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DRAINAGE STUDY REPORT ADDENDUM

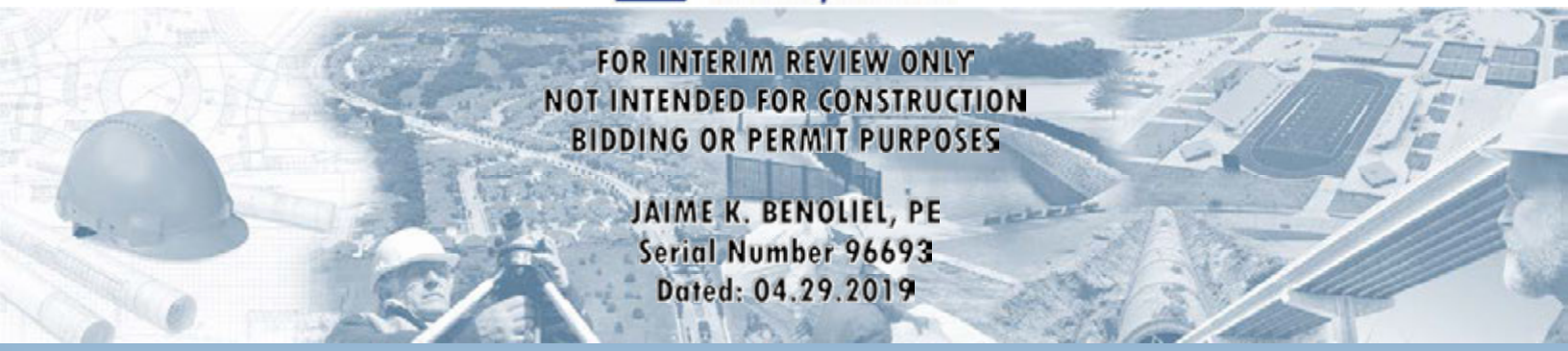
North Houston Improvement Project

Segment 3E: I-45 Downtown Connectors

CSJ: 0500-03-598

Harris County, Texas

Texas Department of Transportation



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Drainage Study Report Addendum
North Houston Highway Improvement Project
Segment 3E: I-45 Downtown Connectors
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Houston, Texas

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Executive Summary

The recommendations contained in this study are intended to provide TxDOT with a preliminary drainage mitigation plan for the revised schematic which includes a main lane depressed section under Dallas and Andrews Street, revised from overpasses in the original schematic. This report is an addendum to the report entitled "Drainage Study Report North Houston Highway Improvement Project Segment 3E: I-45 Downtown Connectors" dated August 2018, prepared by Dannenbaum Engineering Corporation (DEC report).

The existing I-45 right-of-way (ROW) in the proposed project area is drained by four (4) existing storm sewer systems. The storm sewer systems were originally constructed between the 1930s and 1970s, with some upgrades over the years. The existing storm sewer systems range in size from 18" RCPs to 42" RCPs within the project ROW. Hydraulic Analysis of the existing storm sewer systems indicated that the existing systems do not have adequate capacity to meet the design criteria. The project ROW is drained completely by the System F proposed storm sewer system. No improvements are made to Systems G-I storm sewer systems, since these are existing City of Houston storm sewer systems located outside the project ROW. The proposed flows to Systems G-I are reduced due to area within the project ROW and the offsite System G lateral flow at Andrews Street being diverted to System F. The proposed System F storm sewer ranges in size from 24" RCP to 5' x 3' RCB. The proposed storm sewer configuration and sizes are shown on **Exhibit 3**.

The original proposed southbound frontage road profile shown on the design schematic (included in **Appendix A)** is low enough in elevation at the Allen Parkway intersection to allow overflow of the 500-year tailwater from Buffalo Bayou to enter the main lane depressed section. The southbound frontage road schematic profile was adjusted from station 69+00 to 75+18.36 to raise the roadway elevation to prohibit the 500-year flows from Buffalo Bayou from entering the proposed main lane depressed section. The adjusted southbound frontage road profile is shown on the proposed design schematic included in **Appendix B**.

The 100-year and 500-year models were analyzed with the Buffalo Bayou tailwater from the Lockwood, Andrews, & Newnam, Inc. (LAN) Segment 3D unsteady state HEC-RAS models for the Corrected Effective, Mitigated with Detention only, and Mitigated with the North and South Canal, Heights Blvd. improvements and mitigation conditions. For the Corrected Effective and Mitigated with Detention only conditions, the 100-year and 500-year tailwater from Buffalo Bayou results in flooding along the proposed northbound and southbound frontage road systems and the Allen Parkway depressed section. For the Mitigated with the North and South Canal, Heights Blvd. improvements, and mitigation condition, the 500-year tailwater from Buffalo Bayou results in flooding along the proposed northbound and southbound frontage road systems and the Allen Parkway depressed section.

The proposed main lane depressed section will be drained by a proposed pump station. The proposed pump station has a 25' diameter wet well with a flowline elevation of -9.00 feet. The proposed pump station consists of three 5,600 gallon per minute (GPM) pumps and one 1,000 GPM low flow pump.

The proposed project will not increase the impervious area within the right-of-way. However, the proposed storm sewer system provides additional capacity increasing the flows to Buffalo Bayou. Therefore, two detention pond basins are recommended to mitigate the flows that provide an additional

15.94 ac-ft of storage volume. The recommended detention basin locations and characteristic are shown on **Exhibit 4**.

Based on the drainage improvement recommendations presented in this study, the proposed project will result in no adverse flooding impacts to Buffalo Bayou (HCFCD W100-00-00) or adjacent properties for flood events up to and including the 100-year storm event.

1.0 Introduction

Teague Nall and Perkins, Inc. (TNP) (successor by merger to H & H Resources, Inc.) was contracted by HNTB, Inc. and the Texas Department of Transportation (TxDOT) to update the drainage study and analysis for the revised schematic changes along Interstate Highway 45 (I-45) from Buffalo Bayou to Brazos Street near downtown Houston, Texas. The proposed improvements are a part of Segment 3 (Downtown Loop) of the North Houston Highway Improvement Project (NHHIP). The current study focuses on Segment 3E, Outfalls F, G, H and I of the project, which includes converting the existing I-45 through downtown into Downtown Connectors. This report is an addendum to the report entitled "Drainage Study Report North Houston Highway Improvement Project Segment 3E: I-45 Downtown Connectors" dated August 2018, prepared by Dannenbaum Engineering Corporation (DEC report). This report documents the technical findings of the drainage study due to the proposed schematic revision. Outfalls A-E and the hydraulic impact analysis of the proposed bridges over Buffalo Bayou, HCFCD Unit W100-00-00 are documented in the DEC report included in **Appendix E**. This drainage study presents the following for Outfall F, G, H and I: (i) analysis of the existing storm sewer drainage systems, (ii) proposed storm sewer design, (iii) drainage impacts due to the proposed roadway and drainage improvements, and (iv) detention mitigation recommendations.

1.1 Project Location and Description

The DEC report can be referenced for the NHHIP Segment 3E overall project limits and additional background project data. The proposed project documented in this report is the portion of Segment 3E that extends from Buffalo Bayou south to Brazos Street, a length of approximately 2,600 feet. The proposed project location is shown on DEC report Exhibit 1. The project limits are located within the Buffalo Bayou Watershed. Buffalo Bayou, HCFCD Unit W100-00-00 serves as the outfall for the entire Segment 3E project.

The Segment 3E improvements include removing the section of the existing I-45 west of downtown and replacing it with Downtown Connectors. The proposed project revises the Downtown Connectors schematic and includes a main lane depressed section under Dallas and Andrews Street, revised from overpasses included in the original schematic. The Downtown Connectors will have a typical main lane, frontage road, and entrance and exit ramp configuration.

2.0 Existing and Proposed Roadway

The NHHIP Segment 3 will reroute the proposed I-45 downtown area around the east side of downtown following the I-10/I-69 corridor. When approaching downtown along I-45 from the north, the proposed I-45 will be routed east along the I-10 corridor and then south along the I-69 corridor. The proposed I-45 will tie back to the existing I-45 south of downtown. The existing I-45 in Segment 3E will be demolished and replaced with Downtown Connectors.

2.1 Existing Roadway

See the DEC report for the description of the existing roadway. No changes have been made to the existing roadway due to the revised schematic changes.

2.2 Proposed Roadway Improvements

The proposed roadway configuration is shown on **Exhibit 2** and is summarized in **Table 1**. The original Revised Design Schematic is included in **Appendix A**. The southbound frontage road profile was adjusted to eliminate overflow of the 500-year tailwater from Buffalo Bayou to the proposed depressed section. The recommended Adjusted Design Schematic is included in **Appendix B**. The proposed NHHIP improvements will reroute I-45 around the east side of downtown following the I-10 and I-69 corridors. The existing I-45 in segment 3E will be demolished and replaced with Downtown Connectors. The Downtown Connectors will begin from the proposed I-45/I10 corridor and end at Brazos Street. The Downtown Connectors will be comprised of main lanes, entrance and exit ramps, and frontage roads. The existing City of Houston cross streets will remain with proposed roadway improvements to W Dallas Street and Allen Parkway.

No changes were made to the Segment 3E schematic north of Buffalo Bayou. See the DEC report for the proposed roadway improvements north of Buffalo Bayou and the bridges over Buffalo Bayou.

South of Buffalo Bayou, the proposed main lanes are elevated on bridges over Allen Parkway. South of Allen Parkway, the main lanes will be located on retaining walls and will transition to a depressed section under W. Dallas Street and Andrews Street. The main lanes continue south and tie into Pease Street and Jefferson Street at grade. Heiner Street, Pease Street, Allen Parkway, and W. Dallas Street will be replaced with a different configuration than in existing conditions. The ramps in this section include the SBML exit ramp to Bagby Street and the NBML entrance from Allen Parkway.

Table 1 - Existing and Proposed Roadway Configuration

Station	Section	Roadway Configuration	
		Existing	**Proposed**
200+00-225+00	South of Buffalo Bayou	I-45 Main Lanes SBFR (Heiner St.) NBFR (Pease St.) I-45 SBML Entrance Ramp from Allen Pkwy. I-45 SBML Exit Ramp to Dallas St. I-45 NBML Entrance Ramp from Allen Pkwy. I-45 NBML Exit Ramp to Allen Pkwy. I-45 NBML Exit Ramp to Houston Ave. St. Joseph Pkwy. Parallel to I-45 Main Lanes	SBML connection to Jefferson St. NBML connection to Pease St. SBFR (Heiner St.) NBFR (Pease St.) I-45 SBML Exit Ramp to Bagby St. I-45 NBML Entrance Ramp from Allen Pkwy.

3.0 Hydrologic and Hydraulic Methodology

This section describes the design criteria and hydrologic and hydraulic analysis methodology used in this study. The drainage areas, flows, and hydraulic analysis for existing and proposed conditions are presented in the following sections.

3.1 Drainage Area Delineation

No changes were made to the existing drainage area delineation. The existing drainage areas are shown on Exhibit 5 and 6 in the DEC report. The proposed drainage areas within the project ROW were delineated based on the revised schematic high and low points. The proposed drainage areas were delineated approximately every 300'-500' along the revised schematic profile in order to size the proposed storm sewer trunkline. The proposed drainage system areas are shown on **Exhibits 2** and the proposed drainage areas are shown on **Exhibits 3**.

3.2 Drainage Design Hydrology

Hydrologic methods were determined based on drainage area size. Table 2 shows the methodology selection based on the drainage area size.

Table 2 – Flow Calculation Methodology

Drainage Area Size (ac)	Methodology
<=200 acres	Rational Method
>200 acres	HCFCD Clark Unit Hydrograph Method

3.2.1 Rational Method

The Rational Method approach used in this study follows the TxDOT Hydraulic Design Manual (HDM). The methodology uses drainage area, rainfall intensity, and runoff coefficient to calculate peak flows as follows:

$Q = CIA$

Where:

Q = computed peak flow (cfs),

C = weighted runoff coefficient,

I = average rainfall intensity, and

A = drainage area (ac)

Runoff coefficient, C, is based on land use. The proposed land use within the project area is shown on **Exhibit 1**. Runoff coefficients for various land uses were derived from the TxDOT HDM. Within the project right-of-way, a C-value of 0.35 was used for grass areas and 0.90 for pavement areas. For each drainage area, different land use types were delineated and C-value was assigned. A composite area-weighted C-value was then calculated for each drainage area. The rainfall intensity is calculated based on the time of concentration (tc) as follows:

$I = b/(tc + d)^e$

Where:

I = average rainfall intensity (in/hr),

tc = time of concentration (min), and

b, d, and e = coefficients specific for each storm frequency and county.

The b, d, and e coefficients are derived from the Rainfall Intensity-Duration-Frequency data from the Atlas of the Depth-Duration Frequency of Precipitation Annual Maxima for Texas. The Coefficients for Harris County are presented in **Table 3**.

Table 3 – Rainfall Intensity-Duration-Frequency Coefficients for Harris County

Coefficient	50% (2-yr)	10% (10-yr)	1% (100-yr)
b	57.73	86.47	136.33
d	9.48	11.27	14.08
e	0.7939	0.7829	0.772

Time of concentration, Tc, was calculated based on travel velocities along the flow path. The following **Table 4** lists the travel velocity for each flow type.

Table 4 – Travel Time and Flow Velocity Summary

Flow Component	Velocity
Unpaved Sheet Flow	0.5 ft/s
Paved Sheet Flow	1.5 ft/s
Roadside Ditch Flow	2.0 ft/s
Storm Sewer Flow	3.0 ft/s
Channel Flow	3.0 ft/s

Within the project ROW, runoff typically sheet flows over paved areas to the storm sewer inlet. The flow is then carried along the storm sewer to the outfall channel. No changes were made to the existing

conditions rational method calculations and are included in the DEC report. The proposed rational method calculations were updated based on drainage area changes due to the revised schematic profile and are included in **Appendix C**.

3.2.2 Flow Hydrograph Method for Rational Method Peak Flow

The mitigation analysis was performed using the dynamic hydraulic modeling software XP-Storm 2017.2. The dynamic model requires flow hydrographs to be computed for each drainage area. For this analysis user input flow hydrographs were added to the model. For peak flows calculated with Rational method, flow hydrographs were developed based on the Green and Ampt Loss Method and the Clark Unit Hydrograph Method using the Corps of Engineers Hydrologic Modeling Software (HEC-HMS). This methodology is documented in detail in the Harris County Flood Control District HCFCD Guidance Manual. The Green and Ampt parameters provided by HCFCD for the Buffalo Bayou Watershed were utilized for this analysis. The Clark Unit Hydrograph Method uses time of concentration, tc, and storage coefficient, R, to develop hydrographs. The time of concentration, Tc, calculated for Rational Method was used in the HMS model and the storage coefficient, R, was adjusted to match the Rational Method peak flow for the 2-, 10-, and 100-year storm events. The 100-year storage coefficient, R, was utilized for the 250- and 500-year storm events. The HEC-HMS model is included in **Appendix E**.

3.3 Design Criteria

No changes were made to the design criteria. See the DEC report for detailed information on the design criteria used for this analysis. The revised schematic includes a depressed section along the mainlanes under Dallas St and Andrews St. The depressed storm sewer was sized for the 100-year storm event. The depressed section is drained by a proposed pump station that was designed for the 250-year storm event.

3.4 Storm Sewer Design & Hydraulic Analysis Methodology

The preliminary proposed storm sewer trunk lines were sized using GEOPAK Drainage. The proposed frontage road trunk lines were sized for the 2-year storm event and the proposed depressed main lane trunk line was sized for the 100-year storm event. The proposed trunk line systems were then imported into XP-Storm 2017.2 and combined with the existing offsite storm sewer systems to create the proposed hydraulic model. The 2-, 10-, and 100-year existing and proposed XP-Storm results were compared to determine the benefits/impacts of the proposed project. The outfall boundary condition was set to the time stage hydrograph developed from the LAN Corrected Effective Unsteady State HEC-RAS model. The time stage hydrograph was taken from the Buffalo Bayou nearest downstream HEC-RAS cross section. The HEC-RAS cross section location used to develop the tailwater for each outfall is shown in Table 5 below.

Table 5 – HEC-RAS Outfall Tailwater Location

Outfall	HEC-RAS Cross Section
Outfall F	115423.00
Outfall G	116395.70
Outfall H	116167.60
Outfall I	116076.20

For the 2-, 10-, and 100- analysis the time stage hydrographs from the DEC existing model were used, which were taken from the preliminary LAN HEC-RAS model and consistent with the DEC report approach. The 500-year time stage hydrograph was taken from the final LAN HEC-RAS model since the 500-yr frequency was not analyzed in the DEC report. The 250-year time stage hydrograph was developed from the 100-year time stage hydrograph by adjusting the peak stage to match the 250-year peak stage calculated using a probability graph developed from the 2-, 10-, 100-, and 500-year storm events.

Ponding occurs in low lying areas during extreme events for both existing and proposed conditions. This storage was input using elevation vs area curves to model the surcharged storage. Overflow areas were modeled, as needed, using trapezoidal sections to model the weir overflow between nodes.

4.0 Existing Drainage System Analysis

There are four (4) existing storm drainage systems along the project limits that drain the project ROW. These systems are identified as system F through system I. Some of the storm sewer systems within the project ROW are interconnected with City of Houston storm sewer systems that cross the ROW. All of these systems outfall into Buffalo Bayou.

As previously stated, no changes were made to the existing drainage areas or flow hydrographs developed in the DEC report. However, minor changes were made to the existing XP-Storm models documented in the DEC report. The storm sewer systems and modeling changes are described in detail below. The detailed hydraulic analysis results are included in **Appendix D**.

The storm sewer segments within the project ROW were evaluated based on the 10-year design flow criteria. The conveyance capacity of the storm sewer was compared with the 10-year flow. If a storm sewer segment has a flow capacity less than the 10-year flow, then it was determined to be inadequate. For offsite areas, the storm sewer capacity was compared with 2-year design flows since these conform to the City of Houston criteria. The current study does not recommend any storm sewer improvements outside the project right-of-way. The evaluation of the offsite storm sewer capacity is for documentation purposes only. The 2-, 10-, and 100-year existing outflows and water surface elevations will be compared to the proposed model to determine the benefits/impacts of the proposed project.

System F: System F drains the majority of the I-45 main lanes within the project limits. The system drains from south to north and ranges in size from 18" RCP near the south project limit to 42" RCP at Buffalo Bayou near the north project limit. The drainage area of system F is 9.77 acres, and all of it is contained within the I-45 ROW. Near Andrews Street, System F crosses under System G and is not interconnected to System G. System F also crosses under System I near Allen Parkway. Systems F and I are also not interconnected. The surcharge storage was updated to System F from the DEC report. The ponding allowed feature in SWMM was turned off in all system F nodes and the surface storage curve was added/updated to begin at the spillway crest for most nodes. For nodes in which the node invert was used for the storage elevation the top of node elevation was adjusted to the maximum storage elevation.

System G: System G is a City of Houston storm sewer system that drains a portion of the I-45 frontage roads south of Dallas Street. In addition, the system drains significantly large City of Houston offsite areas both east and west of I-45. The storm sewer system ranges in size from 18" to 120" RCP and drains 772.34 acres. The main trunk line of the system runs along Crosby Street just west of I-45 and discharges into Buffalo Bayou. A lateral system runs across I-45 ROW along Andrews Street and collects runoff from a portion of Heiner Street and Pease Street, which currently serve as frontage roads along I-45. The lateral system also drains 45.40 acres from the City of Houston offsite area DA55. The lateral trunk line is a 48" RCP that crosses the I-45 ROW above System F. System G and System F are not interconnected. The drainage area contributing to System G from the I-45 ROW is 4.73 acres. The surcharge storage was updated to System G. The ponding allowed was turned off in all system G nodes and the storage was added/updated to begin at the spillway crest for most nodes. For nodes in which the node invert was used for the storage elevation the top of node elevation was adjusted to the maximum storage elevation. A constant storage of 100 sq-ft was added to the nodes along the 120" RCP trunk line on Crosby Street to account for the larger junction and help stabilize the model.

System H: System H drains a portion of Heiner Street and a small portion of the I-45 main lanes. The original storm sewer main trunk line was constructed by the City of Houston, where as some lateral

connections were added by TxDOT. The storm sewer system discharges into Buffalo Bayou underneath Sabine Street. The system ranges in size from 18" RCP to 36" CMP. The drainage area contributing to System H is 6.90 acres. The surcharge storage was updated to System H. The ponding allowed was turned off in all system H nodes and the storage was added/updated to begin at the spillway crest for most nodes. For nodes in which the node invert was used for the storage elevation the top of node elevation was adjusted to the maximum storage elevation.

System I: System I is a City of Houston system that drains Allen Parkway within the I-45 ROW and offsite area parallel to the roadway. The system I drainage area is 14.61 acres and the system ranges in size from 18" RCP to 36" RCP at the outfall to Buffalo Bayou. Trapezoidal cross sections were used to model the weir overflow from Buffalo Bayou to the Allen Parkway depressed section. The surcharge storage was updated to System I. The ponding allowed was turned off in all system I nodes and the storage was added/updated to begin at the spillway crest for most nodes. For nodes in which the node invert was used for the storage elevation the top of node elevation was adjusted to the maximum storage elevation.

Summary of Existing Storm Sewer Hydraulic Analysis: The hydraulic analysis of the existing storm sewer systems shows that most of the storm sewer systems do not meet the design criteria for pipe capacity. In addition, many of the storm sewer systems are over 40 years old. The storm sewer system segments within the I-45 ROW drain the main lanes, but do not have adequate capacity to convey the 10-year design event flows at least for a part of the system. However, the 10-year hydraulic grade line (HGL) along the storm sewer systems is generally below the natural ground since the storm sewer systems are deep. The 100-year HGL along the storm sewer systems is below the main lane edge of pavement elevation, except within the depressed section under Dallas Street. The 100-year backwater elevation from Buffalo Bayou inundates the main lanes where they pass under Dallas Street (System F). The flows in the bayou peak more than 24 hours after the peak flows from the storm sewer system have passed. Due to a complex roadway network and underpasses in existing conditions, there are minimal over land flow paths to the outfall channel and the flows generally pond overland. The outflows to Buffalo Bayou are mostly through outfall pipes. Therefore, the difference between 10-year and 100-year outflows is not significant.

The hydraulic grade line elevations along the storm sewer systems at key locations along the project are presented in **Table 10**, where they are also compared with proposed condition hydraulic grade line elevations. A summary of the existing storm sewer system and peak outflows are shown below in **Table 6** for each system, along with the combined existing total outflow from the systems to Buffalo Bayou.

Table 6 – Existing Storm Sewer Systems and Peak Flow Summary

System ID	Drainage Area (ac)	ROW Area (ac)	Size Range	Imper-vious (%)	C-Value	Peak flow (cfs)	
						10-Year	100-Year
F	9.77	9.77	18" RCP – 42" RCP	79	0.78	61	87
G	772.34	4.73	18" RCP – 120" RCP	77	0.71	924	1346
H	6.90	4.22	18" RCP – 36" CMP	61	0.67	35	53
I	14.61	11.08	18" RCP – 36" RCP	58	0.68	63	85
Total	803.62	29.80		76	0.71	1009	1476

5.0 Proposed Drainage System Improvements

The proposed Segment 3E improvements will demolish the existing I-45 roadway in Segment 3E and construct new downtown connectors. As part of these improvements, new storm sewer systems are proposed to drain the ROW and provide adequate design capacity. The existing City of Houston storm sewer lateral crossing at Andrews Street will be disconnected and tie into the proposed northbound frontage road storm sewer system. The design concept presented in this study reduces flow from the ROW to the existing City of Houston storm sewer systems. This is achieved by designing new storm sewer systems to drain the ROW directly to Buffalo Bayou. The proposed storm sewer systems are mitigated with two detention ponds, which are described in more detail in **Section 6**. The proposed storm sewer systems are described in detail in **Table 8**. The system flows are summarized in **Table 9**. The proposed storm sewer systems and drainage areas are shown in **Exhibit 2**, and the drainage subareas within each system, detailed storm sewer configuration, and hydraulic analysis nodes are shown in **Exhibit 3**. The detailed rational method parameters, peak flows, and hydrologic analysis results are presented in **Appendix C**. The detailed hydraulic analysis results are included in **Appendix D** and the models are included in **Appendix E**.

The proposed frontage road storm sewer systems were design to convey the 2-year design flows at pipe full capacity. The main lane depressed section storm sewer system was designed to convey the 100-year design flows at pipe full capacity. The proposed storm sewer systems were designed using GEOPAK Drainage and imported into XP-STORM 2017.2 for the pump station design and mitigation analysis. The pump station was designed to maintain the 250-year hydraulic grade lane below the main lane edge of pavement. The hydraulic grade line elevations along the proposed storm sewer at key points along the project are compared with existing condition hydraulic grade line elevations in **Table 10**.

System F: The proposed System F storm sewer drains 81.42 acres, which includes the entire proposed project ROW and offsite areas. The proposed System F includes two proposed detention ponds to mitigate the increase in flows to Buffalo Bayou. The first pond is located within the Allen Parkway northbound entrance ramp, this is the same location as Basin 1 in the DEC report. The second pond is located at the intersection of Brazos Street and St. Joseph Parkway within the proposed ROW and connects to the proposed southbound frontage road system. The impact analysis, mitigation and the detention basin details are presented in **Section 6** of this document.

The proposed southbound frontage road (Heiner Street) system drains 14.22 acres and ranges in size from 24" RCP to 42" RCP. The proposed southbound frontage road system crosses the I-45 ROW with a 42" RCP lateral and outfalls into the Allen Parkway detention pond. The proposed northbound frontage road (Pease Street) system drains 61.64 acres, which includes 45.40 acres of offsite area from the City of Houston existing System G drainage area, DA55. The proposed northbound frontage road system ranges in size from 24" RCP to 6' x 5' RCB. The existing System G 48" RCP lateral along Andrews Street will be disconnected and tie into the proposed northbound frontage road system. The proposed northbound frontage road system drains to the proposed Allen Parkway detention pond and then outfalls to Buffalo Bayou via a 48" RCP restrictor.

The proposed depressed main lanes storm sewer system drains 5.57 acres and ranges in size from 24" RCP to 48" RCP. The proposed main lane system outfalls into the proposed pump station via a 48" RCP at flowline elevation 10.68 feet. The proposed pump station is located in the north east intersection of I-45 and Dallas Street. The proposed pump station has a 25' diameter wet well with a flowline elevation of -9.00 feet. The proposed pump station consists of three (3) 5,600 gallon per minute (GPM) pumps and one 1,000 GPM low flow pump. The proposed pump curves used for this analysis are included in **Appendix D**. A summary of the proposed pump start and stop elevations are included in **Table 7**. The proposed pumps outfall into a box headwall that drains by a gravity 48" RCP to the proposed northbound frontage road 6' x 5' RCB trunkline.

Table 7 – Proposed Pump Station Start and Stop Elevations

Pump No.	Pump Rate (GPM)	Start Elevation (ft)	Stop Elevation (ft)
1	5,600	14.00	-4.00
2	5,600	14.50	13.00
3	5,600	15.00	13.50
Low Flow	1,000	1.00	-7.00

System G: The ROW areas currently draining to the existing System G storm sewer will be diverted to the proposed System F storm sewer. Therefore, in proposed conditions System G will only receive flows from offsite areas. The existing offsite drainage area DA55 will no longer cross the ROW along Andrews Street. The existing lateral system at Andrews Street will be diverted to the proposed System F northbound frontage road storm sewer. The proposed drainage area of System G is reduced to 717.35 acres.

System H: No improvements are recommended to System H since it falls outside the proposed ROW. The subareas within the proposed ROW will be diverted to drain to the System F proposed southbound frontage road storm sewer. The existing System H storm sewer within the ROW will be removed. The System H proposed drainage area is reduced to 4.48 acres.

System I: The majority of the System I drainage area will be diverted to the proposed System F storm sewer. Only the outfall area, outside the project ROW will continue to drain to system I. No proposed improvements are recommended to System I. The existing System I storm sewer within the ROW will be removed. The System I proposed drainage area is reduced to 0.53 acres.

Summary of Proposed Storm Sewer Hydraulic Analysis: A summary of the proposed storm sewer systems is shown below in **Table 8**. The project flows are contained within the proposed System F storm sewer system. No improvements are made to Systems G-I. These are existing City of Houston storm sewer systems located outside the project ROW. The proposed flows to Systems G-I are reduced due to area within the project ROW being diverted to System F. The proposed mitigated outflow for each system is included in **Table 9**. The detailed mitigation analysis is described in more detail in **Section 6**.

Table 8 – Proposed Storm Sewer Improvements Summary

System ID	Existing System	Proposed System	Notes
F	18" RCP – 42" RCP	24" RCP – 6' x 5' RCB	Outflow is restricted to mitigate impacts of entire project within proposed detention ponds.
G	18" RCP – 120" RCP	No Improvements	ROW area and lateral offsite area at Andrews Street diverted to System F.
H	18" RCP – 36" CMP	No Improvements	ROW area diverted to System F.
I	18" RCP – 36" RCP	No Improvements	ROW area diverted to System F.

Table 9 – Proposed (Mitigated) Storm Sewer Systems and Peak Flow Summary

System ID	Drainage Area (ac)	ROW Area (ac)	Size Range	Imper-vious (%)	C-Value	Peak flow (cfs)	
						10-Year	100-Year
F	81.42	36.02	24" RCP – 6' x 5' RCB	77	0.82	232	254
G	717.35	0.00	18" RCP – 120" RCP	76	0.70	715	1168
H	4.48	0.00	18" RCP – 36" CMP	60	0.67	23	33
I	0.53	0.00	18" RCP – 36" RCP	0	0.35	20	34
Total	803.78	36.02		76	0.71	956	1429

The original proposed southbound frontage road profile shown on the design schematic (included in **Appendix A**) is low enough in elevation at the Allen Parkway intersection to allow overflow of the 500-year tailwater from Buffalo Bayou to enter the main lane depressed section. The southbound frontage road profile was adjusted from station 69+00 to 75+18.36 to raise the roadway elevation in order to keep the 500-year flows from Buffalo Bayou from entering the proposed main lane depressed section. The adjusted southbound frontage road profile is shown on the proposed design schematic included in **Appendix B**.

The hydraulic grade line elevations along the storm sewer systems at key locations along the project are presented in **Table 10** where they are also compared with the existing condition hydraulic grade line elevations. The proposed hydraulic analysis results in increases in the 10-year water surface elevations to System F SBFR and System G. These increases in water surface elevations are contained within the

proposed storm sewer systems and do not result in adverse impacts. The proposed hydraulic analysis results in an increase in the 100-year water surface elevation at proposed node DA 71 for System F SBFR. This increase is contained within the proposed storm sewer system and does not result in an adverse impact. Therefore, the proposed project will not result in an adverse impact to the 10-year and 100-year water surface elevations.

Table 10 – Hydraulic Analysis Summary – Existing and Proposed Conditions

System	Node ID Exist/Prop	10-Year WSEL (ft)			100-Year WSEL (ft)			NG/ Gutter Elev (ft)
		Exist	Prop	Pr-Ex	Exist	Prop	Pr-Ex	
System F NBFR	N11/DA47	30.64	30.64	0.00	40.01	40.01	0.00	38.20
	DA57/DA57	42.37	36.63	-5.74	42.56	40.01	-2.55	45.72
	DA58/N-DA58	39.91	37.26	-2.65	42.43	40.01	-2.42	45.90
	DA55/DA55	44.20	43.77	-0.43	45.26	44.95	-0.31	46.61
	DA59/DA59	39.90	39.86	-0.04	42.44	40.27	-2.17	43.71
System F SBFR	DA50+48/DA50	30.69	34.95	4.26	40.10	40.01	-0.09	37.30
	DA45/DA42	30.92	34.38	3.46	40.26	40.01	-0.25	40.96
	DA38/DA38	43.52	38.30	-5.22	45.18	40.00	-5.18	45.45
	N32/DA34	38.18	39.58	1.40	40.56	40.43	-0.13	46.67
	DA34/DA71	38.72	40.96	2.24	40.56	41.16	0.60	45.59
System G	DA65/DA65	30.58	30.58	0.00	40.38	40.33	-0.05	39.00
	N26/N26	30.68	30.70	0.02	40.51	40.47	-0.04	46.00
	N23/N23	30.72	30.75	0.03	40.56	40.53	-0.03	46.54
	DA31/DA31	30.77	30.80	0.03	40.62	40.59	-0.03	45.00
System H	DA68/DA68A	30.92	30.91	-0.01	40.26	40.26	0.00	42.02
	N54.1/DA45A	30.92	30.91	-0.01	40.26	40.26	0.00	43.47
System I	DA50+48/DA49	30.69	30.69	0.00	40.10	40.10	0.00	32.48

The 100-year and 500-year models were analyzed with the Buffalo Bayou tailwater from the LAN Segment 3D unsteady state HEC-RAS models for the Corrected Effective, Mitigated with Detention only, and Mitigated with the North and South Canal, Heights Blvd. improvements and mitigation conditions. For the Corrected Effective and Mitigated with Detention only conditions, the 100-year and 500-year tailwater from Buffalo Bayou results in flooding along the proposed northbound and southbound frontage road systems and the Allen Parkway depressed section. For the Mitigated with the North and South Canal, Heights Blvd. improvements, and mitigation condition, the 500-year tailwater from Buffalo Bayou results in flooding along the proposed northbound and southbound frontage road systems and the Allen Parkway

depressed section. The hydraulic grade line elevations along the storm sewer systems at key locations along the project for each tailwater condition are presented in **Table 11** below.

Table 11 – Hydraulic Analysis Summary – Proposed Tailwater Conditions

Location	Prop Node ID	100-Year WSEL (ft)			500-Year WSEL (ft)			Gutter/ TOB Elev (ft)
		Corr Effec TW	Prop Deten TW	Prop Mit TW	Corr Effec TW	Prop Deten TW	Prop Mit TW	
SB Frontage	DA50	40.01	39.81	37.27	45.30	45.27	42.64	37.30
	DA42	40.01	39.81	36.86	45.30	45.27	42.64	40.96
	DA38	40.00	39.81	39.07	45.30	45.27	42.64	45.45
	DA71	41.16	41.16	41.16	45.31	45.28	42.64	45.59
Allen Parkway	DA47	40.01	39.81	36.86	45.30	45.26	42.64	37.00
Pond	DA43	40.01	39.81	36.86	45.30	45.26	42.64	37.00
NB Frontage	DA57	40.01	39.81	37.38	45.30	45.27	42.64	45.72
	DA59	40.27	40.27	40.27	45.31	45.27	42.64	43.71

6.0 Drainage Impact Analysis and Mitigation

A drainage impact analysis was performed for the proposed project to analyze the impacts of the following: (i) Increases in impervious due to proposed pavement, (ii) increases in conveyance due to the proposed storm sewer improvements, (iii) impacts due to fill in the floodplain due to construction of the revised schematic roadways.

The drainage impact analysis in the DEC report was performed for Systems A-I. The proposed mitigation recommended in the DEC report mitigates the outflows to Buffalo Bayou from System A-I within the System F proposed detention ponds. In the DEC report, the outflow from System F was over mitigated to allow the outflows from Systems A-E and Systems G-I to outfall unmitigated. The analysis documented in this report includes changes to proposed Systems F-I only. The peak outflow and outflow hydrographs for Systems A-E documented in this section of the report were taken from the DEC report and DEC hydraulic models.

The proposed project ROW is 58.42 acres. The existing pavement area is 38.43 acres and the proposed impervious area is 37.40 acres (pavement and detention area). The replacement of the existing I-45 with downtown connectors will not increase the proposed impervious area. However, the existing storm sewer systems are inadequate to convey the design flows, which resulted in upsizing the proposed storm sewer systems within the project ROW. Therefore, mitigation is required to reduce the total outflow into Buffalo Bayou to existing conditions.

Two proposed detention ponds are recommended to mitigate the increase in conveyance due to the proposed improvements. The proposed detention ponds are located within the ROW for storm sewer System F. The proposed System F storm sewer will drain to the proposed detention basins. The proposed detention pond locations and configuration were revised from the DEC report due to the proposed changes to the main lane profile schematic.

Proposed detention Basin 1 is located just south of Allen Parkway and north of the Allen Parkway northbound entrance ramp, as shown on **Exhibit 4a**. Proposed detention Basin 2 is located at the intersection of Bagby Street and St. Joseph Parkway, as shown on **Exhibit 4b**. The proposed detention basins will receive flows from the proposed System F and will provide peak flow impact mitigation for Systems A-I. The proposed System F northbound and southbound frontage road systems and the pump station outflow will drain directly into Basin 1. Basin 1 has an estimated top of pond elevation of 37 ft and a flowline elevation of 20 ft. Basin 1 will provide approximately 14.86 ac-ft of detention volume. The drainage areas adjacent to Basin 2 will drain directly into Basin 2. Basin 2 has an estimated top of pond elevation of 46 ft and a flowline elevation of 39.47 ft. Basin 2 outfalls via a 30” RCP to System F southbound frontage road storm sewer trunkline. Basin 2 will provide approximately 7.21 ac-ft of detention volume. The elevation-area-storage relationship for Basin 1 and 2 is shown below in **Table 12** and **Table 13**, respectively.

Table 12 – Detention Basin 1 Elevation-Area-Storage Relationship

Elevation (ft)	Area (ac)	Storage Volume (ac-ft)
20	0.00	0.00
22	0.49	0.34
24	0.60	1.43
26	0.72	2.74
28	0.84	4.30
30	0.98	6.13
32	1.13	8.23
34	1.28	10.64
36	1.45	13.37
37	1.53	14.86

Table 13 – Detention Basin 2 Elevation-Area-Storage Relationship

Elevation (ft)	Area (ac)	Storage Volume (ac-ft)
39.47	0.00	0.00
41	1.02	1.16
43	1.17	3.34
45	1.33	5.84
46	1.41	7.21

Proposed detention Basin 1 and 2 were modeled in the proposed XP-Storm version 2017.2 hydraulic model. The outflow pipe from Basin 1 was reduced to restrict the 10-year and 100-year outflow to Buffalo Bayou. The proposed outflow pipe from Basin 1 is a 48" RCP restrictor with a length of 500 ft. The results of the detention pond routing analysis and recommended detention pond design are summarized below in **Table 14**.

Table 14 – Detention Pond Routing & Design Summary

Detention Basin Details	Unit	Basin 1		Basin 2	
Detention Basin Drainage Area	ac	78.12		2.86	
Detention Basin Surface Area (Including 20' Maintenance Berm)	ac	2.0		1.86	
Basin Flowline Elevation	ft	20.00		39.47	
Pond Top Elevation	ft	37.00		46.00	
Volume Summary					
Provided Basin Volume	ac-ft	14.86		7.21	
Required Basin Volume	ac-ft	14.86		1.08	
Detention Routing Details		10-YR	100-YR	10-YR	100-YR
Total Basin Inflow	cfs	354.40	428.03	16.23	23.75
Proposed Basin Outflow	cfs	225.88	247.26	3.36	8.73
Water Surface Elevation	ft	30.64	40.01	40.17	40.59
Detention Volume (below Elev. 37)	ac-ft	7.41	14.86	0.67	1.08
Basin Outfall Restrictor					
Outfall Restrictor Size	in	48" RCP		30" RCP	
Outfall Restrictor Length	ft	500		87	

The existing and proposed peak flow summary is shown below in **Table 15**. The existing and proposed 10- and 100-year outfall hydrographs for Systems A-I were summed to determine the total peak outflow to Buffalo Bayou. The 10- and 100-year existing total peak outflow to Buffalo Bayou is 1,186 cfs and 1,730 cfs, respectively. The 10- and 100-year proposed total peak outflow to Buffalo Bayou is 1,106 cfs and 1,678 cfs, respectively. The proposed project results in a decrease in the 10- and 100-year outflow to Buffalo Bayou of 80 cfs and 52 cfs, respectively.

Basin 1 is located within the Buffalo Bayou floodplain and the top of pond elevation is below the 100-year water surface elevation. Therefore, the 100-year peak water surface elevation in the pond will exceed the top of pond elevation. For the 100-year conditions floodplain storage will be provided above the top of pond and within the proposed Allen Parkway depressed section. This is similar to the existing ponding that occurs in this area today. The existing and proposed 10- and 100-year water surface elevations are compared in **Table 10**. The proposed project results in a slight decrease in water surface elevations in this area. The proposed project will result in no adverse flooding impacts to Buffalo Bayou (HCFCD W100-00-00) or adjacent properties for flood events up to and including 100-year storm event.

Table 15 – Existing and Proposed (Mitigated) Peak Flow Summary

System ID	Drainage Area (ac)		Existing Peak flow (cfs)		Proposed Peak flow (cfs)		Peak flow Benefit/Impact (cfs)	
	Existing	Proposed	10-Year	100-Year	10-Year	100-Year	10-Year	100-Year
DEC Systems A-E								
A	25.74	20.00	80	83	73	80	-7	-3
B	5.71	11.45	11	27	68	102	57	75
C	15.45	15.45	85	125	75	113	-1	-1
D	13.90	13.90	55	51	54	63	-1	12
E	7.17	7.17	24	50	26	61	2	11
Total	67.97	67.97	243	297	282	375	39	78
Proposed Project Systems F-I								
F	9.77	81.42	61	87	232	254	171	167
G	772.34	717.35	924	1346	715	1168	-209	-178
H	6.90	4.48	35	53	23	33	-12	-20
I	14.61	0.53	63	85	20	34	-43	-51
Total	803.61	803.78	1009	1476	956	1429	-53	-47
Total	**871.58**	**871.75**	**1186**	**1730**	**1106**	**1678**	**-80**	**-52**

Note: System C drainage areas outfall directly to Buffalo Bayou; Therefore, outfall C peak flow was taken from HEC-HMS junction outfall C.

7.0 Conclusions

The recommendations contained in this study are intended to provide TxDOT with a preliminary drainage mitigation plan for the revised schematic replacing the proposed main lane bridges with a depressed section under Dallas Street and Andrews Street.

The existing I-45 ROW in the proposed project area is drained by four (4) existing storm sewer systems. The storm sewer systems were originally constructed between the 1930s and 1970s, with some upgrades over the years. The existing storm sewer systems range in size from 18" RCPs to 42" RCPs within the project ROW. Analysis of the existing storm sewer systems showed that the existing systems do not have adequate capacity to meet the design criteria. The project ROW is drained completely by the System F proposed storm sewer system. No improvements are made to Systems G-I storm sewer systems, since these are existing City of Houston storm sewer systems located outside the project ROW. The proposed flows to Systems G-I are reduced due to area within the project ROW and the offsite System G lateral flow at Andrews Street being diverted to System F. The proposed System F storm sewer ranges in size from 24" RCP to 6' x 5' RCB. The proposed storm sewer configuration and sizes are shown on **Exhibit 3**.

The original proposed southbound frontage road profile shown on the design schematic (included in **Appendix A**) is low enough in elevation at the Allen Parkway intersection to allow overflow of the 500-year tailwater from Buffalo Bayou to enter the main lane depressed section. The southbound frontage road profile was adjusted from station 69+00 to 75+18.36 to raise the roadway elevation in order to keep the 500-year flows from Buffalo Bayou from entering the proposed main lane depressed section. The recommended adjusted design schematic is included in **Appendix B**.

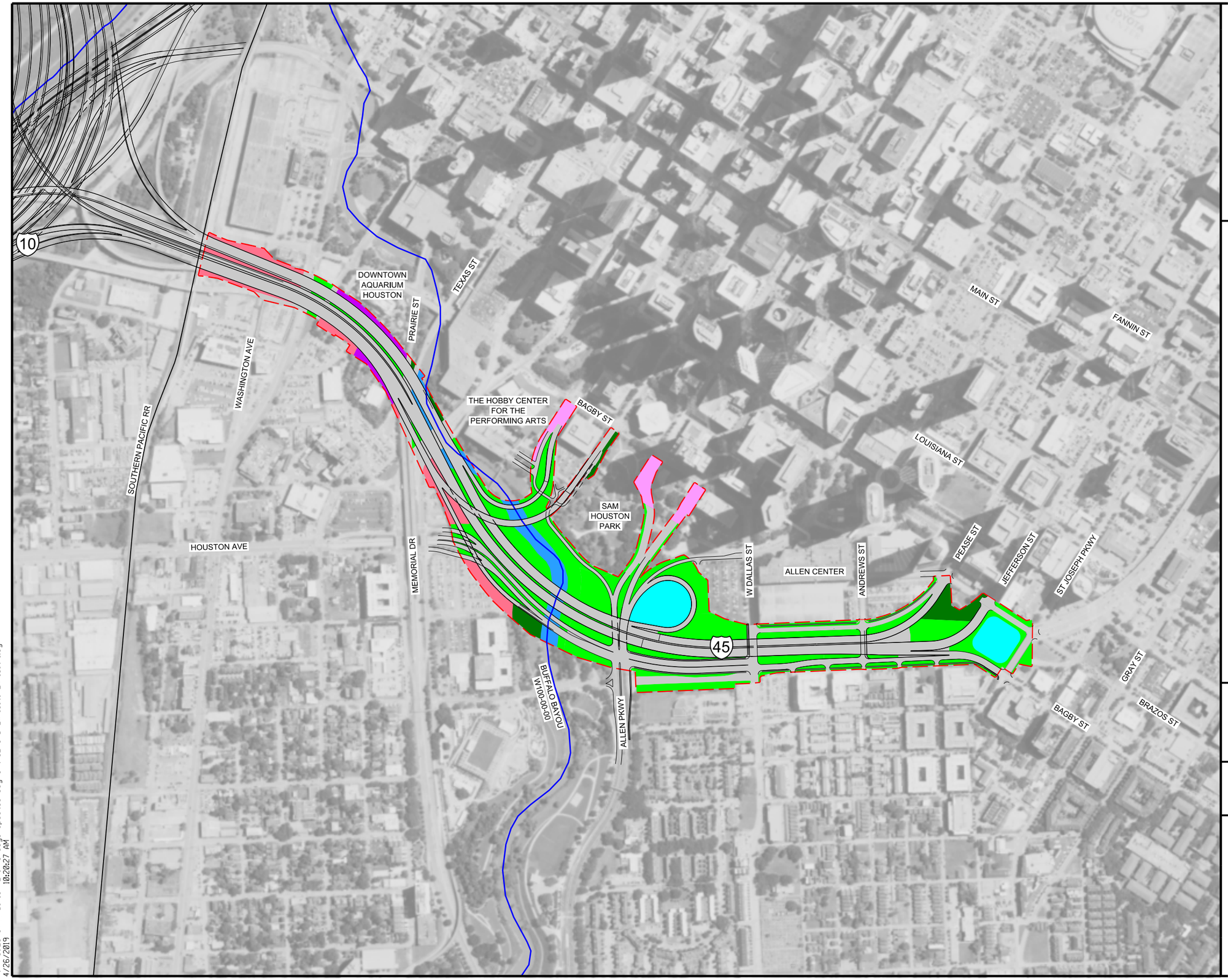
The 100-year and 500-year models were analyzed with the Buffalo Bayou tailwater from the LAN Segment 3D unsteady state HEC-RAS models for the Corrected Effective, Mitigated with Detention only, and Mitigated with the North and South Canal, Heights Blvd. improvements and mitigation conditions. For the Corrected Effective and Mitigated with Detention only conditions, the 100-year and 500-year tailwater from Buffalo Bayou results in flooding along the proposed northbound and southbound frontage road systems and the Allen Parkway depressed section. For the Mitigated with the North and South Canal, Heights Blvd. improvements, and mitigation condition, the 500-year tailwater from Buffalo Bayou results in flooding along the proposed northbound and southbound frontage road systems and the Allen Parkway depressed section.

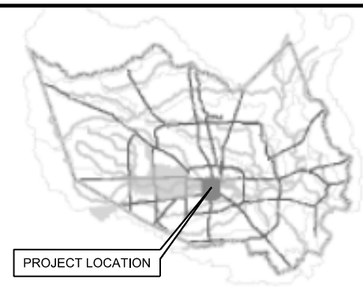
The proposed main lane depressed section will be drained by a proposed pump station. The proposed pump station has a 25' diameter wet well with a flowline elevation of -9.00 feet. The proposed pump station consists of three (3) 5,600 gallon per minute (GPM) pumps and one 1,000 GPM low flow pump.

The proposed project will not increase the impervious area within the right-of-way. However, the proposed storm sewer system provides additional capacity increasing the flows to Buffalo Bayou. Therefore, two (2) detention pond basins are recommended to mitigate the flows that provide an additional 15.94 ac-ft of storage volume. The recommended detention basin locations and characteristics are shown on **Exhibit 4**.

Based on the drainage improvement recommendations in this study, the proposed project will result in no adverse flooding impacts to Buffalo Bayou (HCFCD W100-00-00) or adjacent properties for flood events up to and including 100-year storm event.

EXHIBITS





0 300 600

SCALE: 1" = 300'

Legend

- Railroad
- Drainage Channel
- ROW

Landuse

- Commercial/Industrial
- Commercial/Industrial Light
- Detention Basin
- Downtown Areas
- Grass
- Park/Cemetary
- Proposed Pavement
- Water

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EXHIBIT 1
Right-Of-Way Land Use Map
Proposed/Mitigated Condition
CSJ No: 0050-03-601, etc.

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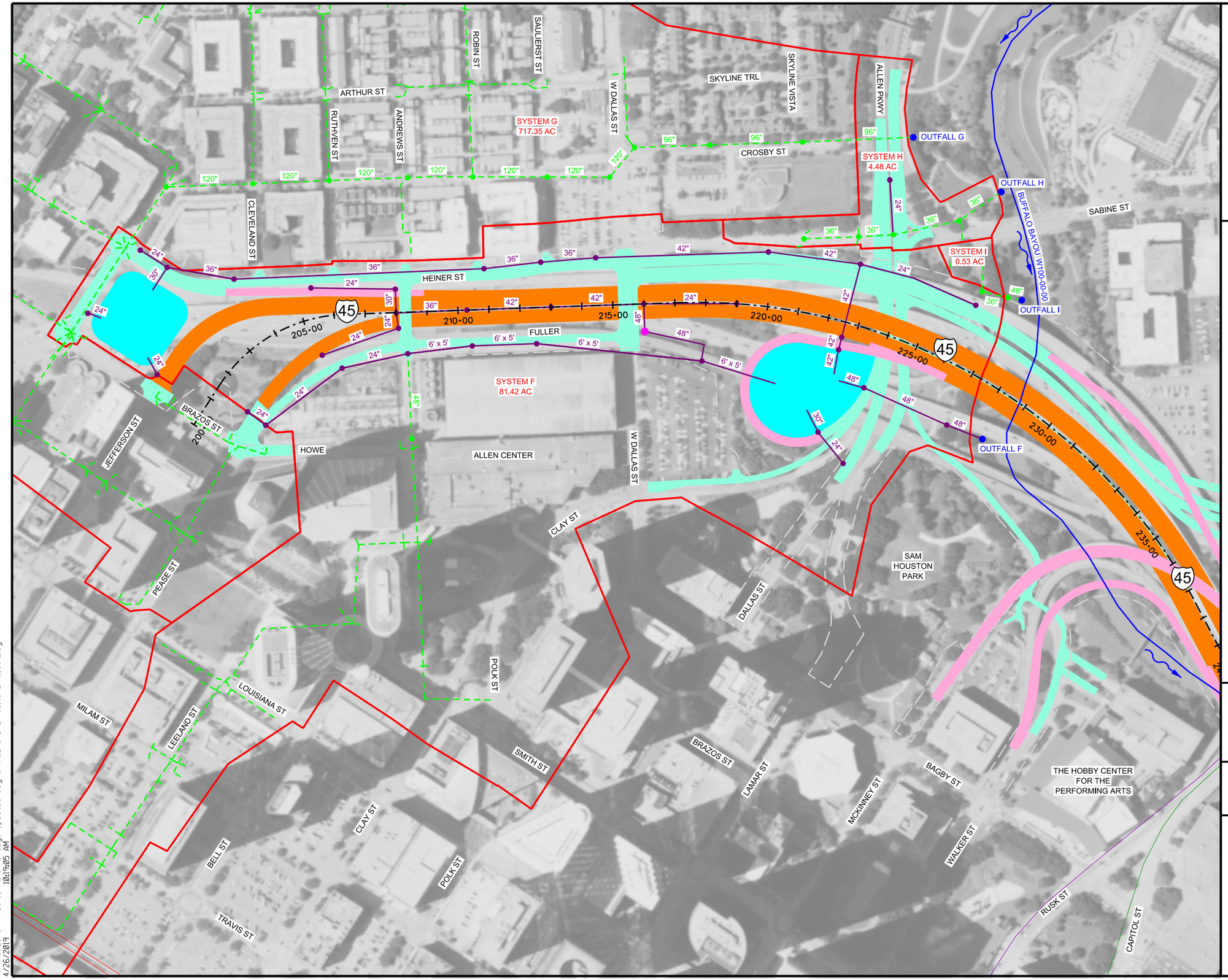

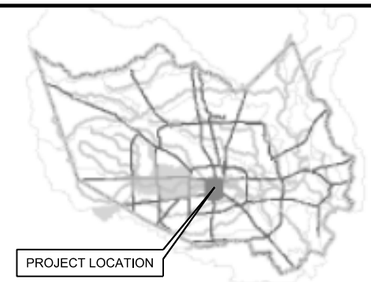

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SCALE: 1" = 300'

LEGEND

- Proposed Drainage Areas
- Outfalls
- Proposed Pump Station
- Proposed Analysis Node
- Proposed Storm Sewer
- Channel Flow Direction
- Drainage Channel
- Right-of-Way

Existing Storm Sewer

- Existing Analysis Node
- Existing Storm Sewer

Proposed Roadway

- Ramp
- Main Lanes
- Frontage Roads
- Proposed Detention Basin

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EXHIBIT 2
Proposed Drainage Systems Map
South of Buffalo Bayou
CSJ No: 0050-03-601, etc.

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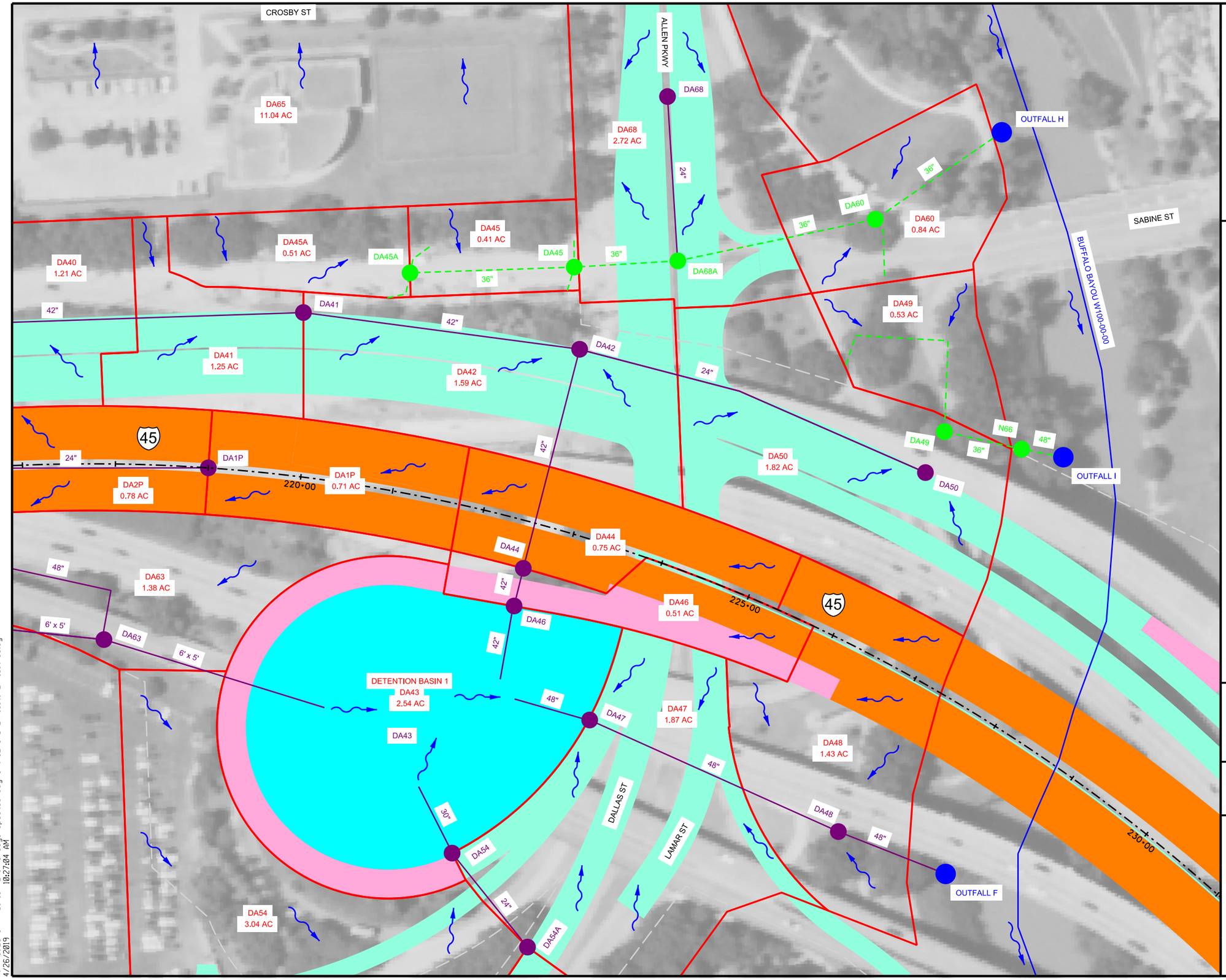

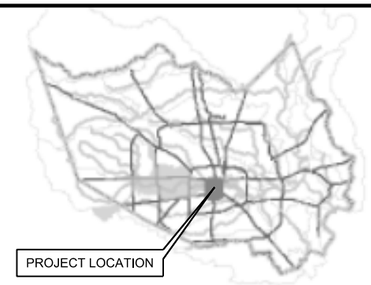

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SCALE: 1" = 100'

LEGEND

- Proposed Drainage Areas
- Outfalls
- Proposed Pump Station
- Proposed Analysis Node
- Proposed Storm Sewer
- Overland Flow Direction
- Drainage Channel
- Right-of-Way

Existing Storm Sewer

- Existing Analysis Node
- Existing Storm Sewer

Proposed Roadway

- Ramp
- Main Lanes
- Frontage Roads
- Proposed Detention Basin

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EXHIBIT 3a
Proposed System Hydraulics Map
South of Buffalo Bayou
CSJ No: 0050-03-601, etc.

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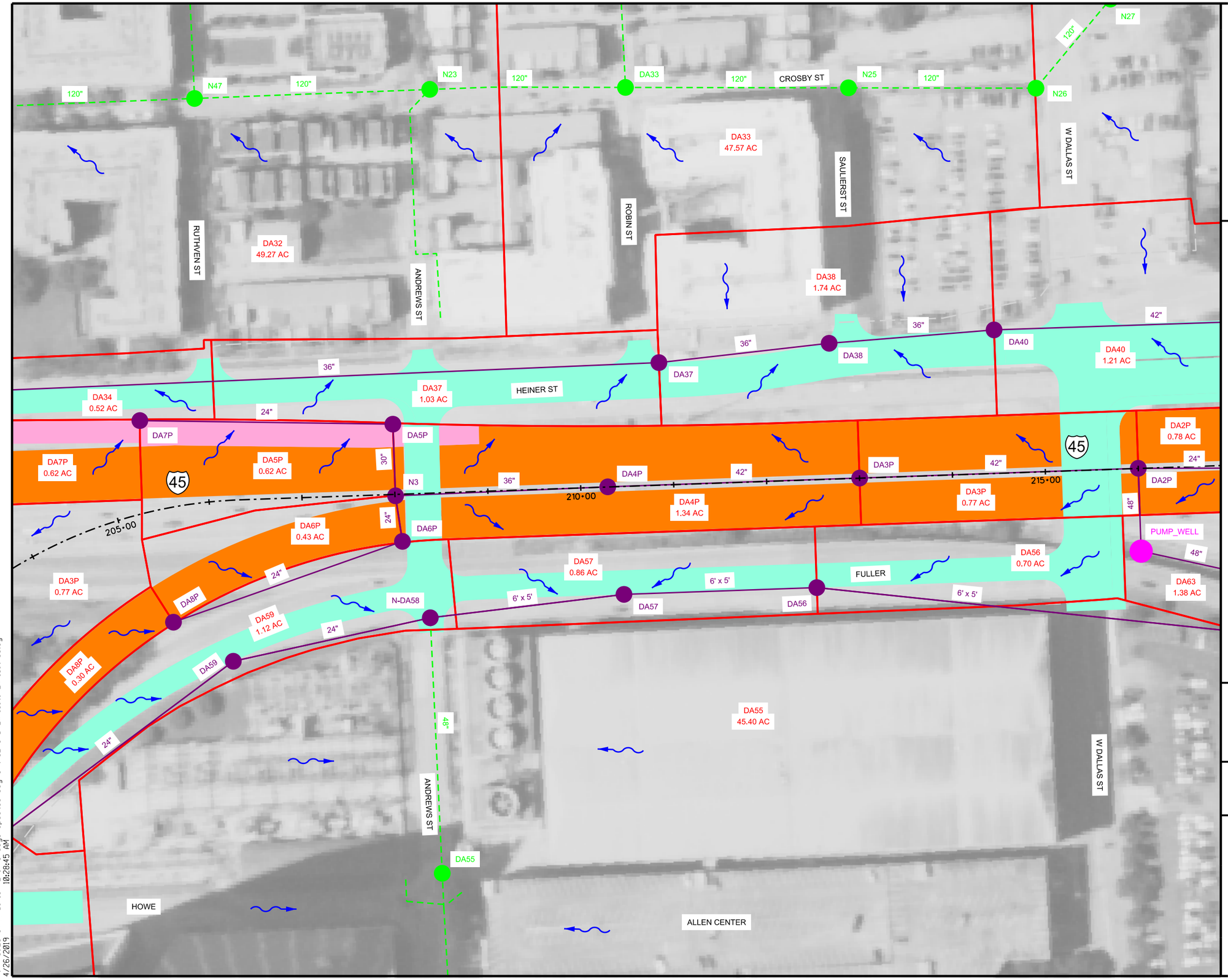

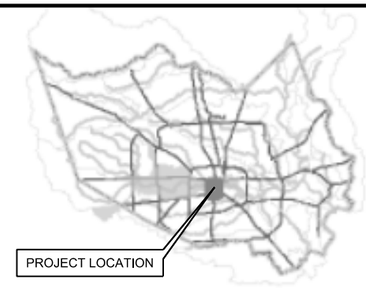

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SCALE: 1" = 100'

LEGEND

- Proposed Drainage Areas
- Outfalls
- Proposed Pump Station
- Proposed Analysis Node
- Proposed Storm Sewer
- Overland Flow Direction
- Drainage Channel
- Right-of-Way

Existing Storm Sewer

- Existing Analysis Node
- Existing Storm Sewer

Proposed Roadway

- Ramp
- Main Lanes
- Frontage Roads
- Proposed Detention Basin

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EXHIBIT 3b
Proposed System Hydraulics Map
South of Buffalo Bayou
CSJ No: 0050-03-601, etc.

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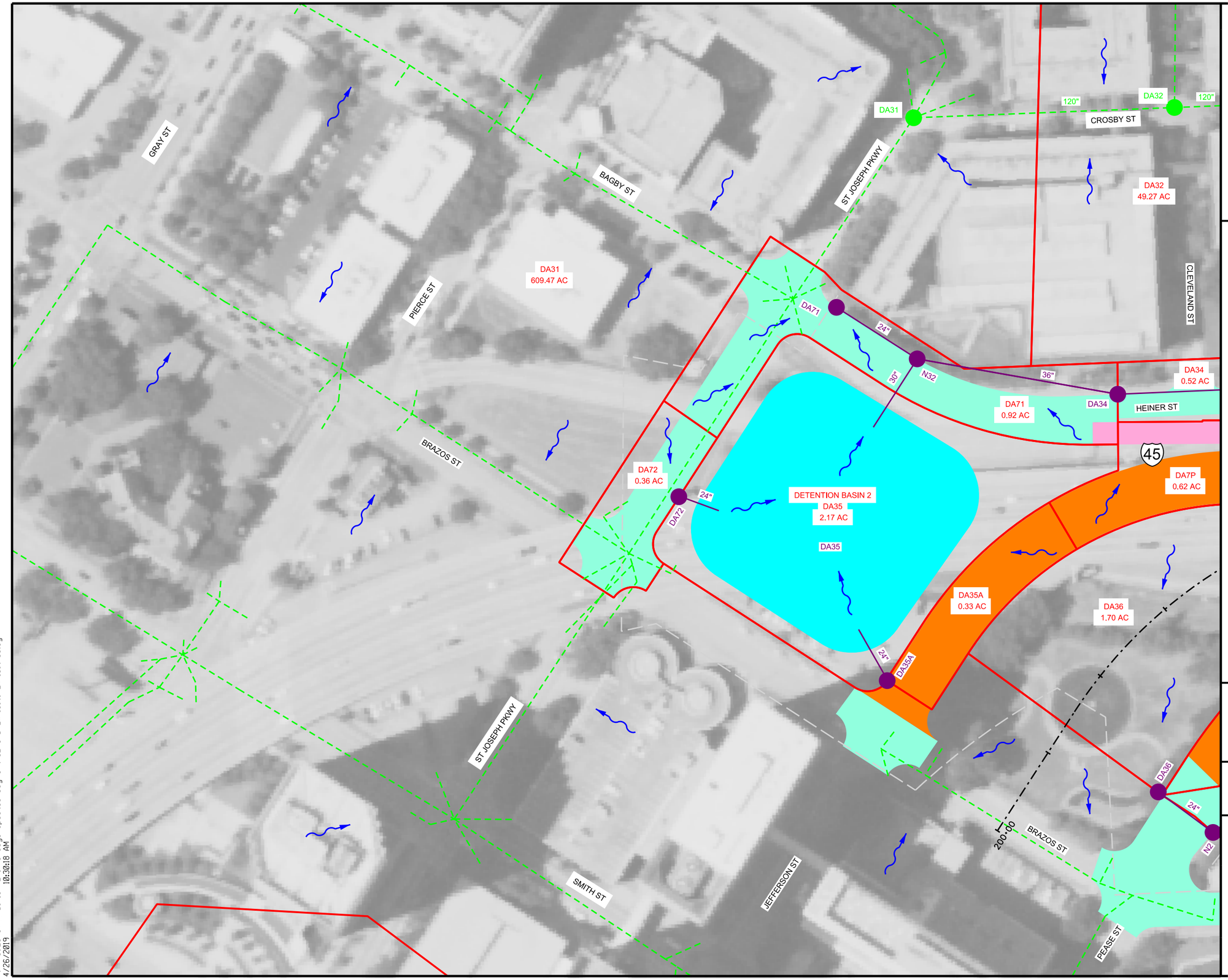

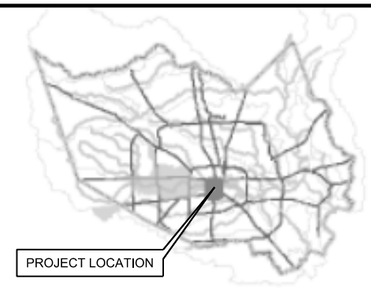

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SCALE: 1" = 100'

LEGEND

- Proposed Drainage Areas
- Outfalls
- Proposed Pump Station
- Proposed Analysis Node
- Proposed Storm Sewer
- Overland Flow Direction
- Drainage Channel
- Right-of-Way

Existing Storm Sewer

- Existing Analysis Node
- Existing Storm Sewer

Proposed Roadway

- Ramp
- Main Lanes
- Frontage Roads
- Proposed Detention Basin

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EXHIBIT 3c
Proposed System Hydraulics Map
South of Howe Bayou
CSJ No: 0050-03-601, etc.

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Min. Detention Volume Required, ac-ft	14.86
Detention Volume Provided, ac-ft	14.86
Basin Area, ac	1.53
Top of Pond, ft	37.00
Toe of Pond, ft	22.00
100-year Discharge (cfs)	247.26
10-year Water Surface Elevation, ft	30.64
100-year Water Surface Elevation, ft	40.01

CROSBY ST
ALLEN PKWY
SABINE ST
BUFFALO BAYOU W100-00-00
DA68
DA68A
DA60
DA45
DA45A
DA41
DA42
DA44
DA46
DA47
DA48
DA49
DA50
DA54
DA54A
DA63
DA1P
N66
OUTFALL H
OUTFALL I
OUTFALL F
36"
42"
24"
48"
30"
6' x 5'
45
220+00
225+00
230+00
TOP=37'
TOE=22'
48"RCP
US FL=20.00'
DETENTION BASIN 1
BERM WIDTH=20'

0 50 100
SCALE: 1" = 100'

PROJECT LOCATION

LEGEND

- Outfalls
- Proposed Pump Station
- Proposed Analysis Node
- Proposed Storm Sewer
- Channel Flow Direction
- Drainage Channel
- Right-of-Way

Existing Storm Sewer

- Existing Analysis Node
- Existing Storm Sewer

Proposed Detention Pond

- Pond Contours
- TOP
- TOE
- BERM

Proposed Roadway

- Ramp
- Main Lanes
- Frontage Roads

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NHHIP Segement 3E

EXHIBIT 4a
Proposed Detention Basin 1 Layout
CSJ No: 0050-03-601, etc.

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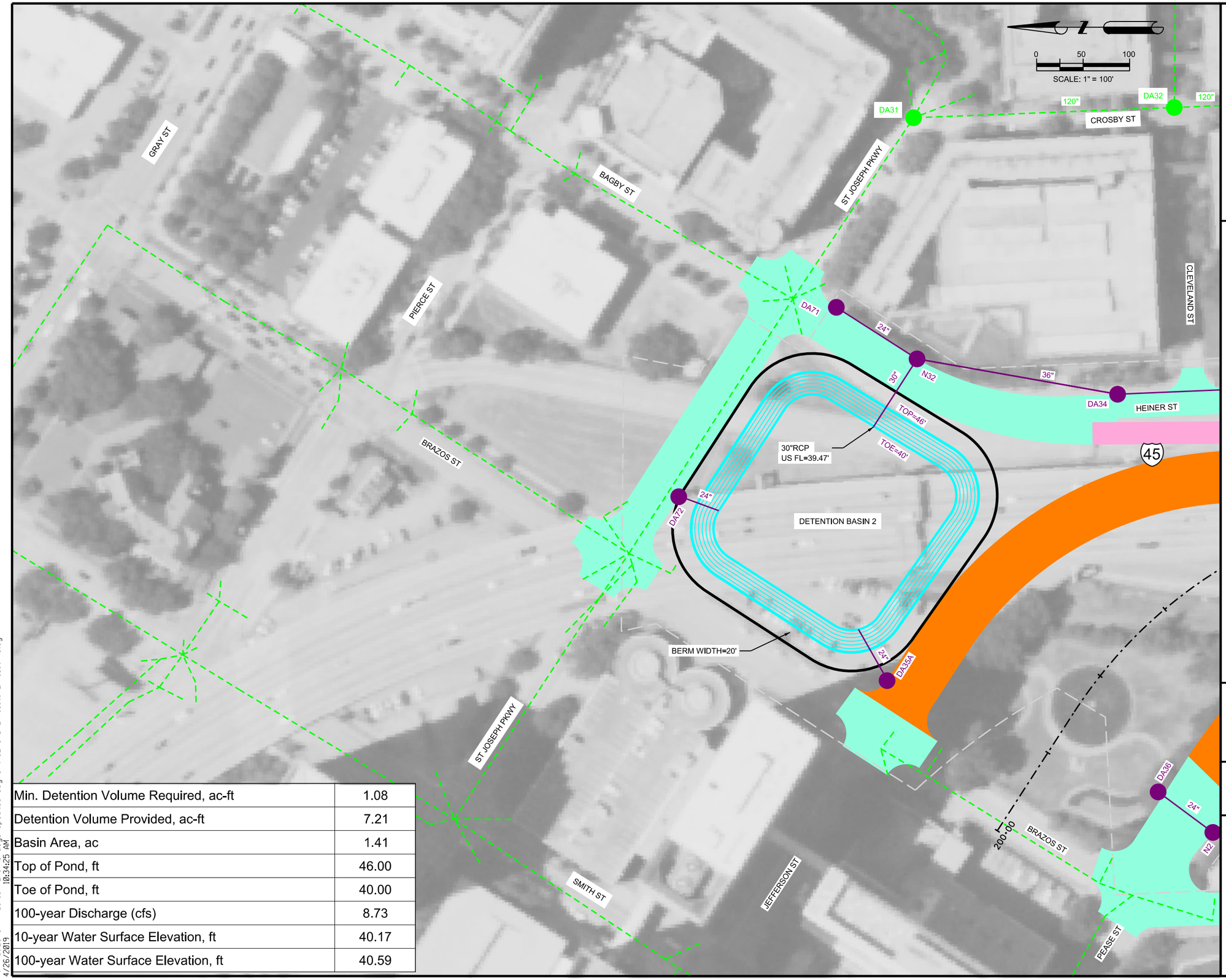

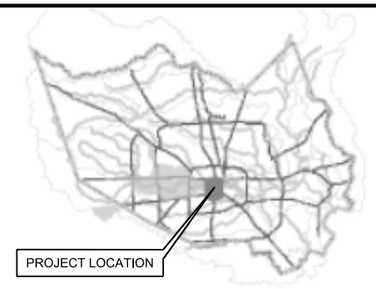

LEGEND

- Outfalls
- Proposed Pump Station
- Proposed Analysis Node
- Proposed Storm Sewer
- Channel Flow Direction
- Drainage Channel
- Right-of-Way

Existing Storm Sewer

- Existing Analysis Node
- Existing Storm Sewer

Proposed Detention Pond

- Pond Contours
- TOP
- TOE
- BERM

Proposed Roadway

- Ramp
- Main Lanes
- Frontage Roads

Min. Detention Volume Required, ac-ft	1.08
Detention Volume Provided, ac-ft	7.21
Basin Area, ac	1.41
Top of Pond, ft	46.00
Toe of Pond, ft	40.00
100-year Discharge (cfs)	8.73
10-year Water Surface Elevation, ft	40.17
100-year Water Surface Elevation, ft	40.59

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NHHIP Segement 3E

EXHIBIT 4b
Proposed Detention Basin 2 Layout
CSJ No: 0050-03-601, etc.

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APPENDIX A

DESIGN SCHEMATIC

HOUSTON DISTRICT
PROJECT DEVELOPMENT

PUBLIC HEARING LAYOUT
NHHIP DOWNTOWN CONN. SEGMENT 3

COUNTY: HARRIS
LIMITS FROM: BRAZOS ST
LIMITS TO: DART ST
DATE: 4/29/2019
APPROVED:

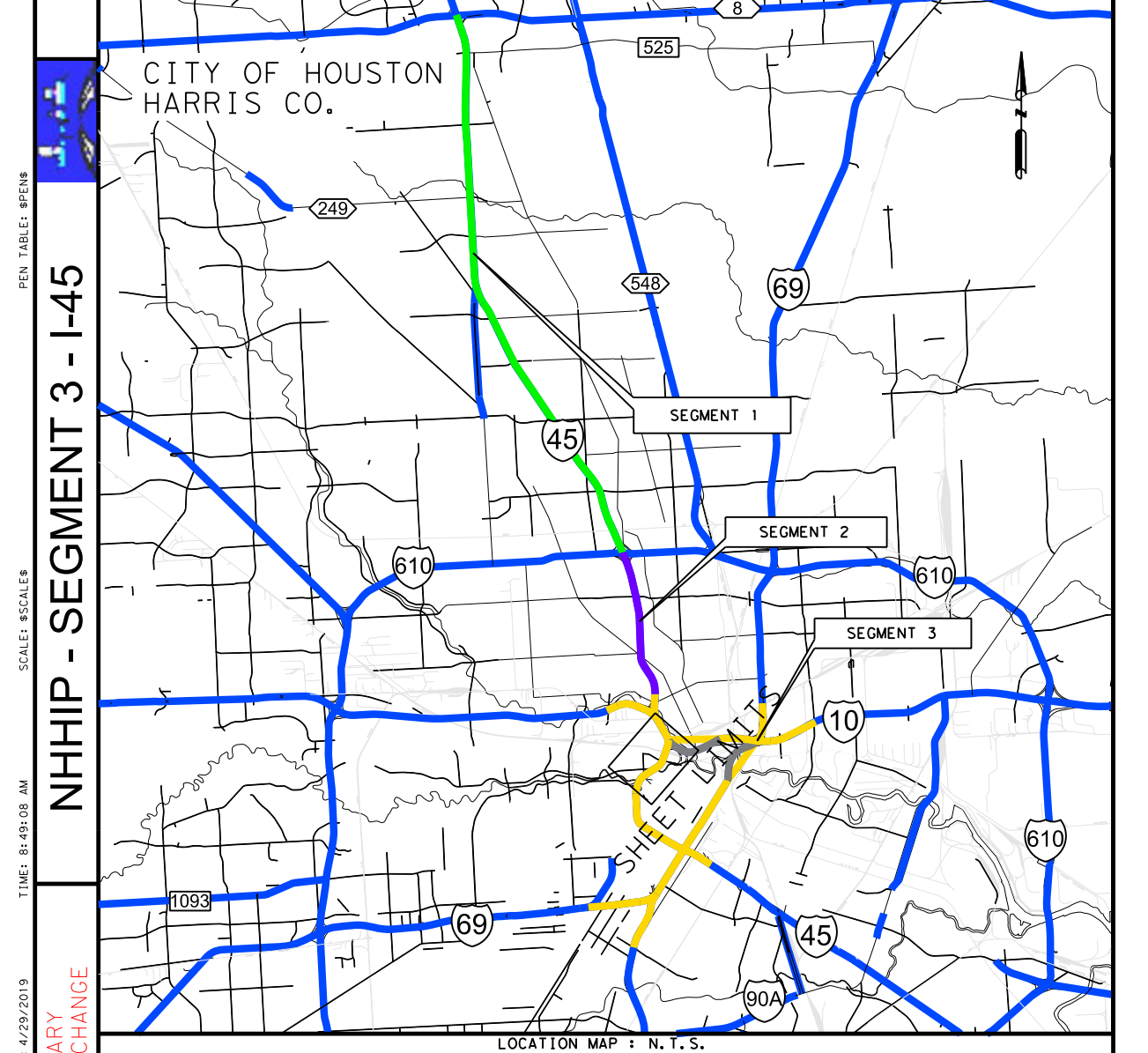
CONSTRUCTION CSJ:0027-13-200, 0027-13-201, 0027-13-221, 0500-03-598, 0500-03-599, 0500-03-601, 0500-08-001

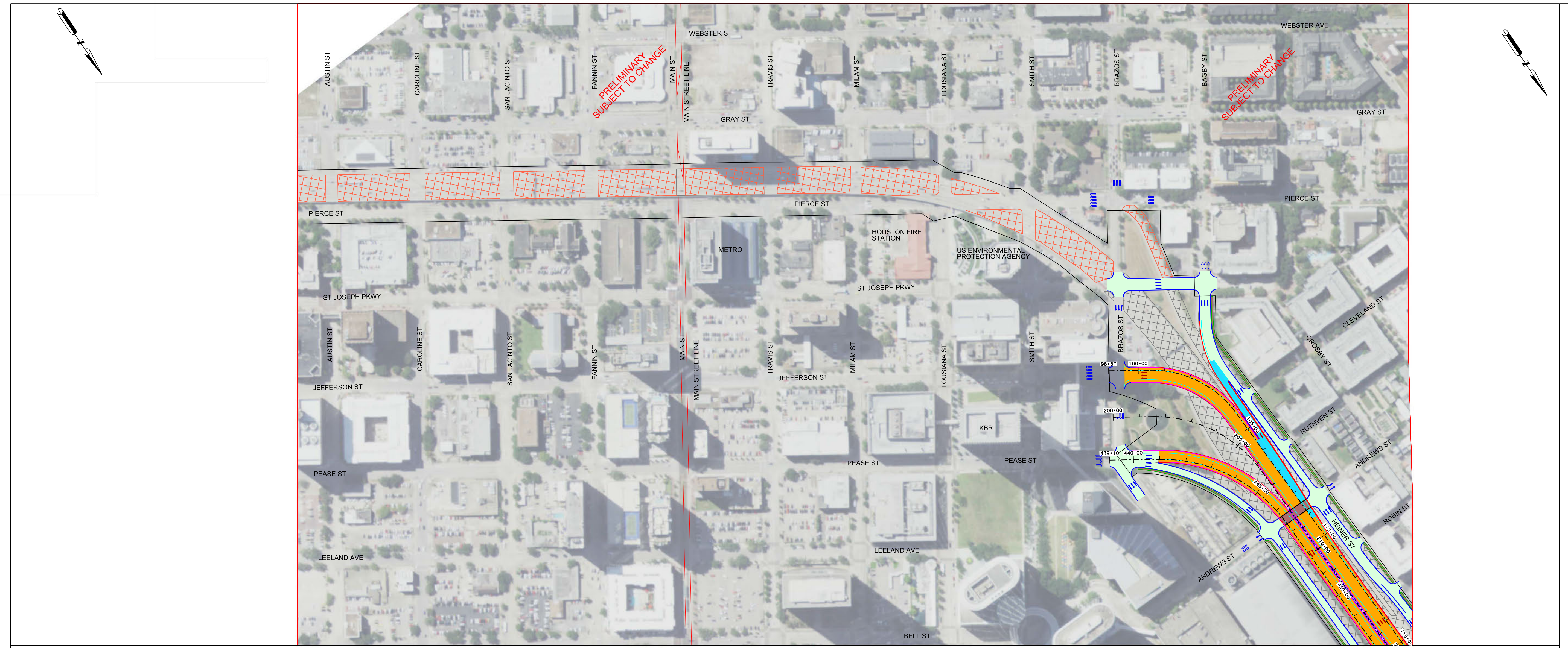
PRELIMINARY CSJ: 0912-00-146, 0912-00-147, 0912-00-479

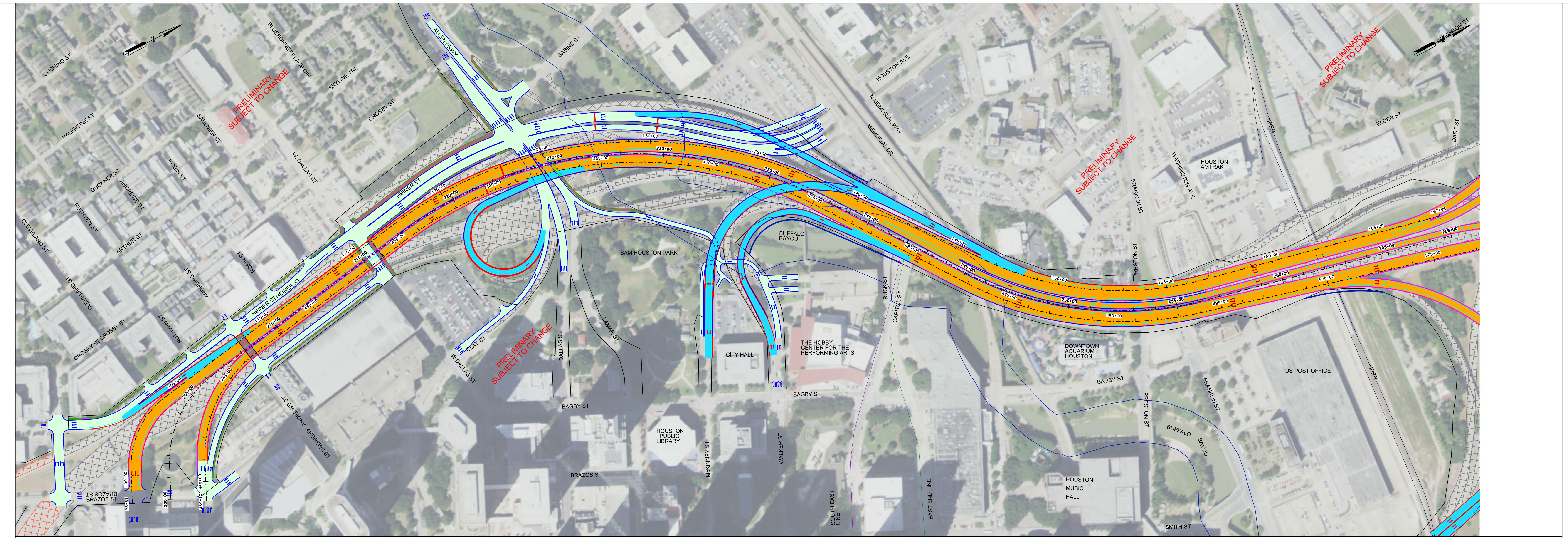
ROADWAY	FUNCTIONAL CLASSIFICATION	DESIGN SPEED
MAINLANES	URBAN FREEWAY	50 MPH
DIRECT CONNECTORS	DIRECT CONNECTORS	40 MPH
RAMPS	RAMPS	40 MPH
COLLECTOR-DISTRIBUTORS	COLLECTOR-DISTRIBUTORS	40 MPH
FRONTAGE ROADS	URBAN COLLECTOR	40 MPH
SIDE STREETS	URBAN MINOR ARTERIAL/ URBAN COLLECTOR	30 MPH

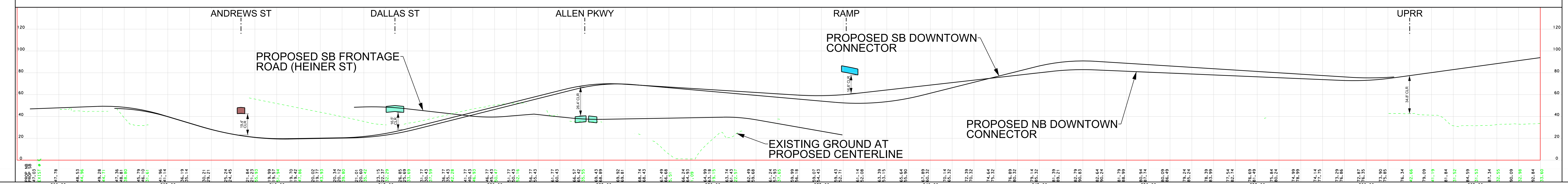
HORZ SCALE: 1"=200'

VERT SCALE: 1"=20'









NHHIP - SEGMENT 3 - I-45

HNTB

SHEET 9 OF 9

APPENDIX B

ADJUSTED DESIGN SCHEMATIC

PUBLIC HEARING LAYOUT

NHHIP DOWNTOWN CONN. SEGMENT 3

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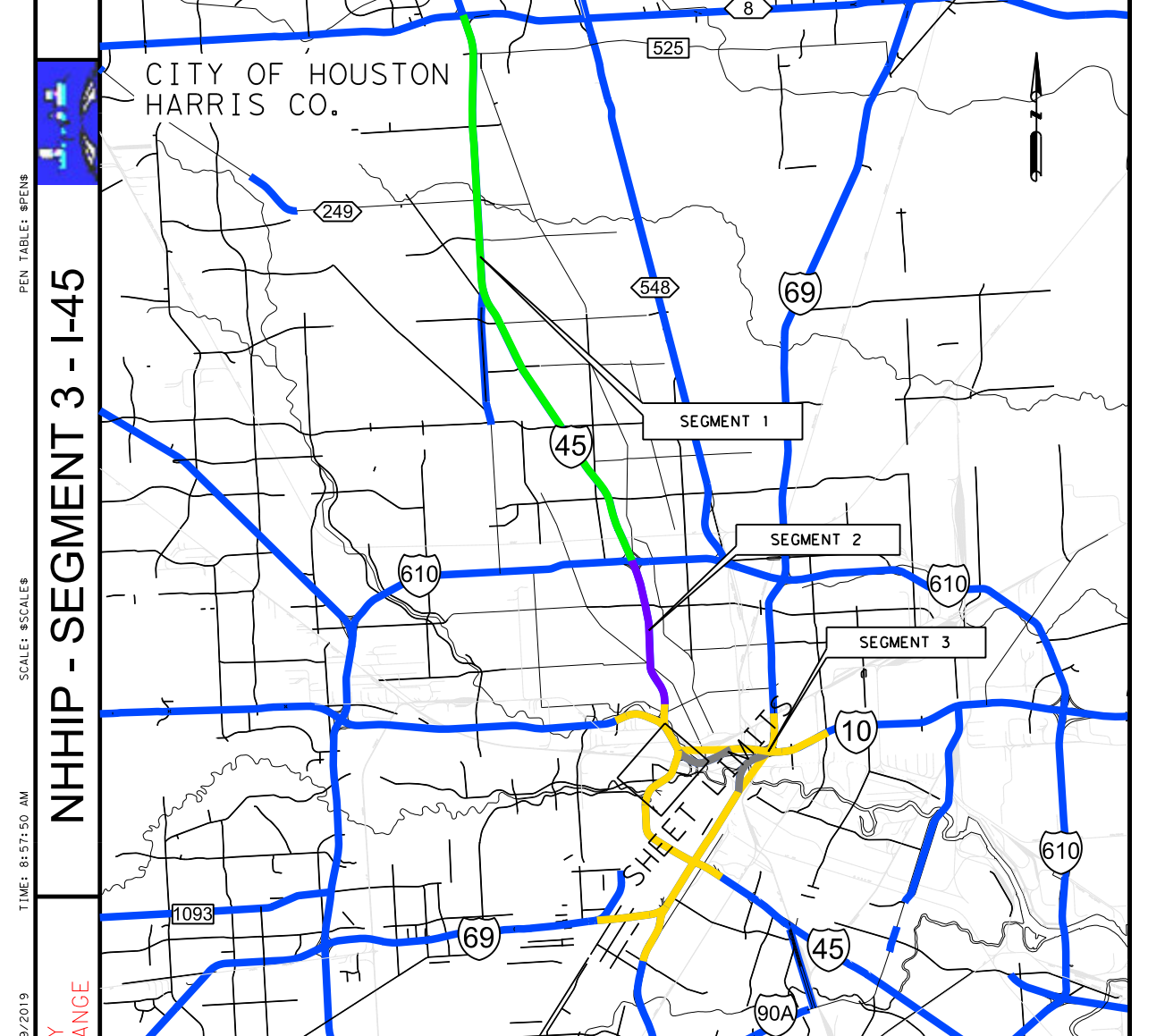
HOUSTON DISTRICT PROJECT DEVELOPMENT

ROADWAY	FUNCTIONAL CLASSIFICATION	DESIGN SPEED
MAINLANES	URBAN FREEWAY	50 MPH
DIRECT CONNECTORS	DIRECT CONNECTORS	40 MPH
RAMPS	RAMPS	40 MPH
COLLECTOR-DISTRIBUTORS	COLLECTOR-DISTRIBUTORS	40 MPH
FRONTAGE ROADS	URBAN COLLECTOR	40 MPH
SIDE STREETS	URBAN MINOR ARTERIAL/	30 MPH
	URBAN COLLECTOR	30 MPH

HORZ SCALE: 1"=200'
0 50 100 200

VERT SCALE: 1"=20'
0 5 10 20



LOCATION MAP : N.T.S.
SURVEY DATA: TEXAS SOUTH CENTRAL ZONE #4204 (HARRIS COUNTY)
ADJUSTED TO SURFACE USING COMBINED SCALE FACTOR 1.00013

PLAN LEGEND

SYMBOLOGY	STYLE / LINE WT	COLOR CODE	
CENTERLINE	2	BLACK	0
I-45 MAINLANES	2	BLACK	0
I-69/US 59 MAINLANES	2	BLACK	0
I-10 MAINLANES	2	BLACK	0
SH 288 MAINLANES	2	BLACK	0
I-610 MAINLANES	2	BLACK	0
I-10 EXPRESS LANES	2	PINK	10
MAX LANES	2	PINK	28
FRONTAGE ROADS	2	GREEN	2
LOCAL STREETS	2	BLUE	1
RAMPS	2	RED	3
DIRECT CONNECTOR	2	MAGENTA	5
PEDESTRIAN REALM	1	GREEN	155
POTENTIAL GREENSPACE	7		
EXISTING RDWY TO BE REMOVED	1		
SURPLUS ROW	3	RED	3
PROPOSED CONTROL OF ACCESS	0	RED	3
PROPOSED FEIS ROW	6	BLUE	126
EXISTING ROW	1	BLACK	0
ACCESS ROAD	1	BLUE	1
METRO RAIL RED (MAIN STREET LINE)	1	RED	3
METRO RAIL(EAST END LINE)	1	GREEN	156
METRO RAIL(SOUTHEAST LINE)	1	PURPLE	203
RAILROAD	1	BLACK	0
LIMITS OF FLOODWAY	1	BLUE	171
PLANIMETRIC	2	GREEN	2
TRAFFIC COUNT YEAR (2040) DHV	0	BLACK	0
AM MAX LANE TRAFFIC COUNT YEAR (2040) DHV	0	BLACK	0
PM MAX LANE TRAFFIC COUNT YEAR (2040) DHV	0	BLACK	0
EXISTING LANE DIRECTIONAL INDICATOR:			
MAIN LANES	0	BLACK	0
FRONTAGE ROADS/TURNAROUNDS	0	BLUE	168
PROPOSED LANE DIRECTIONAL INDICATOR:			
MAIN LANES	1	BLACK	0
FRONTAGE ROADS/TURNAROUNDS	1	BLUE	168
RAMPS	1	RED	3
DIRECT CONNECTOR	1	RED	139
MAX LANES	1	MAGENTA	5
DEPRESSED	3	RED	3
BY OTHERS	3	BLUE	1
RETAINING WALL	6	RED	3
PROPOSED AESTHETIC WALL	6	LT GREEN	196
PROPOSED NOISE BARRIER	6	PURPLE	203

PRELIMINARY
SUBJECT TO CHANGE

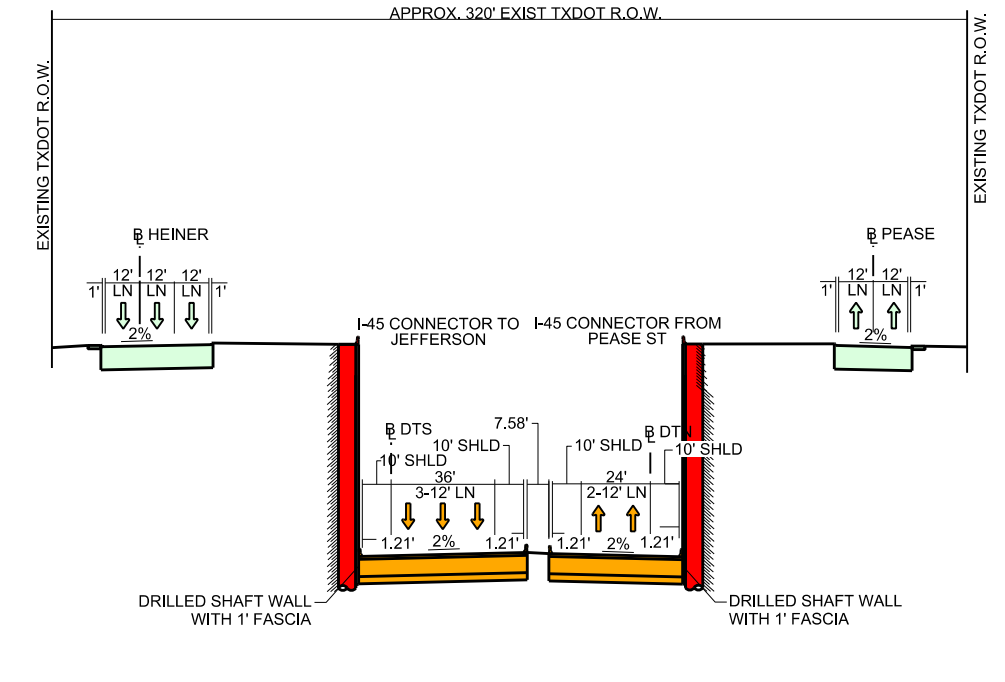
HNTB Corporation
1301 Fannin St, Suite 2000
Houston, TX 77002
TBPE Firm Registration No. 420

ROADWAY: I-45 NORTH
COUNTY: HARRIS
LIMITS FROM: BELTWAY 8
LIMITS TO: I-69

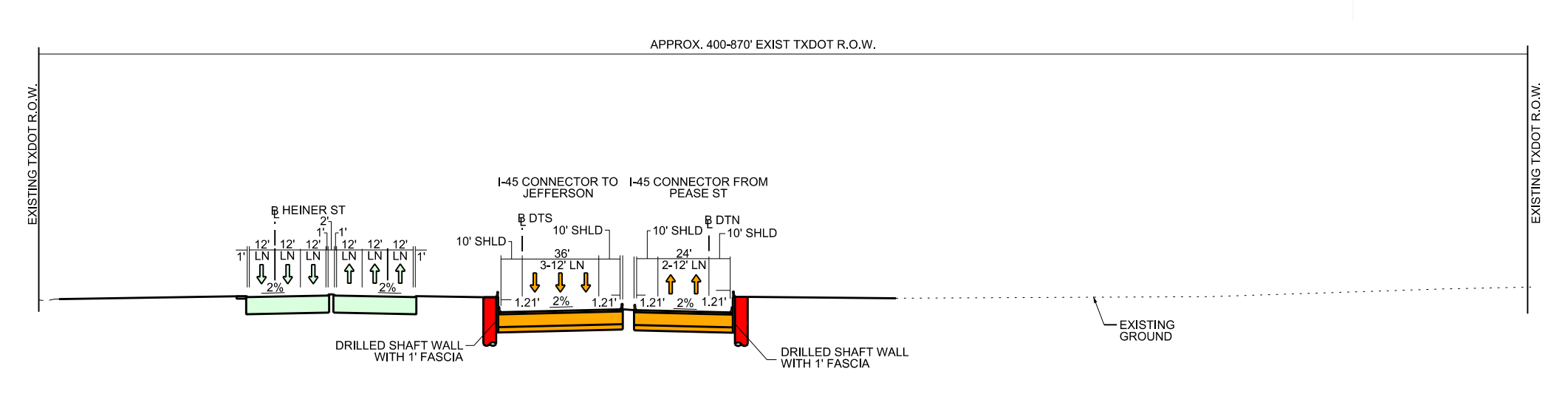
PRELIMINARY
SUBMITTED FOR REVIEW
Engineer: DARRIN J. WILLER
P.E. Serial No.: 82119
Date: 4/29/2019
Signature:
NOT FOR CONSTRUCTION, BIDDING OR PERMITTING

TxDOT (DISTRICT-"APPROVED BY") LETTER DATED

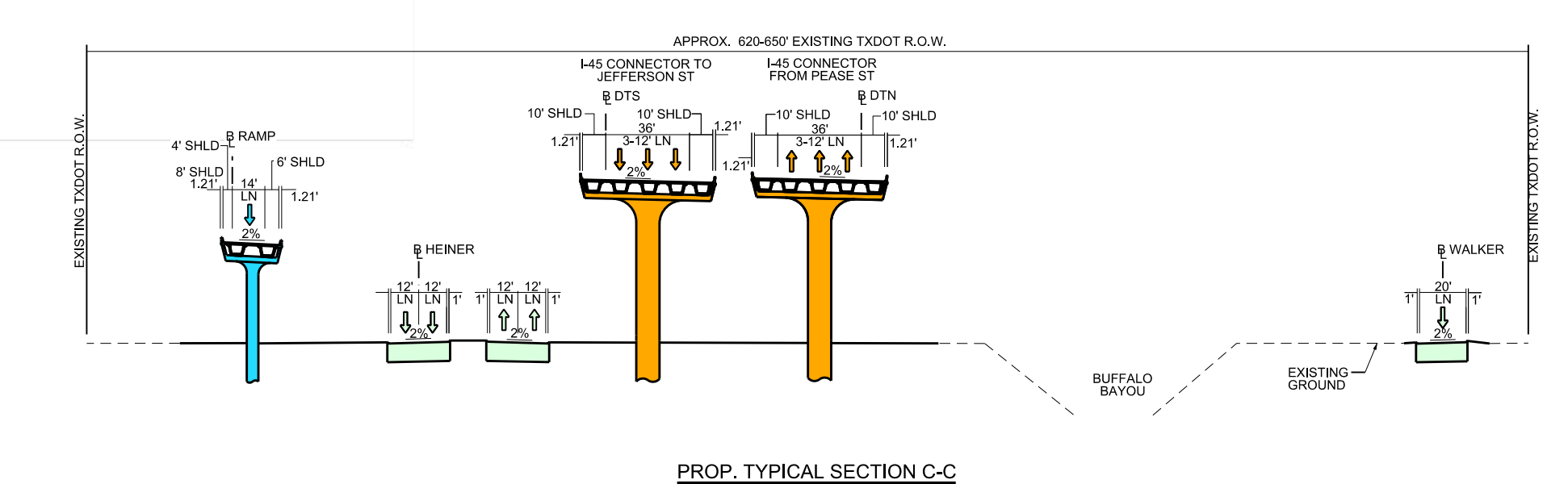
FHWA REPRESENTATIVES ("APPROVED BY") LETTER DATED



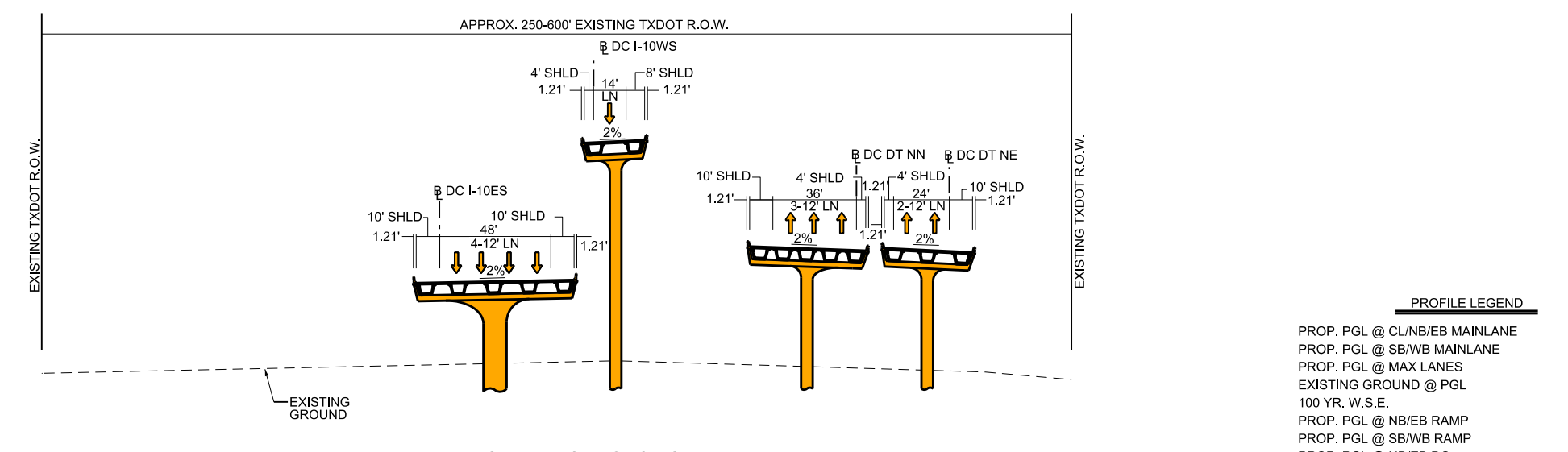
PROP. TYPICAL SECTION A-A
NTS



PROP. TYPICAL SECTION B-B
NTS



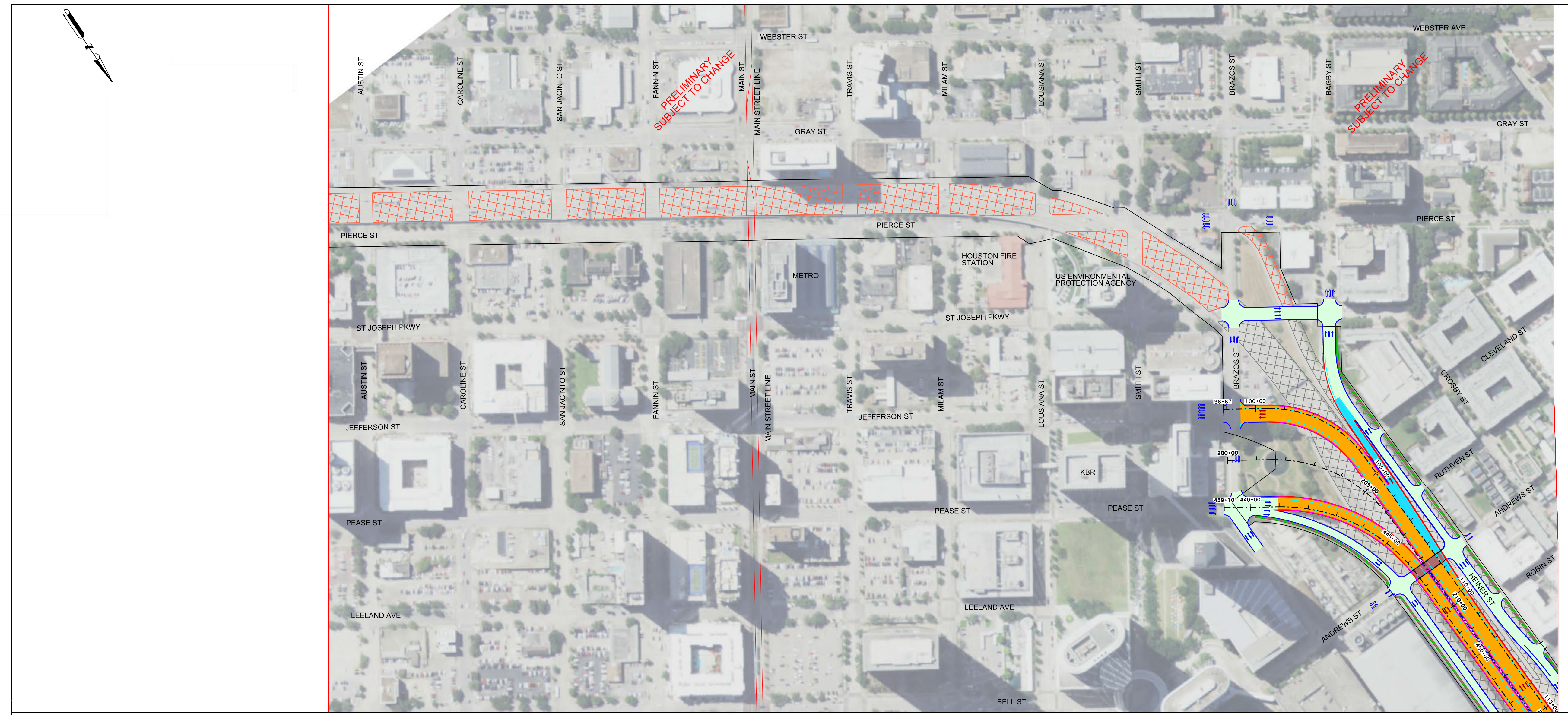
PROP. TYPICAL SECTION C-C
NTS

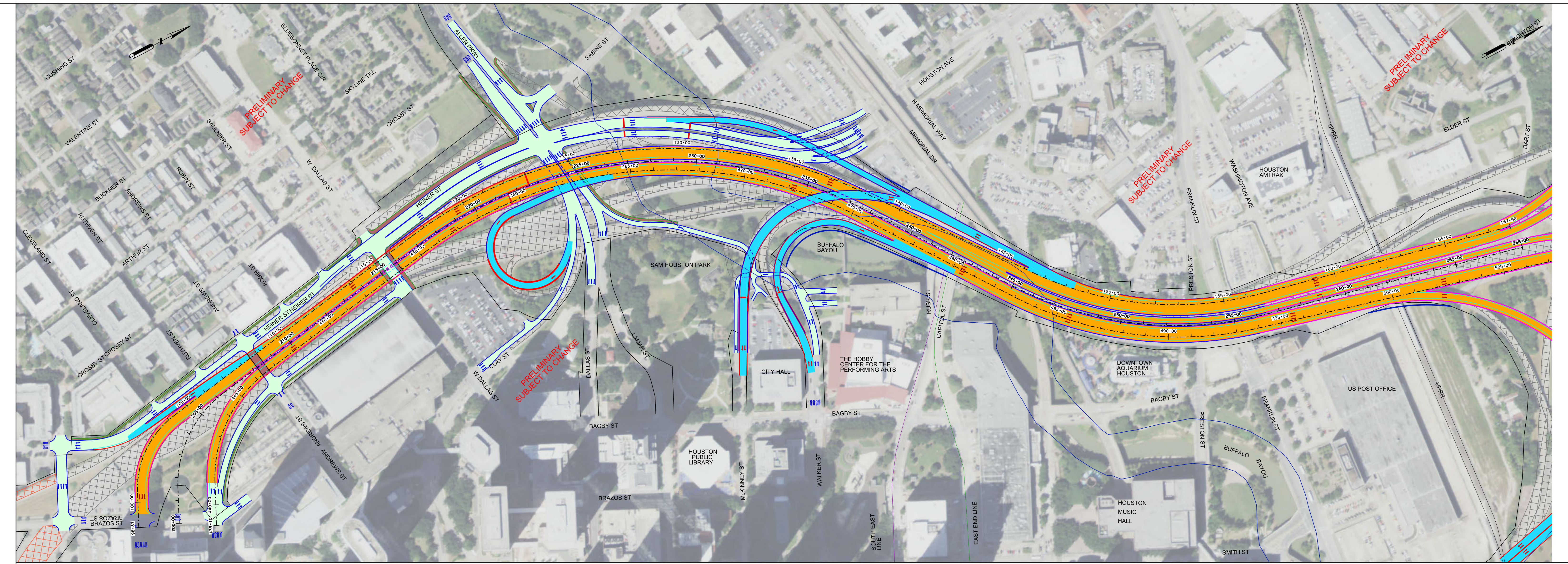


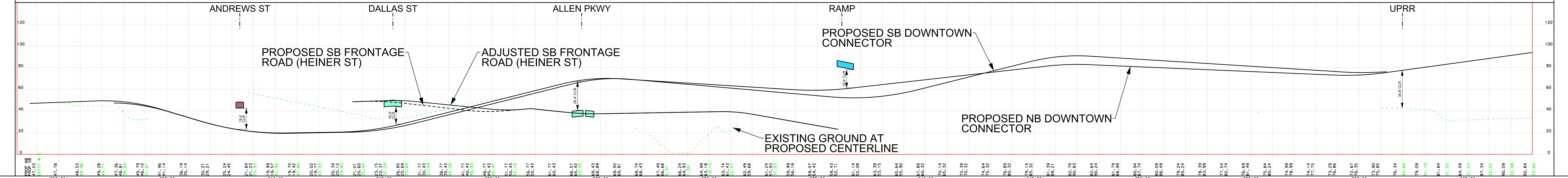
PROP. TYPICAL SECTION D-D
NTS

PROFILE LEGEND

PROP. PGL @ CL/NB/EB MAINLANE	
PROP. PGL @ SB/WB MAINLANE	
PROP. PGL @ MAX LANES	
EXISTING GROUND @ PGL	
100 YR. W.S.E.	
PROP. PGL @ NB/EB RAMP	
PROP. PGL @ SB/WB RAMP	
PROP. PGL @ NB/EB DC	
PROP. PGL @ SB/WB DC	
PROP. PGL @ NB/EB FRONTAGE	
PROP. PGL @ SB/WB FRONTAGE	
PROP. PGL @ LOCAL ST	
EXIST. GRND. @ NB/EB ROW	
EXIST. GRND. @ SB/WB ROW	







APPENDIX C

DRAINAGE SYSTEM

HYDROLOGIC ANALYSIS OUTPUT

Appendix C
Rational Method Calculations - Proposed Conditions

NHHIP Segment 3E (I-45 Downtown Connectors), CSJ: 0500-03-598

Harris County, Texas

Description: Rational Method Calculations
Project Name: NHHIP Drainage Study-Segment 3E
Location: Houston, Texas
Drainage Condition: Proposed Conditions
Date: 4/15/2019

IDF Coefficients	2yr	5yr	10yr	25yr	50yr	50yr	100yr
b	57.73	73.87	86.47	102.23	116.88	116.88	136.33
d	9.5	10.5	11.3	12.3	13.0	13.0	14.1
e	0.7939	0.7855	0.7829	0.7774	0.7727	0.7727	0.7720

Sub-Basin Name	Area Total [acre]	Overland Sheet Flow Length (ft)	Paved Sheet Flow / Gutter Flow Length (ft)	Storm Sewer Length (ft)	Channel Length (ft)	Calculated Time of Conc (min)	Time of Conc (min)	Open Area	Park/ Cemetery	School/ Library	Single Family Residential	Multi Residential Units	Apartments	Light Commercial	Heavy Commercial/ Industrial	Downtown Areas	Railroad	ROW Grass	Pavement	Channel	Detention	% Imperv-ious Cover	Runoff Coeff-icient, C	Peak Flow (cfs)				Peak Flow (cfs)			
Runoff Coefficient								**0.30**	**0.20**	**0.65**	**0.50**	**0.60**	**0.70**	**0.65**	**0.80**	**0.90**	**0.35**	**0.35**	**0.90**	**1.00**	**1.00**										
% Impervious Cover								**0%**	**0%**	**72%**	**60%**	**70%**	**75%**	**72%**	**85%**	**85%**	**40%**	**0%**	**100%**	**100%**	**100%**			**2yr**	**10yr**	**50yr**	**100yr**	**2yr**	**10yr**	**50yr**	**100yr**
Travel Velocity		**0.5 ft/s**	**1.5 ft/s**	**3 ft/s**	**3 ft/s**																										
System F																															
DA34	0.52	0.0	354.0	0.0	0.0	3.9	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.34	0.00	0.00	66%	0.71	5.5	7.9	10.4	11.7	2.0	2.9	3.9	4.4
DA35	2.17	189.0	235.0	0.0	0.0	8.9	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.00	1.41	65%	0.77	5.5	7.9	10.4	11.7	9.1	13.2	17.4	19.6
DA35A	0.33	0.0	290.0	0.0	0.0	3.2	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	1.6	2.4	3.1	3.5
DA36	1.70	280.0	0.0	0.0	0.0	9.3	10.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00	0.00	0%	0.28	5.5	7.9	10.4	11.7	2.6	3.8	5.0	5.6
DA37	1.03	0.0	498.0	0.0	0.0	5.5	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.73	0.00	0.00	71%	0.74	5.5	7.9	10.4	11.7	4.2	6.0	7.9	8.9
DA38	1.74	138.0	165.0	0.0	0.0	6.4	10.00	0.00	0.00	0.00	0.00	0.00	0.44	0.00	0.36	0.00	0.00	0.14	0.80	0.00	0.00	82%	0.78	5.5	7.9	10.4	11.7	7.5	10.8	14.2	16.0
DA40	1.21	50.0	235.0	0.0	0.0	4.3	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.23	0.71	0.00	0.00	78%	0.77	5.5	7.9	10.4	11.7	5.1	7.4	9.8	11.0
DA41	1.25	50.0	304.0	0.0	0.0	5.0	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.86	0.00	0.00	69%	0.73	5.5	7.9	10.4	11.7	5.0	7.2	9.5	10.7
DA42	1.59	144.0	110.0	0.0	0.0	6.0	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	1.05	0.00	0.00	66%	0.71	5.5	7.9	10.4	11.7	6.2	8.9	11.8	13.3
DA43	2.54	0.0	232.0	115.0	0.0	3.2	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	2.04	100%	0.98	5.5	7.9	10.4	11.7	13.6	19.7	25.9	29.1
DA44	0.75	0.0	426.0	0.0	0.0	4.7	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	3.7	5.4	7.0	7.9
DA46	0.51	0.0	449.0	0.0	0.0	5.0	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	2.5	3.6	4.8	5.4
DA47	1.87	81.0	210.0	125.0	0.0	5.7	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	1.00	0.00	0.00	53%	0.64	5.5	7.9	10.4	11.7	6.6	9.5	12.5	14.1
DA48	1.43	70.0	140.0	240.0	0.0	5.2	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.52	0.00	0.00	37%	0.55	5.5	7.9	10.4	11.7	4.3	6.2	8.2	9.2
DA50	1.82	0.0	334.0	60.0	0.0	4.0	10.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.87	0.00	0.00	48%	0.60	5.5	7.9	10.4	11.7	6.0	8.6	11.3	12.7
DA54	3.04	112.0	388.0	0.0	0.0	8.0	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	0.00	1.03	0.25	0.00	0.00	57%	0.71	5.5	7.9	10.4	11.7	11.8	17.1	22.5	25.3
DA54A	1.61	105.0	357.0	0.0	0.0	7.5	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.89	0.00	0.00	55%	0.65	5.5	7.9	10.4	11.7	5.7	8.3	10.9	12.3
DA55	45.40	156.0	105.9	2864.8	0.0	22.3	22.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.76	0.00	0.01	0.63	0.00	0.00	85%	0.90	3.7	5.5	7.5	8.5	151.4	225.7	304.5	347.5
DA56	0.70	0.0	353.0	0.0	0.0	3.9	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.33	0.00	0.00	47%	0.61	5.5	7.9	10.4	11.7	2.3	3.4	4.5	5.0
DA57	0.86	73.0	198.0	0.0	0.0	4.6	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.29	0.00	0.00	34%	0.53	5.5	7.9	10.4	11.7	2.5	3.6	4.8	5.4
DA59	1.12	85.0	302.0	0.0	0.0	6.2	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.62	0.00	0.00	55%	0.66	5.5	7.9	10.4	11.7	4.0	5.8	7.6	8.5
DA63	1.38	86.0	220.0	0.0	0.0	5.3	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0%	0.35	5.5	7.9	10.4	11.7	2.6	3.8	5.0	5.6
DA71	0.92	55.0	328.0	0.0	0.0	5.5	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.79	0.00	0.00	85%	0.82	5.5	7.9	10.4	11.7	4.1	6.0	7.8	8.8
DA72	0.36	70.0	100.0	0.0	0.0	3.4	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.26	0.00	0.00	74%	0.76	5.5	7.9	10.4	11.7	1.5	2.1	2.8	3.2
DA1P	0.71	0.0	311.0	0.0	0.0	3.5	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	3.5	5.0	6.6	7.4
DA2P	0.78	0.0	350.0	0.0	0.0	3.9	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	3.8	5.5	7.2	8.2
DA3P	0.77	0.0	350.0	0.0	0.0	3.9	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	3.8	5.5	7.2	8.1
DA4P	1.34	0.0	335.0	0.0	0.0	3.7	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	6.6	9.5	12.5	14.1
DA5P	0.62	0.0	395.0	0.0	0.0	4.4	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	3.1	4.4	5.8	6.5
DA6P	0.43	0.0	350.0	0.0	0.0	3.9	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	2.1	3.1	4.0	4.6
DA7P	0.62	0.0	390.0	0.0	0.0	4.3	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	3.0	4.4	5.8	6.5
DA8P	0.30	0.0	320.0	0.0	0.0	3.6	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	100%	0.90	5.5	7.9	10.4	11.7	1.5	2.1	2.8	3.2
Total	**81.42**							**0.00**	**0.96**	**0.00**	**0.00**	**0.00**	**0.44**	**0.00**	**0.64**	**46.52**	**0.00**	**10.81**	**18.60**	**0.00**	**3.45**	**77%**	**0.82**								
System G																															
DA31	609.47	**Calculated using HCFCD Clark UH Method**						6.53	2.14	1.74	6.34	184.92	97.64	0.00	272.41	14.12	0.00	0.62	23.02	0.00	0.00	78%	0.72	**Calculated using HCFCD Clark UH Method**							
DA32	49.27	125.1	145.7	3208.8	0.0	23.6	23.62	1.52	0.46	3.81	10.10	9.19	19.03	0.00	5.15	0.00	0.00	0.00	0.01	0.00	0.00	69%	0.63	3.6	5.4	7.2	8.3	111.4	166.3	224.8	256.8
DA33	47.57	111.8	117.0	3202.1	0.0	22.8	22.82	0.75	2.69	0.00	31.19	8.21	0.90	0.00	3.82	0.00	0.00	0.00	0.01	0.00	0.00	60%	0.53	3.7	5.5	7.4	8.4	91.4	136.3	184.0	210.1
DA65	11.04	0.0	226.2	1176.3	0.0	9.0	10.00	0.24	0.07	3.48	0.00	6.10	0.00	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	70%	0.63	5.5	7.9	10.4	11.7	37.8	54.7	71.9	81.0
Total	**717.35**							**9.05**	**5.36**	**9.03**	**47.63**	**208.41**	**117.58**	**0.00**	**282.52**	**14.12**	**0.00**	**0.62**	**23.04**	**0.00**	**0.00**	**76%**	**0.70**								
System H																															
DA45	0.41	44.00	154.00	28.00	0.00	3.3	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.22	0.00	0.00	55%	0.65	5.5	7.9	10.4	11.7	1.4	2.1	2.8	3.1
DA45A	0.51	44.00	280.00	38.00	0.00	4.8	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.24	0.00	0.00	48%	0.61	5.5	7.9	10.4	11.7	1.7	2.5	3.2	3.6
DA60	0.84	145.3	0.0	175.2	0.0	5.8	10.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.22	0.00	0.00	27%	0.42	5.5	7.9	10.4	11.7	1.9	2.8	3.7	4.2
DA68	2.72	0.0	446.6	0.0	0.0	5.0	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	2.02	0.00	0.00	74%	0.76	5.5	7.9	10.4	11.7	11.3	16.3	21.4	24.1
Total	**4.48**							**0.00**	**0.41**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.36**	**2.71**	**0.00**	**0.00**	**60%**	**0.67**								
System I																															
DA49	0.53	230.00	0.00	0.00	0.00	7.7	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0%	0.35	5.5	7.9	10.4	11.7	1.0	1.5	1.9	2.2
Total	**0.53**							**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.53**	**0.00**	**0.00**	**0.00**	**0%**	**0.35**								
Grand Total	**803.78**							**9.05**	**6.74**	**9.03**	**47.63**	**208.41**	**118.02**	**0.00**	**283.16**	**60.64**	**0.00**	**13.31**	**44.35**	**0.00**	**3.45**	**76%**	**0.71**								

Project: W100-00-00
Start of Run: 01Jun2007, 00:00
End of Run: 04Jun2007, 00:00
Compute Time: 04Apr2019, 16:13:53
Volume Units: AC-FT

Simulation Run: NHHIP_Pr10yr
Basin Model: NHHIP_Pr10yr
Meteorologic Model: W1000000_10%
Control Specifications: Control_1min

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA1	0.01430	52.3	01Jun2007, 16:12	4.6
DA11	0.00210	7.9	01Jun2007, 16:12	0.8
DA12	0.00240	9.1	01Jun2007, 16:12	0.9
DA13	0.00190	6.0	01Jun2007, 16:15	0.6
Da14	0.00180	6.8	01Jun2007, 16:12	0.7
Da15	0.00180	6.8	01Jun2007, 16:12	0.7
DA17	0.01540	56.5	01Jun2007, 16:13	5.3
DA19	0.00080	3.1	01Jun2007, 16:12	0.3
DA1P	0.00110	4.2	01Jun2007, 16:12	0.4
DA2	0.00160	6.1	01Jun2007, 16:12	0.6
DA20	0.00710	22.8	01Jun2007, 16:17	2.3
DA21	0.00170	6.2	01Jun2007, 16:12	0.5
DA22	0.00190	7.0	01Jun2007, 16:12	0.6
DA23	0.00250	9.5	01Jun2007, 16:12	0.9
DA26	0.00710	20.0	01Jun2007, 16:19	2.0
DA2P	0.00120	4.6	01Jun2007, 16:12	0.5
DA3	0.00180	6.8	01Jun2007, 16:12	0.7
DA30	0.00020	0.7	01Jun2007, 16:13	0.1
DA31	0.95230	418.9	01Jun2007, 16:51	318.4
DA32	0.07700	166.3	01Jun2007, 16:26	23.6
DA33	0.07430	136.3	01Jun2007, 16:27	20.8
DA34	0.00080	2.9	01Jun2007, 16:12	0.2
DA35	0.00340	12.2	01Jun2007, 16:12	1.0
DA35A	0.00050	1.9	01Jun2007, 16:11	0.2
DA36	0.00270	3.8	01Jun2007, 16:20	0.3
DA37	0.00160	5.8	01Jun2007, 16:12	0.5
DA38	0.00270	10.0	01Jun2007, 16:12	0.9
DA3P	0.00120	4.6	01Jun2007, 16:12	0.5
DA4	0.00110	4.1	01Jun2007, 16:12	0.4
DA40	0.00280	9.8	01Jun2007, 16:13	0.8
DA41	0.00100	3.6	01Jun2007, 16:12	0.3
DA42	0.00250	8.9	01Jun2007, 16:13	0.7
DA43	0.00400	15.3	01Jun2007, 16:11	1.6
DA44	0.00120	4.6	01Jun2007, 16:12	0.5
DA45	0.00060	2.1	01Jun2007, 16:13	0.2
DA45A	0.00080	2.5	01Jun2007, 16:15	0.2
DA46	0.00080	3.1	01Jun2007, 16:12	0.3
DA47	0.00290	9.5	01Jun2007, 16:14	0.7
DA48	0.00220	6.2	01Jun2007, 16:16	0.5
DA49	0.00080	1.5	01Jun2007, 16:18	0.1
DA4P	0.00210	8.1	01Jun2007, 16:11	0.8
DA5	0.00220	8.3	01Jun2007, 16:12	0.8
DA50	0.00280	8.6	01Jun2007, 16:15	0.7
DA51	0.00310	11.1	01Jun2007, 16:12	0.9

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA52	0.00095	2.0	01Jun2007, 16:18	0.2
DA53	0.00760	5.9	01Jun2007, 16:30	0.7
DA54	0.00470	16.7	01Jun2007, 16:12	1.3
DA54A	0.00250	8.3	01Jun2007, 16:14	0.7
DA55	0.07090	238.2	01Jun2007, 16:17	25.2
DA56	0.00110	3.4	01Jun2007, 16:15	0.3
DA57	0.00130	3.6	01Jun2007, 16:16	0.3
DA59	0.00170	5.8	01Jun2007, 16:13	0.4
DA5P	0.00100	3.8	01Jun2007, 16:11	0.4
DA6	0.00230	8.6	01Jun2007, 16:12	0.8
DA60	0.00130	2.8	01Jun2007, 16:18	0.2
DA61	0.00100	3.2	01Jun2007, 16:14	0.2
DA62	0.00130	4.9	01Jun2007, 16:12	0.5
DA63	0.00210	3.8	01Jun2007, 16:18	0.2
DA65	0.01730	54.7	01Jun2007, 16:15	5.4
DA68	0.00430	15.7	01Jun2007, 16:12	1.4
DA69	0.00220	7.4	01Jun2007, 16:14	0.6
DA6P	0.00070	2.7	01Jun2007, 16:12	0.3
DA7	0.00130	4.9	01Jun2007, 16:12	0.5
DA70	0.00041	1.2	01Jun2007, 16:15	0.1
DA71	0.00140	5.2	01Jun2007, 16:12	0.5
DA72	0.00060	2.1	01Jun2007, 16:14	0.2
DA7P	0.00100	3.8	01Jun2007, 16:11	0.4
DA8	0.00120	4.5	01Jun2007, 16:12	0.5
DA8P	0.00050	1.9	01Jun2007, 16:11	0.2
DA9	0.01700	63.6	01Jun2007, 16:12	6.1
Outfall C	0.02400	75.1	01Jun2007, 16:14	7.6

Project: W100-00-00
Start of Run: 01Jun2007, 00:00
End of Run: 04Jun2007, 00:00
Compute Time: 04Apr2019, 15:29:09
Volume Units: AC-FT

Simulation Run: NHHIP_Pr100yr
Basin Model: NHHIP_Pr100yr
Meteorologic Model: W1000000_1%
Control Specifications: Control_1min

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA1	0.01430	75.7	01Jun2007, 16:12	8.4
DA11	0.00210	11.3	01Jun2007, 16:12	1.4
DA12	0.00240	12.9	01Jun2007, 16:12	1.6
DA13	0.00190	9.0	01Jun2007, 16:15	1.1
Da14	0.00180	9.7	01Jun2007, 16:12	1.2
Da15	0.00180	9.7	01Jun2007, 16:12	1.2
DA17	0.01540	82.1	01Jun2007, 16:12	9.5
DA19	0.00080	4.3	01Jun2007, 16:12	0.6
DA1P	0.00110	6.0	01Jun2007, 16:12	0.8
DA2	0.00160	8.6	01Jun2007, 16:12	1.1
DA20	0.00710	34.8	01Jun2007, 16:16	4.2
DA21	0.00170	9.0	01Jun2007, 16:12	0.9
DA22	0.00190	10.1	01Jun2007, 16:12	1.1
DA23	0.00250	13.5	01Jun2007, 16:12	1.7
DA26	0.00710	30.6	01Jun2007, 16:19	3.8
DA2P	0.00120	6.5	01Jun2007, 16:12	0.8
DA3	0.00180	9.7	01Jun2007, 16:12	1.2
DA30	0.00020	1.1	01Jun2007, 16:12	0.1
DA31	0.95230	717.9	01Jun2007, 17:04	574.0
DA32	0.07700	256.8	01Jun2007, 16:26	43.2
DA33	0.07430	210.1	01Jun2007, 16:28	38.6
DA34	0.00080	4.2	01Jun2007, 16:12	0.4
DA35	0.00340	17.9	01Jun2007, 16:12	1.8
DA35A	0.00050	2.7	01Jun2007, 16:12	0.4
DA36	0.00270	5.6	01Jun2007, 16:22	0.7
DA37	0.00160	8.5	01Jun2007, 16:12	0.9
DA38	0.00270	14.4	01Jun2007, 16:12	1.7
DA3P	0.00120	6.5	01Jun2007, 16:12	0.8
DA4	0.00110	5.9	01Jun2007, 16:12	0.7
DA40	0.00280	14.5	01Jun2007, 16:13	1.5
DA41	0.00100	5.3	01Jun2007, 16:12	0.5
DA42	0.00250	13.1	01Jun2007, 16:12	1.4
DA43	0.00400	21.7	01Jun2007, 16:12	2.8
DA44	0.00120	6.5	01Jun2007, 16:12	0.8
DA45	0.00060	3.1	01Jun2007, 16:13	0.3
DA45A	0.00080	3.6	01Jun2007, 16:15	0.4
DA46	0.00080	4.3	01Jun2007, 16:12	0.6
DA47	0.00290	14.1	01Jun2007, 16:14	1.4
DA48	0.00220	9.2	01Jun2007, 16:16	0.9
DA49	0.00080	2.2	01Jun2007, 16:20	0.2
DA4P	0.00210	11.4	01Jun2007, 16:11	1.5
DA5	0.00220	11.8	01Jun2007, 16:12	1.5
DA50	0.00280	12.7	01Jun2007, 16:15	1.3
DA51	0.00310	16.3	01Jun2007, 16:12	1.7

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA52	0.00095	3.1	01Jun2007, 16:18	0.3
DA53	0.00760	9.2	01Jun2007, 16:34	1.9
DA54	0.00470	24.5	01Jun2007, 16:12	2.4
DA54A	0.00250	12.3	01Jun2007, 16:14	1.2
DA55	0.07090	345.9	01Jun2007, 16:17	45.0
DA56	0.00110	5.0	01Jun2007, 16:15	0.5
DA57	0.00130	5.4	01Jun2007, 16:16	0.5
DA59	0.00170	8.5	01Jun2007, 16:14	0.8
DA5P	0.00100	5.4	01Jun2007, 16:12	0.7
DA6	0.00230	12.3	01Jun2007, 16:12	1.5
DA60	0.00130	4.2	01Jun2007, 16:19	0.5
DA61	0.00100	4.8	01Jun2007, 16:14	0.4
DA62	0.00130	7.0	01Jun2007, 16:12	0.9
DA63	0.00210	5.6	01Jun2007, 16:20	0.5
DA65	0.01730	81.0	01Jun2007, 16:15	9.8
DA68	0.00430	22.8	01Jun2007, 16:12	2.5
DA69	0.00220	10.9	01Jun2007, 16:14	1.1
DA6P	0.00070	3.8	01Jun2007, 16:12	0.5
DA7	0.00130	7.0	01Jun2007, 16:12	0.9
DA70	0.00041	1.8	01Jun2007, 16:16	0.2
DA71	0.00140	7.5	01Jun2007, 16:12	0.9
DA72	0.00060	3.2	01Jun2007, 16:12	0.4
DA7P	0.00100	5.4	01Jun2007, 16:12	0.7
DA8	0.00120	6.5	01Jun2007, 16:12	0.8
DA8P	0.00050	2.7	01Jun2007, 16:12	0.4
DA9	0.01700	91.0	01Jun2007, 16:12	10.9
Outfall C	0.02400	113.2	01Jun2007, 16:14	13.9

Project: W100-00-00
Start of Run: 01Jun2007, 00:00
End of Run: 04Jun2007, 00:00
Compute Time: 04Apr2019, 15:51:11
Volume Units: AC-FT

Simulation Run: NHHIP_Pr500yr
Basin Model: NHHIP_Pr100yr
Meteorologic Model: W1000000_0.2%
Control Specifications: Control_1min

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA1	0.01430	94.4	01Jun2007, 16:12	12.4
DA11	0.00210	14.0	01Jun2007, 16:12	2.0
DA12	0.00240	16.0	01Jun2007, 16:12	2.3
DA13	0.00190	11.3	01Jun2007, 16:15	1.6
Da14	0.00180	12.0	01Jun2007, 16:12	1.8
Da15	0.00180	12.0	01Jun2007, 16:12	1.7
DA17	0.01540	102.1	01Jun2007, 16:12	13.9
DA19	0.00080	5.4	01Jun2007, 16:12	0.8
DA1P	0.00110	7.4	01Jun2007, 16:12	1.1
DA2	0.00160	10.7	01Jun2007, 16:12	1.6
DA20	0.00710	43.6	01Jun2007, 16:16	6.2
DA21	0.00170	11.2	01Jun2007, 16:12	1.4
DA22	0.00190	12.6	01Jun2007, 16:12	1.7
DA23	0.00250	16.7	01Jun2007, 16:12	2.4
DA26	0.00710	38.8	01Jun2007, 16:19	5.7
DA2P	0.00120	8.1	01Jun2007, 16:11	1.2
DA3	0.00180	12.0	01Jun2007, 16:12	1.8
DA30	0.00020	1.3	01Jun2007, 16:12	0.2
DA31	0.95230	1016.0	01Jun2007, 17:15	845.9
DA32	0.07700	330.5	01Jun2007, 16:26	64.6
DA33	0.07430	274.8	01Jun2007, 16:28	58.7
DA34	0.00080	5.3	01Jun2007, 16:12	0.7
DA35	0.00340	22.3	01Jun2007, 16:12	2.8
DA35A	0.00050	3.4	01Jun2007, 16:12	0.5
DA36	0.00270	7.8	01Jun2007, 16:22	1.3
DA37	0.00160	10.5	01Jun2007, 16:12	1.4
DA38	0.00270	17.9	01Jun2007, 16:12	2.5
DA3P	0.00120	8.1	01Jun2007, 16:11	1.2
DA4	0.00110	7.3	01Jun2007, 16:12	1.0
DA40	0.00280	18.2	01Jun2007, 16:13	2.2
DA41	0.00100	6.6	01Jun2007, 16:12	0.8
DA42	0.00250	16.4	01Jun2007, 16:12	2.1
DA43	0.00400	26.8	01Jun2007, 16:12	4.0
DA44	0.00120	8.1	01Jun2007, 16:11	1.2
DA45	0.00060	3.9	01Jun2007, 16:13	0.5
DA45A	0.00080	4.6	01Jun2007, 16:15	0.6
DA46	0.00080	5.4	01Jun2007, 16:11	0.8
DA47	0.00290	17.8	01Jun2007, 16:14	2.2
DA48	0.00220	11.7	01Jun2007, 16:16	1.5
DA49	0.00080	3.0	01Jun2007, 16:20	0.4
DA4P	0.00210	14.1	01Jun2007, 16:11	2.1
DA5	0.00220	14.7	01Jun2007, 16:12	2.1
DA50	0.00280	16.1	01Jun2007, 16:15	2.0
DA51	0.00310	20.3	01Jun2007, 16:12	2.5

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
DA52	0.00095	4.0	01Jun2007, 16:19	0.6
DA53	0.00760	13.6	01Jun2007, 16:34	3.5
DA54	0.00470	30.7	01Jun2007, 16:12	3.6
DA54A	0.00250	15.5	01Jun2007, 16:14	1.9
DA55	0.07090	433.0	01Jun2007, 16:17	65.7
DA56	0.00110	6.3	01Jun2007, 16:15	0.8
DA57	0.00130	6.9	01Jun2007, 16:16	0.8
DA59	0.00170	10.7	01Jun2007, 16:14	1.3
DA5P	0.00100	6.7	01Jun2007, 16:12	1.0
DA6	0.00230	15.3	01Jun2007, 16:12	2.2
DA60	0.00130	5.5	01Jun2007, 16:19	0.8
DA61	0.00100	6.1	01Jun2007, 16:14	0.7
DA62	0.00130	8.7	01Jun2007, 16:12	1.2
DA63	0.00210	7.6	01Jun2007, 16:20	1.0
DA65	0.01730	101.9	01Jun2007, 16:15	14.6
DA68	0.00430	28.4	01Jun2007, 16:12	3.7
DA69	0.00220	13.7	01Jun2007, 16:14	1.7
DA6P	0.00070	4.7	01Jun2007, 16:11	0.7
DA7	0.00130	8.7	01Jun2007, 16:12	1.2
DA70	0.00041	2.3	01Jun2007, 16:16	0.3
DA71	0.00140	9.3	01Jun2007, 16:12	1.3
DA72	0.00060	4.0	01Jun2007, 16:12	0.5
DA7P	0.00100	6.7	01Jun2007, 16:12	1.0
DA8	0.00120	8.0	01Jun2007, 16:12	1.2
DA8P	0.00050	3.4	01Jun2007, 16:12	0.5
DA9	0.01700	113.1	01Jun2007, 16:12	15.8
Outfall C	0.02400	142.2	01Jun2007, 16:14	20.6

APPENDIX D

DRAINAGE SYSTEM

HYDRAULIC ANALYSIS OUTPUT

Appendix D1.1

North Houston Highway Improvement Project Segment 3E
Existing XP-STORM Hydraulic Results Summary (10-Year)

Model: ExSystemsFGHI_v18.1_v18.1.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L1	Circular	DA35	N2	28.02	26.69	1.00	0.00	1.50	76.20	1.75	12	16.20	9.36	31.01	30.64	31.76
L5	Circular	DA36	N6	24.06	23.33	1.00	0.00	2.50	335.85	0.22	27	16.21	5.38	30.64	30.64	46.70
L7	Circular	DA39	N8	23.06	22.85	1.00	0.00	3.50	141.97	0.15	49	16.20	4.94	30.64	30.64	34.50
L13	Circular	DA42	DA63	31.30	30.00	1.00	0.00	1.50	83.20	1.56	4	16.20	6.95	31.85	30.64	34.00
L10	Circular	DA43	N11	21.81	21.43	1.00	0.00	3.50	221.00	0.17	62	16.22	6.56	30.64	30.64	53.00
L9	Circular	DA63	DA43	22.51	21.81	1.00	0.00	3.50	418.00	0.17	59	16.22	5.96	30.64	30.64	39.00
L11	Circular	N11	N12	21.43	20.91	1.00	0.00	3.50	307.00	0.17	61	16.24	7.02	30.64	30.63	34.00
L12	**Circular**	**N12**	**OutF**	**1.55**	**1.55**	**1.00**	**0.00**	**3.50**	**42.00**	**0.00**	**61**	**16.24**	**6.32**	**30.63**	**30.63**	**29.70**
L2	Circular	N2	N3	26.20	26.05	1.00	0.00	2.00	83.80	0.18	12	16.20	5.00	30.64	30.64	29.89
L3	Circular	N3	N4	26.05	25.14	1.00	0.00	2.00	67.30	1.35	12	16.21	6.59	30.64	30.64	29.70
L4	Circular	N4	DA36	24.94	24.06	1.00	0.00	2.50	434.80	0.20	12	16.21	2.52	30.64	30.64	30.02
L6	Circular	N6	DA39	24.13	23.08	1.00	0.00	2.50	331.97	0.32	27	16.21	5.40	30.64	30.64	46.90
L8	Circular	N8	DA63	22.89	22.51	1.00	0.00	3.50	250.00	0.15	49	16.21	4.85	30.64	30.64	32.00
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	421	16.84	11.59	30.77	30.75	45.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	574	16.59	12.11	30.75	30.74	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.24	898	16.51	15.10	30.71	30.69	46.00
L31	Circular	DA34	N32	37.71	37.62	1.00	0.00	3.00	31.00	0.29	10	16.20	4.75	38.72	38.61	45.74
L22	Circular	DA37	N23	28.54	27.38	1.00	0.00	4.50	300.00	0.39	212	16.26	13.39	34.42	31.49	45.45
L20	Circular	DA55	DA58	31.75	31.52	1.00	0.00	4.00	275.00	0.08	197	16.46	15.46	44.20	39.91	51.00
L36	Circular	DA56	N37	43.98	43.18	1.00	0.00	1.50	206.00	0.39	2	16.20	3.47	44.56	43.85	48.52
L38	Circular	DA57	N39	41.50	41.42	1.00	0.00	2.00	40.00	0.20	7	16.19	5.17	42.37	42.13	46.30
L21	Circular	DA58	DA37	31.56	31.40	1.00	0.00	4.00	276.00	0.06	201	16.40	15.91	39.91	35.37	45.50
L41	Circular	DA59	DA58	38.65	38.06	1.00	0.00	2.00	143.00	0.41	4	16.19	4.09	39.90	39.91	44.19
L29	**Circular**	**DA65**	**OutG**	**8.83**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**924**	**16.50**	**22.70**	**30.58**	**30.52**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	763	16.53	12.27	30.72	30.71	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	898	16.51	15.75	30.69	30.68	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	898	16.52	17.04	30.68	30.67	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	898	16.52	22.35	30.67	30.63	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	898	16.52	22.39	30.63	30.58	42.63
L32	Circular	N32	DA37	37.26	35.41	1.00	0.00	3.00	442.00	0.42	9	16.22	5.17	38.18	36.32	45.84
L35	Circular	N35	DA56	44.08	43.98	1.00	0.00	1.50	48.00	0.21	0	16.03	-0.13	44.56	44.56	48.38
L37	Circular	N37	DA57	43.33	42.03	1.00	0.00	1.50	228.00	0.57	2	16.22	4.09	43.85	42.55	47.44
L39	Circular	N39	DA58	41.42	39.30	1.00	0.00	2.00	218.00	0.97	7	16.20	6.54	42.13	40.01	46.26
L40	Circular	N40	DA59	39.70	39.15	1.00	0.00	1.50	110.00	0.50	0	16.29	0.60	39.91	39.90	44.04
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	586	16.58	10.79	30.74	30.72	46.00
System H																
L51	Circular	DA38	N52	41.77	42.01	1.00	0.00	1.50	217.00	-0.11	6	16.21	3.62	43.52	42.34	45.94
L53	Circular	DA40	DA41	32.60	30.61	1.00	0.00	3.00	318.50	0.62	14	16.21	6.43	33.64	31.91	46.52
L54	Circular	DA41	N54.1	30.61	29.07	1.00	0.00	3.00	247.19	0.62	22	16.22	7.48	31.91	30.92	45.00
L58	Circular	DA44	DA41	41.62	37.00	1.00	0.00	1.50	223.67	2.07	2	16.20	6.52	42.00	37.38	49.07
L55	Circular	DA45	DA68	27.91	26.60	1.00	0.00	3.00	111.50	1.17	30	16.23	10.32	30.92	30.92	42.38
L57	**Circular**	**DA60**	**OutH**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**35**	**16.23**	**7.30**	**30.91**	**30.91**	**38.00**
L59	Circular	DA64	N101	46.93	40.93	1.00	0.00	1.50	137.96	4.35	2	16.25	7.90	47.21	41.21	51.38
L56	Circular	DA68	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	31	16.23	16.91	30.92	30.91	42.02
L101	Circular	N101	N54.1	40.80	38.00	1.00	0.00	1.25	43.90	6.38	2	16.26	9.25	41.07	38.27	44.05
L52	Circular	N52	DA40	42.01	32.60	1.00	0.00	1.50	37.00	25.43	6	16.21	15.79	42.34	33.64	46.36
L54.1	Circular	N54.1	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	24	16.23	7.69	30.92	30.92	43.47

Appendix D1.1

North Houston Highway Improvement Project Segment 3E
Existing XP-STORM Hydraulic Results Summary (10-Year)

Model: ExSystemsFGHI_v18.1_v18.1.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System I																
L62	Circular	DA47+46	N63	25.25	23.95	1.00	0.00	3.00	136.30	0.95	46	16.27	10.60	30.69	30.69	51.00
L64	Circular	DA49	DA50+48	22.98	15.00	1.00	0.00	3.00	188.00	4.24	49	16.27	18.86	30.69	30.69	33.00
L65	Circular	DA50+48	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	63	16.27	19.08	30.69	30.69	46.00
L65	Trapezoidal	DA50+48	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-30	21.50	0.03	30.69	30.69	46.00
L60	Circular	DA54	N61	35.35	27.58	1.00	0.00	2.00	269.60	2.88	28	16.36	14.23	36.56	30.69	53.00
L61	Circular	N61	DA47+46	26.86	25.25	1.00	0.00	3.00	205.40	0.78	28	16.36	8.43	30.69	30.69	33.94
L63	Circular	N63	DA49	23.95	23.08	1.00	0.00	3.00	91.50	0.95	46	16.27	10.60	30.69	30.69	35.00
L66	**Circular**	**N66**	**Outl**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-73**	**0.00**	**-6.02**	**30.69**	**30.69**	**18.00**
L66	**Trapezoidal**	**N66**	**Outl**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-80**	**17.64**	**0.16**	**30.69**	**30.69**	**18.00**

Appendix D1.2

North Houston Highway Improvement Project Segment 3E
Existing XP-STORM Hydraulic Results Summary (100-Year)

Model: ExSystemsFGHI_v18.1_v18.1.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L1	Circular	DA35	N2	28.02	26.69	1.00	0.00	1.50	76.20	1.75	18	16.19	10.07	40.01	40.01	31.76
L5	Circular	DA36	N6	24.06	23.33	1.00	0.00	2.50	335.85	0.22	33	16.22	6.59	40.01	40.01	46.70
L7	Circular	DA39	N8	23.06	22.85	1.00	0.00	3.50	141.97	0.15	66	16.20	6.79	40.01	40.01	34.50
L13	Circular	DA42	DA63	31.30	30.00	1.00	0.00	1.50	83.20	1.56	6	16.20	7.72	40.01	40.01	34.00
L10	Circular	DA43	N11	21.81	21.43	1.00	0.00	3.50	221.00	0.17	87	16.20	9.00	40.01	40.01	53.00
L9	Circular	DA63	DA43	22.51	21.81	1.00	0.00	3.50	418.00	0.17	82	16.20	8.51	40.01	40.01	39.00
L11	Circular	N11	N12	21.43	20.91	1.00	0.00	3.50	307.00	0.17	87	16.21	8.99	40.01	40.01	34.00
L12	**Circular**	**N12**	**OutF**	**1.55**	**1.55**	**1.00**	**0.00**	**3.50**	**42.00**	**0.00**	**87**	**16.21**	**8.87**	**40.01**	**40.01**	**29.70**
L2	Circular	N2	N3	26.20	26.05	1.00	0.00	2.00	83.80	0.18	18	16.19	5.67	40.01	40.01	29.89
L3	Circular	N3	N4	26.05	25.14	1.00	0.00	2.00	67.30	1.35	18	16.21	6.85	40.01	40.01	29.70
L4	Circular	N4	DA36	24.94	24.06	1.00	0.00	2.50	434.80	0.20	19	16.22	3.77	40.01	40.01	30.02
L6	Circular	N6	DA39	24.13	23.08	1.00	0.00	2.50	331.97	0.32	33	16.22	6.68	40.01	40.01	46.90
L8	Circular	N8	DA63	22.89	22.51	1.00	0.00	3.50	250.00	0.15	66	16.20	6.80	40.01	40.01	32.00
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	726	17.07	9.77	40.62	40.60	45.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	925	16.53	11.69	40.60	40.58	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.24	1301	16.52	16.45	40.54	40.53	46.00
L31	Circular	DA34	N32	37.71	37.62	1.00	0.00	3.00	31.00	0.29	15	16.19	5.34	40.56	40.56	45.74
L22	Circular	DA37	N23	28.54	27.38	1.00	0.00	4.50	300.00	0.39	235	16.21	14.80	40.56	40.56	45.45
L20	Circular	DA55	DA58	31.75	31.52	1.00	0.00	4.00	275.00	0.08	195	16.25	15.31	45.26	42.43	51.00
L36	Circular	DA56	N37	43.98	43.18	1.00	0.00	1.50	206.00	0.39	3	16.20	3.87	44.71	43.98	48.52
L38	Circular	DA57	N39	41.50	41.42	1.00	0.00	2.00	40.00	0.20	10	16.20	5.90	42.56	42.44	46.30
L21	Circular	DA58	DA37	31.56	31.40	1.00	0.00	4.00	276.00	0.06	212	16.25	16.73	42.43	40.56	45.50
L41	Circular	DA59	DA58	38.65	38.06	1.00	0.00	2.00	143.00	0.41	8	17.07	4.97	42.44	42.43	44.19
L29	**Circular**	**DA65**	**OutG**	**8.83**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1346**	**16.48**	**26.62**	**40.38**	**40.31**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	1095	16.55	13.84	40.56	40.54	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1301	16.52	16.45	40.53	40.51	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1301	16.52	16.46	40.51	40.50	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1301	16.52	25.65	40.50	40.44	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1301	16.52	25.69	40.44	40.38	42.63
L32	Circular	N32	DA37	37.26	35.41	1.00	0.00	3.00	442.00	0.42	14	16.21	5.81	40.56	40.56	45.84
L35	Circular	N35	DA56	44.08	43.98	1.00	0.00	1.50	48.00	0.21	0	16.03	-0.08	44.71	44.71	48.38
L37	Circular	N37	DA57	43.33	42.03	1.00	0.00	1.50	228.00	0.57	3	16.22	4.54	43.98	42.67	47.44
L39	Circular	N39	DA58	41.42	39.30	1.00	0.00	2.00	218.00	0.97	10	16.20	6.96	42.44	42.43	46.26
L40	Circular	N40	DA59	39.70	39.15	1.00	0.00	1.50	110.00	0.50	-1	16.27	2.20	42.44	42.44	44.04
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	925	16.54	11.68	40.58	40.56	46.00
System H																
L51	Circular	DA38	N52	41.77	42.01	1.00	0.00	1.50	217.00	-0.11	9	16.19	5.64	45.18	42.42	45.94
L53	Circular	DA40	DA41	32.60	30.61	1.00	0.00	3.00	318.50	0.62	22	16.20	7.09	40.26	40.26	46.52
L54	Circular	DA41	N54.1	30.61	29.07	1.00	0.00	3.00	247.19	0.62	33	16.21	8.25	40.26	40.26	45.00
L58	Circular	DA44	DA41	41.62	37.00	1.00	0.00	1.50	223.67	2.07	3	16.20	7.30	42.08	40.26	49.07
L55	Circular	DA45	DA68	27.91	26.60	1.00	0.00	3.00	111.50	1.17	45	16.22	11.77	40.26	40.26	42.38
L57	**Circular**	**DA60**	**OutH**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**53**	**16.22**	**7.33**	**40.26**	**40.26**	**38.00**
L59	Circular	DA64	N101	46.93	40.93	1.00	0.00	1.50	137.96	4.35	3	16.27	8.88	47.27	41.27	51.38
L56	Circular	DA68	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	47	16.22	16.45	40.26	40.26	42.02
L101	Circular	N101	N54.1	40.80	38.00	1.00	0.00	1.25	43.90	6.38	3	16.26	10.37	41.13	40.26	44.05
L52	Circular	N52	DA40	42.01	32.60	1.00	0.00	1.50	37.00	25.43	9	16.19	17.99	42.42	40.26	46.36
L54.1	Circular	N54.1	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	36	16.22	8.51	40.26	40.26	43.47

Appendix D1.2

North Houston Highway Improvement Project Segment 3E
Existing XP-STORM Hydraulic Results Summary (100-Year)

Model: ExSystemsFGHI_v18.1_v18.1.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System I																
L62	Circular	DA47+46	N63	25.25	23.95	1.00	0.00	3.00	136.30	0.95	62	16.26	11.24	40.04	40.05	51.00
L64	Circular	DA49	DA50+48	22.98	15.00	1.00	0.00	3.00	188.00	4.24	67	16.26	17.81	40.06	40.10	33.00
L65	Circular	DA50+48	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	87	16.25	12.27	40.10	40.10	46.00
L65	Trapezoidal	DA50+48	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-94	21.73	-0.02	40.10	40.10	46.00
L60	Circular	DA54	N61	35.35	27.58	1.00	0.00	2.00	269.60	2.88	41	16.38	15.10	39.96	40.02	53.00
L61	Circular	N61	DA47+46	26.86	25.25	1.00	0.00	3.00	205.40	0.78	41	16.38	9.29	40.02	40.04	33.94
L63	Circular	N63	DA49	23.95	23.08	1.00	0.00	3.00	91.50	0.95	62	16.26	11.24	40.05	40.06	35.00
L66	**Circular**	**N66**	**Outl**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-73**	**0.00**	**-6.02**	**40.10**	**40.10**	**18.00**
L66	**Trapezoidal**	**N66**	**Outl**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-117**	**21.73**	**0.18**	**40.10**	**40.10**	**18.00**

Appendix D2.1

North Houston Highway Improvement Project Segment 3E
Proposed Corrected Effective Tailwater XP-STORM Hydraulic Results Summary (10-Year)

Model: 10YR_PrSysFGHI - Corrected Effective TW - Adjusted LowPoint.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	4	16.20	9.75	36.88	21.89	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	37	16.14	4.14	14.54	14.50	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	10	16.27	3.43	39.58	38.49	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	3	16.55	3.04	40.17	39.90	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.04	31.04	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	2	16.20	2.70	40.69	40.48	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.04	31.04	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	4	16.34	2.76	40.20	40.11	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.40	31.40	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	15	16.28	3.67	38.49	38.30	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	25	16.23	5.21	38.30	37.77	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	28	16.15	4.30	14.67	14.54	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	34	16.26	5.37	37.77	36.21	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	38	16.26	5.79	35.38	34.41	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	55	16.25	6.18	34.38	33.67	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	226	16.50	17.83	30.64	30.64	44.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	0	0.00	0.00	--	--	44.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	59	16.25	7.11	33.67	33.47	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	62	16.25	7.77	33.47	33.04	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	229	16.49	18.06	30.64	30.63	44.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**232**	**16.47**	**18.25**	**30.63**	**30.63**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	23	16.15	3.54	14.87	14.67	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	9	16.25	2.73	34.95	34.38	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	25	16.22	6.10	34.46	34.04	44.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	0	0.00	0.00	--	--	44.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	8	16.24	3.69	34.69	34.46	44.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	0	0.00	0.00	--	--	44.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	225	16.38	17.67	43.77	37.26	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	40.11	40.11	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	240	16.37	8.11	35.98	34.30	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	235	16.38	7.83	36.63	35.98	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	9	16.28	4.05	39.86	39.13	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	8	16.20	6.40	17.29	16.52	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	275	16.34	10.02	34.30	33.12	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	5	16.20	8.63	18.37	16.74	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	5	16.19	3.60	40.96	40.60	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	40.17	40.17	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	2	16.23	2.84	40.67	40.50	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	4	16.20	9.46	31.04	17.43	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	2	16.20	6.94	31.40	18.37	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	4	16.36	3.00	34.37	34.36	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	4	16.36	2.66	40.11	39.86	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.40	31.40	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	12	16.16	6.36	16.19	14.87	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	7	16.26	3.11	39.86	39.58	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	232	16.38	7.74	37.26	36.63	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	-2	16.13	-2.46	34.36	34.36	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	38	16.13	4.79	34.36	34.30	49.00
Pump1		PUMP_Well	Pump1_Out								16	15.91	0.00	14.50	34.76	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.12	0.00	14.50	34.81	49.00
Low		PUMP_Well	Low_Out								3	16.12	0.00	14.50	34.37	49.00
Pump3_Out		PUMP_Well	Pump 3								0	0.00	0.00	14.50	34.36	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	17	15.91	5.97	34.76	34.38	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	17	16.13	6.08	34.81	34.39	49.00

Appendix D2.1

North Houston Highway Improvement Project Segment 3E
Proposed Corrected Effective Tailwater XP-STORM Hydraulic Results Summary (10-Year)

Model: 10YR_PrSysFGHI - Corrected Effective TW - Adjusted LowPoint.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	419	16.84	11.64	30.80	30.78	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	40.96	40.96	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	558	16.55	12.50	30.78	30.76	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	692	16.52	13.89	30.73	30.71	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**715**	**16.49**	**19.78**	**30.58**	**30.52**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	559	16.54	10.88	30.75	30.73	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	692	16.52	14.52	30.71	30.70	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	692	16.53	16.09	30.70	30.69	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	692	16.53	21.11	30.69	30.64	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	693	16.53	20.74	30.64	30.58	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	558	16.55	11.27	30.76	30.75	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	5	16.23	5.76	30.91	30.91	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	2	16.25	4.03	30.91	30.91	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**23**	**16.23**	**6.34**	**30.91**	**30.91**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	16	16.19	7.78	30.91	30.91	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	20	16.21	15.10	30.91	30.91	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-15	20.26	-1.97	30.69	30.69	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-28	21.25	0.03	30.69	30.69	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-73**	**0.00**	**-5.96**	**30.69**	**30.69**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-51**	**20.32**	**-0.01**	**30.69**	**30.69**	**18.00**

Appendix D2.2

North Houston Highway Improvement Project Segment 3E
Proposed Corrected Effective Tailwater XP-STORM Hydraulic Results Summary (100-Year)

Model: 100YR_PrSysFGHI - Corrected Effective TW - Adjusted LowPoint.x **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	6	16.20	10.78	36.96	21.96	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	51	16.16	5.59	15.10	15.01	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	17	16.31	3.95	40.15	40.00	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	9	16.43	4.16	40.59	40.37	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.11	31.11	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	3	16.18	3.03	40.79	40.59	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.11	31.11	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	6	16.35	3.05	40.55	40.49	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.45	31.45	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	25	16.31	4.21	40.00	40.00	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	38	16.24	5.68	40.00	40.00	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	39	16.16	4.91	15.33	15.10	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	52	16.25	6.00	40.00	40.01	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	57	16.29	6.04	40.01	40.01	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	81	16.27	8.40	40.01	40.01	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	247	16.73	19.38	40.01	40.01	44.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	124	32.41	3.06	40.01	40.01	44.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	87	16.26	8.83	40.01	40.01	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	91	16.26	9.61	40.01	40.01	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	250	16.70	19.60	40.01	40.01	44.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**254**	**16.62**	**19.67**	**40.01**	**40.01**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	32	16.16	4.37	15.56	15.33	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	13	16.25	4.00	40.01	40.01	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	37	16.22	7.47	40.01	40.01	44.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	0	0.00	0.00	40.01	40.01	44.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	12	16.23	3.99	40.01	40.01	44.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	-1	24.02	0.03	40.01	40.01	44.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	237	16.53	18.60	44.95	40.01	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	40.49	40.49	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	253	16.43	8.48	40.01	40.01	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	250	16.44	8.33	40.01	40.01	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	13	16.28	4.65	40.27	40.01	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	11	16.19	7.05	17.43	16.66	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	304	16.32	10.27	40.01	40.01	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	7	16.20	9.54	18.46	16.82	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	7	16.19	4.06	41.16	40.77	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	40.59	40.59	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	3	16.19	3.26	40.80	40.62	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	5	16.20	10.48	31.11	17.50	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	3	16.20	7.70	31.45	18.46	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	5	16.33	2.93	40.01	40.01	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	6	16.39	2.95	40.49	40.27	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.45	31.45	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	17	16.21	6.90	16.44	15.56	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	13	16.32	3.71	40.37	40.15	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	246	16.44	8.19	40.01	40.01	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	22	16.13	7.00	40.01	40.01	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	54	16.14	4.82	40.01	40.01	49.00
Pump1		PUMP_Well	Pump1_Out								16	15.62	0.00	15.01	35.10	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.13	0.00	15.01	40.01	49.00
Low		PUMP_Well	Low_Out								3	16.13	0.00	15.01	40.01	49.00
Pump3_Out		PUMP_Well	Pump 3								15	16.13	0.00	15.01	40.01	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	17	18.00	6.01	35.10	40.01	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	18	16.09	6.38	40.01	40.01	49.00

Appendix D2.2

North Houston Highway Improvement Project Segment 3E
Proposed Corrected Effective Tailwater XP-STORM Hydraulic Results Summary (100-Year) **Model: 100YR_PrSysFGHI - Corrected Effective TW - Adjusted LowPoint.x** **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	719	17.03	10.14	40.59	40.57	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	41.16	41.16	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	922	16.53	11.69	40.57	40.55	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	1128	16.51	14.30	40.51	40.49	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1168**	**16.51**	**23.13**	**40.33**	**40.26**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	922	16.53	11.69	40.53	40.51	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1128	16.51	14.30	40.49	40.47	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1128	16.51	14.31	40.47	40.46	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1128	16.51	22.30	40.46	40.40	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1128	16.51	22.32	40.40	40.33	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	922	16.53	11.69	40.55	40.53	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	7	16.24	6.40	40.26	40.26	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	4	16.26	4.48	40.26	40.26	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**33**	**16.22**	**4.63**	**40.26**	**40.26**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	23	16.20	8.21	40.26	40.26	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	29	16.21	14.34	40.26	40.26	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-20	18.25	-2.66	40.10	40.10	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-82	20.24	-0.05	40.10	40.10	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-72**	**0.00**	**-5.96**	**40.10**	**40.10**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-114**	**19.71**	**-0.02**	**40.10**	**40.10**	**18.00**

Appendix D2.3

North Houston Highway Improvement Project Segment 3E
Proposed Corrected Effective Tailwater XP-STORM Hydraulic Results Summary (500-Year)

Model: 500YR_PrSysFGHI - Corrected Effective TW - Adjusted LowPoint.x **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	7	16.20	11.47	37.01	22.02	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	57	16.22	5.35	19.74	19.64	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	21	16.47	4.15	45.31	45.31	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	15	16.53	5.05	45.31	45.31	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.16	31.16	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	3	16.17	3.24	45.31	45.31	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.16	31.16	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	8	16.35	2.84	45.31	45.31	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.48	31.48	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	27	16.45	4.06	45.31	45.30	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	40	16.17	5.83	45.30	45.30	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	42	16.22	4.65	20.14	19.74	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	58	16.18	6.00	45.30	45.30	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	64	16.19	6.59	45.30	45.30	46.15
L_DA41	Trapezoidal	DA41	DA42	45.15	39.96	1.00	24.00	1.00	299.74	1.73	9	29.40	0.47	45.30	45.30	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	95	16.20	9.84	45.30	45.30	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	230	16.75	17.91	45.30	45.30	46.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	187	17.29	4.96	45.30	45.30	46.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	103	16.20	10.36	45.30	45.30	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	109	16.20	10.95	45.30	45.30	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	249	16.93	19.29	45.30	45.30	46.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**252**	**16.92**	**19.32**	**45.30**	**45.31**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	34	16.22	4.18	20.40	20.14	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	16	16.25	5.05	45.30	45.30	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	46	16.22	9.11	45.30	45.30	45.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	-2	21.31	-0.02	45.30	45.30	45.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	15	16.23	4.91	45.30	45.30	45.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	-3	20.49	0.12	45.30	45.30	45.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	225	16.27	17.69	45.46	45.31	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	45.31	45.31	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	256	16.26	8.52	45.30	45.30	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	250	16.27	8.31	45.30	45.30	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	18	16.28	5.49	45.31	45.31	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	14	16.22	7.46	20.65	20.58	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	315	16.26	10.61	45.30	45.30	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	8	16.16	10.13	20.63	20.58	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	9	16.19	4.38	45.31	45.31	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	45.31	45.31	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	4	16.19	3.50	45.31	45.31	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	7	16.20	11.15	31.16	20.65	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	3	16.20	8.19	31.48	20.63	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	5	16.44	2.93	45.30	45.30	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	8	16.39	2.87	45.31	45.31	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.48	31.48	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	21	16.14	6.76	20.58	20.40	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	18	16.48	4.07	45.31	45.31	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	243	16.27	8.08	45.31	45.30	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00		2.00	33.00	0.00	22	16.07	7.16	45.30	45.30	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	54	16.08	4.92	45.30	45.30	49.00
Pump1		PUMP_Well	Pump1_Out								16	16.27	0.00	19.64	39.81	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.27	0.00	19.64	45.30	49.00
Low		PUMP_Well	Low_Out								3	16.27	0.00	19.64	45.30	49.00
Pump3_Out		PUMP_Well	Pump 3								16	16.27	0.00	19.64	45.30	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	19	19.64	6.00	39.81	45.30	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	18	16.03	6.40	45.30	45.30	49.00

Appendix D2.3

North Houston Highway Improvement Project Segment 3E
Proposed Corrected Effective Tailwater XP-STORM Hydraulic Results Summary (500-Year)

Model: 500YR_PrSysFGHI - Corrected Effective TW - Adjusted LowPoint.x **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	968	17.48	12.20	46.05	46.01	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	1	27.68	0.30	46.05	46.01	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	1080	17.09	13.60	46.01	45.98	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	1312	16.45	16.52	45.93	45.90	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1398**	**16.32**	**27.52**	**45.66**	**45.53**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	1080	17.09	13.59	45.96	45.93	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1312	16.45	16.53	45.90	45.88	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1312	16.45	16.54	45.88	45.86	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1312	16.45	25.75	45.86	45.77	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1312	16.48	25.78	45.77	45.66	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	1080	17.09	13.59	45.98	45.96	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	8	16.24	6.14	45.49	45.49	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	5	16.26	4.76	45.49	45.49	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**42**	**16.23**	**5.74**	**45.49**	**45.49**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	28	16.19	9.05	45.49	45.49	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	37	16.21	11.36	45.49	45.49	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-17	16.80	5.99	45.45	45.45	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-128	18.95	-0.04	45.45	45.45	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-162**	**0.00**	**-12.73**	**45.45**	**45.45**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-171**	**18.95**	**0.62**	**45.45**	**45.45**	**18.00**

Appendix D3.1

North Houston Highway Improvement Project Segment 3E
Proposed Detention Tailwater XP-STORM Hydraulic Results Summary (100-Year)

Model: 100YR_PrSysFGHI - PropDetention TW - TNP.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	6	16.20	10.78	36.96	21.96	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	51	16.16	5.59	15.10	15.01	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	17	16.31	3.95	40.15	39.81	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	9	16.43	4.16	40.59	40.37	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.11	31.11	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	3	16.18	3.03	40.79	40.59	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.11	31.11	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	6	16.35	3.05	40.55	40.49	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.45	31.45	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	25	16.31	4.21	39.81	39.81	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	38	16.24	5.68	39.81	39.81	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	39	16.16	4.91	15.33	15.10	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	52	16.25	6.00	39.81	39.81	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	57	16.29	6.04	39.81	39.81	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	81	16.27	8.40	39.81	39.81	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	247	16.73	19.33	39.81	39.81	44.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	121	32.81	3.06	39.81	39.81	44.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	87	16.26	8.83	39.81	39.81	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	91	16.26	9.61	39.81	39.81	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	249	16.71	19.55	39.81	39.81	44.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**253**	**16.62**	**19.62**	**39.81**	**39.81**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	32	16.16	4.37	15.56	15.33	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	13	16.25	4.00	39.81	39.81	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	37	16.22	7.47	39.81	39.81	44.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	0	0.00	0.00	39.81	39.81	44.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	12	16.23	3.99	39.81	39.81	44.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	1	31.24	0.19	39.81	39.81	44.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	237	16.53	18.60	44.95	39.81	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	40.49	40.49	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	253	16.43	8.48	39.81	39.81	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	250	16.44	8.33	39.81	39.81	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	13	16.28	4.65	40.27	39.81	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	11	16.19	7.05	17.43	16.66	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	304	16.32	10.27	39.81	39.81	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	7	16.20	9.54	18.46	16.82	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	7	16.19	4.06	41.16	40.77	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	40.59	40.59	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	3	16.19	3.26	40.80	40.62	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	5	16.20	10.48	31.11	17.50	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	3	16.20	7.70	31.45	18.46	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	5	16.33	2.93	39.81	39.81	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	6	16.39	2.95	40.49	40.27	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.45	31.45	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	17	16.21	6.90	16.44	15.56	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	13	16.32	3.71	40.37	40.15	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	246	16.44	8.19	39.81	39.81	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	22	16.13	7.00	39.81	39.81	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	54	16.14	4.82	39.81	39.81	49.00
Pump1		PUMP_Well	Pump1_Out								16	15.62	0.00	15.01	35.10	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.13	0.00	15.01	39.81	49.00
Low		PUMP_Well	Low_Out								3	16.13	0.00	15.01	39.81	49.00
Pump3_Out		PUMP_Well	Pump 3								15	16.13	0.00	15.01	39.81	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	17	18.00	6.01	35.10	39.81	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	18	16.09	6.38	39.81	39.81	49.00

Appendix D3.1

North Houston Highway Improvement Project Segment 3E
Proposed Detention Tailwater XP-STORM Hydraulic Results Summary (100-Year)

Model: 100YR_PrSysFGHI - PropDetention TW - TNP.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	719	17.03	10.12	40.38	40.36	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	41.16	41.16	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	922	16.53	11.69	40.36	40.34	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	1128	16.51	14.30	40.30	40.28	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1169**	**16.50**	**23.13**	**40.14**	**40.06**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	922	16.53	11.69	40.32	40.30	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1128	16.51	14.30	40.28	40.26	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1128	16.51	14.31	40.26	40.25	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1128	16.51	22.30	40.25	40.20	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1128	16.51	22.32	40.20	40.14	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	922	16.53	11.69	40.34	40.32	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	7	16.24	6.40	40.00	40.00	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	4	16.26	4.48	40.00	40.00	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**33**	**16.22**	**4.63**	**40.00**	**40.00**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	23	16.20	8.21	40.00	40.00	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	29	16.21	14.33	40.00	40.00	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-21	18.17	-2.78	39.87	39.87	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-82	20.50	-0.05	39.87	39.87	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-170**	**0.00**	**-13.42**	**39.87**	**39.87**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-110**	**19.99**	**-0.02**	**39.87**	**39.87**	**18.00**

Appendix D3.2

North Houston Highway Improvement Project Segment 3E
Proposed Detention Tailwater XP-STORM Hydraulic Results Summary (500-Year)

Model: 500YR_PrSysFGHI - PropDetention TW - TNP.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	7	16.20	11.47	37.01	22.02	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	57	16.22	5.35	19.74	19.64	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	22	16.44	4.24	45.28	45.27	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	16	16.51	5.06	45.28	45.28	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.16	31.16	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	3	16.17	3.24	45.28	45.28	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.16	31.16	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	8	16.35	3.00	45.27	45.27	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.48	31.48	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	28	16.43	4.28	45.27	45.27	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	40	16.17	5.83	45.27	45.27	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	42	16.22	4.65	20.14	19.74	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	58	16.18	6.00	45.27	45.27	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	64	16.19	6.59	45.27	45.27	46.15
L_DA41	Trapezoidal	DA41	DA42	45.15	39.96	1.00	24.00	1.00	299.74	1.73	4	29.44	0.26	45.27	45.27	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	95	16.20	9.84	45.27	45.27	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	232	16.73	18.11	45.26	45.26	46.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	157	17.25	4.96	45.26	45.26	46.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	103	16.20	10.36	45.27	45.26	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	109	16.20	10.95	45.26	45.26	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	247	17.04	19.19	45.26	45.27	46.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**250**	**17.04**	**19.19**	**45.27**	**45.28**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	34	16.22	4.18	20.40	20.14	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	16	16.25	5.05	45.27	45.27	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	46	16.22	9.11	45.26	45.26	45.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	-2	21.39	-0.02	45.26	45.26	45.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	15	16.23	4.91	45.26	45.26	45.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	-3	20.56	0.18	45.26	45.26	45.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	226	16.28	17.74	45.46	45.27	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	45.27	45.27	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	257	16.28	8.54	45.27	45.27	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	250	16.28	8.33	45.27	45.27	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	18	16.28	5.49	45.27	45.27	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	14	16.22	7.46	20.65	20.58	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	316	16.28	10.64	45.27	45.26	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	8	16.16	10.13	20.63	20.58	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	9	16.19	4.38	45.28	45.28	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	45.28	45.28	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	4	16.19	3.50	45.28	45.28	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	7	16.20	11.15	31.16	20.65	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	3	16.20	8.19	31.48	20.63	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	5	16.48	2.93	45.27	45.27	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	8	16.42	2.92	45.27	45.27	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.48	31.48	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	21	16.14	6.76	20.58	20.40	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	19	16.47	4.11	45.28	45.28	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	243	16.28	8.10	45.27	45.27	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	22	16.07	7.16	45.27	45.27	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	54	16.08	4.92	45.27	45.27	49.00
Pump1		PUMP_Well	Pump1_Out								16	16.28	0.00	19.64	39.39	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.28	0.00	19.64	45.27	49.00
Low		PUMP_Well	Low_Out								3	16.28	0.00	19.64	45.27	49.00
Pump3_Out		PUMP_Well	Pump 3								16	16.28	0.00	19.64	45.27	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	20	18.02	6.27	39.39	45.27	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	18	16.03	6.40	45.27	45.27	49.00

Appendix D3.2

North Houston Highway Improvement Project Segment 3E
Proposed Detention Tailwater XP-STORM Hydraulic Results Summary (500-Year)

Model: 500YR_PrSysFGHI - PropDetention TW - TNP.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	981	17.48	12.36	46.01	45.97	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	0	27.41	0.03	46.01	46.00	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	1097	17.04	13.82	45.97	45.94	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	1335	16.43	16.81	45.88	45.85	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1420**	**16.33**	**27.97**	**45.58**	**45.44**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	1097	17.04	13.81	45.91	45.88	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1334	16.43	16.82	45.85	45.82	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1334	16.44	16.82	45.82	45.80	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1334	16.43	26.19	45.80	45.70	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1334	16.45	26.23	45.70	45.58	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	1097	17.04	13.81	45.94	45.91	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	8	16.24	6.32	45.40	45.40	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	5	16.26	4.77	45.40	45.40	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**42**	**16.23**	**5.75**	**45.40**	**45.40**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	28	16.19	9.05	45.40	45.40	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	37	16.21	12.25	45.40	45.40	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-19	16.96	-2.59	45.35	45.35	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-128	18.96	-0.04	45.35	45.35	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-170**	**0.00**	**-13.42**	**45.35**	**45.35**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-172**	**18.96**	**-0.02**	**45.35**	**45.35**	**18.00**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	6	16.20	10.78	36.96	21.96	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	51	16.16	5.59	15.10	15.01	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	17	16.31	3.95	40.15	39.28	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	9	16.43	4.16	40.59	40.37	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.11	31.11	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	3	16.18	3.03	40.79	40.59	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.11	31.11	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	6	16.35	3.05	40.55	40.49	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.45	31.45	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	25	16.31	4.21	39.28	39.07	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	38	16.24	5.68	39.07	38.53	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	39	16.16	4.91	15.33	15.10	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	52	16.25	6.00	38.53	36.95	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	57	16.29	6.04	36.95	36.86	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	81	16.27	8.40	36.86	36.86	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	254	16.73	19.94	36.86	36.86	44.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	0	0.00	0.00	--	--	44.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	87	16.26	8.83	36.86	36.86	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	91	16.26	9.61	36.86	36.86	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	257	16.70	20.16	36.86	36.86	44.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**261**	**16.62**	**20.24**	**36.86**	**36.86**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	32	16.16	4.37	15.56	15.33	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	13	16.25	4.00	37.27	36.86	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	37	16.22	7.47	36.86	36.86	44.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	0	0.00	0.00	--	--	44.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	12	16.23	3.99	36.86	36.86	44.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	0	0.00	0.00	--	--	44.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	237	16.53	18.60	44.95	38.06	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	40.49	40.49	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	253	16.43	8.48	36.86	36.86	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	250	16.44	8.32	37.38	36.86	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	13	16.28	4.65	40.27	39.37	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	11	16.19	7.05	17.43	16.66	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	304	16.32	10.27	36.86	36.86	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	7	16.20	9.54	18.46	16.82	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	7	16.19	4.06	41.16	40.77	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	40.59	40.59	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	3	16.19	3.26	40.80	40.62	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	5	16.20	10.48	31.11	17.50	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	3	16.20	7.70	31.45	18.46	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	5	16.33	2.93	36.86	36.86	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	6	16.39	2.95	40.49	40.27	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.45	31.45	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	17	16.21	6.90	16.44	15.56	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	13	16.32	3.71	40.37	40.15	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	246	16.44	8.19	38.06	37.38	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	22	16.13	7.00	36.86	36.86	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	54	16.14	4.82	36.86	36.86	49.00
Pump1		PUMP_Well	Pump1_Out								16	15.62	0.00	15.01	32.90	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.13	0.00	15.01	32.90	49.00
Low		PUMP_Well	Low_Out								3	16.13	0.00	15.01	36.86	49.00
Pump3_Out		PUMP_Well	Pump 3								15	16.13	0.00	15.01	36.86	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	17	18.00	6.07	35.10	36.86	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	18	16.09	6.38	36.86	36.86	49.00

Appendix D4.1

North Houston Highway Improvement Project Segment 3E
Proposed Mitigated Tailwater XP-STORM Hydraulic Results Summary (100-Year)

Model: 100YR_PrSysFGHI - PropMitigated TW - Adjusted LowPoint.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	725	17.15	10.19	37.77	37.69	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	41.16	41.16	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	922	16.53	11.93	37.69	37.63	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	1128	16.52	14.31	37.55	37.52	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1169**	**16.50**	**23.15**	**37.30**	**37.20**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	922	16.53	11.70	37.58	37.55	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1128	16.51	14.31	37.52	37.50	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1128	16.51	14.32	37.50	37.48	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1128	16.51	22.32	37.48	37.40	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1128	16.51	22.34	37.40	37.30	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	922	16.53	11.70	37.63	37.58	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	7	16.24	6.40	37.12	37.12	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	4	16.26	4.48	37.12	37.12	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**33**	**16.22**	**4.64**	**37.12**	**37.12**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	23	16.20	8.21	37.12	37.12	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	29	16.21	14.35	37.12	37.12	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-20	18.52	9.40	36.92	36.92	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-68	20.50	-0.05	36.92	36.92	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-182**	**0.00**	**-14.32**	**36.92**	**36.92**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-95**	**20.50**	**0.48**	**36.92**	**36.92**	**18.00**

Appendix D4.2

North Houston Highway Improvement Project Segment 3E
Proposed Mitigated Tailwater XP-STORM Hydraulic Results Summary (500-Year)

Model: PrSysFGHI - 500yr - Mitigated TW - TNP.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System F																
L_DA1P	Circular	DA1P	DA2P	36.49	21.50	1.00	0.00	2.00	299.83	5.00	7	16.20	11.47	37.01	22.02	41.92
L_DA2P	Circular	DA2P	PUMP_Well	10.86	10.68	1.00	0.00	4.00	89.17	0.20	57	16.22	5.35	19.74	19.64	26.72
L_DA34	Circular	DA34	DA37	38.35	36.74	1.00	0.00	3.00	807.25	0.20	23	16.41	4.34	42.64	42.64	46.67
L_DA35	Circular	DA35	N32	39.47	39.29	1.00	0.00	2.50	87.00	0.20	16	16.49	5.07	42.64	42.64	49.00
L_DA35OL	Trapezoidal	DA35	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.16	31.16	49.00
L_DA35A	Circular	DA35A	DA35	40.13	40.00	1.00	0.00	2.00	63.00	0.21	3	16.17	3.24	42.64	42.64	49.00
L_DA35A_OL	Trapezoidal	DA35A	DA7P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.16	31.16	49.00
L_DA36	Circular	DA36	N2	39.26	39.12	1.00	0.00	2.00	73.22	0.20	8	16.35	3.18	42.64	42.64	49.00
Link57	Trapezoidal	DA36	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.48	31.48	49.00
L_DA37	Circular	DA37	DA38	36.74	36.37	1.00	0.00	3.00	184.28	0.20	30	16.39	4.55	42.64	42.64	46.14
L_DA38	Circular	DA38	DA40	36.37	36.01	1.00	0.00	3.00	177.92	0.20	40	16.17	5.83	42.64	42.64	45.45
L_DA3P	Circular	DA3P	DA2P	11.96	11.36	1.00	0.00	3.50	299.82	0.20	42	16.22	4.65	20.14	19.74	22.00
L_DA40	Circular	DA40	DA41	35.51	34.40	1.00	0.00	3.50	557.56	0.20	58	16.18	6.00	42.64	42.64	46.47
L_DA41	Circular	DA41	DA42	33.10	32.50	1.00	0.00	3.50	299.74	0.20	64	16.19	6.59	42.64	42.64	46.15
L_DA41	Trapezoidal	DA41	DA42	45.15	39.96	1.00	24.00	1.00	299.74	1.73	0	0.00	0.00	42.64	42.64	46.15
L_DA42	Circular	DA42	DA44	31.30	30.82	1.00	0.00	3.50	239.24	0.20	95	16.20	9.84	42.64	42.64	40.96
L_DA43	Circular	DA43	DA47	20.00	19.83	1.00	0.00	4.00	83.46	0.20	242	16.75	18.92	42.64	42.64	46.00
L_DA43	Trapezoidal	DA43	DA47	37.50	37.00	1.00	100.00	6.00	33.00	1.52	-17	24.75	-0.08	42.64	42.64	46.00
L_DA44	Circular	DA44	DA46	30.82	30.73	1.00	0.00	3.50	46.10	0.20	103	16.20	10.36	42.64	42.64	55.44
L_DA46	Circular	DA46	DA43	30.73	30.57	1.00	0.00	3.50	81.21	0.20	109	16.20	10.95	42.64	42.64	54.39
L_DA47	Circular	DA47	DA48	16.59	16.00	1.00	0.00	4.00	293.14	0.20	247	16.70	19.24	42.64	42.63	46.00
L_DA48	**Circular**	**DA48**	**OUTFALL F**	**1.80**	**1.55**	**1.00**	**0.00**	**4.00**	**124.09**	**0.20**	**252**	**16.52**	**19.46**	**42.63**	**42.63**	**24.00**
L_DA4P	Circular	DA4P	DA3P	12.50	11.96	1.00	0.00	3.50	271.10	0.20	34	16.22	4.18	20.40	20.14	19.11
L_DA50	Circular	DA50	DA42	32.10	31.30	1.00	0.00	2.00	398.10	0.20	16	16.25	5.05	42.64	42.64	37.30
L_DA54	Circular	DA54	DA43	32.50	32.34	1.00	0.00	2.50	80.00	0.20	46	16.22	9.11	42.64	42.64	45.45
L_DA54_OL	Trapezoidal	DA54	DA47	40.45	37.00	1.00	38.00	4.00	213.00	1.62	-1	22.77	0.01	42.64	42.64	45.45
L_DA54A	Circular	DA54A	DA54	33.26	33.00	1.00	0.00	2.00	129.60	0.20	15	16.23	4.91	42.64	42.64	45.92
L_DA54A_OL	Trapezoidal	DA54A	DA47	38.92	37.00	1.00	34.00	6.00	78.00	2.46	-2	21.57	0.17	42.64	42.64	45.92
L_DA55	Circular	DA55	N-DA58	31.75	31.52	1.00	0.00	4.00	275.09	-0.28	228	16.32	17.86	45.44	42.64	51.00
L_DA55_OL	Trapezoidal	DA55	N2	47.00	47.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	42.64	42.64	51.00
L_DA56	Rectangular	DA56	DA63	30.68	29.60	1.00	6.00	5.00	536.21	0.20	257	16.31	8.57	42.64	42.64	46.76
L_DA57	Rectangular	DA57	DA56	31.10	30.68	1.00	6.00	5.00	207.55	0.20	251	16.32	8.37	42.64	42.64	45.72
L_DA59	Circular	DA59	N-DA58	38.50	38.06	1.00	0.00	2.00	216.96	0.20	18	16.28	5.49	42.64	42.64	43.71
L_DA5P	Circular	DA5P	N3	16.56	15.79	1.00	0.00	2.50	77.12	1.00	14	16.22	7.46	20.64	20.58	22.87
L_DA63	Rectangular	DA63	DA43	29.60	29.10	1.00	6.00	5.00	248.16	0.20	317	16.31	10.67	42.64	42.64	49.00
L_DA6P	Circular	DA6P	N3	17.92	16.29	1.00	0.00	2.00	49.52	3.30	8	16.16	10.13	20.63	20.58	24.31
L_DA71	Circular	DA71	N32	40.00	39.79	1.00	0.00	2.00	102.98	0.20	9	16.19	4.38	42.64	42.64	55.00
L_DA71_OL	Circular	DA71	DA35	46.00	46.00	1.00	0.00	2.00	33.00	0.00	0	0.00	0.00	42.64	42.64	55.00
L_DA72	Circular	DA72	DA35	40.09	40.00	1.00	0.00	2.00	45.00	0.20	4	16.19	3.50	42.64	42.64	45.89
L_DA7P	Circular	DA7P	DA5P	30.66	17.06	1.00	0.00	2.00	272.14	5.00	7	16.20	11.15	31.16	20.64	49.00
L_DA8P	Circular	DA8P	DA6P	31.13	17.92	1.00	0.00	2.00	261.17	5.06	3	16.20	8.19	31.48	20.63	49.00
L_Low_Out	Circular	Low_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	6	20.08	2.93	42.64	42.64	49.00
L_N2	Circular	N2	DA59	39.12	38.50	1.00	0.00	2.00	307.51	0.20	8	16.43	3.10	42.64	42.64	49.00
L_N2_OL	Trapezoidal	N2	DA8P	47.00	47.00	1.00	24.00	2.00	33.00	0.00	0	0.00	0.00	31.48	31.48	49.00
L_N3	Circular	N3	DA4P	15.29	13.00	1.00	0.00	3.00	228.46	1.00	21	16.14	6.76	20.58	20.40	24.40
L_N32	Circular	N32	DA34	38.79	38.35	1.00	0.00	3.00	219.04	0.20	19	16.43	4.16	42.64	42.64	45.87
L_N-DA58	Rectangular	N-DA58	DA57	31.52	31.10	1.00	6.00	5.00	209.84	0.20	245	16.32	8.14	42.64	42.64	45.50
L_P3_Out	Circular	Pump 3	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	22	16.07	7.17	42.64	42.64	49.00
L_Pump_Outfall	Circular	Pump_Outfall	DA63	30.90	30.60	1.00	0.00	4.00	150.00	0.20	54	16.08	4.92	42.64	42.64	49.00
Pump1		PUMP_Well	Pump1_Out								16	16.28	0.00	19.64	38.56	49.00
Pump2		PUMP_Well	Pump2_Out								16	16.28	0.00	19.64	42.64	49.00
Low		PUMP_Well	Low_Out								3	16.28	0.00	19.64	42.64	49.00
Pump3_Out		PUMP_Well	Pump 3								16	16.28	0.00	19.64	42.64	49.00
L_P1_Out	Circular	Pump1_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	21	18.00	7.13	38.56	42.64	49.00
L_P2_Out	Circular	Pump2_Out	Pump_Outfall	32.90	32.90	1.00	0.00	2.00	33.00	0.00	18	16.03	6.40	42.64	42.64	49.00

Appendix D4.2

North Houston Highway Improvement Project Segment 3E
Proposed Mitigated Tailwater XP-STORM Hydraulic Results Summary (500-Year)

Model: PrSysFGHI - 500yr - Mitigated TW - TNP.xp **4/17/2019**

Name	Link Type	Upstream Node Name	Downstream Node Name	Upstream Invert Elevation ft	Downstream Invert Elevation ft	Number of Barrels	Conduit Span check(ft)	Diameter (Height) ft	Length ft	Conduit Slope %	Max Flow cfs	Time to Peak (hours) hr	Max Velocity fps	Maximum Water Elevation (US) ft	Maximum Water Elevation (DS) ft	Elevation (Spill Crest) (US) ft
System G																
L45	Circular	DA31	DA32	18.17	17.29	1.00	0.00	10.00	289.47	0.30	1032	17.48	13.00	45.50	45.12	55.00
L_DA31OL	Trapezoidal	DA31	DA71	46.00	46.00	1.00	100.00	2.00	33.00	0.00	0	0.00	0.00	42.64	42.64	55.00
L46	Circular	DA32	N47	17.29	16.26	1.00	0.00	10.00	230.45	0.45	1144	17.04	14.41	45.12	44.89	45.00
L24	Circular	DA33	N25	15.28	14.72	1.00	0.00	10.00	228.90	0.25	1377	16.48	17.35	44.47	44.27	46.00
L29	**Circular**	**DA65**	**OUTFALL G**	**8.81**	**3.66**	**1.00**	**0.00**	**8.00**	**346.00**	**1.49**	**1459**	**16.36**	**28.76**	**43.08**	**42.93**	**39.00**
L23	Circular	N23	DA33	15.60	15.28	1.00	0.00	10.00	234.40	0.14	1144	17.04	14.41	44.67	44.47	46.54
L25	Circular	N25	N26	14.72	14.35	1.00	0.00	10.00	220.10	0.17	1377	16.45	17.36	44.27	44.09	46.00
L26	Circular	N26	N27	14.35	14.22	1.00	0.00	10.00	117.00	0.11	1377	16.45	17.37	44.09	43.99	46.00
L27	Circular	N27	N28	14.22	11.72	1.00	0.00	8.00	249.00	1.00	1377	16.48	27.04	43.99	43.39	46.00
L28	Circular	N28	DA65	11.72	8.81	1.00	0.00	8.00	285.00	1.02	1377	16.48	27.09	43.39	43.08	42.63
L47	Circular	N47	N23	16.26	15.66	1.00	0.00	10.00	229.30	0.26	1144	17.04	14.41	44.89	44.67	46.00
System H																
L55	Circular	DA45	DA68A	27.91	26.60	1.00	0.00	3.00	111.50	1.18	8	16.24	6.54	42.85	42.85	42.38
L54.1	Circular	DA45A	DA45	29.07	27.97	1.00	0.00	3.00	176.31	0.62	5	16.26	4.79	42.85	42.85	43.47
L57	**Circular**	**DA60**	**OUTFALL H**	**11.95**	**-0.79**	**1.00**	**0.00**	**3.00**	**175.10**	**7.28**	**42**	**16.23**	**5.77**	**42.85**	**42.85**	**38.00**
L_DA68	Circular	DA68	DA68A	29.37	27.60	1.00	0.00	2.00	177.00	1.00	28	16.19	9.05	42.85	42.85	41.86
L56	Circular	DA68A	DA60	26.60	11.95	1.00	0.00	3.00	201.40	7.27	37	16.21	13.60	42.85	42.85	42.02
System I																
L65	Circular	DA49	N66	12.90	-1.15	1.00	0.00	3.00	77.00	18.25	-22	17.34	9.40	42.71	42.71	46.00
L65	Trapezoidal	DA49	N66	25.00	14.00	1.00	100.00	4.00	77.00	14.29	-109	19.48	-0.05	42.71	42.71	46.00
L66	**Circular**	**N66**	**OUTFALL I**	**-1.15**	**-2.00**	**1.00**	**0.00**	**4.00**	**44.60**	**1.91**	**-182**	**0.00**	**-14.32**	**42.71**	**42.71**	**18.00**
L66	**Trapezoidal**	**N66**	**OUTFALL I**	**14.00**	**10.00**	**1.00**	**100.00**	**4.00**	**44.60**	**8.97**	**-146**	**19.48**	**0.48**	**42.71**	**42.71**	**18.00**

1,000 GPM Low Flow Pump Curve		
GPM	**CFS**	**Head**
0	0.00	39.60
120	0.27	38.00
240	0.53	36.00
360	0.80	34.50
480	1.07	33.00
600	1.34	31.00
720	1.60	29.50
840	1.87	28.00
960	2.14	26.00
1080	2.41	24.00
1200	2.67	22.00
1320	2.94	19.50
1440	3.21	17.50
1560	3.48	14.50
1680	3.74	12.00
1782	3.97	9.30
1980	4.41	0.00

5,600 GPM Pump Curve		
GPM	**CFS**	**Head**
1950	4.34	66.50
2250	5.01	64.50
2550	5.68	62.00
2850	6.35	60.00
3150	7.02	57.50
3450	7.69	55.50
3750	8.36	53.50
4050	9.02	51.50
4350	9.69	50.00
4650	10.36	47.00
4950	11.03	45.00
5250	11.70	42.00
5550	12.37	39.00
5850	13.03	35.00
6150	13.70	31.00
6450	14.37	26.00
6750	15.04	22.50
7050	15.71	18.50
7350	16.38	14.50
7650	17.05	10.50
7950	17.71	7.00
8100	18.05	5.50
8400	18.72	0.00

APPENDIX E

USB DRIVE