DRAINAGE STUDY OF BRIAR BRANCH

Prepared for

Memorial City Redevelopment Authority

On Behalf of

Tax Increment Reinvestment Zone # 17

By

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Executive Summary

EXECUTIVE SUMMARY

In June 2006, Lockwood, Andrews and Newnam, Inc. (LAN) prepared a Drainage Action Plan for Tax Increment Reinvestment Zone # 17 (TIRZ 17). The Drainage Action Plan identified Briar Branch as the only unstudied channel of the four open channels that serve TIRZ 17 as storm sewer outfalls. In response to the Drainage Action Plan, TIRZ 17 authorized LAN in October 2006 to study the unstudied portion of Briar Branch, also known as Harris County Flood Control District (HCFCD) Unit No. W140-01-00. The project limits begin at Gessner Road and extend east to Blalock Road. Briar Branch was previously studied east of Blalock Road as part of the Tropical Storm Allison Recovery Project (TSARP). The goal of the study was to extend the limits of the TSARP floodplain analysis along Briar Branch west of Blalock Road and to identify the existing level of service provided by the channel.

Existing TSARP hydrology and hydraulics reports and models, as well as land use and historical flood files, were reviewed and used as the basis for this study. A detailed topographic survey of Briar Branch was conducted by Martinez, Guy & Maybik Inc., the data from which was used to develop a hydraulic model of the channel.

A hydrologic analysis of Briar Branch was conducted based on the peak flows produced by both overland and underground storm sewer flows. Overland drainage areas were determined using the TSARP defined sub-basin limits and extreme event flow patterns derived from ArcGIS and LiDAR. Overland peak flows were calculated using TSARP methodology and are based on contributing drainage areas. Storm sewer drainage areas were based on the contributing area to each storm sewer trunkline system. Peak flows were based on contributing drainage areas but were capped at the capacity of the storm sewer trunkline. HCFCD methodology mandates the use of overland flow only when modeling floodplains. However, to account for the flow changes associated with storm sewer outfalls, cumulative overland flow was calculated at the storm sewer outfall locations.

A detailed Hydraulic Engineering Center River Analysis System (HEC-RAS) model was prepared for the limits of the study. This model extended the established TSARP HEC-RAS model that previously terminated east of Blalock Road. The model geometry was based on a detailed topographic survey of the channel and bridge/culvert crossings. Using HEC-RAS, water surface elevations were developed for 2-, 5-, 10-, 25-, 50-, 100-, and 500-year rain events.

Using the water surface elevations produced during the hydraulic analysis, the 10-, 50-, 100-, and 500-year floodplains were delineated using ArcGIS and the 2002 LiDAR Digital Elevation Model. The existing channel level of service was also identified.

The existing level of service for Briar Branch was determined through analysis of the delineated floodplains. The level of service is the largest rainfall event that the channel can contain within its banks. Within the limits of this study, Briar Branch provides a 100-year level of service with the exception of three relatively small segments of the channel. Two of the segments lie outside of the TIRZ boundary. The channel segment within the TIRZ boundary, between Gessner and Witte Road, provides a 25-year level of service – allowing shallow flooding of portions of a large paved area. The paved area is primarily used for parking vehicles, most of which are Spring Branch ISD school busses.

For this study, residents of the neighborhood near Briar Branch were surveyed and asked to describe common flooding and drainage problems of the neighborhood. The survey responses supported the modeling results generated by this study, including the overland sheet flow paths and ponding locations.

The analysis was structured to identify areas along the channel with drainage problems. The roadway crossings over Briar Branch were studied to identify channel constrictions. Analysis showed that the existing channel geometry at each bridge crossing did not significantly increase head loss or significantly constrict flow; therefore, changes to the roadway crossing structures were considered unnecessary. Improvement alternatives were considered for enclosing Briar Branch channel with storm sewer allowing the future construction of Claret Road over the existing channel alignment. A hydraulic model was used to determine the storm sewer infrastructure required to enclose the channel and provide a 100-year channel level of service without increasing the current risk of flooding. The 100-year event was chosen as the design storm because the existing channel provides a 100-year LOS for much of the study limits. The analysis determined that though it is possible to replace the channel with a storm sewer system, the design process must be careful to allow the sheetflow from the surrounding areas to be collected into the system without adverse impact. The construction cost for the storm sewer infrastructure is estimated to be $11.7 million, not including the cost of the proposed roadway.

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Section 1

1. PROJECT OVERVIEW

1.1 Background

In June 2006, Lockwood, Andrews and Newnam, Inc. (LAN) prepared a Drainage Action Plan (Plan) for Tax Increment Reinvestment Zone No. 17 (TIRZ 17). The Plan summarized the existing available drainage studies and reports for the region. A prioritization of proposed drainage projects that would impact and benefit TIRZ 17 was produced as part of the Plan. Briar Branch channel was identified in the Plan as the only unstudied channel of the four open channels that serve TIRZ 17 as storm sewer outfalls. The Briar Branch Drainage Study is intended to fill the analytical gap in the Plan by studying the unstudied portion of Briar Branch.

1.2 Authorization

LAN was authorized by TIRZ 17 in October 2006 to study the unstudied portion of Briar Branch, also known as Harris County Flood Control District (HCFCD) Unit No. W140-01-00. The project limits begin at Gessner Road and extends approximately 1.4 miles east to Blalock Road.

1.3 Objectives

The study determined the boundaries of the 2-, 5-, 10-, 25-, 50-, 100-, and 500-year floodplains along the Briar Branch channel within the project limits and identifies the existing level of service provided by the channel. Four roadway crossings over the channel, including Bunker Hill Road, were analyzed in this study to identify potential areas where channel flow may experience significant head losses. Overland sheet flow paths were examined with the intent of locating areas where flow paths into the channel may adversely affect existing structures.

Additionally, this study provides insight into the feasibility of enclosing Briar Branch channel to allow for the future construction of Claret Road. The alignment of the unstudied portion of Briar Branch coincides with the alignment of the proposed Claret Road corridor currently under consideration. As part of this study, the Claret Road alternative was analyzed to determine the necessary infrastructure required to enclose Briar Branch while conveying 100-year flood flows.

1.4 Scope of Work

The scope of work is documented in the approved work authorization. The following items summarize the tasks performed during the study under the scope of work:

Gather and Review Existing TSARP Information

Review and use as the basis for this study the Tropical Strom Allison Recovery Project (TSARP) hydrology and hydraulics reports and models. Utilize additional information such as land use and historical flood files to supplement the analysis.

Hydrology

Form drainage areas based on extreme event flow patterns for both overland and underground storm sewer flows using the TSARP defined sub-basin limits and ArcGIS. Conduct a hydrologic analysis based on the peak flows produced by the drainage areas for each flow type.

Hydraulics

Prepare a detailed hydraulic model for the study limits using the Hydraulic Engineering Center's River Analysis System (HEC-RAS) software. Extend the established TSARP HEC-RAS model that previously terminated at Blalock Road. Base the model on a detailed topographic survey of the channel and bridge/culvert crossings. Develop water surface elevations (WSE) for 2-, 5-, 10-, 25-, 50-, 100-, and 500-year rain events using HEC-RAS.

Delineate Floodplain and Determine Level of Service

Delineate the 10-, 50-, 100-, and 500-year floodplains using the HEC-RAS WSE for the corresponding year event, ArcGIS, and the 2002 LiDAR Digital Elevation Model (DEM). Also identify the existing channel level of service (LOS).

Prepare Preliminary Improvement Alternatives

Determine where there are drainage problem areas along the channel. Present conceptual alternatives for channel improvements and for any channel crossing structures that have been identified as a constriction to the channel. Because the project corridor has been proposed as the future alignment for Claret Road, one alternative is to enclose the channel with box storm sewer.

1.5 Design Criteria

The hydrologic and hydraulic analyses conducted in this study were performed in accordance with the criteria and methodologies set forth in the following references:

Hydrology for Harris County – 1988 Seminar

Tropical Storm Allison Recovery Project Technical White Papers

HCFCD Policy, Criteria, and Procedure Manual (HCFCD Design Manual)

City of Houston Infrastructure Design Manual

1.6 Topographic Survey and Datum

Topographic survey data was collected by Martinez, Guy & Maybik Inc. for the area along Briar Branch within the limits of this study. The survey data was used in conjunction with other existing data to develop an accurate computer model of the channel.

The topographic survey included detailed data collection and channel cross-sections at the existing culverts and bridge crossings. Channel cross-sections were surveyed at the upstream and downstream faces of each crossing, 100 feet downstream of each crossing, and at a maximum interval of 1000 feet along the channel. At roadway crossings, the elevations of the edge of pavement were taken for a distance of 100 feet on each side of the channel along the roadway. The flow lines and structure sizes were identified for all outfall structures along the channel.

The collected survey data is referenced to the TSARP Benchmark Network and was performed in the NAV Datum 1988 with 2001 Adjustment.

Section 2

2. HYDROLOGY

The hydrologic analysis determined the peak runoff rates in cubic feet per second (cfs). The analysis relates precipitation to watershed characteristics such as overland slope and impervious cover to determine peak runoff rates.

2.1 Watershed Characteristics

The unstudied portion of Briar Branch lies within the W140C sub-basin. The W140C sub-basin, as defined by the HCFCD, is one of the sub-basins within the Buffalo Bayou watershed. Sub-basin W140C has an area of 2.75 sq. miles and slopes at approximately 0.14% from the northwest corner of the sub-basin down to the southeast corner. The sub-basin has 58.2% impervious cover and is considered fully developed. While redevelopment of the land in the sub-basin is possible, the opportunities for adding more impervious cover to the land are very few.

The peak flows for the W140C sub-basin are listed in **Table 1** below. The rain events commonly referred to as 10-, 50-, 100-, and 500-year rainfall events, having a 10-, 2-, 1-, and 0.2-percent statistical chance, respectively, of being equaled or exceeded during any given year, were established by the TSARP HEC-HMS model. Using a log extrapolation and interpolation of the known related flows from the HEC-HMS model, the total discharge flows for the 2-, 10-, and 25-year rainfall events were determined. The extrapolated and interpolation flows are also listed in **Table 1** below.

Table 1. Discharge Flow for Sub-Basin W140C

Rainfall Event	Annual Chance of Occurring	W140C Total Discharge (cfs)	Source
2-year	50%	284	Extrapolated
5-year	20%	458	Extrapolated
10-year	10%	588	TSARP
25-year	4%	753	Interpolated
50-year	2%	912	TSARP
100-year	1%	1088	TSARP
500-year	0.20%	1642	TSARP

2.2 Methodology

This study followed the hydrologic analysis methods of Hydrology for Harris County, the HCFCD Design Manual, and the TSARP Technical White Papers. The existing TSARP HEC-HMS model was used to establish boundary conditions for the computer models used in this study. The W140C sub-basin peak outflows from the TSAP HEC-HMS model were used as the upper bounds, with zero as the lower bounds, for interpolating the contributing flows from the sub-basin drainage areas into the channel. Specific methodologies are discussed in Section 2.3.

Drainage areas were delineated for overland sheet flow and underground storm sewer flow. The overland sheet flow drainage areas were delineated using ArcGIS and the ArcHydro extension with the 2002 LiDAR DEM for the elevation data. The underground storm sewer drainage areas were delineated by incorporating the local storm sewer network in ArcGIS with the 2002 LiDAR DEM and ArcHydro. **Exhibit 3** shows the local storm sewer network (shown in green) with the underground storm sewer drainage areas. This exhibit also includes a table which describes the characteristics of the storm sewer system, including drainage area, pipe size, slope of pipe, and flows for the 10- and 100-year flood events. The overland sheet flow paths and drainage areas established using ArcGIS's ArcHydro extension are shown in **Exhibit 4**, which includes a table detailing each sub-watershed's area, percent impervious cover, and peak discharge for the 10- and 100-year flood events. The line thickness of the overland sheet flow path lines (shown in yellow) indicates the concentration of flow from smaller catchments. The thickest line represents the primary overland flow path for a drainage area.

Sub-basin W140C is the uppermost sub-basin that contributes runoff to Briar Branch (see **Exhibit 2**). The existing TSARP delineated floodplain terminates near the downstream boundary of sub-basin W140C. The HCFCD criteria does not recommend sub-dividing W140C into smaller sub-areas for determining the reduction of peak flows at points upstream of the sub-basin boundary. To determine the discharges of the drainage areas within sub-basin W140C, the procedure outlined in TSARP Technical White Paper "*Recommendations for Determining Discharges in Upstream Reaches of Subareas*" was followed, with one exception. The TSARP White Paper recommends that the drainage area versus discharge relationship for the entire Buffalo Bayou watershed be plotted on a log-log graph. The discharges of the sub-divided portions of the sub-basin are then to be extrapolated based on the size of the drainage area of interest.

The reason for the variance from the TSARP White Paper methodology is that sub-basin W140C contains a large amount of storage, both overland and in the underground storm sewer, which is much larger in proportion to its size than the other sub-basins within the Buffalo Bayou watershed. The unique storage characteristics of the W140C sub-basin reduce the peak flow to area ratio compared to other Buffalo Bayou sub-basins. The result of the lower peak flow to area ratio, when applying the TSARP White Paper methodology, is elevated peak flows in the mid-portions of the sub-basin. The methods used to determine the peak flows are described in Section 2.3. The large storage characteristics of the W140C sub-basin may be attributed to the high number of ponding areas located throughout the sub-basin. The ponding area locations and depths in the vicinity of the project limits are shown on **Exhibit 6**.

2.3 Peak Flow Determination

2.3.1 Underground Storm Sewer Contributing Flows

Contributing drainage areas for underground storm sewer flow are described in Section 2.2. The discharge flow of each underground storm sewer drainage area was based on the contributing drainage area, but capped at the capacity of the storm sewer that connects the drainage area to the channel. The controlling factor for underground storm sewer drainage was the storm sewer capacity. The capacity of the underground storm sewer drainage areas were determined by applying Manning's equation to the storm sewer outfall of each drainage area. The storm sewer outfall size and slope were considered the controlling factors for flow. The storm sewer contributing flows are shown on **Exhibit 5.**

2.3.2 Overland Drainage Area Flows

Contributing drainage areas for overland flow are described in Section 2.2. The peak flows for each contributing overland sheet flow drainage area were determined by interpolating between the sub-basin outflows provided by the TSARP HEC-HMS model and zero flow. The interpolations were based on the size of the specific drainage area in relation to the size of the total contributing area. For overland sheet flow, the total contributing area was 1008 acres (1.58 sq. mi.). The discharge flows calculated for the overland flow drainage areas were considered the most conservative. They were considered the most conservative because the flows for the overland flow drainage areas were generally greater than those calculated for underground storm sewer drainage areas. HCFCD criteria recommend the use of extreme event overland sheet flow to determine the peak flows used to define floodplains. The overland sheet flow contributing flows are shown on **Exhibit 5.**

2.4 Assumptions

An important assumption made while analyzing the hydrologic characteristics of the W140C sub-basin involves the confluence of the channel and the storm sewer at Witte Road. The channel crosses Witte Road through two 48-inch diameter culverts. The 48-inch culverts also connect to the existing Witte storm sewer (one 8'x5' box culvert) that flows south, across Briar Branch. Water that enters the junction of Briar Branch and the Witte Road storm sewer has the option of flowing south through the Witte Road storm sewer to W151, or east into Briar Branch. The portion of water that enters Briar Branch versus the Witte Road storm sewer is determined by the current hydraulic head on each system. Water will ultimately follow the path of least resistance. For the extreme event, storm sewer trunk lines carry very little flow relative to overland sheet flow. W151, the receiving waterway for the Witte Road storm sewer, has been widely documented in other reports as ineffective during the extreme event. The assumption was made that the Witte Road storm sewer trunk line is surcharged for the extreme event and therefore receives no flow from upstream of the confluence. For this analysis, the worst case scenario for the community north of IH-10 was assumed for studying Briar Branch. It was assumed that all flow upstream of the confluence contributes to Briar Branch.

Section 3

3. HYDRAULICS

The hydraulic analysis utilized the peak flows determined in the hydrologic analysis to study the flow characteristics of Briar Branch and ultimately determine the channel water surface elevations and associated floodplains.

3.1 Methodology

A detailed HEC-RAS model was prepared for the limits of the study. The HEC-RAS software was developed by the U.S. Army Corp of Engineers for, among other uses, calculating water surface profiles for steady-state flow in open channels such as Briar Branch. HEC-RAS, considered the industry standard for floodplain delineation and water surface profile determination, is used by TSARP, the HCFCD, and FEMA. The hydraulic calculations followed the criteria and methodologies described and required by TSARP and the HCFCD

The existing TSARP HEC-RAS hydraulic model of Briar Branch terminated at Blalock Road. This study extended the established TSARP HEC-RAS model of Briar Branch westward to Gessner Road. To achieve continuity with the TSARP model, the upper most water surface elevation of the TSARP model was used as the downstream boundary condition for the new model. The HEC-RAS model of Briar Branch developed for this study was then analyzed for a variety of rainfall event scenarios.

The model geometry from a detailed topographic survey performed as part of this study and the 2002 LiDAR Digital Elevation Model (DEM). The 2002 LiDAR DEM was used to supplement the topographic survey in the channel overbank areas.

3.2 Channel Geometry

For this study, a detailed topographic field survey of the channel was performed. The survey information was used to ensure accurate channel cross-section geometries for the HEC-RAS model. Roadway and pipeline crossings were also analyzed in the HEC-RAS model based on information obtained in the field survey. The cross-section locations are shown in **Exhibit 5.**

In developing the channel's hydraulic model, three-dimensional cross-section data was captured using ArcGIS with the 2002 LiDAR DEM as the data input. The channel centerline, banklines, and three-dimensional cross-sections geometries were exported to HEC-RAS from ArcGIS using the extension HEC-GeoRAS. The LiDAR based cross-sections were then adjusted in HEC-RAS using the detailed topographic field survey information. Additionally, bridge crossings and culvert structures were modeled based on information obtained by the topographic survey.

3.3 Water Surface Elevations

Using HEC-RAS, water surface elevations (WSE) were developed for 2-, 5-, 10-, 25-, 50-, 100-, and 500-year rainfall events. HEC-RAS model results are provided in **Appendix A**. The WSE for the 10-, 50-, 100-, and 500-year events were later used to delineate the corresponding floodplains (described in Section 4).

Section 4

4. FLOODPLAIN DELINEATION

As part of the hydraulic analysis for this study, water surface elevations were developed for several rainfall events. These elevations were exported from HEC-RAS into ArcGIS using HEC-GeoRAS. Once in ArcGIS, the relevant floodplains were delineated by intersecting the WSE with the 2002 LiDAR Digital Elevation Model (DEM). The 10-, 50-, 100-, and 500-year delineated floodplains are shown in **Exhibits 7, 8, 9, and 10** respectively.

4.1 Existing Level of Service

Further analysis was conducted to determine the existing channel level of service (LOS). The LOS for these areas was then based upon the maximum rainfall event that can be contained within the channel banks.

A 25-year LOS was identified for the channel segment beginning approximately 500 feet east of Gessner Road and stopping at Witte Road. The delineated floodplains created for this analysis indicate that rainfall events greater than a 25-year event will exceed the southern banks of the channel, causing flooding on portions of a large paved area. The paved area is used primarily for parking vehicles, most of which are Spring Branch ISD school busses. It should be noted that only a small portion of the parking lot is inundated by the 100-year flood event. For the channel segment beginning at Witte Road extending east to approximately 300 feet west of Oak Tree Drive, the channel has a 100-year LOS. From approximately 300 feet west of Oak Tree Drive to just west of Cedar Post Lane, the delineated floodplains indicate the channel has a 50-year LOS. Delineated floodplains for greater than 25-year rain events show extensive street flooding between Cedar Post Lane and Blalock Road, indicating a 25-year LOS for the channel in this area. The breakdown of LOS along the entire channel length is shown in **Exhibit 11**.

4.2 Drainage Problems Survey

Attendees of a March 6, 2007 public meeting, held at Woodview Elementary School, were asked to participate in a survey about drainage problems in the neighborhood near Briar Branch. The public meeting was held to discuss the jointly funded City of Houston / TIRZ 17 Bunker Hill Roadway Improvement project. The survey asked respondents to describe flooding and drainage problems as well as locate the problem areas on an attached map. Fourteen people responded to the survey. The data collected through this survey was digitized and graphically displayed in GIS. **Exhibit 5** displays the survey results. The drainage problems described and comments from the neighborhood constituents support the computer model results generated by this study, including the overland sheet flow paths and ponding locations. While it was not a defined scope item for this study, the ponding area west of Bunker Hill was analyzed in further detail and recommendations were made to the Bunker Hill design engineer to ensure that the ponding problem was not passed further downstream. The ponding location along Bunker Hill was the only ponding studied in detail.

Section 5

5. PRELIMINARY IMPROVEMENT ALTERNATIVES

The hydrologic and hydraulic analysis determined the location of drainage problem areas along Briar Branch channel. This section presents conceptual alternatives for improving the channel LOS and enclosing the channel to allow for the future Claret Lane.

5.1 Channel Improvements & Roadway Crossings

The LOS for various channel segments is described in Section 4.1. Many of the channel segments currently provide a 100-year level of protection. Based on a visual inspection of the floodplain delineations, channel segments with less than a 100-year LOS do not appear to cause structural flooding. Drainage problems in the vicinity of Briar Branch appear to be a result of overland sheet flow problems, inadequate storm sewer collection system, or a combination thereof. Because of this, it is not recommended that modifications to Briar Branch be considered to improve the channel LOS.

HEC-RAS bridge crossings were analyzed for signs of significant head loss across each drainage structure. According to the hydraulic model, there were no significant head losses across the bridge crossings. Therefore, modifications to the bridge crossing are not recommended.

5.2 Enclosing Channel with Box Storm Sewer

The project corridor has been proposed as the future alignment for Claret Road. Therefore, one improvement alternative will be to provide a 100-year level of service by enclosing Briar Branch channel with box storm sewer. This scenario was modeled and evaluated using the City of Houston approved storm drain modeling program HouStorm to determine the required sizes of the proposed storm sewer trunkline. Since the existing LOS provided by the channel is an approximately 100-year capacity, the proposed storm sewer would provide that same LOS. The proposed storm sewer would be designed to contain the 100-year flood flows and not exacerbate any existing flooding issues in the area.

5.2.1 Hydrologic Design Criterion

Exhibit 5 illustrates the assessment used to determine the design flows for the storm sewer model. Two categories of flows contribute to the existing Briar Branch Creek. The first category is cumulative overland sheetflow, which represents the 100-year flood event determined by the HMS model following TSARP and HCFCD methods. This model does not focus on the role of storm sewer in the system as it assumes that sheetflow dominates the outcome of the system.

The second category of design flows is cumulative storm sewer contributing flows, which are flows entering the channel from the existing storm sewer system. Design flows for the proposed storm sewer model combined the two previously described scenarios, so as to maintain a conservative approach to the model. There are only two locations where the point source of storm sewer flow is greater than the overland sheetflow in that area. These locations are at Witte Rd. and Bunker Hill Rd.

5.2.2 Hydraulic Design Criterion

Initially, the proposed storm sewer was designed to provide a 100-year level of service. For this design, a minimum of 3.5-feet of ground cover was allowed over the storm sewer trunkline. The critical water surface elevation for each pipe node was set at three feet above the sofit of the storm sewer trunkline. This critical elevation would ensure that in the 100-year flood event, water would not overtop the storm sewer inlets and possibly flood the street as well as the surrounding area. Due to this critical water surface elevation constraint and high tailwater conditions (see high tailwater discussion below) this design scenario is not feasible. No practical size of storm sewer will allow the 100-year level of service conditions to be met along the entire project limits.

Therefore, a feasible hydraulic model of the box storm sewer was created according to the following criterion. The critical water surface elevation for each pipe node was set as the 100-year WSE from the corresponding cross-section of the HEC-RAS model. In cases where a HEC-RAS cross-section does not fall directly on a storm sewer pipe node, the 100-year WSE was interpolated between adjacent cross-sections. This criterion was used to ensure that under proposed conditions (storm sewer in place of the channel) flooding issues would not be any greater than existing conditions. Presently, about 60 percent of the channel achieves a 100-year level of service (LOS shown in **Exhibit 11**).

The storm sewer model was developed under two tailwater boundary conditions; the 10-year and the 100-year WSE of the cross-section immediately downstream of the end of the proposed storm sewer. The system was modeled under the 10-year WSE in accordance with the COH Design Manual. As stated previously, this storm sewer model is not only subject to traditional design rules because of the amount of 100-year sheetflow flowing into the proposed storm sewer. Because the storm sewer is replacing an open man-made channel, it is subject to the more stringent standards of HCFCD and TSARP methods. Therefore, a model was produced which sized the storm sewer in accordance with the 100-year tailwater conditions. For this model the HEC-RAS 100-year WSE of the cross-section immediately downstream of the end of the proposed storm sewer was used as the downstream tailwater boundary condition.

According to the previously described criterion, the following two scenarios with varying project limits were modeled and evaluated:

- Scenario 1: Enclose the channel in box storm sewer from Gessner Rd. to Blalock Rd., which encompasses the entire project corridor.

- Scenario 2: Enclose the channel in box storm sewer from Gessner Rd. to Bunker Hill Rd. This is the portion of the channel within TIRZ 17.

5.2.3 Storm Sewer Model Results

Output from each HouStorm model is found in **Appendix B**. **Tables 2 and 3** summarize the required storm sewer trunkline sizes for design scenarios 1 and 2 for the 100-year tailwater conditions. According to Scenario 1 and 100-year tailwater conditions modeling results, the largest box storm sewer needed will be 4 – 9'x7' boxes over the last 1277 feet of the proposed project limits. See **Exhibit 12** for the proposed preliminary box storm sewer sizes and locations.

Table 2 - Scenario 1 Proposed Storm Sewer Design (Gessner Rd. to Blalock Rd.)

Run	**Cumulative Flow (cfs)**	**% Slope**	**Length (ft)**	**Street Description**	*100-Year TW* **Box Storm Sewer Size**
1	25	0.054	608	Begins at Gessner Rd. and Extends east 608 ft.	1 - 4' x 3'
2	50	0.073	867	Begins 867 ft west of Witte Rd. and Ends at Witte Rd.	1 - 6' x 3'
3	280	0.098	2812	Begins at Witte Rd. and Ends at Bunker Hill Rd.	1 - 9' x 7'
4	522	0.102	837	Begins at Bunker Hill Rd. and Ends 200 ft west of Confederate Rd.	2 - 9' x 7'
5	806	0.102	912	Begins 200 ft west of Confederate Rd. and Ends at Oak Tree Dr.	3 - 8' x 7'
6	961	0.102	718	Begins at Oak Tree Dr. and Ends at Cedar Post Ln.	4 - 9' x 7'
7	1003	0.166	559	Begins at Cedar Post Ln and Ends at Blalock Rd.	4 - 9' x 7'

Table 3 - Scenario 2 Proposed Storm Sewer Design (Gessner Rd. to Bunker Hill Rd.)

Run	**Cumulative Flow (cfs)**	**% Slope**	**Length (ft)**	**Street Description**	*100-Year TW* **Box Storm Sewer Size**
1	25	0.054	608	Begins at Gessner Rd. and Extends 608 ft east.	1 - 4' x 3'
2	50	0.073	867	Begins 867 ft west of Witte Rd. and Ends at Witte Rd.	1 - 6' x 3'
3	280	0.098	2812	Begins at Witte Rd. and Ends at Bunker Hill Rd.	1 - 9' x 7'

Note: Scenario 2 was analyzed separately to isolate improvements in TIRZ 17 and the prevent influence from downstream storm sewer improvements.

5.2.4 Cost Estimate for Proposed Storm Sewer System

A cost estimate was completed for Scenario 1 using the 100-year tailwater condition. Calculations for this estimate are found in **Appendix B**. Key items considered in the cost estimate were linear feet of various sizes of concrete box culverts, customized junction boxes, a trench safety system, and excavation and off-site disposal of soil. (Proposed roadway costs were not considered in this estimate.) Of these key items, the amount of large concrete box culverts controls the final projected cost. Cost per linear foot of various sizes of concrete box culverts were estimated using the TxDOT Houston District's average low bid unit price list. The final proposed cost of the storm sewer system is approximately $11.7 million. This estimate includes a 20 percent contingency fund.

Section 6

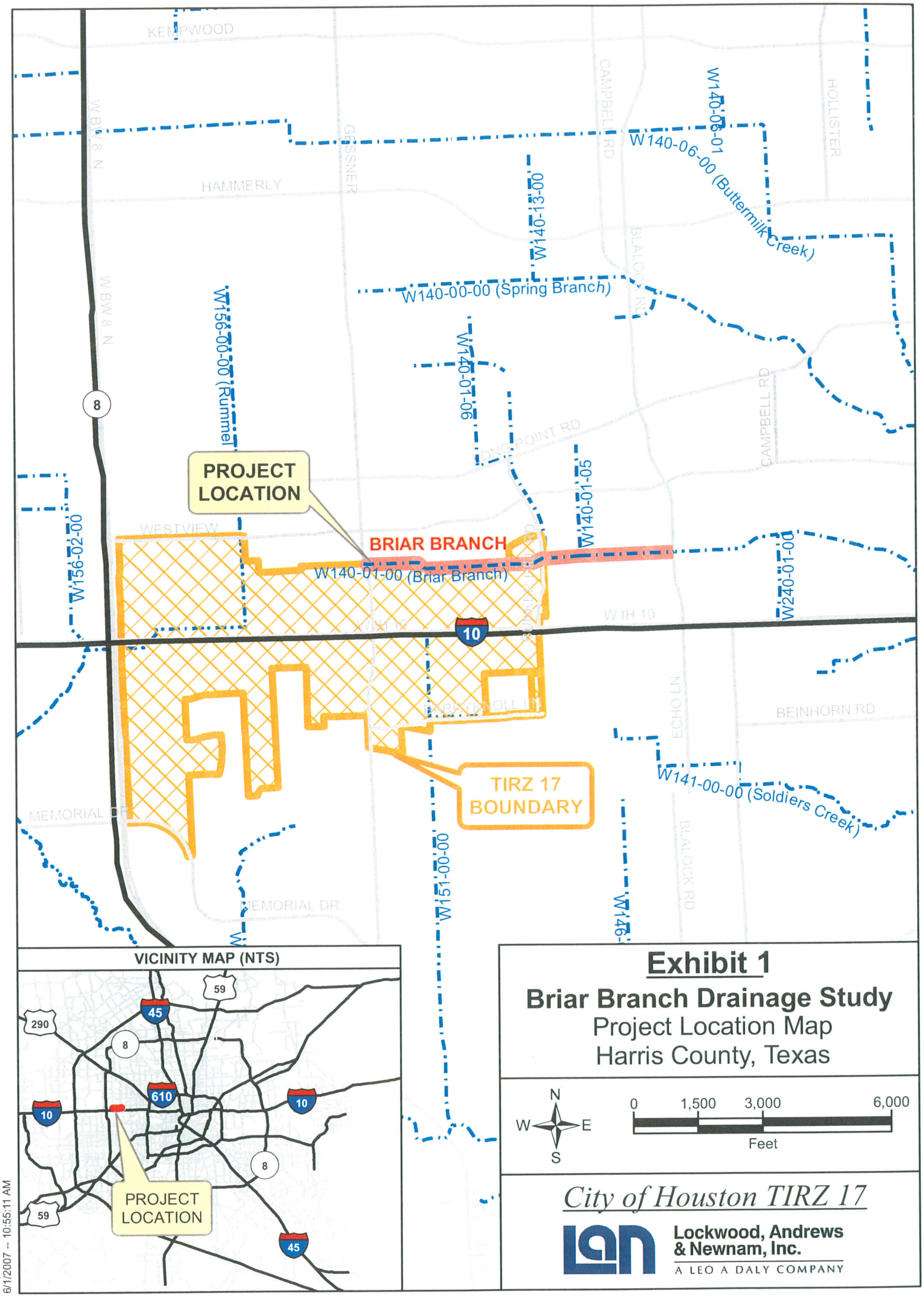
6. CONCLUSION

The existing level of service for Briar Branch was determined through further analysis of the delineated floodplains. The level of service is the largest rainfall event that the channel can contain within its banks. Within the limits of this study, the majority of Briar Branch provides a 100-year level of service. There are three segments of the channel that provide less than a 100-year level of service. Two of those segments lie outside of the TIRZ boundary. The segment of the channel that lies within the TIRZ boundary provides a 25-year level of service between Gessner and Witte Road. The analysis indicates that flooding in that area is likely to occur along the southern bank of Briar Branch – potentially flooding portions of a large paved area. The paved area is used primarily for parking vehicles, most of which are Spring Branch ISD school busses. The 100-year flooding in the parking lot is characterized as shallow (less than 1 foot) and does not extend very far out of bank.

Residents of the neighborhood near Briar Branch were asked in a survey to identify and describe common flooding problems in the neighborhood. The survey respondents described specific locations where flooding and ponding commonly occur, as well as water depth and flooding duration details based on their past observations. The survey responses did not identify any problem areas along the channel. Some of the survey information was used to improve the roadway and drainage design of the Bunker Hill Road Improvement project.

Preliminary alternatives for improving the channel level of service or functionality were considered. Since most of the channel currently provides a 100-year level of service and the channel segments with less than a 100-year LOS do not appear to cause structural flooding, no improvements were recommended. The roadway crossings over Briar Branch were studied to identify areas in need of improvement where significant headloss occurred during major rain events. The analysis concluded that none of the roadway crossings negatively affect channel flow and therefore are not in need of improvements. Another preliminary improvement alternative studied was the enclosure of Briar Branch channel with box storm sewer. Enclosing the channel would allow Claret Lane to be constructed over the existing Briar Branch alignment. Based on the preliminary analysis performed for this report, it is technically feasible to enclose the channel within a box storm sewer and provide a 100-year level of service for the entire length of the channel while allowing a City of Houston standard roadway to be constructed above it. The analysis determined that though it is possible to replace the channel with a storm sewer system, the design process must be careful to allow the sheetflow from the surrounding areas to be collected into the system without adverse impact. The preliminary analysis performed for this report concerning the enclosure of Briar Branch did not consider any existing right-of-way issues, specific roadway design issues, or cost. This preliminary study determined the sizes of the storm sewer infrastructure necessary to enclose the channel with a roadway constructed above it. This preliminary study also estimated a construction cost of approximately $11.7 million for the proposed storm sewer infrastructure.

Exhibits.



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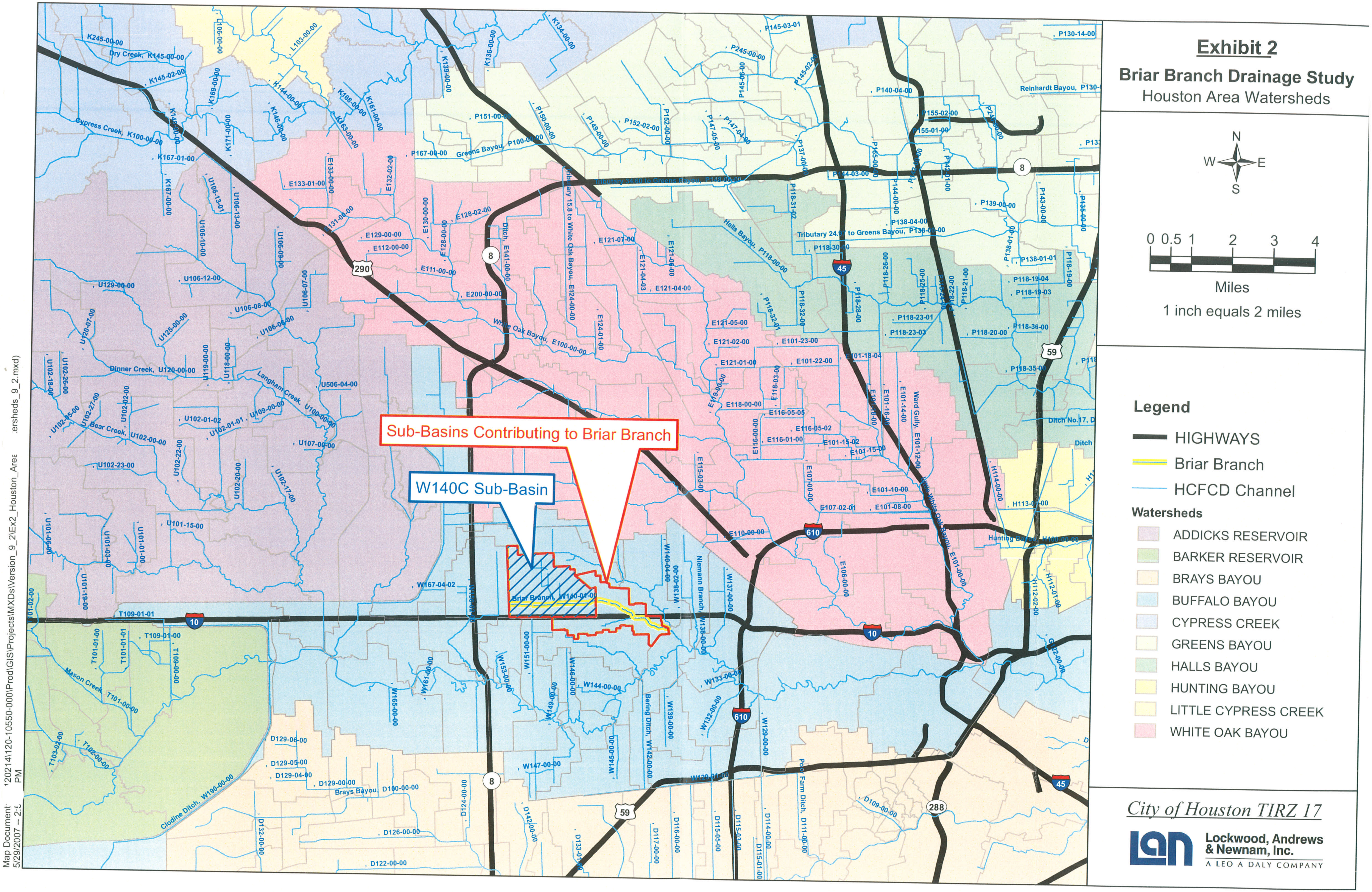
Sub-Basins Contributing to Briar Branch
W140C Sub-Basin
Exhibit 2
Briar Branch Drainage Study
Houston Area Watersheds
N
W
E
S
0 0.5 1 2 3 4
Miles
1 inch equals 2 miles
Legend
HIGHWAYS
Briar Branch
HCFCD Channel
Watersheds
ADDICKS RESERVOIR
BARKER RESERVOIR
BRAYS BAYOU
BUFFALO BAYOU
CYPRESS CREEK
GREENS BAYOU
HALLS BAYOU
HUNTING BAYOU
LITTLE CYPRESS CREEK
WHITE OAK BAYOU
City of Houston TIRZ 17
Lockwood, Andrews & Newnam, Inc.
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Map Document: '2021\4120-10550-000\Prod\GIS\Projects\MXDs\Version_9_2\Ex2_Houston_Area...ersheds_9_2.mxd)
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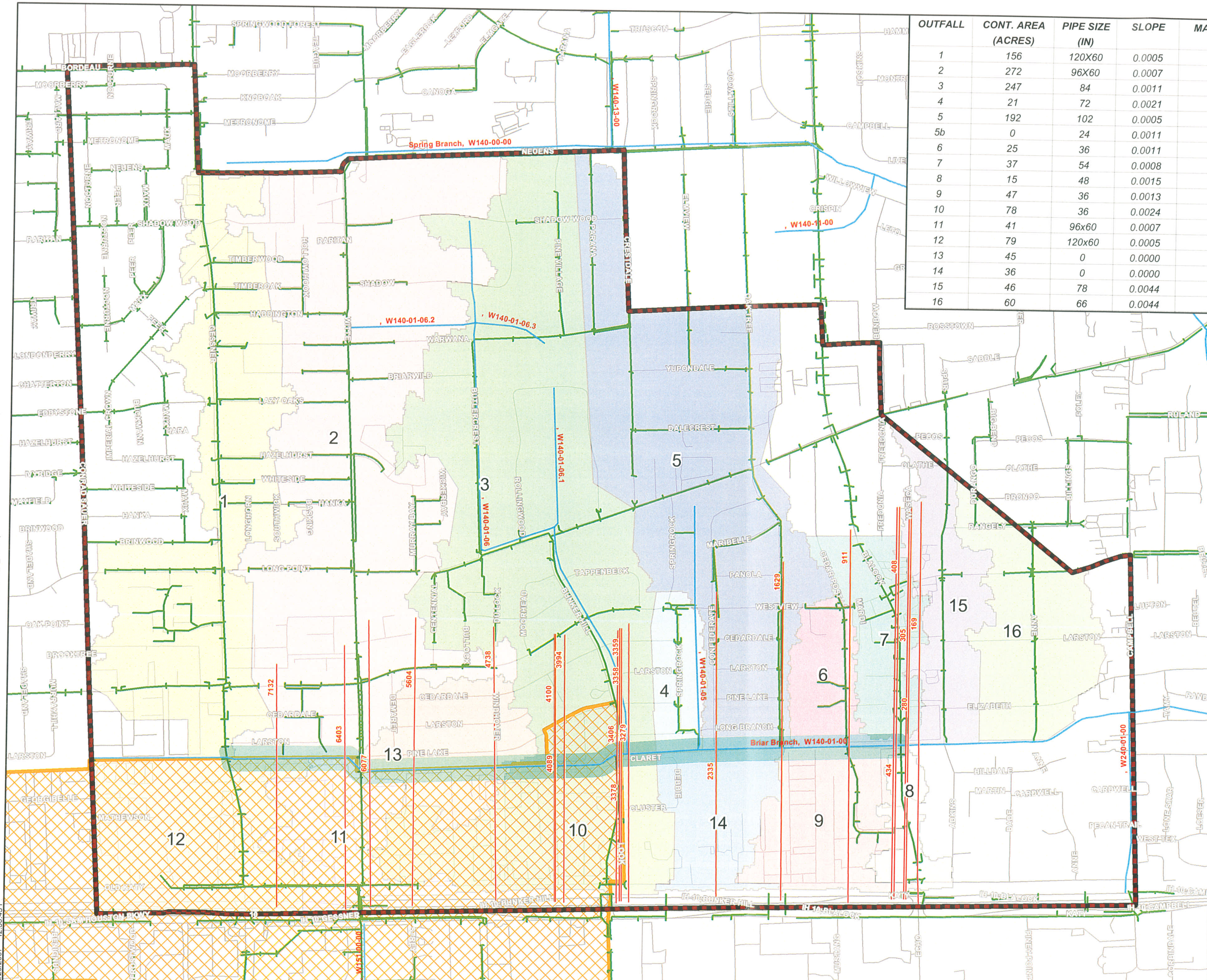


OUTFALL	CONT. AREA (ACRES)	PIPE SIZE (IN)	SLOPE	MANNING'S Q (CFS)	SITE RUNOFF CURVE 10 YEAR Q (CFS)	SITE RUNOFF CURVE 100 YEAR Q (CFS)
1	156	120X60	0.0005	156	312	486
2	272	96X60	0.0007	138	464	736
3	247	84	0.0011	209	428	680
4	21	72	0.0021	197	56	89
5	192	102	0.0005	231	370	576
5b	0	24	0.0011	8	370	576
6	25	36	0.0011	22	73	112
7	37	54	0.0008	55	101	155
8	15	48	0.0015	57	53	77
9	47	36	0.0013	24	137	203
10	78	36	0.0024	33	213	314
11	41	96x60	0.0007	142	213	314
12	79	120x60	0.0005	156	215	317
13	45	0	0.0000	0	112	175
14	36	0	0.0000	0	113	166
15	46	78	0.0044	351	73	73
16	60	66	0.0044	224	90	90

Exhibit 3

Briar Branch Drainage Study

Storm Sewer Drainage Areas

0 500 1,000 2,000

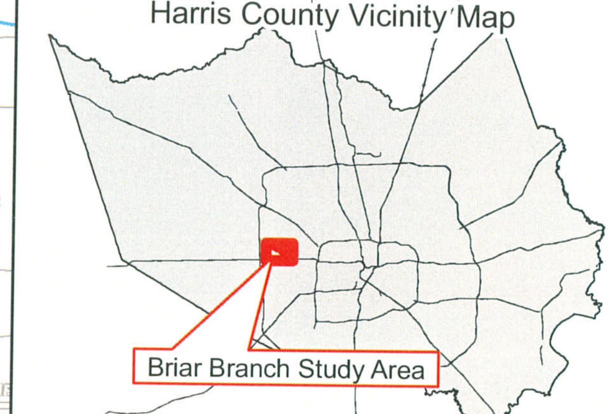
Feet

N E S W

Legend

- # Drainage Area ID
- HEC-RAS Cross-Sections
- Briar Branch Study Limits
- HCFCD Channel
- Storm Sewer Line
- TIRZ 17 Boundary
- W140C Sub-Basin

Harris County Vicinity Map



City of Houston TIRZ 17

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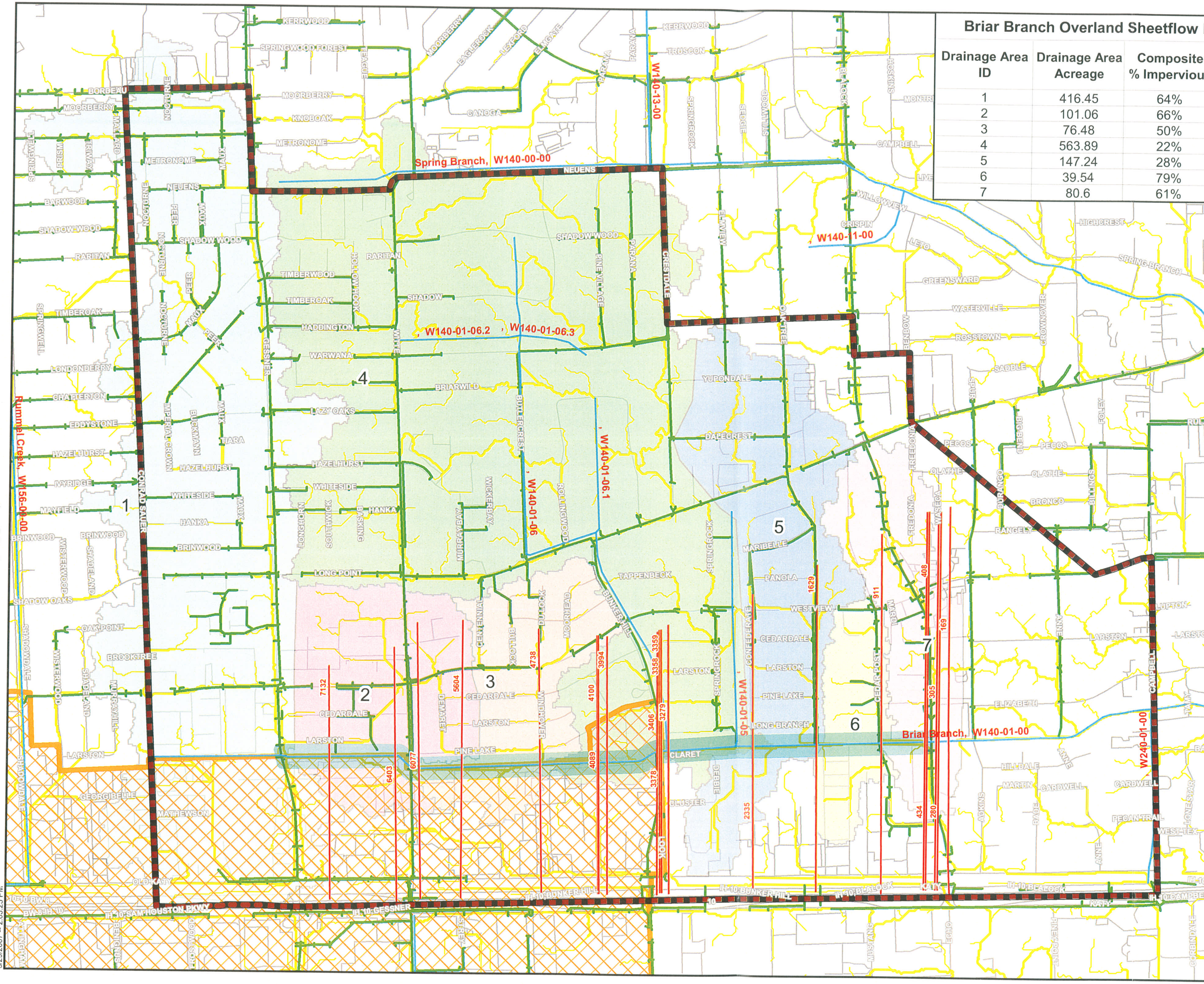
Briar Branch Overland Sheetflow Drainage Area - Peak Discharge Table

Drainage Area ID	Drainage Area Acreage	Composite % Impervious	10-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)
1	416.45	64%	756	1150
2	101.06	66%	239	362
3	76.48	50%	174	270
4	563.89	22%	596	1011
5	147.24	28%	230	379
6	39.54	79%	118	175
7	80.6	61%	193	295

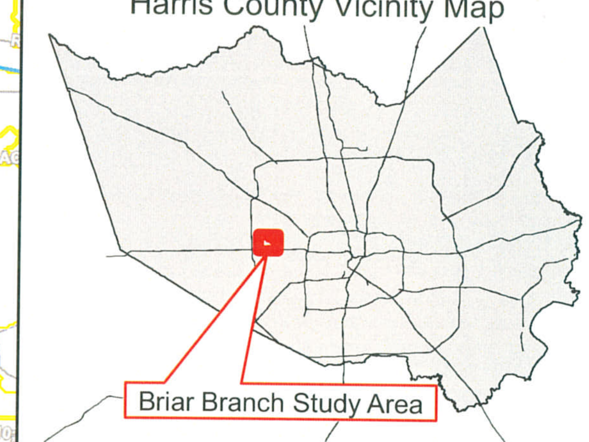
Exhibit 4

Briar Branch Drainage Study
Overland Sheet Flow
Drainage Areas



Legend
- # Drainage Area ID
- Overland Sheetflow Lines
- HEC-RAS Cross-Sections
- Briar Branch Study Limits
- HCFCD Channel
- Storm Sewer Lines
- TIRZ 17 Boundary
- W140C Sub-Basin

Harris County Vicinity Map



City of Houston TIRZ 17

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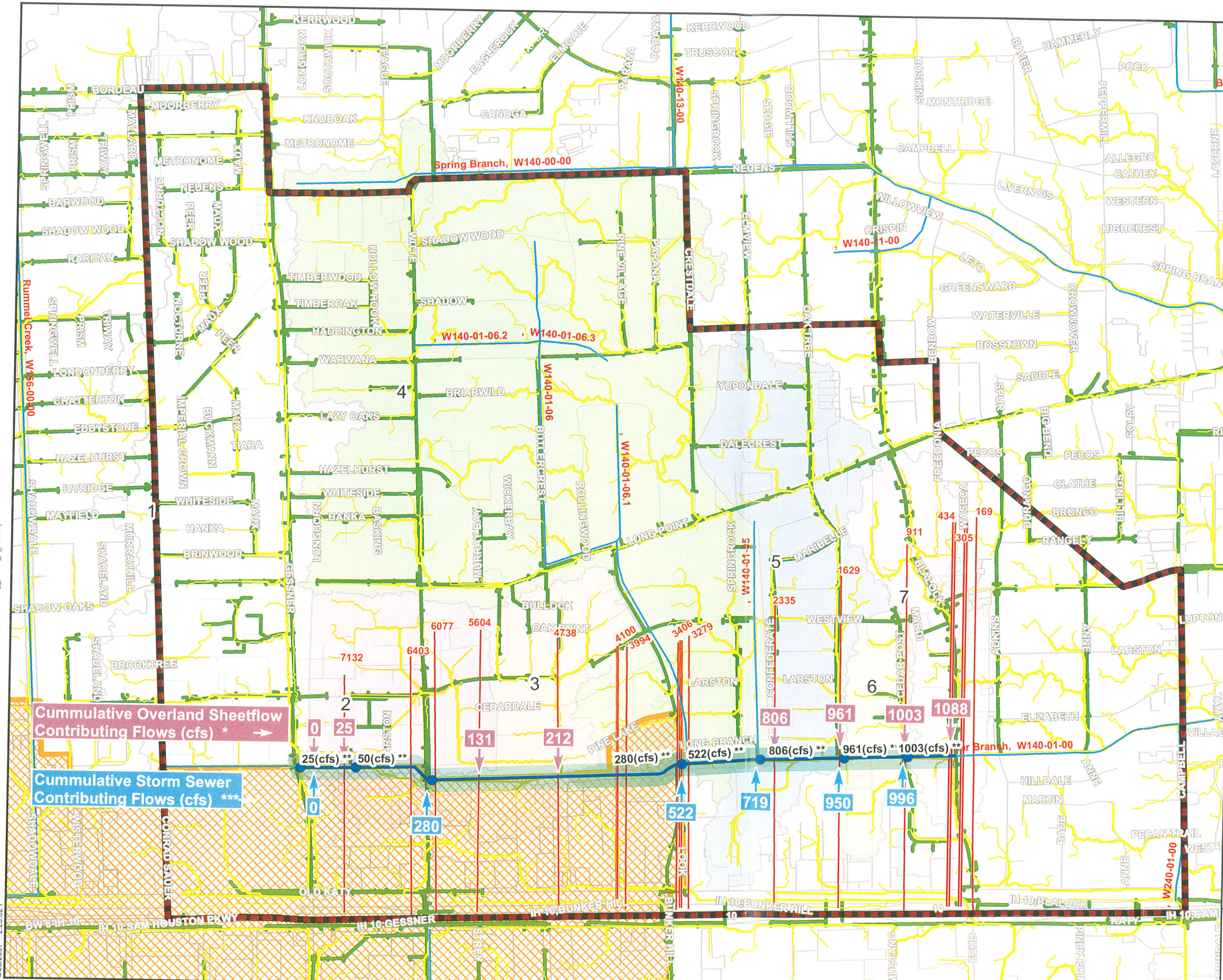

Exhibit 5
Briar Branch Drainage Study
Contributing Flows

N W E S

0 500 1,000 2,000
Feet

Legend

- # Drainage Area ID
- Overland Sheetflow Lines
- HEC-RAS Cross-Sectrions
- Storm Sewer Lines
- HCFCD Channel
- Briar Branch Study Limits
- W140C Sub-Basin
- TIRZ 17 Boundary
- Proposed Storm Sewer (Contributing flow rates are denoted above each storm sewer segment.)

NOTES:
- * Flows used to deliniate the 100-Yr floodplain.
- ** Design flows for proposed storm sewer trunkline under Claret Rd.
- *** Flows contributing from the existing storm sewer trunklines.

Harris County Vicinity Map

Briar Branch Study Area

City of Houston TIRZ 17

Lockwood, Andrews & Newnam, Inc.
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Map Document: (L:\120-10550-000\Prod\GIS\Projects\MXDs\Version_9_2\Ex5_Briar_Branch_Contributing_Flows_9_2.mxd)
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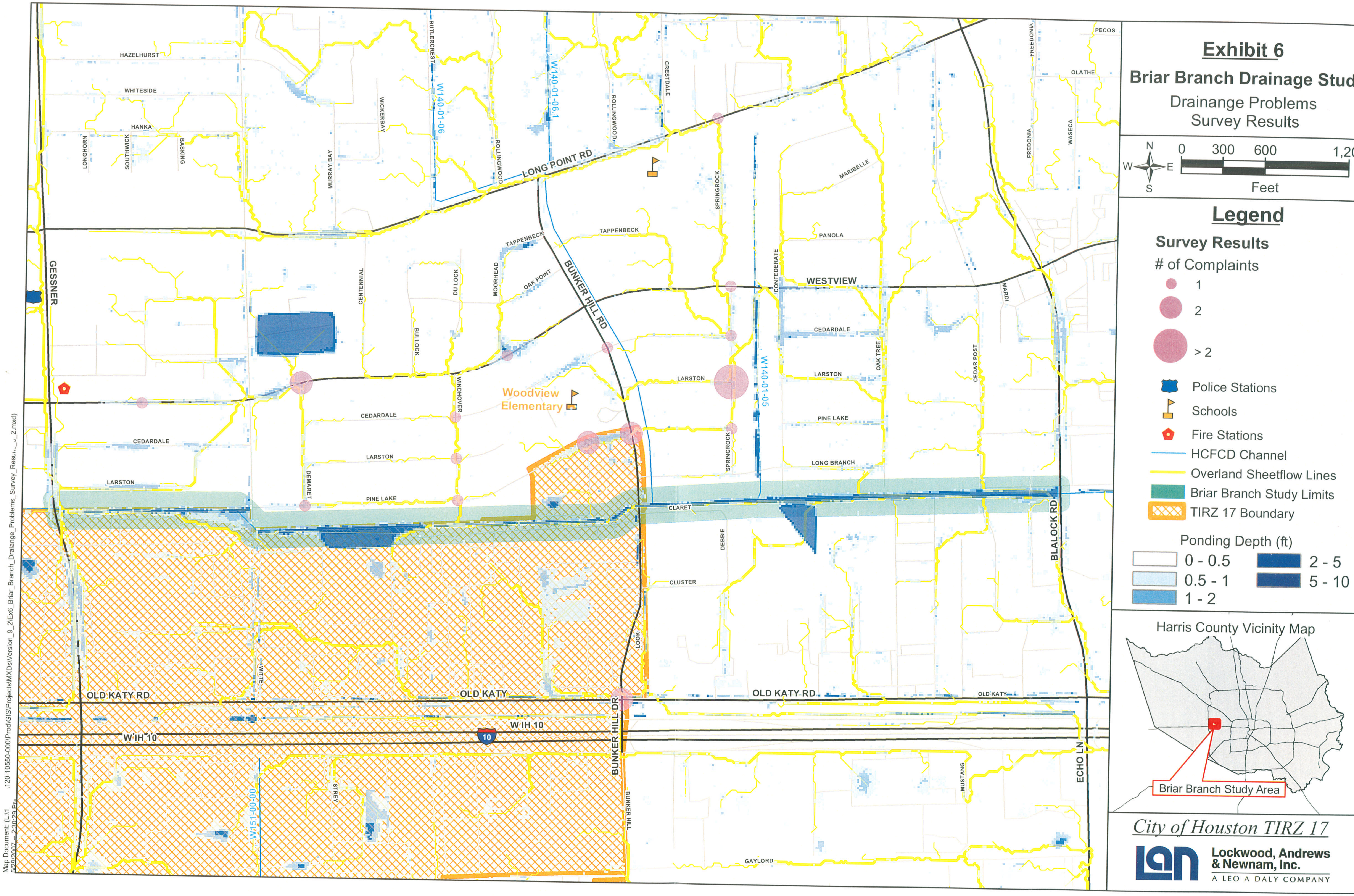
Exhibit 6

Briar Branch Drainage Study

Drainange Problems
Survey Results



Legend

Survey Results

# of Complaints

- 1
- 2
- > 2

- Police Stations
- Schools
- Fire Stations
- HCFCD Channel
- Overland Sheetflow Lines
- Briar Branch Study Limits
- TIRZ 17 Boundary

Ponding Depth (ft)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 5
- 5 - 10

City of Houston TIRZ 17

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Map Document: (L:\120-10550-000\Prod\GIS\Projects\MXDs\Version_9_2\Ex6_Briar_Branch_Drainage_Problems_Survey_Resu..._2.mxd)
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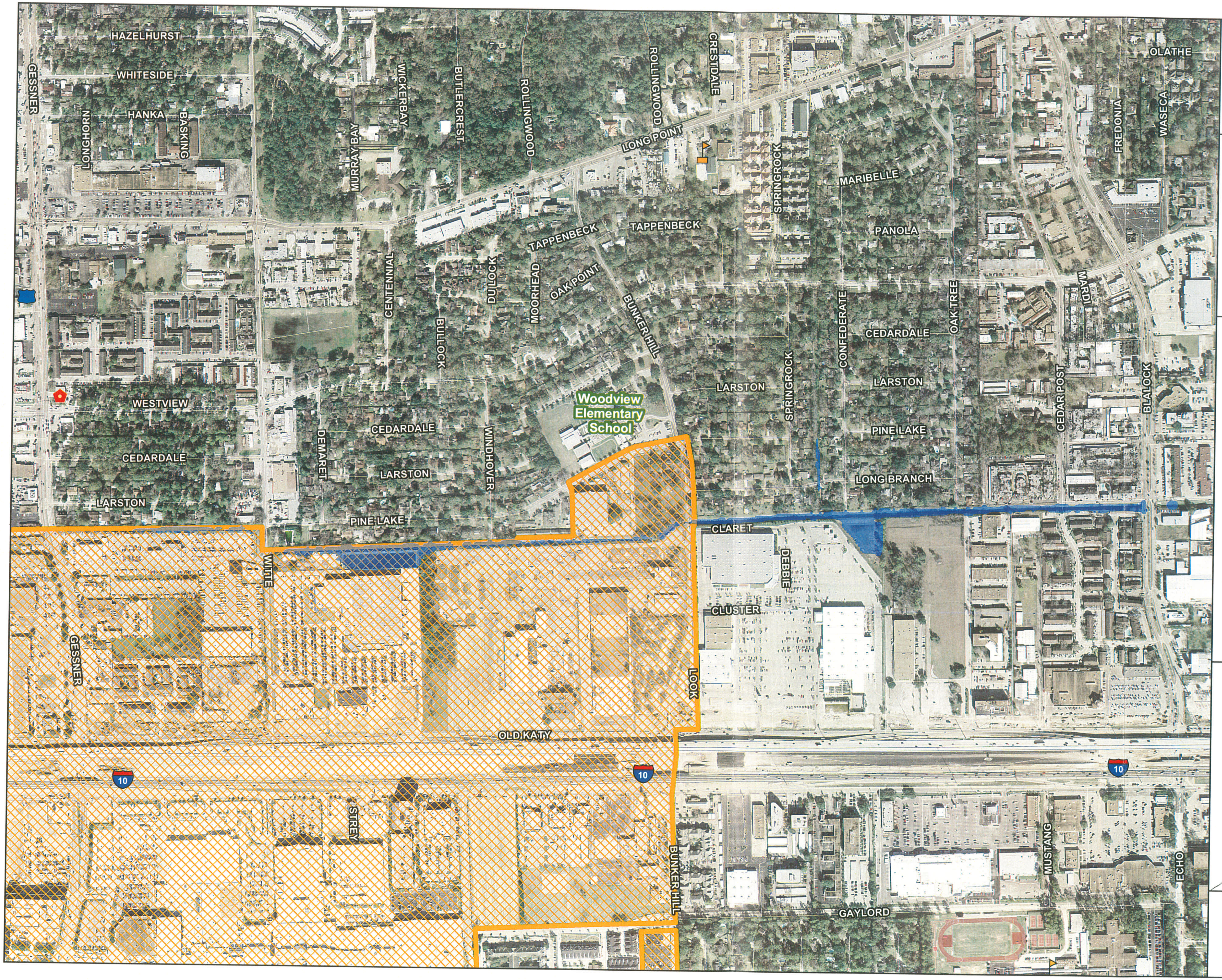

Exhibit 7

Briar Branch Drainage Study

10-Year Floodplain

N W E S

0 300 600 1,200

Feet

Legend

- 10-Year Floodplain
- TIRZ 17
- Fire Stations
- Schools
- Police Stations

Harris County Vicinity Map

Briar Branch Study Area

City of Houston TIRZ 17

LAN Lockwood, Andrews & Newnam, Inc.

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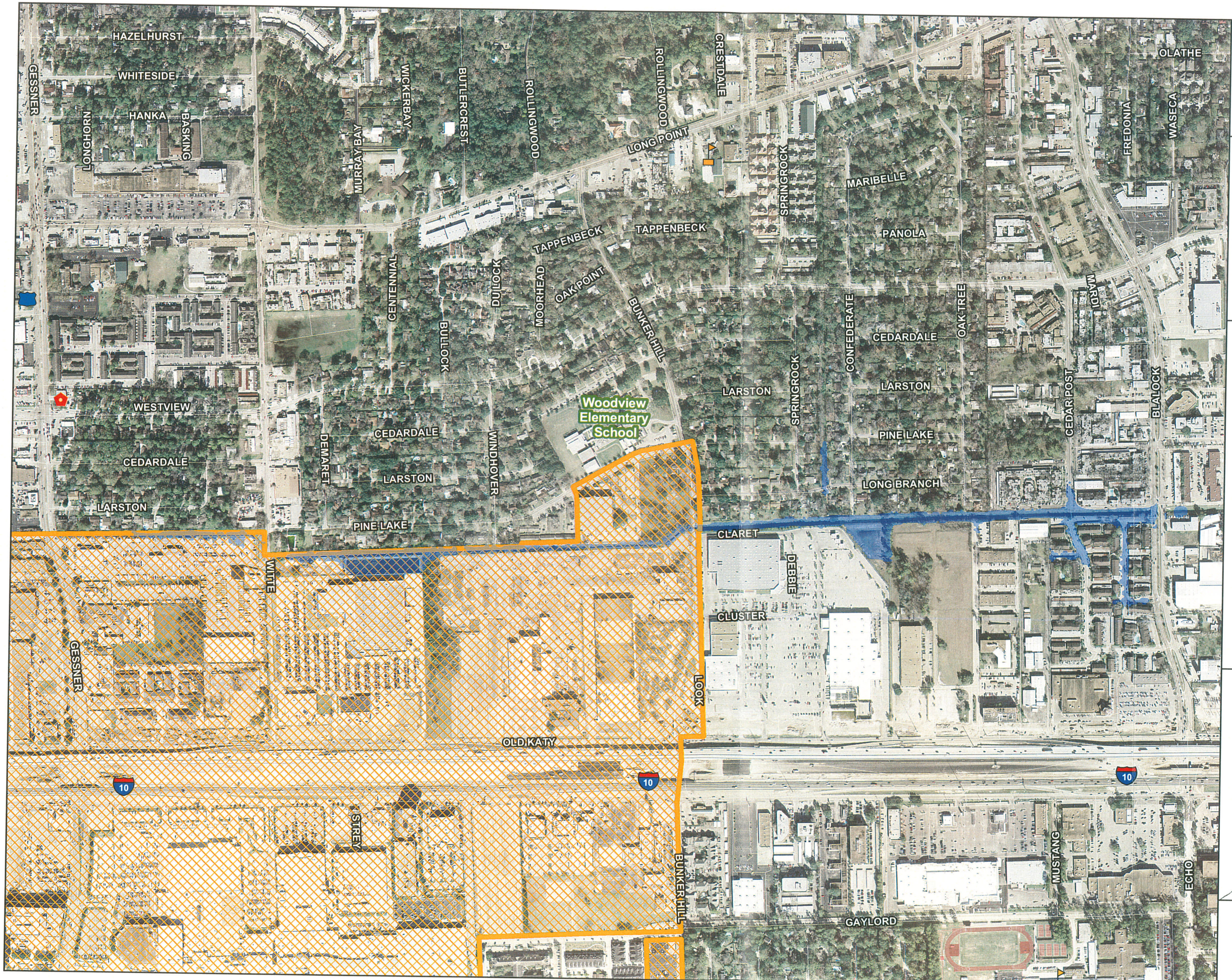


Exhibit 8

Briar Branch Drainage Study

50-Year Floodplain

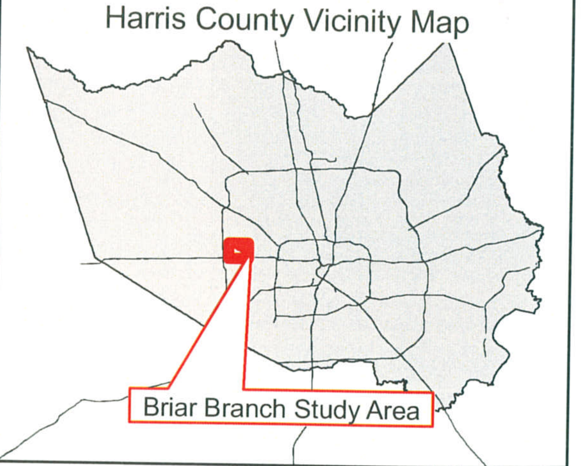
N / E / S / W

0 300 600 1,200

Feet

Legend

- 50-Year Floodplain
- TIRZ 17
- Fire Stations
- Schools
- Police Stations



City of Houston TIRZ 17

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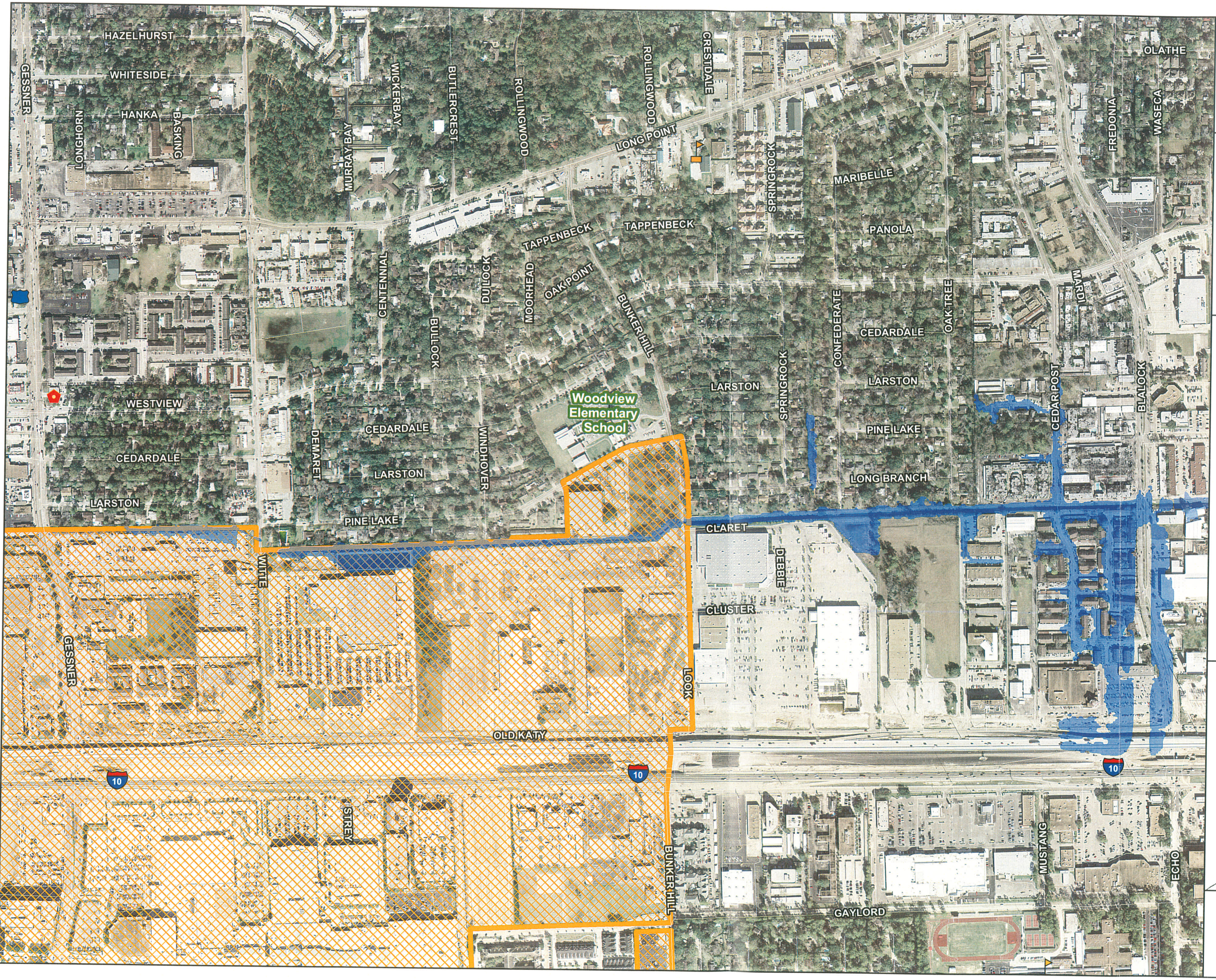
Exhibit 9

Briar Branch Drainage Study

100-Year Floodplain



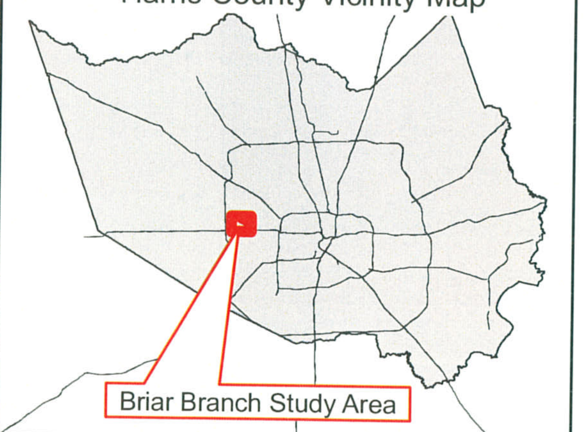
N
W E
S

0 300 600 1,200
Feet

Legend

- 100-Year Floodplain
- TIRZ 17
- Fire Stations
- Schools
- Police Stations

Harris County Vicinity Map



City of Houston TIRZ 17

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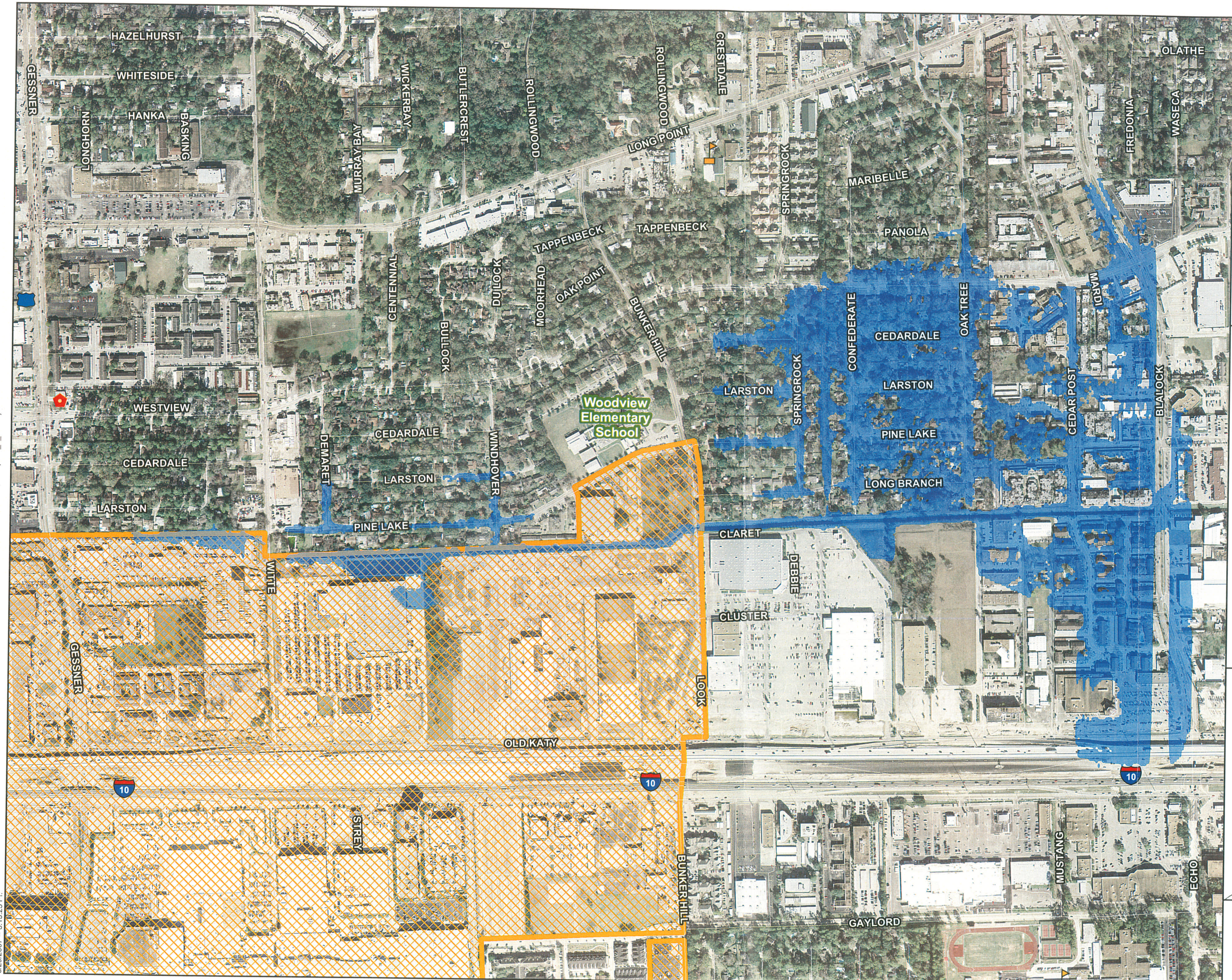
Exhibit 10

Briar Branch Drainage Study

500-Year Floodplain



N
W E
S

0 300 600 1,200

Feet

Legend

- 500-Year Floodplain
- TIRZ 17
- Fire Stations
- Schools
- Police Stations

Harris County Vicinity Map

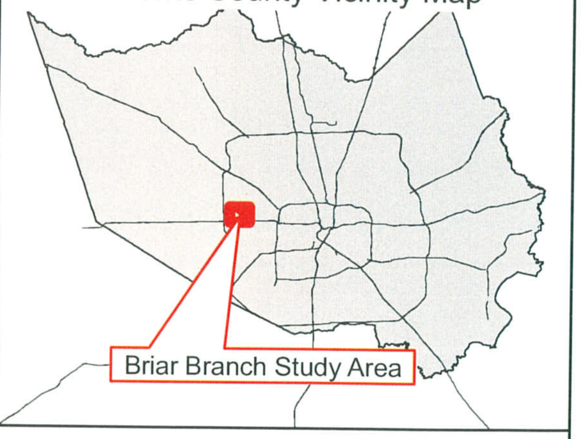


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Exhibit 11

Briar Branch Drainage Study

Channel Level of Service

N / E / S / W

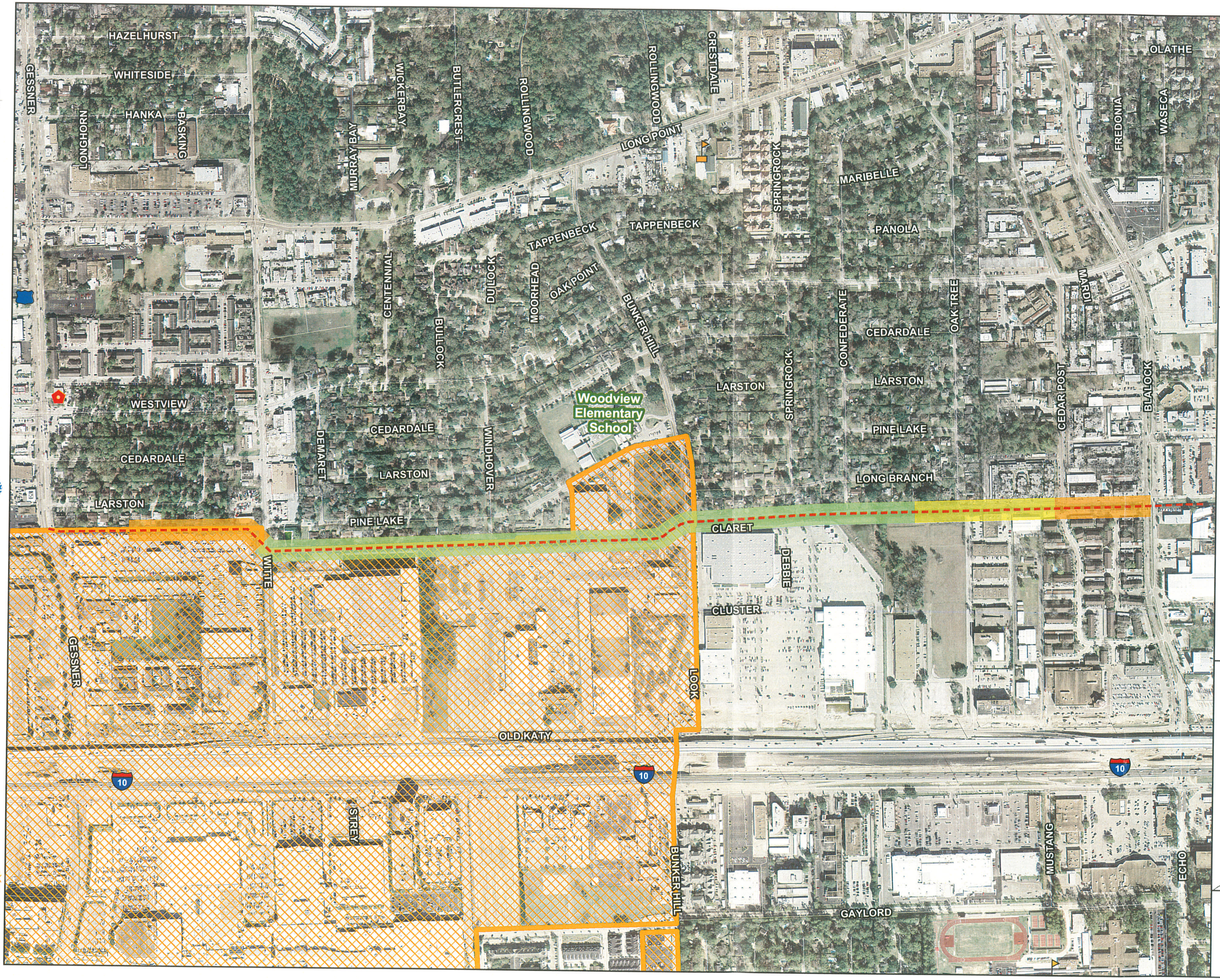
0 300 600 1,200
Feet

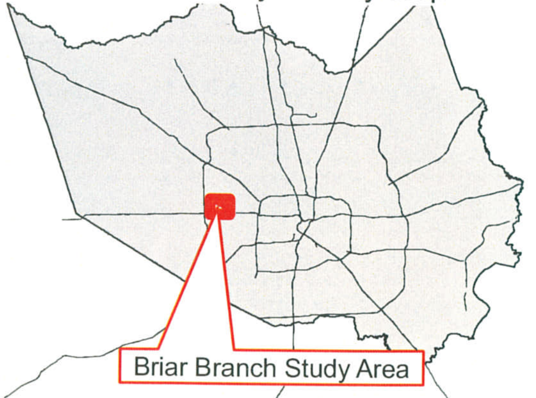
Legend

- Fire Stations
- Schools
- Police Stations
- Briar Branch Centerline
- TIRZ 17 Boundary

Channel Level of Service (LOS)

- 25-Year LOS
- 50-Year LOS
- 100-Year LOS





City of Houston TIRZ 17

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

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Appendix A

Appendix A

HEC-RAS Modeling Results

HEC-RAS Plan: Plan 06 River: Briar_Branch Reach: BB_Reach

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BB_Reach	7131.642	2-yr	25.00	75.53	78.23	76.20	78.23	0.000131	0.62	40.32	21.79	0.08
BB_Reach	7131.642	5-yr	25.00	75.53	78.75	76.20	78.75	0.000064	0.48	53.81	38.14	0.06
BB_Reach	7131.642	10-yr	25.00	75.53	79.05	76.20	79.05	0.000043	0.41	68.09	55.97	0.05
BB_Reach	7131.642	25-yr	25.00	75.53	79.39	76.20	79.40	0.000028	0.35	89.65	68.84	0.04
BB_Reach	7131.642	50-yr	25.00	75.53	79.67	76.20	79.67	0.000019	0.30	110.32	82.07	0.03
BB_Reach	7131.642	100-yr	25.00	75.53	79.96	76.20	79.96	0.000013	0.27	137.80	110.97	0.03
BB_Reach	7131.642	500-yr	25.00	75.53	80.15	76.20	80.15	0.000011	0.25	172.17	240.78	0.03
BB_Reach	6402.843	2-yr	25.00	73.77	78.22	74.52	78.22	0.000008	0.22	111.56	35.43	0.02
BB_Reach	6402.843	5-yr	25.00	73.77	78.74	74.52	78.74	0.000005	0.19	130.65	71.16	0.02
BB_Reach	6402.843	10-yr	25.00	73.77	79.04	74.52	79.04	0.000004	0.18	141.85	131.77	0.02
BB_Reach	6402.843	25-yr	25.00	73.77	79.39	74.52	79.39	0.000003	0.16	154.68	153.03	0.01
BB_Reach	6402.843	50-yr	25.00	73.77	79.67	74.52	79.67	0.000002	0.15	164.95	277.80	0.01
BB_Reach	6402.843	100-yr	25.00	73.77	79.96	74.52	79.96	0.000002	0.14	175.72	303.85	0.01
BB_Reach	6402.843	500-yr	25.00	73.77	80.15	74.52	80.15	0.000002	0.14	182.85	321.07	0.01
BB_Reach	6240		Culvert									
BB_Reach	6077.012	2-yr	25.00	74.40	78.17	75.55	78.17	0.000051	0.43	57.95	26.61	0.05
BB_Reach	6077.012	5-yr	25.00	74.40	78.69	75.55	78.70	0.000027	0.34	72.47	28.78	0.04
BB_Reach	6077.012	10-yr	25.00	74.40	79.00	75.55	79.00	0.000019	0.31	81.32	39.46	0.03
BB_Reach	6077.012	25-yr	25.00	74.40	79.34	75.55	79.34	0.000013	0.27	91.75	54.70	0.03
BB_Reach	6077.012	50-yr	25.00	74.40	79.62	75.55	79.62	0.000010	0.25	100.31	94.46	0.02
BB_Reach	6077.012	100-yr	25.00	74.40	79.91	75.55	79.91	0.000008	0.23	109.33	259.75	0.02
BB_Reach	6077.012	500-yr	25.00	74.40	80.10	75.55	80.11	0.000006	0.22	115.30	283.77	0.02
BB_Reach	5604.393	2-yr	47.00	74.91	78.09	75.92	78.10	0.000340	1.08	43.39	141.49	0.13
BB_Reach	5604.393	5-yr	67.00	74.91	78.61	76.16	78.64	0.000368	1.22	54.72	146.81	0.14
BB_Reach	5604.393	10-yr	81.00	74.91	78.91	76.31	78.94	0.000388	1.31	61.74	149.86	0.14
BB_Reach	5604.393	25-yr	99.00	74.91	79.26	76.48	79.29	0.000409	1.41	70.22	153.34	0.15
BB_Reach	5604.393	50-yr	114.00	74.91	79.53	76.61	79.57	0.000416	1.47	79.75	174.67	0.15
BB_Reach	5604.393	100-yr	131.00	74.91	79.83	76.75	79.86	0.000414	1.52	96.00	198.73	0.15
BB_Reach	5604.393	500-yr	187.00	74.91	80.10	80.10	80.10	0.000017	0.32	933.61	237.94	0.03
BB_Reach	4737.855	2-yr	66.00	75.17	77.00	76.51	77.14	0.005793	3.04	21.71	18.90	0.50
BB_Reach	4737.855	5-yr	100.00	75.17	77.50	76.78	77.65	0.004454	3.14	31.81	21.51	0.46
BB_Reach	4737.855	10-yr	124.00	75.17	77.74	76.94	77.91	0.004414	3.34	37.16	22.78	0.46
BB_Reach	4737.855	25-yr	154.00	75.17	78.03	77.13	78.22	0.004252	3.50	43.95	24.29	0.46
BB_Reach	4737.855	50-yr	181.00	75.17	78.32	77.30	78.51	0.003828	3.53	51.24	25.81	0.44
BB_Reach	4737.855	100-yr	212.00	75.17	78.66	77.46	78.85	0.003336	3.51	63.22	63.21	0.42
BB_Reach	4737.855	500-yr	310.00	75.17	79.34	77.92	79.46	0.002137	3.13	267.37	720.17	0.34
BB_Reach	4099.951	2-yr	66.00	72.12	74.93	73.72	75.02	0.002130	2.38	27.77	15.82	0.32
BB_Reach	4099.951	5-yr	100.00	72.12	75.34	74.08	75.47	0.002693	2.89	34.58	17.41	0.36
BB_Reach	4099.951	10-yr	124.00	72.12	75.79	74.30	75.92	0.002321	2.90	42.80	19.17	0.34
BB_Reach	4099.951	25-yr	154.00	72.12	76.46	74.54	76.58	0.001686	2.72	56.58	21.79	0.30
BB_Reach	4099.951	50-yr	181.00	72.12	77.05	74.74	77.15	0.001313	2.59	70.01	24.07	0.27
BB_Reach	4099.951	100-yr	212.00	72.12	77.55	74.95	77.65	0.001160	2.57	82.49	34.94	0.25
BB_Reach	4099.951	500-yr	310.00	72.12	78.17	75.52	78.32	0.001505	3.12	99.37	196.25	0.29
BB_Reach	4094.5		Bridge									
BB_Reach	4088.949	2-yr	66.00	71.76	74.93	73.32	74.99	0.001252	1.99	33.25	16.37	0.25
BB_Reach	4088.949	5-yr	100.00	71.76	75.34	73.69	75.44	0.001711	2.49	40.23	17.78	0.29
BB_Reach	4088.949	10-yr	124.00	71.76	75.79	73.91	75.89	0.001580	2.55	48.56	19.34	0.28
BB_Reach	4088.949	25-yr	154.00	71.76	76.46	74.15	76.56	0.001242	2.47	62.33	21.66	0.26
BB_Reach	4088.949	50-yr	181.00	71.76	77.05	74.36	77.14	0.001021	2.39	75.60	23.68	0.24
BB_Reach	4088.949	100-yr	212.00	71.76	77.54	74.57	77.63	0.000937	2.41	87.82	25.41	0.23
BB_Reach	4088.949	500-yr	310.00	71.76	78.16	75.16	78.30	0.001268	2.98	104.17	36.80	0.27
BB_Reach	3994.240	2-yr	66.00	72.45	74.56	73.93	74.75	0.006187	3.54	18.63	12.94	0.52
BB_Reach	3994.240	5-yr	100.00	72.45	74.72	74.30	75.08	0.010507	4.81	20.81	13.57	0.68
BB_Reach	3994.240	10-yr	124.00	72.45	75.35	74.53	75.61	0.005918	4.12	30.10	15.97	0.53
BB_Reach	3994.240	25-yr	154.00	72.45	76.19	74.78	76.37	0.003117	3.44	44.80	19.17	0.40
BB_Reach	3994.240	50-yr	181.00	72.45	76.84	74.99	76.99	0.002128	3.11	58.23	21.69	0.33
BB_Reach	3994.240	100-yr	212.00	72.45	77.37	75.20	77.51	0.001772	3.02	70.13	23.69	0.31
BB_Reach	3994.240	500-yr	310.00	72.45	77.92	75.79	78.13	0.002293	3.70	84.05	27.69	0.36
BB_Reach	3405.665	2-yr	66.00	70.22	72.37	71.87	72.66	0.002289	4.31	15.33	9.88	0.61
BB_Reach	3405.665	5-yr	100.00	70.22	73.94	72.28	74.08	0.000608	2.99	33.41	13.09	0.33
BB_Reach	3405.665	10-yr	124.00	70.22	74.89	72.53	75.00	0.000376	2.65	46.75	15.02	0.26
BB_Reach	3405.665	25-yr	154.00	70.22	75.87	72.82	75.97	0.000266	2.47	62.46	48.58	0.23
BB_Reach	3405.665	50-yr	181.00	70.22	76.58	73.05	76.67	0.000224	2.41	75.08	104.05	0.21

HEC-RAS Plan: Plan 06 River: Briar_Branch Reach: BB_Reach (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BB_Reach	3405.665	100-yr	212.00	70.22	77.12	73.30	77.22	0.000217	2.49	85.20	124.85	0.21
BB_Reach	3405.665	500-yr	310.00	70.22	77.51	73.99	77.68	0.000366	3.34	92.69	191.32	0.27
BB_Reach	3392		Bridge									
BB_Reach	3377.861	2-yr	66.00	70.13	71.93	71.93	72.56	0.002738	6.37	10.37	8.25	1.00
BB_Reach	3377.861	5-yr	100.00	70.13	73.91	72.38	74.07	0.000301	3.15	31.70	13.24	0.36
BB_Reach	3377.861	10-yr	124.00	70.13	74.88	72.64	74.99	0.000174	2.72	45.64	15.66	0.28
BB_Reach	3377.861	25-yr	154.00	70.13	75.87	72.94	75.96	0.000117	2.47	62.35	18.15	0.23
BB_Reach	3377.861	50-yr	181.00	70.13	76.58	73.18	76.67	0.000094	2.39	75.80	19.38	0.21
BB_Reach	3377.861	100-yr	212.00	70.13	77.12	73.43	77.21	0.000089	2.46	86.33	19.94	0.21
BB_Reach	3377.861	500-yr	310.00	70.13	77.50	74.13	77.67	0.000150	3.29	94.11	20.34	0.27
BB_Reach	3358.85	2-yr	66.00	70.27	72.17	71.49	72.37	0.000611	3.54	18.63	11.56	0.49
BB_Reach	3358.85	5-yr	100.00	70.27	73.96	71.85	74.05	0.000140	2.37	42.21	14.89	0.25
BB_Reach	3358.85	10-yr	124.00	70.27	74.91	72.09	74.98	0.000094	2.17	57.17	16.66	0.21
BB_Reach	3358.85	25-yr	154.00	70.27	75.89	72.35	75.95	0.000071	2.07	74.40	18.50	0.18
BB_Reach	3358.85	50-yr	181.00	70.27	76.60	72.56	76.66	0.000062	2.06	87.88	19.40	0.17
BB_Reach	3358.85	100-yr	212.00	70.27	77.13	72.79	77.20	0.000062	2.15	98.40	19.95	0.17
BB_Reach	3358.85	500-yr	310.00	70.27	77.53	73.43	77.66	0.000106	2.91	106.37	20.36	0.22
BB_Reach	3357.850	2-yr	66.00	66.27	72.29	67.58	72.32	0.000107	1.28	51.60	11.78	0.11
BB_Reach	3357.850	5-yr	100.00	66.27	74.00	67.99	74.03	0.000131	1.34	74.43	14.97	0.11
BB_Reach	3357.850	10-yr	124.00	66.27	74.94	68.25	74.97	0.000139	1.39	89.27	16.72	0.11
BB_Reach	3357.850	25-yr	154.00	66.27	75.91	68.56	75.94	0.000148	1.45	106.43	18.54	0.11
BB_Reach	3357.850	50-yr	181.00	66.27	76.62	68.82	76.65	0.000154	1.51	119.89	19.42	0.11
BB_Reach	3357.850	100-yr	212.00	66.27	77.15	69.10	77.19	0.000172	1.63	130.43	19.98	0.11
BB_Reach	3357.850	500-yr	310.00	66.27	77.56	69.92	77.64	0.000317	2.23	138.74	20.40	0.15
BB_Reach	3278.776	2-yr	66.00	66.09	72.29	67.44	72.31	0.000117	1.11	59.58	17.25	0.11
BB_Reach	3278.776	5-yr	100.00	66.09	74.00	67.85	74.01	0.000106	1.05	95.19	24.42	0.09
BB_Reach	3278.776	10-yr	124.00	66.09	74.94	68.12	74.95	0.000097	1.03	119.96	28.35	0.09
BB_Reach	3278.776	25-yr	154.00	66.09	75.91	68.42	75.93	0.000089	1.03	149.62	32.45	0.08
BB_Reach	3278.776	50-yr	181.00	66.09	76.62	68.68	76.64	0.000086	1.04	173.68	35.42	0.08
BB_Reach	3278.776	100-yr	212.00	66.09	77.16	68.95	77.18	0.000091	1.10	193.31	37.67	0.09
BB_Reach	3278.776	500-yr	310.00	66.09	77.58	69.76	77.61	0.000160	1.48	209.44	39.43	0.11
BB_Reach	2335.149	2-yr	214.00	64.70	71.80	67.52	71.92	0.000729	2.74	77.99	21.03	0.25
BB_Reach	2335.149	5-yr	343.00	64.70	73.50	68.55	73.63	0.000737	2.87	119.59	27.93	0.24
BB_Reach	2335.149	10-yr	439.00	64.70	74.44	69.63	74.58	0.000739	2.98	147.50	31.73	0.24
BB_Reach	2335.149	25-yr	560.00	64.70	75.41	70.46	75.56	0.000745	3.11	180.16	35.66	0.24
BB_Reach	2335.149	50-yr	677.00	64.70	76.09	71.06	76.26	0.000786	3.29	218.46	118.36	0.25
BB_Reach	2335.149	100-yr	806.00	64.70	76.57	71.62	76.76	0.000871	3.53	290.27	350.78	0.26
BB_Reach	2335.149	500-yr	1213.00	64.70	77.13	72.99	77.22	0.000570	3.01	1665.19	1818.95	0.22
BB_Reach	1629.327	2-yr	252.00	63.71	71.26	66.87	71.38	0.000802	2.82	89.39	24.12	0.26
BB_Reach	1629.327	5-yr	406.00	63.71	72.95	68.38	73.09	0.000797	2.97	136.76	31.74	0.25
BB_Reach	1629.327	10-yr	521.00	63.71	73.88	69.27	74.03	0.000801	3.10	168.25	35.92	0.25
BB_Reach	1629.327	25-yr	667.00	63.71	74.84	70.05	75.01	0.000814	3.26	204.75	40.22	0.25
BB_Reach	1629.327	50-yr	806.00	63.71	75.48	70.65	75.67	0.000868	3.48	236.82	90.13	0.26
BB_Reach	1629.327	100-yr	961.00	63.71	76.02	71.20	76.18	0.000761	3.40	703.30	1364.55	0.25
BB_Reach	1629.327	500-yr	1449.00	63.71	76.68	72.57	76.79	0.000622	3.30	1784.26	1771.78	0.23
BB_Reach	910.9760	2-yr	263.00	62.78	70.71	66.04	70.83	0.000717	2.75	95.49	24.15	0.24
BB_Reach	910.9760	5-yr	423.00	62.78	72.39	67.58	72.53	0.000755	2.98	141.75	31.00	0.25
BB_Reach	910.9760	10-yr	543.00	62.78	73.30	68.48	73.46	0.000787	3.16	171.70	34.72	0.25
BB_Reach	910.9760	25-yr	695.00	62.78	74.27	69.27	74.44	0.000759	3.34	245.59	240.60	0.25
BB_Reach	910.9760	50-yr	841.00	62.78	75.01	69.89	75.15	0.000584	3.18	556.36	495.46	0.22
BB_Reach	910.9760	100-yr	1003.00	62.78	75.63	70.47	75.74	0.000473	3.05	912.67	790.73	0.20
BB_Reach	910.9760	500-yr	1513.00	62.78	76.19	71.91	76.34	0.000633	3.72	1611.73	1529.41	0.24
BB_Reach	433.8807	2-yr	284.00	62.54	70.58	65.93	70.70	0.000150	2.83	100.24	25.20	0.25
BB_Reach	433.8807	5-yr	458.00	62.54	72.26	67.62	72.40	0.000137	3.09	148.44	32.17	0.25
BB_Reach	433.8807	10-yr	588.00	62.54	73.17	68.45	73.33	0.000137	3.28	179.38	35.94	0.26
BB_Reach	433.8807	25-yr	753.00	62.54	74.11	69.23	74.30	0.000161	3.47	216.72	47.42	0.29
BB_Reach	433.8807	50-yr	912.00	62.54	74.81	69.85	75.01	0.000165	3.62	252.07	53.83	0.29
BB_Reach	433.8807	100-yr	1088.00	62.54	75.57	70.43	75.66	0.000083	2.72	2662.48	3032.19	0.21
BB_Reach	433.8807	500-yr	1642.00	62.54	76.16	71.89	76.24	0.000083	2.92	4566.42	3423.85	0.22
BB_Reach	407.8807	2-yr	284.00	62.54	70.64	64.13	70.67	0.000018	1.40	203.03	25.15	0.09
BB_Reach	407.8807	5-yr	458.00	62.54	72.32	64.73	72.38	0.000027	1.87	245.30	25.18	0.11
BB_Reach	407.8807	10-yr	588.00	62.54	73.23	65.12	73.30	0.000035	2.19	268.15	25.20	0.12
BB_Reach	407.8807	25-yr	753.00	62.54	74.17	65.59	74.27	0.000066	2.48	303.58	48.18	0.17

HEC-RAS Plan: Plan 06 River: Briar_Branch Reach: BB_Reach (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
BB_Reach	407.8807	50-yr	912.00	62.54	74.87	66.00	74.98	0.000075	2.69	339.38	54.46	0.19
BB_Reach	407.8807	100-yr	1088.00	62.54	75.57	66.44	75.65	0.000063	2.54	1581.06	1603.47	0.18
BB_Reach	407.8807	500-yr	1642.00	62.54	76.16	67.66	76.23	0.000058	2.59	4667.37	3426.17	0.17
BB_Reach	356		Bridge									
BB_Reach	304.7485	2-yr	284.00	62.32	70.64	63.93	70.67	0.000017	1.37	208.04	25.15	0.08
BB_Reach	304.7485	5-yr	458.00	62.32	72.32	64.53	72.37	0.000026	1.83	250.26	25.19	0.10
BB_Reach	304.7485	10-yr	588.00	62.32	73.21	64.93	73.28	0.000035	2.15	272.89	26.55	0.12
BB_Reach	304.7485	25-yr	753.00	62.32	74.13	65.38	74.23	0.000055	2.48	303.30	38.72	0.16
BB_Reach	304.7485	50-yr	912.00	62.32	74.80	65.81	74.91	0.000069	2.75	331.26	1045.42	0.18
BB_Reach	304.7485	100-yr	1088.00	62.32	75.44	66.23	75.53	0.000059	2.61	1694.04	1525.48	0.17
BB_Reach	304.7485	500-yr	1642.00	62.32	76.10	67.46	76.20	0.000073	3.03	3472.76	3056.91	0.19
BB_Reach	279.7003	2-yr	284.00	62.35	70.54	65.73	70.66	0.000675	2.71	104.84	25.49	0.24
BB_Reach	279.7003	5-yr	458.00	62.35	72.22	67.39	72.36	0.000728	2.99	153.03	32.07	0.24
BB_Reach	279.7003	10-yr	588.00	62.35	73.11	68.20	73.27	0.000777	3.21	183.28	35.58	0.25
BB_Reach	279.7003	25-yr	753.00	62.35	74.03	68.97	74.22	0.000918	3.45	218.29	42.51	0.27
BB_Reach	279.7003	50-yr	912.00	62.35	74.69	69.60	74.90	0.001069	3.66	268.77	200.86	0.29
BB_Reach	279.7003	100-yr	1088.00	62.35	75.46	70.19	75.52	0.000438	2.48	1615.02	1649.40	0.19
BB_Reach	279.7003	500-yr	1642.00	62.35	76.14	71.66	76.18	0.000344	2.38	2907.66	2266.73	0.17
BB_Reach	168.5953	2-yr	284.00	61.93	70.48	65.37	70.58	0.000609	2.57	110.38	26.65	0.22
BB_Reach	168.5953	5-yr	458.00	61.93	72.15	67.05	72.28	0.000661	2.85	160.67	33.57	0.23
BB_Reach	168.5953	10-yr	588.00	61.93	73.04	67.91	73.19	0.000707	3.06	192.18	37.25	0.24
BB_Reach	168.5953	25-yr	753.00	61.93	73.95	68.72	74.12	0.000755	3.29	256.88	176.79	0.25
BB_Reach	168.5953	50-yr	912.00	61.93	74.63	69.34	74.79	0.000709	3.31	468.18	368.75	0.24
BB_Reach	168.5953	100-yr	1088.00	61.93	75.33	69.93	75.46	0.000578	3.14	785.76	672.55	0.22
BB_Reach	168.5953	500-yr	1642.00	61.93	75.94	71.40	76.11	0.000775	3.84	1405.64	1503.77	0.26

Appendix B

APPENDIX B

PRELIMINARY IMPROVEMENT ALTERNATIVE – CHANNEL ENCLOSURE

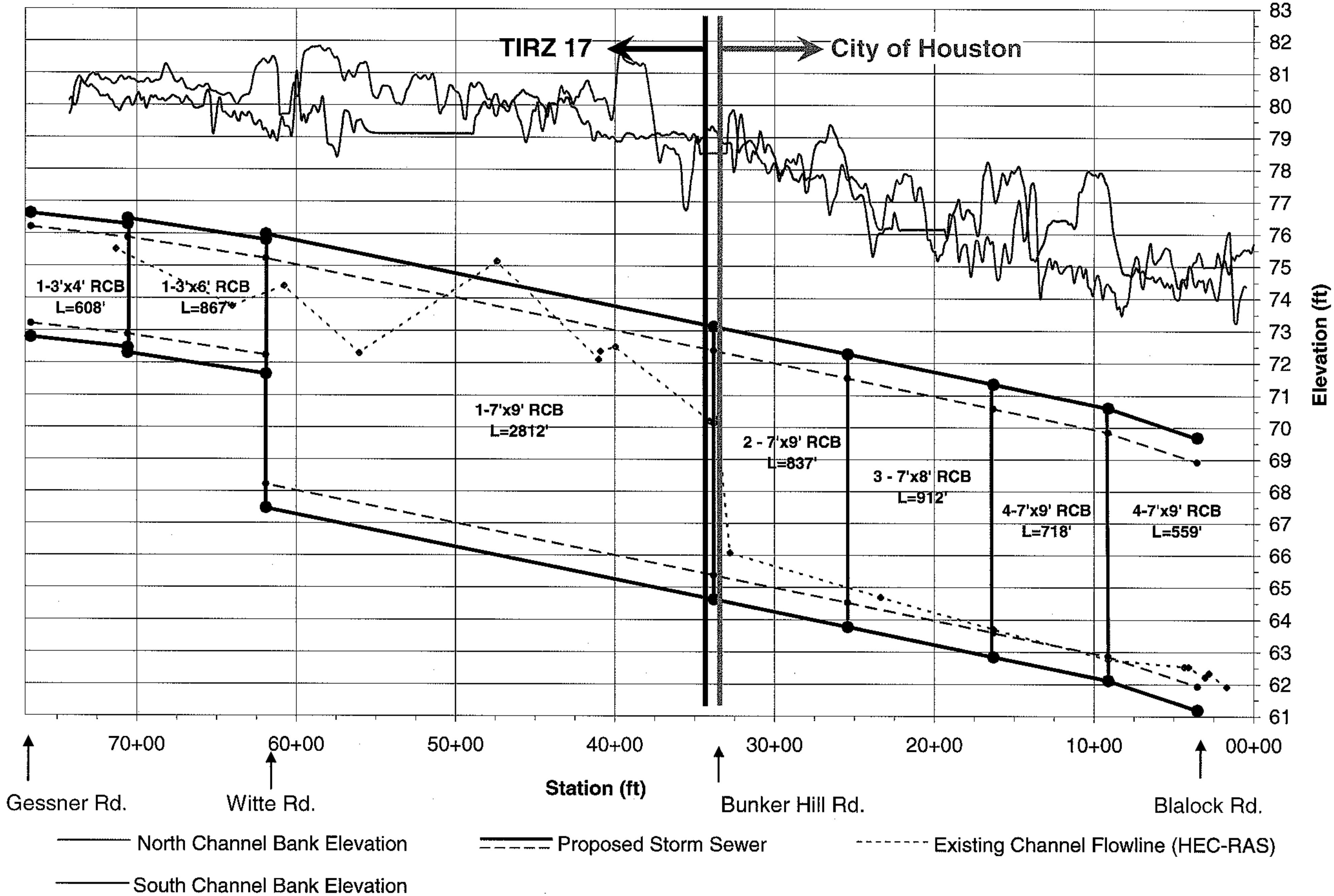
B.1. Proposed Storm Sewer Profile

B.2. HouStorm Modeling Results

B.3. Proposed Storm Sewer Cost Estimate

Briar Branch Drainage Study

Approximate Channel Bank Elevations with Proposed Storm Sewer



Briar Branch – RAS 10 Year

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Jan/5/05
Run @ 5/11/2007 1:25:45 PM

PROJECT NAME : Briar Branch Drainage Study
JOB NUMBER :
PROJECT DESCRIPTION : Sizing storm sewer under Claret Street.
PROJECT File: L:\120214\120-10550-000\Prod\Data\Refined\Houstorm\Briar_Branch_

DESIGN FREQUENCY : 100 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 100 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
A-4	Junct	0.350	0.04	24.86	7.02		522.00	522.098
A-5	Junct	0.350	0.05	27.08	6.78		806.00	806.119
A-6	Junct	0.350	0.06	29.25	6.57		961.00	961.138
A-7	Junct	0.350	0.07	31.05	6.40		1003.00	1003.157
OUT	Outlt	0.350	0.07	31.05	6.40		1003.00	1003.157

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value

1	A-1	A-2	73.21	72.88	Box 1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box 1	6.0	3.0	867.0	0.075	0.013
3	A-3	A-4	68.23	65.37	Box 1	8.0	7.0	2812.0	0.102	0.013
4	A-4	A-5	65.37	64.52	Box 2	8.0	7.0	837.0	0.102	0.013
5	A-5	A-6	64.52	63.59	Box 2	10.0	7.0	912.0	0.102	0.013
6	A-6	A-7	63.59	62.86	Box 3	9.0	7.0	718.0	0.102	0.013
7	A-7	OUT	62.86	61.93	Box 3	9.0	7.0	559.0	0.166	0.013

Conveyance Hydraulic Computations. Tailwater = 73.040 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	78.70	78.45	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	78.45	77.94	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	77.94	75.59	79.94	0.083	5.47	7.00	6.40	5.00	280.1	309.5	0.000
4	75.59	74.99	77.12	0.072	5.20	7.00	6.28	4.66	522.1	618.9	0.000
5	74.99	74.10	76.70	0.097	5.74	7.00	7.02	5.76	806.1	826.2	0.000
6	74.10	73.53	76.02	0.080	5.36	7.00	6.64	5.09	961.1	1082.1	0.000
7	73.53	73.04	75.63	0.087	4.62	7.00	8.04	5.31	1003.2	1382.0	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0
Box	Concrete	3.0	6.0	1	867.0
Box	Concrete	7.0	8.0	2	4486.0
Box	Concrete	7.0	10.0	1	1824.0
Box	Concrete	7.0	9.0	2	3831.0

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction		0.0	0.0	0.0	0.0	0.0	7
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
A-4	Junct	0.350	0.04	24.86	7.02		522.00	522.098
A-5	Junct	0.350	0.05	27.08	6.78		806.00	806.119
A-6	Junct	0.350	0.06	29.25	6.57		961.00	961.138
A-7	Junct	0.350	0.07	31.05	6.40		1003.00	1003.157
OUT	Outlt	0.350	0.07	31.05	6.40		1003.00	1003.157

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	A-2	73.21	72.88	Box	1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box	1	6.0	3.0	867.0	0.075	0.013
3	A-3	A-4	68.23	65.37	Box	1	8.0	7.0	2812.0	0.102	0.013
4	A-4	A-5	65.37	64.52	Box	2	8.0	7.0	837.0	0.102	0.013
5	A-5	A-6	64.52	63.59	Box	2	10.0	7.0	912.0	0.102	0.013
6	A-6	A-7	63.59	62.86	Box	3	9.0	7.0	718.0	0.102	0.013
7	A-7	OUT	62.86	61.93	Box	3	9.0	7.0	559.0	0.166	0.013

Conveyance Hydraulic Computations. Tailwater = 73.040 (ft)

Run Hyd. Gr.line Crit.Elev Depth Velocity Junc

#	US (ft)	DS (ft)	US (ft)	Fr.Slope (%)	Unif. (ft)	Actual (ft)	Unif. (f/s)	Actual (f/s)	Q (cfs)	Cap (cfs)	Loss (ft)
1	78.70	78.45	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	78.45	77.94	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	77.94	75.59	79.94	0.083	5.47	7.00	6.40	5.00	280.1	309.5	0.000
4	75.59	74.99	77.12	0.072	5.20	7.00	6.28	4.66	522.1	618.9	0.000
5	74.99	74.10	76.70	0.097	5.74	7.00	7.02	5.76	806.1	826.2	0.000
6	74.10	73.53	76.02	0.080	5.36	7.00	6.64	5.09	961.1	1082.1	0.000
7	73.53	73.04	75.63	0.087	4.62	7.00	8.04	5.31	1003.2	1382.0	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0
Box	Concrete	3.0	6.0	1	867.0
Box	Concrete	7.0	8.0	2	4486.0
Box	Concrete	7.0	10.0	1	1824.0
Box	Concrete	7.0	9.0	2	3831.0

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction	0.0	0.0	0.0	0.0	0.0	7
Outlet	0.0	0.0	0.0	0.0	0.0	1

=================================END===

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 100 Years

Runoff Frequency of: 100 Years

Briar Branch – RAS 100 Year

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Jan/5/05
Run @ 5/11/2007 1:25:10 PM

PROJECT NAME : Briar Branch Drainage Study
JOB NUMBER :
PROJECT DESCRIPTION : Sizing storm sewer under Claret Street.
PROJECT File: L:\120214\120-10550-000\Prod\Data\Refined\Houstorm\Briar_Branch_

DESIGN FREQUENCY : 100 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 100 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
A-4	Junct	0.350	0.04	24.87	7.02		522.00	522.098
A-5	Junct	0.350	0.05	27.08	6.78		806.00	806.119
A-6	Junct	0.350	0.06	29.48	6.54		961.00	961.137
A-7	Junct	0.350	0.07	31.42	6.36		1003.00	1003.156
OUT	Outlt	0.350	0.07	31.42	6.36		1003.00	1003.156

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value

1	A-1	A-2	73.21	72.88	Box 1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box 1	6.0	3.0	867.0	0.075	0.013
3	A-3	A-4	68.23	65.37	Box 1	9.0	7.0	2812.0	0.102	0.013
4	A-4	A-5	65.37	64.52	Box 2	9.0	7.0	837.0	0.102	0.013
5	A-5	A-6	64.52	63.59	Box 3	8.0	7.0	912.0	0.102	0.013
6	A-6	A-7	63.59	62.86	Box 4	9.0	7.0	718.0	0.102	0.013
7	A-7	OUT	62.86	61.93	Box 4	9.0	7.0	559.0	0.166	0.013

Conveyance Hydraulic Computations. Tailwater = 75.330 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Junc Loss (ft)
1	79.56	79.31	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	79.31	78.80	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	78.80	77.07	79.94	0.061	4.87	7.00	6.39	4.45	280.1	360.8	0.000
4	77.07	76.63	77.12	0.053	4.59	7.00	6.31	4.14	522.1	721.4	0.000
5	76.63	75.93	76.70	0.077	5.30	7.00	6.33	4.80	806.1	928.7	0.000
6	75.93	75.60	76.02	0.045	4.32	7.00	6.18	3.81	961.1	1442.8	0.000
7	75.60	75.33	75.63	0.049	3.72	7.00	7.49	3.98	1003.2	1842.6	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:

The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0
Box	Concrete	3.0	6.0	1	867.0
Box	Concrete	7.0	9.0	4	9594.0
Box	Concrete	7.0	8.0	1	2736.0

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction		0.0	0.0	0.0	0.0	0.0	7
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
A-4	Junct	0.350	0.04	24.87	7.02		522.00	522.098
A-5	Junct	0.350	0.05	27.08	6.78		806.00	806.119
A-6	Junct	0.350	0.06	29.48	6.54		961.00	961.137
A-7	Junct	0.350	0.07	31.42	6.36		1003.00	1003.156
OUT	Outlt	0.350	0.07	31.42	6.36		1003.00	1003.156

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	A-2	73.21	72.88	Box	1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box	1	6.0	3.0	867.0	0.075	0.013
3	A-3	A-4	68.23	65.37	Box	1	9.0	7.0	2812.0	0.102	0.013
4	A-4	A-5	65.37	64.52	Box	2	9.0	7.0	837.0	0.102	0.013
5	A-5	A-6	64.52	63.59	Box	3	8.0	7.0	912.0	0.102	0.013
6	A-6	A-7	63.59	62.86	Box	4	9.0	7.0	718.0	0.102	0.013
7	A-7	OUT	62.86	61.93	Box	4	9.0	7.0	559.0	0.166	0.013

Conveyance Hydraulic Computations. Tailwater = 75.330 (ft)

Run #	Hyd. Gr.line US	DS	Crit.Elev US	Fr.Slope	Depth Unif.	Actual	Velocity Unif.	Actual	Q	Junc Cap	Loss

	(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(f/s)	(f/s)	(cfs)	(cfs)	(ft)
1	79.56	79.31	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	79.31	78.80	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	78.80	77.07	79.94	0.061	4.87	7.00	6.39	4.45	280.1	360.8	0.000
4	77.07	76.63	77.12	0.053	4.59	7.00	6.31	4.14	522.1	721.4	0.000
5	76.63	75.93	76.70	0.077	5.30	7.00	6.33	4.80	806.1	928.7	0.000
6	75.93	75.60	76.02	0.045	4.32	7.00	6.18	3.81	961.1	1442.8	0.000
7	75.60	75.33	75.63	0.049	3.72	7.00	7.49	3.98	1003.2	1842.6	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0
Box	Concrete	3.0	6.0	1	867.0
Box	Concrete	7.0	9.0	4	9594.0
Box	Concrete	7.0	8.0	1	2736.0

NODES:

Type of Inlet Structure	Type of Grate Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction	0.0	0.0	0.0	0.0	0.0	7
Outlet	0.0	0.0	0.0	0.0	0.0	1

END

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 100 Years

Runoff Frequency of: 100 Years

Briar Branch to Bunker Hill – RAS 10 Year

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Jan/5/05
Run @ 5/11/2007 1:26:36 PM

PROJECT NAME : Briar Branch Drainage Study
JOB NUMBER :
PROJECT DESCRIPTION : Sizing storm sewer under Claret Street.
PROJECT File: L:\120214\120-10550-000\Prod\Data\Refined\Houstorm\Briar_to_Bunk

DESIGN FREQUENCY : 100 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 100 Years
==

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
OUT	Outlt	0.350	0.03	17.54	7.98		280.00	280.084

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	A-2	73.21	72.88	Box	1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box	1	6.0	3.0	867.0	0.075	0.013
3	A-3	OUT	68.23	65.37	Box	1	8.0	7.0	2812.0	0.102	0.013

Conveyance Hydraulic Computations. Tailwater = 74.880 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	77.98	77.74	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	77.74	77.22	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	77.22	74.88	79.94	0.083	5.47	7.00	6.40	5.00	280.1	309.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0
Box	Concrete	3.0	6.0	1	867.0
Box	Concrete	7.0	8.0	1	2812.0

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction		0.0	0.0	0.0	0.0	0.0	3
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033

A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
OUT	Outlt	0.350	0.03	17.54	7.98		280.00	280.084

Conveyance Configuration Data

Run #	Node I.D. US	Node I.D. DS	FlowLine Elev. US (ft)	FlowLine Elev. DS (ft)	Shape #	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	A-2	73.21	72.88	Box 1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box 1	6.0	3.0	867.0	0.075	0.013
3	A-3	OUT	68.23	65.37	Box 1	8.0	7.0	2812.0	0.102	0.013

Conveyance Hydraulic Computations. Tailwater = 74.880 (ft)

Run #	Hyd. Gr.line US (ft)	Hyd. Gr.line DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Depth Actual (ft)	Velocity Unif. (f/s)	Velocity Actual (f/s)	Q (cfs)	Cap (cfs)	Junc Loss (ft)
1	77.98	77.74	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	77.74	77.22	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	77.22	74.88	79.94	0.083	5.47	7.00	6.40	5.00	280.1	309.5	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0

Box	Concrete	3.0	6.0	1	867.0
Box	Concrete	7.0	8.0	1	2812.0

NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction		0.0	0.0	0.0	0.0	0.0	3
Outlet		0.0	0.0	0.0	0.0	0.0	1

=================================END=======================================

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 100 Years

Runoff Frequency of: 100 Years

Briar Branch to Bunker Hill – RAS 100 Year

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Jan/5/05
Run @ 5/11/2007 1:27:38 PM

PROJECT NAME : Briar Branch Drainage Study
JOB NUMBER :
PROJECT DESCRIPTION : Sizing storm sewer under Claret Street.
PROJECT File: L:\120214\120-10550-000\Prod\Data\Refined\Houstorm\Briar_to_Bunk

DESIGN FREQUENCY : 100 Years
ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 100 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-4	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-5	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-6	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-7	0.35	0.01	10.00	10.00	9.36	0.000	0.033

Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
A-1	Junct	0.350	0.01	10.00	9.36		25.00	25.033
A-2	Junct	0.350	0.02	13.64	8.63		50.00	50.060
A-3	Junct	0.350	0.03	17.54	7.98		280.00	280.084
OUT	Outlt	0.350	0.03	17.54	7.98		280.00	280.084

Conveyance Configuration Data

Run #	Node I.D. US	DS	FlowLine Elev. US (ft)	DS (ft)	Shape	#	Span (ft)	Rise (ft)	Length (ft)	Slope (%)	n_value
1	A-1	A-2	73.21	72.88	Box	1	4.0	3.0	608.0	0.054	0.013
2	A-2	A-3	72.88	72.23	Box	1	6.0	3.0	867.0	0.075	0.013
3	A-3	OUT	68.23	65.37	Box	1	9.0	7.0	2812.0	0.102	0.013

Conveyance Hydraulic Computations. Tailwater = 77.120 (ft)

Run #	Hyd. Gr.line US (ft)	DS (ft)	Crit.Elev US (ft)	Fr.Slope (%)	Depth Unif. (ft)	Actual (ft)	Velocity Unif. (f/s)	Actual (f/s)	Q (cfs)	Junc Cap (cfs)	Loss (ft)
1	79.61	79.36	79.96	0.041	2.25	3.00	2.78	2.09	25.0	28.8	0.000
2	79.36	78.84	79.96	0.059	2.25	3.00	3.71	2.78	50.1	56.3	0.000
3	78.84	77.12	79.94	0.061	4.87	7.00	6.39	4.45	280.1	360.8	0.000

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)
Box	Concrete	3.0	4.0	1	608.0
Box	Concrete	3.0	6.0	1	867.0
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NODES:

Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Conduit Junction		0.0	0.0	0.0	0.0	0.0	3
Outlet		0.0	0.0	0.0	0.0	0.0	1

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Analysis Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A-1	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-2	0.35	0.01	10.00	10.00	9.36	0.000	0.033
A-3	0.35	0.01	10.00	10.00	9.36	0.000	0.033
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Cumulative Junction Discharge Computations

Node I.D.	Node Type	Weighted C-Value	Cumulat. Dr.Area (acres)	Cumulat. Tc (min)	Intens. (in/hr)	User Supply Q cfs)	Additional Q in Node (cfs)	Total Disch. (cfs)
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Conveyance Configuration Data

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Conveyance Hydraulic Computations. Tailwater = 77.120 (ft)

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Type of Inlet Structure	Type of Grate	Inlet Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
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Outlet		0.0	0.0	0.0	0.0	0.0	1

==========END==========

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 100 Years

Runoff Frequency of: 100 Years