

Existing Conditions

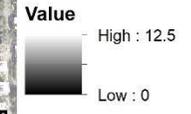
Flooding Conditions 100-Year Vs Harvey Reported Structure Flooding



Legend

- FEMA Claims (Hurricane Harvey)
- Reported Flooding by West U.
- Elevation Certificates

Existing 100-Year Scenario



Ground Elev.: 55.2 ft
F.F. Elev.: 55.9 ft
WSEL: 55.7 ft

Ground Elev.: 49.0 ft
F.F. Elev.: 49.8 ft
WSEL: 49.4 ft

Existing 100-Year Event
Inundation Map

Flooded Homes

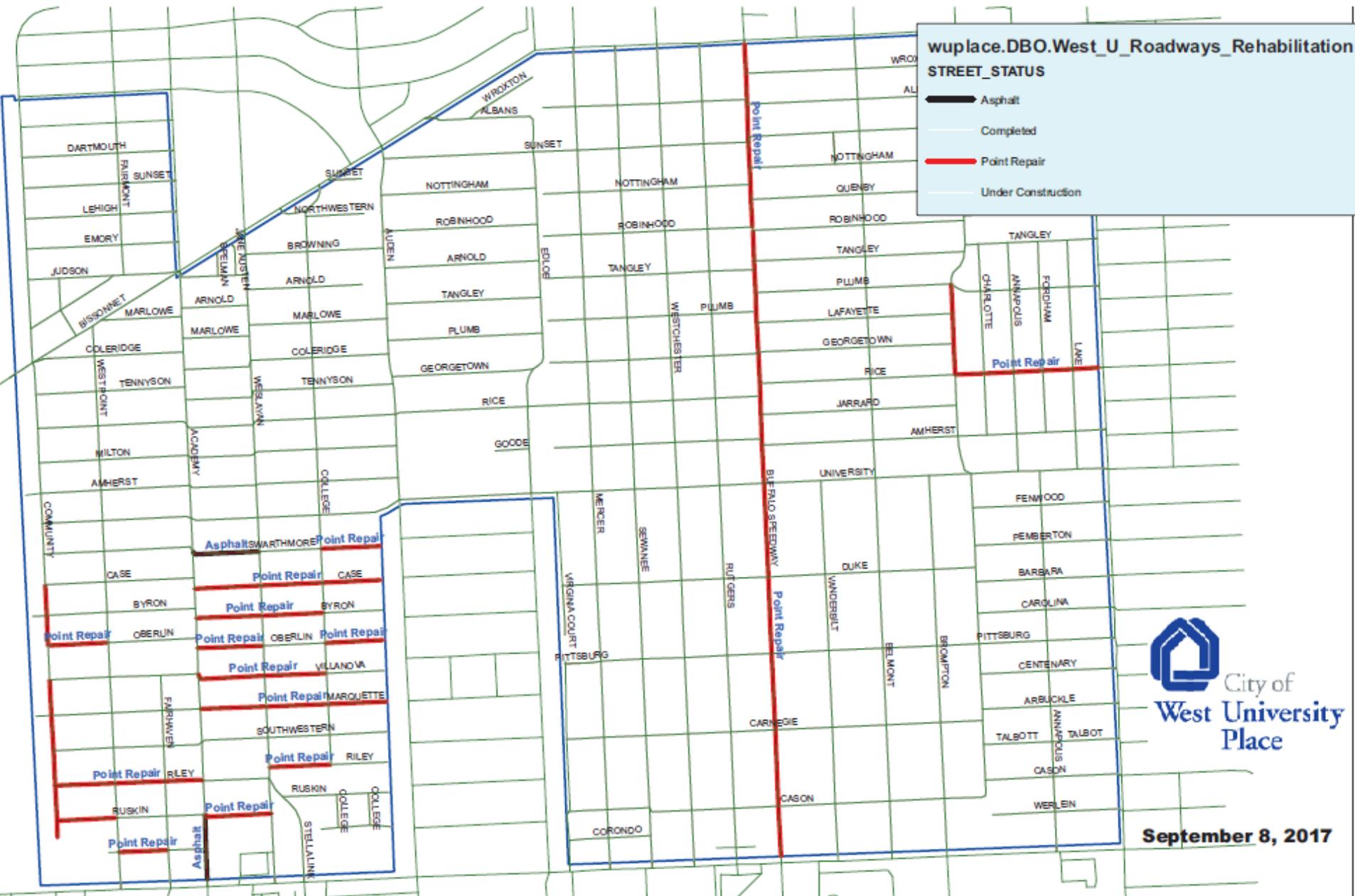
WSEL = Water Surface Elevation

Proposed Conditions

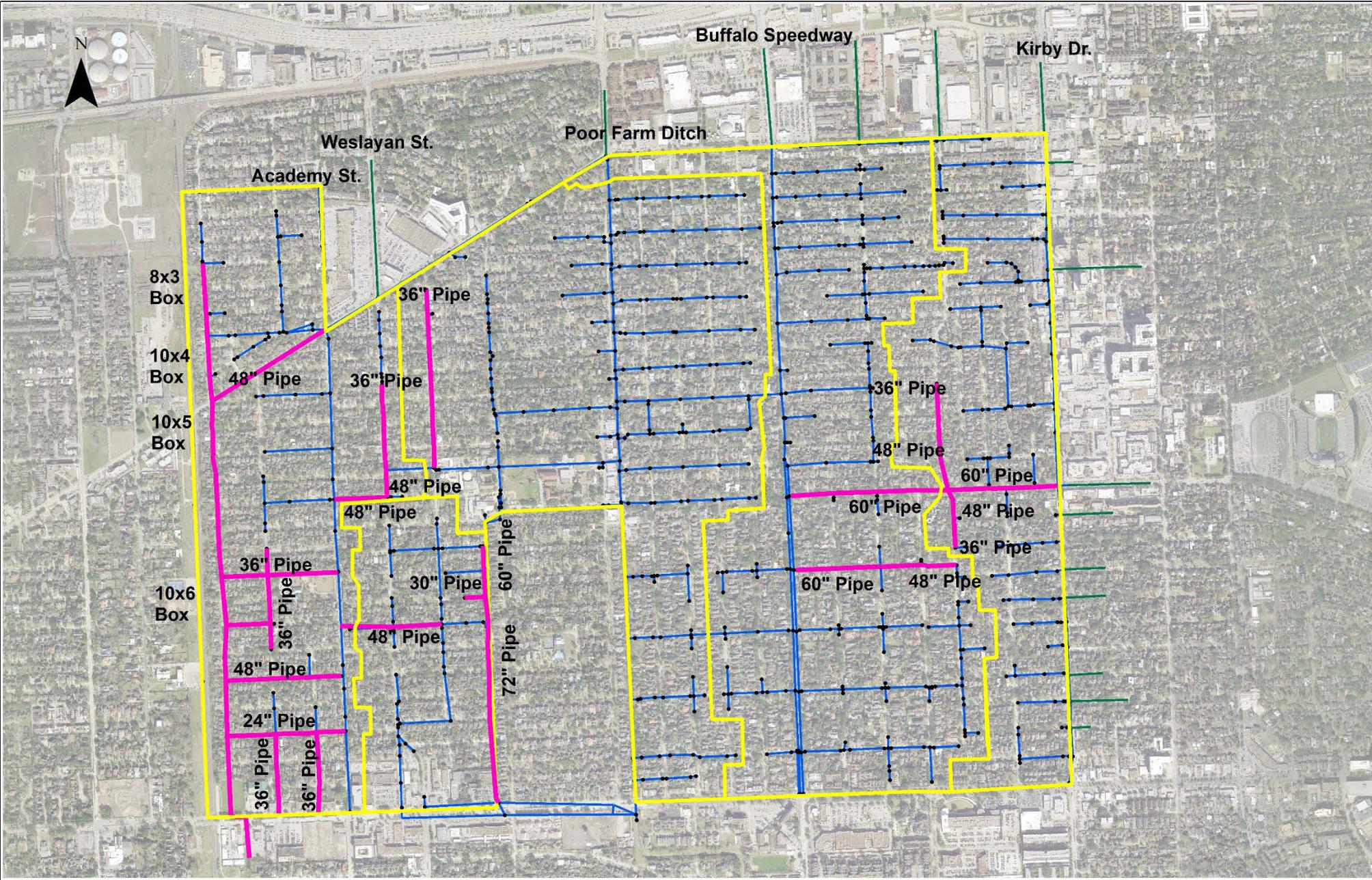
Flooding Conditions Comparison
Existing Vs Proposed

Without Restrictor

Road Reconstruction



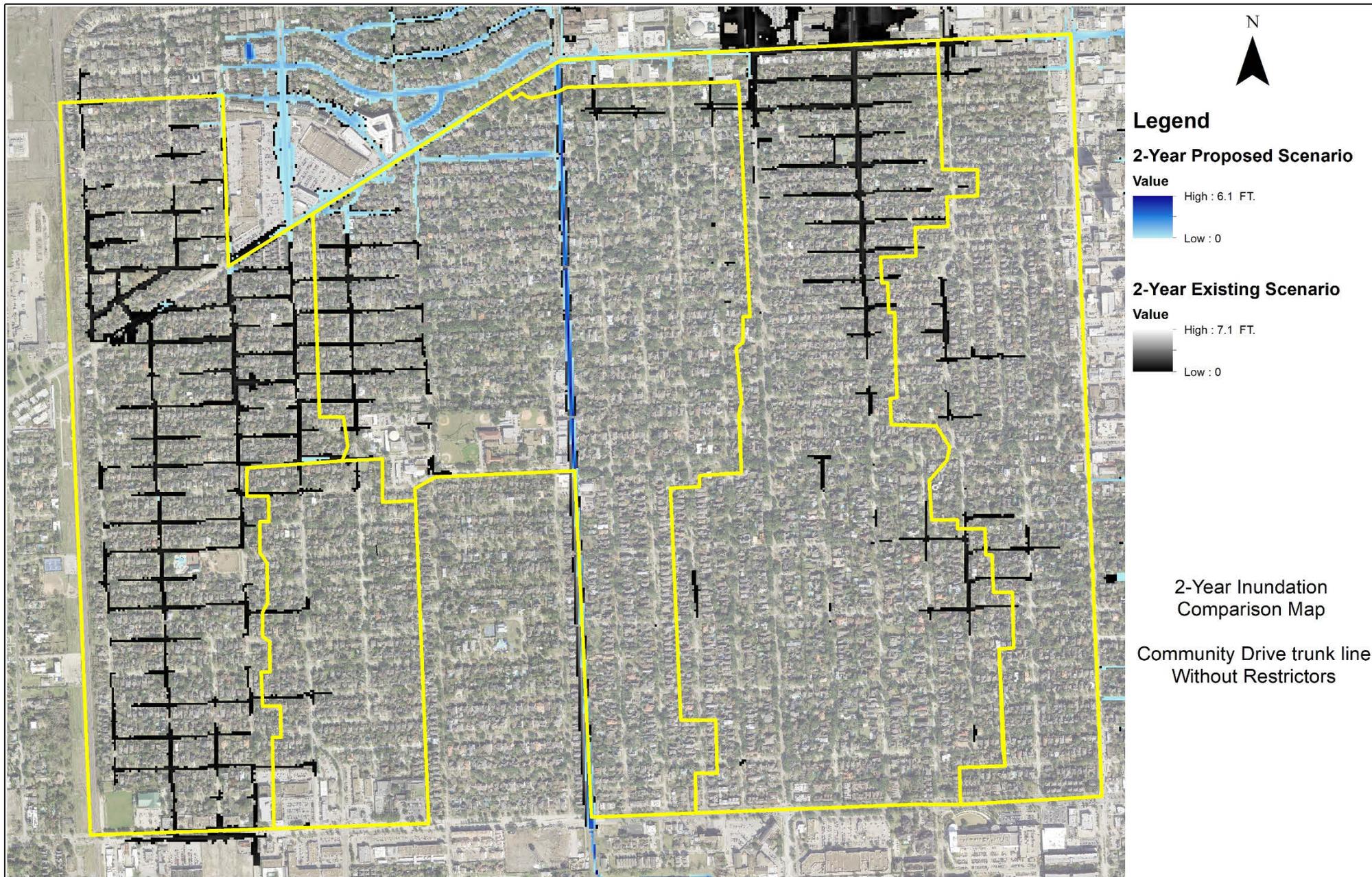
* Work includes road and storm sewer replacement needed within the next 5-year



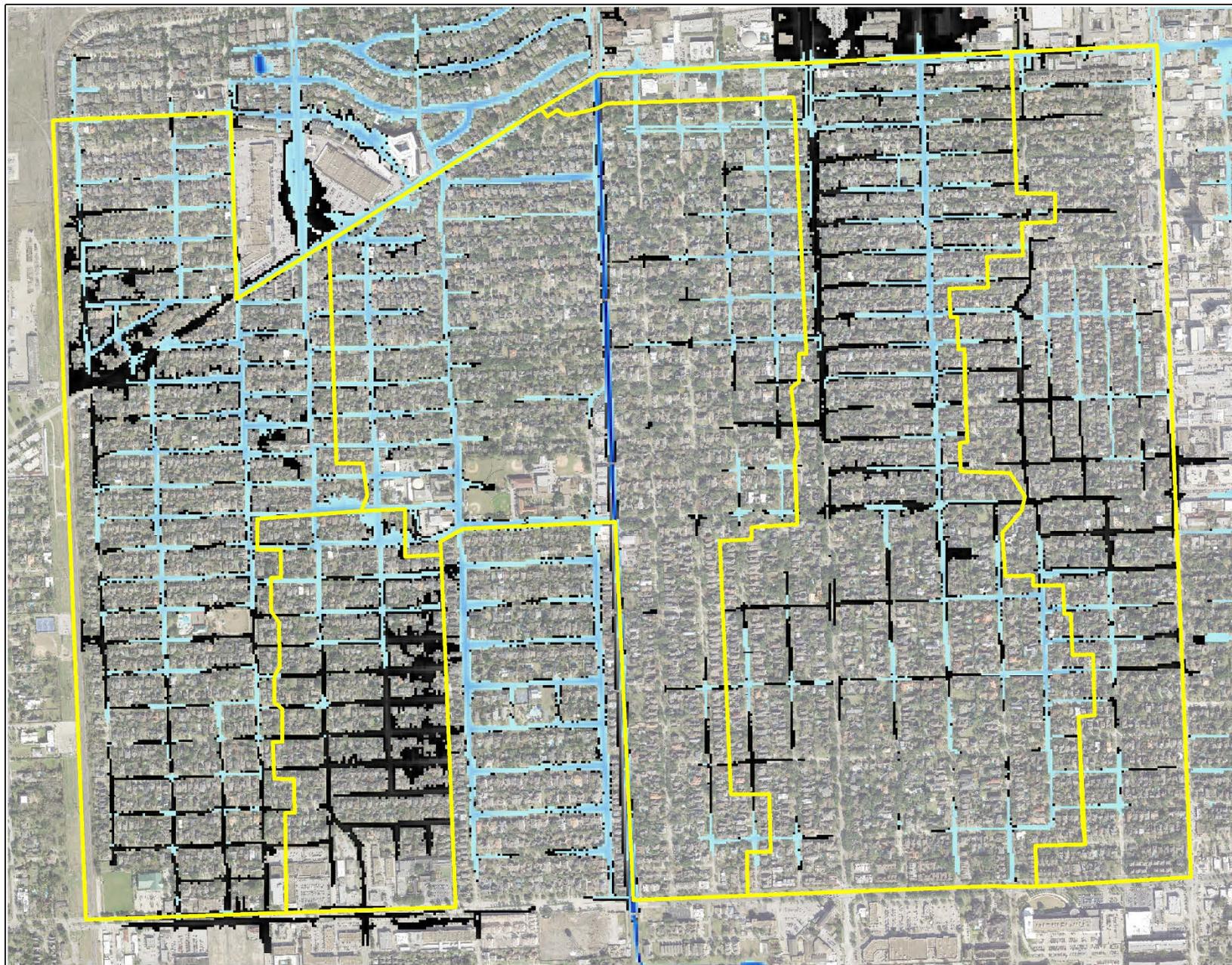
Estimate
\$60M*

* Estimated cost for drainage upgrades and associated road replacement for sections as shown

Along Community Drive and shared line at city limit



Note
 Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions



Legend

10-Year Proposed Scenario

Value
 High : 9.3 FT.
 Low : 0

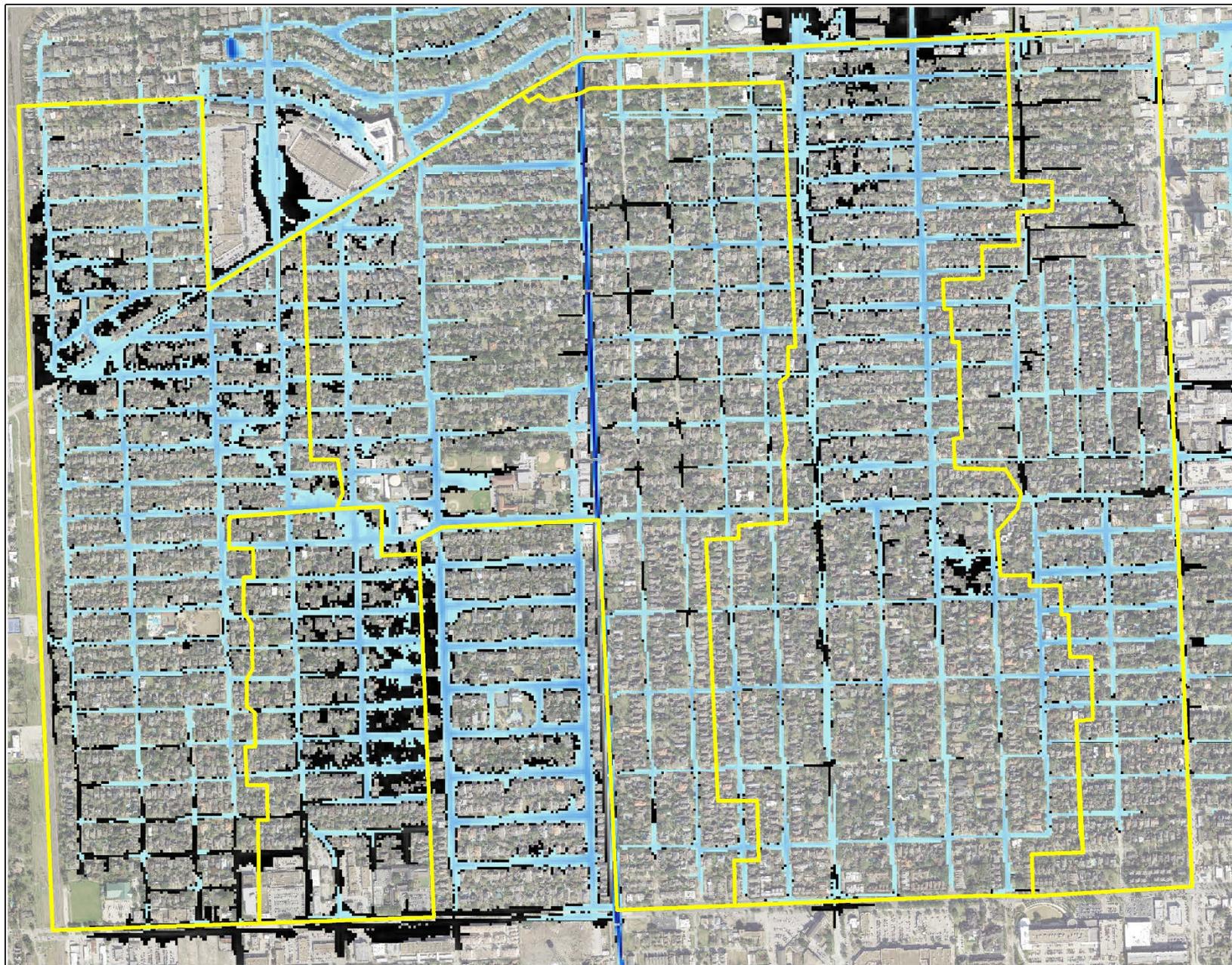
10-Year Existing Scenario

Value
 High : 8.5 Ft.
 Low : 0

10-Year Inundation Comparison Map
 Community Drive trunk line Without Restrictor

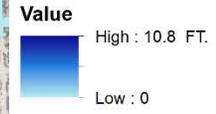
Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions

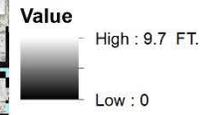


Legend

50-Year Proposed Scenario



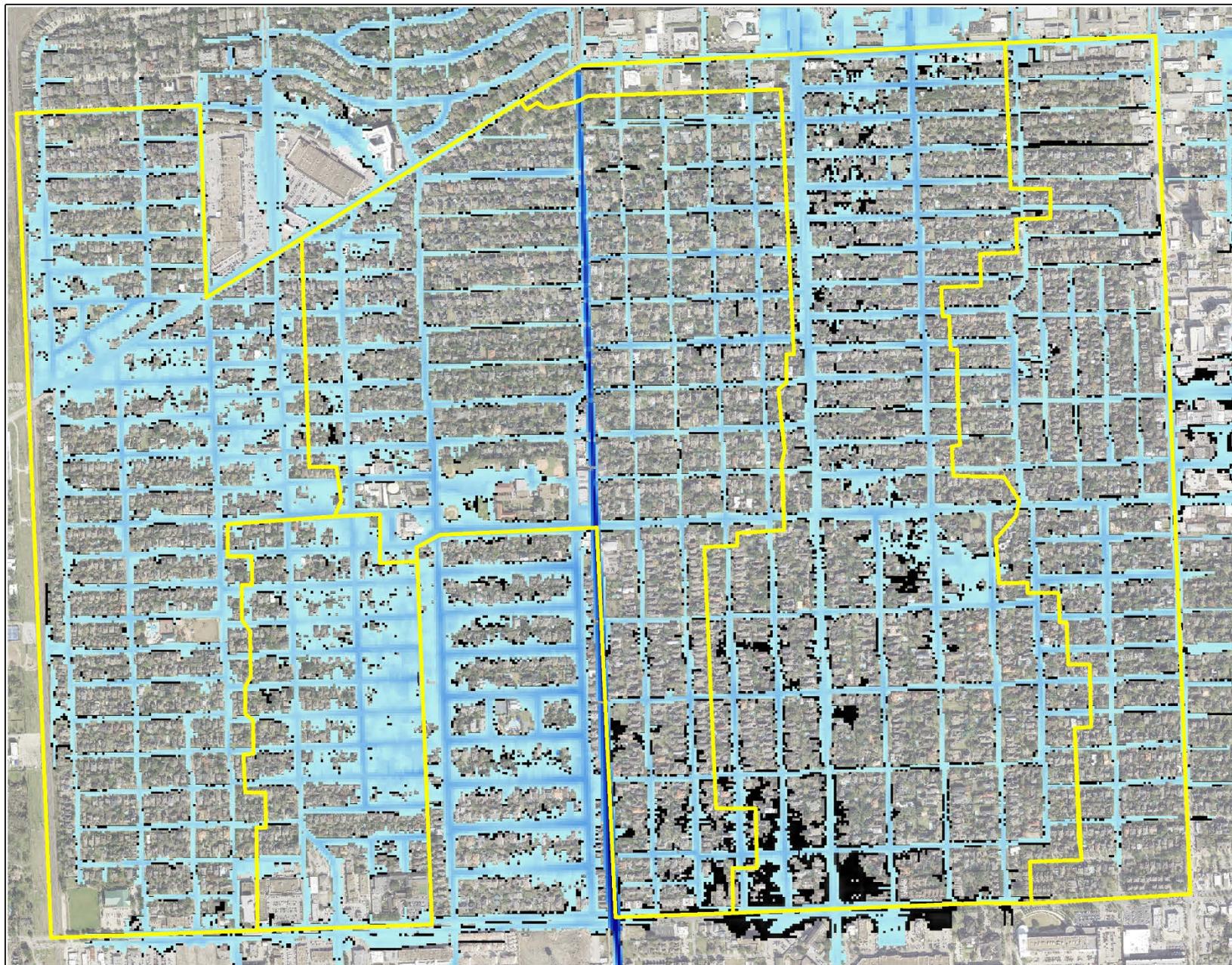
50-Year Existing Scenario



50-Year Inundation Comparison Map
Community Drive trunk line Without Restrictor

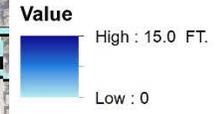
Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions



Legend

Proposed 100-Year Scenario



Existing 100-Year Scenario



100-Year Inundation Comparison Map
Community Drive trunk line Without Restrictor

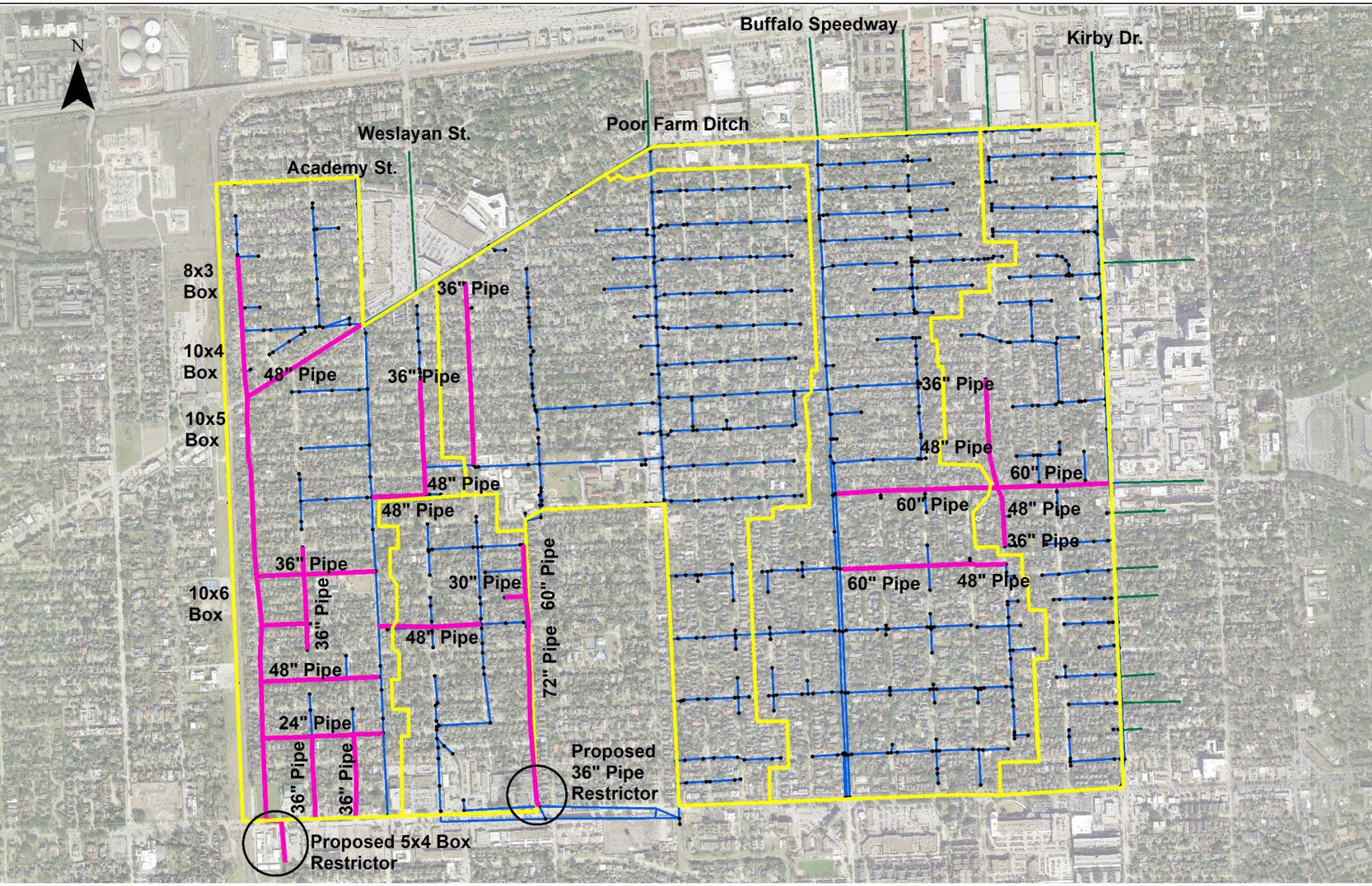
Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions

Proposed Conditions

Flooding Conditions Comparison
Existing Vs Proposed

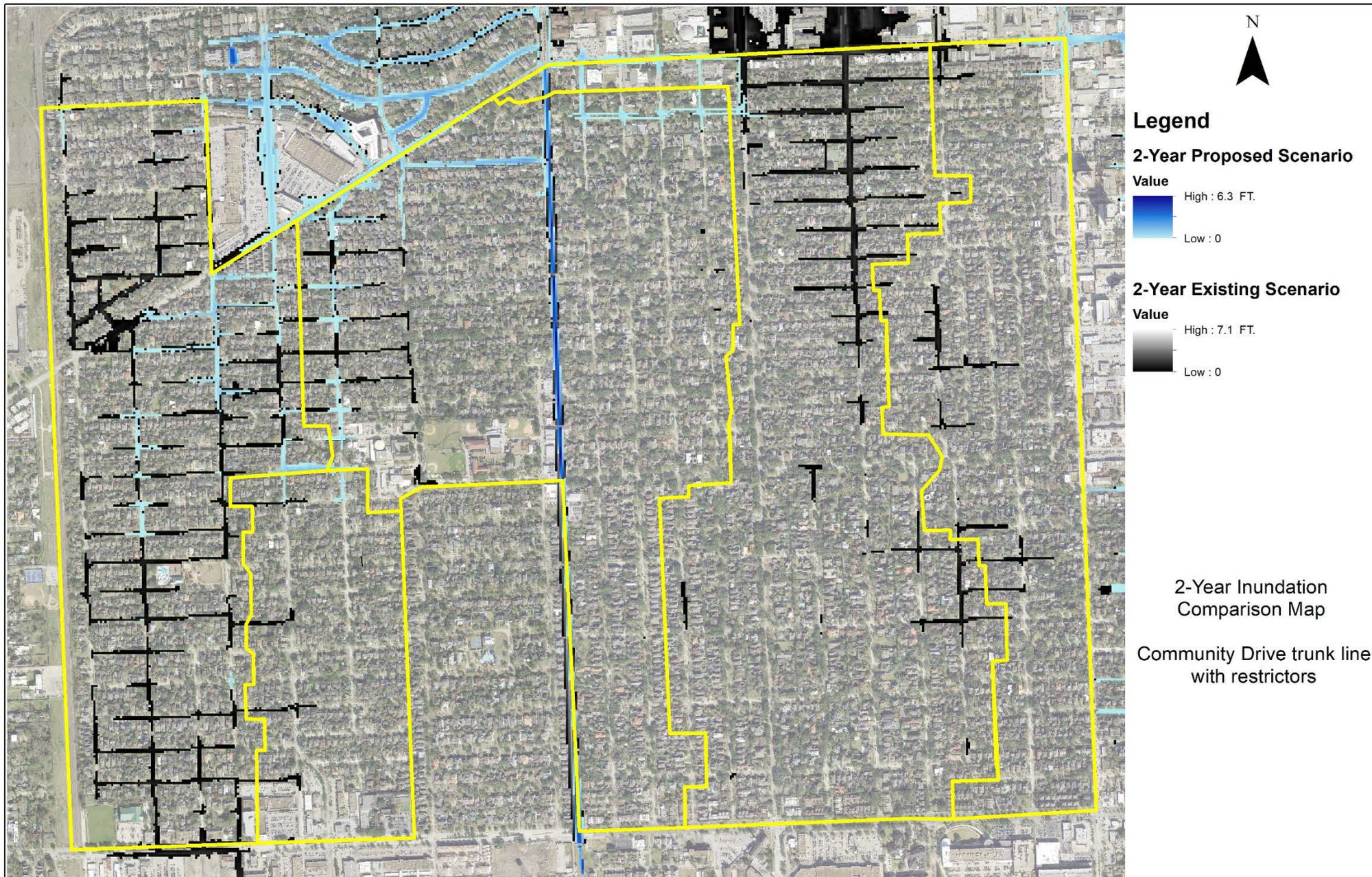
With Restrictor



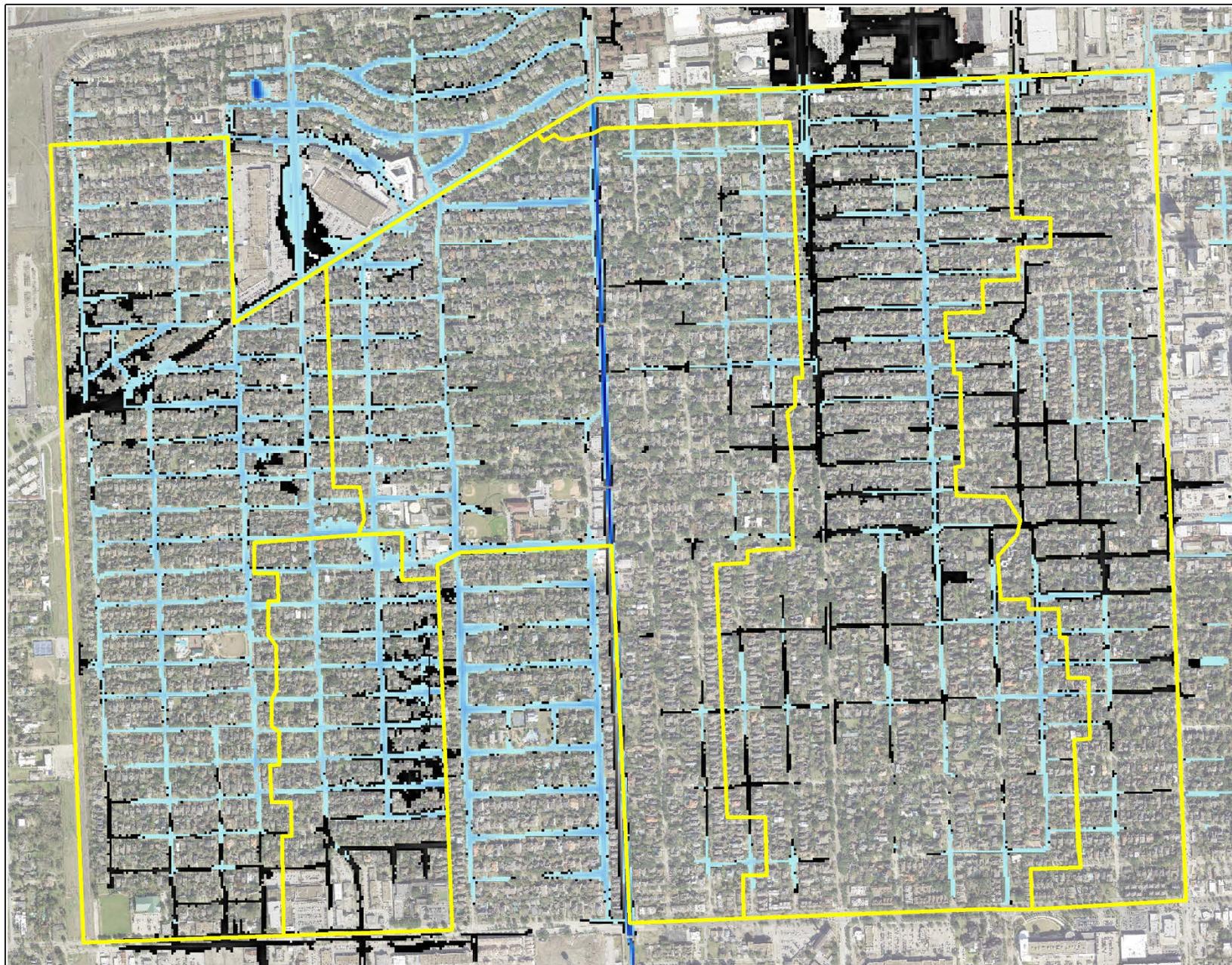
Estimate \$60M*

* Estimated cost for drainage upgrades and associated road replacement for sections as shown

Along Community Drive and shared line at city limit

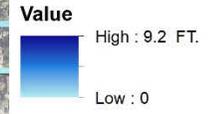


Note
 Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions



Legend

10-Year Proposed Scenario



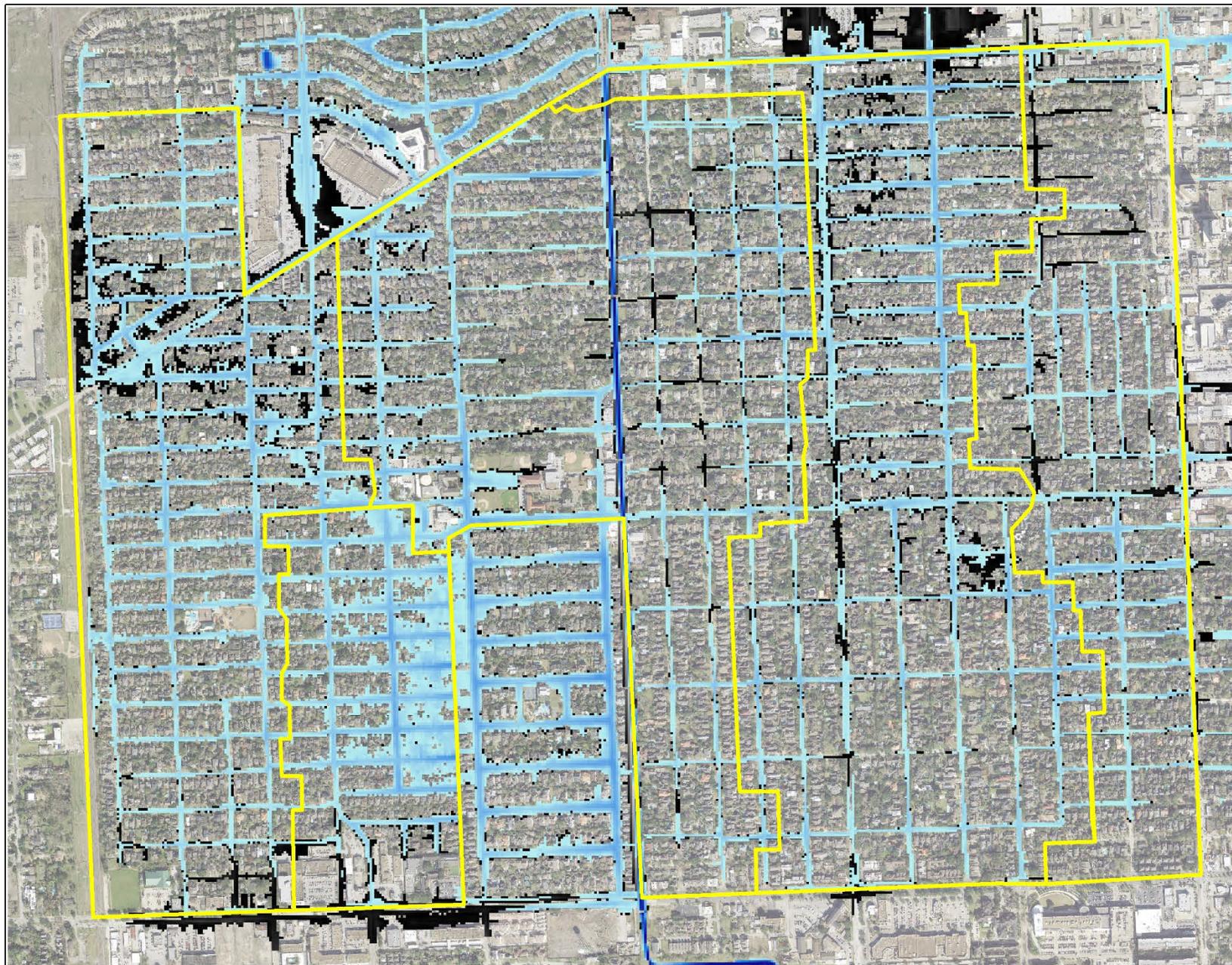
10-Year Existing Scenario



10-Year Inundation Comparison Map
Community Drive trunk line with restrictors

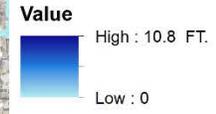


Note
Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions

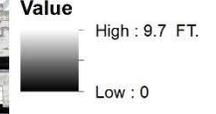


Legend

50-Year Proposed Scenario



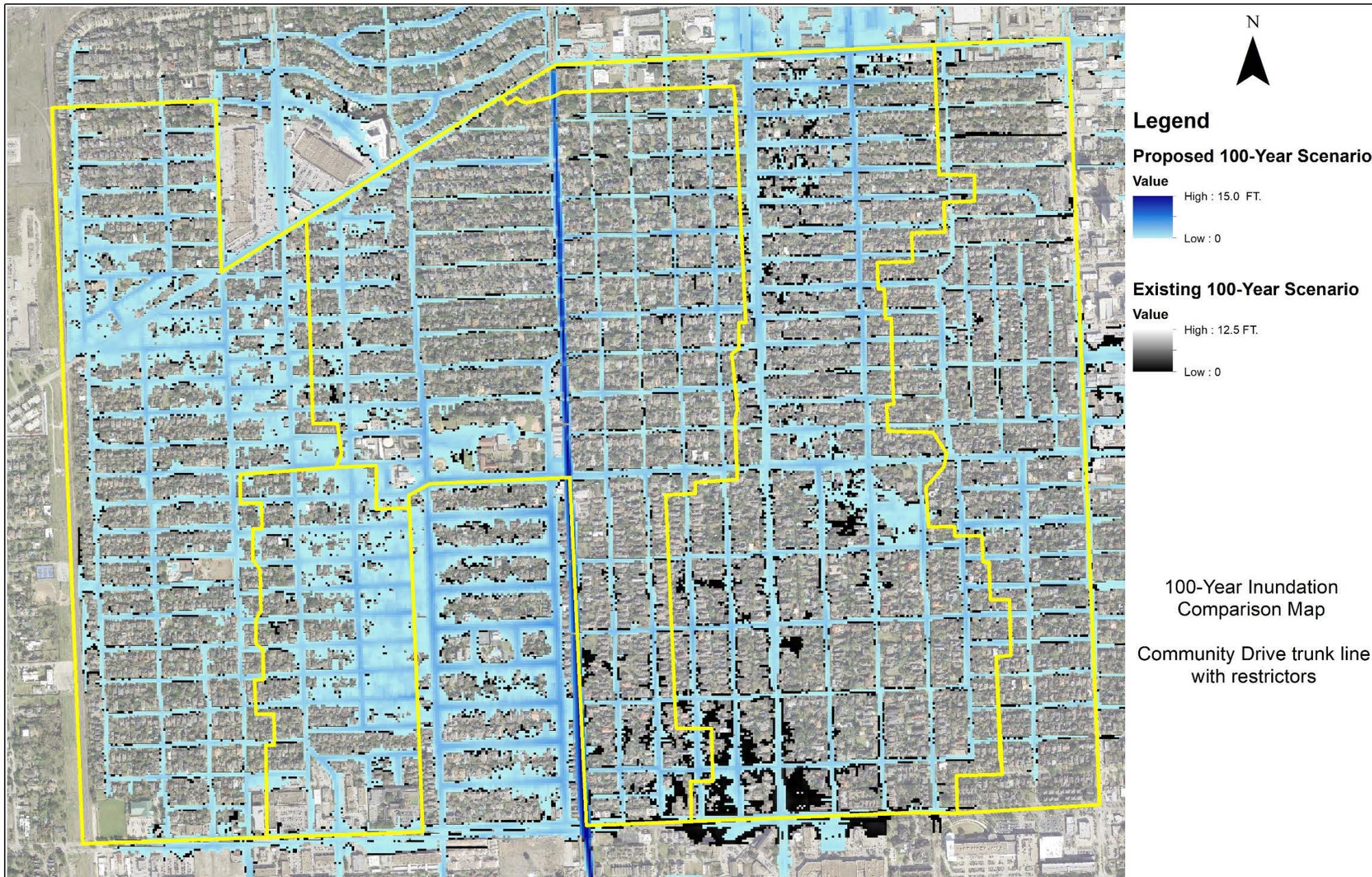
50-Year Existing Scenario



50-Year Inundation Comparison Map
Community Drive trunk line with restrictor

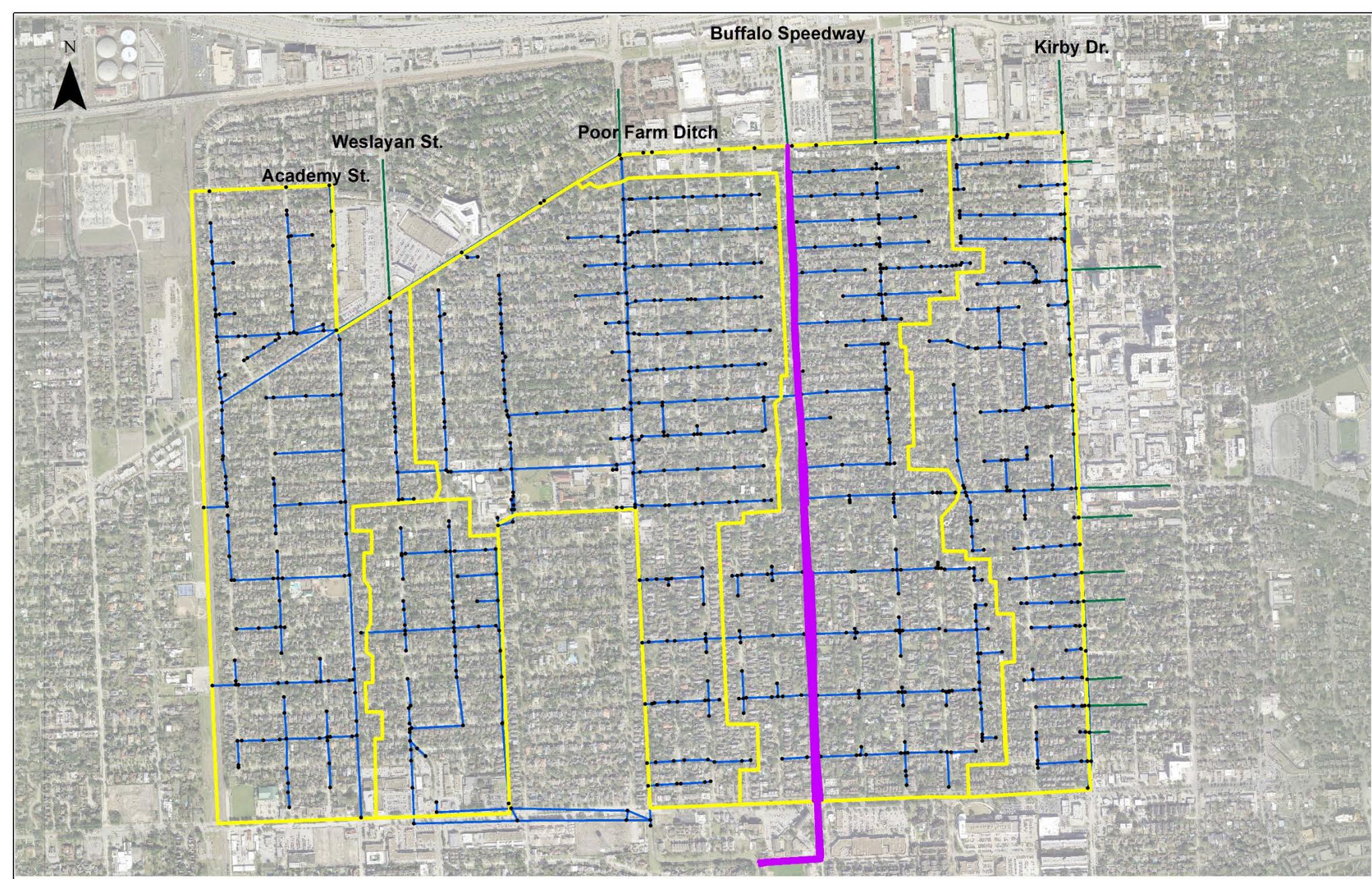
Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions

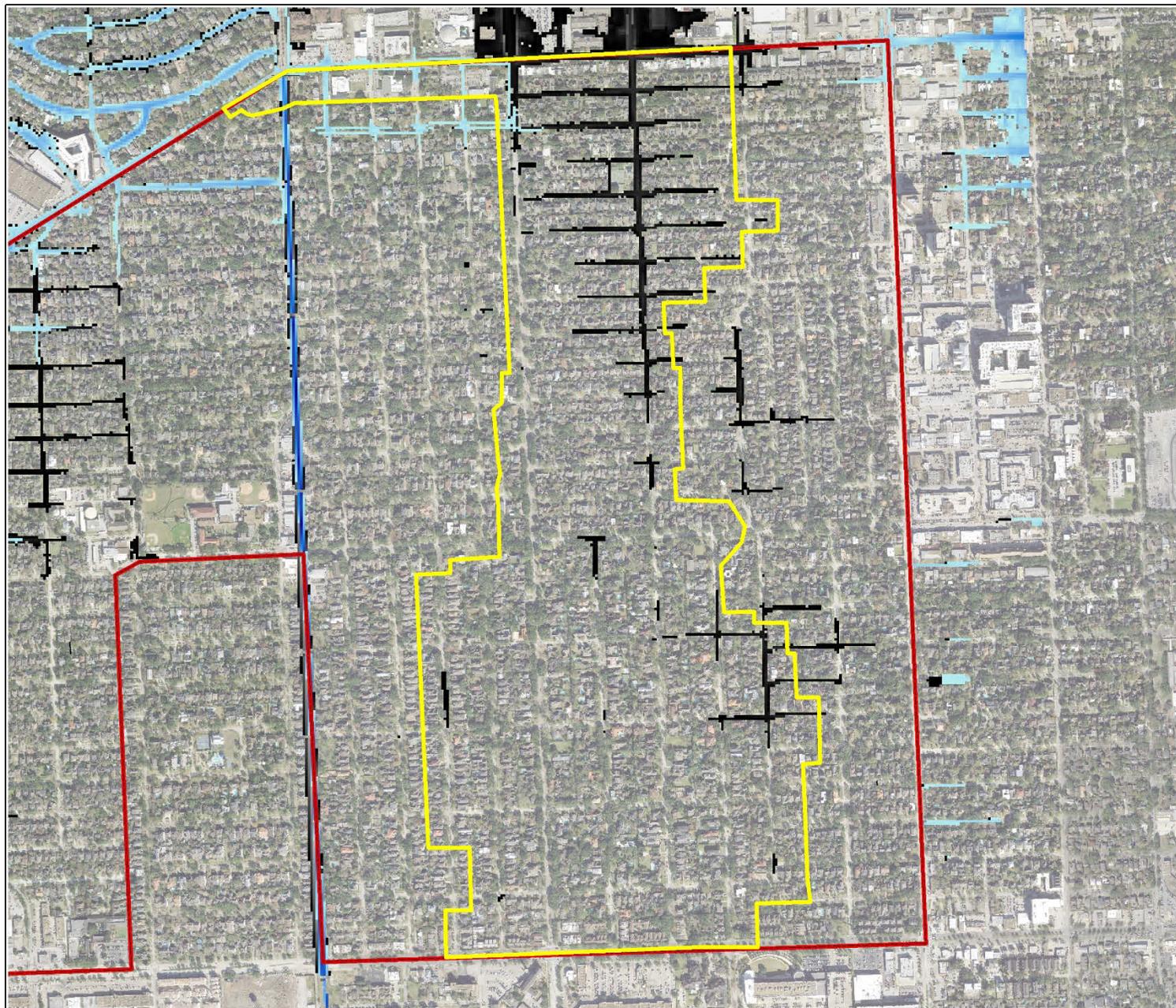


Note
 Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions

Buffalo Speedway Improvement



Buffalo Speedway
Improvements



Legend

 Buffalo Speedway Drainage Area

2-Year Buffalo Spdwy Imp.

Value

 High : 6.2575

Low : 0

2-Year Existing Scenario

Value

 High : 7.1 FT.

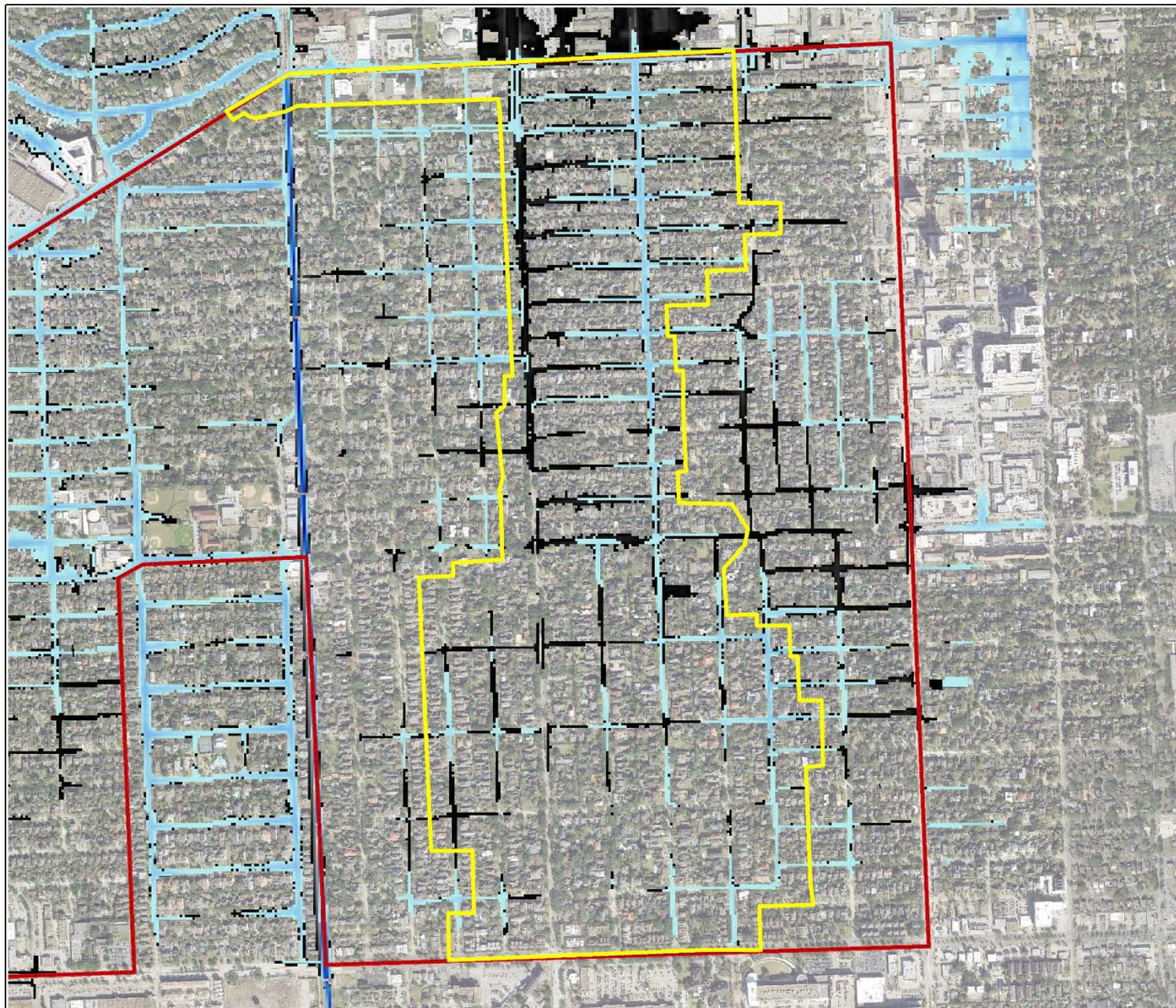
Low : 0

2-Year Inundation Comparison Map

Buffalo Speedway Improvements

Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions



Legend

 Buffalo Speedway Drainage Area

10-Year Buffalo Spdwy Imp.

Value
 High : 9.2689
 Low : 0

10-Year Existing Scenario

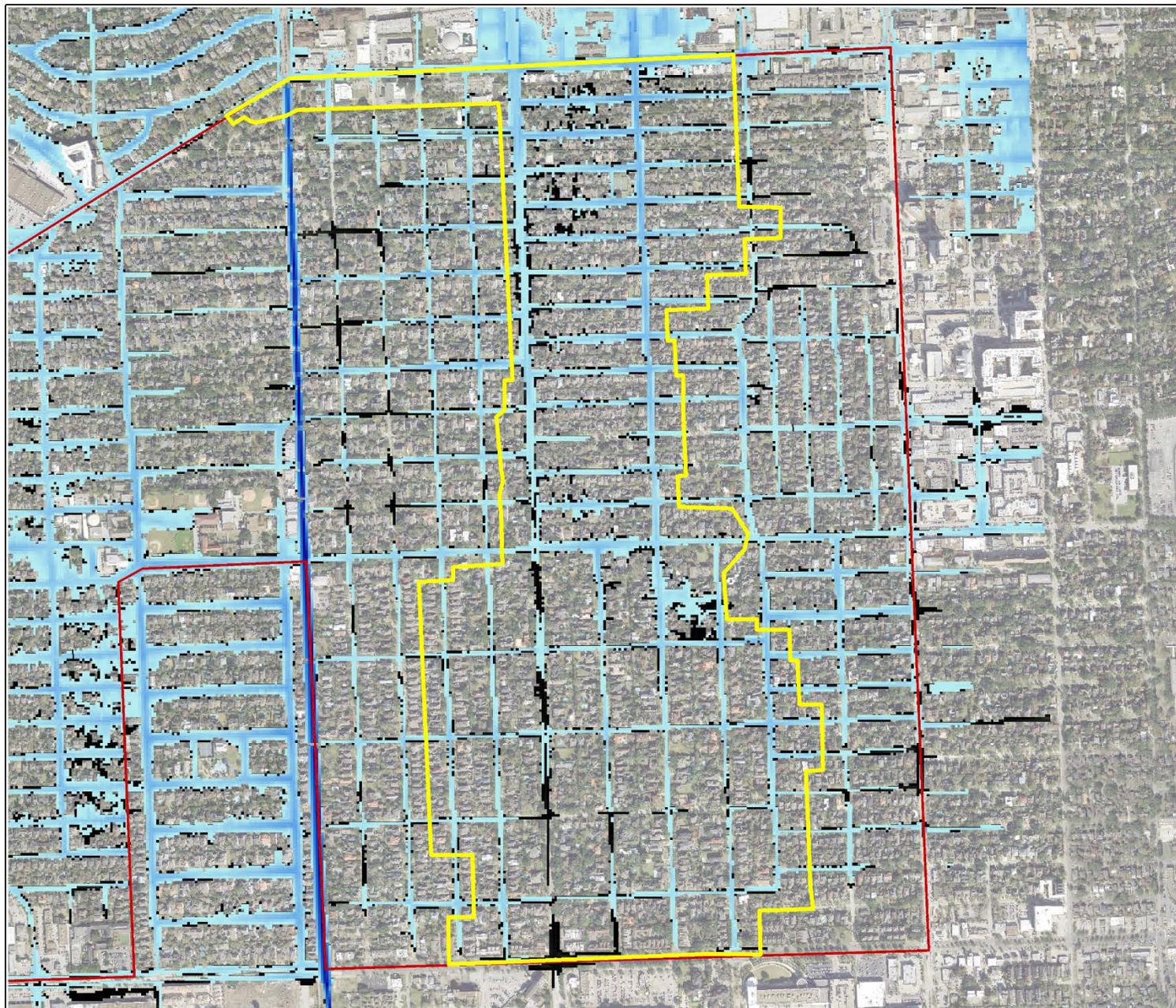
Value
 High : 8.5 FT.
 Low : 0

10-Year Inundation Comparison Map

Buffalo Speedway Improvements

Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions



Legend

 Buffalo Speedway Drainage Area

50-Year Buffalo Spdwy Imp.

Value
 High : 11.5 FT.
 Low : 0

50-Year Existing Scenario

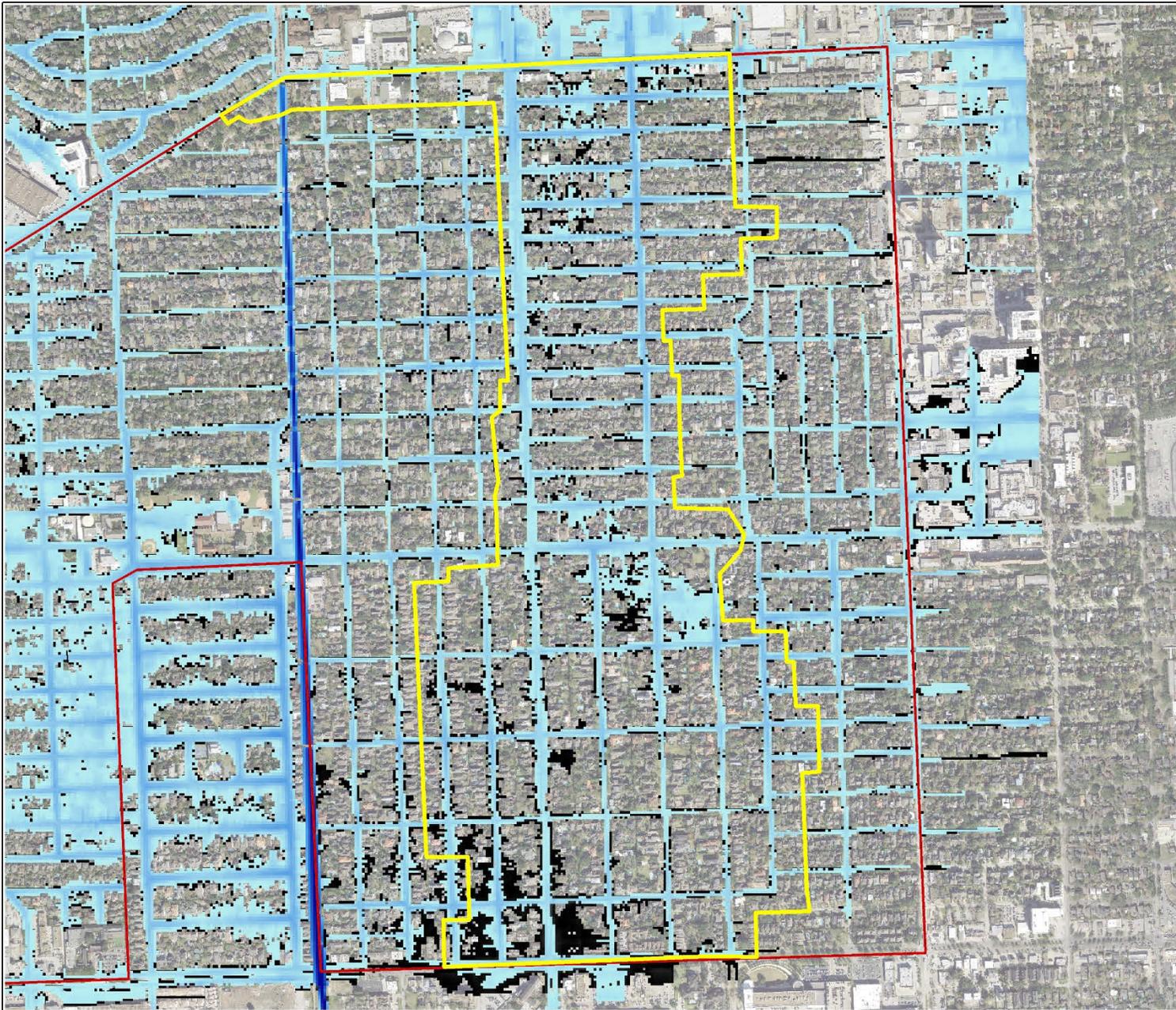
Value
 High : 9.7 FT.
 Low : 0

50-Year Inundation Comparison Map

Buffalo Speedway Improvements

Note

Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions



Legend

 Buffalo Speedway Drainage Area

100-Year Buffalo Spdwy Imp.

Value
 High : 15.0 FT.
 Low : 0

Existing 100-Year Scenario

Value
 High : 12.5 FT.
 Low : 0

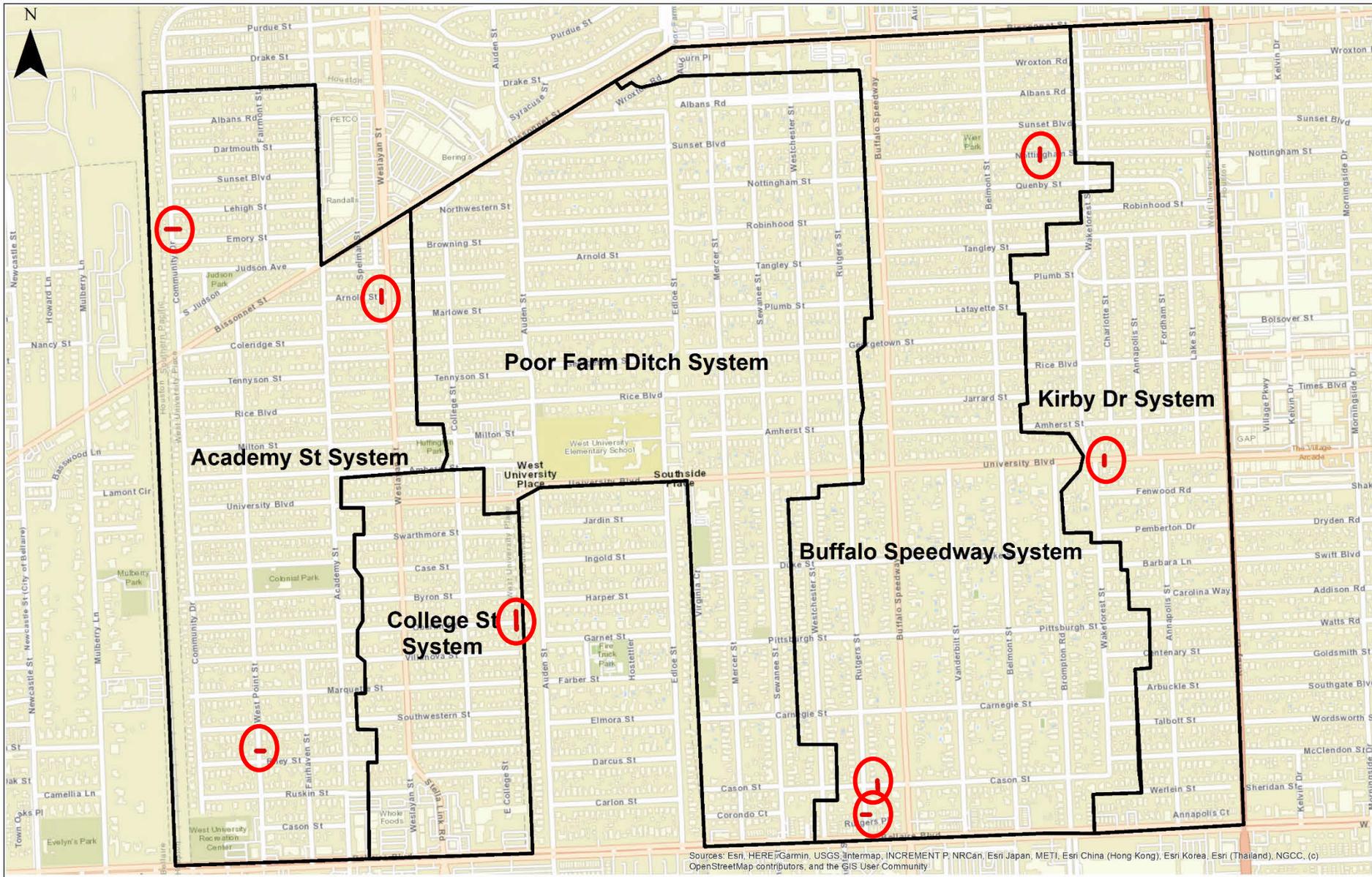
100-Year Inundation
Comparison Map

Buffalo Speedway
Improvements

Note

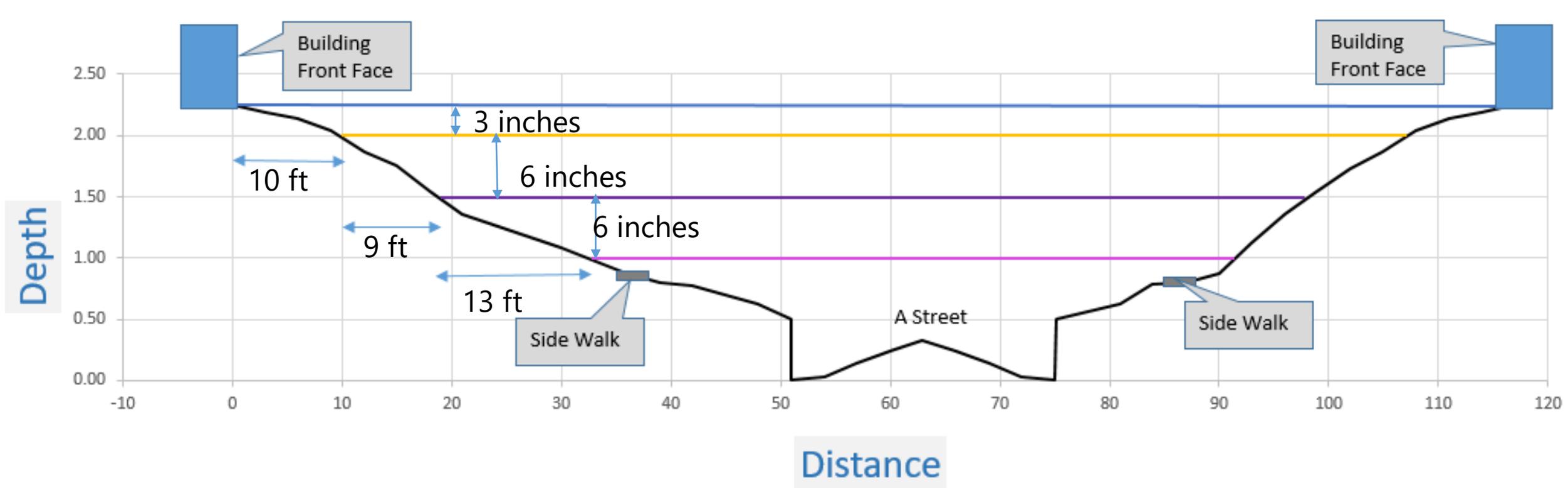
Appearance of Black hatch in the proposed conditions indicates the improvement to the flooding conditions

Water Surface Comparison at Selected Locations



Locations of Cross Sections

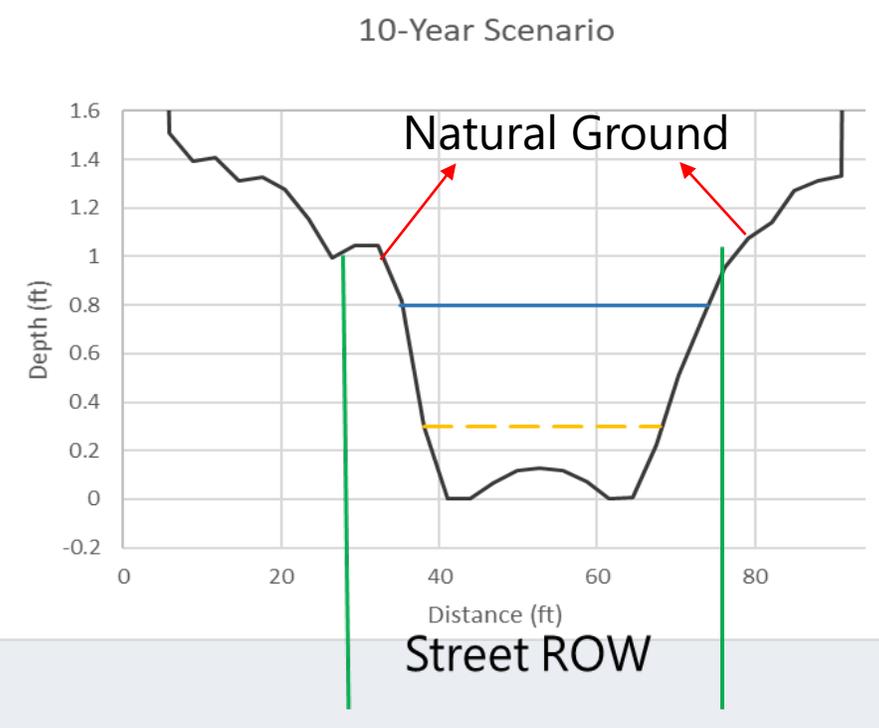
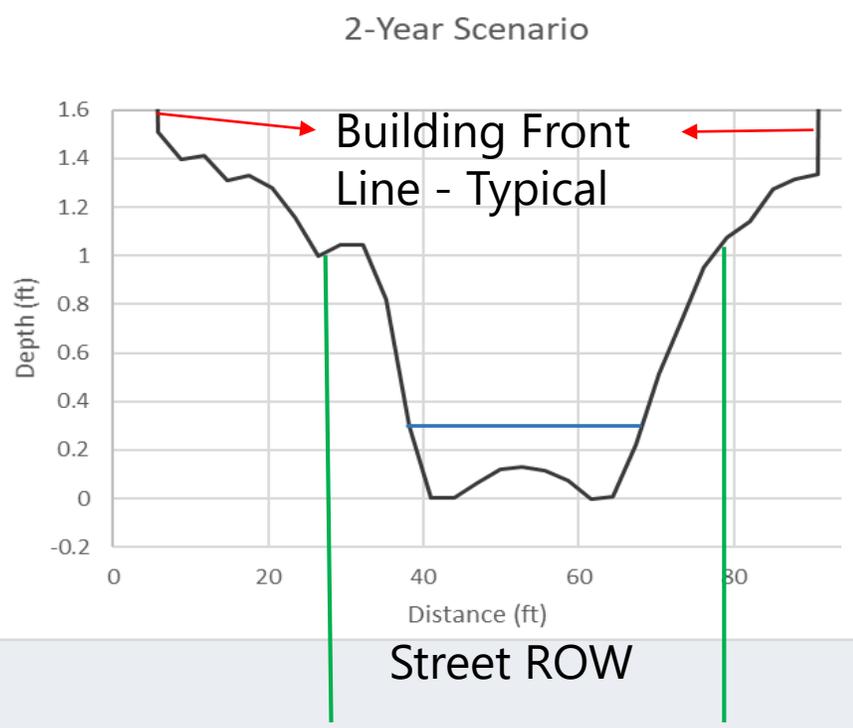
Typical WSEL Drop Vs Horizontal Shift



- At the critical elevation (near door step), the shift is more than the average shift (est.10 ft. for 3 inches drop)
- This is a typical section, not relevant to any storm event – only the relationship based on the slope
- Average shift = 6ft. per 3 inches drop.



WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation



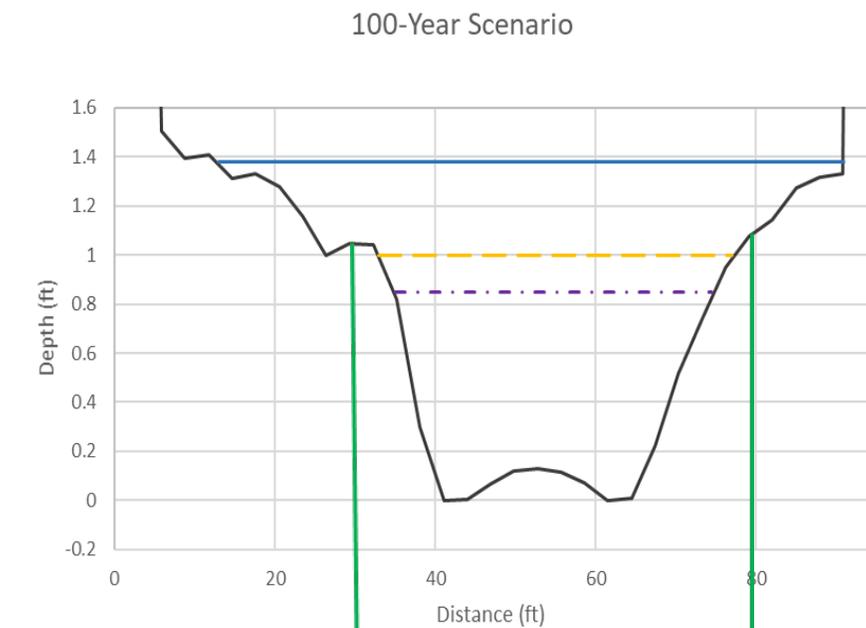
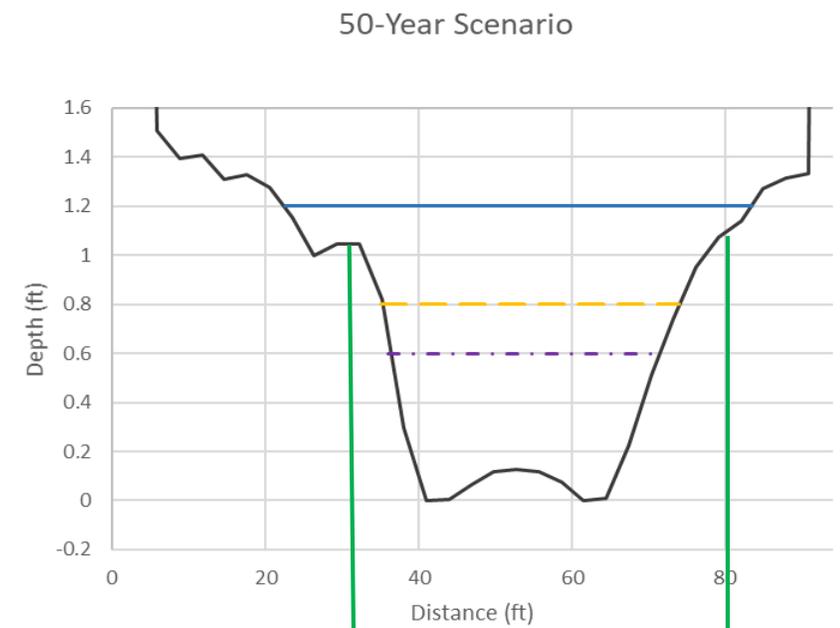
- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- - - WSEL Proposed w/o Restrictor

- **Cross Sections were taken building to building from 2018 LiDAR**
- **Vertical Line at the end indicate the face of the structure.**
- **ROW is approximate**



WSEL = Water Surface Elevation

No WSEL line means the WSEL is below the street elevation



Street ROW

Street ROW

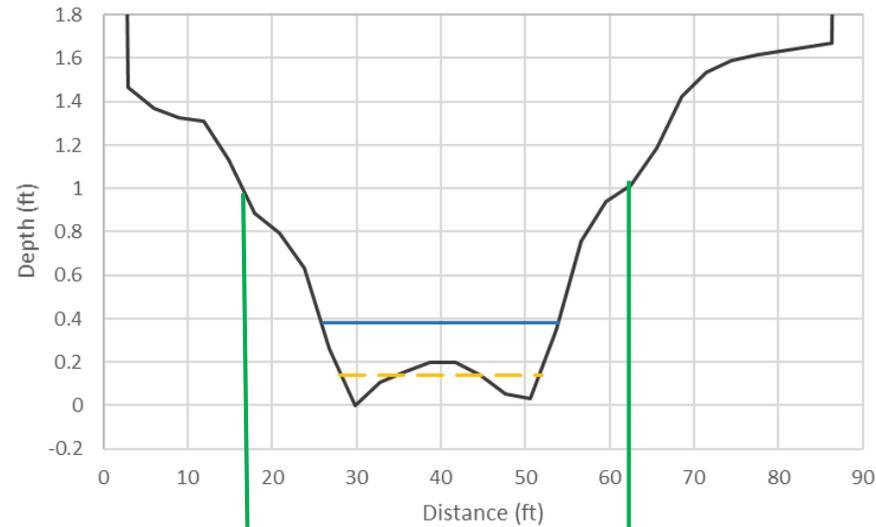
- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- . . - WSEL Proposed w/o Restrictor

WSEL = Water Surface Elevation

No WSEL line means the WSEL is below the street elevation

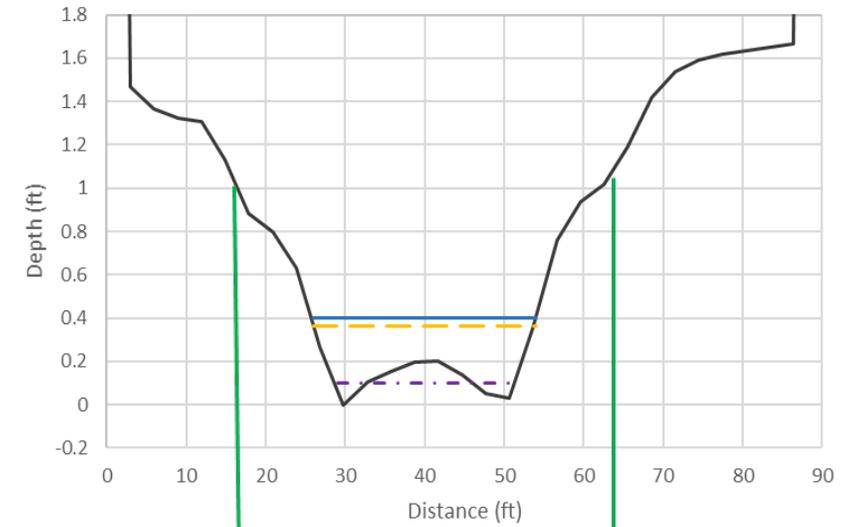


2-Year Scenario



Street ROW

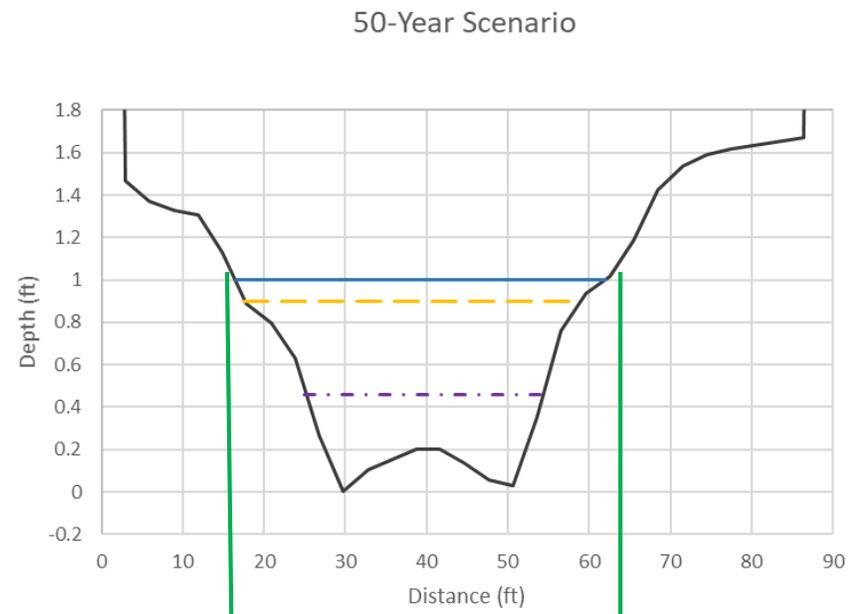
10-Year Scenario



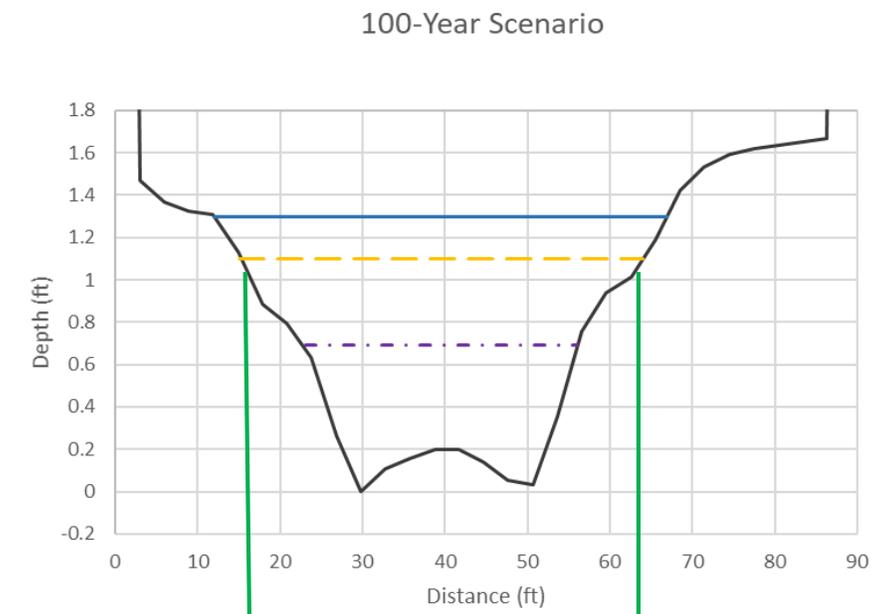
Street ROW

- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- . . - WSEL Proposed w/o Restrictor

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation



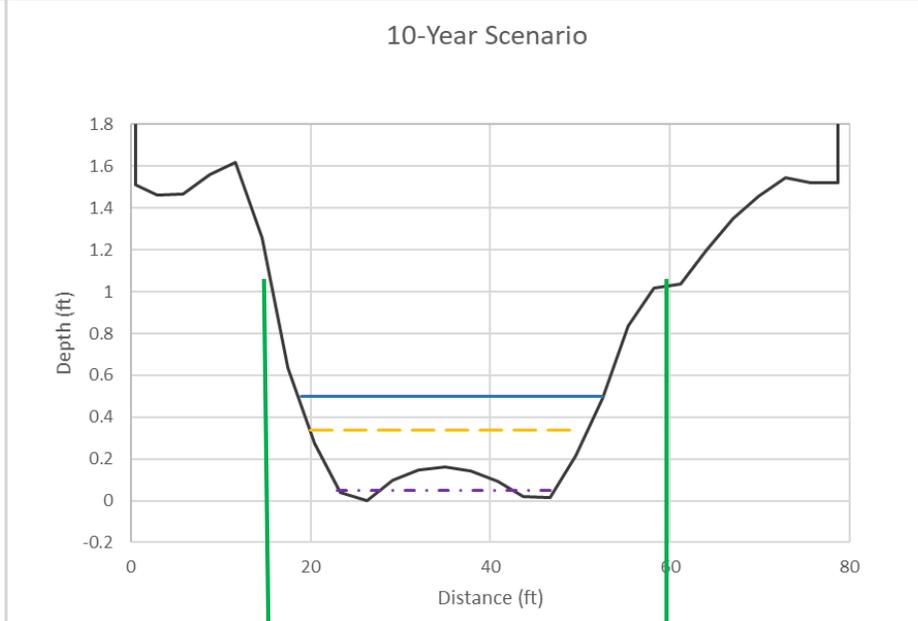
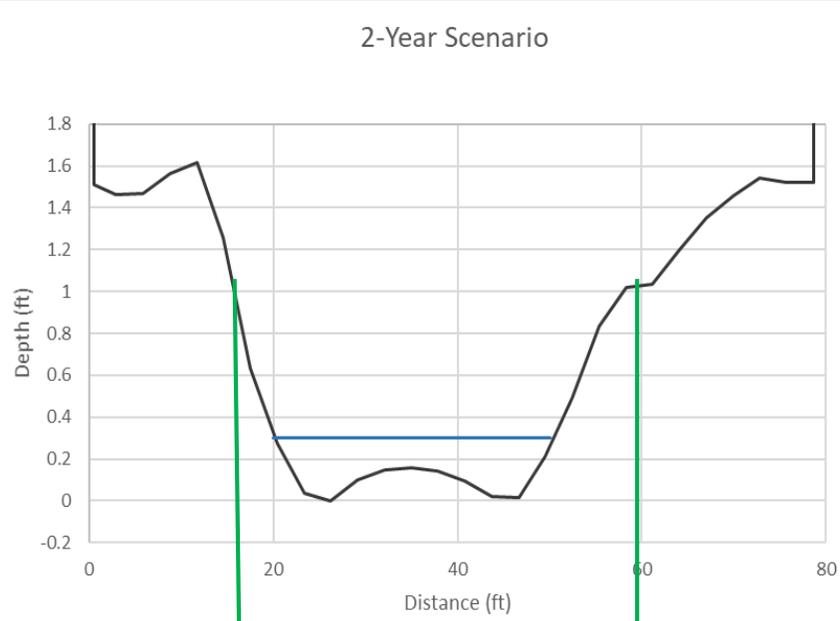
Street ROW



Street ROW

- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- . . - WSEL Proposed w/o Restrictor

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation



Street ROW

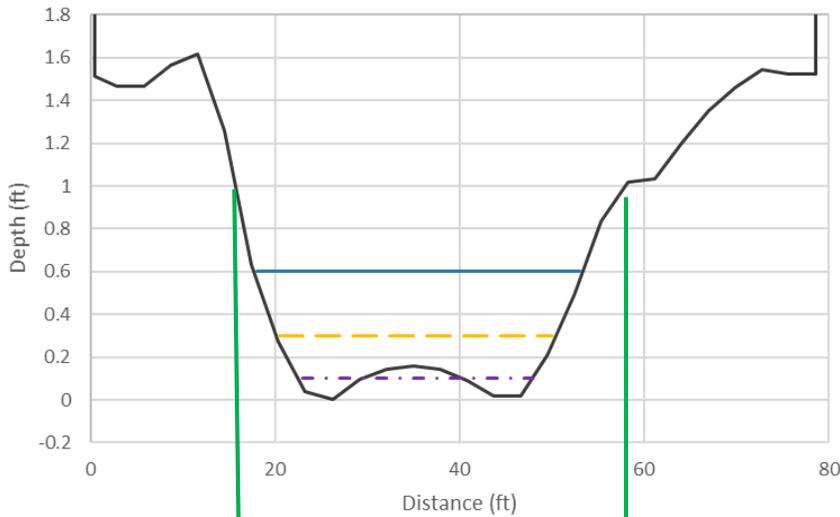
Street ROW

- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- - - WSEL Proposed w/o Restrictor

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

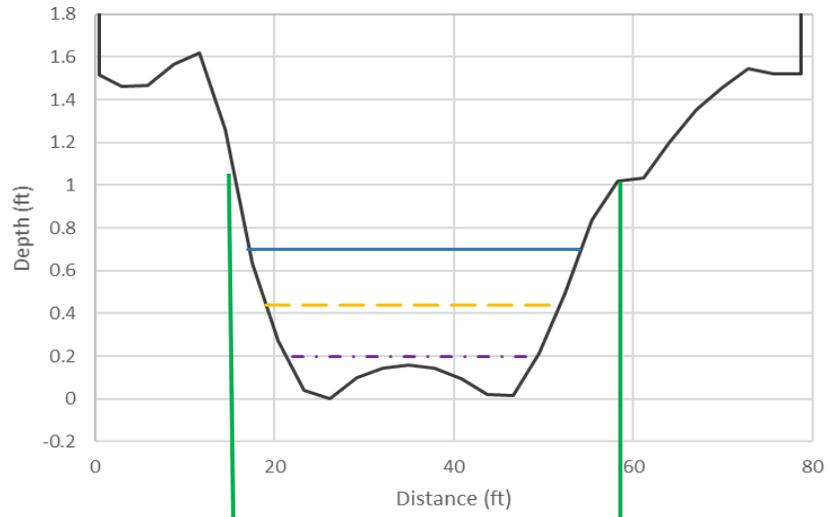


50-Year Scenario



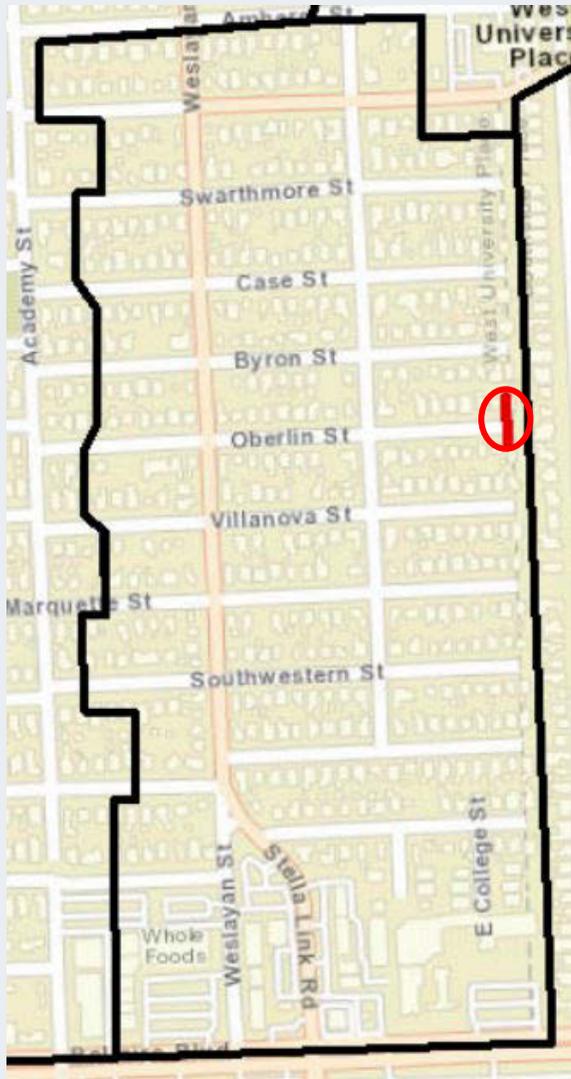
Street ROW

100-Year Scenario



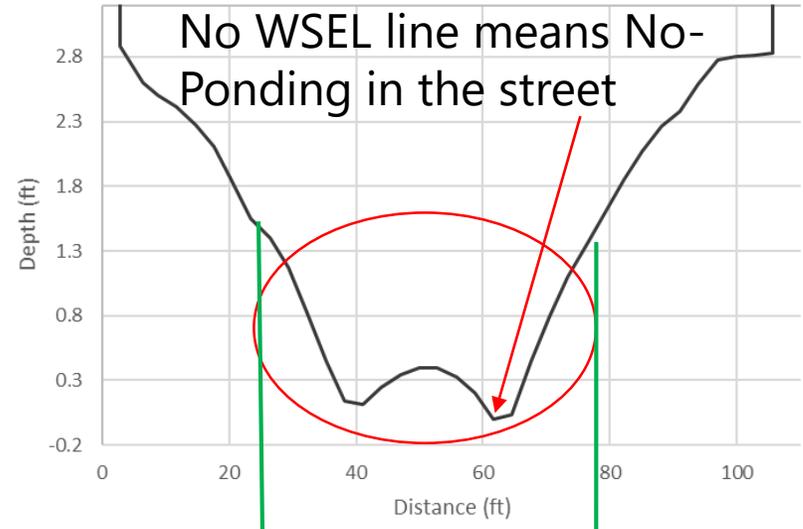
Street ROW

- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- . . - WSEL Proposed w/o Restrictor



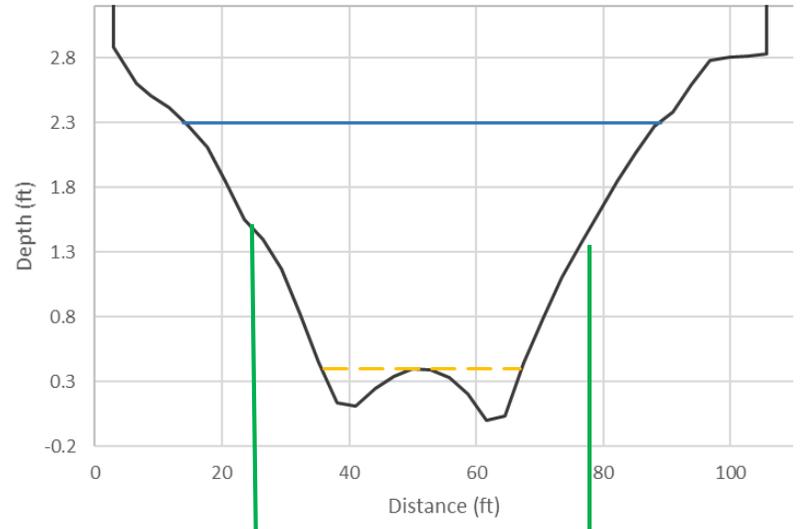
WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

2-Year Scenario



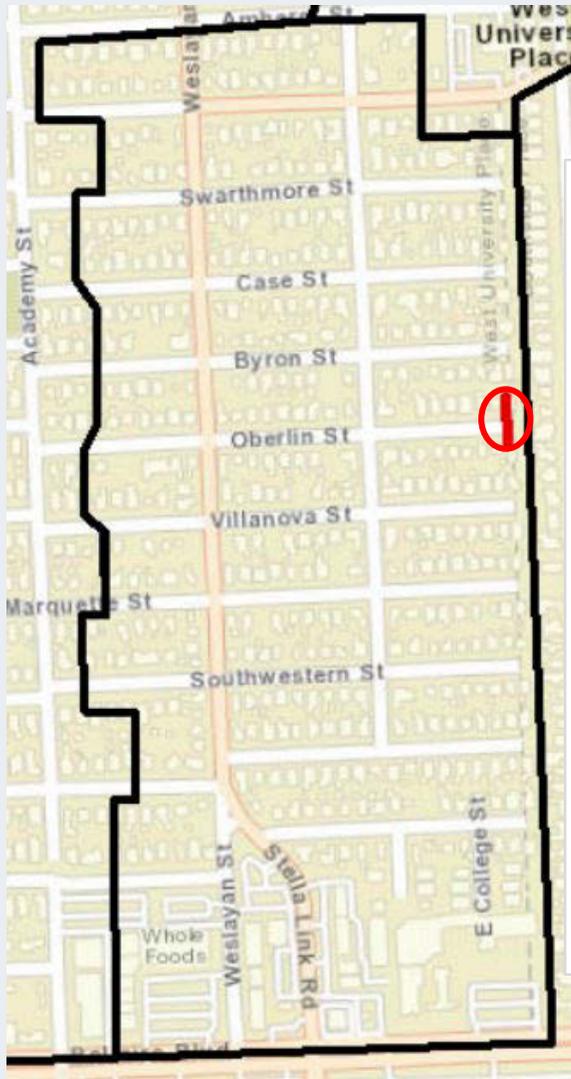
Street ROW

10-Year Scenario



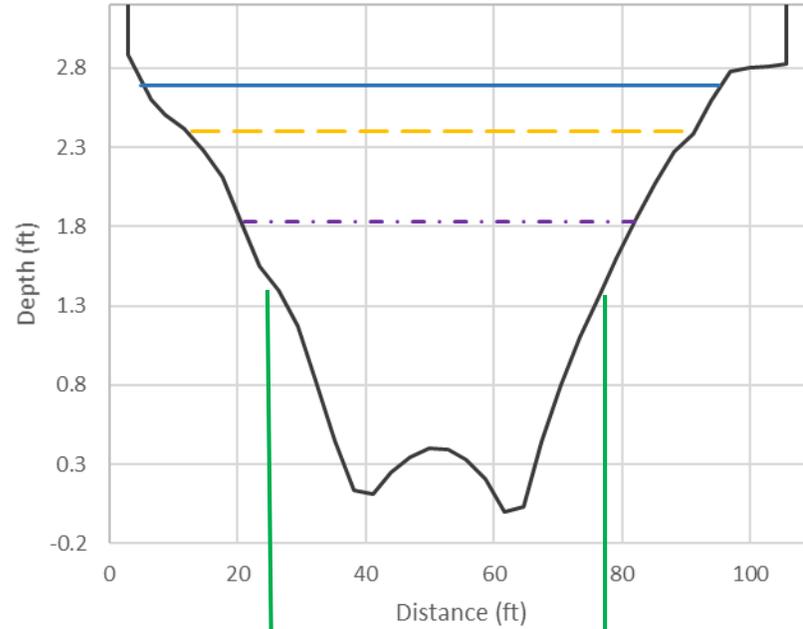
Street ROW

- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- . . . WSEL Proposed w/o Restrictor



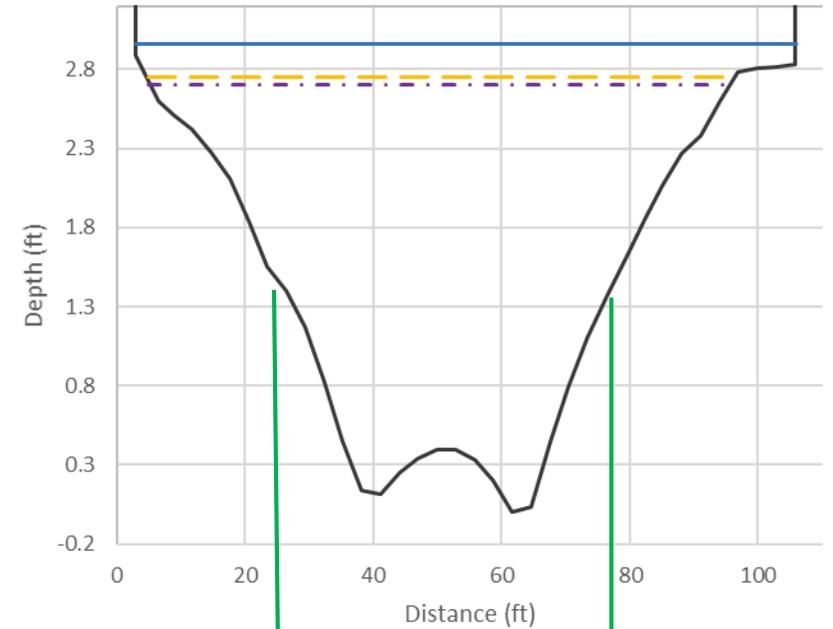
WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

50-Year Scenario



Street ROW

100-Year Scenario



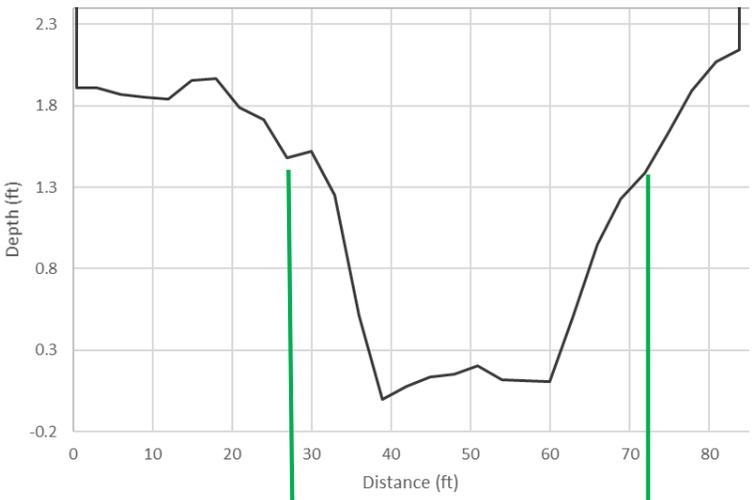
Street ROW

- WSEL Existing
- - - WSEL Proposed w/ Restrictor
- · - · WSEL Proposed w/o Restrictor

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

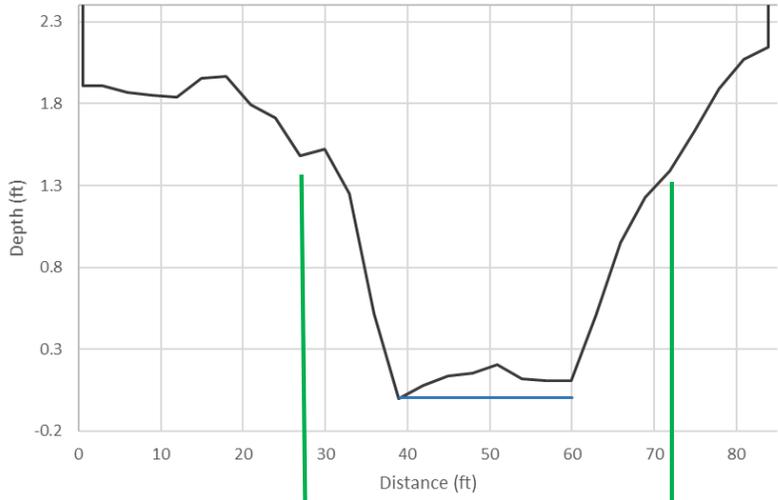


2-Year Scenario



Street ROW

10-Year Scenario



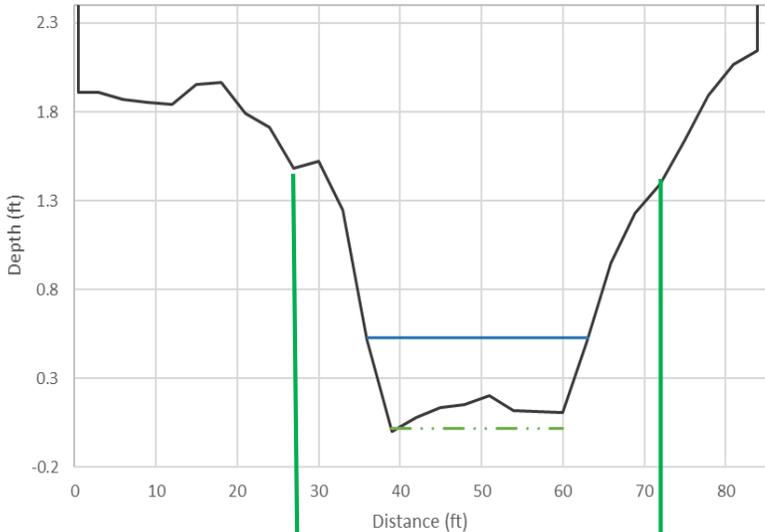
Street ROW

- WSEL Existing
- - - WSEL - Buffalo Speedway
- . - . WSEL - Proposed

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

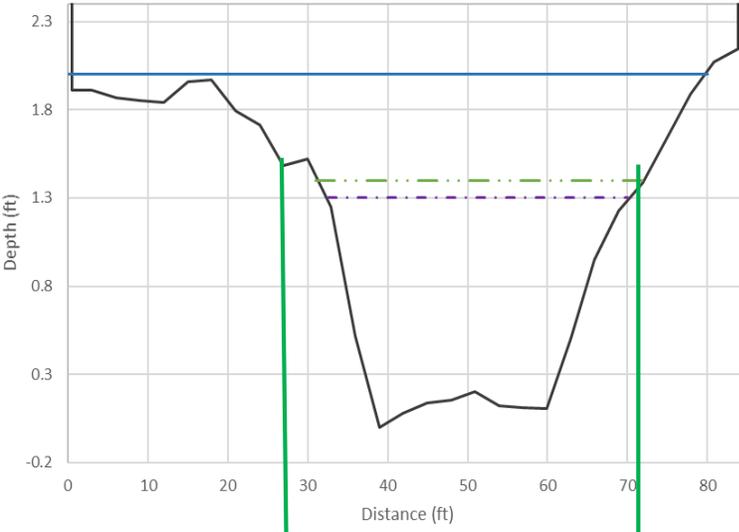


50-Year Scenario



Street ROW

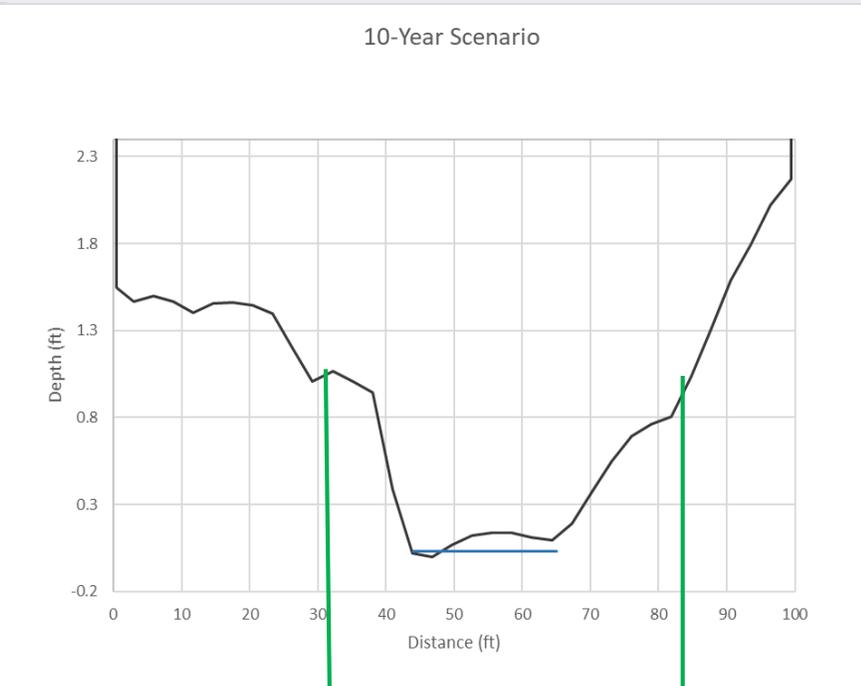
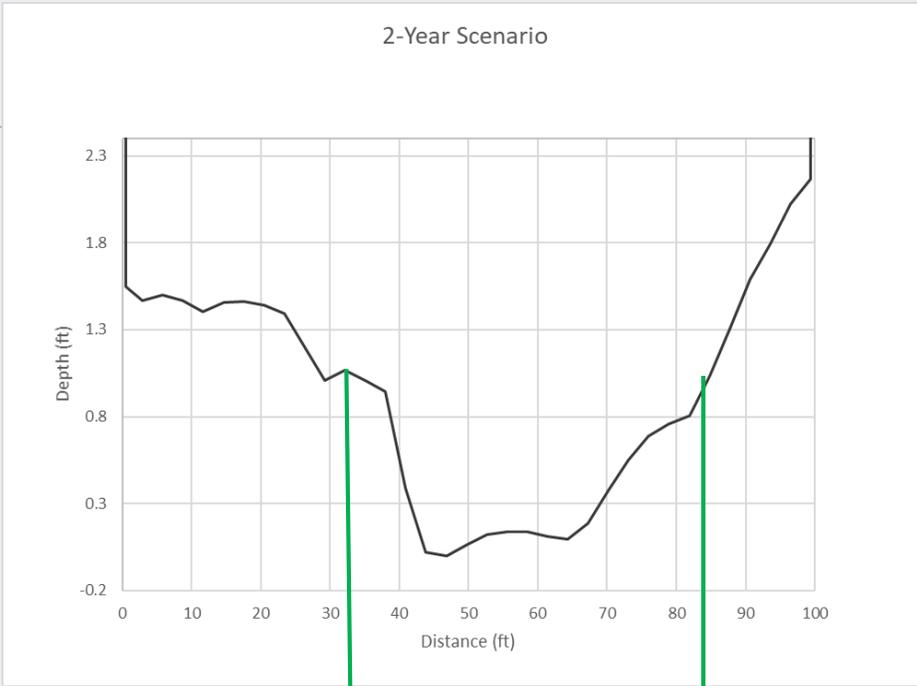
100-Year Scenario



Street ROW

- WSEL Existing
- - - WSEL - Buffalo Speedway
- - - WSEL - Proposed

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation



Street ROW

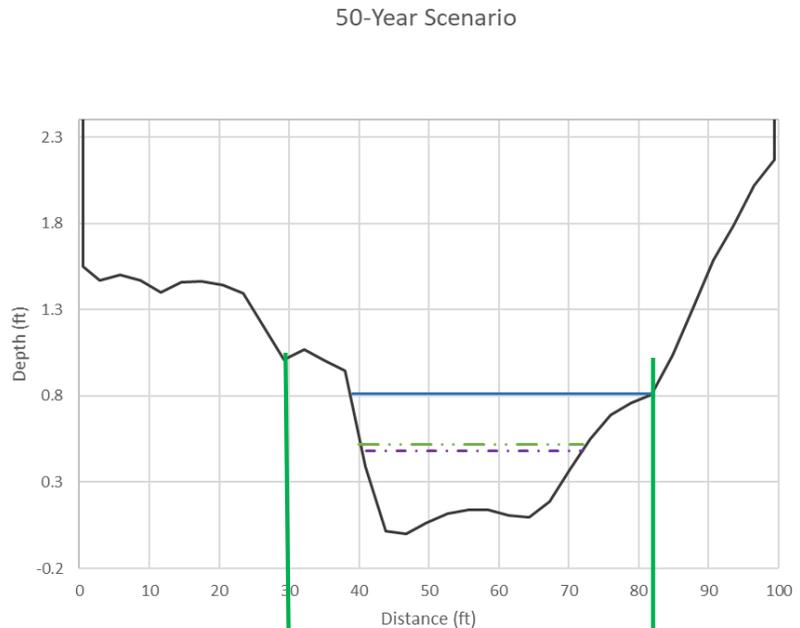
Street ROW

- WSEL Existing
- - - WSEL - Buffalo Speedway
- . - . WSEL - Proposed

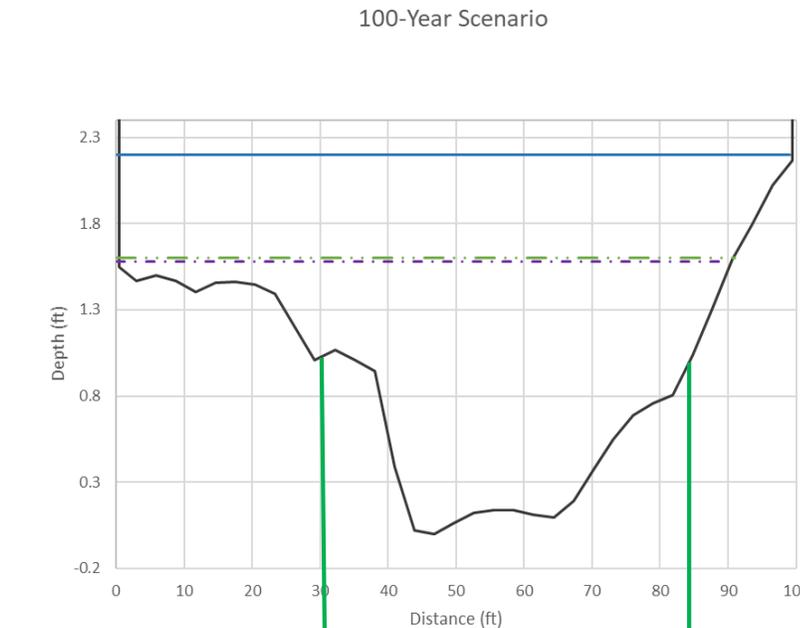
WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation



- WSEL Existing
- - - WSEL - Buffalo Speedway
- · - · WSEL - Proposed

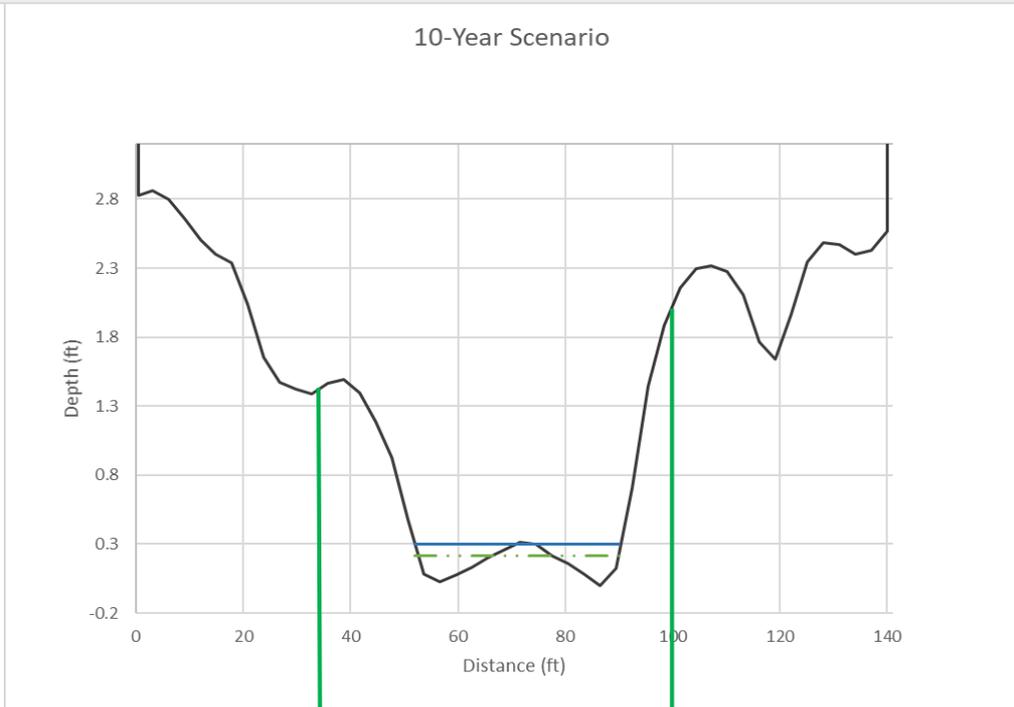
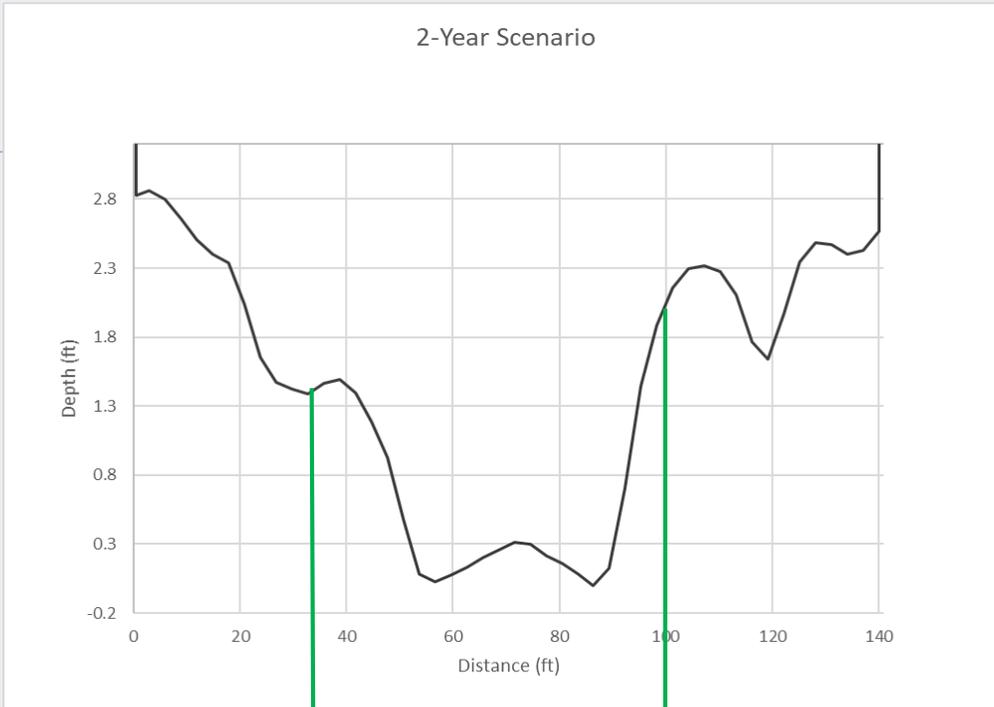


Street ROW



Street ROW

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

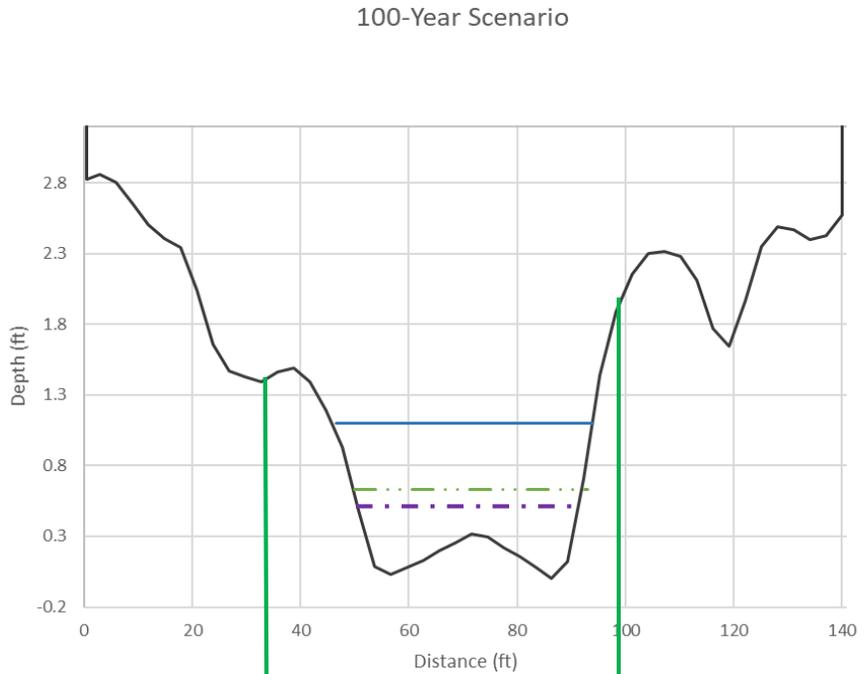
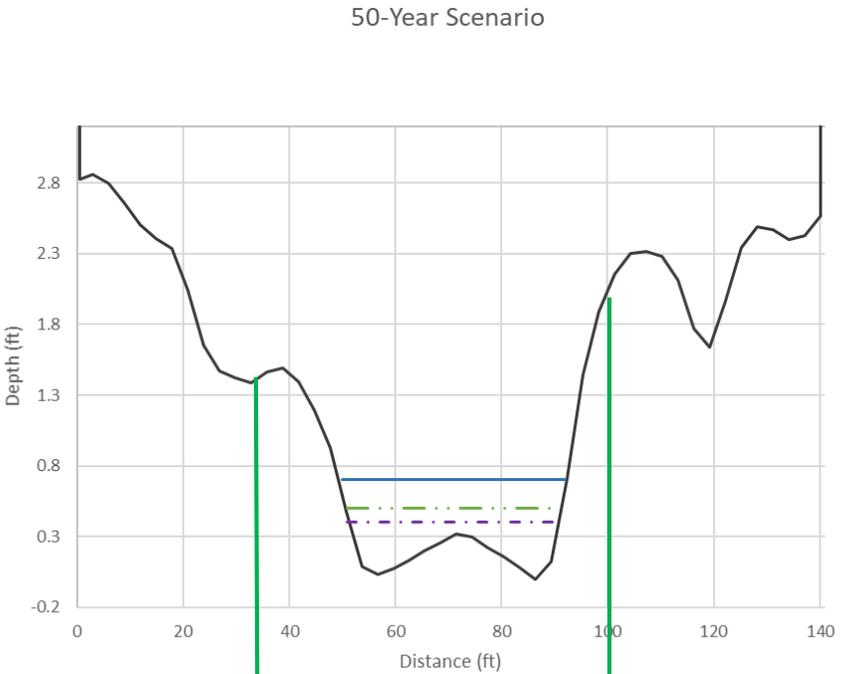


Street ROW

Street ROW

- WSEL Existing
- - - WSEL –Buffalo Speedway
- - - WSEL – Proposed

WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation



Street ROW

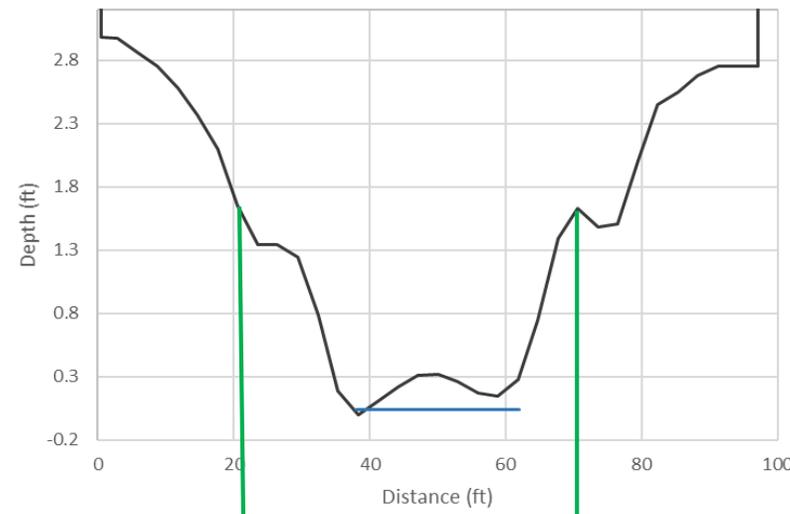
Street ROW

- WSEL Existing
- - - WSEL - Buffalo Speedway
- - - WSEL - Proposed

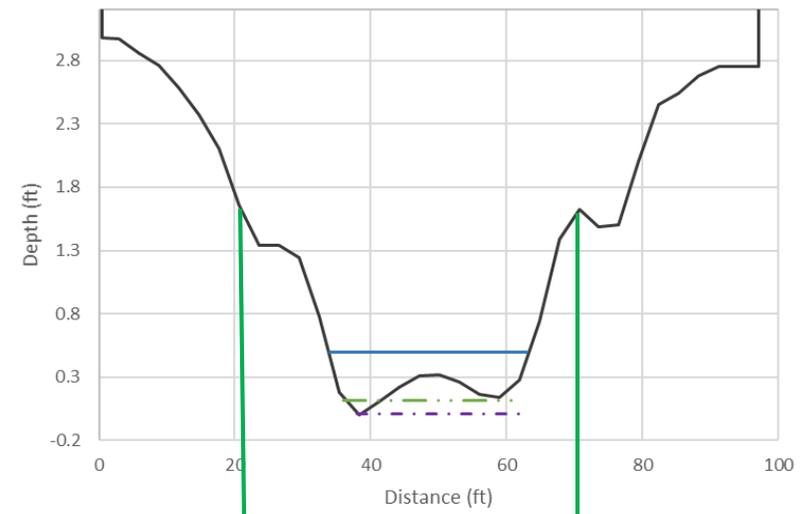


WSEL = Water Surface Elevation
 No WSEL line means the WSEL is below the street elevation

2-Year Scenario



10-Year Scenario



Street ROW

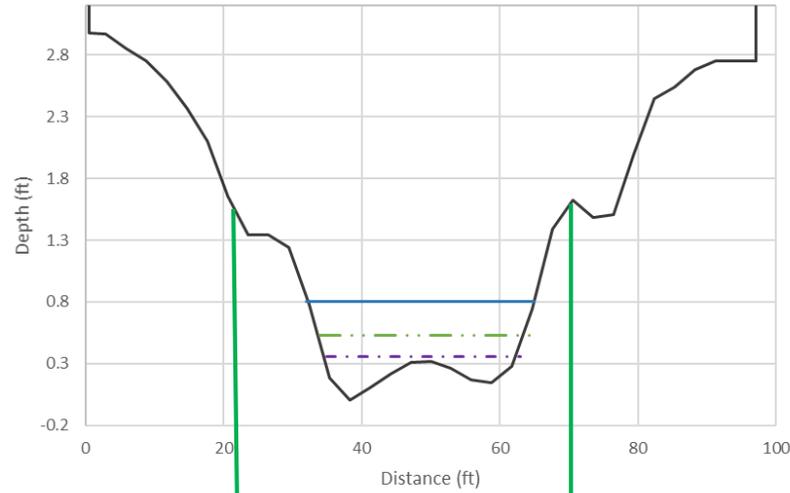
Street ROW

- WSEL Existing
- - - WSEL - Buffalo Speedway
- - - WSEL - Proposed



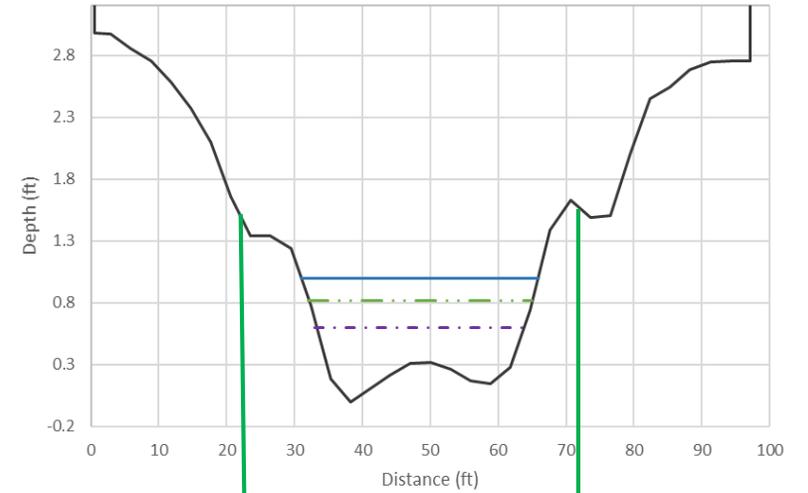
WSEL = Water Surface Elevation
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50-Year Scenario



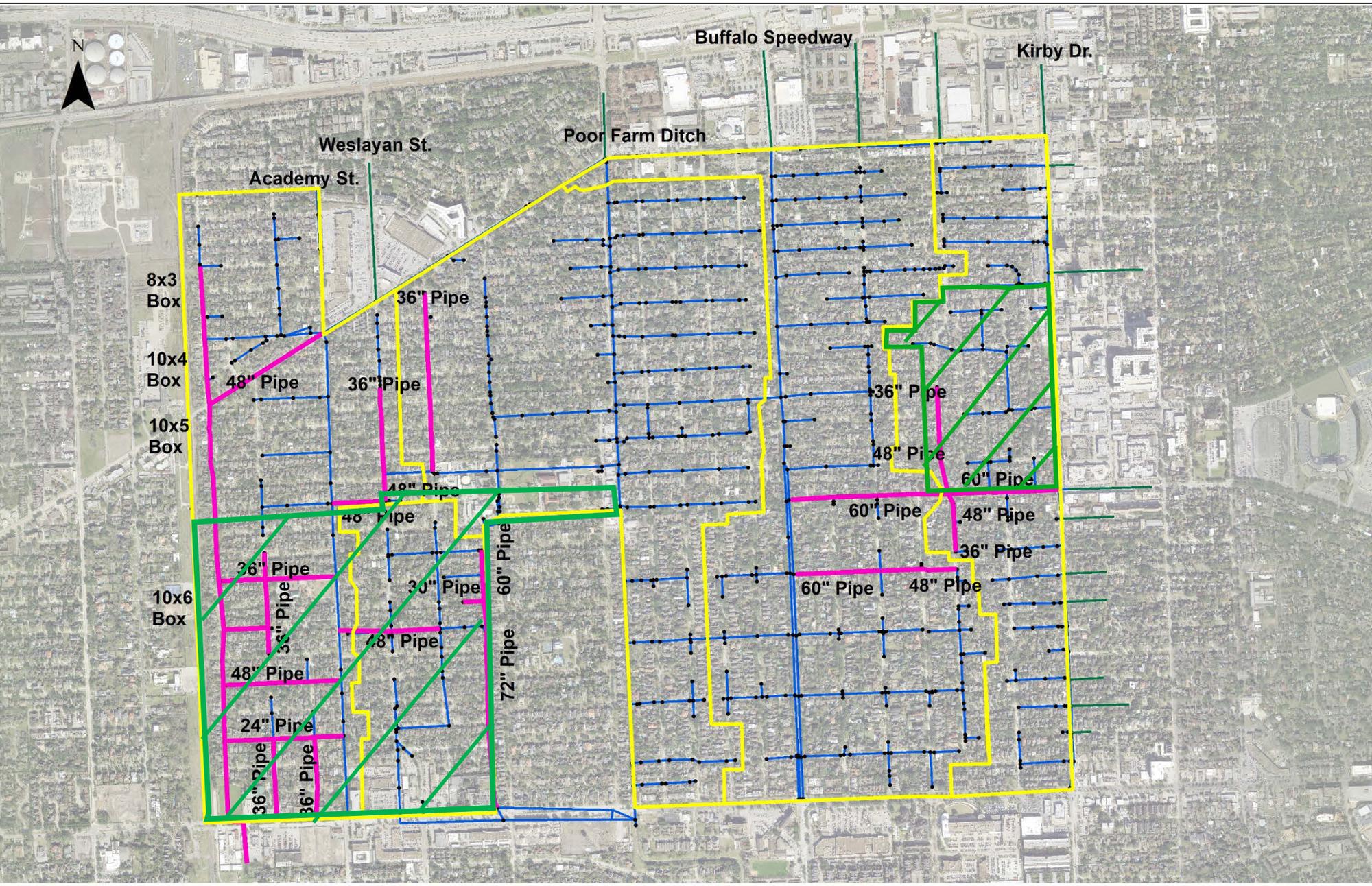
Street ROW

100-Year Scenario



Street ROW

- WSEL Existing
- - - WSEL - Buffalo Speedway
- · - · WSEL - Proposed



Estimate
\$60M*

 Priority
 Areas 1-3

Est. Cost = \$21M

 New Proposed
 Pipes

Est. Cost = \$39M

* Cost is in today's
 dollars

Conclusion

- Proposed storm Sewer Improvements provide nearly 50-year Level-of-Service (LOS)
- The estimate cost of Proposed improvements
 - Estimated cost of road and associated drainage improvements, **21M**. Priority Area 1-3 of Infrastructure Program.
 - These roadways will need replacement in the next five years if not sooner.
 - Estimated cost of the proposed drainage improvements, total **\$39M**.
- **TOTAL EST. COST OF IMPROVEMENTS = \$60Millions***

(*Shown in today's dollars)

Questions & Answers

Thank You

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Houston, Texas 77025

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hfc@ht-j.com

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(F) 832-767-0141

ATTACHMENT 1C

Council Workshop Presentation

7/27/2020

City of West University Place Citywide Storm Sewer Analysis

July 27, 2020

Prepared for:

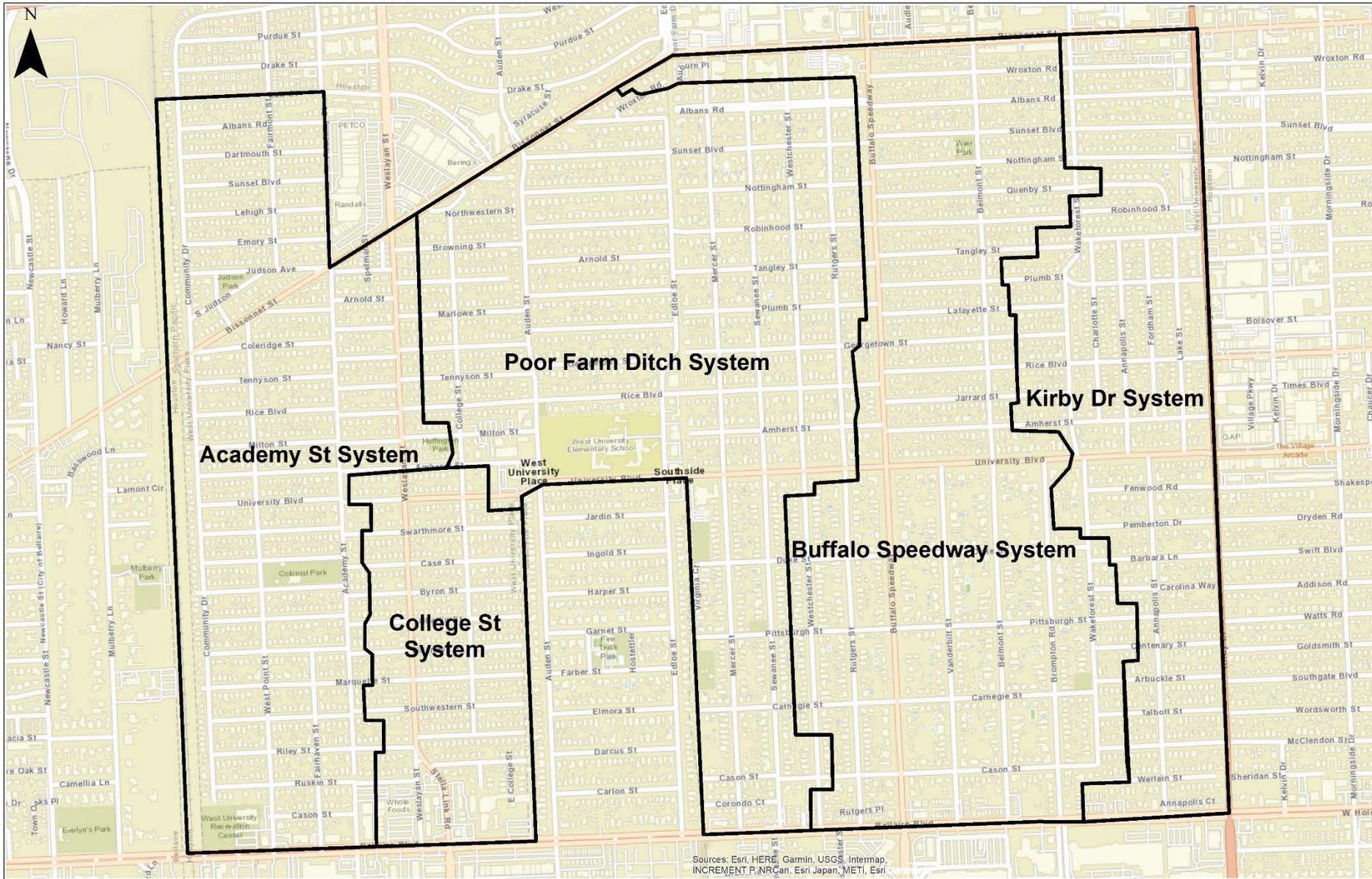


Prepared by:



Agenda

Additional Results Discussion



Major Drainage Systems

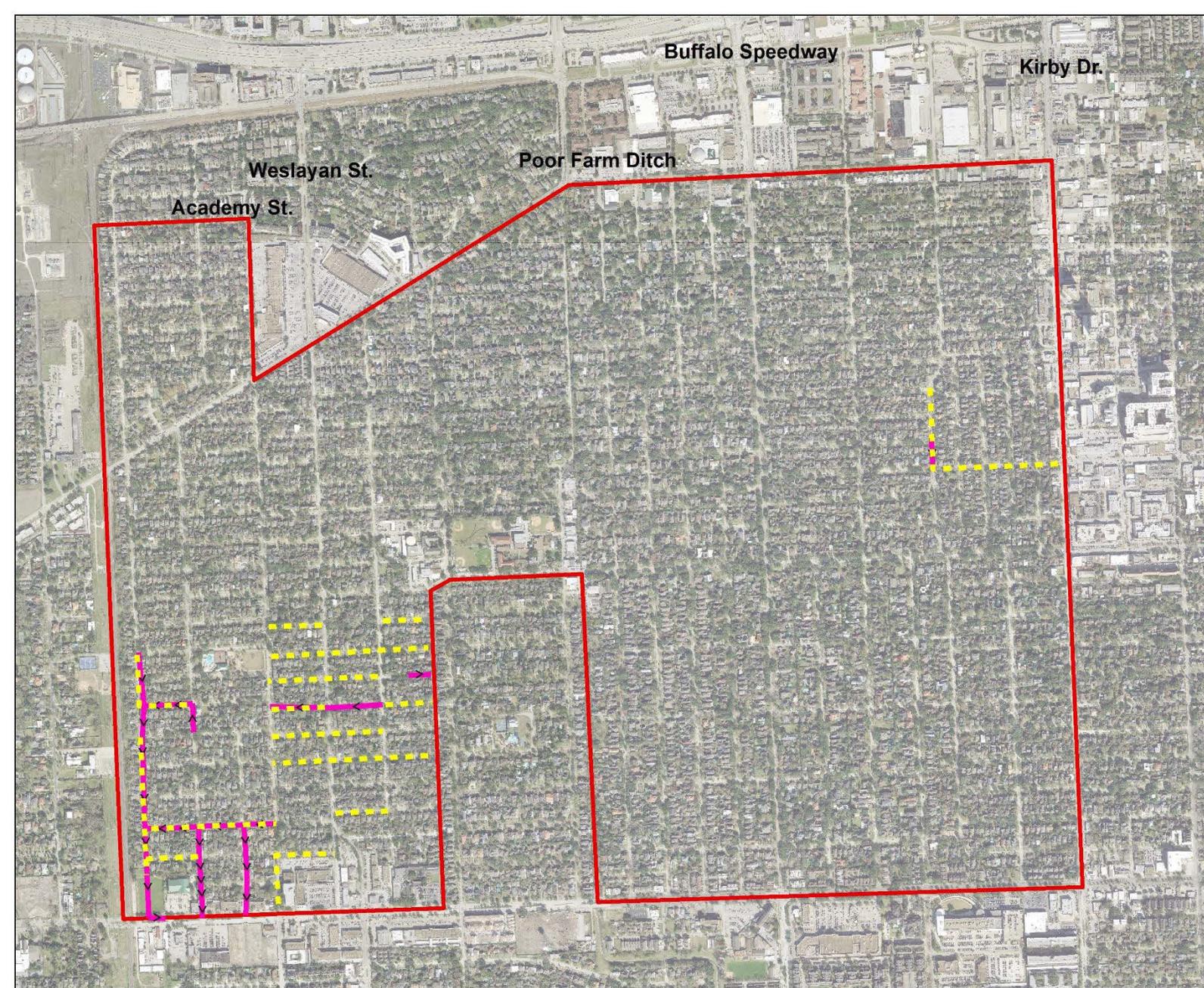
Proposed Improvements and Cost

Reported FEMA Claims

Drainage System	FEMA Flooded Homes
Academy	12
College	34
PFD	26
Buffalo	68
Kirby	9
TOTAL:	149

Total Cost Per Drainage System

Drainage System	Improvements Cost
Academy	\$31,000,000
College	\$15,000,000
PFD	\$2,000,000
Buffalo & Kirby	\$12,000,000
TOTAL:	\$60,000,000



N

West University Road Rehabilitation

Proposed HT&J Drainage Improvements

West University Boundary

City of West University Place
Citywide Drainage System Study

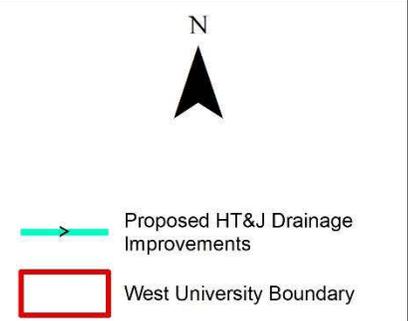
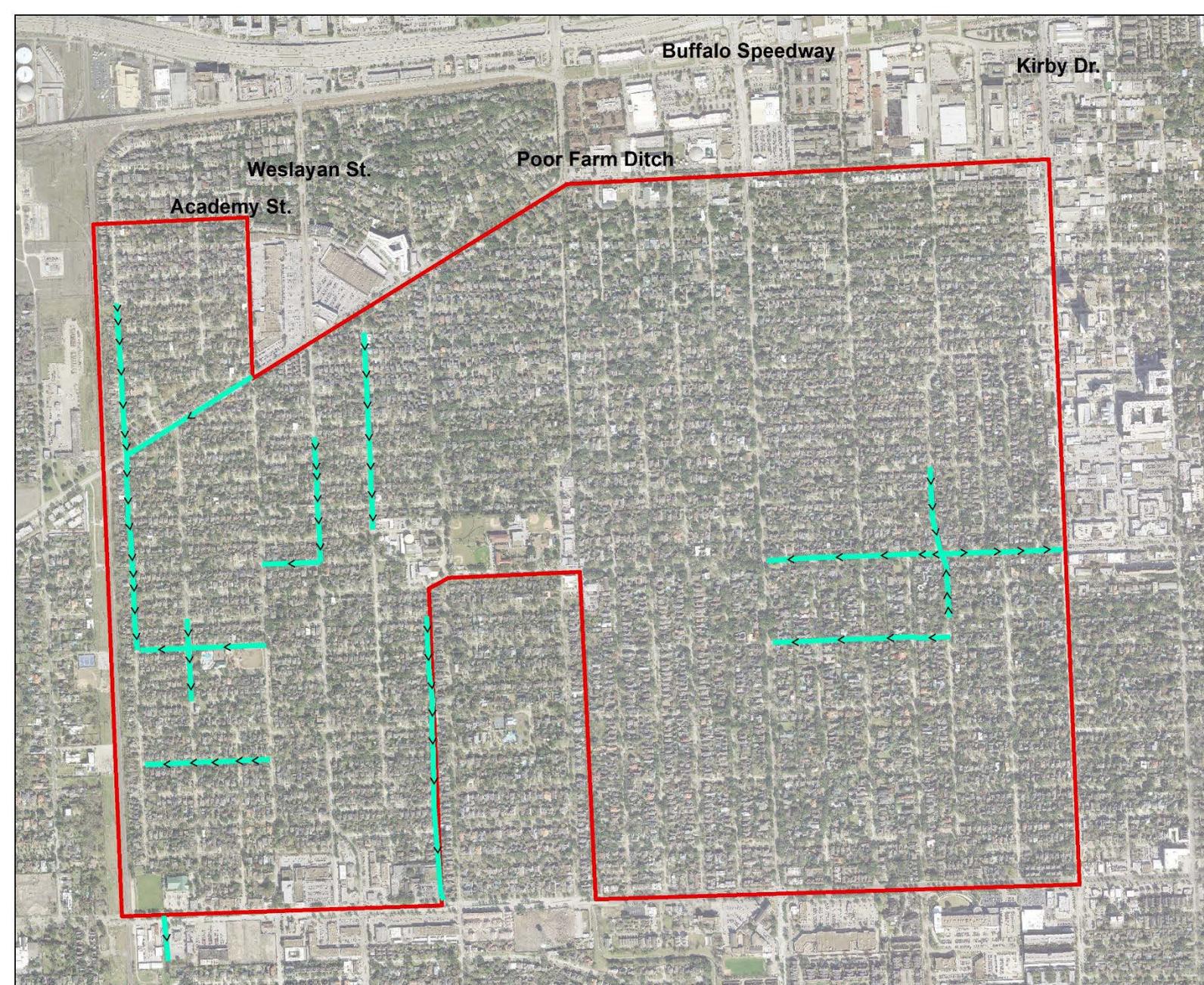
Road Rehabilitation &
Select Drainage Improvements

Estimate
\$31M*

Road Replacement
\$21M

Proposed
Improvements
\$10M

* Includes 4-year
cost escalation

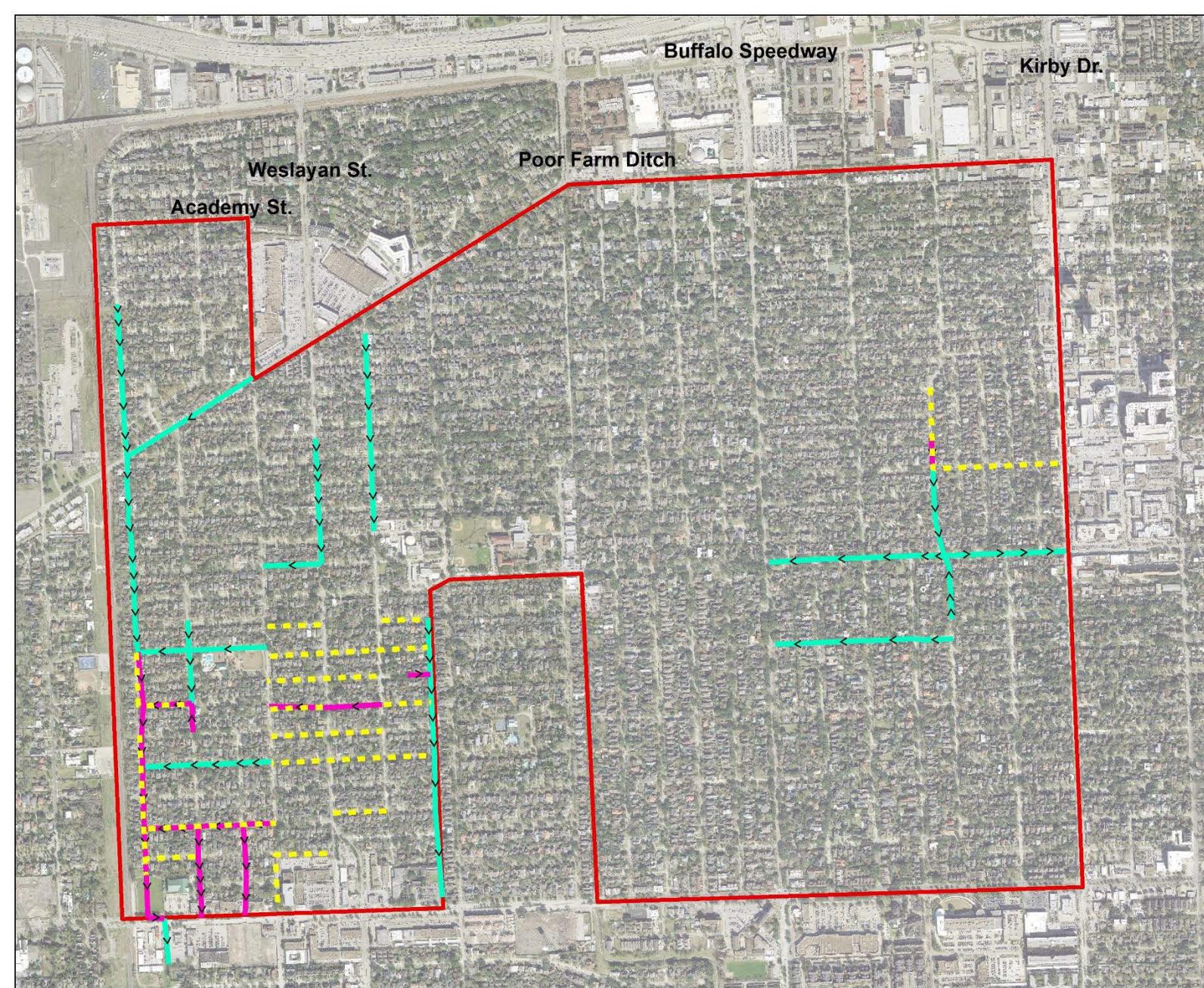


City of West University Place
Citywide Drainage System Study

Road Rehabilitation &
Select Drainage Improvements

Estimate
\$29M*

* Includes 4-year
cost escalation



-  N
-  West University Road Rehabilitation
-  Proposed HT&J Drainage Improvements
-  Proposed HT&J Drainage Improvements
-  West University Boundary

City of West University Place
Citywide Drainage System Study

Road Rehabilitation &
Drainage Improvements

Estimate
\$60M*

* Includes 4-year
cost escalation

Summary of Average Drop in Water Surface Elevation, Inches

System	W/ Restrictor			
	2-Year	10-Year	50-Year	100-Year
Academy	6.6	5.1	2.3	1.8
College	7.0	4.8	1.8	1.2
Poor Farm Ditch	4.8	3.4	1.5	1.0
*Buffalo Speedway	7.2	4.5	3.0	1.7
Kirby	4.2	3.0	1.6	1.0

Average was estimated based on 4 locations within each system

* As designed

Design Phase Services and Schedule

-
- | | |
|--|----------------------------|
| • Preliminary Engineering Report | 6-8 Months |
| • Survey | |
| • Geotechnical | |
| • Environmental | |
| • Landscaping | |
| • Utility Conflicts and Resolution | |
| • Design, Permit and Coordination | 9-12 months |
| • 60%, 90% and 100% | |
| • Permit coordination starts at 60% design phase | |
| • Bid and Construction Contract Award | 3-4 Months |
| | Total: 18-24 months |

Construction Time

3-4 years.

Questions & Answers
Thank You

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ATTACHMENT 2

Hydrologic Calculations

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node2	0.00	0.00	25.56	0.00	0.00
Node3	0.00	0.00	25.56	0.00	0.00
Node5	6.29	28.82	7.95	24.01	24.37
Node6	0.00	0.00	25.56	0.00	0.00
Node8	0.00	0.00	25.56	0.00	0.00
Node10	0.00	0.00	25.56	0.00	0.00
Node11	0.00	0.00	25.56	0.00	0.00
Node12	1.76	26.05	8.37	7.08	7.15
Node13	0.00	0.00	25.56	0.00	0.00
Node15	3.81	27.66	8.12	14.85	14.99
Node17	0.00	0.00	25.56	0.00	0.00
Node19	2.68	26.89	8.24	10.57	10.67
Node23	0.00	0.00	25.56	0.00	0.00
Node24	0.00	0.00	25.56	0.00	0.00
Node25	3.81	27.66	8.12	14.85	14.99
Node26	0.00	0.00	25.56	0.00	0.00
Node27	3.14	27.23	8.18	12.33	12.45
Node28	0.00	0.00	25.56	0.00	0.00
Node29	0.00	0.00	25.56	0.00	0.00
Node30	0.00	0.00	25.56	0.00	0.00
Node32	3.14	27.23	8.18	12.33	12.45
Node33	6.10	28.75	7.96	23.34	23.54
Node34	0.00	0.00	25.56	0.00	0.00
Node35	7.02	29.09	7.92	26.68	26.91
Node37	0.00	0.00	25.56	0.00	0.00
Node38	0.00	0.00	25.56	0.00	0.00
Node39	5.29	28.41	8.01	20.33	20.51
Node40	0.00	0.00	25.56	0.00	0.00
Node41	0.00	0.00	25.56	0.00	0.00
Node42	0.00	0.00	25.56	0.00	0.00
Node43	4.52	28.04	8.06	17.50	17.66
Node45	0.00	0.00	25.56	0.00	0.00
Node46	0.00	0.00	25.56	0.00	0.00
Node47	3.99	27.76	8.11	15.52	15.66
Node48	0.00	0.00	25.56	0.00	0.00
Node51	3.99	27.76	8.11	15.52	15.66
Node52	0.00	0.00	25.56	0.00	0.00
Node53	3.99	27.76	8.11	15.52	15.66
Node54	0.00	0.00	25.56	0.00	0.00
Node55	0.00	0.00	25.56	0.00	0.00
Node57	4.20	27.87	8.09	16.30	16.45
Node60	0.00	0.00	25.56	0.00	0.00
Node61	0.10	21.67	9.15	0.44	0.40
Node62	0.00	0.00	25.56	0.00	0.00
Node63	3.33	27.36	8.16	13.06	13.18
Node65	0.10	21.67	9.15	0.44	0.40

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node66	0.00	0.00	25.56	0.00	0.00
Node67	0.10	21.67	9.15	0.44	0.40
Node69	0.00	0.00	25.56	0.00	0.00
Node70	0.00	0.00	25.56	0.00	0.00
Node71	6.06	28.73	7.97	23.16	23.37
Node72	0.00	0.00	25.56	0.00	0.00
Node73	0.00	0.00	25.56	0.00	0.00
Node75	0.00	0.00	25.56	0.00	0.00
Node76	0.10	21.67	9.15	0.44	0.40
Node77	0.00	0.00	25.56	0.00	0.00
Node79	6.94	29.07	7.92	26.40	26.63
Node80	3.99	27.76	8.11	15.52	15.66
Node81	0.00	0.00	25.56	0.00	0.00
Node82	0.00	0.00	25.56	0.00	0.00
Node83	3.96	27.74	8.11	15.39	15.53
Node84	0.00	0.00	25.56	0.00	0.00
Node85	0.10	21.67	9.15	0.44	0.40
Node86	0.10	21.67	9.15	0.44	0.40
Node87	0.00	0.00	25.56	0.00	0.00
Node88	0.00	0.00	25.56	0.00	0.00
Node90	3.99	27.76	8.11	15.52	15.66
Node91	0.00	0.00	25.56	0.00	0.00
Node92	0.00	0.00	25.56	0.00	0.00
Node93	15.59	31.22	7.64	57.18	57.66
Node94	0.00	0.00	25.56	0.00	0.00
Node95	0.10	21.67	9.15	0.44	0.40
Node96	0.00	0.00	25.56	0.00	0.00
Node97	6.43	28.88	7.95	24.53	24.74
Node99	6.43	28.88	7.95	24.53	24.74
Node100	0.00	0.00	25.56	0.00	0.00
Node101	0.00	0.00	25.56	0.00	0.00
Node103	3.90	27.71	8.11	15.20	15.34
Node105	2.34	26.61	8.28	9.28	9.36
Node106	0.55	24.00	8.71	2.30	2.33
Node107	0.00	0.00	25.56	0.00	0.00
Node108	2.91	27.07	8.21	11.45	11.56
Node109	1.92	26.22	8.34	7.69	7.76
Node110	1.94	26.24	8.34	7.78	7.85
Node111	0.36	23.33	8.83	1.50	1.52
Node112	0.00	0.00	25.56	0.00	0.00
Node113	0.00	0.00	25.56	0.00	0.00
Node114	3.15	27.24	8.18	12.37	12.48
Node115	0.00	0.00	25.56	0.00	0.00
Node116	0.00	0.00	25.56	0.00	0.00
Node117	0.97	24.95	8.55	3.99	4.02
Node118	0.45	23.70	8.76	1.91	1.93

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node119	1.05	25.09	8.52	4.31	4.35
Node120	0.51	23.88	8.73	2.14	2.16
Node121	1.01	25.01	8.54	4.13	4.17
Node122	0.00	0.00	25.56	0.00	0.00
Node123	0.00	0.00	25.56	0.00	0.00
Node124	1.91	26.20	8.34	7.64	7.71
Node125	0.41	23.53	8.80	1.71	1.73
Node126	0.84	24.71	8.59	3.48	3.51
Node127	3.61	27.53	8.14	14.08	14.21
Node128	0.00	0.00	25.56	0.00	0.00
Node129	3.40	27.41	8.16	13.33	13.45
Node130	1.40	25.61	8.44	5.65	5.71
Node131	0.00	0.00	25.56	0.00	0.00
Node133	2.69	26.91	8.23	10.64	10.74
Node134	5.35	28.43	8.01	20.56	20.74
Node135	0.00	0.00	25.56	0.00	0.00
Node136	2.51	26.76	8.26	9.94	10.03
Node138	0.00	0.00	25.56	0.00	0.00
Node139	0.00	0.00	25.56	0.00	0.00
Node140	0.93	24.87	8.56	3.82	3.86
Node141	3.30	27.34	8.17	12.95	13.06
Node142	3.89	27.70	8.11	15.15	15.29
Node145	0.68	24.33	8.65	2.81	2.84
Node146	0.00	0.00	25.56	0.00	0.00
Node148	0.00	0.00	25.56	0.00	0.00
Node149	6.43	28.88	7.95	24.53	24.74
Node150	0.00	0.00	25.56	0.00	0.00
Node151	0.00	0.00	25.56	0.00	0.00
Node152	0.00	0.00	25.56	0.00	0.00
Node153	0.00	0.00	25.56	0.00	0.00
Node154	0.00	0.00	25.56	0.00	0.00
Node155	0.00	0.00	25.56	0.00	0.00
Node156	0.00	0.00	25.56	0.00	0.00
Node157	0.00	0.00	25.56	0.00	0.00
Node158	6.43	28.88	7.95	24.53	24.74
Node159	0.00	0.00	25.56	0.00	0.00
Node160	0.00	0.00	25.56	0.00	0.00
Node162	2.34	26.61	8.28	9.30	9.39
Node163	0.00	0.00	25.56	0.00	0.00
Node164	2.34	26.61	8.28	9.30	9.39
Node165	11.70	30.42	7.74	43.47	44.12
Node166	0.00	0.00	25.56	0.00	0.00
Node168	2.34	26.61	8.28	9.30	9.39
Node169	2.34	26.61	8.28	9.30	9.39
Node170	0.00	0.00	25.56	0.00	0.00
Node171	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node172	0.00	0.00	25.56	0.00	0.00
Node174	0.00	0.00	25.56	0.00	0.00
Node175	0.00	0.00	25.56	0.00	0.00
Node176	2.34	26.61	8.28	9.30	9.39
Node177	6.43	28.88	7.95	24.53	24.74
Node179	0.00	0.00	25.56	0.00	0.00
Node180	0.00	0.00	25.56	0.00	0.00
Node181	5.04	28.30	8.03	19.42	19.64
Node182	5.04	28.30	8.03	19.42	19.64
Node183	0.00	0.00	25.56	0.00	0.00
Node184	0.00	0.00	25.56	0.00	0.00
Node185	0.00	0.00	25.56	0.00	0.00
Node187	0.00	0.00	25.56	0.00	0.00
Node188	5.04	28.30	8.03	19.42	19.64
Node189	5.04	28.30	8.03	19.42	19.64
Node190	5.04	28.30	8.03	19.42	19.64
Node191	0.00	0.00	25.56	0.00	0.00
Node192	7.02	29.09	7.92	26.68	26.91
Node194	0.00	0.00	25.56	0.00	0.00
Node195	0.00	0.00	25.56	0.00	0.00
Node197	0.00	0.00	25.56	0.00	0.00
Node199	0.00	0.00	25.56	0.00	0.00
Node200	0.00	0.00	25.56	0.00	0.00
Node201	0.00	0.00	25.56	0.00	0.00
Node204	0.00	0.00	25.56	0.00	0.00
Node205	3.72	27.61	8.13	14.53	14.67
Node206	0.00	0.00	25.56	0.00	0.00
Node207	0.00	0.00	25.56	0.00	0.00
Node208	0.00	0.00	25.56	0.00	0.00
Node209	19.88	31.93	7.55	72.06	73.14
Node210	9.94	29.98	7.80	37.21	37.54
Node212	0.00	0.00	25.56	0.00	0.00
Node213	0.00	0.00	25.56	0.00	0.00
Node214	0.00	0.00	25.56	0.00	0.00
Node215	0.00	0.00	25.56	0.00	0.00
Node216	0.00	0.00	25.56	0.00	0.00
Node217	0.00	0.00	25.56	0.00	0.00
Node218	0.00	0.00	25.56	0.00	0.00
Node219	7.02	29.09	7.92	26.68	26.91
Node220	7.02	29.09	7.92	26.68	26.91
Node222	0.00	0.00	25.56	0.00	0.00
Node225	2.78	26.97	8.22	10.96	11.06
Node226	2.06	26.36	8.32	8.23	8.31
Node228	3.11	27.21	8.19	12.21	12.32
Node229	0.00	0.00	25.56	0.00	0.00
Node231	2.50	26.75	8.26	9.90	9.99

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node232	1.71	25.99	8.38	6.86	6.93
Node233	0.00	0.00	25.56	0.00	0.00
Node234	0.00	0.00	25.56	0.00	0.00
Node235	2.75	26.95	8.23	10.87	10.97
Node236	1.96	26.26	8.33	7.84	7.91
Node237	1.16	25.26	8.50	4.71	4.76
Node238	2.48	26.73	8.26	9.82	9.91
Node239	0.00	0.00	25.56	0.00	0.00
Node241	0.59	24.12	8.69	2.47	2.50
Node243	1.70	25.98	8.38	6.83	6.89
Node244	1.24	25.38	8.47	5.03	5.08
Node246	0.00	0.00	25.56	0.00	0.00
Node247	0.00	0.00	25.56	0.00	0.00
Node248	2.81	27.00	8.22	11.09	11.19
Node249	2.39	26.65	8.27	9.47	9.56
Node250	0.57	24.05	8.70	2.37	2.40
Node251	0.00	0.00	25.56	0.00	0.00
Node252	3.35	27.37	8.16	13.13	13.25
Node253	0.00	0.00	25.56	0.00	0.00
Node255	2.48	26.74	8.26	9.84	9.93
Node256	0.00	0.00	25.56	0.00	0.00
Node257	1.67	25.94	8.38	6.70	6.77
Node258	3.46	27.44	8.15	13.52	13.65
Node260	2.98	27.12	8.20	11.75	11.85
Node261	1.09	25.15	8.51	4.46	4.50
Node262	0.00	0.00	25.56	0.00	0.00
Node263	2.70	26.91	8.23	10.65	10.75
Node264	0.00	0.00	25.56	0.00	0.00
Node265	0.00	0.00	25.56	0.00	0.00
Node266	0.00	0.00	25.56	0.00	0.00
Node267	5.07	28.31	8.03	19.54	19.72
Node268	3.40	27.41	8.16	13.33	13.45
Node270	1.15	25.24	8.50	4.67	4.72
Node271	3.47	27.45	8.15	13.58	13.71
Node272	1.93	26.22	8.34	7.71	7.78
Node274	3.88	27.70	8.12	15.11	15.25
Node275	2.20	26.49	8.30	8.77	8.85
Node276	1.77	26.06	8.36	7.11	7.18
Node277	0.00	0.00	25.56	0.00	0.00
Node279	3.62	27.54	8.14	14.14	14.27
Node280	0.00	0.00	25.56	0.00	0.00
Node281	1.15	25.25	8.50	4.70	4.74
Node282	1.83	26.12	8.35	7.34	7.41
Node283	0.00	0.00	25.56	0.00	0.00
Node285	0.00	0.00	25.56	0.00	0.00
Node286	3.34	27.37	8.16	13.08	13.20

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node287	0.00	0.00	25.56	0.00	0.00
Node288	3.51	27.48	8.15	13.73	13.86
Node289	2.69	26.90	8.23	10.62	10.71
Node290	0.00	0.00	25.56	0.00	0.00
Node291	0.00	0.00	25.56	0.00	0.00
Node292	1.68	25.96	8.38	6.76	6.83
Node293	1.06	25.11	8.52	4.35	4.39
Node294	0.00	0.00	25.56	0.00	0.00
Node295	1.74	26.02	8.37	6.99	7.06
Node296	1.74	26.02	8.37	6.99	7.06
Node297	2.19	26.48	8.30	8.71	8.79
Node298	0.35	23.31	8.84	1.48	1.50
Node299	0.00	0.00	25.56	0.00	0.00
Node300	0.35	23.31	8.84	1.48	1.50
Node301	0.00	0.00	25.56	0.00	0.00
Node303	0.71	24.41	8.64	2.94	2.98
Node304	1.65	25.92	8.39	6.62	6.68
Node305	1.87	26.17	8.35	7.50	7.57
Node306	1.38	25.58	8.44	5.58	5.63
Node307	2.28	26.56	8.29	9.08	9.17
Node308	3.33	27.36	8.16	13.05	13.16
Node309	1.45	25.67	8.43	5.86	5.91
Node310	0.00	0.00	25.56	0.00	0.00
Node311	2.40	26.67	8.27	9.54	9.68
Node312	1.20	25.33	8.48	4.89	4.93
Node313	1.60	25.86	8.40	6.43	6.49
Node314	2.18	26.47	8.30	8.69	8.77
Node315	3.38	27.39	8.16	13.24	13.36
Node316	0.00	0.00	25.56	0.00	0.00
Node317	0.58	24.09	8.70	2.42	2.44
Node318	1.16	25.26	8.49	4.71	4.78
Node319	0.58	24.09	8.70	2.42	2.44
Node320	2.52	26.77	8.25	10.00	10.09
Node321	2.19	26.48	8.30	8.74	8.82
Node322	0.00	0.00	25.56	0.00	0.00
Node323	0.00	0.00	25.56	0.00	0.00
Node324	1.89	26.18	8.35	7.56	7.63
Node325	4.10	27.82	8.10	15.92	16.07
Node326	0.00	0.00	25.56	0.00	0.00
Node327	0.00	0.00	25.56	0.00	0.00
Node328	1.10	25.17	8.51	4.49	4.54
Node329	1.10	25.17	8.51	4.49	4.54
Node330	2.86	27.03	8.21	11.26	11.36
Node331	1.15	25.25	8.50	4.69	4.73
Node333	0.00	0.00	25.56	0.00	0.00
Node334	0.33	23.22	8.85	1.40	1.41

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node336	1.81	26.10	8.36	7.27	7.34
Node337	0.00	0.00	25.56	0.00	0.00
Node338	0.00	0.00	25.56	0.00	0.00
Node339	3.41	27.41	8.16	13.36	13.48
Node340	0.00	0.00	25.56	0.00	0.00
Node341	3.64	27.55	8.14	14.20	14.42
Node342	1.82	26.11	8.36	7.30	7.37
Node343	0.00	0.00	25.56	0.00	0.00
Node344	1.82	26.11	8.36	7.30	7.37
Node345	2.27	26.55	8.29	9.01	9.10
Node346	0.42	23.59	8.78	1.78	1.80
Node347	0.69	24.37	8.64	2.88	2.90
Node348	0.00	0.00	25.56	0.00	0.00
Node350	4.00	27.76	8.11	15.55	15.69
Node351	0.00	0.00	25.56	0.00	0.00
Node353	0.00	0.00	25.56	0.00	0.00
Node354	0.00	0.00	25.56	0.00	0.00
Node356	1.29	25.46	8.46	5.25	5.30
Node357	0.00	0.00	25.56	0.00	0.00
Node358	1.99	26.29	8.33	7.96	8.04
Node359	0.00	0.00	25.56	0.00	0.00
Node360	0.00	0.00	25.56	0.00	0.00
Node361	0.00	0.00	25.56	0.00	0.00
Node362	0.00	0.00	25.56	0.00	0.00
Node363	0.98	24.97	8.54	4.03	4.07
Node364	2.02	26.32	8.32	8.09	8.16
Node365	0.00	0.00	25.56	0.00	0.00
Node366	1.02	25.03	8.53	4.16	4.20
Node367	0.00	0.00	25.56	0.00	0.00
Node369	0.00	0.00	25.56	0.00	0.00
Node371	0.00	0.00	25.56	0.00	0.00
Node373	0.00	0.00	25.56	0.00	0.00
Node374	1.17	25.28	8.49	4.78	4.83
Node375	1.23	25.37	8.48	4.99	5.04
Node376	0.00	0.00	25.56	0.00	0.00
Node377	3.13	27.23	8.18	12.30	12.41
Node378	0.00	0.00	25.56	0.00	0.00
Node379	1.66	25.93	8.39	6.67	6.74
Node381	3.10	27.20	8.19	12.18	12.30
Node382	0.00	0.00	25.56	0.00	0.00
Node383	3.54	27.49	8.14	13.85	13.97
Node384	0.00	0.00	25.56	0.00	0.00
Node385	5.51	28.50	8.00	21.14	21.33
Node386	0.90	24.81	8.57	3.69	3.73
Node387	2.02	26.32	8.32	8.08	8.16
Node388	2.05	26.35	8.32	8.19	8.27

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node389	1.66	25.94	8.38	6.69	6.76
Node390	1.56	25.82	8.40	6.30	6.36
Node391	1.15	25.25	8.50	4.68	4.73
Node392	0.00	0.00	25.56	0.00	0.00
Node393	5.05	28.30	8.03	19.46	19.63
Node394	0.00	0.00	25.56	0.00	0.00
Node395	1.41	25.63	8.43	5.71	5.76
Node396	0.00	0.00	25.56	0.00	0.00
Node398	0.00	0.00	25.56	0.00	0.00
Node399	0.00	0.00	25.56	0.00	0.00
Node400	1.74	26.03	8.37	7.00	7.06
Node401	2.02	26.32	8.32	8.07	8.15
Node402	3.10	27.20	8.19	12.18	12.30
Node403	0.00	0.00	25.56	0.00	0.00
Node404	6.20	28.79	7.96	23.70	24.05
Node405	3.10	27.20	8.19	12.18	12.30
Node406	0.00	0.00	25.56	0.00	0.00
Node407	7.24	29.17	7.91	27.47	27.88
Node408	3.62	27.54	8.14	14.14	14.27
Node409	3.62	27.54	8.14	14.14	14.27
Node412	1.13	25.22	8.50	4.61	4.66
Node413	0.00	0.00	25.56	0.00	0.00
Node415	6.97	29.08	7.92	26.50	26.72
Node416	0.00	0.00	25.56	0.00	0.00
Node417	6.03	28.72	7.97	23.08	23.42
Node418	3.02	27.15	8.20	11.88	11.99
Node419	0.00	0.00	25.56	0.00	0.00
Node420	3.02	27.15	8.20	11.88	11.99
Node421	6.34	28.84	7.95	24.21	24.57
Node422	3.17	27.25	8.18	12.45	12.56
Node423	3.17	27.25	8.18	12.45	12.56
Node424	5.62	28.55	7.99	21.55	21.75
Node425	2.63	26.85	8.24	10.38	10.48
Node427	0.00	0.00	25.56	0.00	0.00
Node428	0.00	0.00	25.56	0.00	0.00
Node429	5.48	28.49	8.00	21.04	21.24
Node430	0.00	0.00	25.56	0.00	0.00
Node431	4.41	27.99	8.07	17.10	17.26
Node432	0.00	0.00	25.56	0.00	0.00
Node433	0.10	21.67	9.15	0.44	0.40
Node434	0.10	21.67	9.15	0.44	0.40
Node435	0.10	21.67	9.15	0.44	0.40
Node436	1.76	26.05	8.37	7.07	7.14
Node437	0.00	0.00	25.56	0.00	0.00
Node438	1.76	26.05	8.37	7.07	7.14
Node439	1.76	26.05	8.37	7.07	7.14

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node440	0.00	0.00	25.56	0.00	0.00
Node441	0.00	0.00	25.56	0.00	0.00
Node442	0.00	0.00	25.56	0.00	0.00
Node443	3.56	27.51	8.14	13.92	14.04
Node444	0.00	0.00	25.56	0.00	0.00
Node445	0.53	23.94	8.72	2.21	2.24
Node447	0.00	0.00	25.56	0.00	0.00
Node448	8.90	29.69	7.84	33.46	33.76
Node449	6.83	29.03	7.93	25.99	26.22
Node450	0.00	0.00	25.56	0.00	0.00
Node451	0.00	0.00	25.56	0.00	0.00
Node452	4.36	27.96	8.08	16.91	17.06
Node453	0.00	0.00	25.56	0.00	0.00
Node454	4.90	28.23	8.04	18.91	19.08
Node455	0.00	0.00	25.56	0.00	0.00
Node456	2.20	26.49	8.30	8.75	8.83
Node457	0.00	0.00	25.56	0.00	0.00
Node458	0.00	0.00	25.56	0.00	0.00
Node459	2.56	26.80	8.25	10.12	10.21
Node460	0.00	0.00	25.56	0.00	0.00
Node462	3.27	27.32	8.17	12.83	12.95
Node466	4.87	28.21	8.04	18.79	18.96
Node467	0.00	0.00	25.56	0.00	0.00
Node469	2.09	26.38	8.31	8.32	8.40
Node470	4.96	28.26	8.03	19.12	19.29
Node471	0.00	0.00	25.56	0.00	0.00
Node472	2.06	26.36	8.32	8.23	8.31
Node473	0.00	0.00	25.56	0.00	0.00
Node474	1.63	25.90	8.39	6.56	6.63
Node475	0.00	0.00	25.56	0.00	0.00
Node476	3.68	27.58	8.13	14.37	14.50
Node477	0.00	0.00	25.56	0.00	0.00
Node479	0.00	0.00	25.56	0.00	0.00
Node480	2.54	26.79	8.25	10.08	10.17
Node481	4.04	27.79	8.10	15.70	15.84
Node482	2.82	27.00	8.22	11.11	11.21
Node483	1.99	26.28	8.33	7.94	8.01
Node484	2.66	26.88	8.24	10.51	10.60
Node485	3.65	27.56	8.14	14.24	14.37
Node486	0.00	0.00	25.56	0.00	0.00
Node487	2.33	26.61	8.28	9.27	9.36
Node488	0.00	0.00	25.56	0.00	0.00
Node489	2.80	26.99	8.22	11.06	11.16
Node490	0.00	0.00	25.56	0.00	0.00
Node492	0.00	0.00	25.56	0.00	0.00
Node493	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node494	0.00	0.00	25.56	0.00	0.00
Node495	3.49	27.46	8.15	13.66	13.79
Node499	5.28	28.41	8.01	20.31	20.49
Node500	0.00	0.00	25.56	0.00	0.00
Node502	0.00	0.00	25.56	0.00	0.00
Node503	0.00	0.00	25.56	0.00	0.00
Node504	2.87	27.04	8.21	11.31	11.41
Node506	0.69	24.37	8.64	2.88	2.90
Node507	2.04	26.34	8.32	8.14	8.22
Node508	2.04	26.34	8.32	8.16	8.24
Node509	3.34	27.37	8.16	13.08	13.20
Node510	3.54	27.50	8.14	13.86	13.98
Node512	0.00	0.00	25.56	0.00	0.00
Node513	1.30	25.48	8.46	5.29	5.35
Node514	0.00	0.00	25.56	0.00	0.00
Node515	2.76	26.96	8.22	10.91	11.01
Node517	3.14	27.23	8.18	12.33	12.45
Node518	0.00	0.00	25.56	0.00	0.00
Node519	3.27	27.32	8.17	12.82	12.93
Node520	1.21	25.34	8.48	4.93	4.98
Node521	5.26	28.40	8.01	20.24	20.41
Node522	2.26	26.54	8.29	8.98	9.06
Node523	2.69	26.91	8.23	10.64	10.74
Node524	2.27	26.55	8.29	9.03	9.11
Node525	0.00	0.00	25.56	0.00	0.00
Node526	1.33	25.52	8.45	5.40	5.46
Node527	2.74	26.94	8.23	10.80	10.90
Node528	2.06	26.36	8.32	8.22	8.30
Node529	0.00	0.00	25.56	0.00	0.00
Node530	1.36	25.55	8.45	5.49	5.55
Node531	0.00	0.00	25.56	0.00	0.00
Node533	0.00	0.00	25.56	0.00	0.00
Node534	0.79	24.60	8.61	3.27	3.30
Node535	1.11	25.19	8.51	4.54	4.58
Node536	1.20	25.33	8.48	4.89	4.93
Node537	3.26	27.31	8.17	12.79	12.90
Node538	0.00	0.00	25.56	0.00	0.00
Node540	0.00	0.00	25.56	0.00	0.00
Node541	2.67	26.89	8.24	10.57	10.67
Node542	0.00	0.00	25.56	0.00	0.00
Node544	3.63	27.55	8.14	14.17	14.30
Node545	0.00	0.00	25.56	0.00	0.00
Node547	4.29	27.92	8.08	16.65	16.80
Node549	0.00	0.00	25.56	0.00	0.00
Node550	0.00	0.00	25.56	0.00	0.00
Node551	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node552	6.94	29.06	7.92	26.38	26.60
Node553	0.00	0.00	25.56	0.00	0.00
Node554	2.97	27.11	8.20	11.68	11.78
Node555	0.87	24.76	8.58	3.58	3.62
Node556	0.00	0.00	25.56	0.00	0.00
Node557	1.71	25.99	8.38	6.86	6.92
Node559	0.00	0.00	25.56	0.00	0.00
Node563	9.94	29.98	7.80	37.21	37.54
Node565	0.00	0.00	25.56	0.00	0.00
Node566	2.40	26.67	8.27	9.52	9.61
Node568	0.00	0.00	25.56	0.00	0.00
Node569	0.00	0.00	25.56	0.00	0.00
Node570	0.00	0.00	25.56	0.00	0.00
Node572	0.00	0.00	25.56	0.00	0.00
Node574	0.00	0.00	25.56	0.00	0.00
Node575	23.93	32.49	7.49	85.98	87.27
Node576	0.00	0.00	25.56	0.00	0.00
Node578	0.00	0.00	25.56	0.00	0.00
Node579	0.00	0.00	25.56	0.00	0.00
Node580	0.00	0.00	25.56	0.00	0.00
Node581	0.00	0.00	25.56	0.00	0.00
Node583	0.00	0.00	25.56	0.00	0.00
Node584	0.00	0.00	25.56	0.00	0.00
Node585	0.00	0.00	25.56	0.00	0.00
Node587	0.00	0.00	25.56	0.00	0.00
Node588	3.99	27.76	8.11	15.52	15.66
Node589	0.00	0.00	25.56	0.00	0.00
Node590	3.81	27.66	8.12	14.85	14.99
Node591	0.00	0.00	25.56	0.00	0.00
Node592	0.00	0.00	25.56	0.00	0.00
Node593	0.00	0.00	25.56	0.00	0.00
Node594	0.00	0.00	25.56	0.00	0.00
Node599	2.00	26.30	8.33	8.00	8.08
Node600	0.00	0.00	25.56	0.00	0.00
Node601	1.94	26.24	8.34	7.76	7.83
Node602	1.32	25.49	8.46	5.34	5.39
Node603	0.00	0.00	25.56	0.00	0.00
Node604	0.00	0.00	25.56	0.00	0.00
Node605	1.36	25.56	8.45	5.52	5.57
Node606	2.74	26.94	8.23	10.82	10.92
Node608	3.43	27.42	8.16	13.43	13.55
Node609	0.00	0.00	25.56	0.00	0.00
Node610	3.09	27.20	8.19	12.16	12.27
Node611	0.00	0.00	25.56	0.00	0.00
Node612	3.50	27.47	8.15	13.68	13.81
Node613	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node614	5.58	28.54	7.99	21.42	21.61
Node615	0.00	0.00	25.56	0.00	0.00
Node616	3.41	27.41	8.16	13.34	13.47
Node618	0.00	0.00	25.56	0.00	0.00
Node619	3.81	27.66	8.12	14.85	14.98
Node620	0.00	0.00	25.56	0.00	0.00
Node621	0.00	0.00	25.56	0.00	0.00
Node622	3.43	27.42	8.16	13.43	13.55
Node623	6.19	28.79	7.96	23.66	23.87
Node624	0.00	0.00	25.56	0.00	0.00
Node625	3.65	27.56	8.13	14.26	14.39
Node626	0.00	0.00	25.56	0.00	0.00
Node627	3.56	27.50	8.14	13.90	14.03
Node628	0.00	0.00	25.56	0.00	0.00
Node630	3.45	27.44	8.15	13.50	13.62
Node631	0.00	0.00	25.56	0.00	0.00
Node632	6.89	29.05	7.92	26.21	26.60
Node633	0.00	0.00	25.56	0.00	0.00
Node634	0.00	0.00	25.56	0.00	0.00
Node635	0.00	0.00	25.56	0.00	0.00
Node636	3.45	27.44	8.15	13.50	13.62
Node637	3.43	27.42	8.16	13.42	13.54
Node638	0.00	0.00	25.56	0.00	0.00
Node639	0.00	0.00	25.56	0.00	0.00
Node640	3.38	27.39	8.16	13.24	13.36
Node642	3.55	27.50	8.14	13.86	13.99
Node643	0.00	0.00	25.56	0.00	0.00
Node644	3.18	27.26	8.18	12.47	12.58
Node646	0.00	0.00	25.56	0.00	0.00
Node647	0.00	0.00	25.56	0.00	0.00
Node648	0.00	0.00	25.56	0.00	0.00
Node649	1.82	26.11	8.36	7.30	7.37
Node650	1.86	26.15	8.35	7.44	7.50
Node651	3.20	27.27	8.18	12.55	12.66
Node652	7.23	29.17	7.91	27.43	27.66
Node653	4.63	28.10	8.06	17.89	18.05
Node654	3.12	27.22	8.19	12.27	12.38
Node655	0.00	0.00	25.56	0.00	0.00
Node656	0.00	0.00	25.56	0.00	0.00
Node657	2.52	26.76	8.25	9.97	10.06
Node658	0.00	0.00	25.56	0.00	0.00
Node659	2.77	26.97	8.22	10.94	11.04
Node660	0.00	0.00	25.56	0.00	0.00
Node661	0.00	0.00	25.56	0.00	0.00
Node662	0.00	0.00	25.56	0.00	0.00
Node663	1.70	25.98	8.38	6.85	6.92

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node664	0.00	0.00	25.56	0.00	0.00
Node665	3.26	27.32	8.17	12.80	12.92
Node666	8.71	29.64	7.84	32.81	33.10
Node667	0.00	0.00	25.56	0.00	0.00
Node668	3.20	27.27	8.18	12.54	12.66
Node669	2.77	26.97	8.22	10.95	11.05
Node670	0.00	0.00	25.56	0.00	0.00
Node671	4.30	27.93	8.08	16.68	16.83
Node672	1.73	26.01	8.37	6.95	7.02
Node674	0.00	0.00	25.56	0.00	0.00
Node675	3.51	27.48	8.15	13.74	13.87
Node676	0.00	0.00	25.56	0.00	0.00
Node677	3.76	27.63	8.13	14.67	14.81
Node678	0.00	0.00	25.56	0.00	0.00
Node679	0.00	0.00	25.56	0.00	0.00
Node680	1.45	25.68	8.43	5.88	5.93
Node681	2.52	26.77	8.25	9.99	10.08
Node682	2.74	26.94	8.23	10.81	10.91
Node683	3.75	27.62	8.13	14.63	14.76
Node684	3.94	27.73	8.11	15.34	15.48
Node685	1.59	25.85	8.40	6.40	6.46
Node686	0.00	0.00	25.56	0.00	0.00
Node687	0.00	0.00	25.56	0.00	0.00
Node688	0.00	0.00	25.56	0.00	0.00
Node689	4.28	27.92	8.08	16.62	16.77
Node690	0.00	0.00	25.56	0.00	0.00
Node691	0.00	0.00	25.56	0.00	0.00
Node692	8.49	29.57	7.85	32.00	32.28
Node694	5.66	28.57	7.99	21.69	21.88
Node695	5.35	28.44	8.01	20.58	20.76
Node696	0.00	0.00	25.56	0.00	0.00
Node697	0.00	0.00	25.56	0.00	0.00
Node698	0.10	21.67	9.15	0.44	0.40
Node699	1.45	25.68	8.43	5.88	5.93
Node700	4.44	28.00	8.07	17.21	17.36
Node701	0.00	0.00	25.56	0.00	0.00
Node702	2.44	26.70	8.26	9.67	9.75
Node704	0.00	0.00	25.56	0.00	0.00
Node705	2.65	26.87	8.24	10.49	10.58
Node706	0.00	0.00	25.56	0.00	0.00
Node707	0.00	0.00	25.56	0.00	0.00
Node708	3.93	27.73	8.11	15.30	15.44
Node709	0.00	0.00	25.56	0.00	0.00
Node712	3.86	27.69	8.12	15.04	15.18
Node713	3.30	27.34	8.17	12.95	13.07
Node714	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node715	0.00	0.00	25.56	0.00	0.00
Node716	1.15	25.26	8.50	4.71	4.75
Node717	5.29	28.41	8.01	20.35	20.53
Node718	3.11	27.21	8.19	12.24	12.35
Node719	3.47	27.45	8.15	13.56	13.69
Node720	0.00	0.00	25.56	0.00	0.00
Node721	0.00	0.00	25.56	0.00	0.00
Node722	0.00	0.00	25.56	0.00	0.00
Node723	3.26	27.31	8.17	12.78	12.90
Node724	0.00	0.00	25.56	0.00	0.00
Node725	2.77	26.96	8.22	10.93	11.02
Node726	0.00	0.00	25.56	0.00	0.00
Node727	0.00	0.00	25.56	0.00	0.00
Node728	5.29	28.41	8.01	20.35	20.53
Node729	0.00	0.00	25.56	0.00	0.00
Node730	2.35	26.62	8.28	9.33	9.41
Node731	1.83	26.13	8.35	7.35	7.42
Node732	2.43	26.69	8.27	9.64	9.73
Node733	2.61	26.84	8.24	10.31	10.41
Node734	0.00	0.00	25.56	0.00	0.00
Node735	3.07	27.18	8.19	12.07	12.18
Node738	0.00	0.00	25.56	0.00	0.00
Node739	0.00	0.00	25.56	0.00	0.00
Node741	0.00	0.00	25.56	0.00	0.00
Node742	3.74	27.61	8.13	14.58	14.72
Node743	0.00	0.00	25.56	0.00	0.00
Node744	5.17	28.36	8.02	19.91	20.09
Node745	0.00	0.00	25.56	0.00	0.00
Node746	0.00	0.00	25.56	0.00	0.00
Node747	6.11	28.75	7.96	23.35	23.57
Node748	0.00	0.00	25.56	0.00	0.00
Node749	5.33	28.43	8.01	20.48	20.67
Node750	0.00	0.00	25.56	0.00	0.00
Node751	0.00	0.00	25.56	0.00	0.00
Node752	3.60	27.53	8.14	14.05	14.19
Node754	5.63	28.56	7.99	21.59	21.78
Node755	3.69	27.58	8.13	14.40	14.52
Node756	3.72	27.60	8.13	14.52	14.65
Node757	2.88	27.05	8.21	11.36	11.46
Node758	0.00	0.00	25.56	0.00	0.00
Node759	6.79	29.01	7.93	25.85	26.08
Node760	4.85	28.21	8.04	18.72	18.90
Node761	4.19	27.87	8.09	16.26	16.40
Node762	0.00	0.00	25.56	0.00	0.00
Node763	2.91	27.07	8.21	11.45	11.55
Node764	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node765	0.00	0.00	25.56	0.00	0.00
Node766	3.88	27.69	8.12	15.10	15.25
Node767	0.00	0.00	25.56	0.00	0.00
Node768	1.42	25.64	8.43	5.76	5.81
Node770	2.79	26.98	8.22	11.01	11.11
Node771	0.00	0.00	25.56	0.00	0.00
Node772	2.93	27.08	8.21	11.53	11.64
Node773	3.67	27.57	8.13	14.31	14.44
Node774	3.96	27.74	8.11	15.41	15.55
Node775	0.00	0.00	25.56	0.00	0.00
Node777	2.63	26.86	8.24	10.40	10.50
Node778	0.00	0.00	25.56	0.00	0.00
Node779	3.87	27.69	8.12	15.07	15.21
Node780	2.84	27.02	8.22	11.19	11.30
Node783	2.36	26.63	8.28	9.35	9.44
Node784	2.73	26.93	8.23	10.78	10.87
Node785	3.01	27.14	8.20	11.86	11.97
Node786	0.00	0.00	25.56	0.00	0.00
Node787	9.51	29.87	7.81	35.67	35.99
Node788	1.25	25.40	8.47	5.09	5.14
Node789	2.05	26.35	8.32	8.18	8.24
Node791	3.06	27.18	8.19	12.04	12.15
Node792	2.95	27.10	8.20	11.63	11.74
Node793	0.00	0.00	25.56	0.00	0.00
Node794	0.00	0.00	25.56	0.00	0.00
Node795	3.34	27.37	8.16	13.09	13.21
Node796	4.89	28.22	8.04	18.85	19.03
Node797	0.00	0.00	25.56	0.00	0.00
Node798	1.06	25.11	8.52	4.35	4.39
Node799	0.00	0.00	25.56	0.00	0.00
Node800	0.00	0.00	25.56	0.00	0.00
Node801	0.00	0.00	25.56	0.00	0.00
Node802	2.81	27.00	8.22	11.09	11.20
Node803	0.00	0.00	25.56	0.00	0.00
Node804	0.00	0.00	25.56	0.00	0.00
Node805	2.81	27.00	8.22	11.09	11.20
Node806	0.10	21.67	9.15	0.44	0.40
Node807	0.00	0.00	25.56	0.00	0.00
Node808	0.00	0.00	25.56	0.00	0.00
Node809	4.73	28.15	8.05	18.28	18.44
Node811	0.00	0.00	25.56	0.00	0.00
Node813	0.00	0.00	25.56	0.00	0.00
Node814	0.00	0.00	25.56	0.00	0.00
Node815	4.61	28.09	8.06	17.82	17.99
Node816	0.00	0.00	25.56	0.00	0.00
Node818	0.10	21.67	9.15	0.44	0.40

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node819	0.00	0.00	25.56	0.00	0.00
Node820	0.92	24.85	8.56	3.77	3.81
Node821	18.03	31.64	7.59	65.69	66.29
Node822	0.00	0.00	25.56	0.00	0.00
Node823	0.10	21.67	9.15	0.44	0.40
Node825	1.31	25.49	8.46	5.31	5.39
Node826	0.10	21.67	9.15	0.44	0.40
Node827	0.32	23.19	8.86	1.36	1.38
Node828	0.00	0.00	25.56	0.00	0.00
Node829	2.12	26.42	8.31	8.47	8.55
Node830	0.00	0.00	25.56	0.00	0.00
Node831	6.50	28.91	7.94	24.79	25.02
Node832	0.00	0.00	25.56	0.00	0.00
Node833	0.79	24.58	8.61	3.24	3.27
Node834	0.00	0.00	25.56	0.00	0.00
Node835	2.30	26.58	8.28	9.15	9.24
Node836	0.00	0.00	25.56	0.00	0.00
Node837	0.00	0.00	25.56	0.00	0.00
Node838	0.00	0.00	25.56	0.00	0.00
Node839	0.00	0.00	25.56	0.00	0.00
Node840	7.08	29.12	7.91	26.91	27.16
Node841	4.18	27.87	8.09	16.24	16.39
Node842	5.05	28.30	8.03	19.46	19.63
Node843	0.00	0.00	25.56	0.00	0.00
Node844	4.19	27.87	8.09	16.28	16.43
Node845	3.61	27.54	8.14	14.11	14.25
Node846	0.00	0.00	25.56	0.00	0.00
Node847	3.34	27.36	8.16	13.08	13.20
Node849	0.00	0.00	25.56	0.00	0.00
Node850	3.12	27.22	8.19	12.25	12.36
Node851	3.05	27.17	8.19	11.98	12.09
Node852	0.00	0.00	25.56	0.00	0.00
Node853	3.10	27.21	8.19	12.19	12.30
Node854	0.00	0.00	25.56	0.00	0.00
Node855	0.00	0.00	25.56	0.00	0.00
Node856	2.92	27.08	8.21	11.50	11.61
Node857	0.10	21.67	9.15	0.44	0.40
Node858	0.00	0.00	25.56	0.00	0.00
Node859	0.10	21.67	9.15	0.44	0.40
Node860	0.82	24.65	8.60	3.37	3.40
Node861	3.29	27.33	8.17	12.91	13.03
Node863	0.00	0.00	25.56	0.00	0.00
Node864	2.05	26.35	8.32	8.20	8.27
Node865	2.31	26.59	8.28	9.19	9.29
Node866	0.00	0.00	25.56	0.00	0.00
Node867	2.53	26.78	8.25	10.02	10.11

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node868	0.95	24.91	8.55	3.89	3.93
Node869	4.33	27.95	8.08	16.80	16.96
Node870	2.91	27.07	8.21	11.47	11.57
Node871	0.00	0.00	25.56	0.00	0.00
Node872	1.51	25.76	8.41	6.11	6.17
Node873	1.19	25.31	8.49	4.84	4.88
Node874	3.43	27.42	8.16	13.41	13.54
Node875	0.00	0.00	25.56	0.00	0.00
Node876	2.57	26.81	8.25	10.18	10.27
Node877	0.00	0.00	25.56	0.00	0.00
Node878	1.51	25.75	8.41	6.08	6.14
Node879	1.50	25.74	8.42	6.07	6.13
Node880	1.88	26.18	8.35	7.54	7.61
Node881	0.00	0.00	25.56	0.00	0.00
Node882	2.31	26.59	8.28	9.18	9.27
Node883	0.00	0.00	25.56	0.00	0.00
Node884	4.01	27.77	8.10	15.61	15.75
Node886	0.00	0.00	25.56	0.00	0.00
Node887	5.19	28.37	8.02	19.99	20.17
Node888	0.00	0.00	25.56	0.00	0.00
Node889	0.00	0.00	25.56	0.00	0.00
Node890	0.00	0.00	25.56	0.00	0.00
Node891	2.57	26.81	8.25	10.19	10.29
Node892	0.00	0.00	25.56	0.00	0.00
Node893	1.73	26.02	8.37	6.96	7.03
Node894	1.26	25.42	8.47	5.13	5.18
Node896	0.76	24.53	8.62	3.15	3.18
Node897	16.18	31.33	7.63	59.24	59.76
Node898	5.49	28.50	8.00	21.10	21.29
Node899	5.60	28.54	7.99	21.48	21.65
Node900	5.66	28.57	7.99	21.69	21.89
Node901	0.00	0.00	25.56	0.00	0.00
Node902	2.88	27.04	8.21	11.34	11.43
Node903	0.00	0.00	25.56	0.00	0.00
Node904	0.00	0.00	25.56	0.00	0.00
Node905	0.00	0.00	25.56	0.00	0.00
Node906	0.00	0.00	25.56	0.00	0.00
Node907	7.32	29.20	7.90	27.76	28.02
Node908	0.00	0.00	25.56	0.00	0.00
Node909	0.00	0.00	25.56	0.00	0.00
Node910	0.00	0.00	25.56	0.00	0.00
Node911	0.00	0.00	25.56	0.00	0.00
Node912	0.10	21.67	9.15	0.44	0.40
Node913	7.28	29.19	7.90	27.63	27.88
Node914	5.25	28.39	8.02	20.19	20.37
Node915	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node916	0.00	0.00	25.56	0.00	0.00
Node917	0.00	0.00	25.56	0.00	0.00
Node918	5.11	28.33	8.02	19.70	19.88
Node919	0.00	0.00	25.56	0.00	0.00
Node920	0.00	0.00	25.56	0.00	0.00
Node921	5.62	28.55	7.99	21.54	21.74
Node922	5.09	28.32	8.03	19.62	19.79
Node923	2.29	26.57	8.29	9.09	9.17
Node924	4.74	28.15	8.05	18.30	18.46
Node925	1.84	26.14	8.35	7.39	7.46
Node926	9.61	29.89	7.81	36.01	36.34
Node927	0.00	0.00	25.56	0.00	0.00
Node928	0.00	0.00	25.56	0.00	0.00
Node929	8.83	29.67	7.84	33.21	33.52
Node930	2.84	27.02	8.22	11.20	11.30
Node935	0.00	0.00	25.56	0.00	0.00
Node936	0.00	0.00	25.56	0.00	0.00
Node937	0.00	0.00	25.56	0.00	0.00
Node938	0.00	0.00	25.56	0.00	0.00
Node939	0.00	0.00	25.56	0.00	0.00
Node940	0.00	0.00	25.56	0.00	0.00
Node941	0.00	0.00	25.56	0.00	0.00
Node942	0.00	0.00	25.56	0.00	0.00
Node943	5.45	28.48	8.00	20.95	21.15
Node944	3.11	27.21	8.19	12.21	12.33
Node945	0.10	21.67	9.15	0.44	0.40
Node946	2.95	27.10	8.20	11.60	11.71
Node947	5.35	28.43	8.01	20.56	20.74
Node948	6.06	28.74	7.97	23.19	23.39
Node949	0.00	0.00	25.56	0.00	0.00
Node950	0.00	0.00	25.56	0.00	0.00
Node951	8.61	29.61	7.85	32.43	32.73
Node952	0.00	0.00	25.56	0.00	0.00
Node953	8.57	29.60	7.85	32.27	32.57
Node954	2.17	26.46	8.30	8.65	8.72
Node958	3.44	27.43	8.15	13.48	13.59
Node959	0.00	0.00	25.56	0.00	0.00
Node960	0.00	0.00	25.56	0.00	0.00
Node961	0.00	0.00	25.56	0.00	0.00
Node962	0.00	0.00	25.56	0.00	0.00
Node963	2.75	26.95	8.23	10.85	10.95
Node965	0.00	0.00	25.56	0.00	0.00
Node966	0.00	0.00	25.56	0.00	0.00
Node967	0.00	0.00	25.56	0.00	0.00
Node968	0.00	0.00	25.56	0.00	0.00
Node969	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node970	1.19	25.31	8.49	4.85	4.90
Node971	4.88	28.22	8.04	18.83	19.00
Node973	81.01	36.68	7.03	273.51	275.79
Node974	5.96	28.69	7.97	22.80	23.01
Node824	18.56	31.73	7.58	67.49	68.10
Node981	20.72	32.05	7.54	74.97	75.61
Node982	0.00	0.00	25.56	0.00	0.00
Node983	0.00	0.00	25.56	0.00	0.00
Node984	8.14	29.47	7.87	30.75	31.01
Node986	25.81	32.73	7.46	92.39	93.20
Node987	50.25	34.93	7.21	174.01	175.49
Node988	38.99	34.06	7.31	136.76	137.89
Node989	28.99	33.09	7.42	103.21	104.08
Node992	0.00	0.00	25.56	0.00	0.00
Node995	0.00	0.00	25.56	0.00	0.00
Node996	0.00	0.00	25.56	0.00	0.00
Node997	0.00	0.00	25.56	0.00	0.00
Node998	0.00	0.00	25.56	0.00	0.00
Node999	0.10	21.67	9.15	0.44	0.40
Node1000	0.00	0.00	25.56	0.00	0.00
Node1001	0.10	21.67	9.15	0.44	0.40
Node1002	0.00	0.00	25.56	0.00	0.00
Node1003	0.00	0.00	25.56	0.00	0.00
Node1004	0.00	0.00	25.56	0.00	0.00
Node1005	0.00	0.00	25.56	0.00	0.00
Node1006	0.00	0.00	25.56	0.00	0.00
Node1008	0.00	0.00	25.56	0.00	0.00
Node1010	0.00	0.00	25.56	0.00	0.00
Node1011	0.00	0.00	25.56	0.00	0.00
Node1012	2.67	26.89	8.24	10.56	10.65
Node557.1	0.00	0.00	25.56	0.00	0.00
Node1015	0.00	0.00	25.56	0.00	0.00
Node1016	0.00	0.00	25.56	0.00	0.00
Node1017	0.00	0.00	25.56	0.00	0.00
Node1018	0.00	0.00	25.56	0.00	0.00
Node1023	0.00	0.00	25.56	0.00	0.00
Node1024	0.00	0.00	25.56	0.00	0.00
Node1025	0.00	0.00	25.56	0.00	0.00
Node1026	0.00	0.00	25.56	0.00	0.00
Node1027	0.00	0.00	25.56	0.00	0.00
Node1029	0.00	0.00	25.56	0.00	0.00
Node1030	0.00	0.00	25.56	0.00	0.00
Node1034	0.00	0.00	25.56	0.00	0.00
Node1035	0.00	0.00	25.56	0.00	0.00
Node1036	0.00	0.00	25.56	0.00	0.00
Node1038	0.00	0.00	25.56	0.00	0.00

Node	Area (ac)	TC	Intensity (in/hr)	100-year Peak Flow (cfs)	
				Rational Method	XPSWMM Model Result
Node1039	0.00	0.00	25.56	0.00	0.00
Node1040	0.00	0.00	25.56	0.00	0.00
Node1041	0.00	0.00	25.56	0.00	0.00
Node1046	0.00	0.00	25.56	0.00	0.00
Node1047	0.93	24.87	8.56	3.81	3.85
Node1048	0.00	0.00	25.56	0.00	0.00
Node1049	0.00	0.00	25.56	0.00	0.00
Node1050	0.00	0.00	25.56	0.00	0.00
Node1051	0.00	0.00	25.56	0.00	0.00
Node1052	0.00	0.00	25.56	0.00	0.00
Node1053	0.00	0.00	25.56	0.00	0.00
Node1054	0.00	0.00	25.56	0.00	0.00
Node1055	0.00	0.00	25.56	0.00	0.00
Node1056	2.86	27.03	8.21	11.27	11.37
Node1057	0.00	0.00	25.56	0.00	0.00
Node1058	0.00	0.00	25.56	0.00	0.00
Node1059	3.32	27.35	8.17	13.01	13.13
Node1062	2.31	26.59	8.28	9.17	9.25
Node1063	0.00	0.00	25.56	0.00	0.00
Node1065	0.00	0.00	25.56	0.00	0.00
Node1066	0.00	0.00	25.56	0.00	0.00
Node1053.1	0.00	0.00	25.56	0.00	0.00
Node1054.1	0.00	0.00	25.56	0.00	0.00
Node1071	0.00	0.00	25.56	0.00	0.00
Node1072	0.00	0.00	25.56	0.00	0.00
Node1073	0.00	0.00	25.56	0.00	0.00
Node1074	1.05	25.09	8.52	4.30	4.34
Node1075	4.01	27.77	8.10	15.60	15.74
Node1076	0.00	0.00	25.56	0.00	0.00
Node1077	0.00	0.00	25.56	0.00	0.00
Node1078	0.00	0.00	25.56	0.00	0.00
Node1079	0.00	0.00	25.56	0.00	0.00
Node1080	0.00	0.00	25.56	0.00	0.00
Node1081	0.00	0.00	25.56	0.00	0.00
Node1082	0.00	0.00	25.56	0.00	0.00
Node1085	0.00	0.00	25.56	0.00	0.00
Node1086	0.00	0.00	25.56	0.00	0.00
Node1029.1	0.00	0.00	25.56	0.00	0.00
Node1088	0.00	0.00	25.56	0.00	0.00
Node1017.1	0.00	0.00	25.56	0.00	0.00
Node1093	0.00	0.00	25.56	0.00	0.00
Node1094	0.00	0.00	25.56	0.00	0.00
Node1095	0.00	0.00	25.56	0.00	0.00

ATTACHMENT 3

Cross-Sections with Water Surface Elevations



Academy St. System

Poor Farm Ditch System

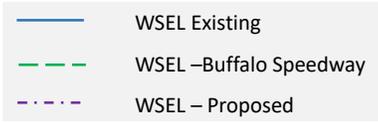
College St System

Buffalo Speedway System

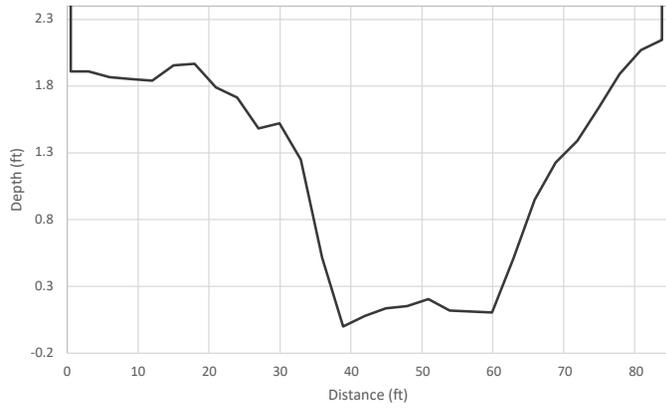
Kirby Dr. System



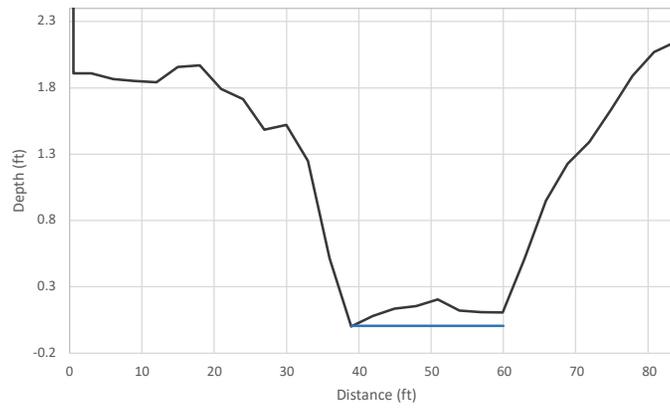
Cason Street



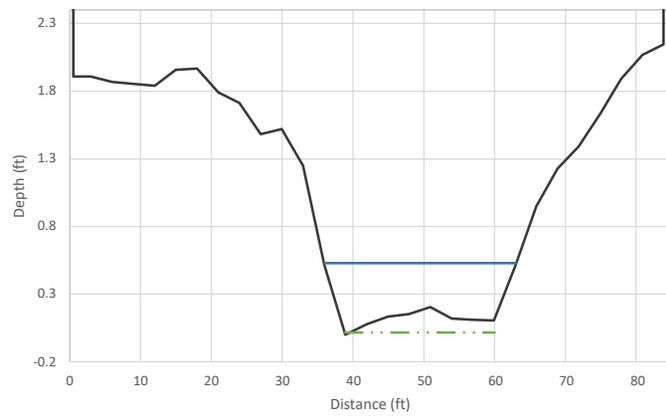
2-Year Scenario



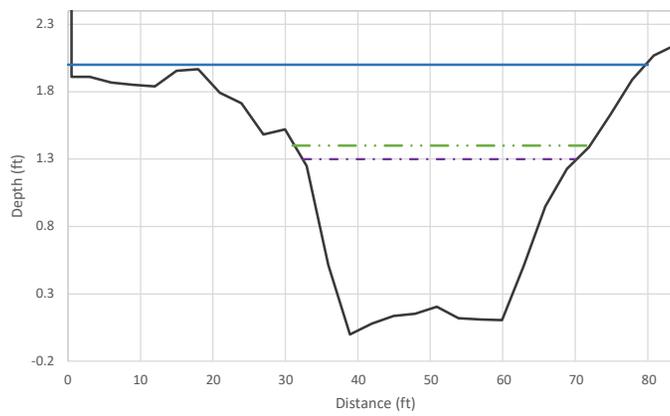
10-Year Scenario



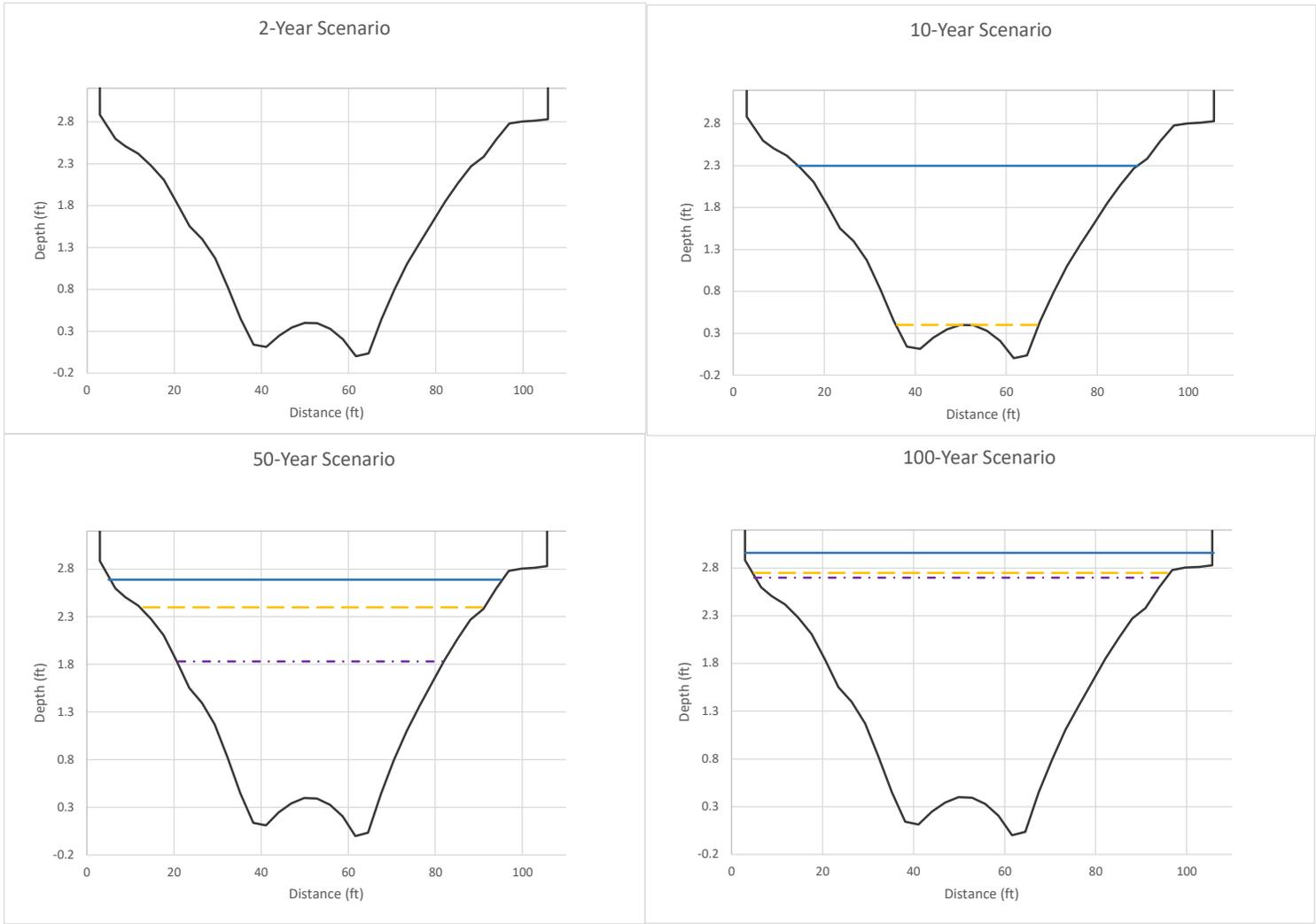
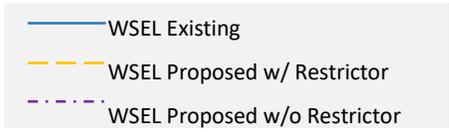
50-Year Scenario



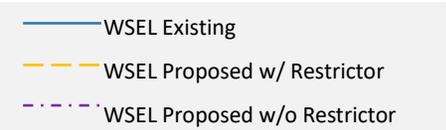
100-Year Scenario



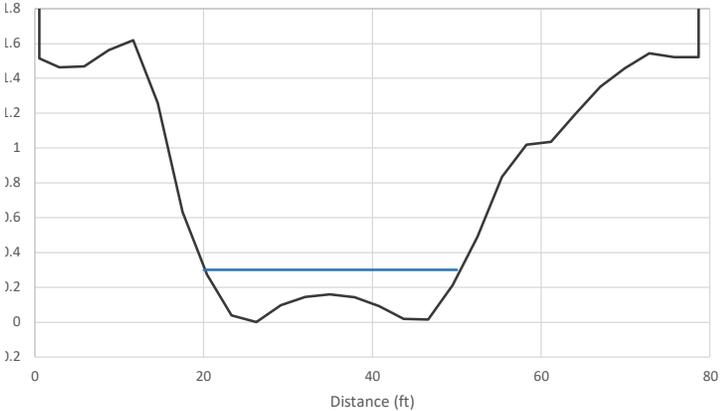
Oberlin Street



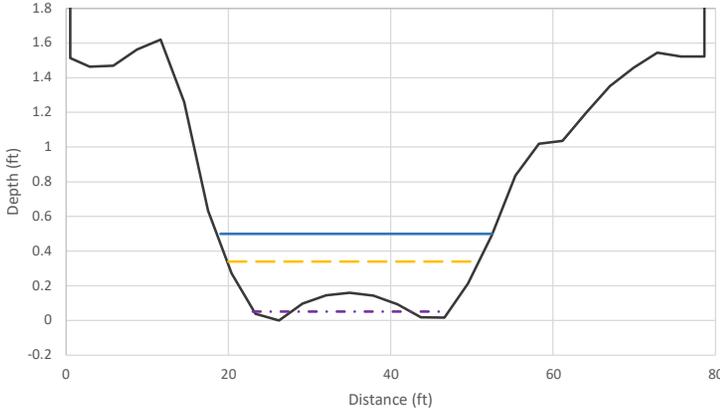
West Point Drive



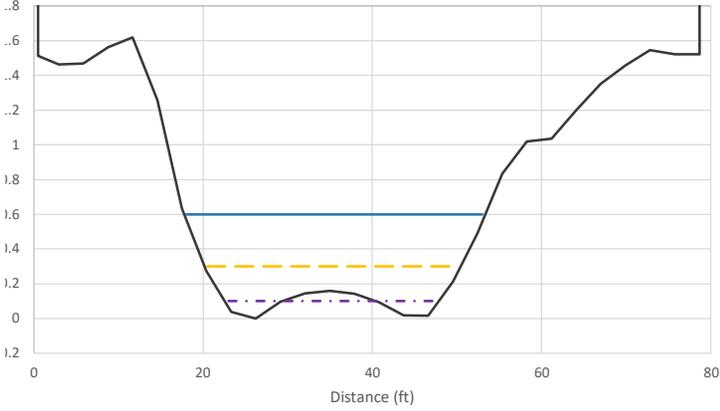
2-Year Scenario



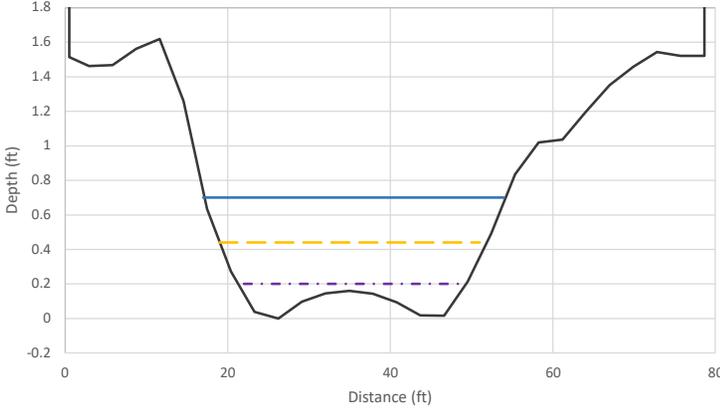
10-Year Scenario



50-Year Scenario



100-Year Scenario



ATTACHMENT 4

Opinion of Probable Cost

City of West University - Opinion of Probable Cost for Drainage Improvements
 Community Drive Trunkline

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 136,000.00	\$ 136,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 68,000.00	\$ 68,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 676,000.00	\$ 676,000.00
Subtotal General Items:					\$ 880,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	8,990	\$ 15.00	\$ 134,850.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	8,990	\$ 90.00	\$ 809,100.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	11,013	\$ 4.00	\$ 44,051.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	280	\$ 165.00	\$ 46,200.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	5,775	\$ 5.00	\$ 28,875.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	5,775	\$ 85.00	\$ 490,875.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	18	\$ 2,000.00	\$ 36,000.00
	Driveway Reconnection	L.S.	1	\$ 238,500.00	\$ 238,500.00
Subtotal Paving Items:					\$ 1,828,451.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	4,280	\$ 30.00	\$ 128,400.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	36	\$ 600.00	\$ 21,600.00
	24" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 115.00	\$ -
	30" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 150.00	\$ -
	36" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 180.00	\$ -
	42" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 215.00	\$ -
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 250.00	\$ -
	60" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 350.00	\$ -
	72" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 485.00	\$ -
	5'x4' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 325.00	\$ -
	5'x5' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 382.00	\$ -
	7'x5' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 550.00	\$ -
	8'x4' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	665	\$ 600.00	\$ 399,000.00
	8'x6' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	1,920	\$ 690.00	\$ 1,324,800.00
	10'x4' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 790.00	\$ -
	10'x5' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 808.00	\$ -
	10'x6' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,750	\$ 845.00	\$ 2,323,750.00
	10'x7' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	-	\$ 865.00	\$ -
	10'x10' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	440	\$ 916.00	\$ 403,040.00
	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	Ea.	-	\$ 3,500.00	\$ -
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	-	\$ 6,340.00	\$ -
	Manholes (For 78" Dia. Pipe and Larger) (All Types)	Ea.	12	\$ 16,500.00	\$ 198,000.00
	Inlets (Type BB with grate)	Ea.	36	\$ 3,500.00	\$ 126,000.00
Subtotal Drainage Items:					\$ 4,924,590.00
Estimated Probable Cost of Construction:					\$ 7,633,041.00
30% Contingency:					\$ 2,289,912.30
Total Estimated Probable Cost of Construction:					\$ 9,922,953.30
	Design Engineering Services				\$ 992,295.33
	Bid Phase Services				\$ 297,688.60
	Construction Admin Services				\$ 496,147.67
	Surveying Services				\$ 51,360.00
	Geotechnical Services				\$ 27,000.00
	Urban Forester				\$ 49,614.77
OPCC Including Professional Services:					\$ 11,837,059.66
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 14,401,592.99
\$ 14,500,000.00					

City of West University - Opinion of Probable Cost
Academy System (Area 3)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 117,000.00	\$ 117,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 59,000.00	\$ 59,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 585,000.00	\$ 585,000.00
Subtotal General Items:					\$ 761,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	16,880	\$ 15.00	\$ 253,200.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	16,880	\$ 90.00	\$ 1,519,200.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	20,678	\$ 4.00	\$ 82,712.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	525	\$ 165.00	\$ 86,625.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	15,460	\$ 5.00	\$ 77,300.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	11,360	\$ 85.00	\$ 965,600.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	32	\$ 2,000.00	\$ 64,000.00
	Driveway Reconnection	L.S.	1	\$ 457,300.00	\$ 457,300.00
Subtotal Paving Items:					\$ 3,505,937.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	8,560	\$ 30.00	\$ 256,800.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	86	\$ 600.00	\$ 51,600.00
	24" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,060	\$ 115.00	\$ 236,900.00
	36" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,510	\$ 180.00	\$ 451,800.00
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	3,990	\$ 250.00	\$ 997,500.00
	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	Ea.	24	\$ 3,500.00	\$ 84,000.00
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	17	\$ 6,340.00	\$ 107,780.00
	Inlets (Type BB with grate)	Ea.	45	\$ 3,500.00	\$ 157,500.00
Subtotal Drainage Items:					\$ 2,343,880.00
Estimated Probable Cost of Construction:					\$ 6,610,817.00
30% Contingency:					\$ 1,983,245.10
Total Estimated Probable Cost of Construction:					\$ 8,594,062.10
	Design Engineering Services				\$ 859,406.21
	Bid Phase Services				\$ 257,821.86
	Construction Admin Services				\$ 429,703.11
	Surveying Services				\$ 55,440.00
	Geotechnical Services				\$ 48,600.00
	Urban Forester				\$ 42,970.31
OPCC Including Professional Services:					\$ 10,288,003.59
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 12,516,929.43
\$					12,600,000.00

City of West University - Opinion of Probable Cost
Academy System (Area 4)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 17,000.00	\$ 17,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 9,000.00	\$ 9,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 83,000.00	\$ 83,000.00
Subtotal General Items:					\$ 109,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	3,460	\$ 15.00	\$ 51,900.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	3,460	\$ 90.00	\$ 311,400.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	4,239	\$ 4.00	\$ 16,954.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	110	\$ 165.00	\$ 18,150.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	3,085	\$ 5.00	\$ 15,425.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	3,085	\$ 85.00	\$ 262,225.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	6	\$ 2,000.00	\$ 12,000.00
	Driveway Reconnection	L.S.	1	\$ 103,300.00	\$ 103,300.00
Subtotal Paving Items:					\$ 791,354.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	960	\$ 30.00	\$ 28,800.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	15	\$ 600.00	\$ 9,000.00
	36" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	960	\$ 180.00	\$ 172,800.00
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	860	\$ 250.00	\$ 215,000.00
	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	Ea.	7	\$ 3,500.00	\$ 24,500.00
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	3	\$ 6,340.00	\$ 19,020.00
	Inlets (Type BB with grate)	Ea.	10	\$ 3,500.00	\$ 35,000.00
Subtotal Drainage Items:					\$ 504,120.00
Estimated Probable Cost of Construction:					\$ 1,404,474.00
30% Contingency:					\$ 421,342.20
Total Estimated Probable Cost of Construction:					\$ 1,825,816.20
	Design Engineering Services				\$ 182,581.62
	Bid Phase Services				\$ 54,774.49
	Construction Admin Services				\$ 91,290.81
	Surveying Services				\$ 21,840.00
	Geotechnical Services				\$ 13,500.00
	Urban Forester				\$ 9,129.08
OPCC Including Professional Services:					\$ 2,198,932.20
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 2,675,337.24
\$					2,700,000.00

City of West University - Opinion of Probable Cost
Academy System (Area 5 Part 1)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 6,000.00	\$ 6,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 3,000.00	\$ 3,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 26,000.00	\$ 26,000.00
Subtotal General Items:					\$ 35,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	850	\$ 15.00	\$ 12,750.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	850	\$ 90.00	\$ 76,500.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	1,041	\$ 4.00	\$ 4,165.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	26	\$ 165.00	\$ 4,290.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	318	\$ 5.00	\$ 1,590.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	318	\$ 85.00	\$ 27,030.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	2	\$ 2,000.00	\$ 4,000.00
	Driveway Reconnection	L.S.	1	\$ 19,600.00	\$ 19,600.00
Subtotal Paving Items:					\$ 149,925.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	318	\$ 30.00	\$ 9,540.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	2	\$ 600.00	\$ 1,200.00
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	318	\$ 250.00	\$ 79,500.00
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	1	\$ 6,340.00	\$ 6,340.00
	Inlets (Type BB with grate)	Ea.	2	\$ 3,500.00	\$ 7,000.00
Subtotal Drainage Items:					\$ 103,580.00
Estimated Probable Cost of Construction:					\$ 288,505.00
30% Contingency:					\$ 86,551.50
Total Estimated Probable Cost of Construction:					\$ 375,056.50
	Design Engineering Services				\$ 37,505.65
	Bid Phase Services				\$ 11,251.70
	Construction Admin Services				\$ 18,752.83
	Surveying Services				\$ 55,440.00
	Geotechnical Services				\$ 13,500.00
	Urban Forester				\$ 1,875.28
OPCC Including Professional Services:					\$ 513,381.95
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 624,607.64
					\$ 630,000.00

City of West University - Opinion of Probable Cost
College System (Area 2)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 144,000.00	\$ 144,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 72,000.00	\$ 72,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 717,000.00	\$ 717,000.00
Subtotal General Items:					\$ 933,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	26,350	\$ 15.00	\$ 395,250.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	26,350	\$ 90.00	\$ 2,371,500.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	32,279	\$ 4.00	\$ 129,115.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	815	\$ 165.00	\$ 134,475.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	18,485	\$ 5.00	\$ 92,425.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	12,085	\$ 85.00	\$ 1,027,225.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	35	\$ 2,000.00	\$ 70,000.00
	Driveway Reconnection	L.S.	1	\$ 633,000.00	\$ 633,000.00
Subtotal Paving Items:					\$ 4,852,990.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	2,420	\$ 30.00	\$ 72,600.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	26	\$ 600.00	\$ 15,600.00
	24" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	85	\$ 115.00	\$ 9,775.00
	30" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	220	\$ 150.00	\$ 33,000.00
	36" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	690	\$ 180.00	\$ 124,200.00
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,420	\$ 250.00	\$ 605,000.00
	60" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,260	\$ 350.00	\$ 791,000.00
	72" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	830	\$ 485.00	\$ 402,550.00
	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	Ea.	3	\$ 3,500.00	\$ 10,500.00
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	18	\$ 6,340.00	\$ 114,120.00
	Inlets (Type BB with grate)	Ea.	37	\$ 3,500.00	\$ 129,500.00
Subtotal Drainage Items:					\$ 2,307,845.00
Estimated Probable Cost of Construction:					\$ 8,093,835.00
30% Contingency:					\$ 2,428,150.50
Total Estimated Probable Cost of Construction:					\$ 10,521,985.50
	Design Engineering Services				\$ 1,052,198.55
	Bid Phase Services				\$ 315,659.57
	Construction Admin Services				\$ 526,099.28
	Surveying Services				\$ 86,400.00
	Geotechnical Services				\$ 13,500.00
	Urban Forester				\$ 52,609.93
OPCC Including Professional Services:					\$ 12,568,452.82
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 15,291,444.60
\$					15,300,000.00

City of West University - Opinion of Probable Cost
Poor Farm Ditch (Area 5 Part 2)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 28,000.00	\$ 28,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 14,000.00	\$ 14,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 138,000.00	\$ 138,000.00
Subtotal General Items:					\$ 180,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	3,340	\$ 15.00	\$ 50,100.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	3,340	\$ 90.00	\$ 300,600.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	4,092	\$ 4.00	\$ 16,366.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	102	\$ 165.00	\$ 16,830.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	2,405	\$ 5.00	\$ 12,025.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	2,405	\$ 85.00	\$ 204,425.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	8	\$ 2,000.00	\$ 16,000.00
	Driveway Reconnection	L.S.	1	\$ 92,500.00	\$ 92,500.00
Subtotal Paving Items:					\$ 708,846.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	2,405	\$ 30.00	\$ 72,150.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	28	\$ 600.00	\$ 16,800.00
	36" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,640	\$ 180.00	\$ 475,200.00
	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	Ea.	10	\$ 3,500.00	\$ 35,000.00
	Inlets (Type BB with grate)	Ea.	18	\$ 3,500.00	\$ 63,000.00
Subtotal Drainage Items:					\$ 662,150.00
Estimated Probable Cost of Construction:					\$ 1,550,996.00
30% Contingency:					\$ 465,298.80
Total Estimated Probable Cost of Construction:					\$ 2,016,294.80
	Design Engineering Services				\$ 201,629.48
	Bid Phase Services				\$ 60,488.84
	Construction Admin Services				\$ 100,814.74
	Surveying Services				\$ 55,440.00
	Geotechnical Services				\$ 13,500.00
	Urban Forester				\$ 10,081.47
OPCC Including Professional Services:					\$ 2,458,249.34
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 2,990,836.19
\$					3,000,000.00

City of West University - Opinion of Probable Cost
Buffalo Speedway & Kirby System (Area 1)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 29,000.00	\$ 29,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 15,000.00	\$ 15,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 144,000.00	\$ 144,000.00
Subtotal General Items:					\$ 188,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	5,600	\$ 15.00	\$ 84,000.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	5,600	\$ 90.00	\$ 504,000.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	6,860	\$ 4.00	\$ 27,440.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	200	\$ 165.00	\$ 33,000.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	4,020	\$ 5.00	\$ 20,100.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	2,240	\$ 85.00	\$ 190,400.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	9	\$ 2,000.00	\$ 18,000.00
	Driveway Reconnection	L.S.	1	\$ 131,600.00	\$ 131,600.00
Subtotal Paving Items:					\$ 1,008,540.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	1,300	\$ 30.00	\$ 39,000.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	12	\$ 600.00	\$ 7,200.00
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	1,300	\$ 250.00	\$ 325,000.00
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	4	\$ 6,340.00	\$ 25,360.00
	Inlets (Type BB with grate)	Ea.	8	\$ 3,500.00	\$ 28,000.00
Subtotal Drainage Items:					\$ 424,560.00
Estimated Probable Cost of Construction:					\$ 1,621,100.00
30% Contingency:					\$ 486,330.00
Total Estimated Probable Cost of Construction:					\$ 2,107,430.00
	Design Engineering Services				\$ 210,743.00
	Bid Phase Services				\$ 63,222.90
	Construction Admin Services				\$ 105,371.50
	Surveying Services				\$ 24,120.00
	Geotechnical Services				\$ 13,500.00
	Urban Forester				\$ 10,537.15
OPCC Including Professional Services:					\$ 2,534,924.55
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 3,084,123.31
\$					3,100,000.00

City of West University - Opinion of Probable Cost
Buffalo Speedway & Kirby System (Area 10)

Item No.	Item Description	Unit	Quantity	Unit Price	Total Amount
General Items					
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	\$ 90,000.00	\$ 90,000.00
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	\$ 45,000.00	\$ 45,000.00
3	Utility Conflicts / Relocation / Adjustment	L.S.	1	\$ 449,000.00	\$ 449,000.00
Subtotal General Items:					\$ 584,000.00
Paving Items					
	Existing Concrete pavement removal, complete in place the sum of:	S.Y.	10,000	\$ 15.00	\$ 150,000.00
	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	10,000	\$ 90.00	\$ 900,000.00
	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	12,250	\$ 4.00	\$ 49,000.00
	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	310	\$ 165.00	\$ 51,150.00
	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	6,425	\$ 5.00	\$ 32,125.00
	5' concrete sidewalk, complete in place the sum of:	S.Y.	6,425	\$ 85.00	\$ 546,125.00
	Concrete curb ramp per ADA requirements, complete in place the sum of:	Ea.	18	\$ 2,000.00	\$ 36,000.00
	Driveway Reconnection	L.S.	1	\$ 264,700.00	\$ 264,700.00
Subtotal Paving Items:					\$ 2,029,100.00
Drainage Items					
	Remove existing storm sewer, all sizes and all depths, complete in place the sum of:	L.F.	6,425	\$ 30.00	\$ 192,750.00
	Remove existing storm sewer inlet/manhole, complete in place the sum of:	Ea.	54	\$ 600.00	\$ 32,400.00
	36" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	940	\$ 180.00	\$ 169,200.00
	48" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	1,270	\$ 250.00	\$ 317,500.00
	60" RCP, ASTM C76, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	2,420	\$ 350.00	\$ 847,000.00
	5'x4' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	415	\$ 325.00	\$ 134,875.00
	5'x5' RCB, Class III storm sewer, rubber gasket joints, all depths, cement stabilized sand bedding and backfill, complete in place the sum of:	L.F.	1,380	\$ 382.00	\$ 527,160.00
	Manholes (For 42" Dia. Pipe and Smaller) (All Types)	Ea.	3	\$ 3,500.00	\$ 10,500.00
	Manholes (For 48" to 72" Dia. Pipe) (All Typ)	Ea.	15	\$ 6,340.00	\$ 95,100.00
	Inlets (Type BB with grate)	Ea.	36	\$ 3,500.00	\$ 126,000.00
Subtotal Drainage Items:					\$ 2,452,485.00
Estimated Probable Cost of Construction:					\$ 5,065,585.00
30% Contingency:					\$ 1,519,675.50
Total Estimated Probable Cost of Construction:					\$ 6,585,260.50
	Design Engineering Services				\$ 658,526.05
	Bid Phase Services				\$ 197,557.82
	Construction Admin Services				\$ 329,263.03
	Surveying Services				\$ 55,440.00
	Geotechnical Services				\$ 37,800.00
	Urban Forester				\$ 32,926.30
OPCC Including Professional Services:					\$ 7,896,773.69
OPCC Including Professional Services (Including 5 years of Inflation):					\$ 9,607,632.63
					\$ 9,700,000.00

Summary of Opinion of Probable Cost

ACADEMY	
Improvement Area	Cost
Trunkline	\$ 14,500,000
Area 3	\$ 12,600,000
Area 4	\$ 2,700,000
Area 5 Part 1	\$ 630,000
TOTAL:	\$ 30,430,000

COLLEGE	
Improvement Area	Cost
Area 2	\$ 15,300,000.00
TOTAL:	\$ 15,300,000.00

POOR FARM DITCH	
Improvement Area	Cost
Area 5 Part 2	\$ 3,000,000.00
TOTAL:	\$ 3,000,000.00

BUFFALO SPDWY & KIRBY	
Improvement Area	Cost
Area 1	\$ 3,100,000.00
Area 10	\$ 9,700,000.00
TOTAL:	\$ 12,800,000.00

GRAND TOTAL: \$ 61,530,000.00