Drainage Study for North Houston Highway Improvement Project Segment 1 from South of Shepherd Drive to South of West Road

Harris County, Texas

Prepared for TxDOT; CSJ: 0110-06-139

Any questions shall be submitted to:

CivilTech Engineering, Inc.

11821 Telge Road

Cypress, Texas 77429

281-304-0200

www.civiltecheng.com

Firm Registration No. F-382

Re: CEI Job No. 405011.00

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List of Acronyms

AC	Acres
AC-FT	Acre-Feet
AEP	Annual Exceedance Probability
BFE	Base Flood Elevation
C.E.	Corrected Effective
CEI	CivilTech Engineering, Inc.
CFS	Cubic Feet per Second
COH	City of Houston
CSJ	Control-Section-Job
CLOMR	Conditional Letter of Map Revision
DEIS	Draft Environmental Impact Statement
EOP	Edge of Pavement
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FIRM	Flood Insurance Rate Map
FPS	Feet per Second
FT	Feet
GIS	Geographic Information System
IDF	Intensity-Duration-Frequency
IP	Individual Permit
HDM	Hydraulic Design Manual
HCFCD	Harris County Flood Control District
H-GAC	Houston-Galveston Area Council
HGL	Hydraulic Grade Line
HEC-RAS	Hydrologic Engineering Center – River Analysis System
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
H.O.V.	High Occupancy Vehicle
LWOB	Little White Oak Bayou
LiDAR	Light Detection and Ranging
LOMR	Letter of Map Revision
M3	Model and Map Management System
ML	Mainlanes
NAD	North American Datum
NAVD	North American Vertical Datum
NBFR	Northbound Frontage Road
NBML	Northbound Mainlane
NEPA	National Environmental Policy Act
NHHIP	North Houston Highway Improvement Project
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
OHW	Ordinary Highwater Mark
PGL	Proposed Grade Line

PS&E	Plans, Specifications & Estimate
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
ROW	Right-of-Way
SBFR	Southbound Frontage Road
SBML	Southbound Mainlane
SFHA	Special Flood Hazard Area
SWMM	Storm Water Management Model
TNP	Teague Nall and Perkins, Inc.
TNRIS	Texas Natural Resources Information System
TxDOT	Texas Department of Transportation
USACE	United States Army Corps of Engineers
WSE	Water Surface Elevation

EXECUTIVE SUMMARY

Overview

This study report presents the preliminary drainage design, analysis, and drainage study for a portion of Segment 1 of the North Houston Highway Improvement Project (NHHIP) from South of Shepherd Drive to South of West Road. The NHHIP is a proposed Texas Department of Transportation (TxDOT) mobility project that will manage congestion, enhance safety, and improve mobility and operational efficiency in and around downtown Houston. NHHIP Segment 1, from South of Shepherd Drive to South of West Road, is identified under TxDOT CSJ: 0110-06-139.

To facilitate in the design and analysis, the NHHIP was divided into three (3) segments identified as:

- Segment 1: From I-610 to Beltway 8 North,
- Segment 2: From I-10 to I-610, and
- Segment 3: Downtown Loop System (I-45, I-10, and US 59/I-69).

TxDOT provided the recommended schematic for NHHIP Segment 1 which is the basis of this drainage study. In addition, TxDOT and the drainage team coordinated closely with the Harris County Flood Control District (HCFCD) regarding previously identified and/or potential future drainage improvement projects within the limits of Segment 1.

Report Organization

This study report has been organized by the major drainage components for the project. The major drainage components and analyses are listed below:

- Roadway Profile Analysis
- Proposed Storm Drain Design
- Halls Bayou Schematic Bridges
- Drainage Crossings
- Roadway and Floodplain Impacts
- Detention Basin Design

The preliminary drainage criteria developed by TxDOT and the NHHIP Segment 1 Drainage Engineers was applied for this study. The Atlas 14 rainfall data, and associated TxDOT Rainfall Intensity-Duration-Frequency (IDF) coefficients, were utilized for the following drainage components of the project:

- Storm Trunk Drain Design
- Crossing Analysis of the Minor Crossing (STA 1631+30)
- Roadway Impact Analysis
- Detention Basin Design

The pre-Atlas 14 hydrologic and hydraulic models obtained from the HCFCD were used for the drainage crossing analysis of Halls Bayou and the floodplain impact analysis. TxDOT directed that for these two (2)

analyses the pre-Atlas 14 500-year storm event should be considered equivalent to the Atlas 14 100-year storm event.

A brief summary of the preliminary drainage design and analysis for the major drainage components are discussed in this Executive Summary.

Roadway Profile Analysis

A roadway profile analysis was completed to evaluate the proposed I-45 (mainlane and frontage road) profiles relative to overbank flooding or potential backwater flooding through the existing storm sewer systems that outfall into Halls Bayou or P118-27-01. No profile adjustments are recommended for the main lanes, as the main lanes were found to be well above the 100-year (Atlas 14) or 500-year (pre-Atlas 14) water surface elevations.

Through coordination with TxDOT, the northbound and southbound frontage road profiles are recommended to be adjusted such that the proposed profile grade lines (PGLs) remain above the 10-year water surface elevation (WSE), while still being able to accommodate the proposed roadway design within the current proposed right-of-way (ROW) limits. The limits of the recommended profile adjustments can be seen below in **Table ES- 1.**

Table ES- 1 – Recommended Roadway Profile Adjustments

Southbound Frontage Road	
From STA.	**To STA.**
1605+00	1610+00
1617+00	1762+00
Northbound Frontage Road	
From STA.	**To STA.**
1646+00	1796+00

Proposed Storm Drain Trunk System Design

The preliminary sizing of the proposed storm sewer trunkline systems (no laterals sizing) was performed for the following roadways:

- I-45 Northbound and Southbound Mainlanes, Max Lanes and Frontage Roads
- Shepherd Drive from the interchange of Shepherd Drive, Veterans Memorial Drive, and the proposed I-45 Southbound frontage road to approximately 1,000 feet south of the interchange.

Preliminary storm sewer plan and profiles (trunkline level) are provided in this study. The preliminary design did not include inlets for the mainlanes storm sewer trunkline. Also, drainage system components (bridge deck drains, piping, etc.) were not included for bridges, direct connectors, and ramps. A manhole level analysis was performed to size trunk lines for the 10-year design storm event, which served as the basis for the construction cost estimate.

Halls Bayou Schematic Bridge Design

Three (3) bridges are located at Halls Bayou within the project corridor – the southbound frontage road, mainlane, and northbound frontage road bridges. As part of this study, a schematic level (approximately 15% design) was developed for each of the proposed bridges. Through coordination with TxDOT and

HCFCD, the bridges were designed to accommodate the ultimate channel section of Halls Bayou at I-45, as identified in HCFCD's Halls Bayou Vision Plan (Watershed Flood Risk Reduction Study).

Drainage Crossing Analysis

This study recommends replacing two (2) drainage crossings under I-45 as listed below:

- Minor Crossing – a non-bridge class culvert located at STA 1631+30: replace 2 – 6' x 3' box culverts with the following:
    - 1 – 6' x 3' RCB from just upstream of the SBFR to the SB Max Lane
    - 2 – 6' x 3' RCB from the SB Max Lane to the NB Max Lane
    - 2 – 8' x 3' RCB from the NB Max Lane to just downstream of the NBFR
- Hall's Bayou Crossing: Replace the existing bridges (approximate span of 160 ft) with three (3) 5 Span – 400 ft wide bridges to accommodate the ultimate Halls Bayou channel section.

Due to the NHHIP Segment 1 project likely being constructed prior to the Halls Bayou Vision Plan ultimate channel, an interim condition was assumed in which the ultimate I-45 bridges will be constructed with an interim condition channel. This is to ensure no adverse impacts to existing conditions along Halls Bayou.

Once the Halls Bayou Vision Plan ultimate conditions channel section is in place, the 500-year (Pre-Atlas 14)/approximate 100-year Atlas 14 WSEs will be contained within the channel banks.

Roadway Impact Analysis

A roadway impact analysis was completed as part of this study to identify and quantify measures to mitigate the increased runoff from the proposed highway improvements and hydraulic system changes due to the proposed storm drainage improvements for Segment 1. The most southerly section of the study limits, System A, which extends from just south of West Little York Road to approximately 1,200 feet south of Mitchell Road shares an outfall, Outfall A, with study section to the south. For the purposes of the roadway impact analysis, the drainage design consultant, TNP, who is completing the drainage analysis for the section south of CEI's section, is responsible for completing the impact analysis related to Outfall A. The following table outlines the mitigation measures provided and a summary of the detention volumes associated with each outfall.

Table ES- 2 – Roadway Impact Mitigation Summary Table

Outfall Region ID	Mitigation Provided By	Net Change in Drainage Area	In-Line Storage Provided	Offline Storage Provided	Total Storage Provided	Mitigation Storage Required
(--)	(--)	(ac)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)
B	-Drainage Area Redirection -In-line Storage	-7.50	0.07	-	0.07	0.00
C	-Drainage Area Redirection -In-Line Storage -Offline Storage	-8.40	0.69	5.87	6.56	0.00
D	-Drainage Area Redirection	-7.10	-0.19	-	-0.19	0.00

Outfall Region ID	Mitigation Provided By	Net Change in Drainage Area	In-Line Storage Provided	Offline Storage Provided	Total Storage Provided	Mitigation Storage Required
E	-In-Line Storage -Offline Storage	23.00	5.38	12.00	17.38	12.00
Totals	**(--)**	**0.00**	**5.95**	**17.87**	**23.82**	**12.00**

As Systems B, C, and D have drainage area redirected to System E (proposed drainage area < existing drainage area), no mitigation storage is required.

Floodplain Impact Analysis

A floodplain impact analysis was completed along I-45 to determine the preliminary floodplain storage mitigation needs for the proposed roadway improvements within the Halls Bayou watershed. **Table ES- 3** below summarizes the net cut and fill volumes associated with the proposed roadway. The estimated fill volumes are based on the Halls Bayou corrected effective 500-year WSE (Pre-Atlas 14). The mitigation for the fill within the floodplain, 135.8 ac-ft, will be provided within detention basin E.

Table ES- 3 – NHHIP Segment 1 Cut and Fill Volumes

Roadway	Cut Volume	Fill Volume	Net Volume
(--)	(ac-ft)	(ac-ft)	(ac-ft)
Southbound Frontage Road	0.1	29.9	29.8
Mainlanes	0.0	82.7	82.7
Northbound Frontage Road	1.8	25.1	23.3
Total	**1.9**	**137.7**	**135.8**

Detention Basin Design

As shown in **Table ES- 2**, two (2) offline storage facilities are proposed for mitigation purposes for Systems C and E. Detention Pond C is proposed just west of I-45 and north of P118-27-01 to help mitigate roadway impacts associated with System C. This detention pond will provide approximately 5.87 ac-ft of storage volume.

Detention Pond E is proposed to be located just east of I-45 and north of Halls Bayou and will provide the necessary volume to mitigate the NHHIP improvements at Outfall E. This includes the required volume associated with the roadway impacts (12.0 ac-ft) and floodplain impacts (135.8 ac-ft). This basin has been designed through coordination with TxDOT and HCFCD and is to be located within the area identified by HCFCD for a future regional detention basin servicing Halls Bayou. Detention Pond E will provide the required storage volume of 147.8 ac-ft needed for System E.

ROW Considerations

Extensive coordination with HCFCD will be needed at Halls Bayou where Detention Pond E is proposed. If HCFCD does not acquire the necessary properties in a timely manner, TxDOT may need to acquire

additional ROW to be able to construct Detention Pond E when the construction of the NHHIP Segment 1 begins.

Environmental Considerations

Because channel work below the ordinary highwater mark (OHM) is being proposed within the TxDOT ROW at Halls Bayou, an Individual Permit (IP) may be required by the United States Army Corps of Engineers (USACE). Extensive coordination will be needed with both USACE and HCFCD.

Summary

The proposed drainage systems were designed to ensure the mainlanes would not be inundated during a 100-year storm event and the frontage roads would not be inundated during a 10-year storm event.

A preliminary drainage cost was prepared for the proposed drainage components. The cost estimate includes a proposed culvert replacement, storm sewers, detention ponds, storm sewer and culvert removals, bridges and channel modifications. The total preliminary drainage cost is $53 million, which assumes TxDOT will construct the ultimate bridges at Halls Bayou and provide additional mitigation volume underneath the Halls Bayou bridges. If TxDOT were to move forward with the bridge design, as outlined in the schematic, the total preliminary drainage cost is $44 million. Both preliminary cost estimates include a 20% contingency.

Based on the mitigation analysis presented in this study, the proposed roadway and storm drainage improvements for NHHIP Segment 1, from South of Shepherd Drive to South of West Road, will not adversely impact existing conditions for storm events up to and including the 100-year (Atlas 14) and the 500-year storm (Pre-Atlas 14).

1. INTRODUCTION

1.1 Overall Study Introduction

The North Houston Highway Improvement Project (NHHIP) is a proposed Texas Department of Transportation (TxDOT) mobility project in the City of Houston (COH). The NHHIP will create additional roadway capacity to manage congestion, enhance safety, and improve both mobility and operational efficiency in and around downtown Houston and north along I-45. To facilitate this analysis, the NHHIP was divided into three (3) segments as shown in **Exhibit 1**:

- Segment 1: I-610 to Beltway 8 North
- Segment 2: I-10 to I-610
- Segment 3: Downtown Loop System (I-45, I-10, US-59/I-69)

The drainage study herein addresses the drainage features specific to Segment 1 from south of Shepherd Drive (STA 1581+00) to south of West Road (STA 1744+00).

1.2 Study Purpose

CivilTech Engineering, Inc. (CEI) was contracted by TxDOT to provide professional engineering services for the preparation of a preliminary drainage study for a portion of NHHIP Segment 1, from south of Shepherd Drive (STA 1581+00) to south of West Road (STA 1744+00). The CSJ for this project is 0110-06-139. The purpose of the drainage study is to perform the hydrologic and hydraulic analyses required for the preliminary design of drainage features needed to service the proposed roadway improvements along I-45, within CEI's section of Segment 1. The drainage study provides a preliminary assessment of the drainage features, impacts, and mitigation needed for this portion of NHHIP Segment 1. This report documents the preliminary drainage design and analysis to assist TxDOT in the development of Plans, Specifications, and Estimates (PS&E) for the project.

It should be noted that the information in this drainage study report, including all assumptions, acquired data, technical calculations, supporting hydrologic and hydraulic modeling, and exhibits are preliminary and must be verified for accuracy by the Design Engineer during PS&E development.

1.3 Project Location

The project limits cover approximately 2.9 miles of I-45 from south of Shepherd Dr. to south of West Rd. The project also includes approximately 800 feet of Shepherd Drive, the Metro T direct connector, ramps, and frontage roads within the project extents. The project is located in two (2) Harris County Flood Control District (HCFCD) defined watersheds, Halls Bayou (P118-00-00) and Little White Oak Bayou (E101-00-00). The project location details are shown in **Exhibit 2**.

1.4 Project Scope

The study scope includes the following primary work tasks:

1. Field Survey – Collect survey data, including channel cross sections along Halls Bayou and limited existing storm sewer manhole elevation data throughout the project corridor. This work was completed by Vickery and Associates, LLC., a sub-consultant to CEI.

2. Roadway Profile Analysis – Develop profile sheets depicting the proposed PGLs of the southbound and northbound frontage roads and mainlanes with water surface elevations shown for various storm events. Provide recommendations to TxDOT in regards to any adjustments that may be needed in order to meet the required roadway level of service.
3. Storm Drain Design (trunkline level) – Analyze in GeoPAK and develop preliminary plan and profile sheets (approximately a 30% level design) of the proposed storm sewer trunkline system. Additionally, produce drainage area maps and hydraulic computation sheets reflecting the proposed drainage design.
4. Drainage Crossing Analysis – Analyze two (2) drainage crossings within the project limits under existing and proposed conditions to determine impacts upstream and downstream of the drainage crossings.
5. Floodplain Fill Analysis – Determine the quantity of cut and fill in the floodplain throughout the project corridor. Identify mitigation measures and any right-of-way (ROW) needs to mitigate impacts.
6. Roadway Impact Analysis – Analyze existing and proposed discharges to four (4) outfalls within the project limits and determine detention required to mitigate any impacts to peak flows at the outfalls.
7. Detention Basin Preliminary Layouts – Develop preliminary detention basin layouts for proposed detention basins required based on the roadway impact analysis.
8. Preliminary Bridge Design – Develop conceptual bridge layouts (approximately a 15% level design) of the three (3) bridge structures at Halls Bayou – the southbound frontage road, northbound frontage road, and the mainlanes bridges.
9. Drainage Report – Develop a comprehensive drainage report to document methodologies and procedures used in the different analyses associated with the drainage study and provide conclusions and recommendations.

Project correspondence documenting coordination meetings with TxDOT can be found in **Appendix A**.

1.5 FEMA Special Flood Hazard Areas

The project limits are shown on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for Harris County, Texas and Incorporated Areas included in **Appendix B**. The project limits cover the following panels: Panel Numbers 48201C0470L and 48201C0660M, dated June 18, 2007 and June 9, 2014, respectively. The regulatory floodplain, floodway, and base flood elevations (BFEs) are shown on **Exhibit 2**. The FEMA FIRM, floodway data table and flood profiles for the project area are provided in **Appendix B**. The following outlines the details of the FEMA Special Flood Hazard Areas (SFHAs) the roadway encompasses:

- From STA 1581+00 to STA 1652+88 – Zone X, Area of Minimal Flood Hazard
- From STA 1652+88 to STA 1653+53 – Zone X, 0.2% Annual Exceedance Probability (AEP) Flood Zone (500-year floodplain)
- From STA 1653+53 to STA 1684+71 – Zone AE, 1% AEP Flood Zone (100-year floodplain)
- From STA 1684+71 to STA 1692+47 – Zone AE, Floodway

- From STA 1692+47 to STA 1699+86 – Zone AE, 1% AEP Flood Zone (100-year floodplain)
- From STA 1699+86 to STA 1712+72 – Zone X, 0.2% AEP Flood Zone (500-year floodplain)
- From STA 1712+72 to STA 1744+00 – Zone X, Area of Minimal Flood Hazard

At the time of this study, the Harris County Flood Control District (HCFCD) was conducting a restudy of the Little White Oak Bayou and Halls Bayou watersheds for the purpose of updating floodplain maps under the MAAPNext program. No MAAPNext data was available for reference at the time of this drainage study.

Formal coordination will be required with the City of Houston Floodplain Management Office and the Harris County Flood Control District to obtain a floodplain development permit for the proposed drainage crossing improvements at I-45 and Halls Bayou. In addition, a FEMA Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR) will be required for the project development.

1.6 Project Datum

All mapping and GIS data in this study are referenced to NAD 83, Texas State Plane South Central, US Survey Feet, with a grid-to-surface scaling factor of 1.000130. All mapping and elevations are tied to NAVD 1988, 2001 adj. unless otherwise noted in the report and/or supporting calculations.

2. DATA COLLECTION

The following section outlines the documents and data obtained and referenced in this study:

2.1 Data Sources

- Hydraulic Design Manual (HDM), Texas Department of Transportation, Revised September 2019.
- TxDOT Rainfall Intensity-Duration-Frequency Coefficients for Texas, based on NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas (Perica et al. 2018)
- NHHIP I-45 Segment 1 Drainage Criteria (CSJs: 0500-03-596, 0500-03-446, 0110-06-139, and 0110-06-132), prepared by TNP, dated June 2020. This document can be found in **Appendix A**.
- Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for Harris County, Texas and Incorporated Areas, Panel Numbers 48201C0470L and 48201C0660M, effective map date of June 18, 2007 and June 9, 2014, respectively.
- NHHIP Final Environmental Impact Statement (FEIS) Schematic – Segment 1 – I-45, TxDOT, April 2019.
- Various schematic roadway design files (DGN files) provided by TxDOT, April 2020.
- Various survey information collected by Vickery and Associates, LLC. for the NHHIP Segment 1.
- 2018 HGAC Aerial Imagery, Texas Natural Resources Information System (TNRIS).
- 2008 Adjusted Light Detection and Ranging (LiDAR) data obtained from Harris County Flood Control District. This LiDAR dataset is based on NAVD88, 2001 adj.
- Hydrologic and Hydraulic Models of the Halls Bayou Watershed, provided through the HCFCD Model and Map Management (M3) system.
- DRAFT Halls Bayou Watershed Flood Risk Reduction Phasing Study, prepared for HCFCD by LAN, dated August 2019, and the associated Vision Plan HEC-RAS model.
- NHHIP Preliminary Drainage Study, AECOM, November 2016.

2.2 Previous Studies

- North Houston Highway Improvement Project – Preliminary Drainage Study (CSJ: 0912-00-146), Prepared by AECOM, November 2016. This study presents a preliminary planning level drainage study of three reasonable alternatives that were identified in a November 2013 NHHIP public meeting. This NHHIP Segment 1 drainage study expands on this previous drainage study, further analyzing and preliminarily designing the drainage features associated with the recommended schematic alternative for Segment 1**.**
- Draft Environmental Impact Statement, North Houston Highway Improvement Project, Texas Department of Transportation, Houston District, From US 59/I-69 at Spur 527 to I-45 Beltway 8 North, CSJ: 0912-00-146, Harris County, Texas, dated April 2017. Presentation of alternatives for the NHHIP to describe the problem(s) or other needs that the proposed action is intended to

address in accordance with the National Environmental Policy Act (NEPA) for compliance with environmental laws.

2.3 Record Drawings

Record construction plans for previous projects within the project area were obtained from TxDOT. The record construction plans were reviewed to obtain relevant data on existing utilities (storm drainage, water, sewer, gas, etc.) for this drainage study. Existing storm drainage systems within the ROW were mainly identified studying the two (2) construction drawings outlined below.

- Plans of Proposed IH-45 Direct Connectors at Shepherd, Project No: C 0500-03-577, etc., CSJ: 0500-03-0577, etc. Limits: IH 45 at Shepherd (Direct Connectors) and from north of West Road to north of Shepherd, dated January 2013.
- Plans of Proposed State Highway Improvements, Project No: IR 45-I (215) 061, CSJ: 0110-06-189. I-45 North Freeway – Freeway Widening – Frontage Road Replacement and Authorized Vehicle Lane. Limits from South of Shepherd Drive to North of Beltway 8, dated August 1985.

It should be noted that the record construction plans that were relied upon for this study were based on various vertical datums. The software program, Corpscon v6.0, maintained by the U.S. Army Corp of Engineers (USACE), was used to convert the flowline information found in the record drawings from NGVD29 to NAVD88. An additional vertical datum adjustment was made to go from NAVD88 to NAVD88, 2001 adj. which was outlined in the NHHIP – Preliminary Drainage Study developed by AECOM and is included in **Appendix A** for reference. In most instances, average vertical correction factors were applied to adjust the vertical datum for the information in the record construction plans to obtain approximate flowlines for existing storm sewers. It is recommended that during the PS&E phase, detailed topographic surveys should be performed to obtain the actual elevation of all existing storm sewers and utilities.

3. PROJECT OVERVIEW

3.1 Existing Conditions

I-45, from south of Shepherd Drive to south of West Road, currently consists of the following roadway configuration:

- Approximate ROW Width – 300-310'
- Southbound and Northbound Frontage Roads – 2-11' lanes with no shoulder
- Southbound and Northbound Mainlanes – 4-11' lanes with a shoulder on either side
- High Occupancy Vehicle (H.O.V.) Lanes – 2 lanes, totaling 20' that vary in travel direction with no shoulder

The frontage roads and mainlanes are separated by a roadside ditch (swale) of varying width, while the H.O.V. lanes are separated from the mainlanes via a concrete safety barrier. The existing roadway typical section can be seen below in **Figure 3-1**. Note that the south and northbound frontage roads have approximately 6" curbs.

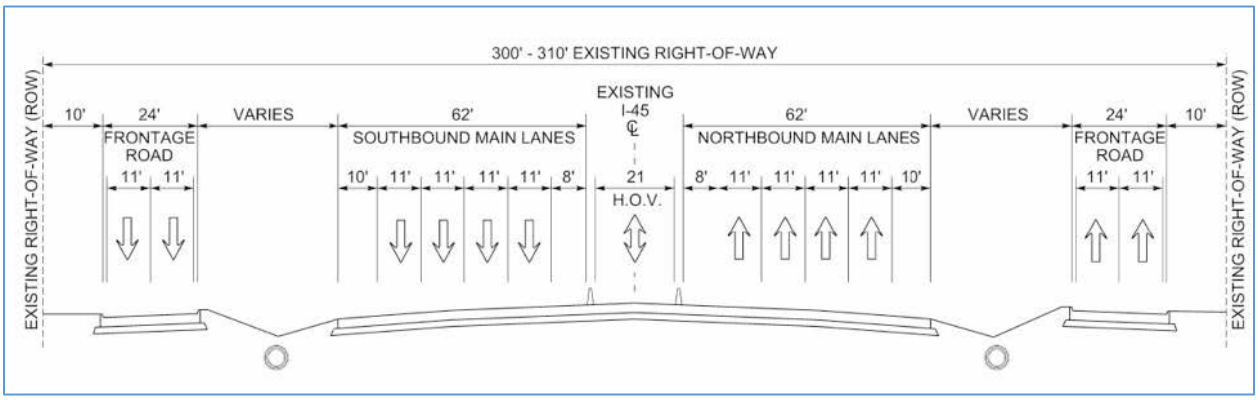


Figure 3-1 – Existing Typical Section from South of Shepherd Drive to South of West Road

The existing roadway is serviced by storm sewer systems and drains to five (5) major outfalls throughout the project corridor. For the purposes of this study, the outfalls are named as follows and can be seen on **Exhibit 2**.

- Outfall A – HCFCD Unit No. E101-18-04
- Outfall B – 60" RCP discharging to HCFCD Unit No. E101-00-00 (Little White Oak Bayou)
- Outfall C – HCFCD Unit No. P118-27-01 (Minor Crossing)
- Outfall D – HCFCD Unit No. P118-28-00
- Outfall E – HCFCD Unit No. P118-00-00 (Halls Bayou)

The existing drainage system typically consists of one (1) trunk line placed in between the Southbound Frontage Road (SBFR) and Southbound Mainlanes (SBML) and one (1) trunkline placed in between the Northbound Frontage Road (NBFR) and Northbound Mainlanes (NBML). Runoff from the frontage roads is picked up by laterals on the outside of the frontage roads and drained into the main trunkline systems.

3.2 Proposed Conditions

Under proposed conditions, the existing ROW on the east side of the roadway will generally remain the same as the existing ROW, while an additional 170 ~ 180 feet of ROW will be acquired to the west, providing an overall proposed ROW width of approximately 480 feet. The roadway is proposed to be configured as follows:

- Southbound and Northbound Frontage Roads – 2-12' lanes plus a 15' shared lane
- Southbound and Northbound Mainlanes – 4-12' lanes with 2-12' shoulders on either side
- Southbound and Northbound Max Lanes – 2-12' lanes with a 12' shoulder in between the max lanes and mainlanes

The frontage roads and mainlanes are separated by a roadside ditch (swale) of varying width, while the northbound and southbound max lanes are separated from one another and by the mainlanes via a concrete safety barrier. The proposed roadway typical section can be seen below in **Figure 3-2**.

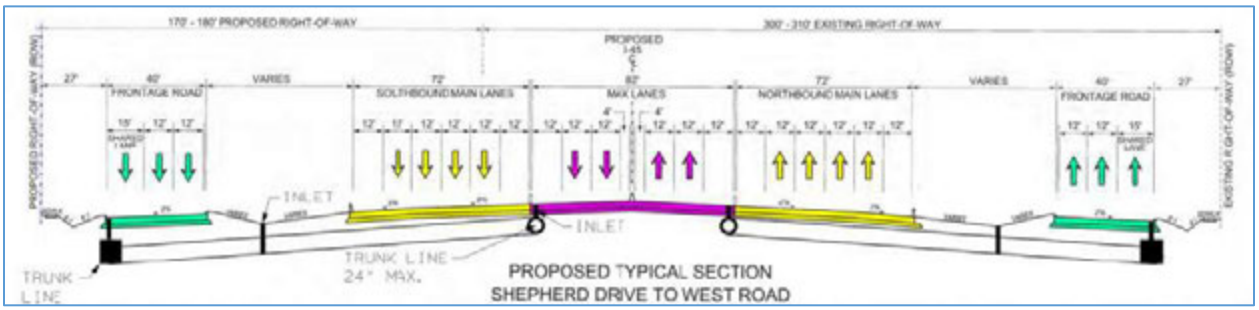


Figure 3-2 – Proposed Typical Section from South of Shepherd Drive to South of West Road

In general, the proposed drainage system will consist of one (1) trunkline placed underneath the curb of the frontage road that will service the frontage road and mainlanes and one (1) trunkline placed in between the max lanes and mainlanes to service the max lanes. Laterals will be placed to drain the max lane storm sewers to the main frontage road trunk line systems.

3.3 Design Criteria

A meeting was held with the Segment 1 drainage consultants and TxDOT on June 22, 2020 to discuss the drainage design criteria for the NHHIP Segment 1 project. Subsequently, a drainage criteria memo was disseminated by drainage consultant TNP to further outline the criteria. This memorandum can be found in **Appendix A**. All drainage design and analysis elements are based on the Atlas 14 rainfall data, unless noted otherwise. The following summarizes the general criteria of the project:

- Design Element: Storm Drains
    - Frontage Roads: Atlas 14 10-year (max ponding of 1 Lane)
    - Mainlanes and Max Lanes: Atlas 14 100-year
    - Minimum height for storm drain conduit for frontage road and mainlanes – 24"
    - Size conduits for non-pressure full flow, check for 100-year hydraulic grade line (HGL) below the edge of pavement (EOP) for mainlanes and max lanes

- Design Element: Drainage Crossings
    - Drainage design frequency for Minor Crossing at STA 1631+30: Atlas 14 100-year storm event
    - Drainage design frequency for Halls Bayou Bridge Crossings: Atlas 14 100-year storm event
- Design Element: Detention Basins
    - Drainage design frequency: Atlas 14 100-year storm event with 2’ freeboard

4. ROADWAY PROFILE ANALYSIS

The NHHIP Segment 1 schematic profile grade line (PGL) for the proposed I-45 mainlanes and frontage roads was superimposed with the 10-year, 50-year, 100-year, and 500-year peak water surface elevations (WSE) of Halls Bayou, HCFCD Unit P118-00-00, and a non-bridge class culvert crossing, located at STA 1631+30, that outfalls to HCFCD Unit P118-27-01. This non-bridge class drainage crossing is herein referred to as the Minor Drainage Crossing. The roadway profile grade line analysis was performed to evaluate the proposed I-45 (mainlane and frontage road) profiles relative to overbank flooding or potential backwater flooding through the existing storm sewer systems that outfall into Halls Bayou or P118-27-01. The limits of each drainage system relative to the mainlane station is outlined below:

- Minor Crossing Drainage Area Extents – STA 1620+00 to STA 1647+00
- Halls Bayou Drainage Area Extents – STA 1647+00 to STA 1748+00

Note: the roadway area south of the Minor Crossing Drainage Area (from STA 1581+00 to STA 1620+00) is within the Little White Oak Bayou (E101-00-00) watershed and the proposed roadway improvements are located in a FEMA Zone X (unshaded), Area of Minimal Flood Hazard. There is one existing drainage crossing within this area and it is located on the southern limits of the study at STA 1591+00. This crossing is evaluated as part of the adjacent study segment being managed by drainage consultant TNP. Extensive coordination between CivilTech and TNP was conducted to ensure the roadway profiles in this area met the design criteria.

4.1 Minor Crossing Water Surface Elevations

Water surface elevations for the minor crossing drainage area were developed based on the Atlas 14 rainfall data. Further discussion regarding the drainage crossing analysis and results is outlined in **Section 7**.

4.2 Halls Bayou Water Surface Elevations

The current effective model from the Harris County Flood Control District's (HCFCD) M3 System was used as the basis of determining the water surface elevations throughout the Halls Bayou watershed at I-45. Revisions to the effective model were made, as further outlined in **Section 7**, to create a corrected effective scenario to better define the existing conditions water surface elevations. Based on coordination with TxDOT, the corrected effective 500-year water surface elevation was used as the pseudo-Atlas 14 100-year WSE.

4.3 Evaluation of Proposed Roadway Profiles

Based on the results of the drainage crossing analysis, the existing WSEs were plotted against the frontage road and main lane proposed PGLs to determine any locations where adjustments may be needed to the profile to meet the recommended roadway level of service. Results showed for the mainlanes, the proposed profiles are above the 100-year (Atlas 14) and 500-year (pre-Atlas 14) WSEs for the Minor Crossing and the Halls Bayou drainage areas, respectively. In most places, the profiles are well above the respective WSEs (more than 5 feet). No profile adjustments are recommended for the mainlanes.

Through coordination with TxDOT, the northbound and southbound frontage road profiles are recommended to be adjusted such that the proposed PGLs remain above the Atlas 14 10-year WSE, while

still being able to accommodate the proposed roadway design within the current proposed ROW limits. The limits of the recommended profile adjustments can be seen below in **Table 1**.

Table 1 – Recommended Roadway Profile Adjustments

Southbound Frontage Road	
From STA.	**To STA.**
1605+00	1610+00
1617+00	1762+00
Northbound Frontage Road	
From STA.	**To STA.**
1646+00	1796+00

Water surface elevations for the various storm events, along with the proposed PGLs can be seen on **Exhibit 3-1**, **Exhibit 3-2**, and **Exhibit 3-3** for the southbound frontage road, northbound frontage road, and mainlanes, respectively. In areas where the frontage road profile is recommended to be adjusted, the recommended profile adjustment is depicted.

5. PROPOSED TRUNKLINE SYSTEM DESIGN

5.1 Drainage Design Criteria

The preliminary drainage design criteria for mainlanes, max lanes, and frontage road storm sewer systems is provided in **Appendix A** and summarized in **Table 2**. All storm sewer systems were sized under non-pressure flow conditions. The preliminary sizing of the storm sewer systems was performed using Bentley's Power GEOPAK Drainage V8i, SELECTseries4.

Table 2 – Drainage Design Criteria for Storm Drains

Design Element	Design Frequency	Proposed HGL
Mainlanes	10-Yr	100-Yr < EOP
Max Lanes	10-Yr	100-Yr < EOP
Frontage Roads	10-Yr	10-Yr (Max 1-Lane Ponding)

5.2 Drainage Areas & Peak Flows

For the storm drain design, each drainage area was developed based on the existing topography outside of the ROW, drainage areas outlined in record drawings, and the proposed roadway profile within the ROW. In general, the drainage areas were divided as follows:

- Drainage areas encompassing the area outside of the ROW draining to the frontage road, the adjacent frontage road, and the adjacent mainlane. This was done for both the northbound and southbound systems.
- Drainage areas encompassing the max lane. This was done for both the northbound and southbound max lanes.

The rational method was used to develop peak flows for all storm sewer drainage areas, as all areas were less than 200 acres.

5.3 Proposed Conditions

All storm sewers within TxDOT ROW will be replaced. The preliminary sizing of the proposed storm sewer trunklines was performed for the mainlanes, max lanes, and frontage roads using GeoPAK Drainage. Note, the preliminary design did not include inlet design.

Typically, one trunkline is proposed to be placed underneath the curb of the frontage road and will service the frontage road and the mainlane and one trunkline will be placed in between the mainlane and max lane and will service the max lane. In general, this will occur in both travel directions, resulting in four parallel trunklines:

- One (1) trunkline for the northbound frontage road and northbound mainlane
- One (1) trunkline for the northbound max lane
- One (1) trunkline for the southbound frontage road and southbound mainlane
- One (1) trunkline for the southbound max lane

The max lane storm sewer system typically connects to the mainlane/frontage road trunkline system via lateral systems.

The proposed storm sewer plan and profile sheets can be found on **Exhibit 4** as outlined below**:**

- **Exhibit 4-1** I-45 NBML and NBFR Storm Sewer Plan and Profile
- **Exhibit 4-2** I-45 North Max Lanes Storm Sewer Plan and Profile
- **Exhibit 4-3** I-45 South Max Lanes Storm Sewer Plan and Profile
- **Exhibit 4-4** I-45 SBML and SBFR Storm Sewer Plan and Profile
- **Exhibit 4-5** Shepherd Drive Storm Sewer Plan and Profile

Associated drainage area maps and hydraulic data sheets can be found in **Appendix C**, and the associated GeoPAK models are provided in **Appendix I**. Note that sections of storm sewer systems for Systems B and C were sized to also provide mitigation volume and the last segment of each of these storm sewer systems was sized to match the capacity of the existing outfalls.

5.4 PC-SWMM Modeling Check

Once the preliminary drainage system was designed, it was verified in PC-SWMM, as part of the roadway impact analysis, to ensure the 100-year HGLs were below the mainlanes and max lanes and a maximum of one lane ponded along the frontage roads in a 10-year event. Further discussion on the roadway impact analysis and the associated SWMM model can be found in **Section 8**.

In PC-SWMM, to determine the maximum HGLs throughout each system, a normal tailwater condition was used at each outfall. For Systems C and D, where the model was extended to include a portion of the outfall channel, the channel was removed, and the model was terminated at the TxDOT ROW. For System E (Halls Bayou), a normal tailwater condition was used, opposed to a variable stage tailwater condition representing the water surface elevations at Halls Bayou. This was done to ensure the storm drain design was not driven by tailwater effects, which may have artificially oversized the storm sewer systems.

6. HALLS BAYOU BRIDGE CROSSING

The crossing at Halls Bayou within the project corridor is made up of three (3) components, the SBFR, mainlane, and NBFR bridges. As part of this study, schematic bridge layouts (approximately 15% level design) are to be developed for the three (3) bridges to accommodate the proposed roadway improvements. The proposed schematics of the bridges were designed in coordination with TxDOT and HCFCD and are different than the bridge section included on the TxDOT IH-45 Segment 1 roadway schematics.

HCFCD, as part of their Halls Bayou Vision Plan (Watershed Flood Risk Reduction Study), has outlined a drainage master plan for Halls Bayou to obtain the 500-year level of service (Pre-Atlas 14) throughout the watershed. This includes channel improvements within Halls Bayou, as well as regional detention basins planned throughout the watershed. The Halls Bayou Vision Plan in the vicinity of the I-45 bridge crossings, with HCFCD's ultimate ROW extents, can be seen on **Exhibit 5**. TxDOT has the intent to accommodate the Halls Bayou ultimate channel ROW in the Halls Bayou bridge design. The ultimate channel section within the vicinity of I-45 includes the following.

For the purposes of this study, it was assumed the timing of construction of the two (2) projects (NHHIP vs. HCFCD's Halls Bayou Channel Improvements) would not align with one another and the NHHIP Segment 1 project would likely be constructed prior to the Halls Bayou ultimate channel being in place. Therefore, an interim condition was assumed. The interim condition assumes the ultimate bridges will be constructed at I-45 with an interim condition channel to ensure no adverse impacts to existing conditions along Halls Bayou.

The proposed I-45 bridges at Halls Bayou are to be realigned to better accommodate the proposed roadway and remove some of the bends in the existing Halls Bayou alignment within the TxDOT ROW. For interim conditions, the realigned channel centerline will tie back to the existing channel centerline at the TxDOT ROW. The proposed bridges and the realignment of the Halls Bayou channel can be seen on **Exhibit 6**. The interim and ultimate conditions channel sections within the TxDOT ROW are summarized in **Table 3**.

Table 3 – Halls Bayou Ultimate Channel Geometry at I-45

Geometry	Interim Configuration	Ultimate Configuration
Channel ROW Width	340 ft.	340 ft.
Bottom Width	80 ft.	160 ft.
Approximate Top Width	160 - 170 ft.	250 - 260 ft.
Side Slopes	4H:1V	4H:1V
Approximate Channel Depth	10.5 ft. – 11 ft.	11 ft. – 12 ft.

Bridge layout sheets, depicting the bridge deck, interim, and ultimate channel information can be found on **Exhibit 7-1**, **Exhibit 7-2**, and **Exhibit 7-3**, for the southbound frontage road, mainlane, and northbound frontage road bridges, respectively. As illustrated, the interim channels are connected laterally through a spillway to utilize the available channel capacity during high flow conditions. Once the Halls Bayou Channel improvement by HCFCD is carried out, the interim channel will be excavated to the ultimate channel configuration. A summary of the Halls Bayou bridge hydraulic impact analysis is included in **Section 7**.

7. DRAINAGE CROSSING ANALYSIS

The drainage crossings of I-45 were analyzed to determine the impacts of the proposed roadway project on the WSE upstream and downstream of I-45. Within the project limits, there are two (2) drainage crossings, as outlined below in **Table 4.**

Table 4 – Existing Drainage Crossings

Crossing ID	Sub-unit ID	CL Station	Type	Size
Minor Crossing	Minor Crossing	1631+30	Non-Bridge Class Culvert	2 – 6' x 3' RCB
Halls Bayou Crossing	Southbound Frontage Road	1691+82	Bridge	3 Span Bridge Length = 140'
	Mainlane	1691+17		1 Span Bridge Length = 130'
	Northbound Frontage Road	1690+91		3 Span Bridge Length = 105'

The Halls Bayou bridge crossings are FEMA studied crossings, while the Minor Crossing is an unstudied crossing. All crossings are located in the Halls Bayou watershed, draining west to east across I-45. The Minor Crossing outfalls into HCFCD Unit No. P118-27-01, a tributary to Halls Bayou.

7.1 Methodology

Minor Crossing

The Minor Crossing, located at STA 1631+30, was analyzed for the Atlas 14 10-year and 100-year storm events. The Rational Method was the basis to determine peak flows for each storm event, as the contributing drainage area is less than 200 acres. Due to the complexity of the hydraulic system under proposed conditions, the hydraulic analysis to determine the existing and proposed water surface elevations was completed using the PC-SWMM models developed as part of the roadway impact analysis. Further discussion regarding the PC-SWMM models and the roadway impact analysis can be found in **Section 8**.

Halls Bayou Bridge Crossings

For the Halls Bayou bridge crossings, the HEC-RAS model obtained from HCFCD's M3 system was the basis of the drainage crossing analysis. This model utilizes the steady state capabilities of HEC-RAS and is based on pre-Atlas 14 rainfall data and includes the 10-year, 50-year, 100-year, and 500-year storm events. For the purposes of this analysis, the hydrology remained unchanged from the effective M3 model, and it was assumed the pre-Atlas 14 500-year WSE would serve as the pseudo-Atlas 14 100-year WSE. The geometry of the HEC-RAS model was updated to create a corrected effective model to better reflect existing conditions within the TxDOT ROW based on survey data and record drawings.

7.2 Minor Crossing Drainage Crossing Analysis

The following sections outline the results of the drainage crossing analysis associated with the Minor Crossing, the non-bridge class culvert located at STA 1631+30 that serves as the outfall for System C. See **Appendix D** for supporting data and models.

7.2.1 Existing Conditions

The existing contributing drainage area for the Minor Crossing was delineated using ArcHydro tools within ArcGIS, in conjunction with the LiDAR data, survey, and aerials. The drainage area was determined to be 82.6 acres. See **Exhibit 8** for the drainage area limits. Because the drainage area was less than 200 acres, the Rational Method was used to determine peak flows. A summary of peak flows is outlined below in **Table 5**.

Table 5 – Existing Conditions Peak Flows for Minor Crossing

Storm Event	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	500-Yr	Area (acre)
Peak Flow (cfs)	125	159	190	235	271	311	428	82.6

The existing crossing is 2 – 6’ x 3’ RCB culverts. The tailwater condition in SWMM was defined as an irregular channel based on survey data collected downstream of I-45 along P118-27-01. Results of the water surface elevations upstream of the Minor Crossing are outlined below in **Table 6**.

Table 6 – Existing Conditions Upstream Water Surface Elevations for Minor Crossing

Mainlane Roadway Elev.	Frontage Roadway Elev.		WSE		Level of Service
	Northbound	Southbound	10-Yr	100-Yr	
84.10	82.80	83.03	82.37	82.86	100-Yr

The roadway elevation reported in **Table 6** is based on the existing roadway elevation of the mainlanes. The Minor Crossing meets a 100-year level of service under existing conditions.

7.2.2 Proposed Conditions

Under proposed conditions, a detention basin will be located just north of P118-27-01 and west of I-45. Additional information regarding the proposed detention basin can be found in **Section 9.** The outfall of the proposed basin, along with five (5) proposed storm sewer trunklines are proposed to tie into the proposed Minor Crossing culvert. The proposed drainage configuration depicting the proposed drainage crossing can be seen on **Exhibit 9**. See **Appendix E** for detailed data tables.

The cross culvert is proposed to be as follows:

- 1 – 6’ x 3’ RCB from just upstream of the SBFR to the SB Max Lane
- 2 – 6’ x 3’ RCB from the SB Max Lane to the NB Max Lane
- 2 – 8’ x 3’ RCB from the NB Max Lane to just downstream of the NBFR

A summary of peak flows is outlined in **Table 7**. Note that this is based on the SWMM results, and as such, only the 10- and 100-yr results are available.

Table 7 - Proposed Conditions Peak Flows for Minor Crossing

Inflow (cfs) at:	10-Yr	100-Yr	Area (acre)
1 – 6' x 3'	101.8	116.4	66.62
2 – 6' x 3'	102.7	117.4	68.26
2 – 8' x 3'	106.0	122.2	73.54

Results of the water surface elevations upstream of the Minor Crossing under proposed conditions are outlined below in **Table 8**.

Table 8 – Proposed Conditions Upstream Water Surface Elevations for Minor Crossing

Mainlane Roadway Elev.	Frontage Roadway Elev.		WSE		Level of Service
	Northbound	Southbound	10-Yr	100-Yr	
84.78	84.10	84.56	82.30	82.78	100-Yr

7.2.3 Minor Crossing Impact Analysis Results

The existing condition and proposed condition SWMM models were compared to determine the impacts at the Minor Crossing. As shown in **Table 9**, the proposed roadway improvements do not cause adverse impact to the existing conditions.

Table 9 – Minor Crossing Impact Analysis Summary of Results

Crossing ID	Approximate Mainlane Roadway Elevation		Headwater Elevation 100-Year		Proposed – Existing WSE (ft.)
	Existing	Proposed	Existing	Proposed	
Minor Crossing	84.10	84.78	82.86	82.78	-0.08

7.3 Halls Bayou Drainage Crossing Analysis

The following sections outline the results of the drainage crossing analysis associated with the Halls Bayou bridge crossings.

7.3.1 Existing Conditions

As mentioned previously, the HEC-RAS model from HCFCD's M3 system was used as the basis of the hydraulic analysis for the Halls Bayou bridges. The hydrology was not changed from the M3 model due to the size and complexity of the Halls Bayou watershed upstream of I-45. The peak flows, based on pre-Atlas 14 rainfall, are outlined below in **Table 10**.

Table 10 – Existing Conditions Peak Flows for Halls Bayou Bridges

Storm Event	10-Yr	50-Yr	100-Yr	500-Yr	Area (acre)
Peak Flow (cfs)	4,153	5,617	6,309	8,137	7,294

The HEC-RAS model was updated within the proposed TxDOT ROW to better align and update cross sections. Additionally, the bridge information for the three (3) bridges was modified based on survey data and record drawings. The existing northbound and southbound frontage road bridges in the M3 model were found to generally reflect existing conditions accurately and minimal updates were needed. However, modifications were needed for the mainlane bridge. The largest updates include updated high chord elevations to better represent the existing PGL, the addition of the embankment in between the Halls Bayou bridge and the West Mount Houston Road overpass, and the addition of the existing concrete barrier located on the outside of the mainlanes, as well as in between the mainlanes and H.O.V. lanes. A comparison of the effective (M3) WSEs and corrected effective (C.E.) WSEs can be seen in **Table 11.**

Table 11 – Corrected Effective vs. Effective WSEs at Halls Bayou

	Roadway Elevation (ft.)	10-Yr WSE	50-Yr WSE	100-Yr WSE	500-Yr WSE	Level of Service	Low Chord Elevation
Southbound Frontage Road							
Effective	79.5	79.24	80.03	80.35	81.09	10-Year	77.93
C.E.		80.35	81.48	81.87	82.00	<10-Year	78.38
Mainlanes							
Effective	85.0	79.12	79.90	80.21	80.95	>500-Year	83.41
C.E.		80.25	81.34	81.70	81.71		84.95
Northbound Frontage Road							
Effective	78.7	79.02	79.77	80.07	80.76	<10-Year	77.77
C.E.		79.30	80.37	80.60	81.02		77.14

The increases in WSEs from the effective to corrected effective models can be attributed to the addition of the concrete barriers on the mainlanes. In the effective model, there is significant overflow in the overbank areas in the larger storm events. However, with the addition of the concrete barriers in the corrected effective model, this overflow is eliminated. As indicated in **Table 11**, under existing conditions the frontage roads do not meet a 10-year level of service, while the mainlane bridge is significantly elevated, providing a 500-year level of service. The low chords for these bridges are provided. Note that the level of service above is set comparing WSEs to the roadway elevations.

7.3.2 Proposed Interim Conditions

For the purposes of the drainage crossing analysis, the interim channel configuration was analyzed to determine impacts to existing conditions. Additional information regarding the bridges can be found in **Section 6** and can be seen in **Exhibits 7-1**, **7-2**, and **7-3**.

The corrected effective HEC-RAS model was used as the basis of the interim model and modified to incorporate the ultimate bridges, proposed road deck information, and interim channel design. Results of the interim channel can be seen below in **Table 12**. The low chords for these bridges are provided. Note that the level of service above is set comparing WSEs to the roadway elevations.

Table 12 – Proposed Interim Water Surface Elevations at Halls Bayou

	Roadway Elevation (ft.)	10-Yr WSE	50-Yr WSE	100-Yr WSE	500-Yr WSE	Level of Service	Low Chord Elevation
Southbound Frontage Road	80.16	79.57	80.73	81.23	81.96	10-Yr	77.36
Mainlanes	90.13	79.37	80.34	80.77	81.37	500-Yr	88.97
Northbound Frontage Road	81.22	79.29	80.25	80.68	81.28	100-Yr	76.67
Flow Rate (cfs):		4,153	5,617	6,309	8,137		

7.3.3 Halls Bayou Impact Analysis Results

The existing and proposed conditions crossing model for Halls Bayou were compared to determine the impacts at each bridge. Error! Reference source not found. shows a summary of the impacts analysis results for the Halls Bayou Bridges.

Table 13 – Halls Bayou Bridges Impact Analysis Summary of Results

Roadway	Roadway Elevation (ft.)		Headwater Elevation 500-Year (ft.)		Proposed – Existing WSE (ft.)
	Existing	Proposed	Existing	Proposed	
Southbound Frontage Road	79.5	80.16	82.00	81.96	-0.04
Mainlanes	85.0	90.13	81.71	81.37	-0.34
Northbound Frontage Road	78.7	81.22	81.02	81.28	0.26*

*Increase in WSE contained within TxDOT ROW

As shown in **Table 13**, the proposed roadway improvements have no impact on the 500-year (Pre-Atlas 14) WSE for the southbound frontage road and mainlanes, but there is an increase in WSE of approximately 0.26 feet upstream of the northbound frontage road. This increase in WSE is contained within the TxDOT ROW. Supporting data detailing the drainage crossing analysis can be found in **Appendix D**, and the existing and proposed HEC-RAS model associated with the Halls Bayou analysis can be found in **Appendix J**.

7.3.4 Ultimate Conditions

Once the ultimate conditions channel section is in place based on the Halls Bayou Vision Plan, the 500-year (Pre-Atlas 14) WSEs will be contained within the channel banks. The three (3) bridges at the Hall's Bayou crossing will have a level of service equivalent to that provided for the 100-year Atlas 14 event. The water surface elevation based on the ultimate conditions is depicted on **Exhibits 7-1**, **7-2**, and **7-3**.

Formal coordination will be required with the City of Houston Floodplain Management Office and the Harris County Flood Control District to obtain a floodplain development permit for the proposed drainage crossing improvements at I-45 and Halls Bayou. In addition, a FEMA Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR) will be required for the project development.

8. ROADWAY IMPACT ANALYSIS

A roadway impact analysis was performed for NHHIP Segment 1 to determine detention needs due to the increased runoff from the proposed highway improvements and for hydraulic system changes associated with the proposed storm drainage systems. The mitigation analysis addresses:

- Peak flow impacts for the proposed highway at the system outfalls.
- Hydraulic system changes for the storm drainage systems servicing the highway.

PC-SWMM was used to perform the roadway impact analysis.

8.1 Methodology

EPA SWMM v5.1.015 was used for the hydraulic modeling, using the PCSWMM 2019 (v7.3.3095) user interface. The traditional 1D link/node system was utilized. The proposed ROW was isolated and used as the existing and proposed roadway drainage boundary. The offsite drainage areas and detention facilities were represented with storage nodes. The storage nodes for the offsite areas include depth-area curves based on LiDAR, used to represent the storage available within each drainage area. Proposed stage-storage information, converted to a depth-area curve, was used to represent the volume within the proposed detention basins. Transects were used to represent drainage area divides and to allow flow interaction between nodes.

Further discussion regarding the limits of the modeling extents and tailwater conditions can be found in **Section 8.5.**

8.2 Existing and Proposed Land Uses

A comparison was done within the proposed TxDOT ROW to determine the changes to impervious cover from existing to proposed conditions. The proposed ROW encompasses approximately 193 acres. The existing and proposed land uses within the proposed ROW can be seen on **Exhibit 10** and **Exhibit 11**, respectively. The calculated existing and proposed impervious covers are listed in **Table 14**.

Table 14 – Changes to Impervious Cover for NHHIP Segment 1

NHHIP Segment 1	
Proposed ROW (acres)	193
Existing Impervious Cover (acres)	145
Proposed Impervious Cover (acres)	153
Increased Impervious Cover (acres)	**8**

Due to the nature of the I-45 corridor and the existing highly developed commercial properties adjacent to the existing TxDOT ROW, the proposed project will only add approximately 8 acres of additional impervious cover. Further calculations regarding the existing and proposed hydrology used for the roadway impact analysis can be found in **Appendix E**.

8.3 Storm Drain Outfalls and Drainage Systems

NHHIP Segment 1 has five (5) primary outfalls and associated storm sewer systems along I-45. The existing storm sewer system within the ROW and existing outfalls can be seen on **Exhibit 12**.

The general outfall regions of the storm drain systems are listed below for existing conditions:

- **System A** – Along I-45 from just south of West Little York Road to approximately 1,200 feet south of Mitchell Road (Outfall E101-18-04), part of the study by TNP
- **System B** – Outfalls directly into 60" RCP just west of N Shepherd Drive which outfalls to E101-00-00 approximately 700 feet west of Outfall B. This outfall includes the following storm drain systems:
    - Approximately 1,000 feet along Shepherd Drive and approximately 1,300 feet of Veterans Memorial Blvd
    - The interchange of N Shepherd Drive, Veterans Memorial Blvd and I-45
    - Approximately 1,400 feet of the I-45 SBFR north of the interchange
    - Approximately 800 feet of I-45 SBMLs south of the interchange
- **System C** – Along I-45 from approximately 1,200 feet south of Mitchell Road to approximately 500 feet south of W Gulf Bank Road (Outfall P118-27-01)
- **System D** – Along I-45 from approximately 500 feet south of W Gulf Bank Road to just north of W Gulf Bank Road (Outfall P118-28-00)
- **System E** – Just north of W Gulf Bank Road to just south of West Road (Outfall P118-00-00 – Halls Bayou)

Under proposed conditions, the internal ROW systems were slightly reconfigured to better accommodate the proposed roadway improvements, but generally followed the same drainage patterns as the existing storm sewer systems. The proposed drainage system and outfalls are shown on **Exhibit 13**. The most substantial changes in drainage area systems include the following:

- **System A to C** –
    - Approximately 1.6 acres will be rerouted from System A to System C.
- **System B to A** –
    - The area south of the interchange of N Shepherd Drive, Veterans Memorial Blvd and I-45, approximately 3.9 acres, will be rerouted from System B to System A.
- **System B to C –**
    - The northern portion of System B along the proposed SBFR and SBMLs, approximately 3.7 acres, will be rerouted from System B to System C.
- **System D to C –**
    - Approximately 1.7 acres will be rerouted from System D to System C.

- **Systems C & D to E** –
    - The SBFR and SBML drainage areas and associated offsite areas just north of Outfall C, approximately 15.3 acres, will be rerouted to Outfall E.
    - The SBFR and SBML drainage areas and associated offsite areas within System D, approximately 5.3 acres, will be rerouted to Outfall E.

Due to the widening of the I-45 ROW, ~2.4 acres of drainage area that was flowing away was redirected to System E under proposed conditions (i.e., net gain of 2.4 acres).

Note that for the purposes of the roadway impact analysis, the drainage design consultant, TNP, who is completing the drainage analysis for the section of Segment 1 south of CEI's section, is responsible for completing the impact analysis related to Outfall A.

CEI is tasked with completing the preliminary storm drain design for the section of roadway north of the cross culvert at Outfall A (STA 1591+00). Extensive coordination between the two consultants has occurred to ensure both trunkline storm drain designs are compatible with one another, and determining no adverse impacts to the existing flows at Outfall A. For the remainder of the discussion regarding the roadway impact analysis, the focus will be on Outfall Systems B – E.

The existing and proposed drainage areas associated with the outfall regions are listed in **Table 15**. Note, offsite drainage areas and associated hydrologic parameters remained unchanged between existing and proposed conditions.

Table 15 – Existing and Proposed Outfall Drainage Areas

Outfall Region ID	Existing Drainage Area	Proposed Drainage Area	Difference (Prop – Exist)
B	40.5	33.0	-7.5
C	106.5	98.1	-8.4
D	16.5	9.4	-7.1
E	347.0	370	23.0
Total	**510.5**	**510.5**	**0.0**

8.4 Mitigation Measures

Mitigation measures are necessary to ensure no adverse impacts to peak flows at the outfall. Mitigation was provided in terms of the following for each system:

- **System B** – Inline detention provided in the form of oversized storm sewers. Additionally, a portion of the existing drainage area for System B is proposed to be redirected to System A, approximately 3.9 acres, and to System C, approximately 3.7 acres.
- **System C** – A proposed detention basin, located just west of I-45 and north of P118-27-01. Further information regarding this proposed detention basin can be found in **Section 9.1**. Additionally, a portion of the existing drainage area for System C is proposed to be redirected to System E, approximately 15.3 acres.

- **System D** – A portion of the existing drainage area for System D is proposed to be redirected to System C, approximately 1.7 acres, and to System E, approximately 5.3 acres.
- **System E** – Through coordination with HCFCD, a portion of a HCFCD regional detention basin will be utilized by TxDOT for roadway mitigation measures. Note, this regional detention basin was not included in the proposed SWMM model.

8.5 Tailwater Conditions

The following tailwater conditions were used for the existing SWMM analysis:

- **System B** – System B discharges into a City of Houston 60" pipe (approximately 700' from the TxDOT ROW) that drains to E101-00-00 (Little White Oak Bayou). For the purposes of modeling, assumptions were made regarding the slope and downstream invert of the 60" pipe. A variable stage tailwater condition was extrapolated (based on the last cross section of the E101-00-00 model) and applied to the downstream end of the pipe at the outfall with Little White Oak Bayou.
- **System C** – System C outfalls into HCFCD Unit P118-27-01. The model was extended approximately 800' downstream of the TxDOT ROW and a transect was used to represent the channel cross section. A normal depth tailwater condition was applied at the downstream end of the channel section.
- **System D** – System D outfalls into HCFCD Unit P128-00-00. The model was extended approximately 900' downstream of the TxDOT ROW and a transect was used to represent the channel cross section. A normal depth tailwater condition was applied at the downstream end of the channel section.
- **System E** – System E outfalls into HCFCD Unit P118-00-00 (Halls Bayou). Halls Bayou is a FEMA studied stream and is currently being analyzed by HCFCD as part of their Halls Bayou Watershed Flood Risk Reduction Phasing Study. Variable stage information was taken from HCFCD's HEC-RAS base condition model and applied to the four (4) outfalls of System E. The 10-year (Pre-Atlas 14) storm event was utilized to determine the variable tailwater condition.

The existing and proposed SWMM configurations can be found in **Appendix E**.

8.6 Peak Flow Impacts

The existing and proposed PC-SWMM models were used to determine the 100-year storm event (Atlas 14) peak flows at each of the drainage system outfalls. The drainage systems include both ROW drainage areas and offsite drainage areas that drain to the ROW. The hydraulic design for the proposed storm drainage systems is presented in **Section 5.**

A comparison of the existing and proposed 100-year peak flows for each outfall is provided below in **Table 16**. The proposed 100-year peak flows at Systems B, C, and D are slightly less than that of the existing conditions. Because the detention basin at Outfall E is not incorporated into the proposed conditions SWMM model, there is an increase in peak flows shown at System E. The detention basin at outfall E will be constructed as part of the Segment 1 project and will be included as part of the HCFCD regional detention plan Halls Bayou. Further details regarding the detention needs at System E can be found in **Section 8.7.2**, and the existing and proposed SWMM models can be found in **Appendix J**.

Table 16 – Comparison of Existing and Proposed Peak Flows at Outfalls

Outfall Region ID	Existing Drainage Area	100-Yr Existing Peak Flow	Proposed Drainage Area	100-Yr Proposed Peak Flow	Difference (Prop – Exist)
(--)	(ac)	(cfs)	(ac)	(cfs)	(cfs)
B	40.5	151	31.9	148	-3
C	106.5	157	98.1	146	-11
D	16.5	107	9.4	91	-16
E	347.0	824	370	988	164

8.7 Detention Mitigation

The following section outlines the detention needs to mitigate the proposed roadway and storm sewer improvements.

8.7.1 Storm Sewer Volume

The existing and proposed storm sewer volumes within each drainage area system is outlined below in **Table 17**.

Table 17 – Existing and Proposed Storm Sewer Volumes

Outfall Region ID	Existing Storm Sewer Volume	Proposed Storm Sewer Volume	Difference (Prop – Exist)
(--)	(ac-ft)	(ac-ft)	(ac-ft)
B	1.26	1.34	0.07
C	1.26	1.94	0.69
D	0.37	0.17	-0.19
E	9.15	14.54	5.38

As indicated in **Table 17**, additional volume is being provided within the storm sewers under proposed conditions, compared to existing conditions. The exception to this is within System D, where a portion of the existing drainage area is being redirected to Systems C and E to offset the increase in peak flows due to the proposed roadway improvements.

8.7.2 Proposed Detention Basin Volumes

In addition to the increase in storm sewer volume under proposed conditions, two (2) detention basins will provide mitigation volume within Systems C and E, as documented below in **Table 18**.

Table 18 – Proposed Detention Basin Volumes

Outfall Region ID	Proposed Detention Basin Volume
(--)	(ac-ft)
C	5.9
E	12.0

Detention Basin C

The proposed detention basin servicing Outfall C was developed by maximizing the volume within the TxDOT ROW that was designated for a detention basin. This is an approximate 2.3-acre area located just north of P118-27-01 and west of the proposed roadway. Further details regarding Detention Basin C can be found in **Section 9.1**.

Detention Basin E

Through coordination with HCFCD, proposed Detention Basin E is to be located within the area identified by HCFCD for a future regional detention basin just east of I-45 and north of Halls Bayou, as shown on **Exhibit 14**. Detention Basin E will be used to mitigate any increase to flows to Halls Bayou at the System E outfall. The flow hydrographs from the existing and proposed SWMM models were used to determine the detention needs to mitigate the increase in peak flows under proposed conditions. The combined (E1, E2, E3, & E4) outfall hydrographs for existing and proposed conditions are shown below in **Figure 8-1**.

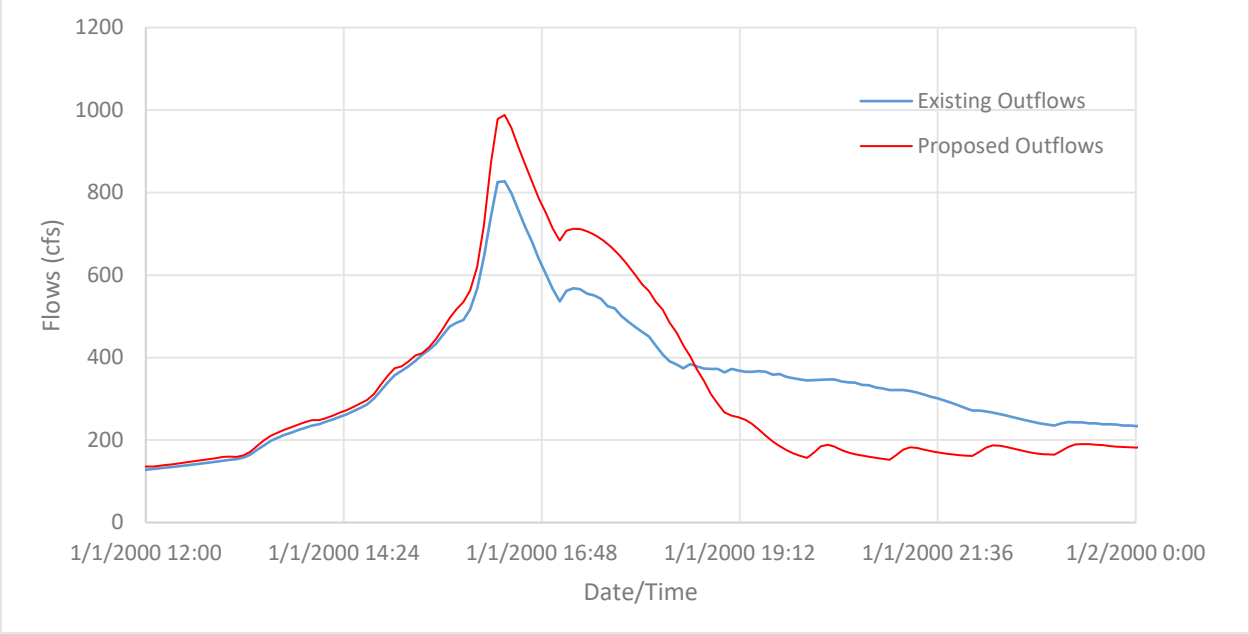


Figure 8-1 – Combined Existing and Proposed Hydrographs at Halls Bayou Outfalls

Based on the difference in hydrographs (proposed minus existing) along the rising limb and until the time at which the proposed flows fall below the peak of the existing flows (824 cfs), it was determined that approximately 12 ac-ft of storage will be needed within the footprint of the HCFCD regional detention

basin to cause no adverse impacts to Halls Bayou under proposed conditions. Further details regarding Detention Basin E can be found in **Section 9.2.**

8.7.3 Detention Mitigation Summary

Table 19 summarizes the roadway impact mitigation within CEI's section of Segment 1. Note that in **Table 19**, System A is not shown. This is because part of the existing System B was directed to the proposed System A which is being modeled by TNP. A total detention volume of 23.82 ac-ft will be provided to mitigate the increase in impervious cover and improved storm sewer conveyance associated with the proposed roadway and drainage improvements.

Table 19 – Detention Mitigation Summary Table

Outfall Region ID	Mitigation Provided by	Net Change in Drainage Area	In-Line Storage Provided	Offline Storage Provided	Total Storage Provided	Offline Storage Required
(--)	**(--)**	**(ac)**	**(ac-ft)**	**(ac-ft)**	**(ac-ft)**	**(ac-ft)**
B	-Drainage Area Redirection -In-line Storage	-7.50	0.07	-	0.07	0.00
C	-Drainage Area Redirection -In-Line Storage -Offline Storage	-8.40	0.69	5.87	6.56	0.00
D	-Drainage Area Redirection	-7.10	-0.19	-	-0.19	0.00
E	-In-Line Storage -Offline Storage	23.00	5.38	12.00	17.38	12.00
Totals	**(--)**	**0.00**	**5.95**	**17.87**	**23.82**	**12.00**

9. DETENTION BASIN DESIGN

9.1 Detention Basin C

The following section outlines the details of the detention basin design for the detention basin associated with System C. This detention basin will serve as a roadway impact detention basin. The proposed detention basin is located just west of I-45 and north of P118-27-01. The preliminary detention basin layout sheets (plan and section views) can be found in **Exhibit 15-1**. **Table 20** below outlines the details of the proposed detention basin.

Table 20 – Detention Basin C

Detention Basin C Element	Value
Top of Bank Elev.	82.59 ft
Basin Toe Elev.	78 ft
Side Slopes	4H:1V
Design WSE (100-Yr HGL from SWMM)	82.21 ft
Freeboard	0.38 ft
Design Volume (at El. 82.21)	5.87 ac-ft
Maximum Storage Volume (at El. 82.59)	6.47 ac-ft

9.2 Detention Basin E

As discussed in **Section 6**, TxDOT is in coordination with HCFCD to utilize a portion of HCFCD's identified future regional detention basin servicing Halls Bayou, just east of I-45. For the purpose of this study, it was assumed the TxDOT NHHIP Segment 1 project would precede the HCFCD Halls Bayou project. Therefore, a preliminary design of Detention Basin E was developed to provide the necessary volume to mitigate the NHHIP improvements at Outfall E. In addition to the 12 ac-ft required by the proposed roadway storm sewer network, Detention Basin E also provides mitigation volume, approximately 135.8 ac-ft (refer to **Section 10.2**), for the fill within the Halls Bayou floodplain associated with the roadway improvements. In total, this pond requires 147.8 (12 + 135.8) ac-ft of storage volume. Further discussion regarding the floodplain impact analysis can be found in **Section 10**. The preliminary detention basin layout sheets (plan and section views) can be found in **Exhibit 15-2**. **Table 21** below outlines the details of the proposed detention basin.

Table 21 – Detention Basin E

Detention Basin E Element	Value
Top of Bank Elev.	76.50
Basin Toe Elev.	67.53
Side Slopes	4H:1V
Design WSE	74.50
Freeboard	2 ft
Design Volume (at El. 74.50)	150.65 ac-ft
Maximum Storage Volume (at El. 76.50)	197.57 ac-ft

10. FLOODPLAIN IMPACT ANALYSIS

A floodplain impact analysis was completed along I-45 to determine the preliminary floodplain storage mitigation needs for the proposed roadway improvements within the Halls Bayou watershed. The 500-year (approximate Atlas 14 100-year) corrected effective water surface elevations from the Halls Bayou HEC-RAS model were used in conjunction with the schematic proposed roadway profiles and typical sections to estimate the net cut and fill quantities for the proposed highway improvements within the Halls Bayou watershed.

10.1 Methodology

The schematic proposed roadway profiles and typical sections, provided by TxDOT, were used in determining the cut and fill quantities along the roadway. Because a roadway corridor model nor a proposed surface has yet been developed for the project, it was not possible to use a surface calculation approach to determine the cut and fill quantities. Instead, the WSEs were plotted against the southbound frontage road, mainlane, and northbound frontage road proposed profiles within the Halls Bayou 500-year floodplain. The cut and fill area at 100' increments were then determined as follows:

- **Fill** – If the 500-year WSE > Proposed PGL Elevation; Proposed PGL Elevation – Natural Ground Elevation
- **Fill** – If the 500-year WSE < Proposed PGL Elevation and the 500-year WSE > Natural Ground Elevation; 500-year WSE – Natural Ground Elevation
- **Cut** – If the 500-year WSE > Proposed PGL Elevation and the Proposed PGL Elevation < Natural Ground Elevation; Natural Ground Elevation – Proposed PGL Elevation

Once these areas were determined along each proposed roadway profile, the average width of each roadway (SBFR, ML, NBFR) was determined for each 100' increment. The fill or cut area was then multiplied by the width to determine the fill or cut volume.

10.2 Results

Based on the calculations, as outlined in the methodology above, **Table 22** summarized the cut and fill volumes determined for each of the roadways (depicted on **Exhibit 16**).

Table 22 – NHHIP Segment 1 Cut and Fill Volumes

Roadway	Cut Volume	Fill Volume	Net Volume
(--)	(ac-ft)	(ac-ft)	(ac-ft)
Southbound Frontage Road	0.1	29.9	29.8
Mainlanes	0.0	82.7	82.7
Northbound Frontage Road	1.8	25.1	23.3
Total	**1.9**	**137.7**	**135.8**

This total floodplain mitigation volume of 135.8 ac-ft will be provided for in Detention Basin E. Further details regarding the cut and fill calculations can be found in **Appendix F**. **Table 23** outlines the total detention volume needed in Detention Pond E based on the roadway and floodplain impact mitigation volumes.

Table 23 – Total Volume Required Within Detention Basin E

Detention Needs	Volume
(--)	(ac-ft)
Roadway Impact Mitigation	12.0
Floodplain Impact Mitigation	135.8
Total Volume	**147.8**

11. ROW CONSIDERATIONS

Based on the overall results of the drainage analysis completed for the project, no additional ROW, beyond what is shown on the schematic, was found to be needed for the project corridor. The one area of further consideration and where extensive coordination will be warranted is the area of the proposed detention pond E at Halls Bayou. If HCFCD does not acquire the designated property in a timely manner that would allow TxDOT to excavate the area associated with Detention Pond E for mitigation purposes at the time of construction of the project, it may be necessary for TxDOT to acquire this property in advance. This area is located just east of I-45 and north of Halls Bayou and can be seen on **Exhibit 15-2**.

12. ENVIRONMENTAL CONSIDERATIONS

As discussed in detail in **Section 6**, Halls Bayou within the TxDOT ROW is proposed to be realigned under interim and ultimate conditions. Work below the Ordinary High Water (OHW) will likely trigger the need for an Individual Permit (IP) under Section 404 of the Clean Water Act. This will require extensive coordination with HCFCD and the U.S. Army Corps of Engineers (USACE). Timing of the NHHIP (interim channel) and the implementation of HCFCD's Halls Bayou Watershed Flood Risk Reduction Phasing Study (ultimate channel) will need to be considered to determine which entity will be responsible for obtaining an IP from the USACE.

13. UTILITY CONFLICTS

Potential utility conflicts were identified within the project limits. Available utility GIS databases for the existing water lines, sanitary sewers, electrical transmission lines, and gas lines were used to identify any potential utility conflicts with the proposed drainage systems. The City of Houston GIMs information was used to located conflicts with existing water lines and sanitary sewers. Electrical transmission lines and gas line information was obtained from CenterPoint Energy. No subsurface utility surveys were performed to verify the existence or location of the utilities identified in this study, therefore, consider all utilities shown in exhibits as approximate and subject to verification during PS&E.

The potential utility conflicts for the project are shown on **Exhibit 17** and summarized in a table in **Appendix G**. The number of potential utility conflicts by utility type is summarized below in **Table 24.**

Table 24 – Potential Utility Conflicts with Proposed Drainage Systems

Utility Type	Number of Potential Conflict Locations
Water Line	9
Gas Line	46
Electrical Line	29
Wastewater Line	4
Total	**88**

14. PRELIMINARY DRAINAGE COST ESTIMATE

The preliminary drainage costs for the proposed drainage features were completed for the project. Costs have been identified for cross storm drains, storm drains, detention ponds, bridge deck drains, and storm sewer removal. The quantities for each drainage component were based on the preliminary design presented for each drainage system. Unit cost values were obtained from the TxDOT 12-Month Houston District and Statewide Averages, working on the assumption of 300 ft inlet spacing for two- and three-lane segments, and 200 ft inlet spacing for four-lane segments.

Two (2) preliminary cost estimates were developed to identify the additional cost associated with providing a bridge structure at I-45 and Halls Bayou to accommodate the HCFCD regional plan (the ultimate bridge condition) compared to the bridge provided in the roadway schematic design. The first cost estimate was developed assuming the original, schematic bridge layout at Halls Bayou, per the TxDOT roadway schematics, will be constructed and no excess excavation of Halls Bayou will be provided as part of the project. This cost estimate is depicted below in **Table 25**.

Table 25 – Preliminary Drainage Costs for NHHIP Segment 1 with Schematic Halls Bayou Bridge

Drainage Component	**Cost**
Storm Sewer Systems	$22,274,000
Detention Ponds	$11,381,000
Bridge Deck Drains	$151,000
Storm Sewer Removal	$2,000,000
Cross Culverts	$323,000
Sub Total	*$36,129,000*
Roadway Component	**Cost**
Original Schematic Halls Bayou Bridge Cost	$6,850,000
Sub Total	*$6,850,000*
Halls Bayou Channel Components	**Cost**
Halls Bayou Channel Widening	$1,352,000
Sub Total	*$1,352,000*
Grand Total	**$44,331,000**

The second cost estimate was developed assuming the ultimate bridge layout at Halls Bayou will be constructed to accommodate the HCFCD Halls Bayou ultimate channel section at I-45. Additionally, this estimate considers the excess excavation volume of the Halls Bayou channel that is being proposed beneath the ultimate bridge section of Halls Bayou. This cost estimate is depicted below in **Table 26**.

Note, these cost estimates do not include real estate acquisition and include a 20% contingency. The breakdown of the preliminary drainage cost for the project is provided in **Appendix H**.

As can be seen based on **Table 25** and **Table 26**, TxDOT will potentially spend an additional $8.8 million to construct the ultimate Halls Bayou bridges and to provide excess mitigation (approximately 60 ac-ft) for the project.

Table 26 – Preliminary Drainage Costs for NHHIP Segment 1 with Ultimate Halls Bayou Bridge

Drainage Component	**Cost**
Storm Sewer Systems	$22,274,000
Detention Ponds	$11,381,000
Bridge Deck Drains	$151,000
Storm Sewer Removal	$2,000,000
Cross Culverts	$323,000
Sub Total	*$36,129,000*
Roadway Component	**Cost**
Ultimate (HCFCD) Halls Bayou Bridge	$14,645,000
Sub Total	*$14,645,000*
Halls Bayou Channel Components	**Cost**
Halls Bayou Channel Widening	$1,352,000
Additional Channel Excavation Under Bridges	$1,033,000
Sub Total	*$2,385,000*
Grand Total	**$53,159,000**

15. CONCLUSION

This drainage study provides the preliminary drainage design and analysis for the major drainage components in NHHIP Segment 1, from South of Shepherd Drive to South of West Road. The major drainage components are based on the Segment 1 schematic provided by TxDOT. The major drainage components include:

- Roadway profile adjustments due to water surface elevations
- Drainage crossings
- Storm sewer trunklines for the mainlanes, max lanes, and frontage roads
- Mitigation ponds

This study report is intended to assist TxDOT in the development of Plans, Specifications & Estimates (PS&E) for the drainage components in the project. The drainage design conforms to the preliminary drainage design criteria developed by TxDOT and the Segment 1 drainage consultants. All information in this study report shall be considered preliminary and subject to review and verification by the Design Engineer for NHHIP Segment 1.

A mitigation analysis was performed to ensure the project will not adversely impact existing flood levels at the project outfalls located within the Halls Bayou and Little White Oak Bayou watersheds. This drainage study report will be submitted to the Harris County Flood Control District and the City of Houston Public Works Department for review and acceptance. It will be the responsibility of the Design Engineer to coordinate with the agencies and obtain approvals for the final drainage report for the project.

15.1 Roadway Profile Analysis

A roadway profile analysis was completed to evaluate the proposed I-45 (mainlane and frontage road) profiles relative to overbank flooding or potential backwater flooding through the existing storm sewer systems that outfall into Halls Bayou or P118-27-01. No profile adjustments are recommended for the main lanes, as the main lanes were found to be well above the 100-year (Atlas 14) or 500-year (pre-Atlas 14) water surface elevations.

Through coordination with TxDOT, the northbound and southbound frontage road profiles are recommended to be adjusted such that the proposed PGLs remain above the 10-year WSE, while still being able to accommodate the proposed roadway design within the current proposed ROW limits. The limits of the recommended profile adjustments can be seen below in **Table 27.**

Table 27 – Recommended Roadway Profile Adjustments

Southbound Frontage Road	
From STA.	**To STA.**
1605+00	1610+00
1617+00	1762+00
Northbound Frontage Road	
From STA.	**To STA.**
1646+00	1796+00

15.2 Proposed Storm Drain Design

The preliminary sizing of the proposed storm sewer trunkline systems was performed for the following roadways:

- I-45 northbound and southbound mainlanes, max lanes and frontage roads
- Shepherd Drive from the interchange of Shepherd Drive, Veterans Memorial Drive, and the proposed I-45 southbound frontage road to approximately 1,000 feet south of the interchange.

The preliminary design did not include inlets for the mainlanes storm sewer trunkline. Also, drainage system components (bridge deck drains, piping, etc.) were not included for bridges, direct connectors, and ramps. A manhole level analysis was performed to size trunklines for the 10-year design storm event.

15.3 Halls Bayou Schematic Bridge Design

Three (3) bridges are located at Halls Bayou within the project corridor – the southbound frontage road, mainlane, and northbound frontage road bridges. As part of this study, a schematic level (approximately 15% design) was developed for each of the proposed bridges. Through coordination with TxDOT and HCFCD, the bridges were designed to accommodate the ultimate channel section of Halls Bayou at I-45, as has been identified in HCFCD's Halls Bayou Vision Plan (Watershed Flood Risk Reduction Study).

15.4 Drainage Crossing Analysis

This study recommends replacing two (2) major drainage crossings under I-45 as listed below:

- Minor Crossing – a non-bridge class culvert located at STA 1631+30: replace 2 – 6' x 3' box culverts with the following:
    - 1 – 6' x 3' RCB from just upstream of the SBFR to the SB Max Lane
    - 2 – 6' x 3' RCB from the SB Max Lane to the NB Max Lane
    - 2 – 8' x 3' RCB from the NB Max Lane to just downstream of the NBFR
- The three (3) Halls Bayou Bridges: replace the existing bridges (approximate span of 160 ft) with three (3) 5 Span – 400 ft. wide bridges to accommodate the ultimate Halls Bayou channel section.

Due to the timing of the two (2) projects (NHHIP and the Halls Bayou Vision Plan) and the NHHIP Segment 1 project likely being constructed prior to the Halls Bayou ultimate channel being in place, an interim condition was assumed in which the ultimate bridges will be constructed at I-45 with an interim condition channel to ensure no adverse impacts to existing conditions along Halls Bayou.

15.5 Roadway Impact Analysis

A roadway impact analysis was completed as part of this study to identify mitigation measures to mitigate the increased runoff from the proposed highway improvements and hydraulic system changes due to the proposed storm drainage improvements for Segment 1. The following table outlines the mitigation measures provided and a summary of the detention volumes associated with each outfall. Note that in **Table 28**, System A is not shown as it is being modeled by TNP.

Table 28 – Detention Mitigation Summary Table

Outfall Region ID	Mitigation Provided By	Net Change in Drainage Area	In-Line Storage Provided	Offline Storage Provided	Total Storage Provided	Offline Storage Required
(--)	(--)	(ac)	(ac-ft)	(ac-ft)	(ac-ft)	(ac-ft)
B	-Drainage Area Redirection -In-line Storage	-7.50	0.07	-	0.07	0.00
C	-Drainage Area Redirection -In-Line Storage -Offline Storage	-8.40	0.69	5.87	6.56	0.00
D	-Drainage Area Redirection	-7.10	-0.19	-	-0.19	0.00
E	-In-Line Storage -Offline Storage	23.00	5.38	12.00	17.38	12.00
Totals	**(--)**	**0.00**	**5.95**	**17.87**	**23.82**	**12.00**

15.6 Floodplain Impact Analysis

A floodplain impact analysis was completed along I-45 to determine the preliminary floodplain storage mitigation needs for the proposed roadway improvements within the Halls Bayou watershed. **Table 29** below summarizes the net cut and fill volumes associated with the proposed roadway.

Table 29 – NHHIP Segment 1 Cut and Fill Volumes

Roadway	Cut Volume	Fill Volume	Net Volume
(--)	(ac-ft)	(ac-ft)	(ac-ft)
Southbound Frontage Road	0.1	29.9	29.8
Mainlanes	0.0	82.7	82.7
Northbound Frontage Road	1.8	25.1	23.3
Total	**1.9**	**137.7**	**135.8**

15.7 Detention Basin Design

Two detention ponds were designed as part of this study – Detention Pond C and Detention Pond E. Detention Pond C is proposed to be located just west of I-45 and north of P118-27-01. This pond will serve to provide mitigation volume for System C. The pond will provide approximately 5.9 ac-ft of storage volume.

Detention Pond E is proposed just east of I-45 and north of Halls Bayou to provide the necessary volume to mitigate the NHHIP improvements at Outfall E. This includes the required volume associated with the roadway and floodplain impacts. This basin has been designed through coordination with TxDOT and HCFCD and is to be located within the area identified by HCFCD for a future regional detention basin servicing Halls Bayou. Detention Pond E will provide the required storage volume of 147.8 ac-ft needed for System E (roadway improvement and floodplain fill mitigation).

15.8 ROW Considerations

Extensive coordination with HCFCD will be needed at Halls Bayou where Detention Pond E is proposed. If HCFCD does not acquire the necessary properties in a timely manner, TxDOT may need to acquire additional ROW to be able to construct Detention Pond E when the construction of the NHHIP Segment 1 begins.

15.9 Environmental Considerations

Because channel work below the ordinary highwater mark (OHM) is being proposed within the TxDOT ROW at Halls Bayou, an Individual Permit (IP) may be required by the United States Army Corps of Engineers (USACE). Extensive coordination will be needed with both USACE and HCFCD.

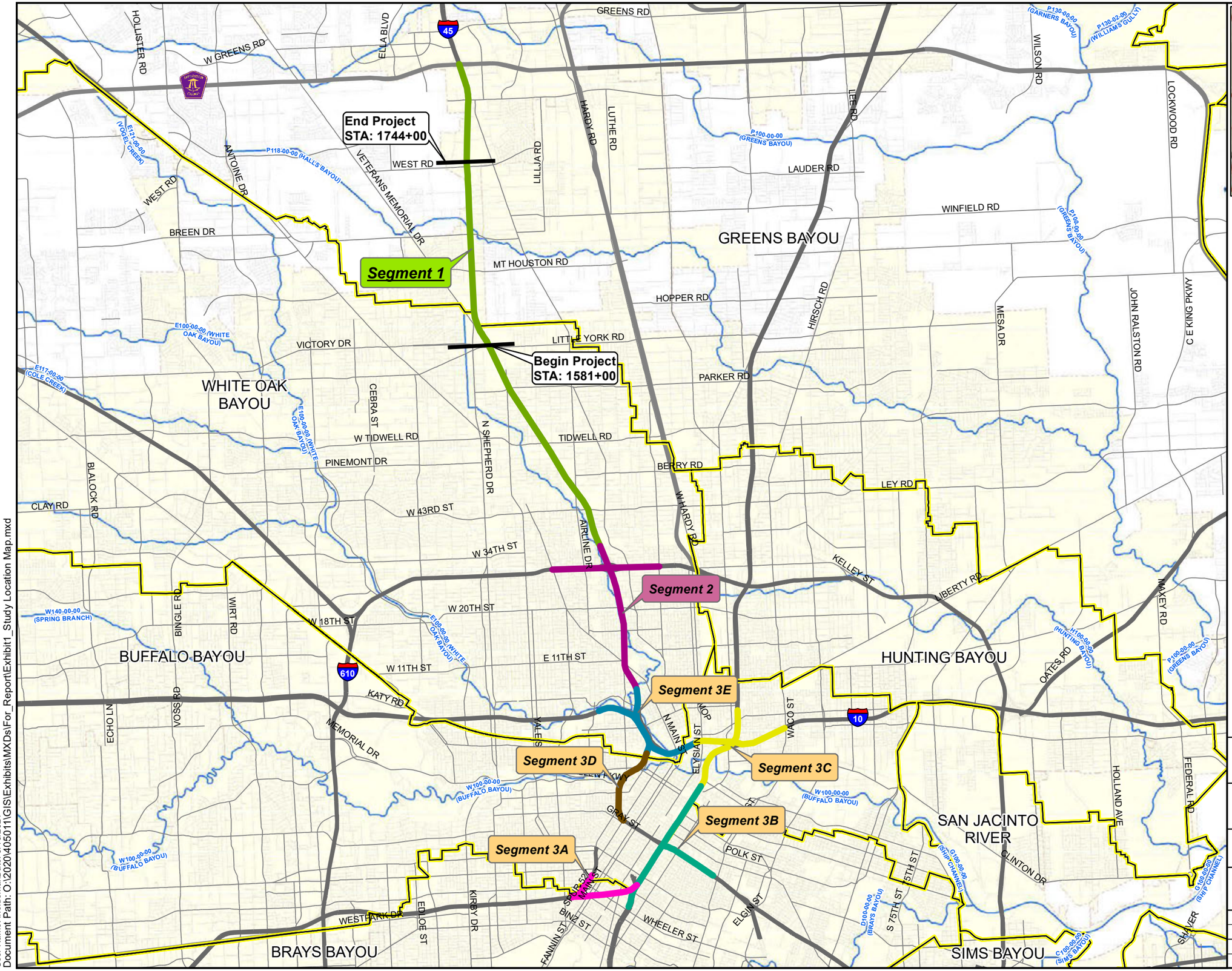
15.10 Summary

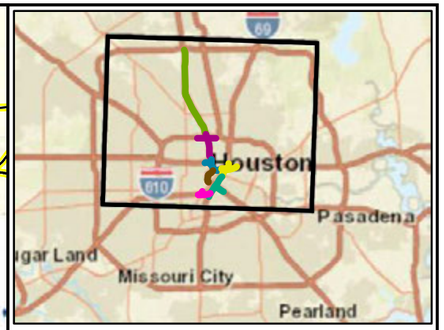
The proposed trunkline drainage systems were designed to ensure the mainlanes and max lanes would not be inundated during a 100-year storm event and the frontage roads would not be inundate during a 10-year storm event.

There are several potential conflicts with existing utilities (water, sewer, gas and electrical) as noted in the study. It is recommended that a subsurface utility survey be performed to verify all existing utilities.

A preliminary drainage cost was prepared for the proposed trunkline drainage components. The cost estimate includes a proposed culvert replacement, storm sewers, detention ponds, storm sewer and culvert removals, bridges and channel modifications. The total preliminary drainage cost is $53 million, which assumes TxDOT will construct the ultimate bridges at Halls Bayou and provide additional mitigation volume underneath the Halls Bayou bridges. If TxDOT were to move forward with the Halls Bayou bridge design, as outlined in the schematic, the total preliminary drainage cost is $44 million. Both preliminary cost estimates include a 20% contingency.

Based on the mitigation analysis presented in this study, the proposed roadway and storm drainage improvements for NHHIP Segment 1, from South of Shepherd Drive to South of West Road, will not adversely impact existing conditions for storm events up to and including the 100-year (Atlas 14) and the 500-year storm (Pre-Atlas 14).





LEGEND

- Project Limit
- HCFCD Stream
- Segment 1
- Segment 2
- Segment 3A
- Segment 3B
- Segment 3C
- Segment 3D
- Segment 3E
- City of Houston
- HCFCD Watershed

0 4,000 8,000

Basemap: H-GAC STAR Map

N

CivilTech Engineering, Inc.
11750 Katy Fwy, Suite 1260
Houston, Texas 77079
Tel: 346-409-2067
Fax: 281-304-0210

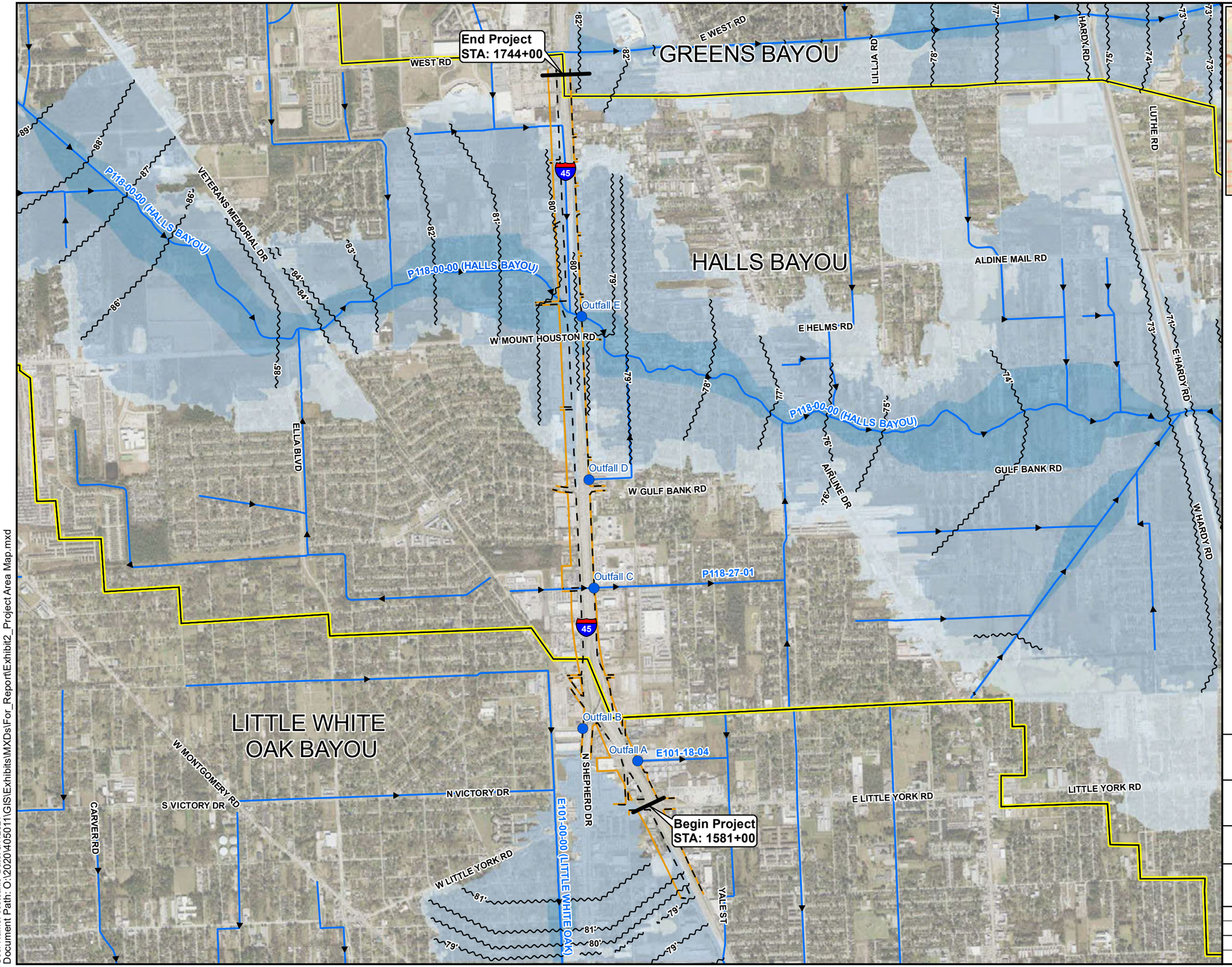
Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Study Location Map

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	1

User Name: iholdemanDate: 6/16/2021
Document Path: O:\2020\405011\GIS\Exhibits\MXDs\For_Report\Exhibit1_Study Location Map.mxd



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Fax: 281-304-0210

Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Project Area Map

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	2

User Name: ccotsakis Date: 5/7/2021
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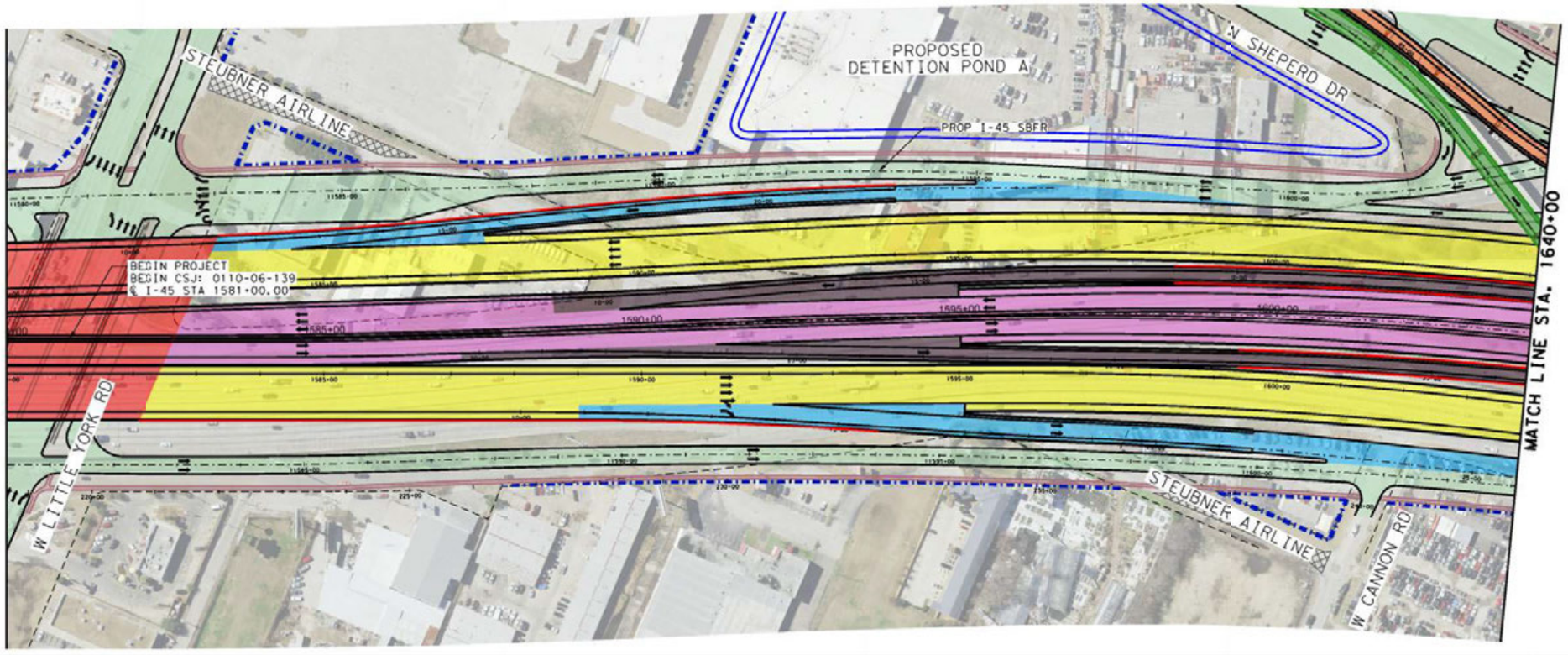

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
- 10-YR WSEL
- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
- RECOMMENDED PROFILE ADJUSTMENT

NOTES:
PROPOSED ROADWAY PROFILE BASED ON TXDOT NHHIP SEGMENT 1 SCHEMATIC.

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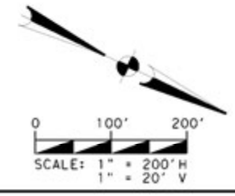
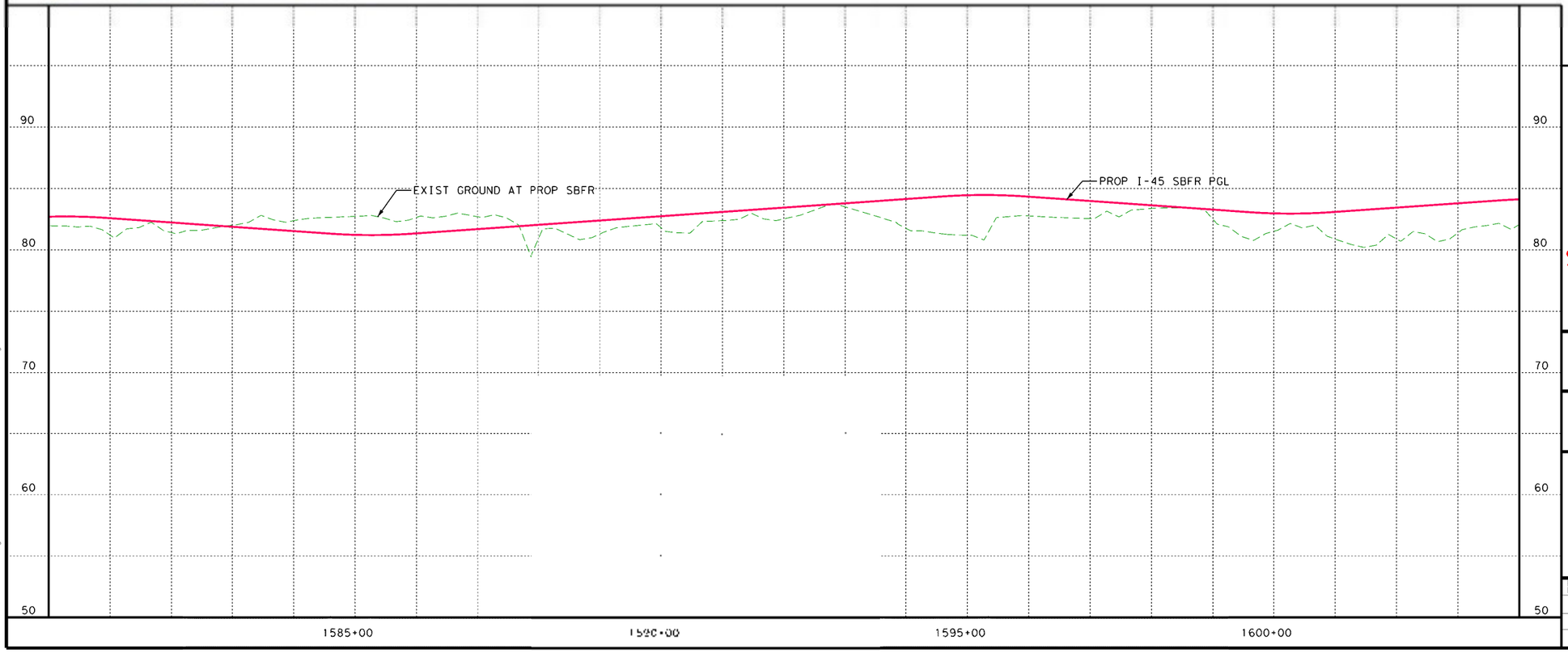
WATER SURFACE ELEVATIONS OBTAINED FROM HEC-RAS CORRECTED EFFECTIVE MODEL FOR HALLS BAYOU, HCFCD UNIT MODEL FILENAME: P118-00-00.PRJ





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SUBJECT TO CHANGE

CivilTech Engineering Inc.
11821 Telge Road
Cypress, Texas 77429
(281)304-0200 Fax:(281)304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1
ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE
ROAD SOUTHBOUND

SEPT 2020 SHEET 1 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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LEGEND

- PROPOSED ROW
- EXISTING ROW
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- 500-YR WSEL
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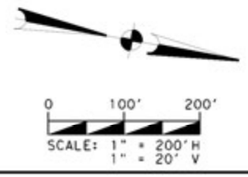

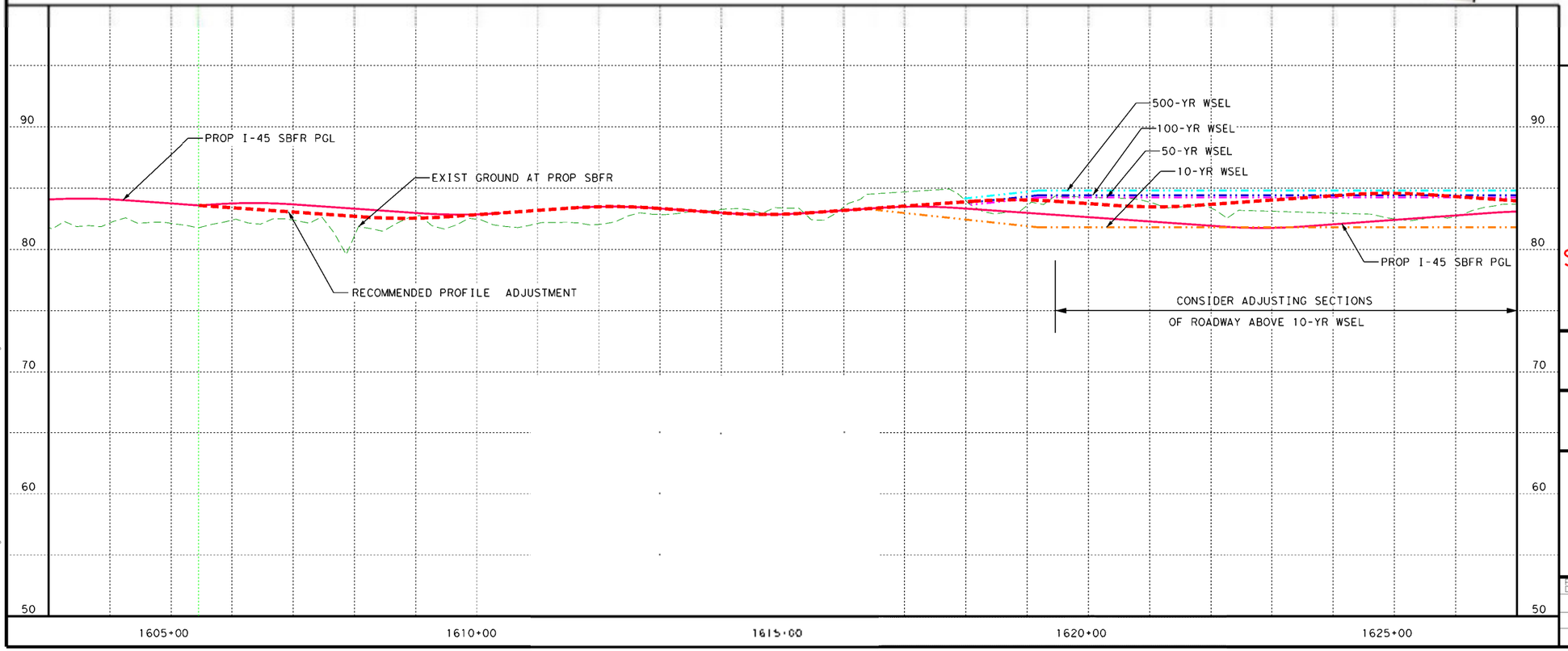

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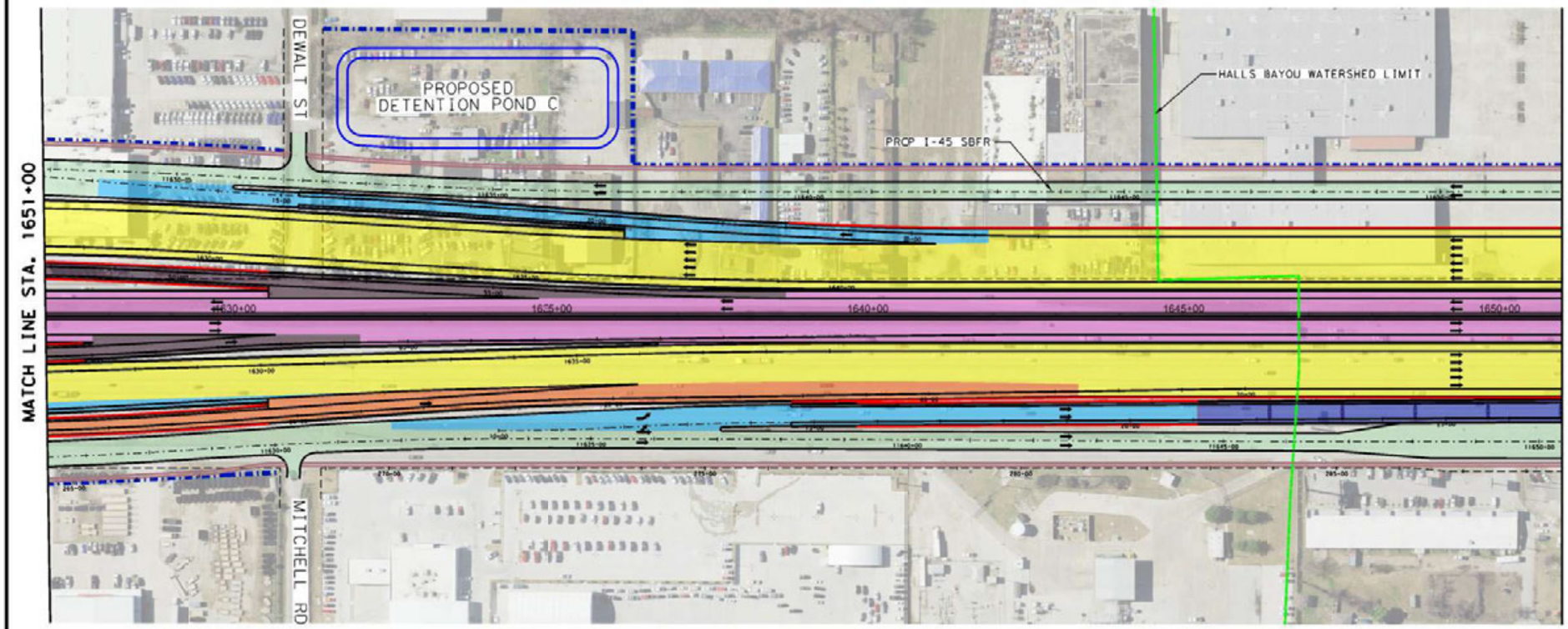
ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD SOUTHBOUND

SEPT 2020 SHEET 2 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1



LEGEND

- PROPOSED ROW
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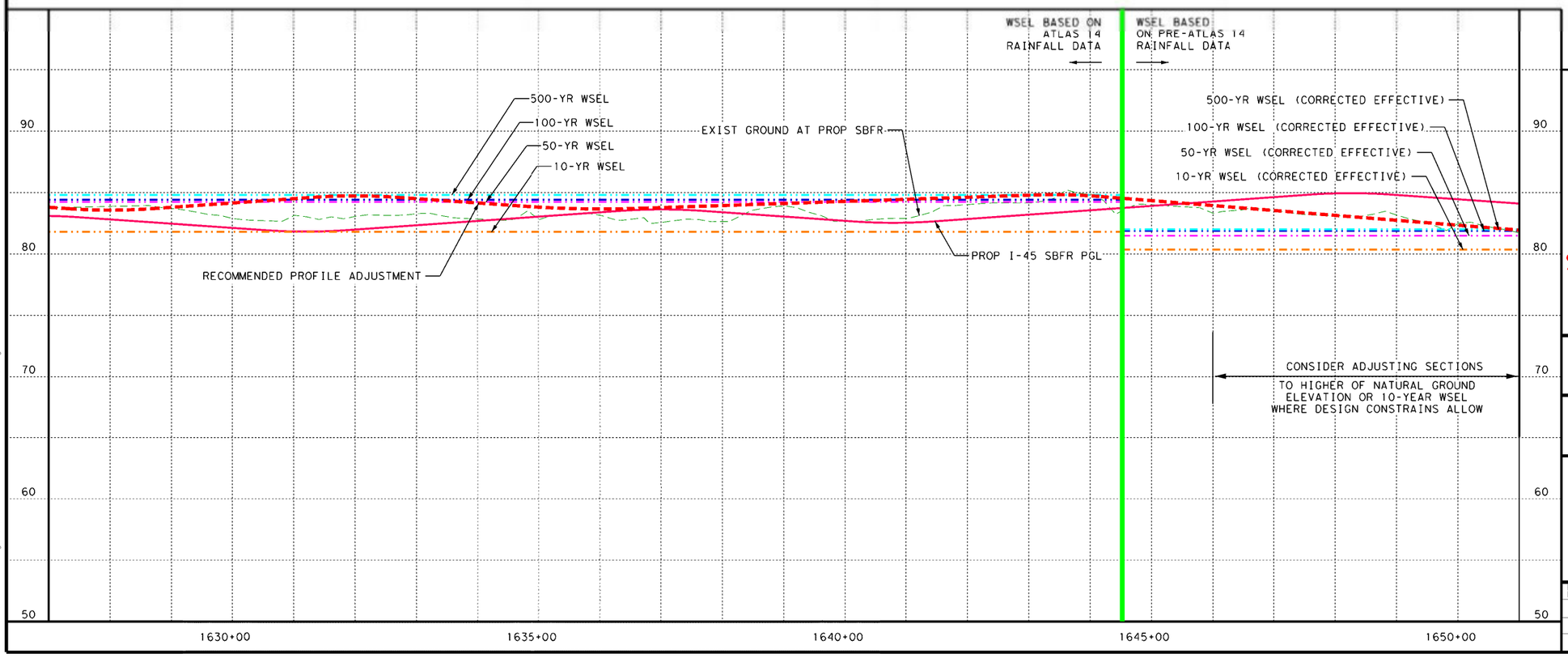

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SCALE: 1" = 200' H
1" = 20' V

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I-45 FRONTAGE ROAD SOUTHBOUND

SEPT 2020 SHEET 3 OF 8

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6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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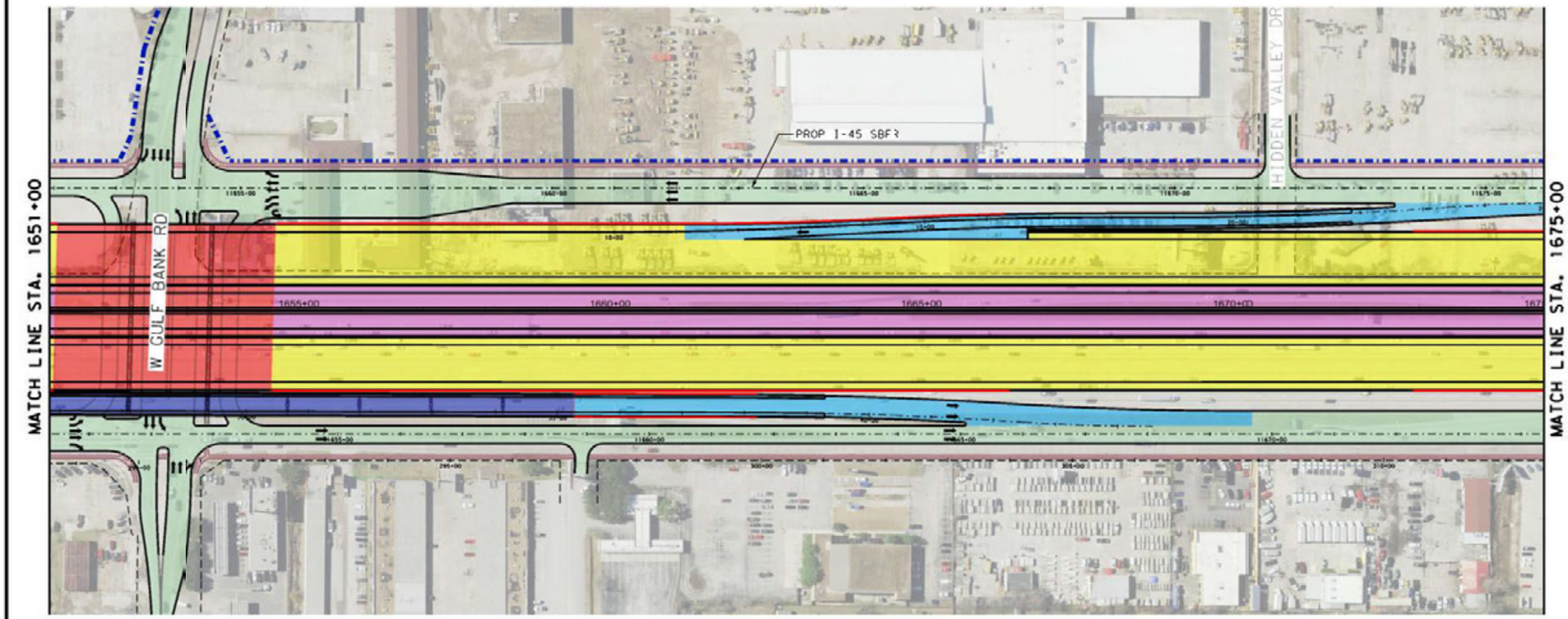

LEGEND

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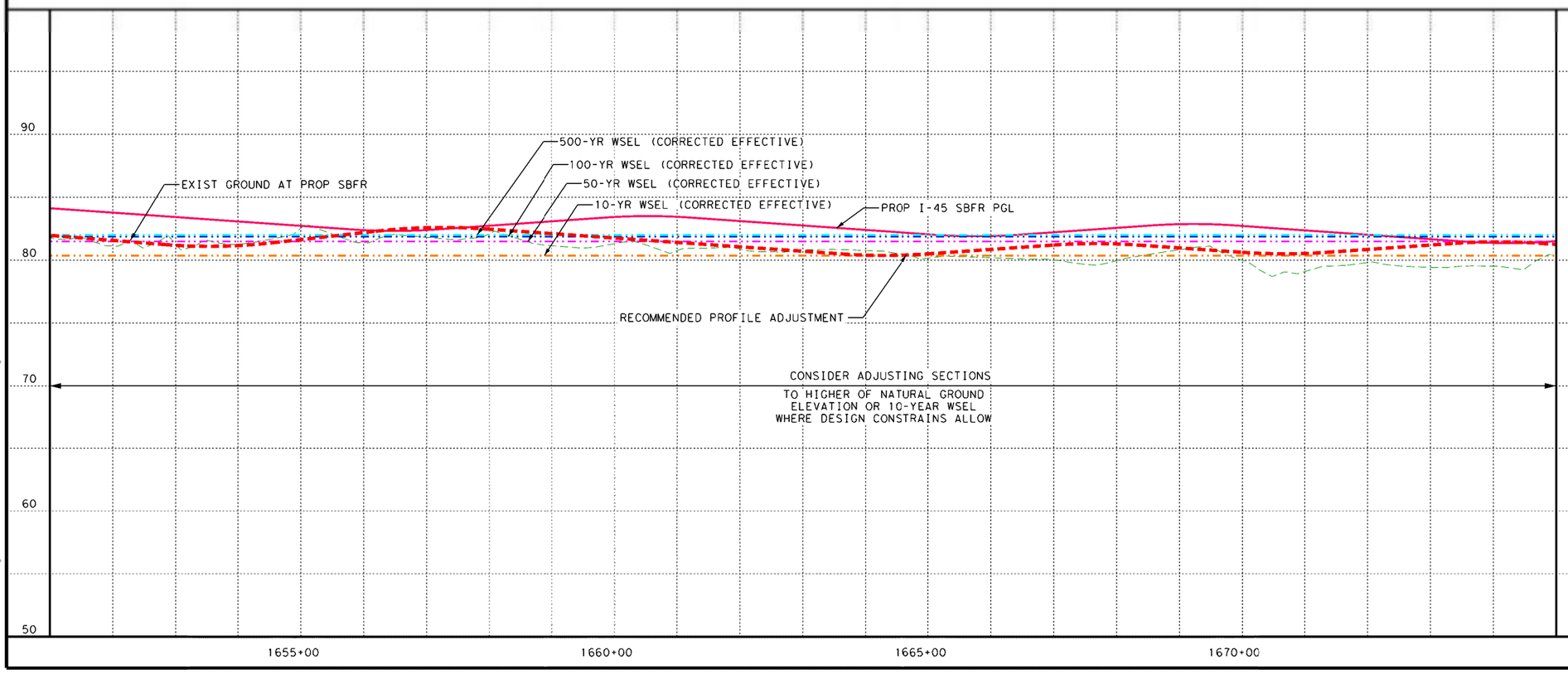

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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD SOUTHBOUND

SEPT 2020 SHEET 4 OF 8

FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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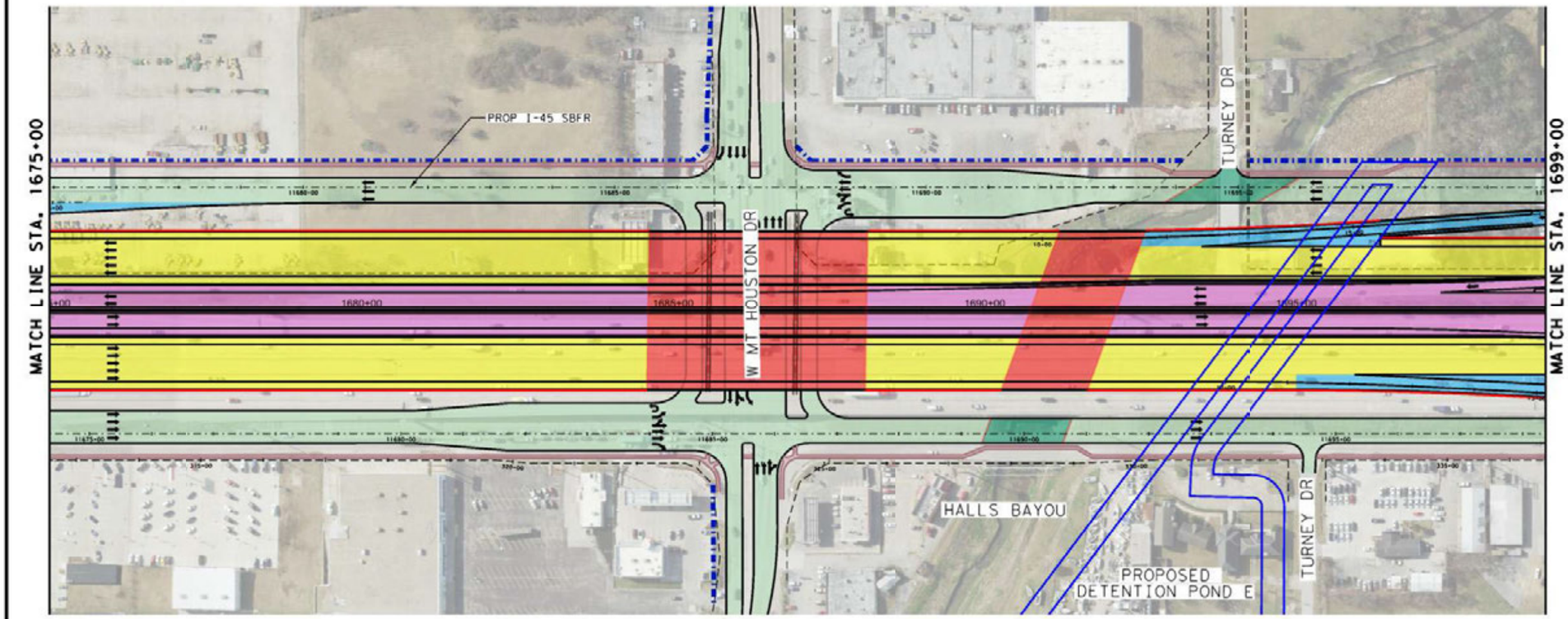

LEGEND

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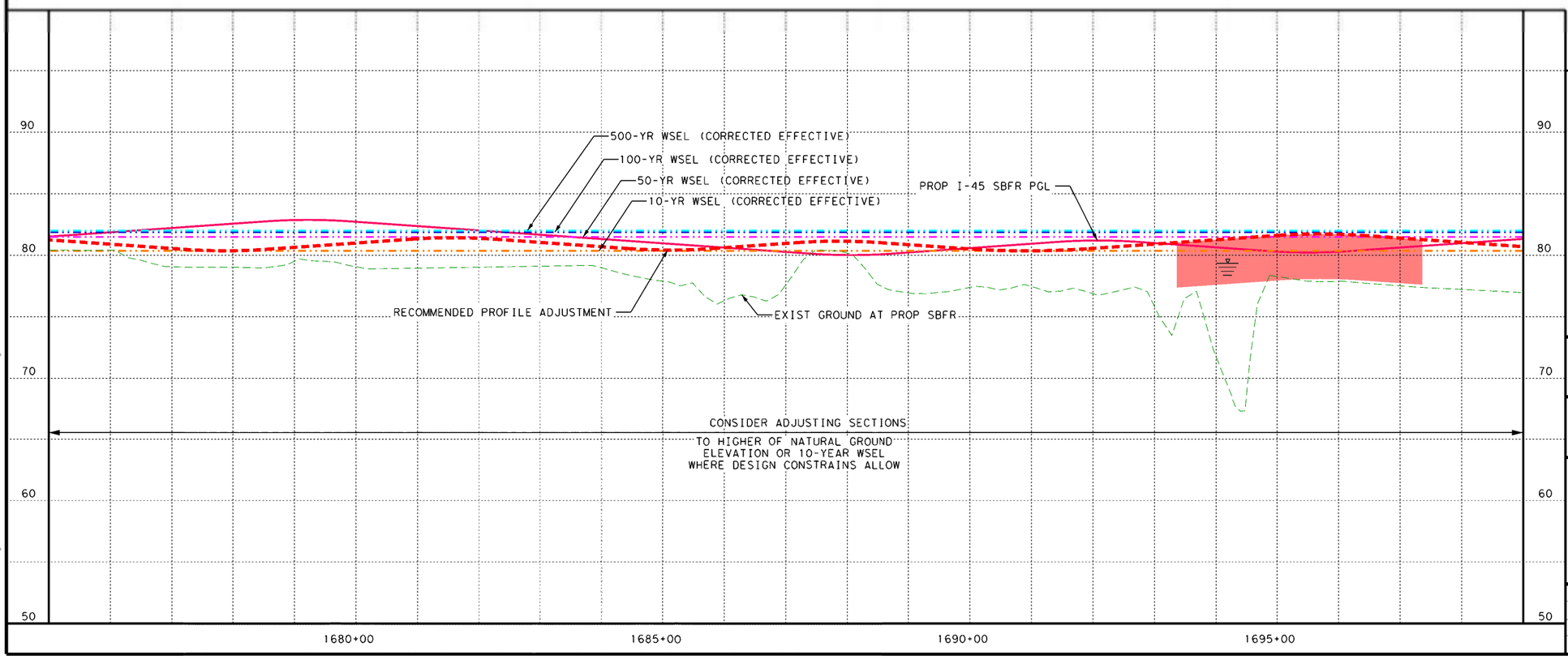

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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE
ROAD SOUTHBOUND

SEPT 2020 SHEET 5 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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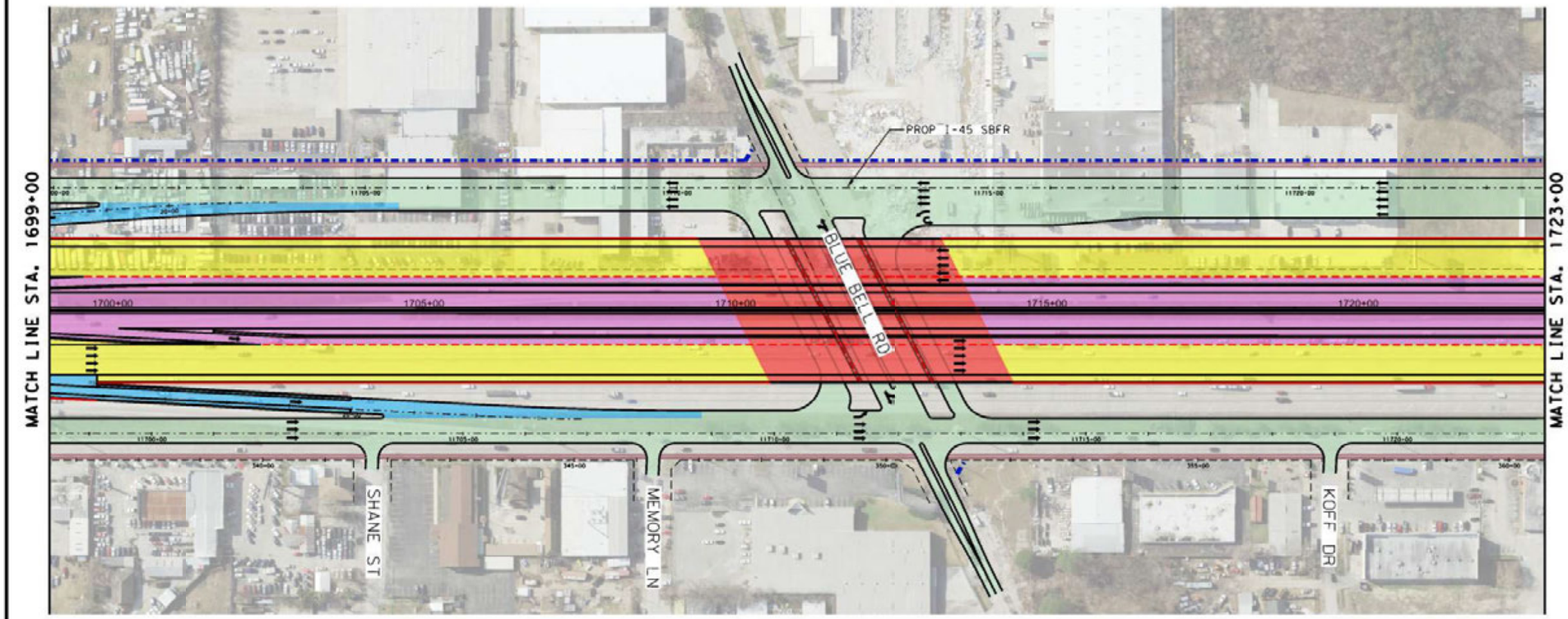

LEGEND

- PROPOSED ROW
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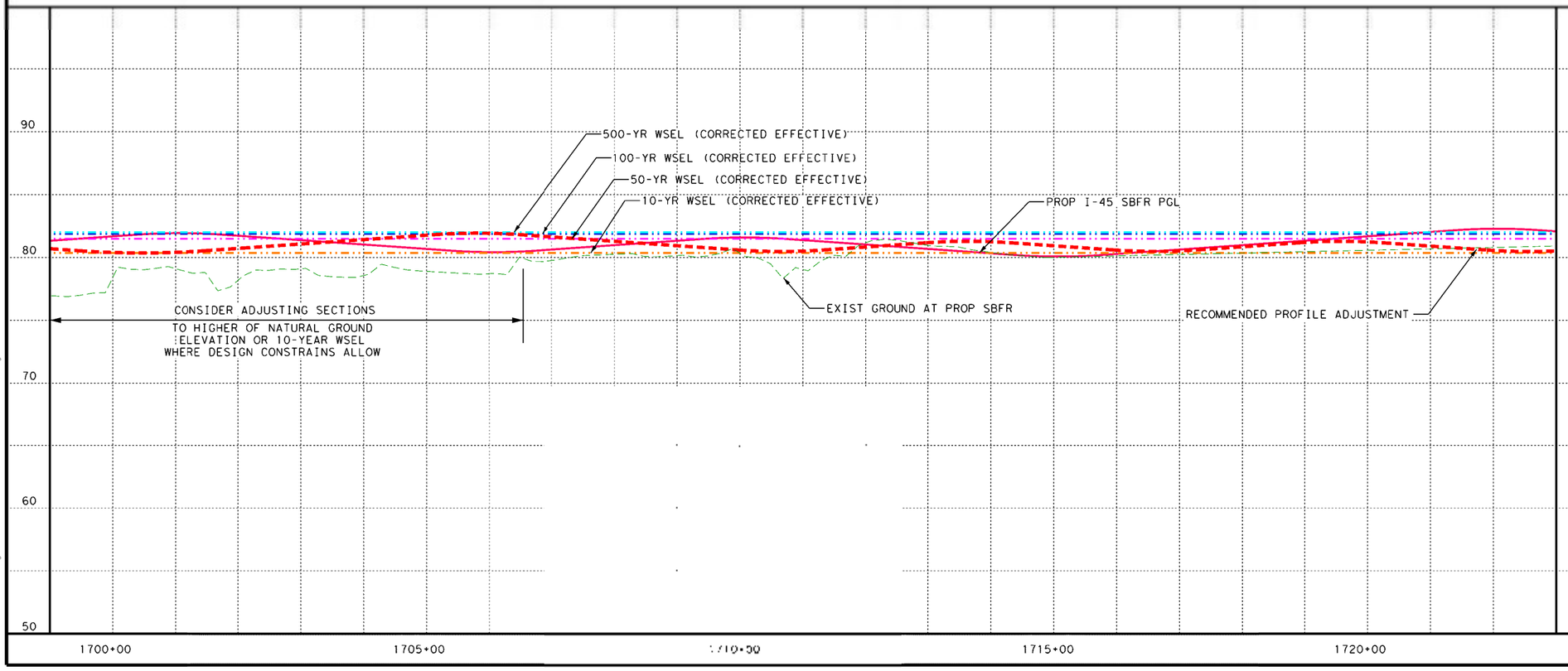

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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD SOUTHBOUND

SEPT 2020 SHEET 6 OF 8

FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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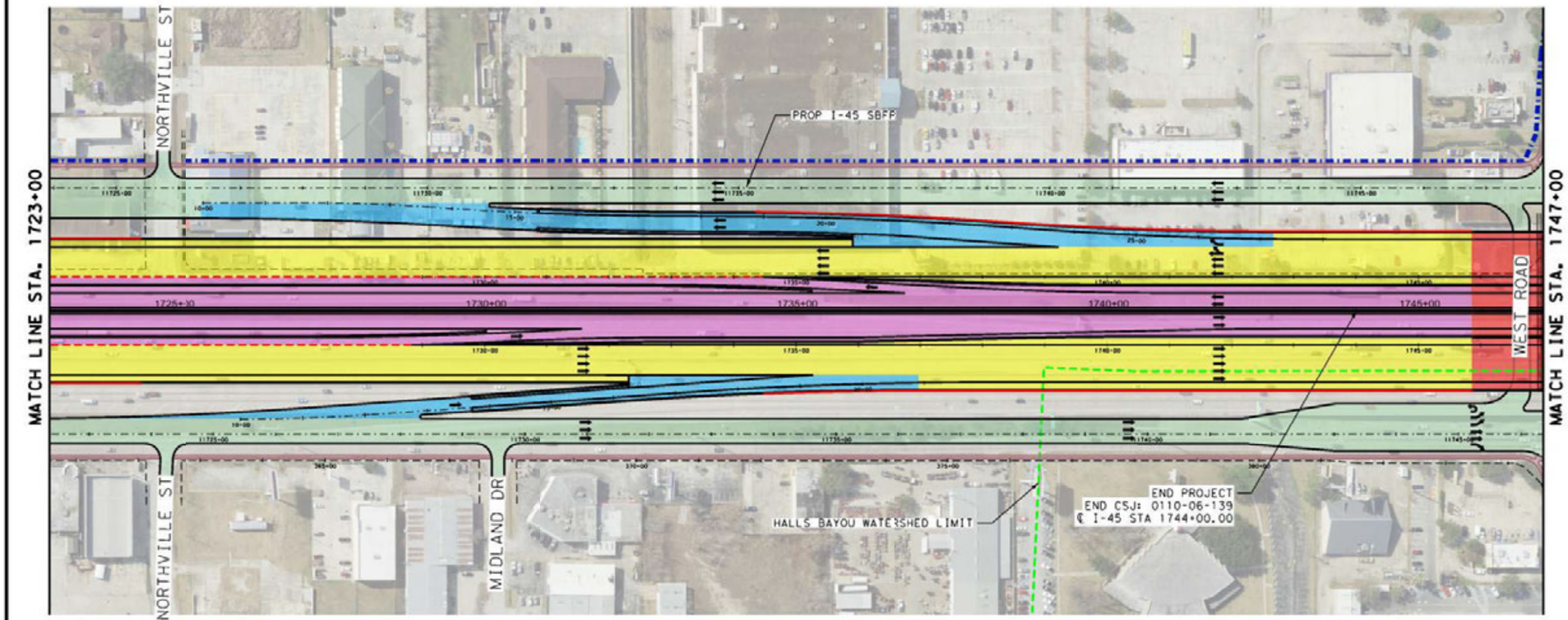

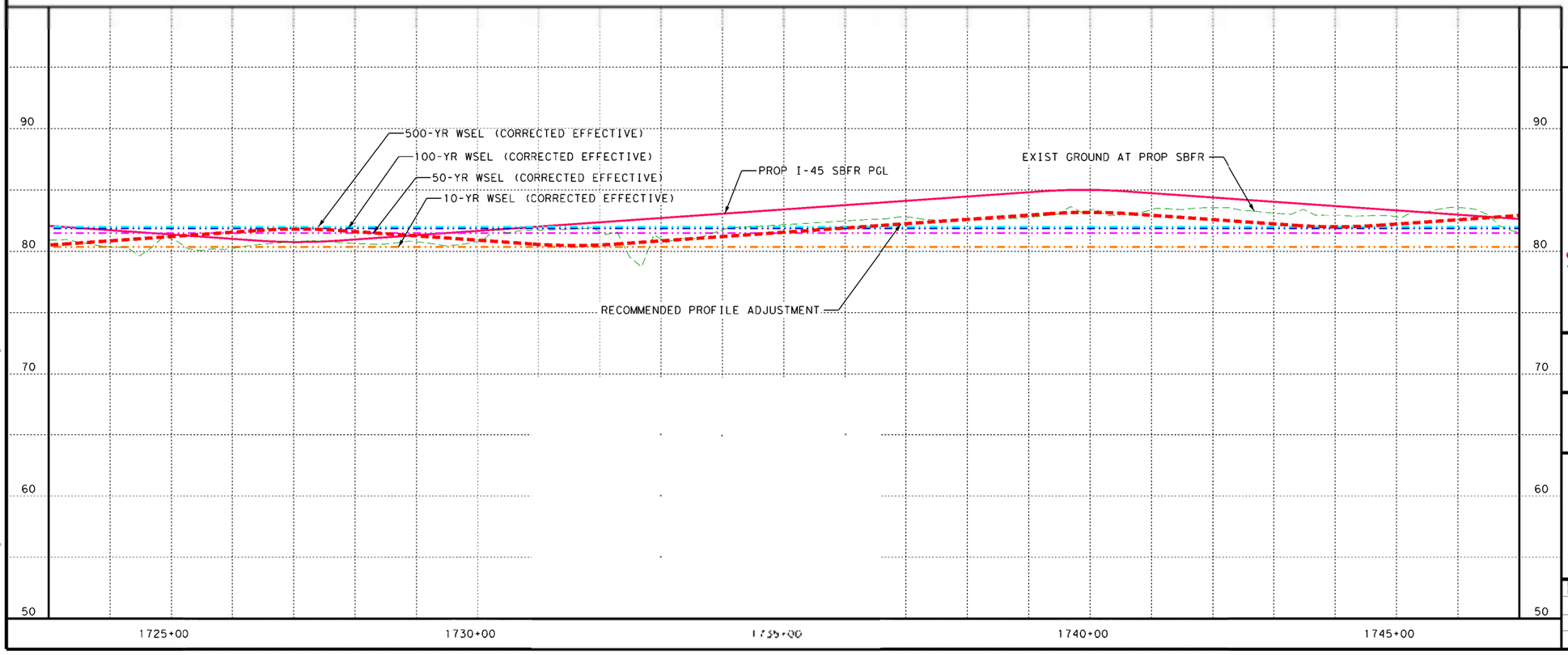

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
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I-45 FRONTAGE ROAD SOUTHBOUND

SEPT 2020 SHEET 7 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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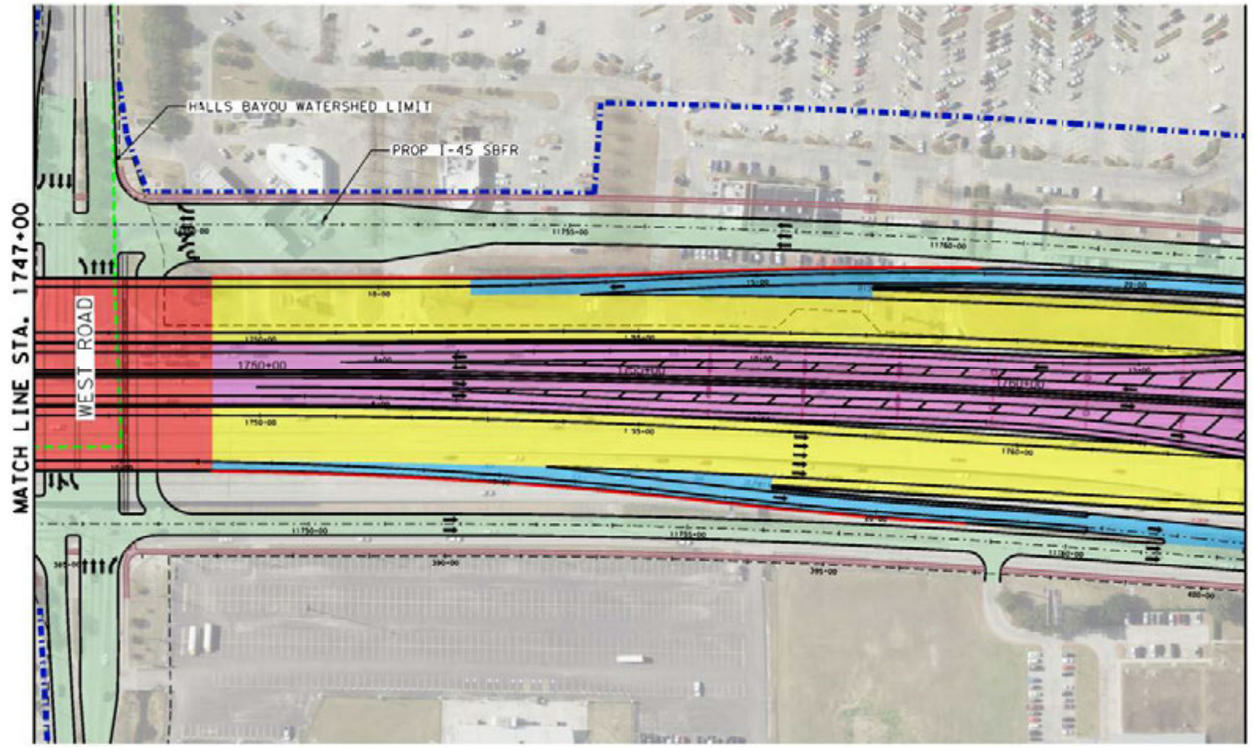

LEGEND

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- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
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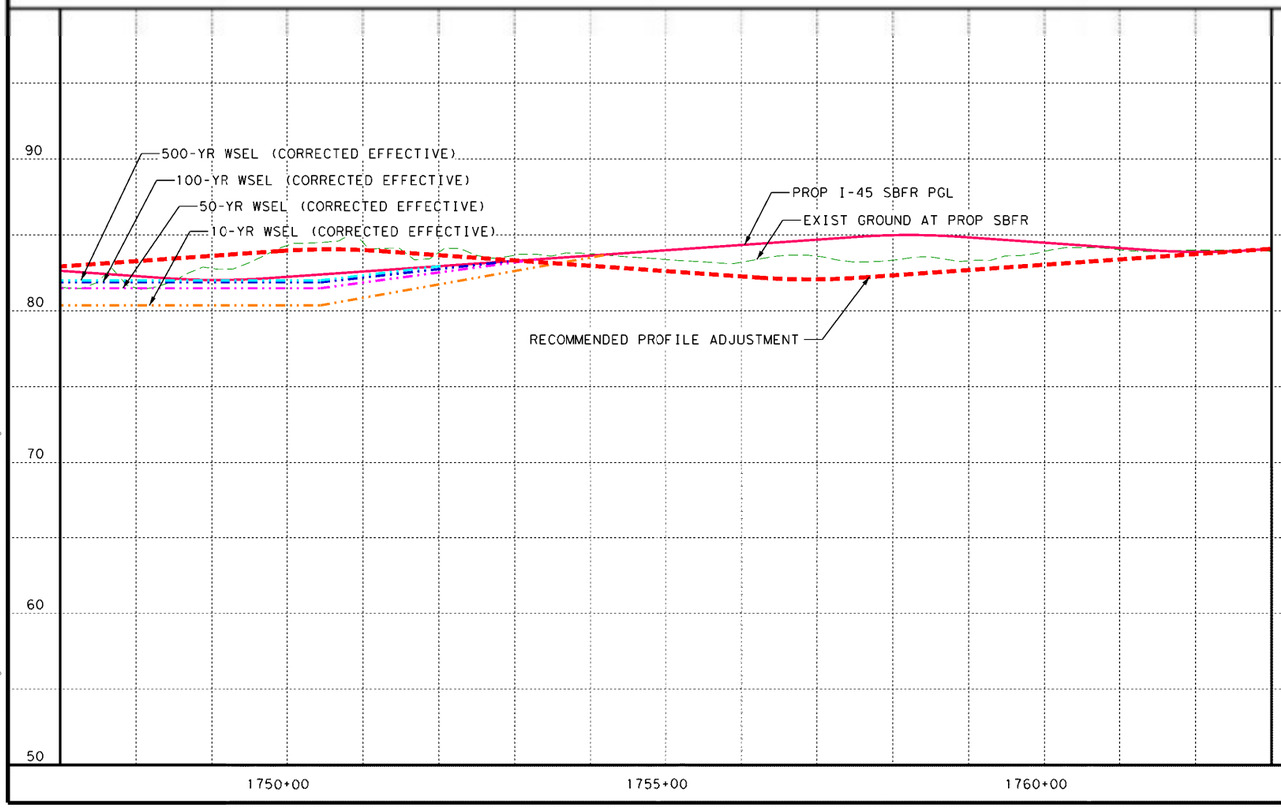

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I-45 FRONTAGE ROAD SOUTHBOUND

SEPT 2020 SHEET 8 OF 8

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6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-1

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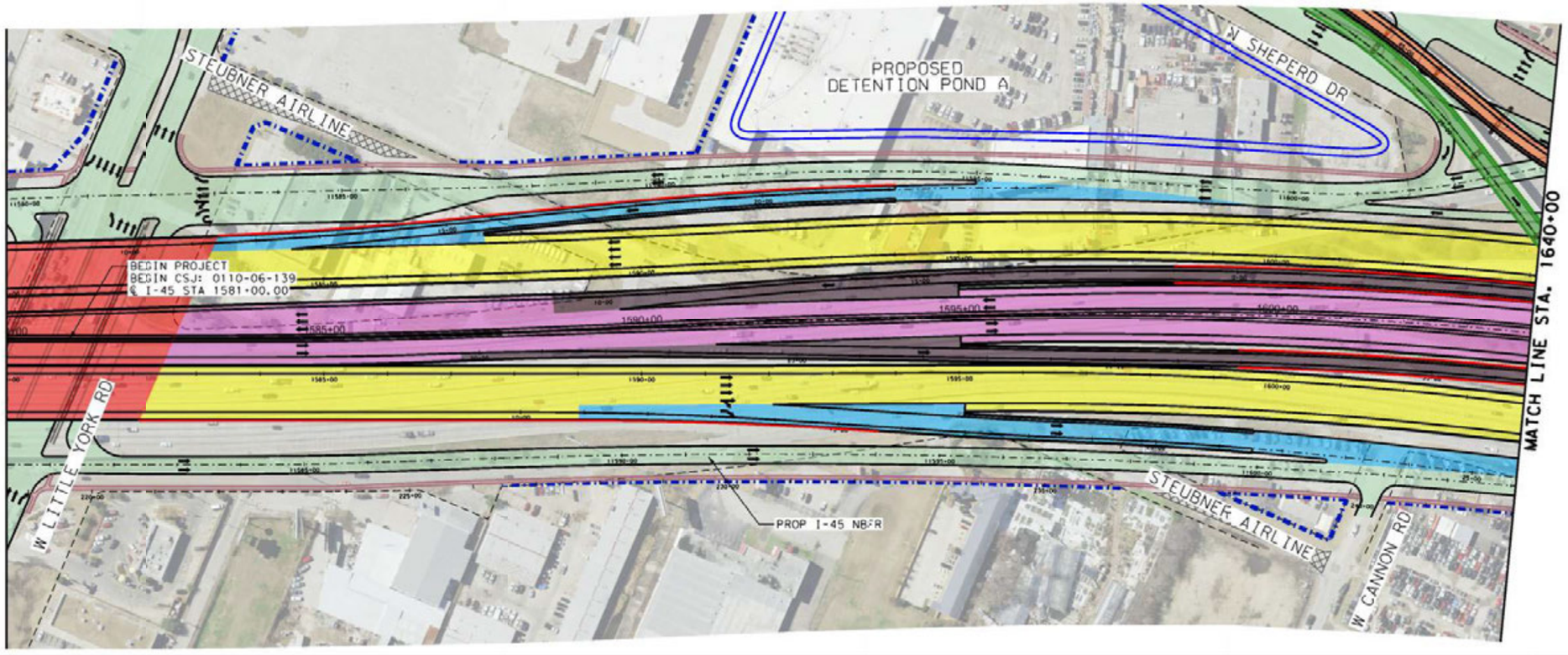

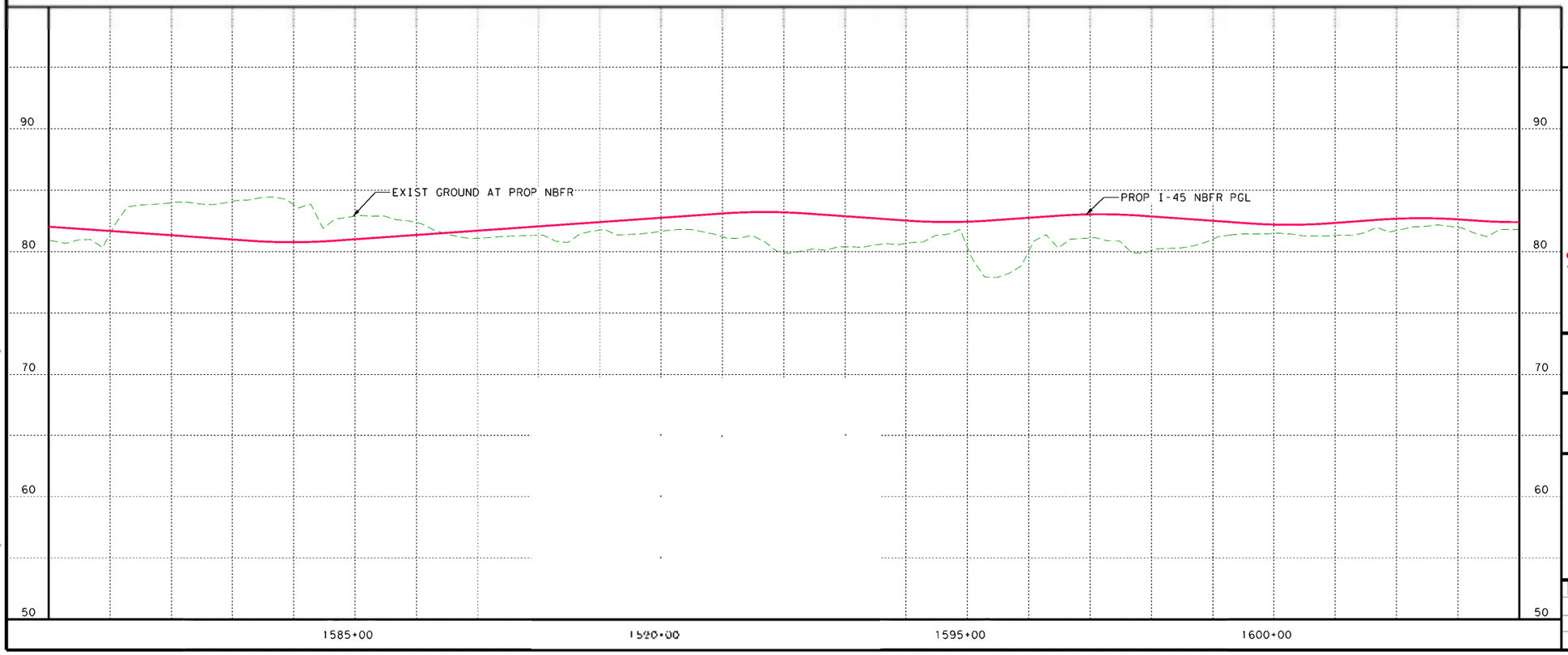

LEGEND

- PROPOSED ROW
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- MINOR CROSSING DA LIMIT
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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 1 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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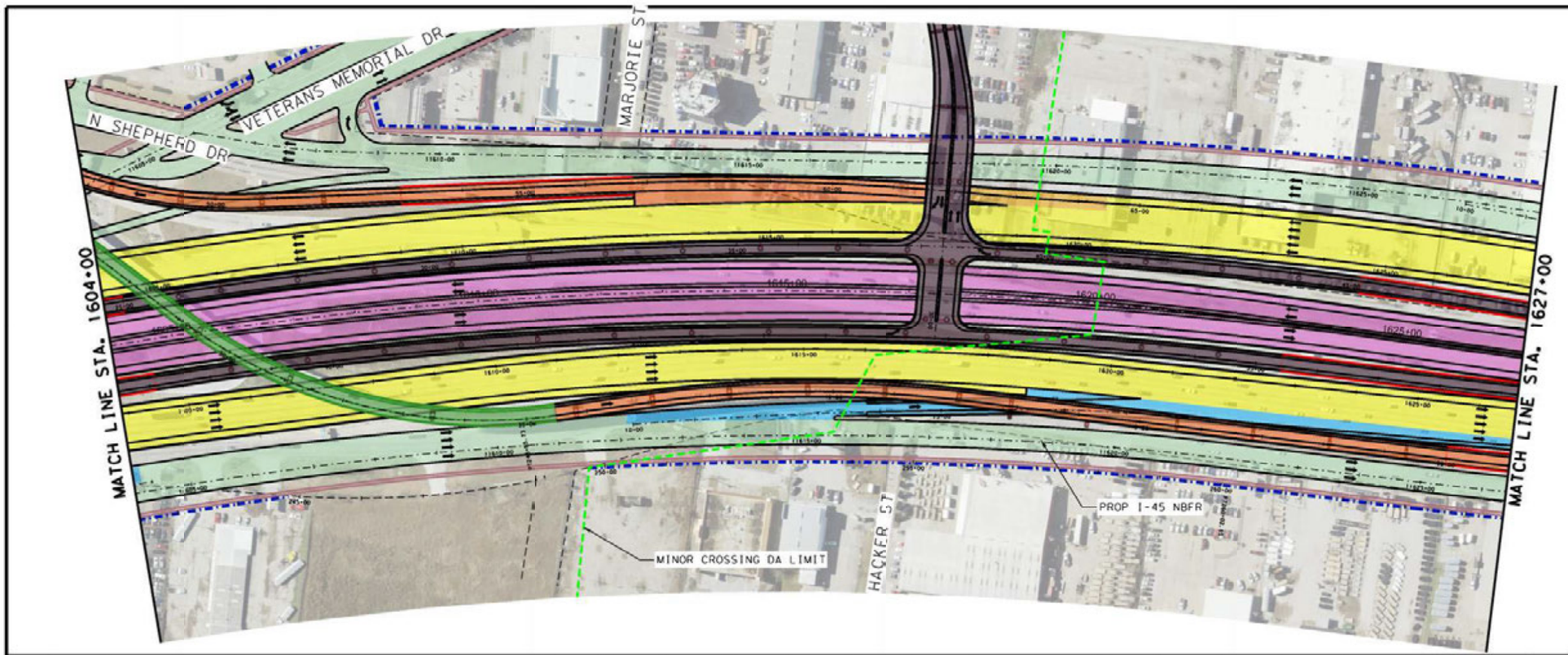

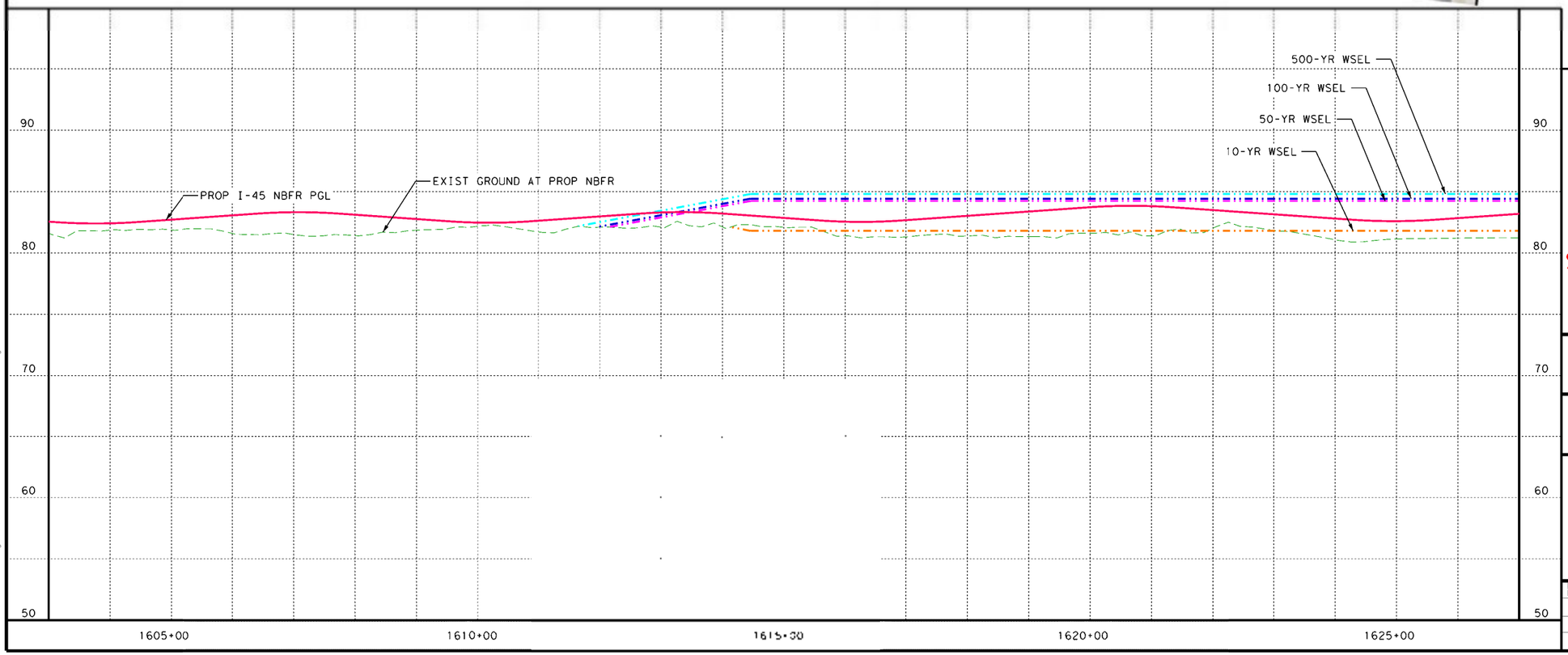

LEGEND

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1" = 20' V

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PRELIMINARY
SUBJECT TO CHANGE

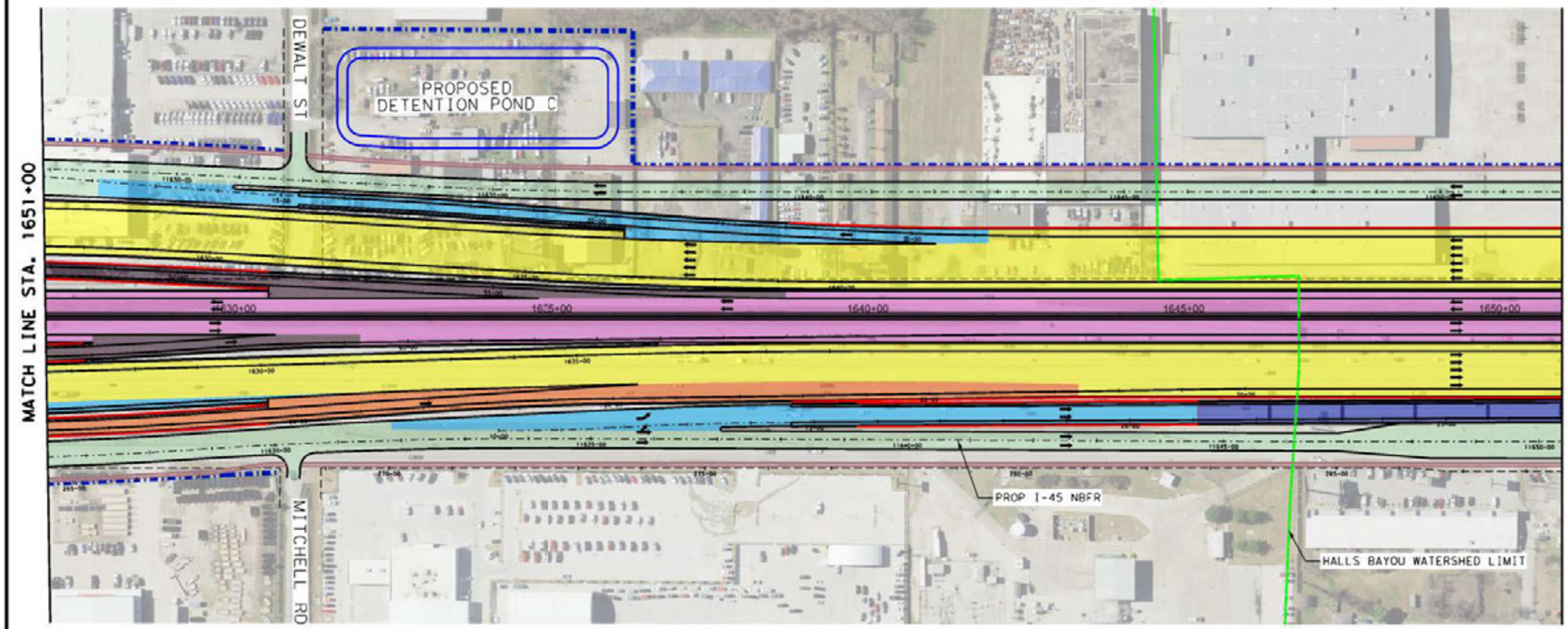
CivilTech Engineering Inc.
11821 Telge Road
Cypress, Texas 77429
(281)304-0200 Fax:(281)304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1
ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 2 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2



LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
- 10-YR WSEL
- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
- RECOMMENDED PROFILE ADJUSTMENT

NOTES:
PROPOSED ROADWAY PROFILE BASED ON TXDOT NHHIP SEGMENT 1 SCHEMATIC.

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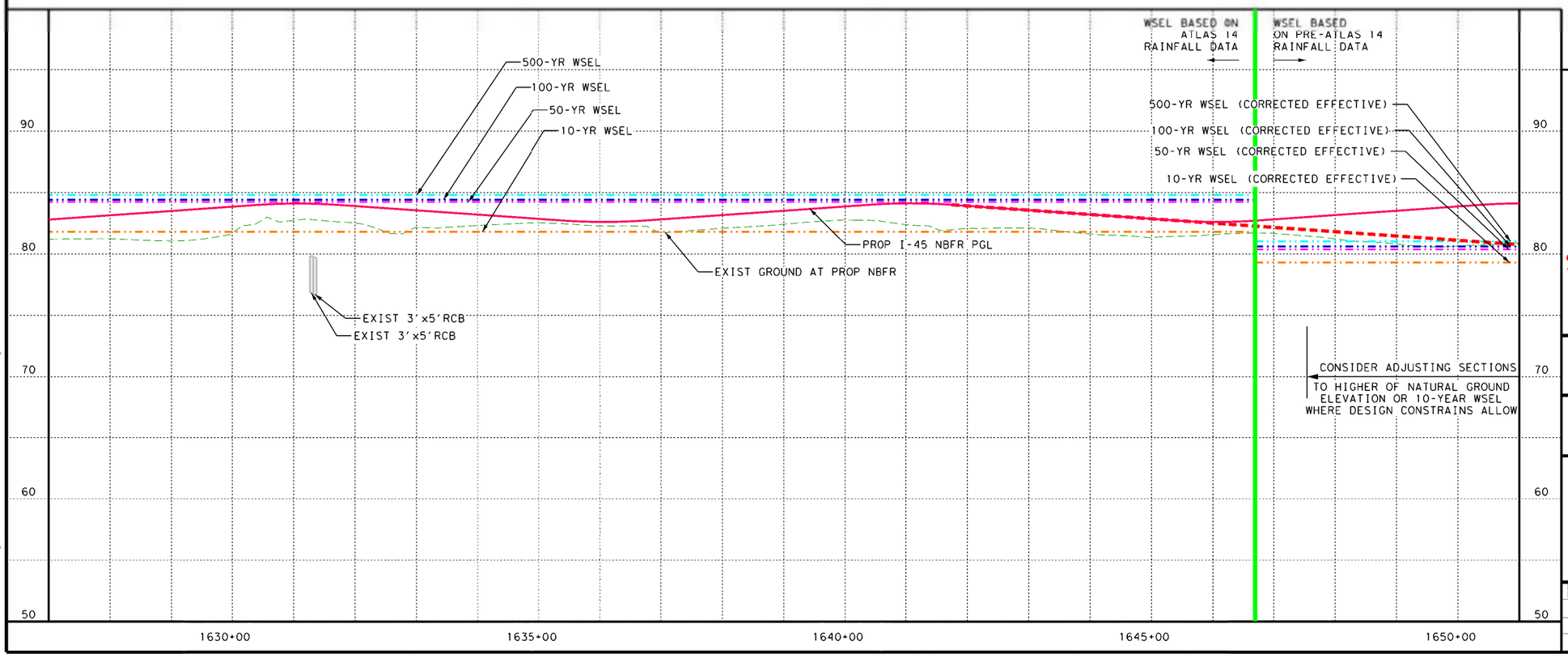
WSEs AT MINOR CROSSING (STA 1631+00) ARE BASED ON ATLAS 14 RAINFALL DATA

WATER SURFACE ELEVATIONS OBTAINED FROM HEC-RAS CORRECTED EFFECTIVE MODEL FOR HALLS BAYOU, HCFCD UNIT MODEL FILENAME: P118-00-00.PRJ



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I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 3 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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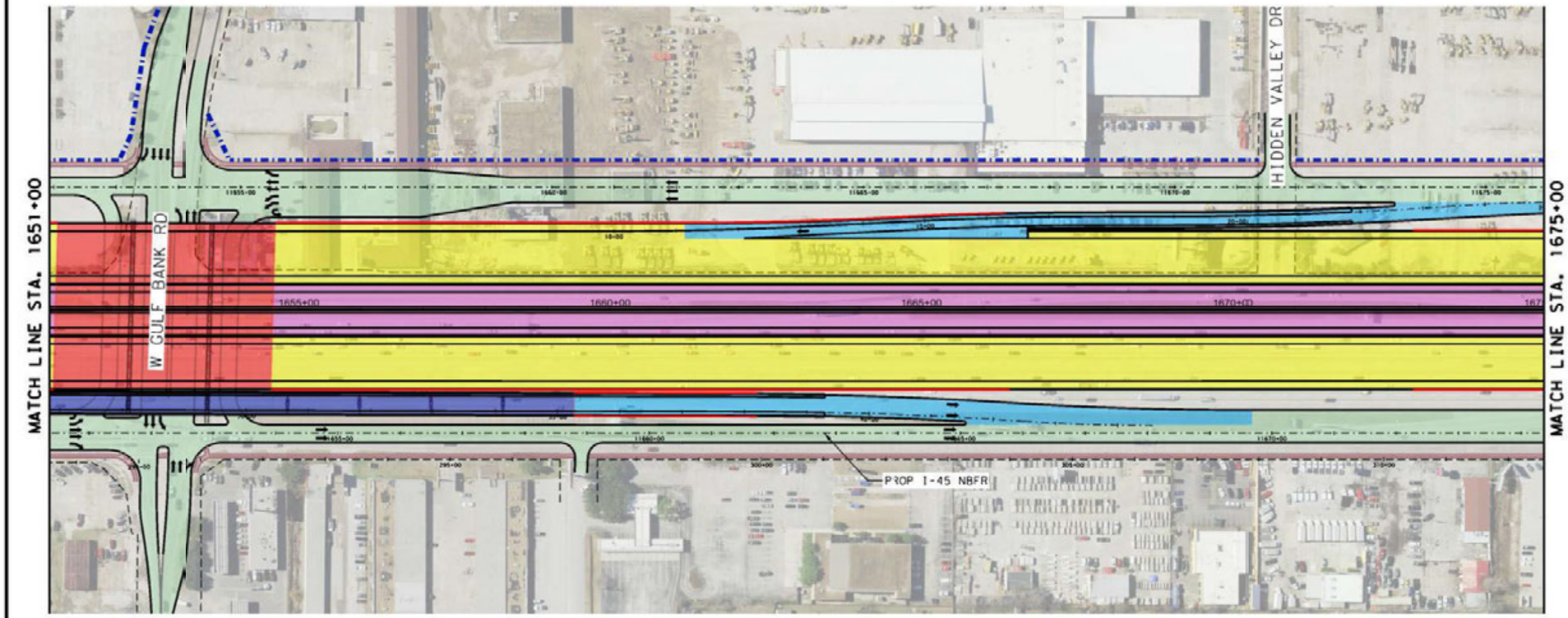

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
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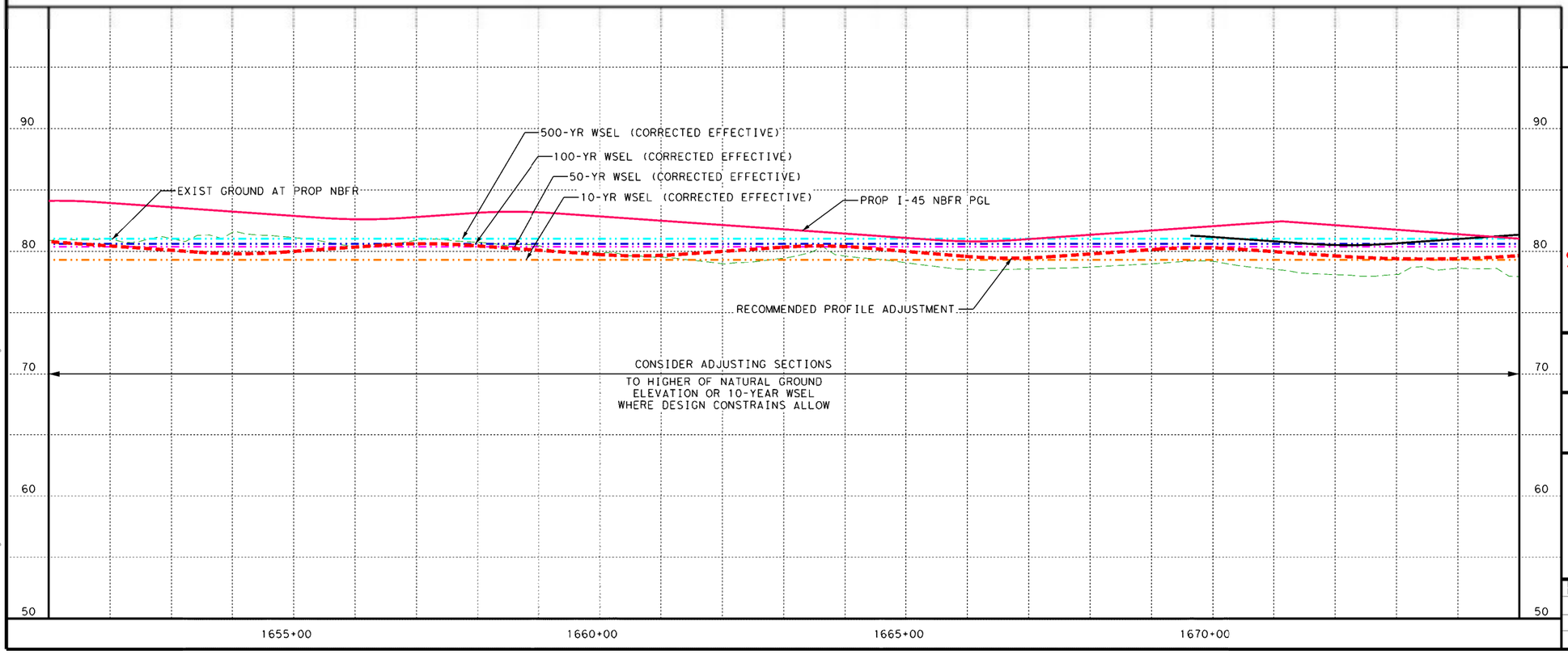

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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 4 OF 8

FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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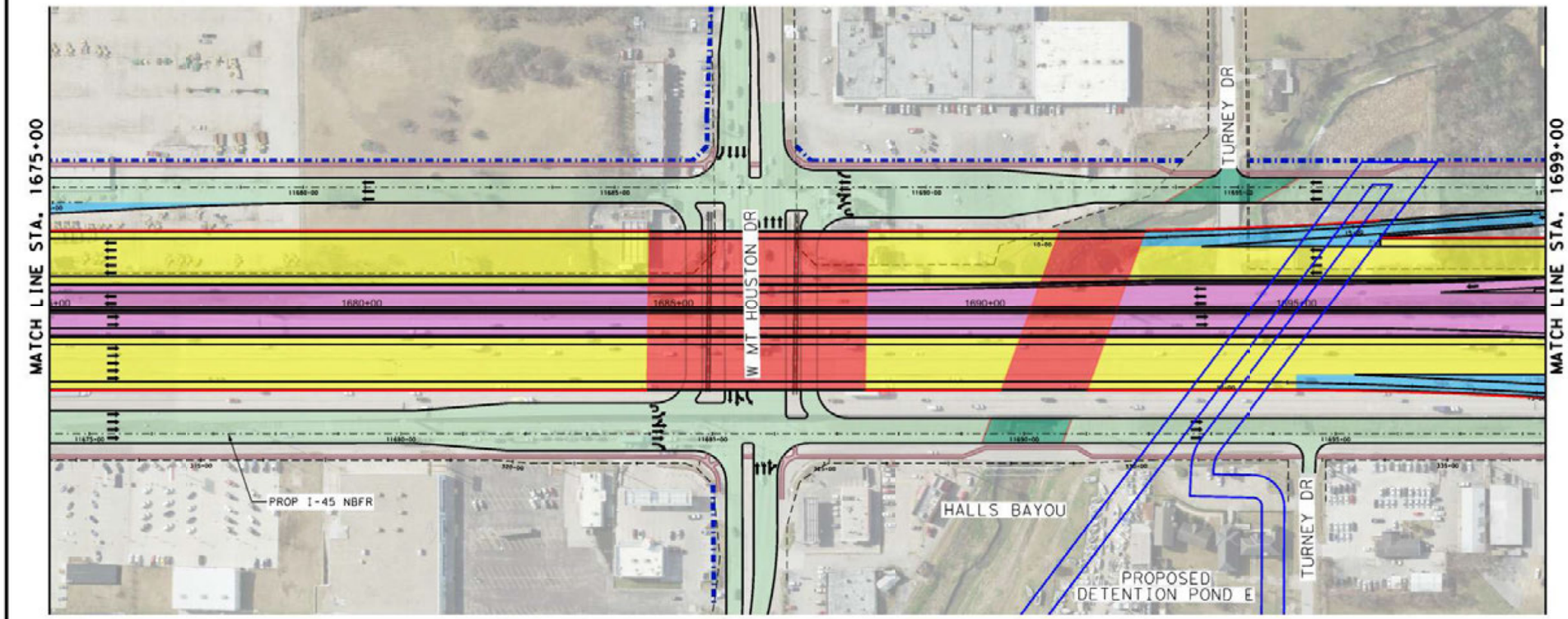

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
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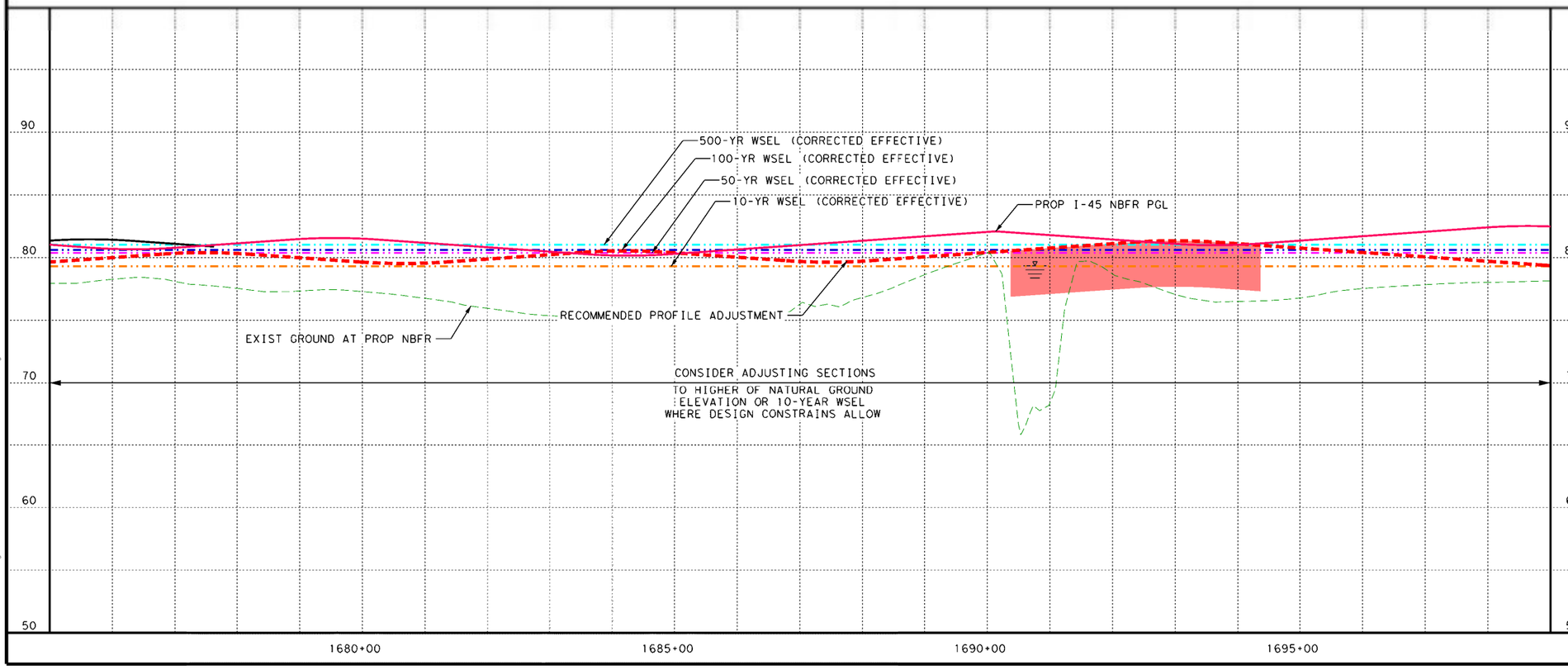

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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 5 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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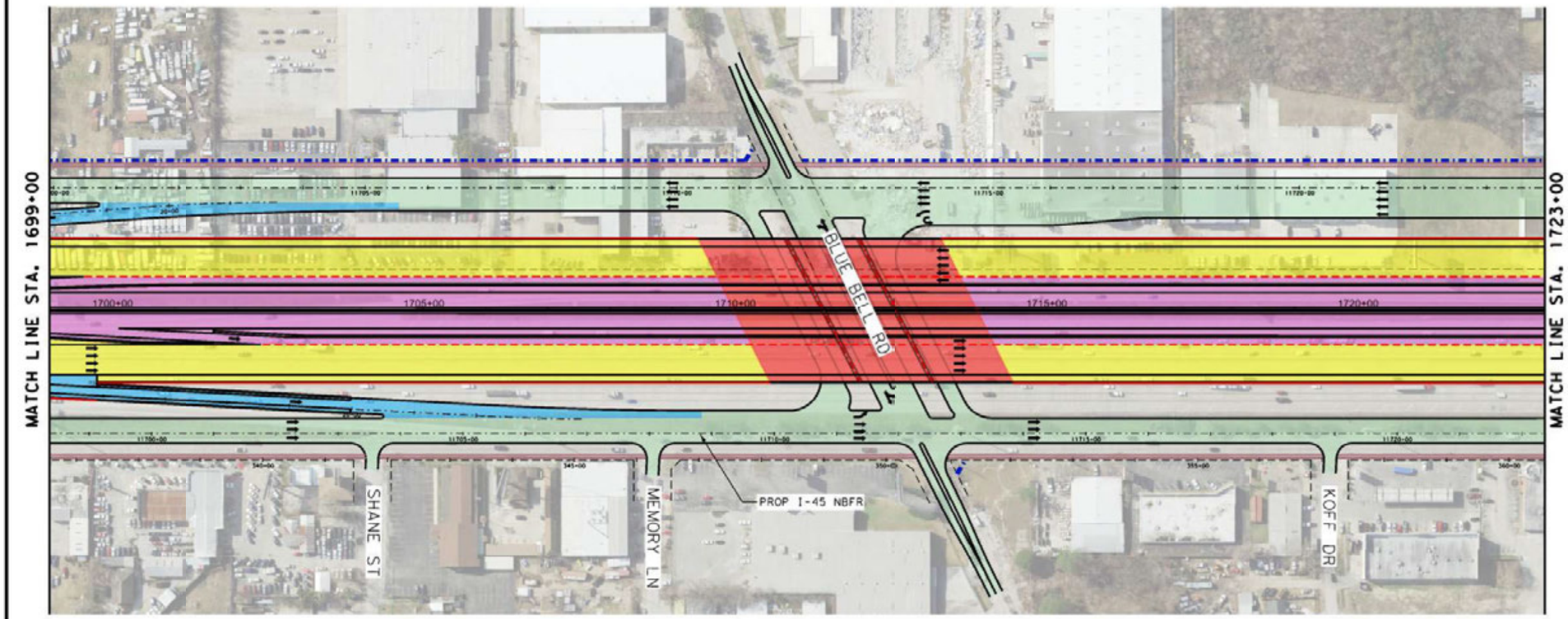

LEGEND

- PROPOSED ROW
- EXISTING ROW
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- MINOR CROSSING DA LIMIT
- 500-YR WSEL
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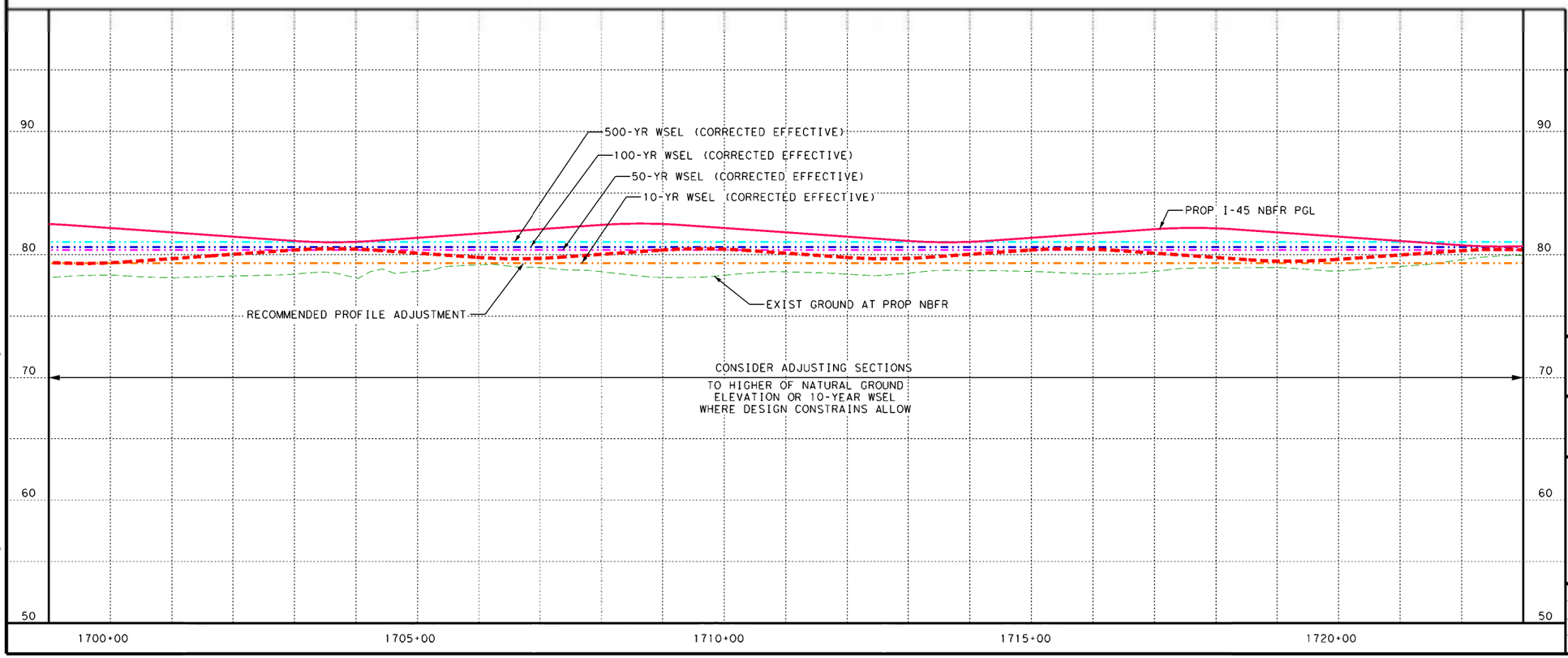

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I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 6 OF 8

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6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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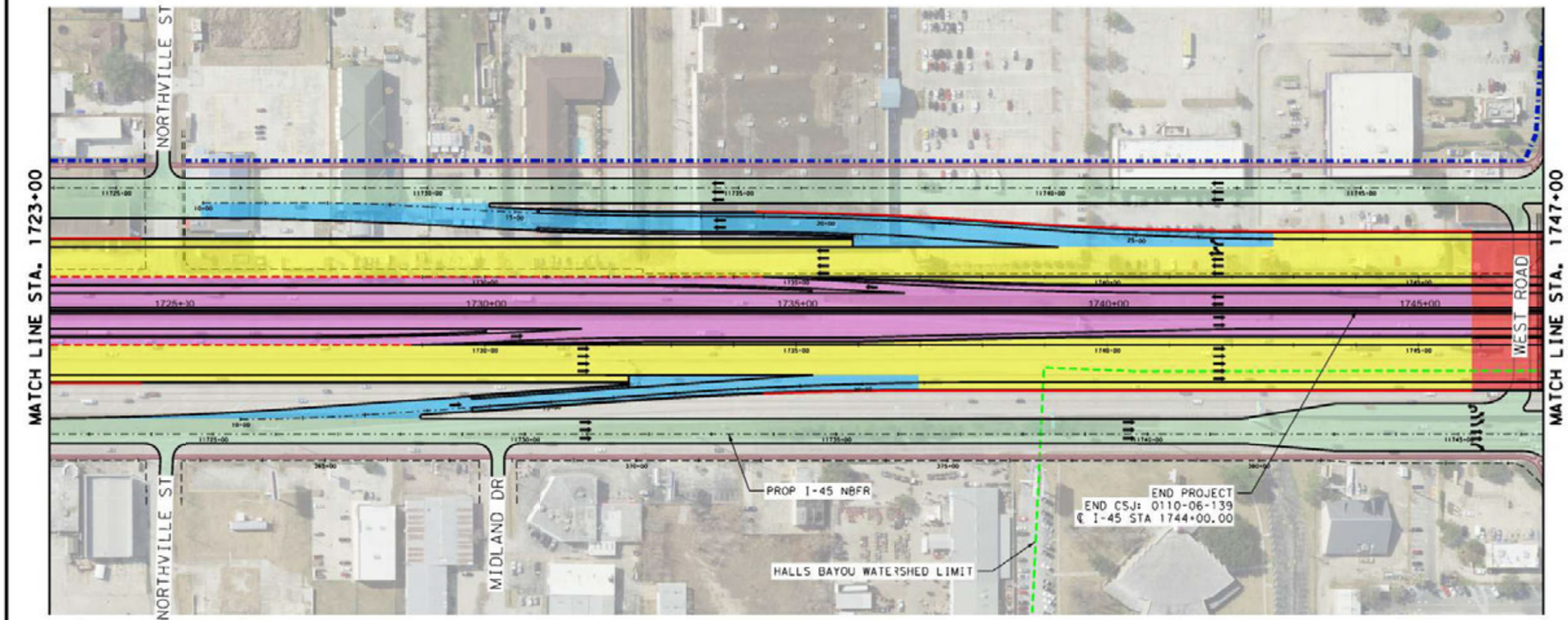

LEGEND

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- EXISTING ROW
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- MINOR CROSSING DA LIMIT
- 500-YR WSEL
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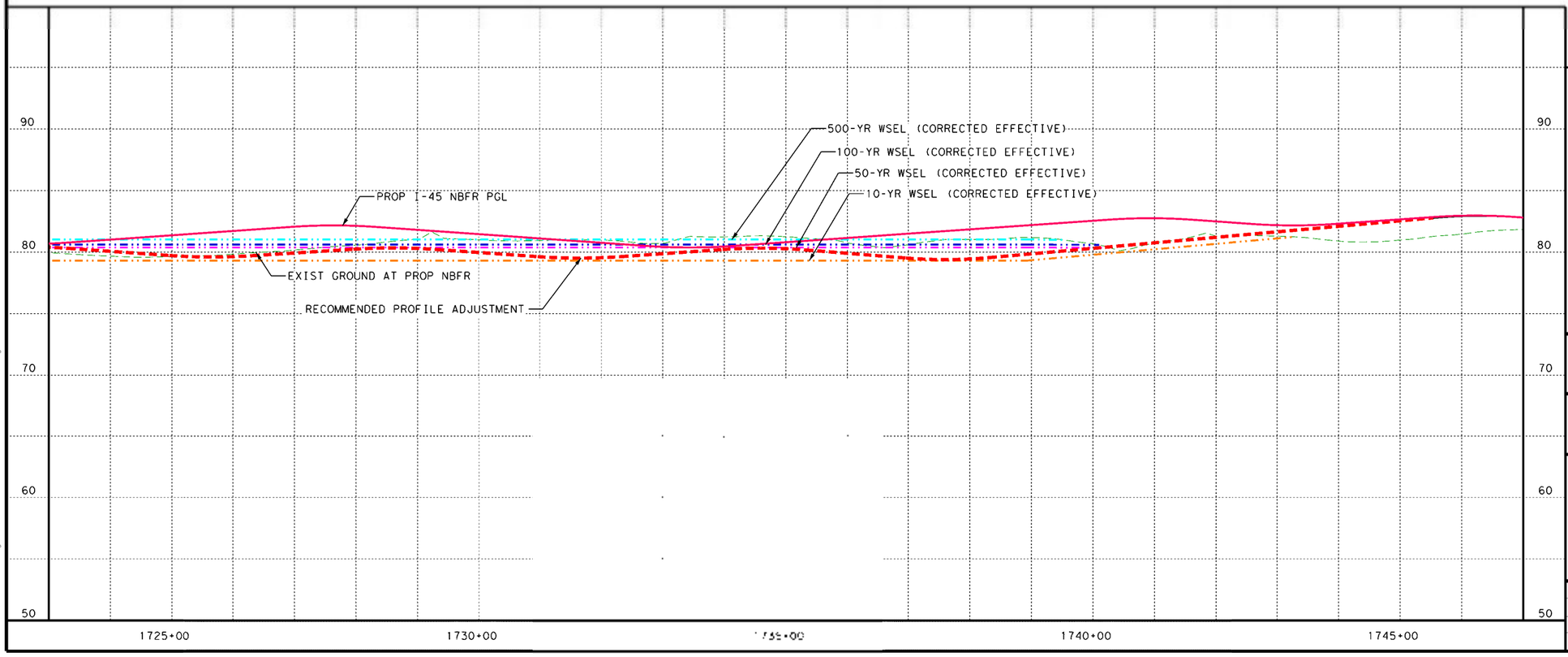

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ROADWAY PROFILE ANALYSIS
I-45 FRONTAGE ROAD NORTHBOUND

SEPT 2020 SHEET 7 OF 8

FED.RD. DIV.NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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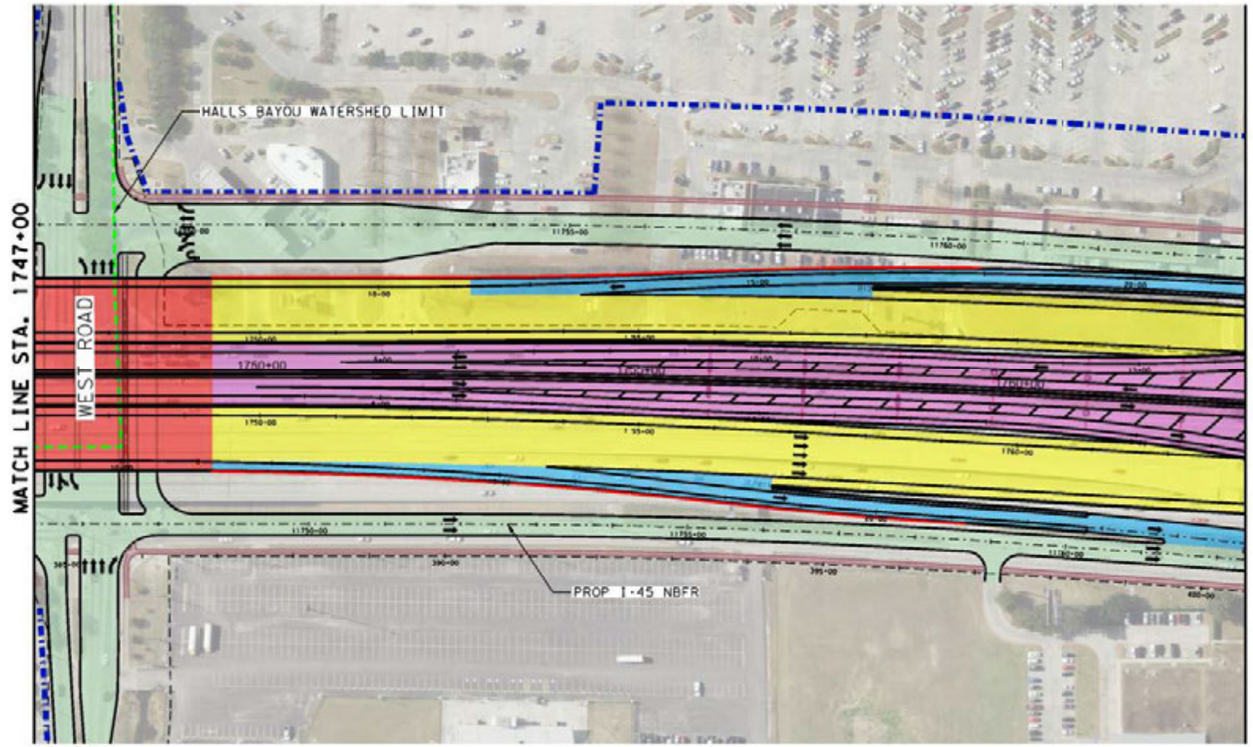

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
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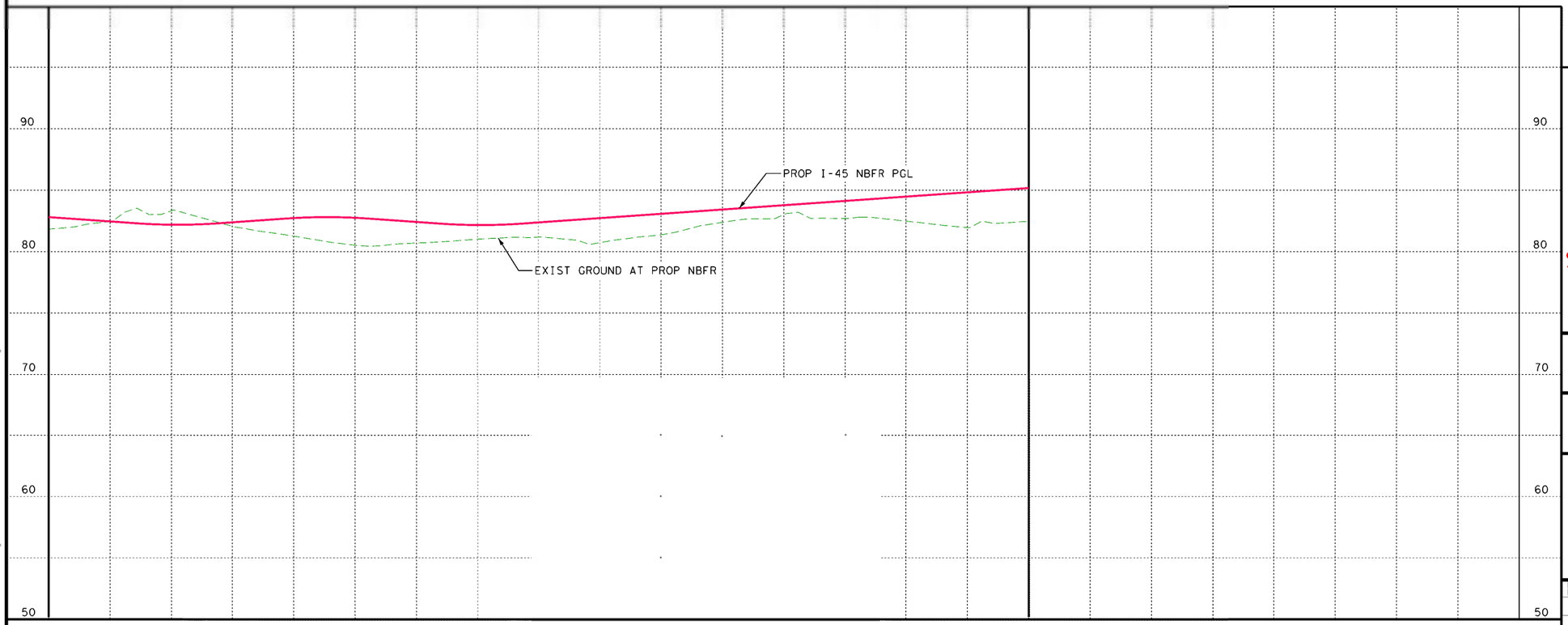

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SEPT 2020 SHEET 8 OF 8

FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-0IDP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-2

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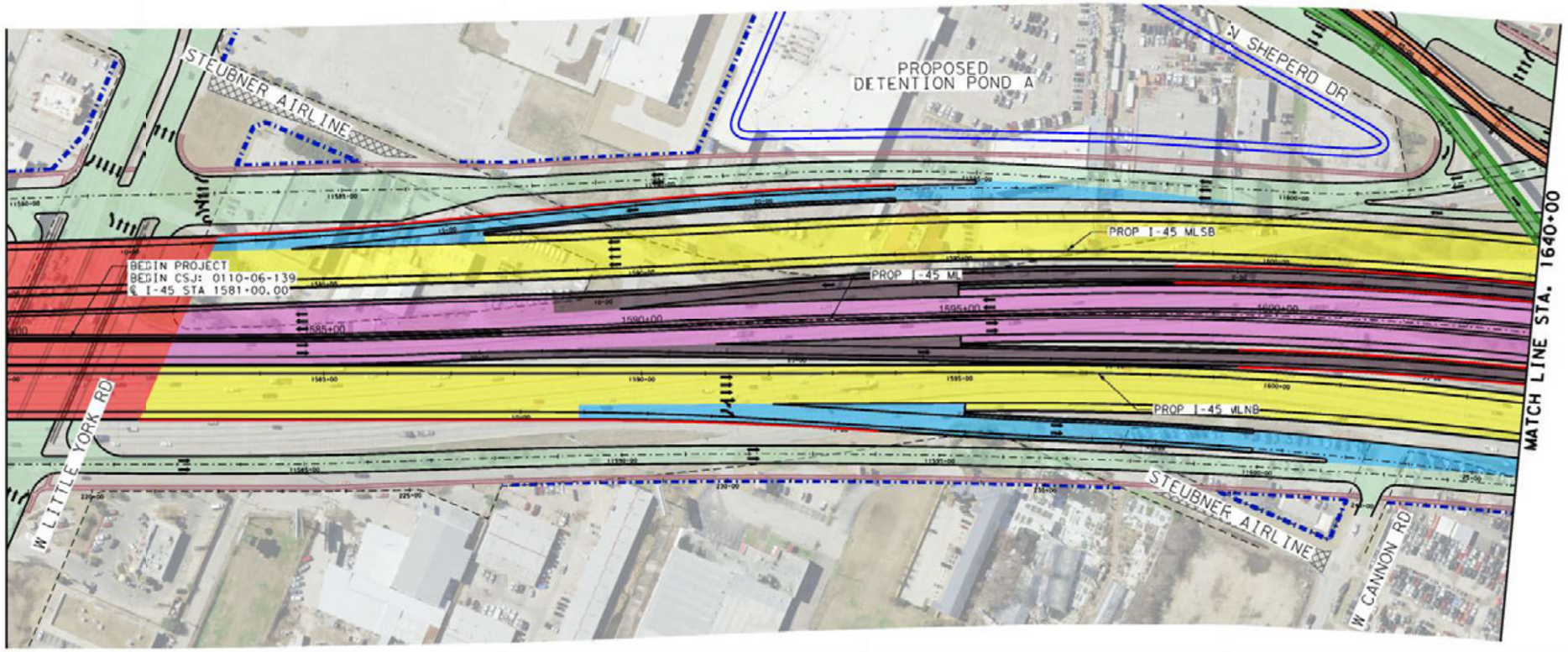

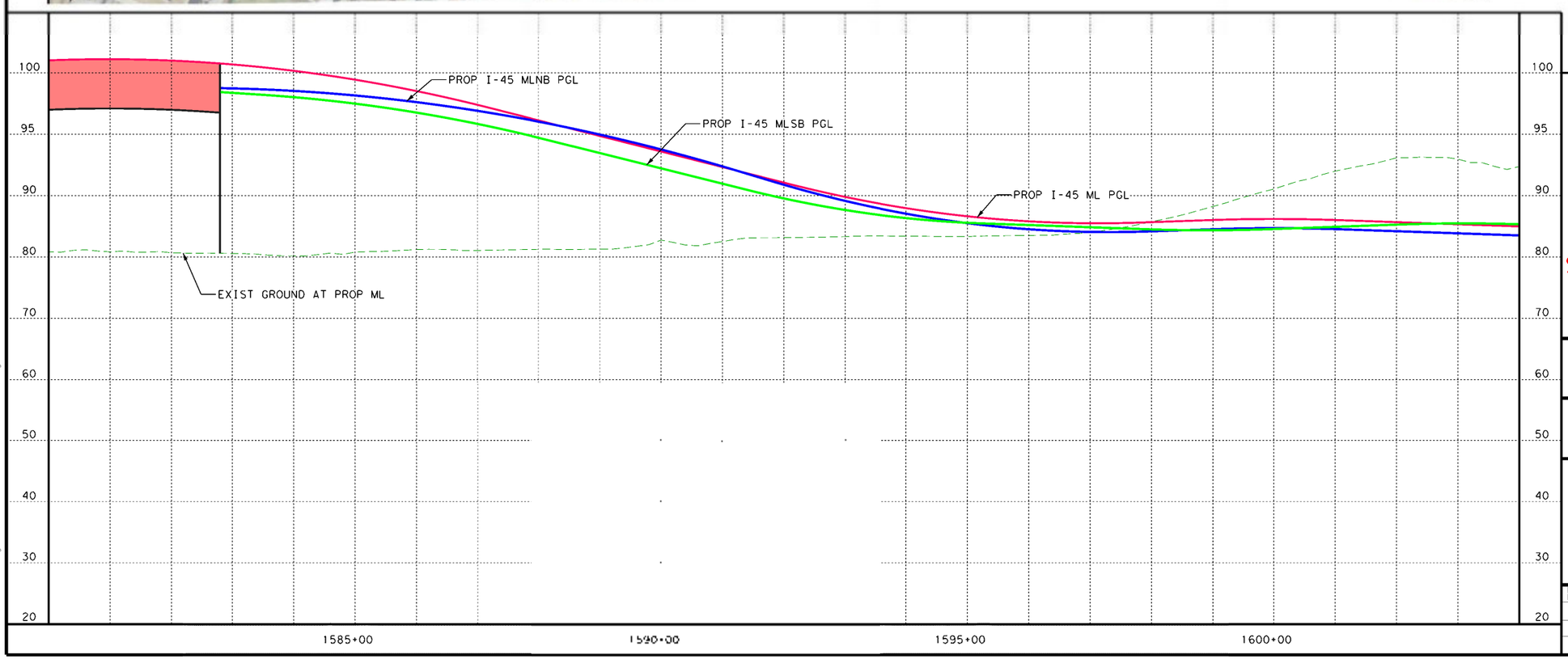

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
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- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
- RECOMMENDED PROFILE ADJUSTMENT

NOTES:
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NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 1 OF 8

FED.RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3

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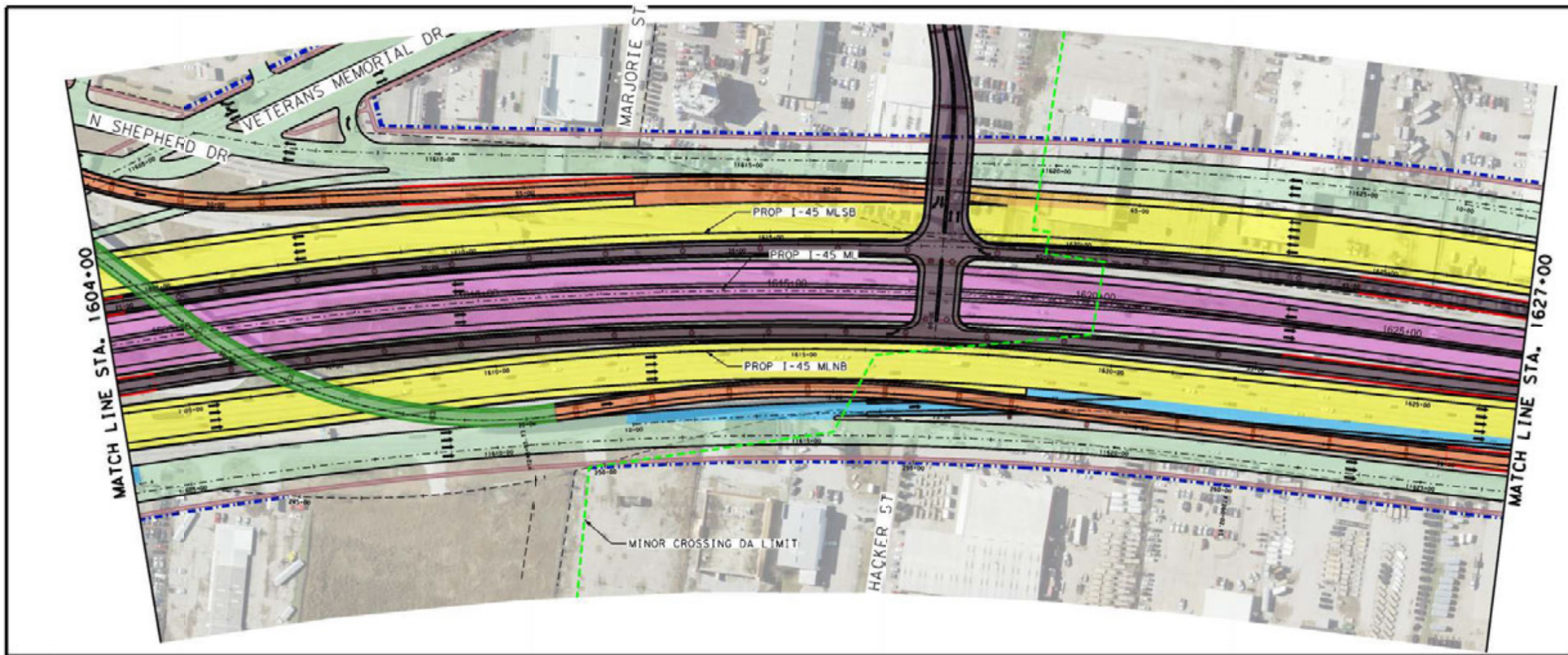

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
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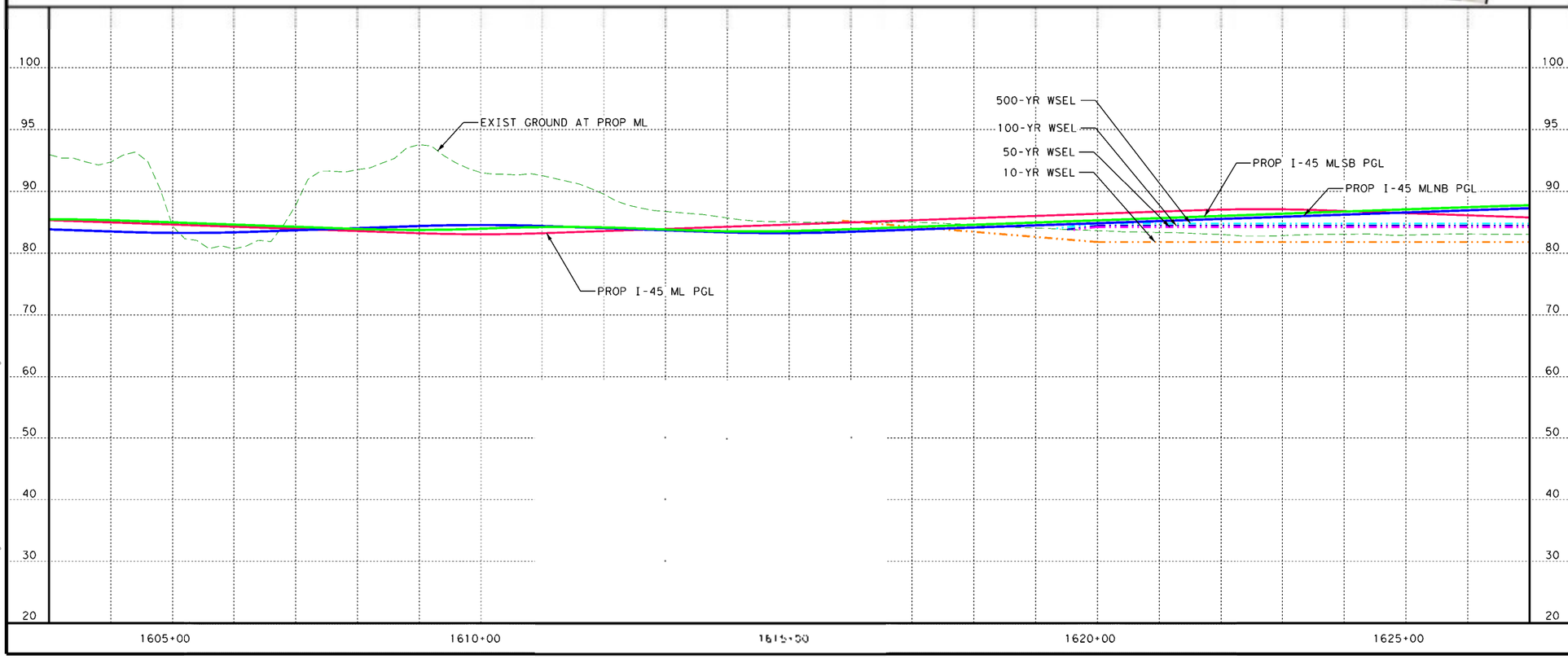

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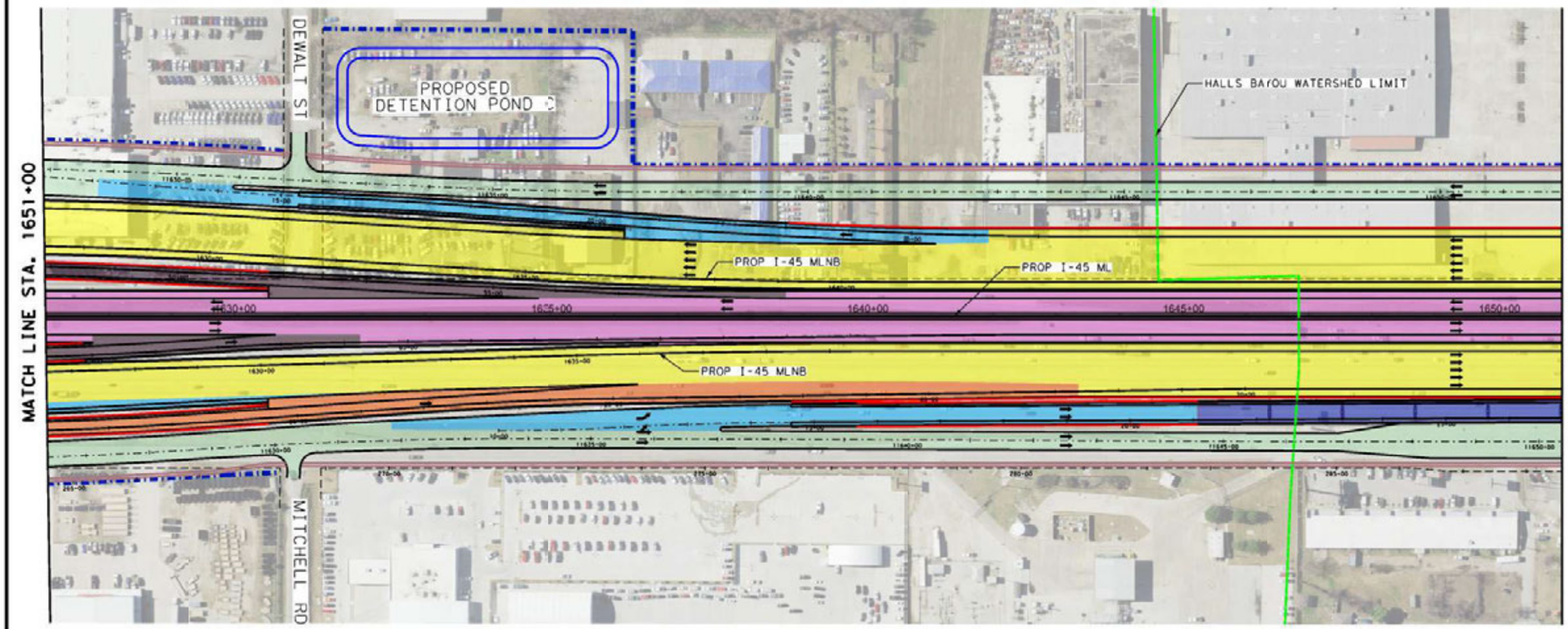
NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 2 OF 8

FED.RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3



LEGEND

- PROPOSED ROW
- EXISTING ROW
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- MINOR CROSSING DA LIMIT
- 500-YR WSEL
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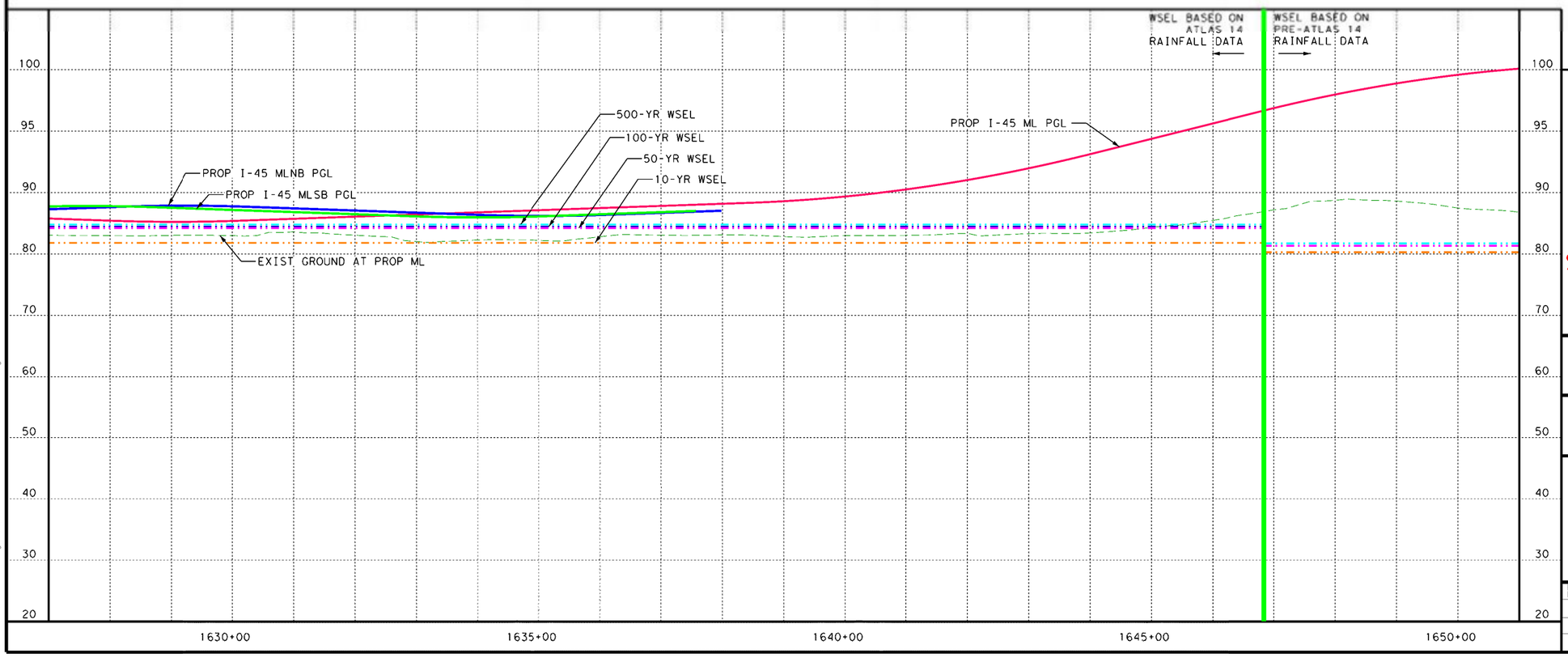

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ROADWAY PROFILE ANALYSIS I-45 MAIN LANES

SEPT 2020 SHEET 3 OF 8

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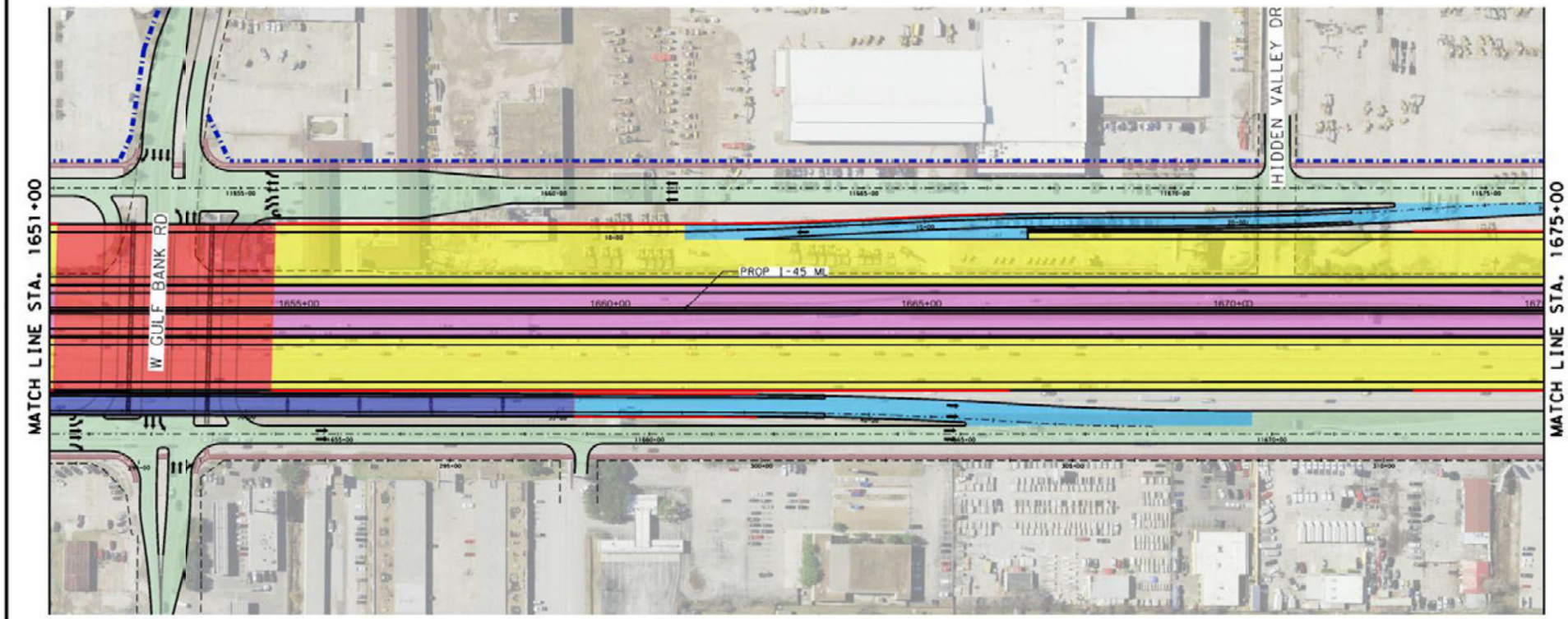
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3



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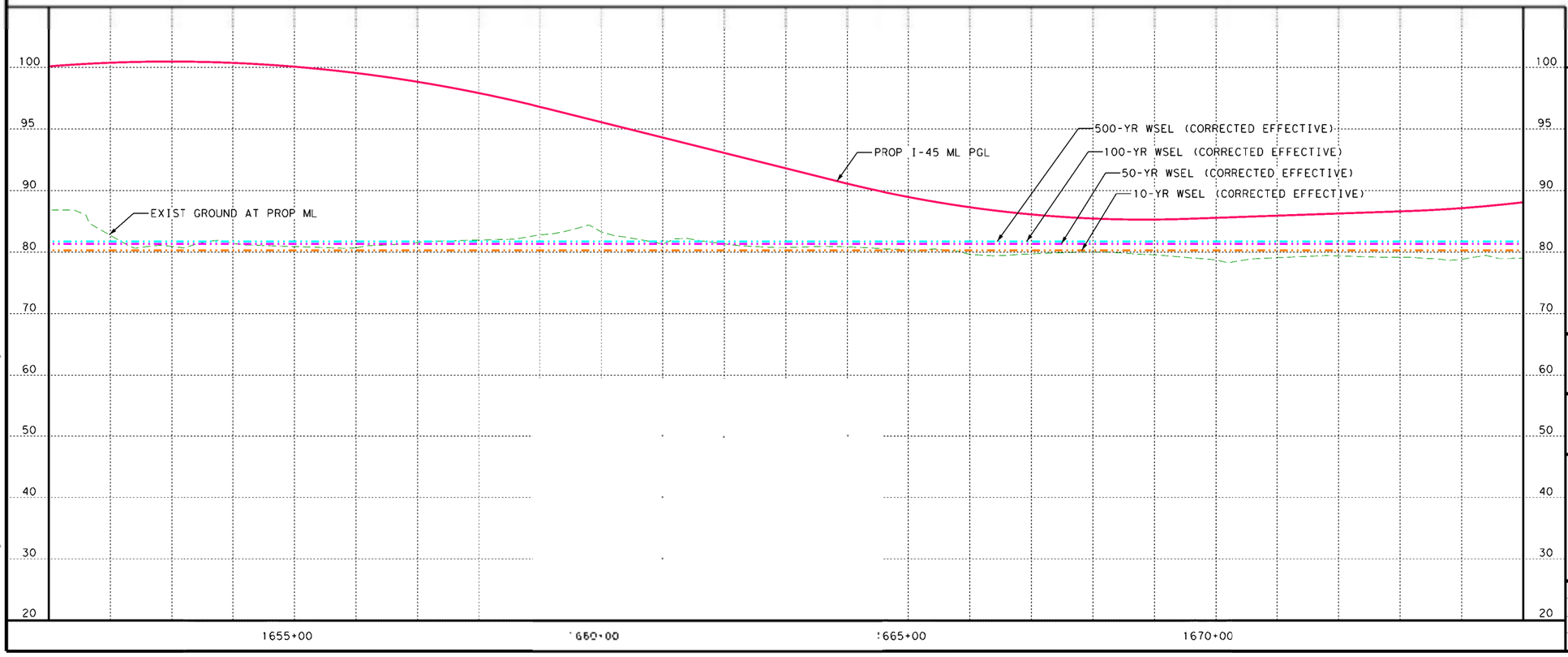
WATER SURFACE ELEVATIONS OBTAINED FROM HEC-RAS CORRECTED EFFECTIVE MODEL FOR HALLS BAYOU, HCFCD UNIT MODEL FILENAME: P118-00-00.PRJ



0 100' 200'
SCALE: 1" = 200'H
1" = 10' V

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering Inc.
11821 Telge Road
Cypress, Texas 77429
(281)304-0200 Fax:(281)304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 4 OF 8

FED. RD. DIST. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3

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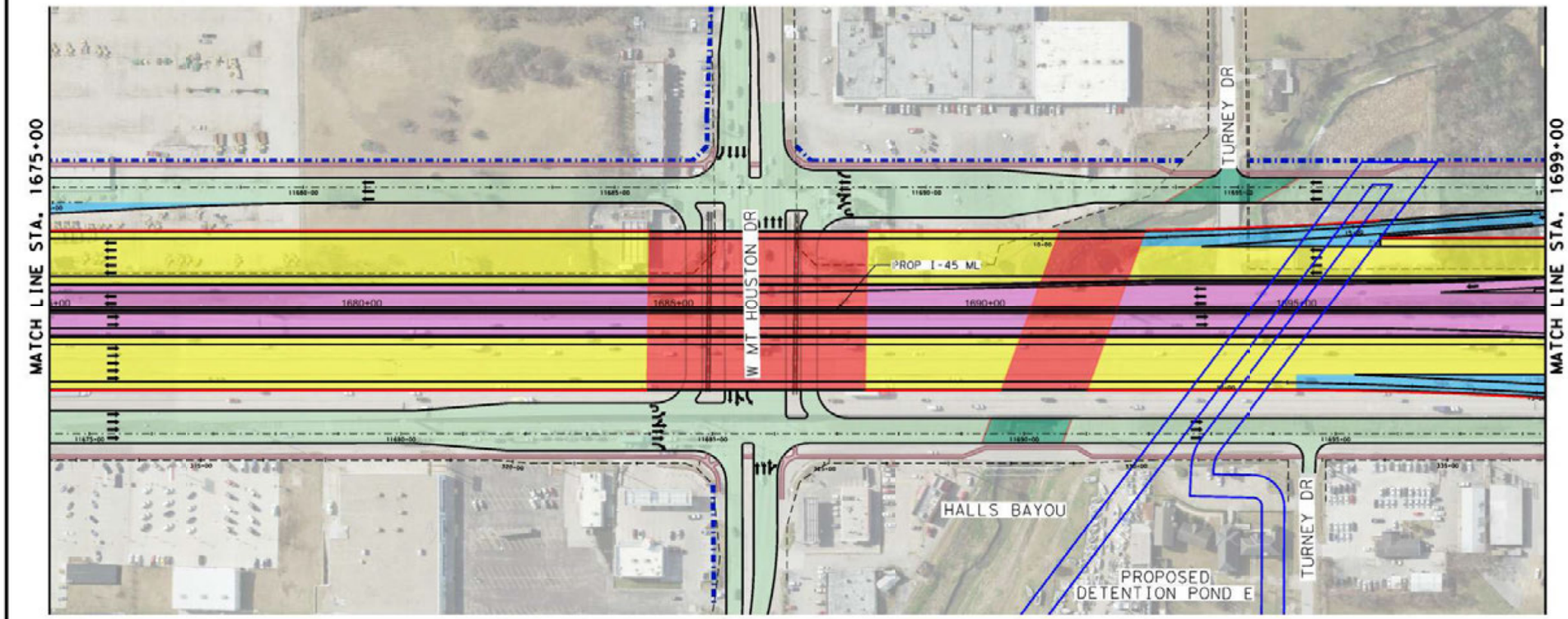

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
- 10-YR WSEL
- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
- RECOMMENDED PROFILE ADJUSTMENT

NOTES:
PROPOSED ROADWAY PROFILE BASED ON TXDOT NHHIP SEGMENT 1 SCHEMATIC.

ALL ELEVATIONS ARE REFERENCED TO NAVD 1988, 2001 ADJ.

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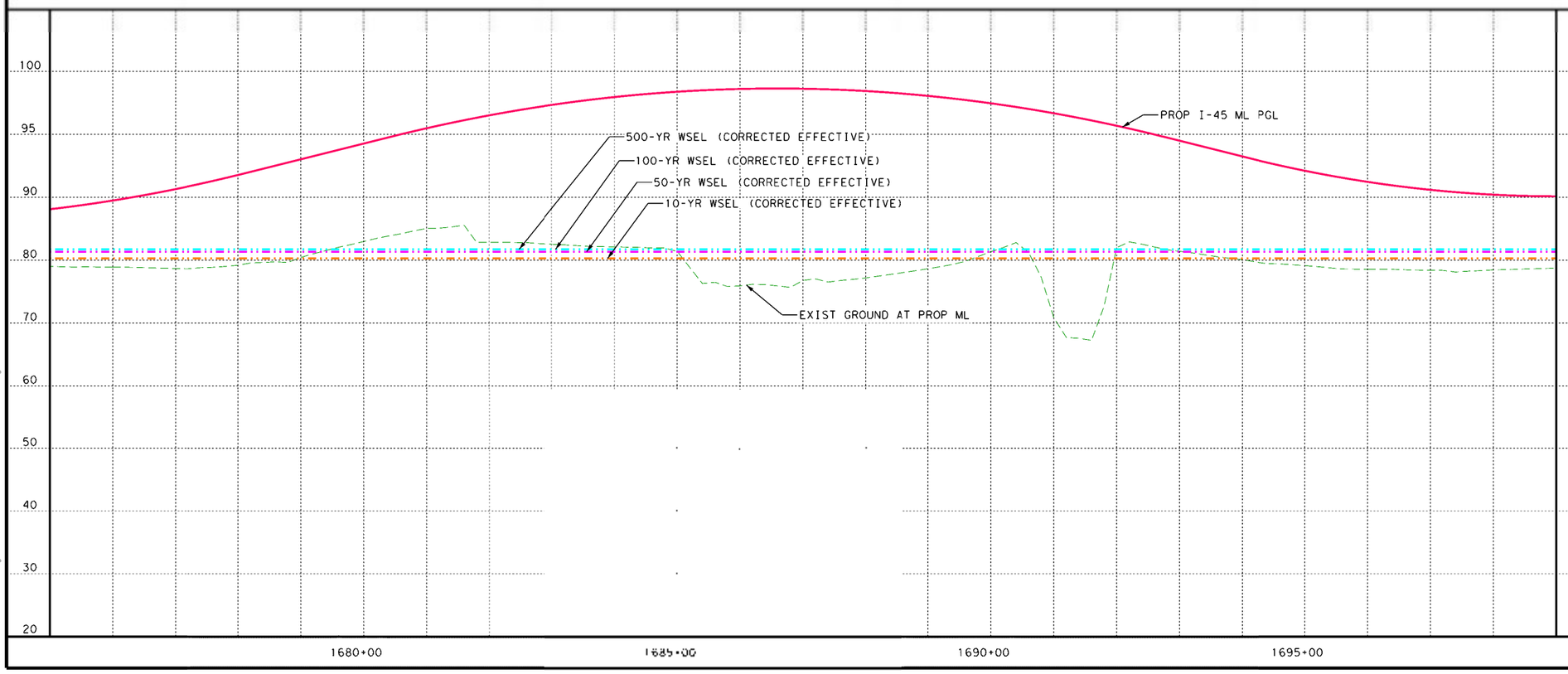

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NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 5 OF 8

FED. RD. DIST. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3

I45-SEG1-ML-CEF-PP-05.dgn

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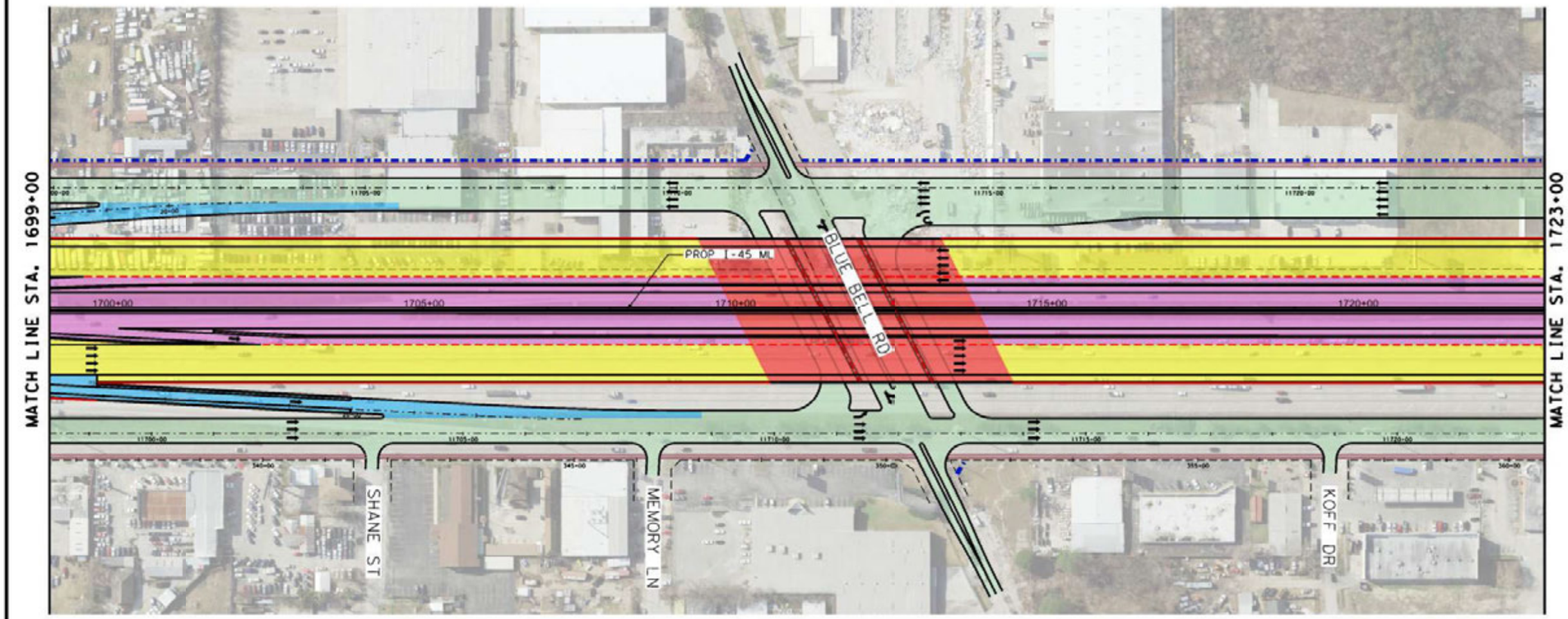

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
- 10-YR WSEL
- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
- RECOMMENDED PROFILE ADJUSTMENT

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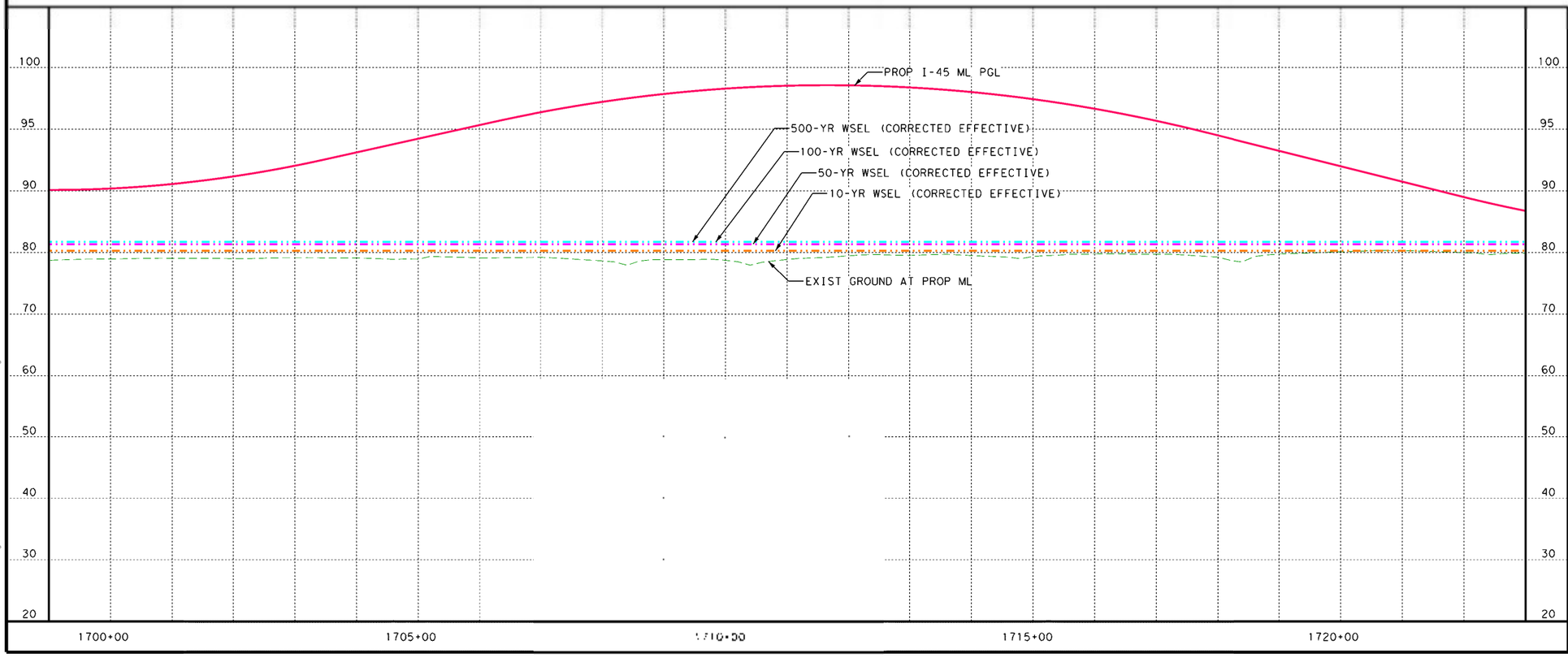

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NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 6 OF 8

FED.RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3

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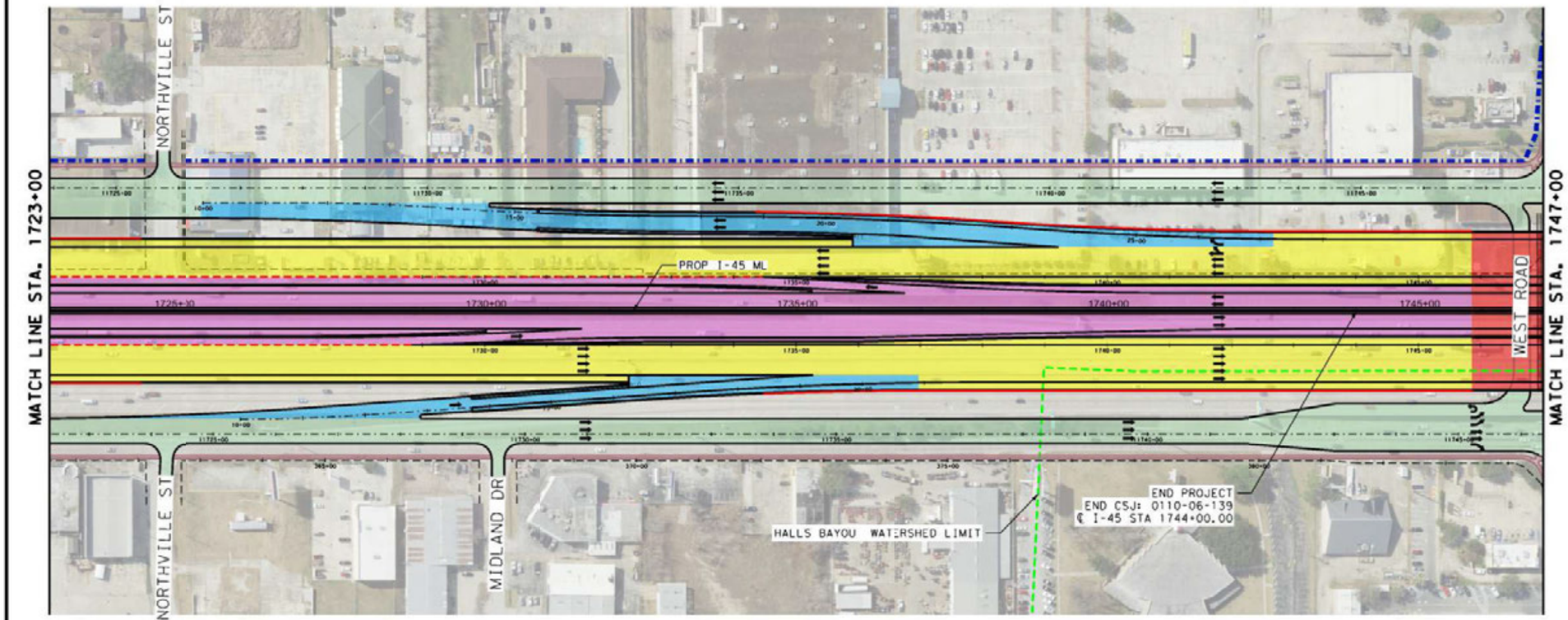

LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
- 10-YR WSEL
- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
- RECOMMENDED PROFILE ADJUSTMENT

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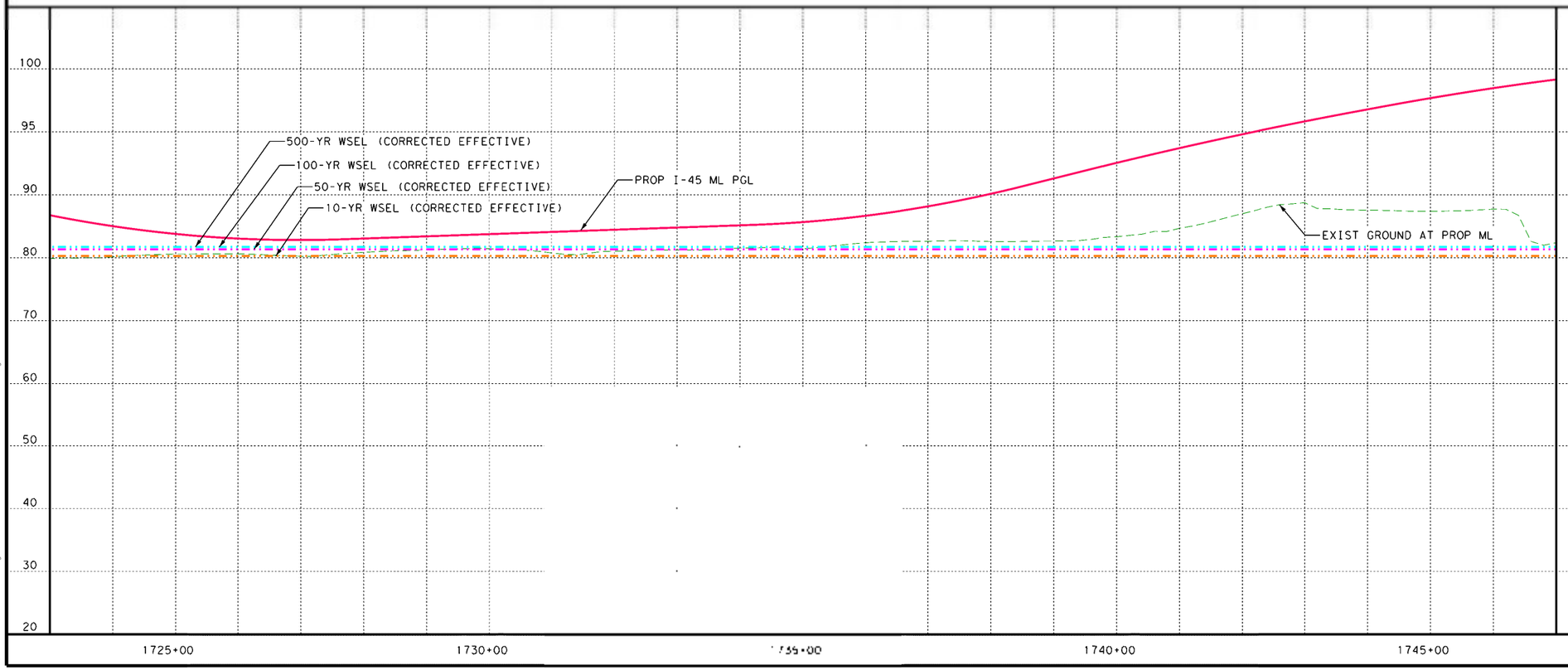

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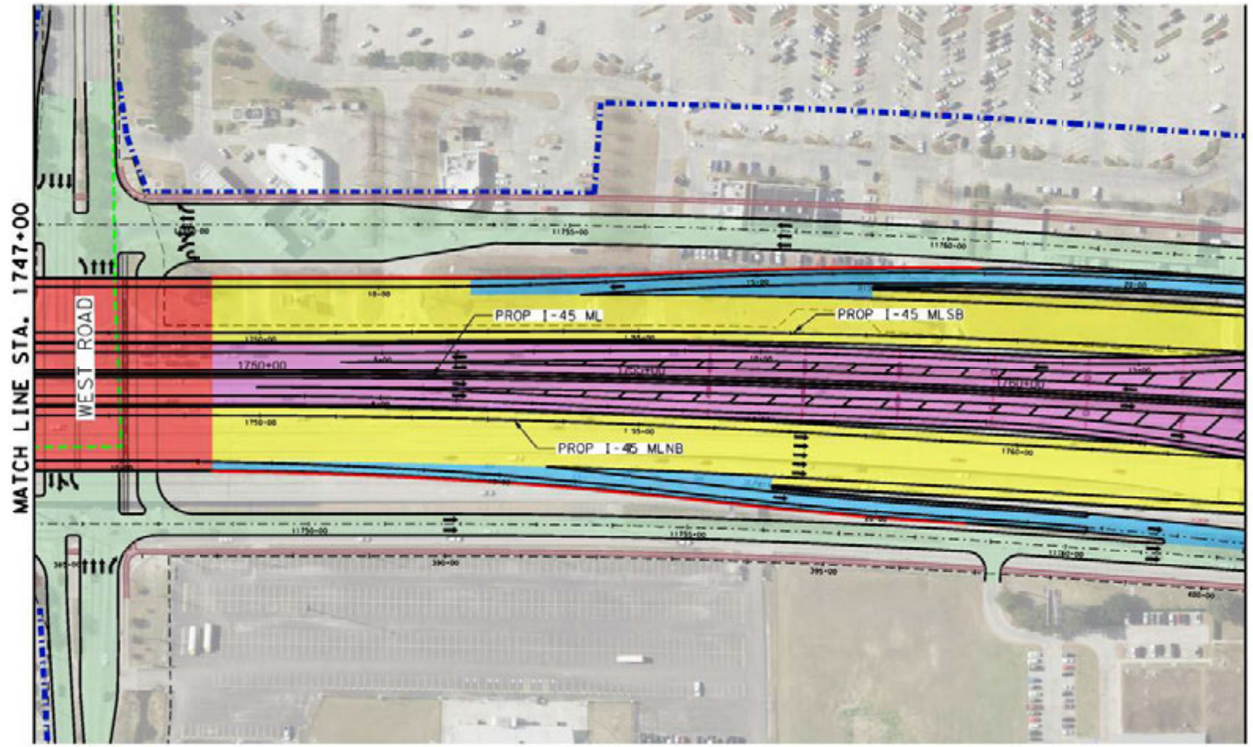
NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 7 OF 8

FED. RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3



LEGEND

- PROPOSED ROW
- EXISTING ROW
- NATURAL GROUND
- MINOR CROSSING DA LIMIT
- 500-YR WSEL
- 100-YR WSEL
- 50-YR WSEL
- 10-YR WSEL
- PROPOSED I-45 MLNB PGL
- PROPOSED I-45 PGL
- PROPOSED I-45 MLSB PGL
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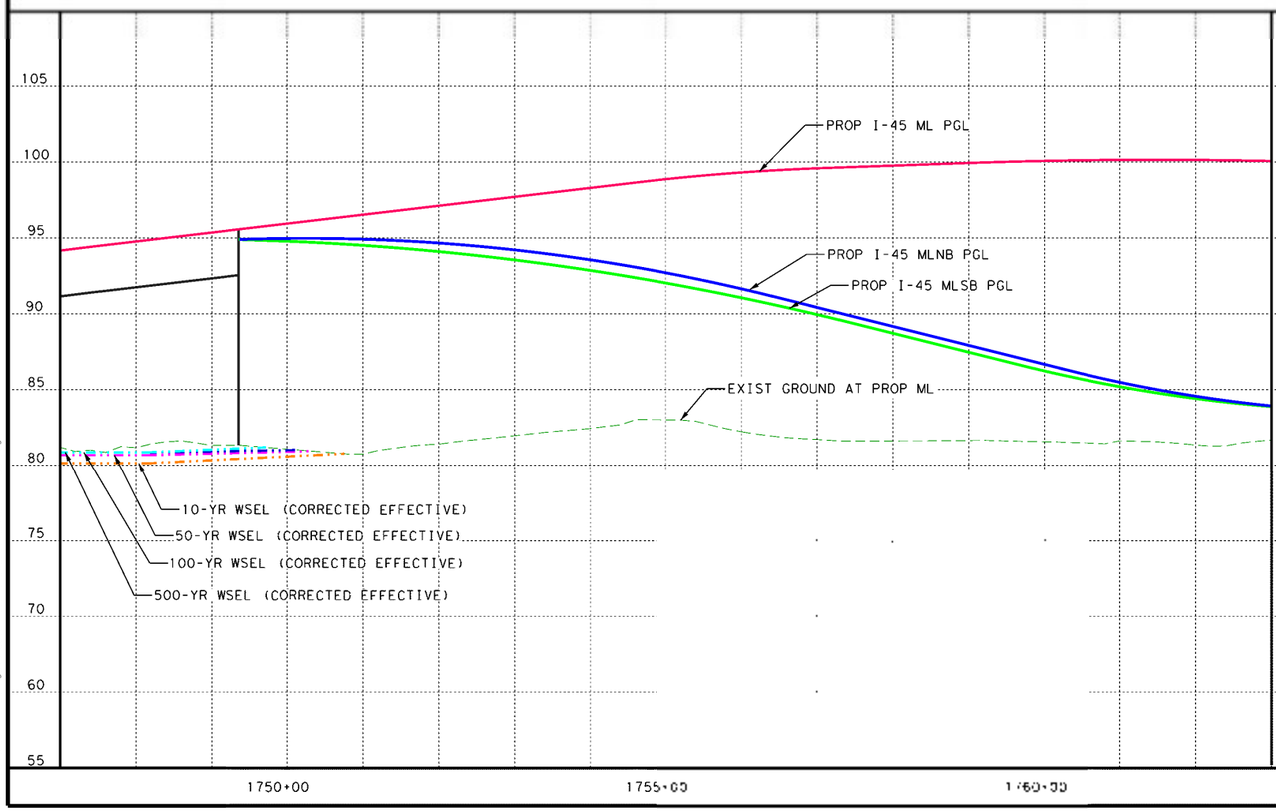

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NHHIP SEGMENT 1

ROADWAY PROFILE ANALYSIS
I-45 MAIN LANES

SEPT 2020 SHEET 8 OF 8

FED.RD. DIV. NO.	STATE	PROJECT NO.			HIGHWAY
6	TX	12-01DP5012			I-45
STATE DIST	COUNTY	CONT	SECT	JOB	EXHIBIT NO.
HOU	HARRIS	0110	06	139	3-3

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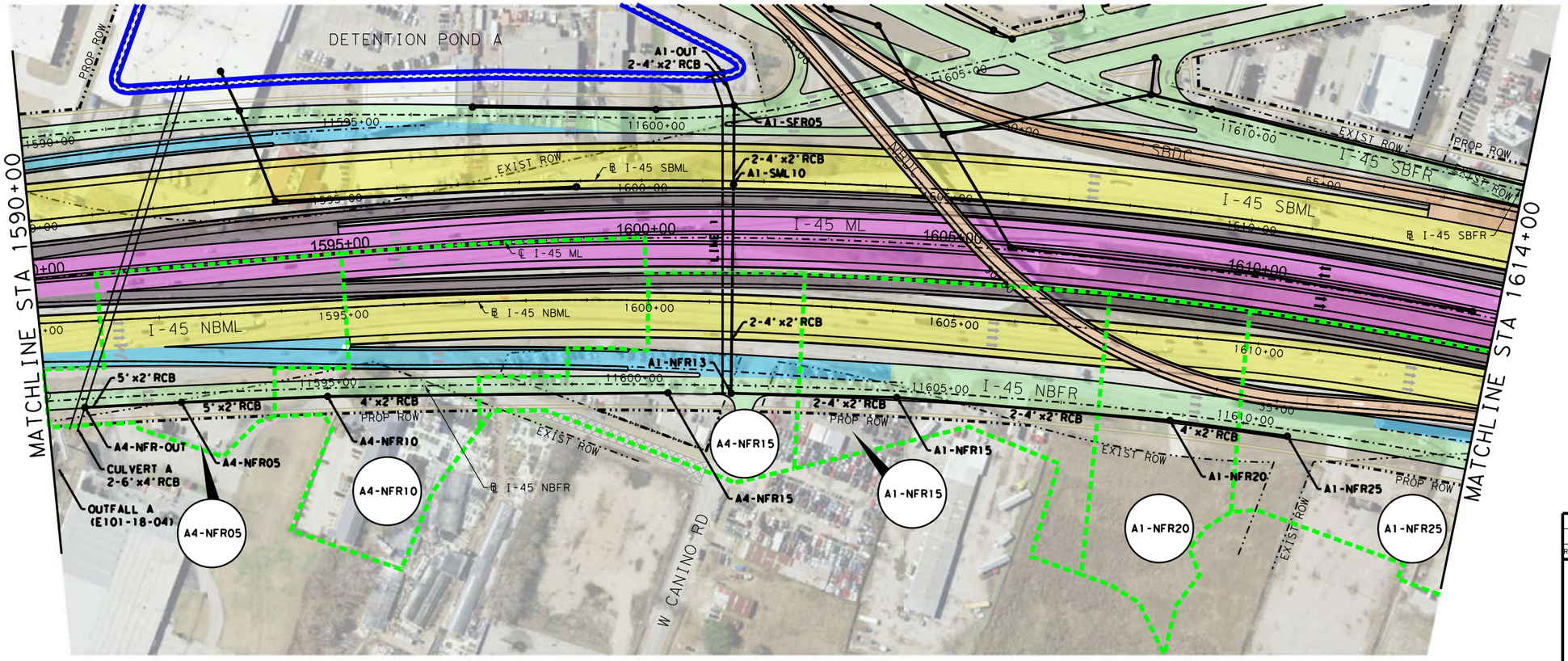

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
0 10 20 (V)

REV NO.	DATE	BY	REVISION

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Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NBML AND NBFR STORM SEWER PLAN AND PROFILE

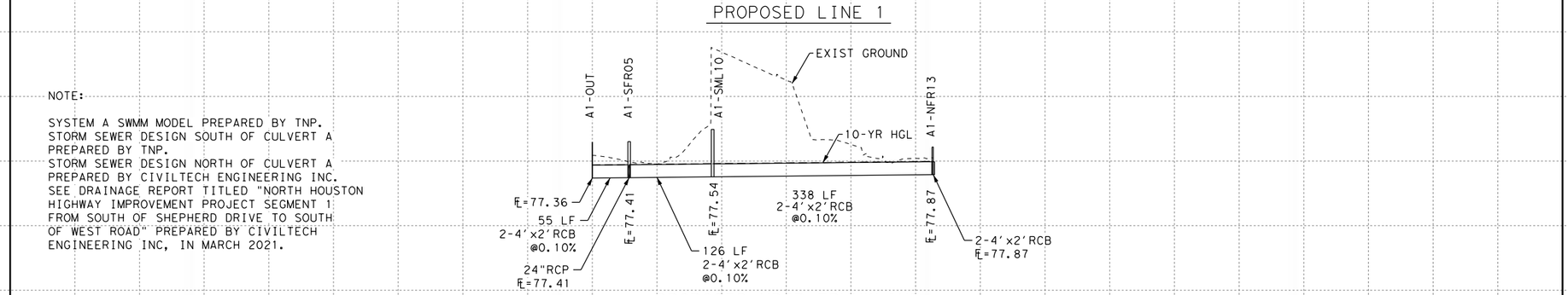
STA 1590+00 TO STA 1614+00
℄ I-45 MAXLANES

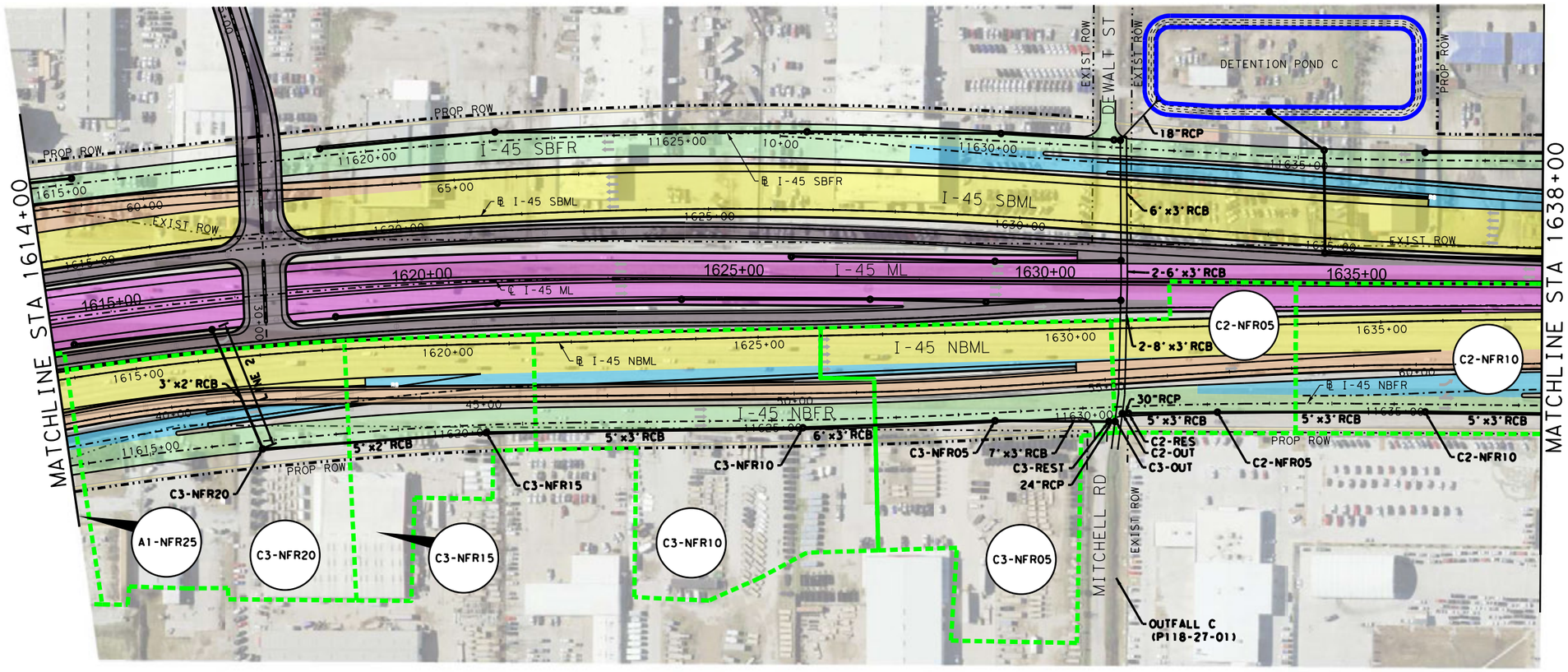
SHEET 1 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-1
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

NOTE:

SYSTEM A SWMM MODEL PREPARED BY TNP.
STORM SEWER DESIGN SOUTH OF CULVERT A PREPARED BY TNP.
STORM SEWER DESIGN NORTH OF CULVERT A PREPARED BY CIVILTECH ENGINEERING INC.
SEE DRAINAGE REPORT TITLED "NORTH HOUSTON HIGHWAY IMPROVEMENT PROJECT SEGMENT 1 FROM SOUTH OF SHEPHERD DRIVE TO SOUTH OF WEST ROAD" PREPARED BY CIVILTECH ENGINEERING INC, IN MARCH 2021.





LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.
3. SEE EXHIBIT 15 FOR FURTHER DETAILS REGARDING DETETION POND.

0 100 200 (H)
0 10 20 (V)

REV NO.	DATE	BY	REVISION

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Cypress, Texas 77429
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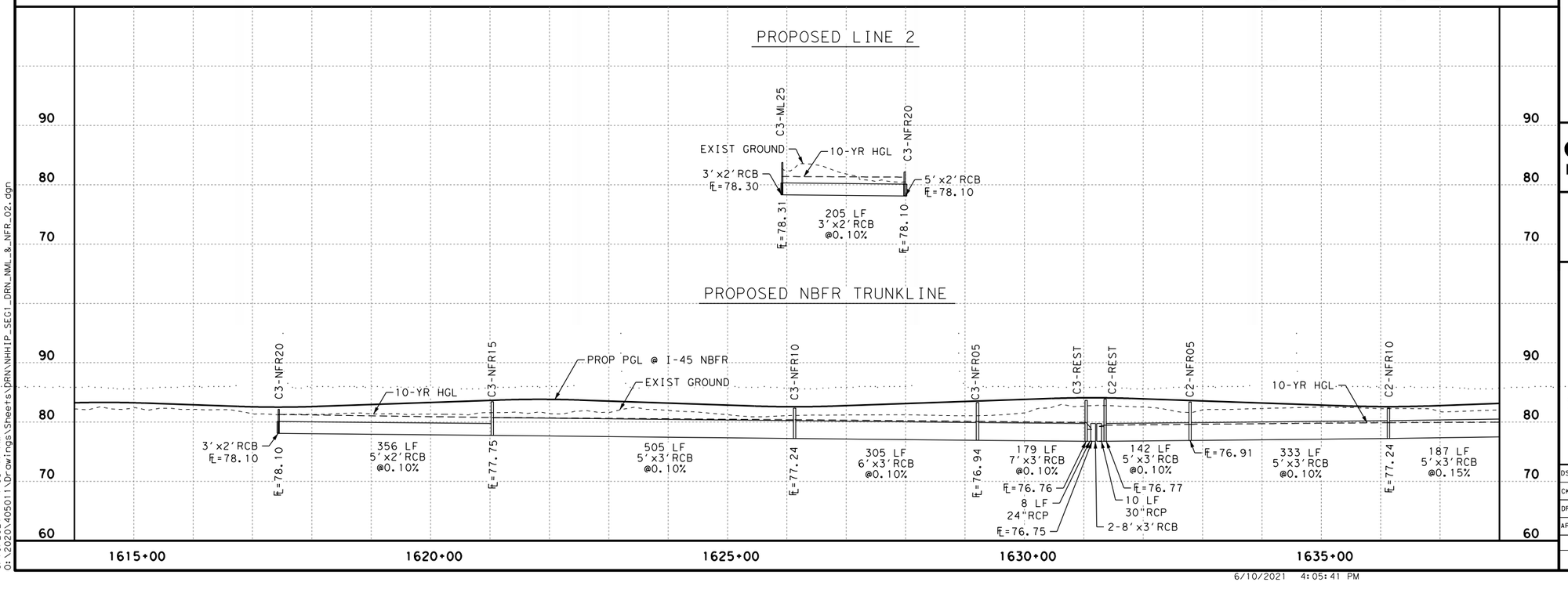
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NBML AND NBFR STORM SEWER PLAN AND PROFILE
STA 1614+00 TO STA 1638+00
℄ I-45 MAXLANES

SHEET 2 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-1
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	



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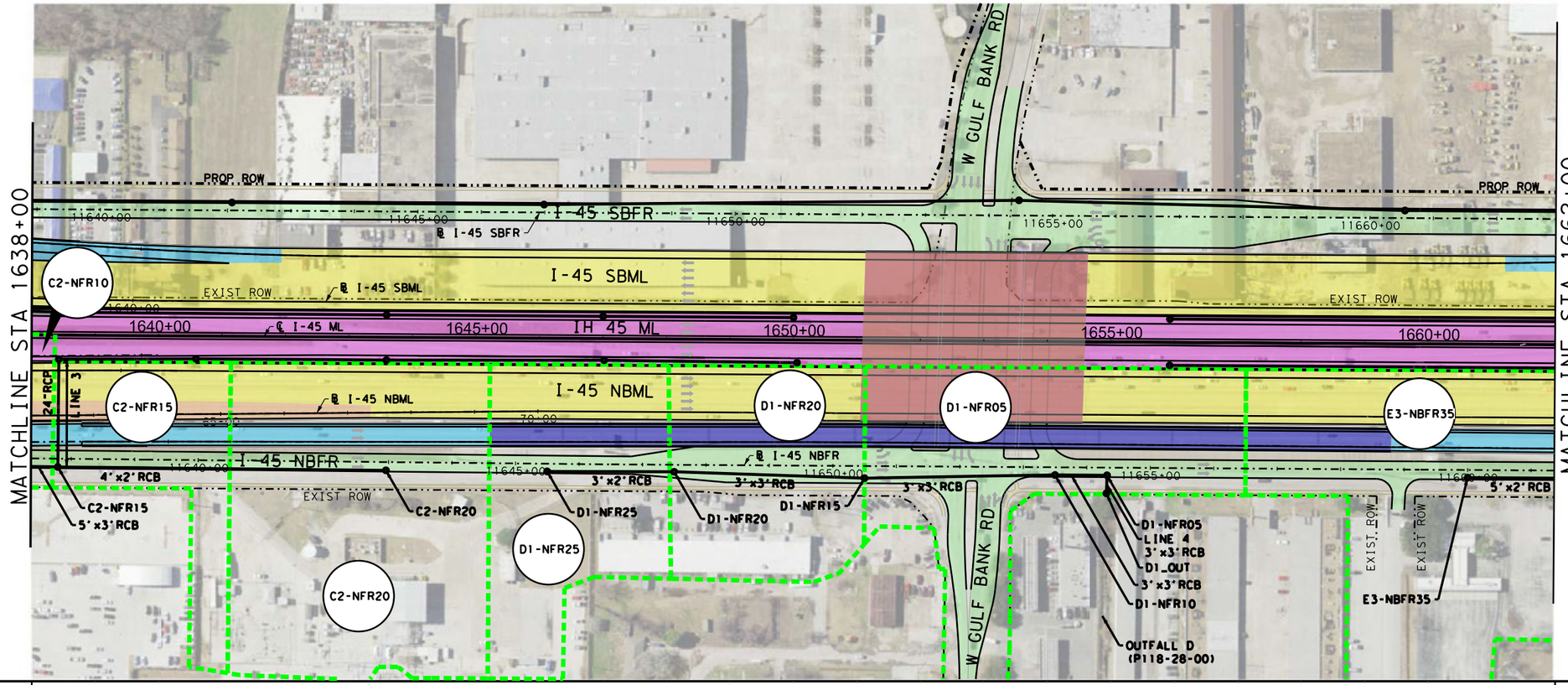

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
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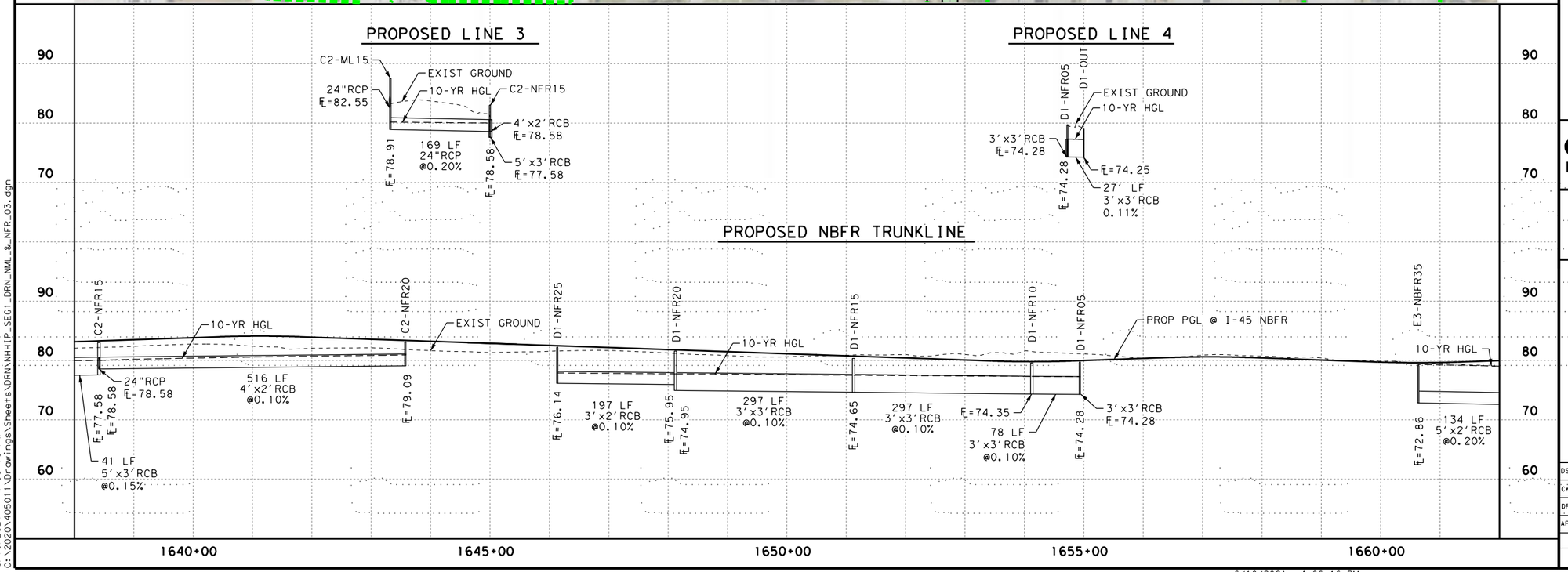
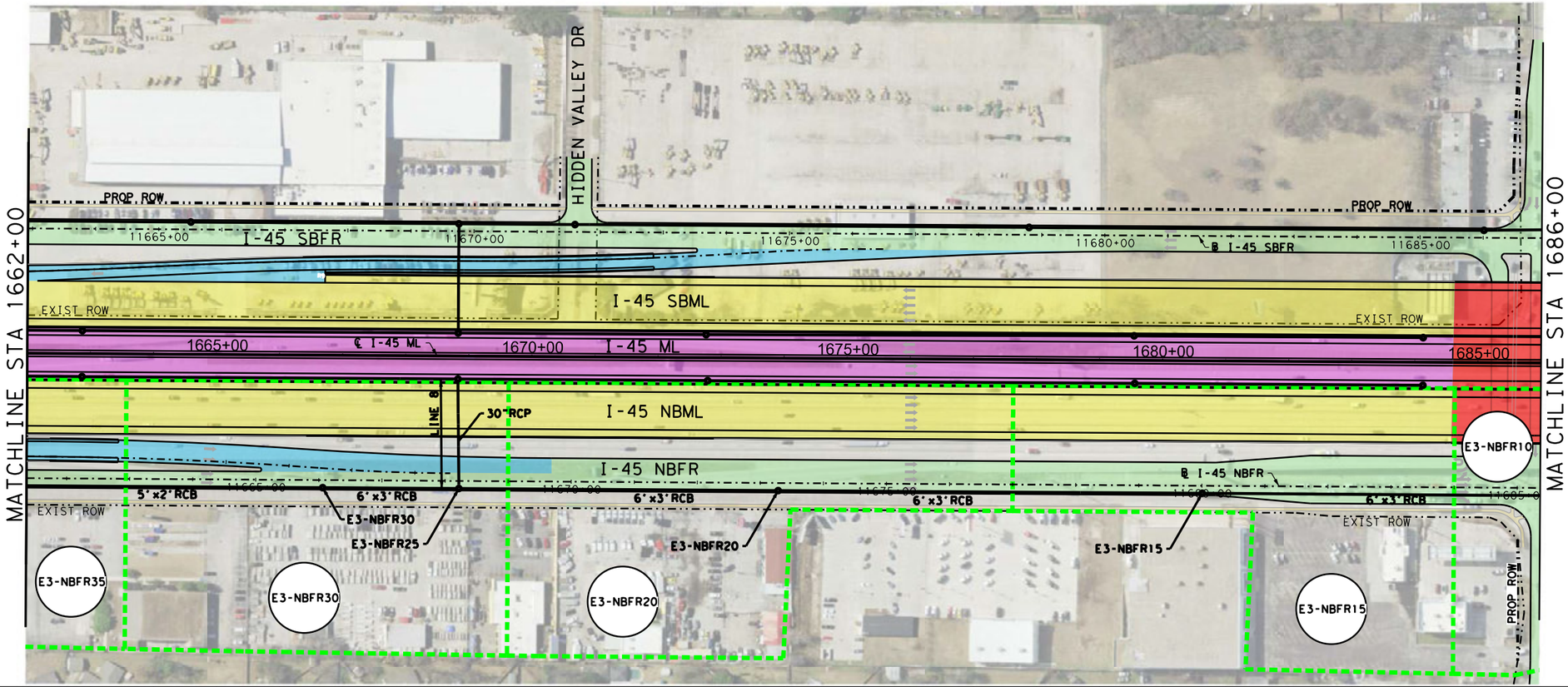
NHHIP SEGMENT 1
I-45 NBFR STORM SEWER PLAN AND PROFILE
STA 1638+00 TO STA 1662+00
℄ I-45 MAXLANES

SHEET 3 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-1
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45





LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
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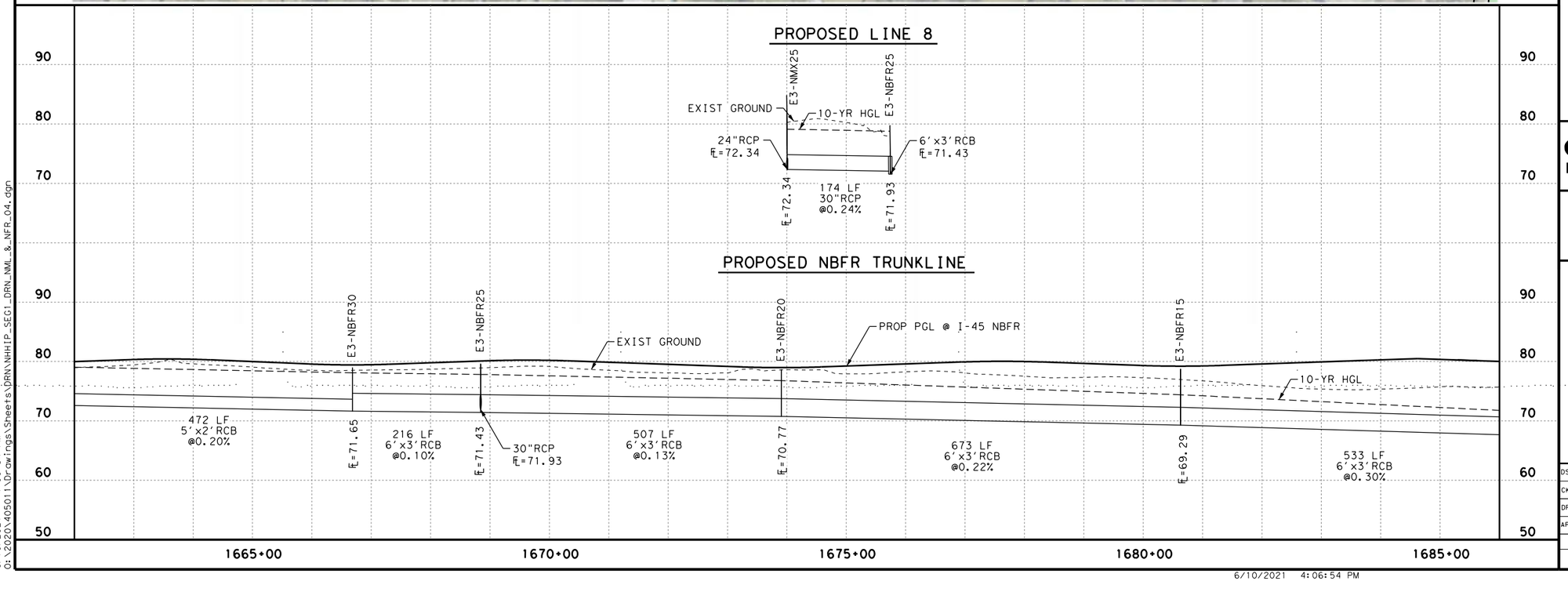
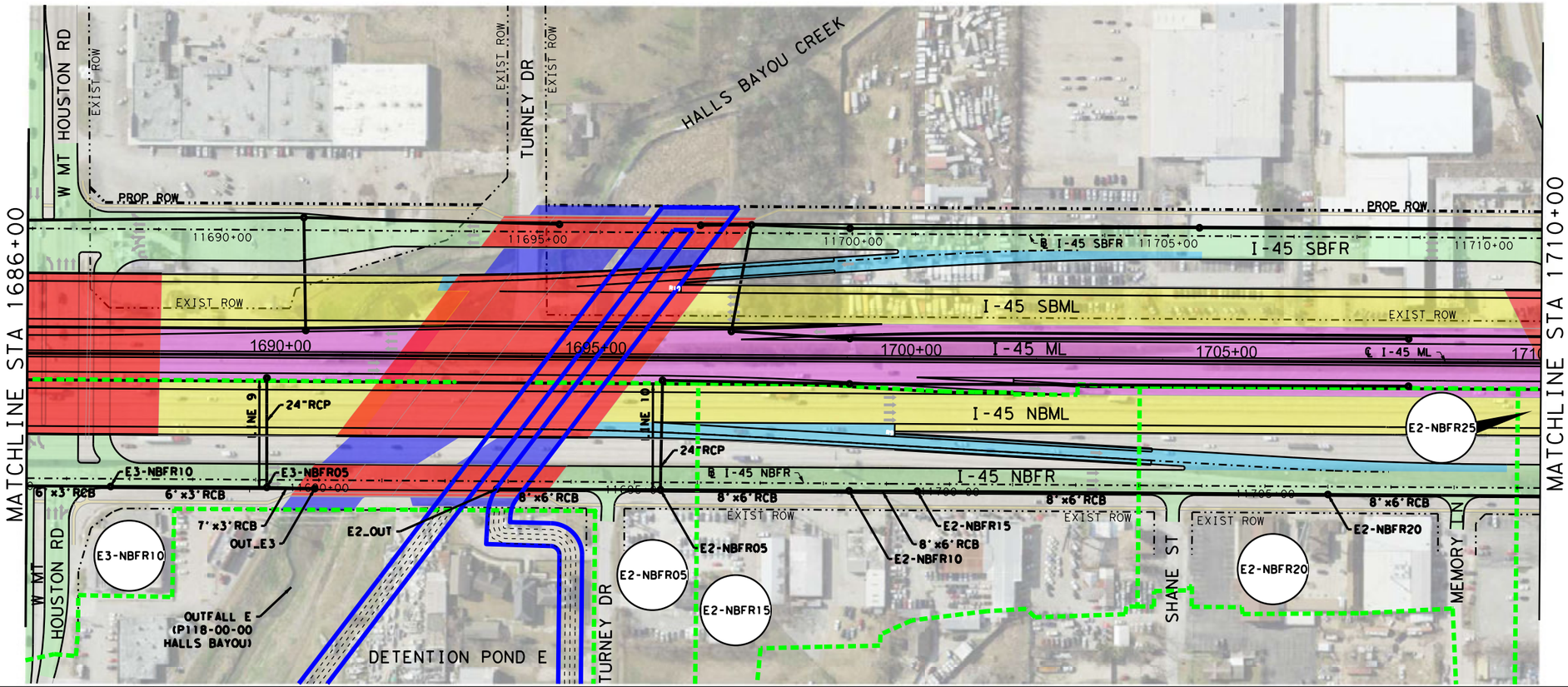
Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NBFR STORM SEWER PLAN AND PROFILE
STA 1662+00 TO STA 1686+00
℄ I-45 MAXLANES

SHEET 4 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-1
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45





LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

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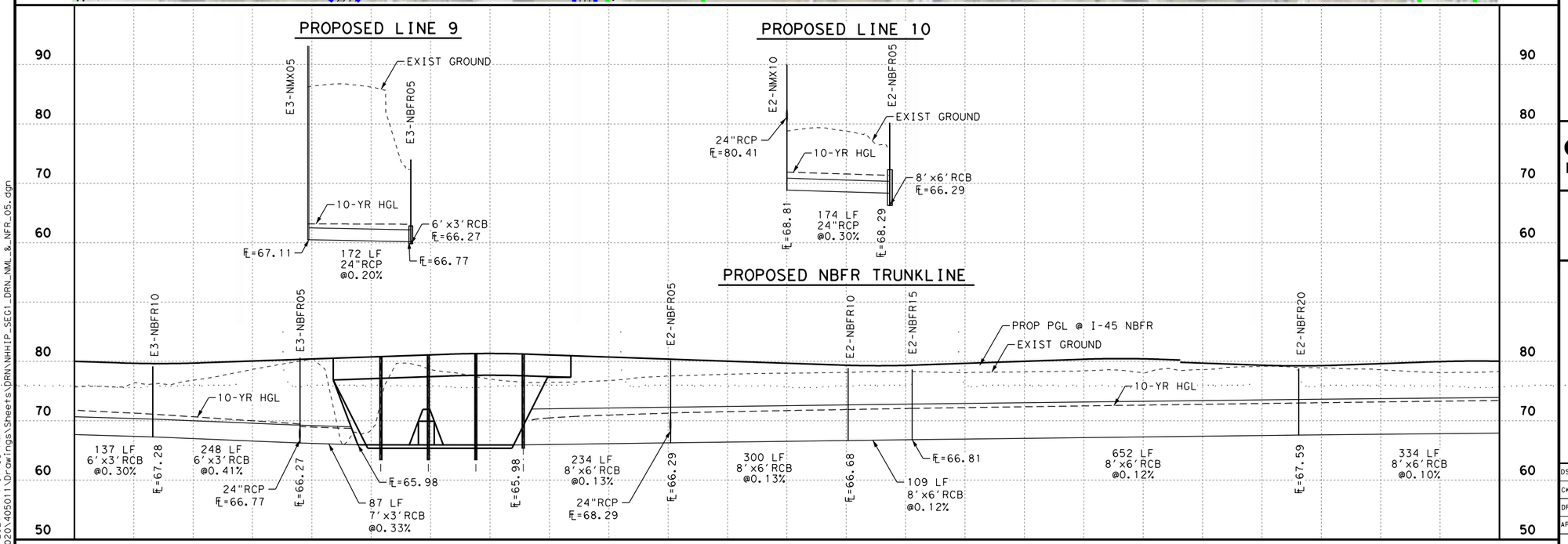

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NHHIP SEGMENT 1
I-45 NBFR STORM SEWER PLAN AND PROFILE

STA 1686+00 TO STA 1710+00
℄ I-45 MAXLANES

SHEET 5 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-1
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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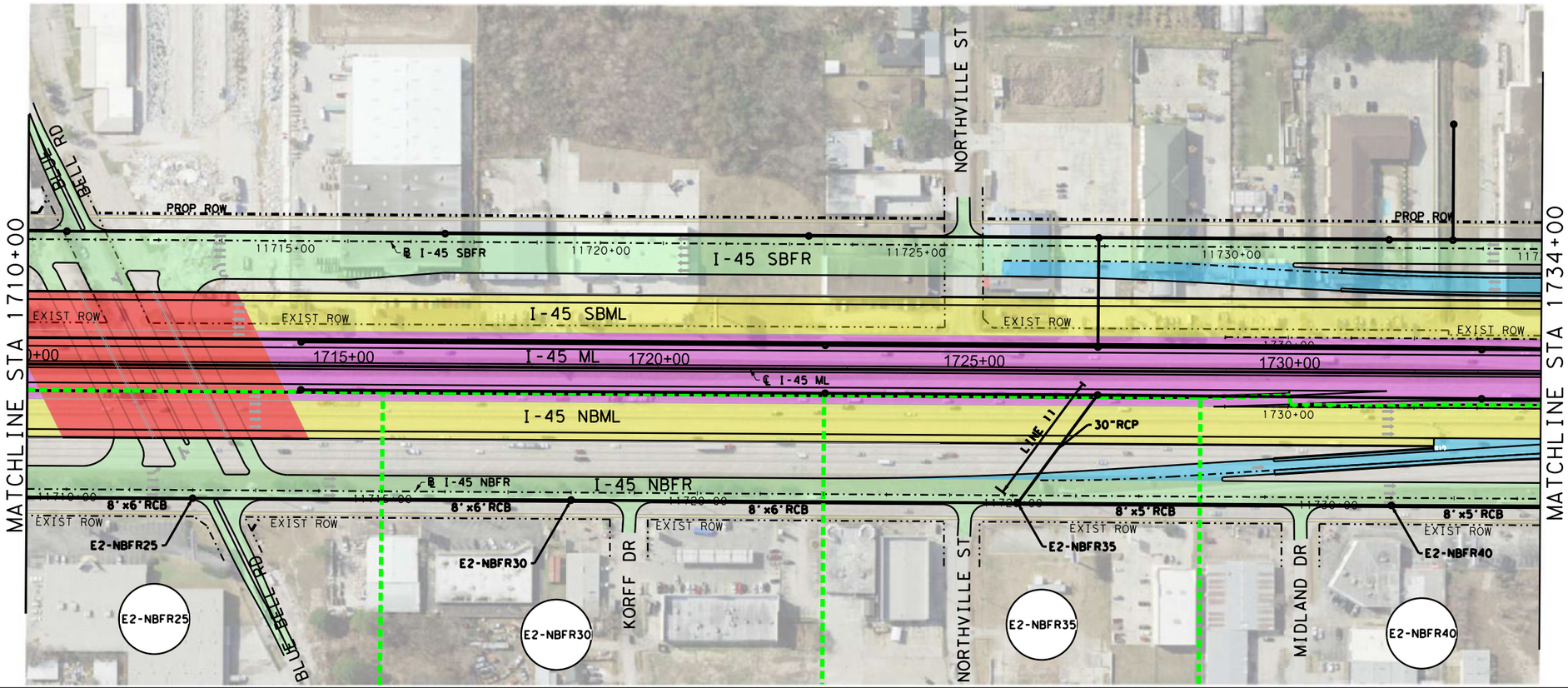

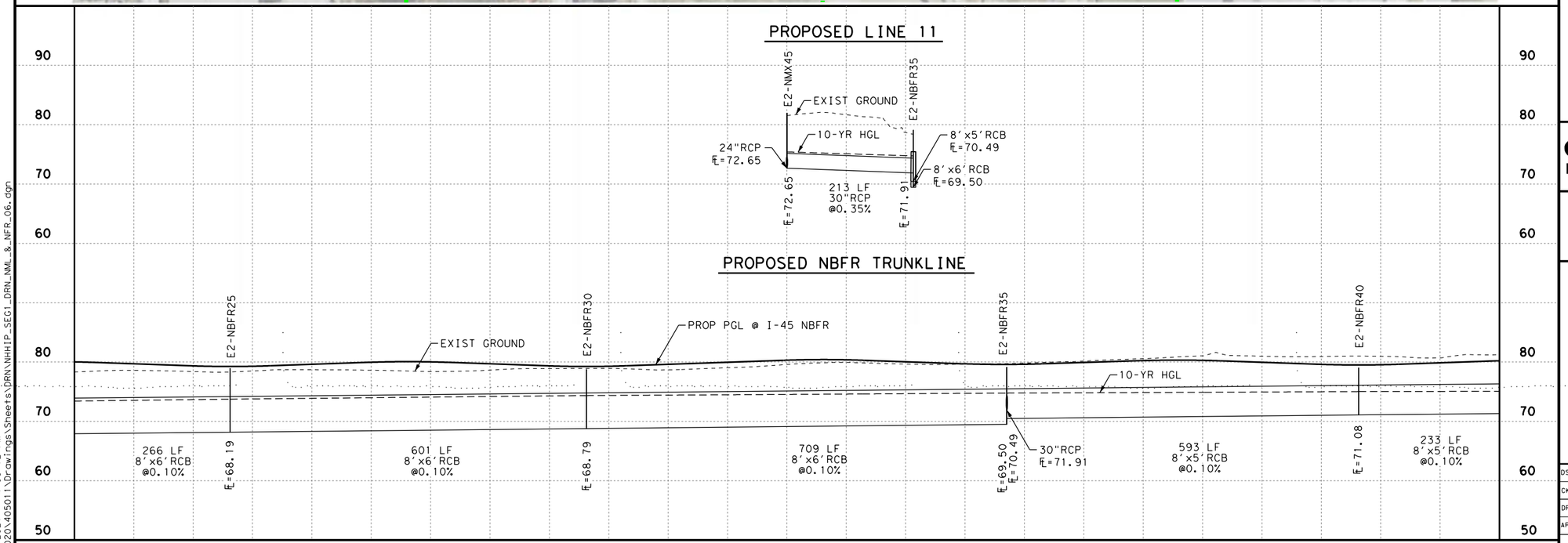

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

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2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
0 10 20 (V)

REV NO.	DATE	BY	REVISION

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PRELIMINARY SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NBFR STORM SEWER PLAN AND PROFILE
STA 1710+00 TO STA 1734+00
℄ I-45 MAXLANES

SHEET 6 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-1
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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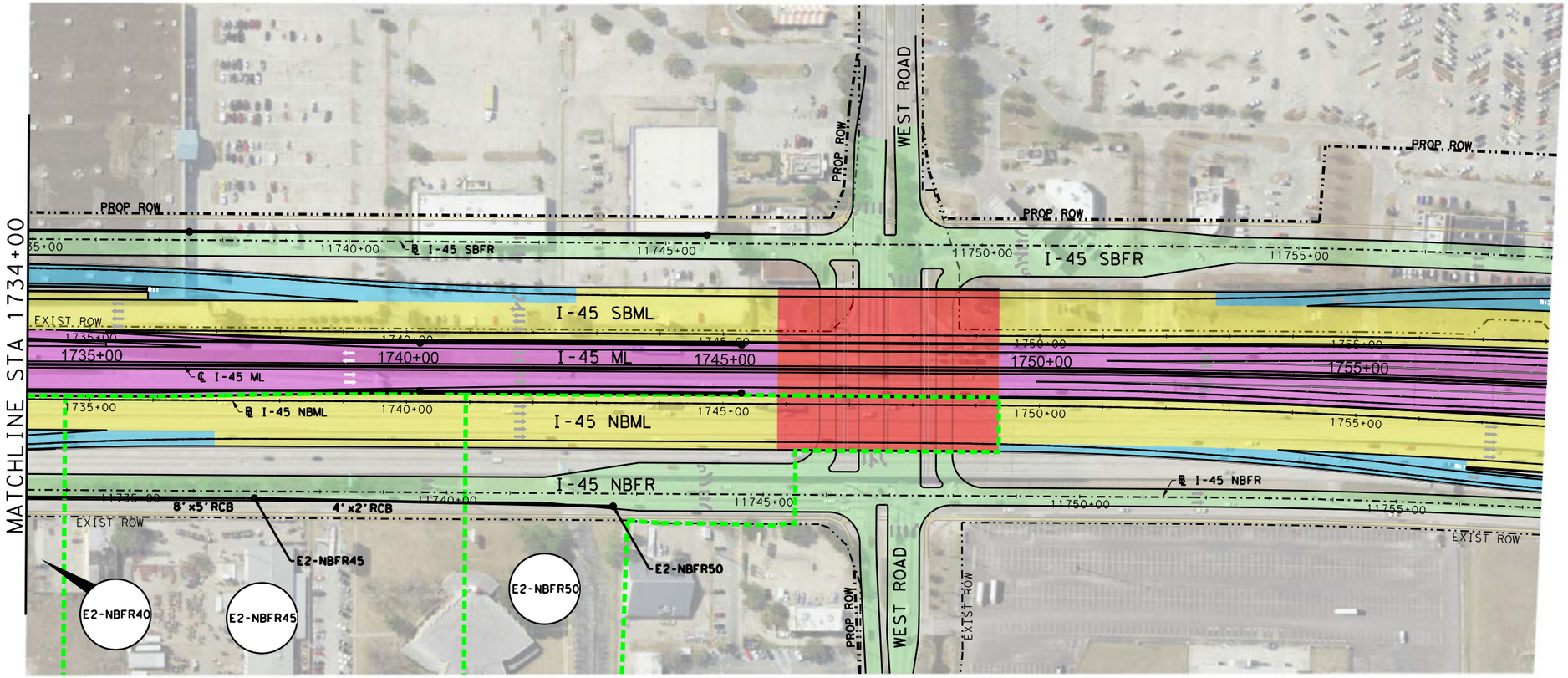

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
0 10 20 (V)

REV NO.	DATE	BY	REVISION

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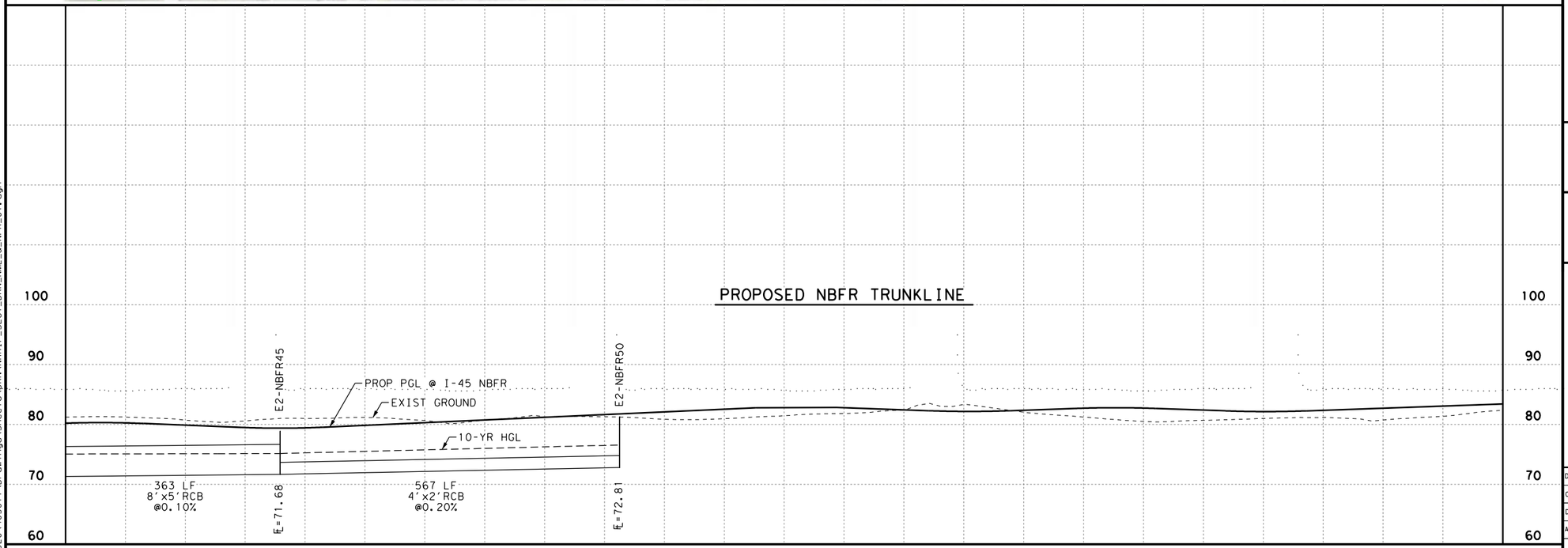
Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NBFR STORM SEWER PLAN AND PROFILE
STA 1734+00 TO END
℄ I-45 MAXLANES

SHEET 7 OF 7



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CK: CW	6	12-01DP5012	4-1
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
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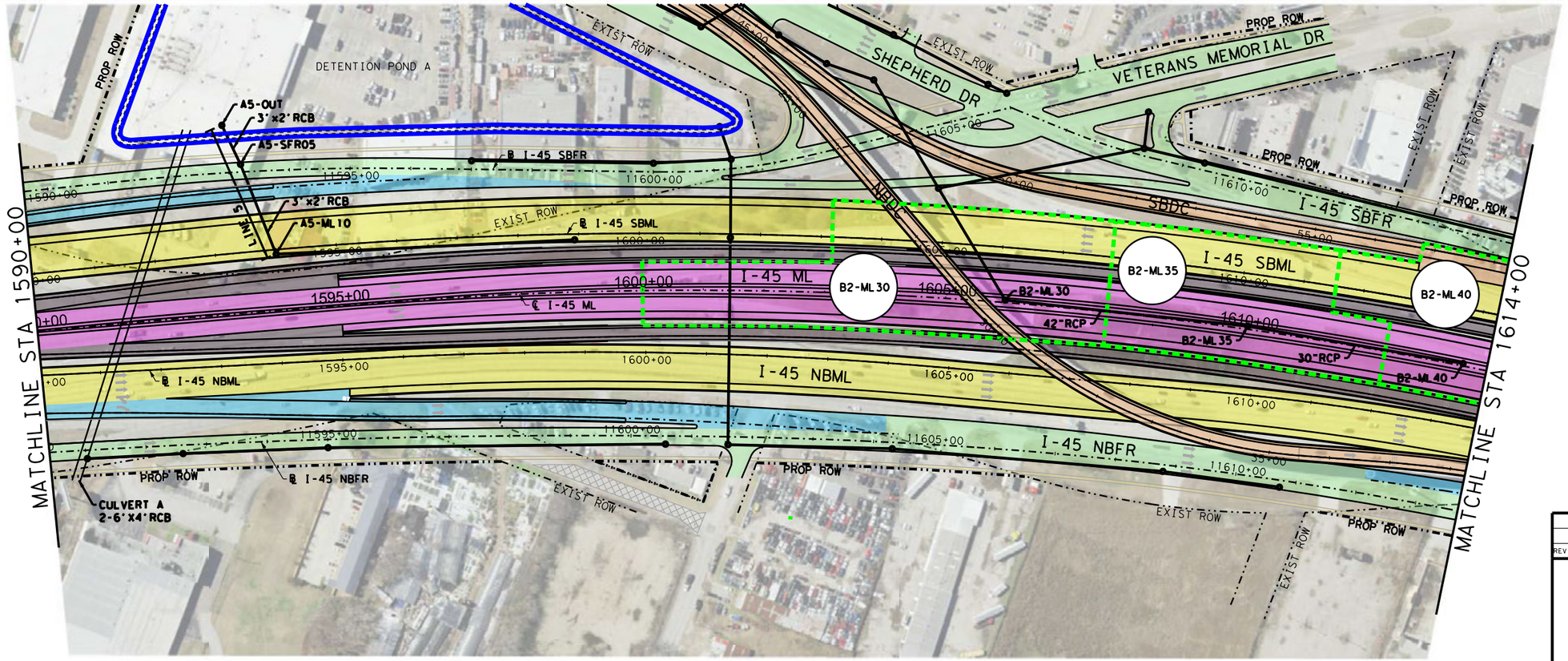

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

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Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1590+00 TO STA 1614+00
℄ I-45 MAXLANES

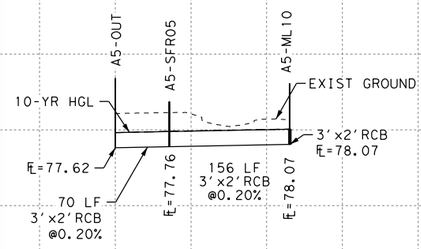
SHEET 1 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-2
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

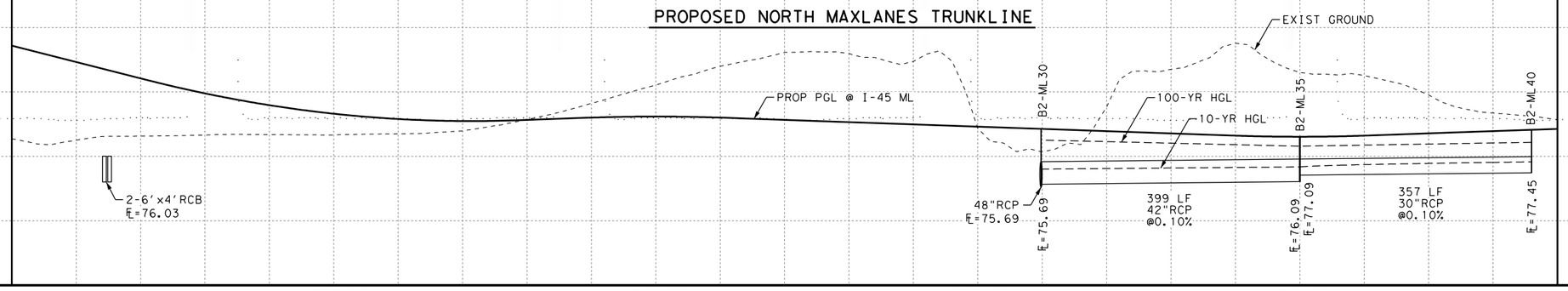
NOTE:

SYSTEM A SWMM MODEL PREPARED BY TNP.
STORM SEWER DESIGN SOUTH OF CULVERT A PREPARED BY TNP.
STORM SEWER DESIGN NORTH OF CULVERT A PREPARED BY CIVILTECH ENGINEERING INC.
SEE DRAINAGE REPORT TITLED "NORTH HOUSTON HIGHWAY IMPROVEMENT PROJECT SEGMENT 1 FROM SOUTH OF SHEPHERD DRIVE TO SOUTH OF WEST ROAD" PREPARED BY CIVILTECH ENGINEERING INC, IN MARCH 2021.

PROPOSED LINE 5



PROPOSED NORTH MAXLANES TRUNKLINE



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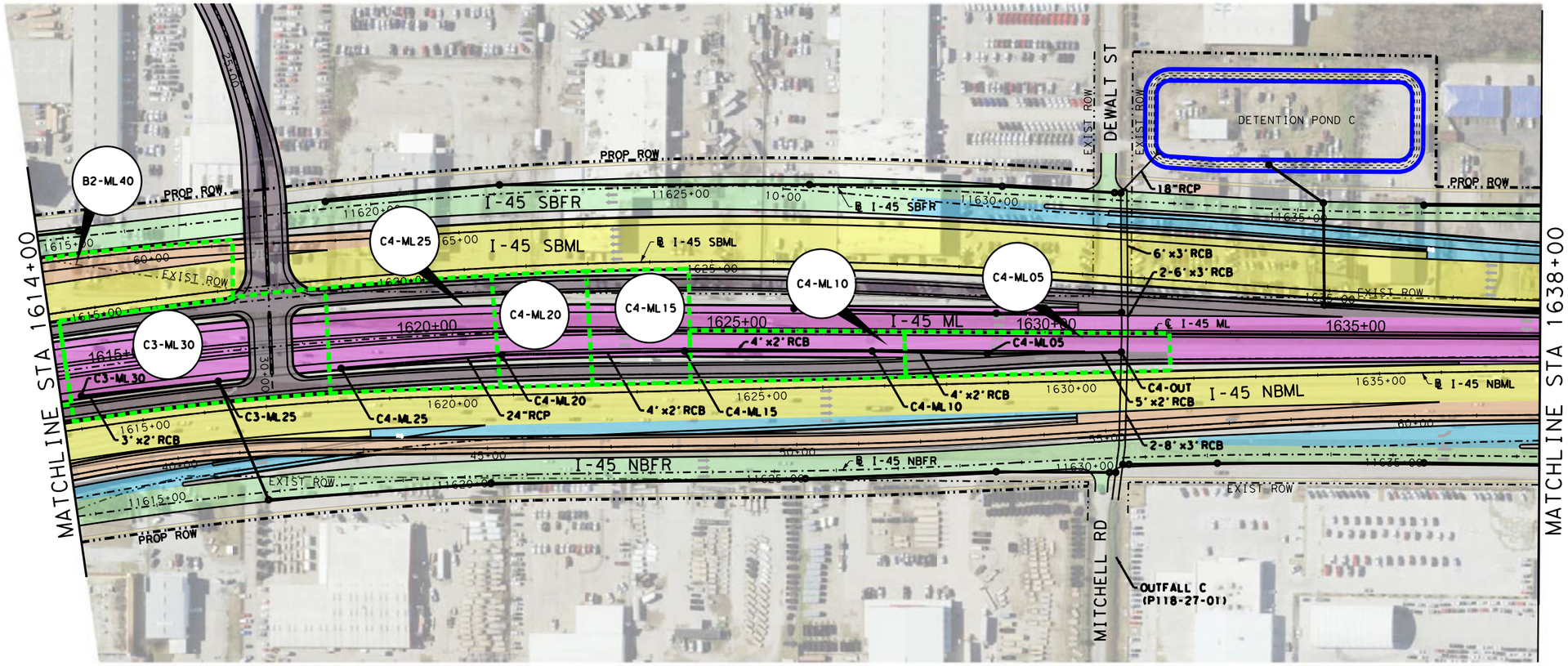

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

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2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.
3. SEE EXHIBIT 15 FOR FURTHER DETAILS REGARDING DETETION POND.

0 100 200 (H)
0 10 20 (V)

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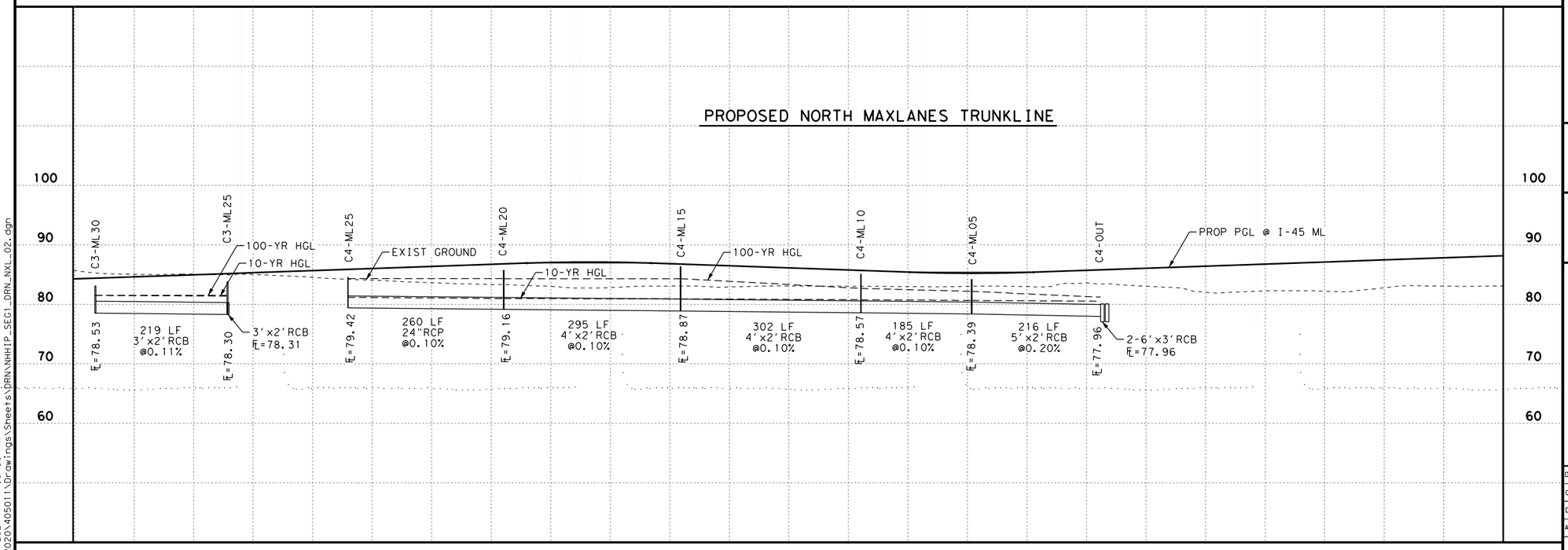
NHHIP SEGMENT 1
I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1614+00 TO STA 1638+00
℄ I-45 MAXLANES



DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-2
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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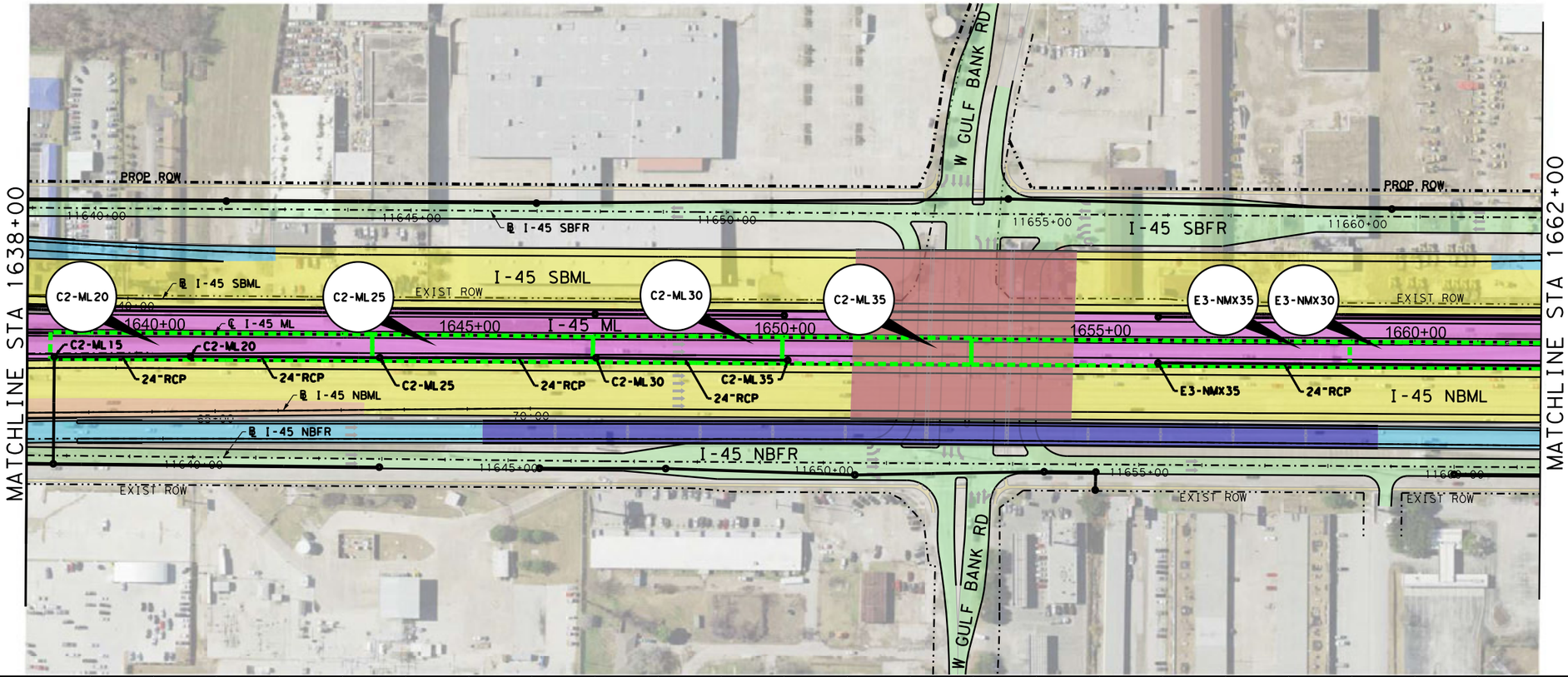

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
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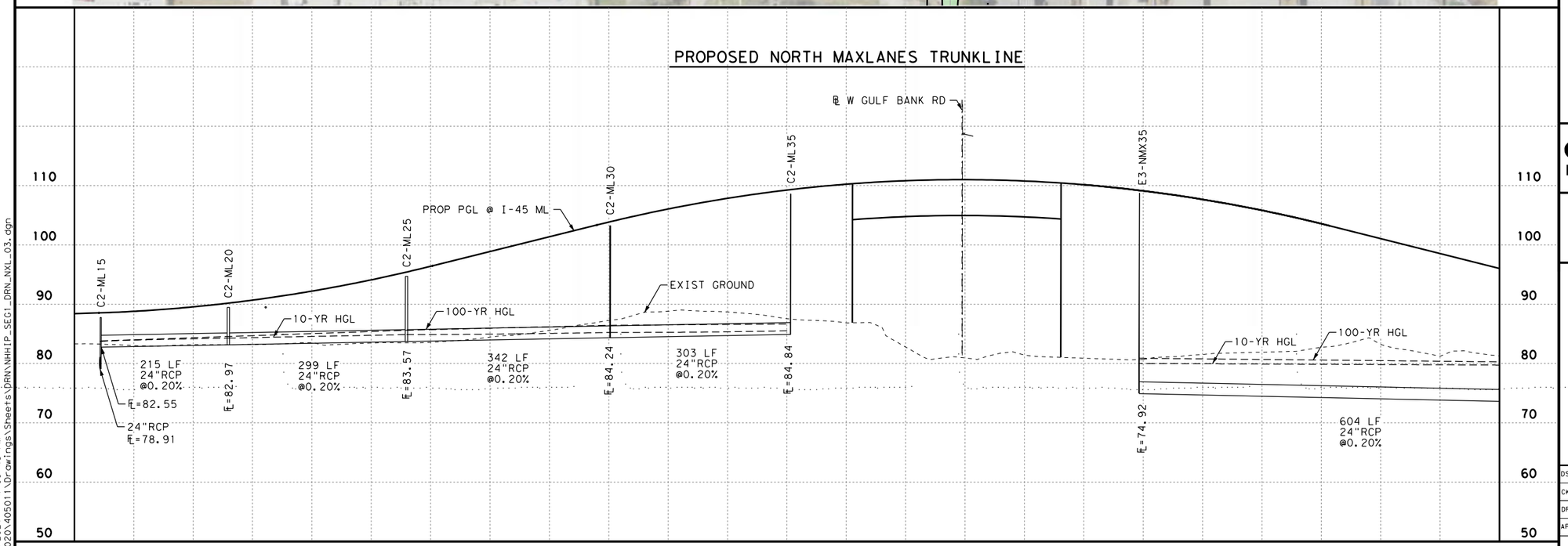
NHHIP SEGMENT 1
I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE
STA 1638+00 TO STA 1662+00
℄ I-45 MAXLANES

SHEET 3 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-2
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

PROPOSED NORTH MAXLANES TRUNKLINE



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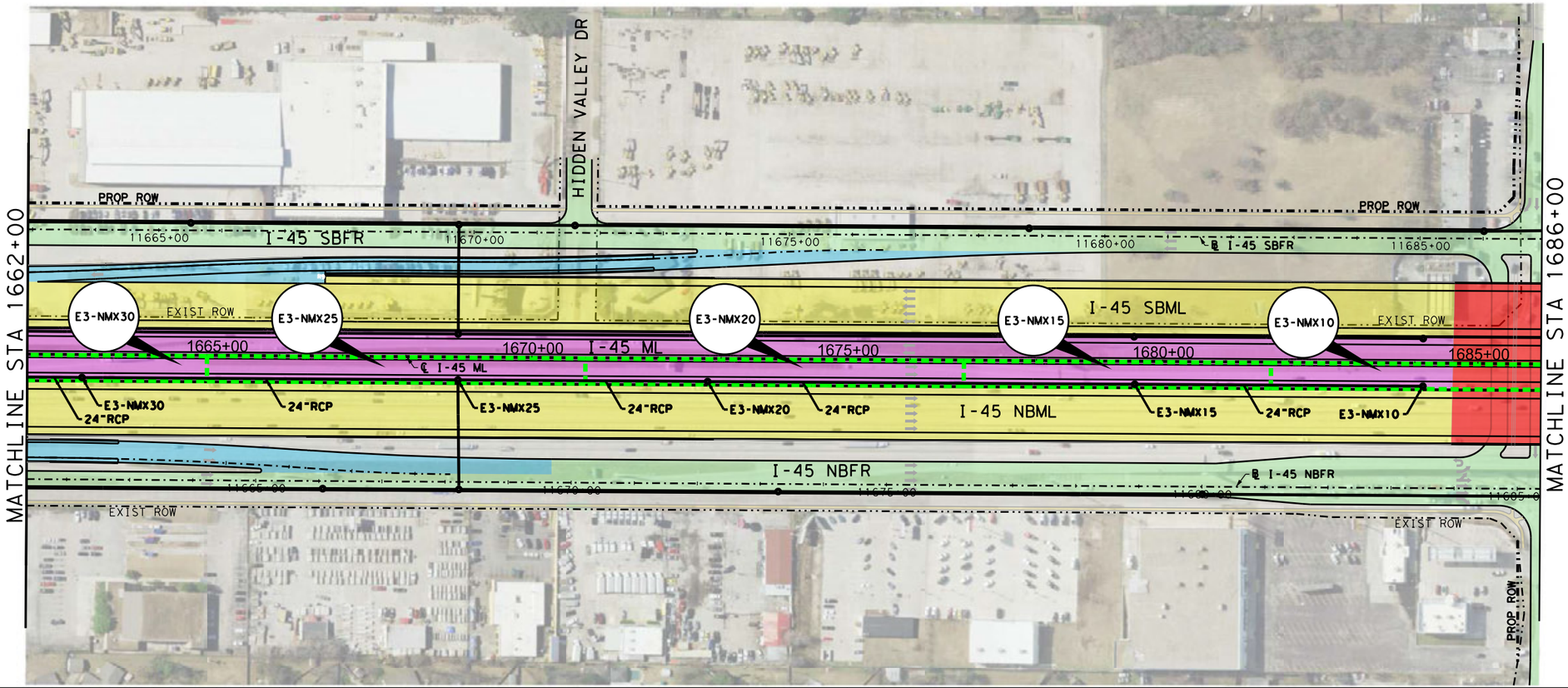

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

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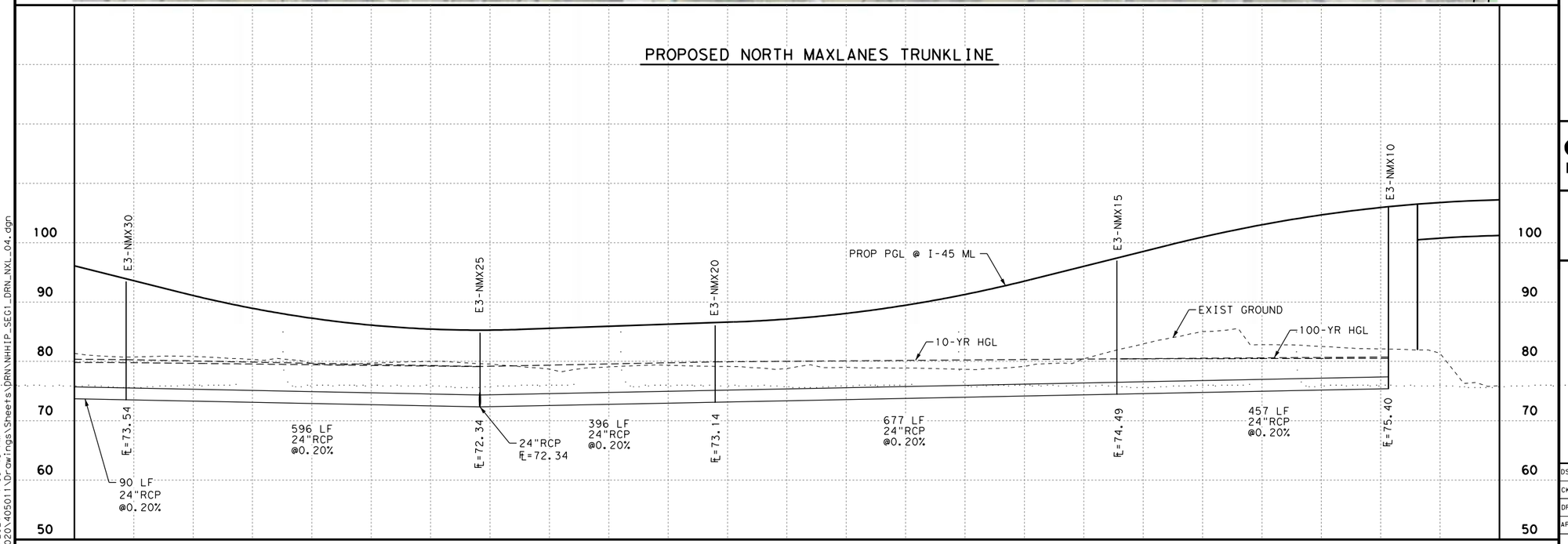
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

Texas Department of Transportation

PROPOSED NORTH MAXLANES TRUNKLINE



NHHIP SEGMENT 1

I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1662+00 TO STA 1686+00
℄ I-45 MAXLANES

SHEET 4 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-2
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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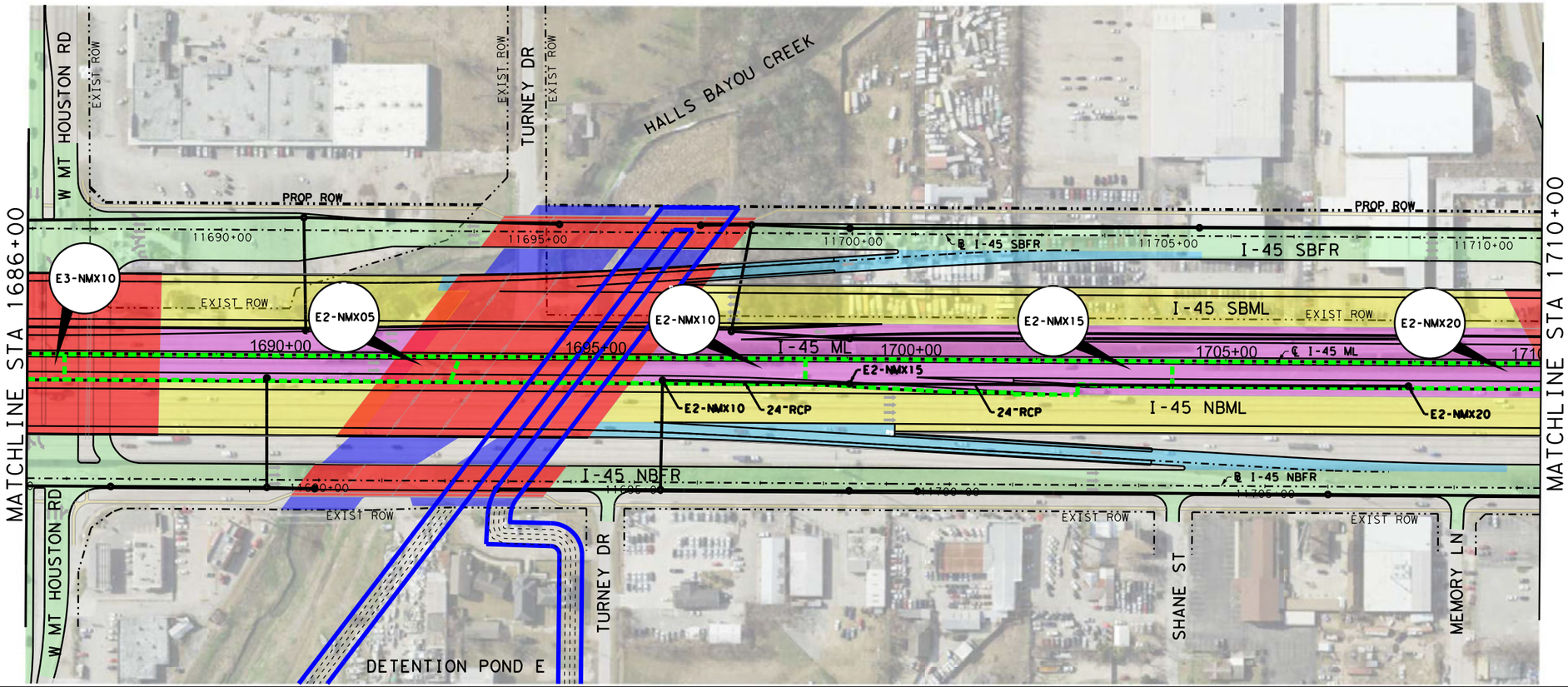

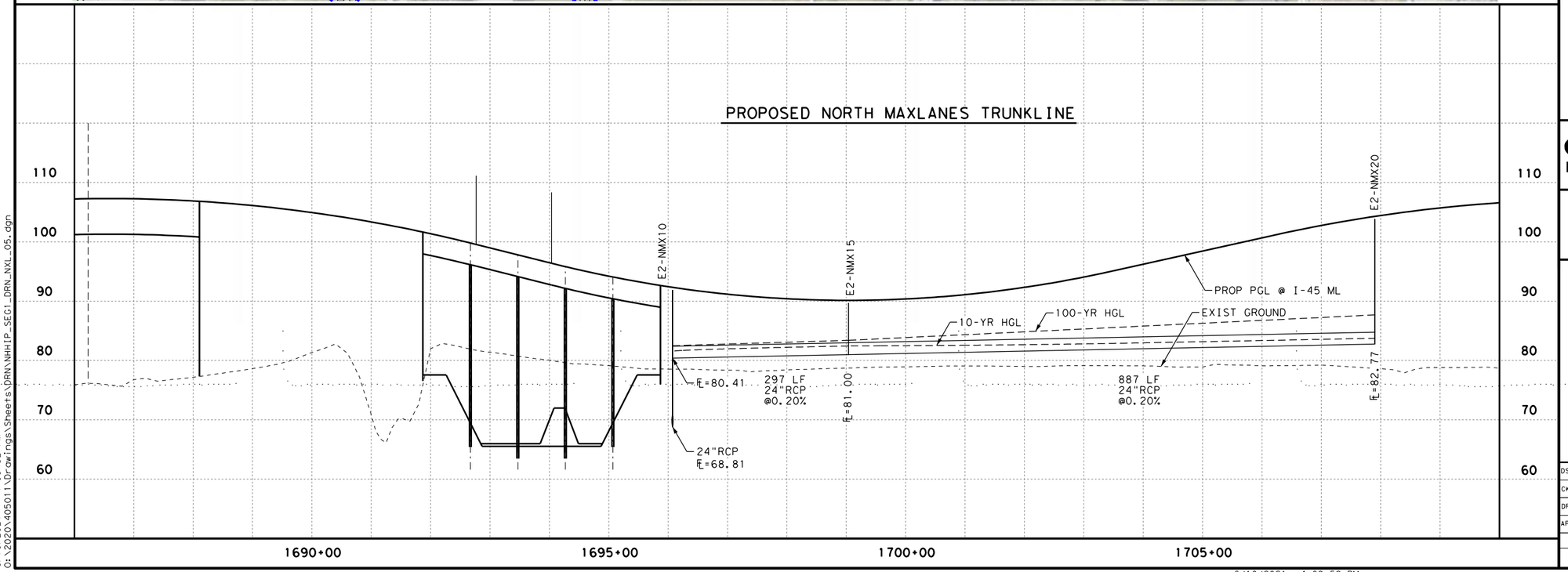

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

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2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.
3. SEE EXHIBIT 15 FOR FURTHER DETAILS REGARDING DETETION POND.

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REV NO.	DATE	BY	REVISION

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NHHIP SEGMENT 1
I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE
STA 1686+00 TO STA 1710+00
℄ I-45 MAXLANES

SHEET 5 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-2
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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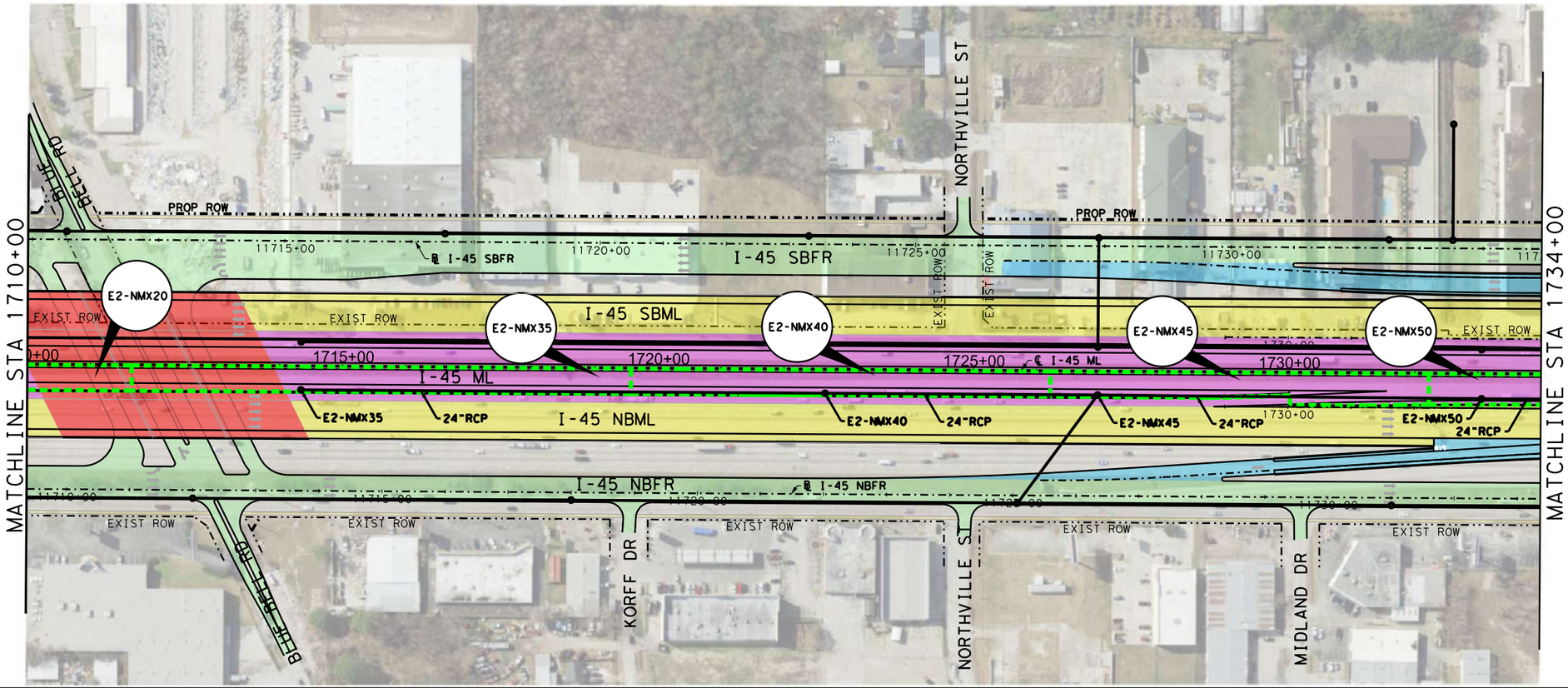

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

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REV NO.	DATE	BY	REVISION

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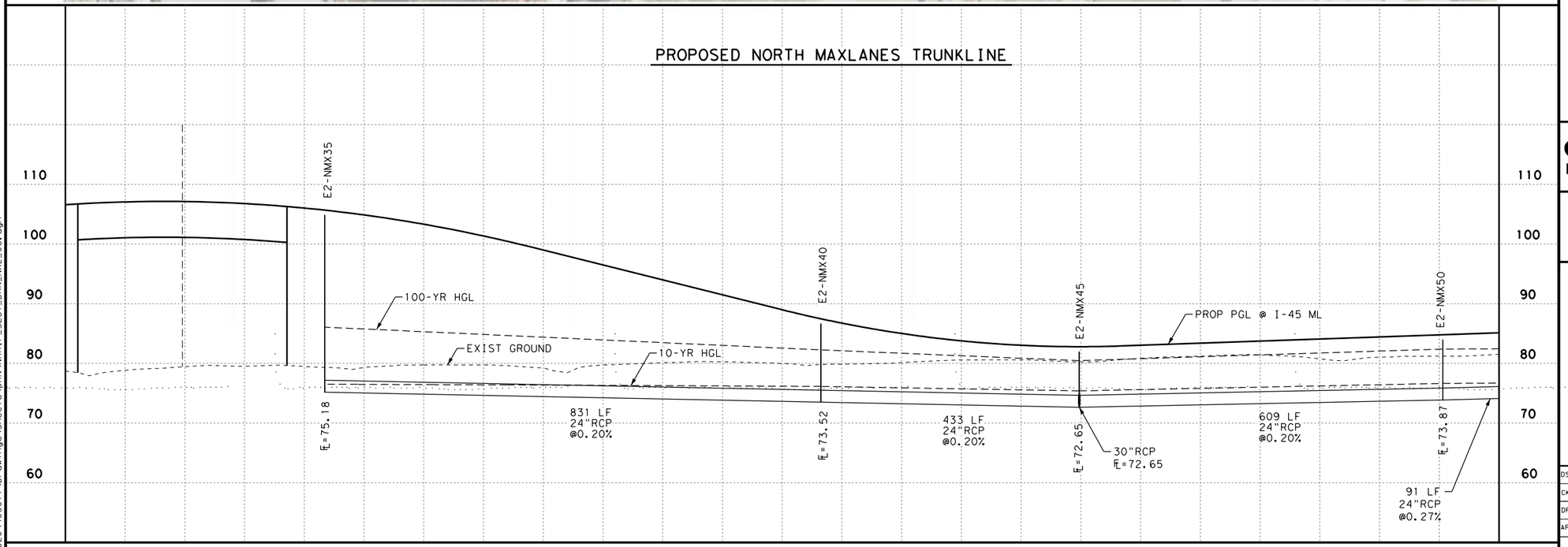
Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1710+00 TO STA 1734+00
℄ I-45 MAXLANES

SHEET 6 OF 7

PROPOSED NORTH MAXLANES TRUNKLINE



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CK: CW	6	12-01DP5012	4-2
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APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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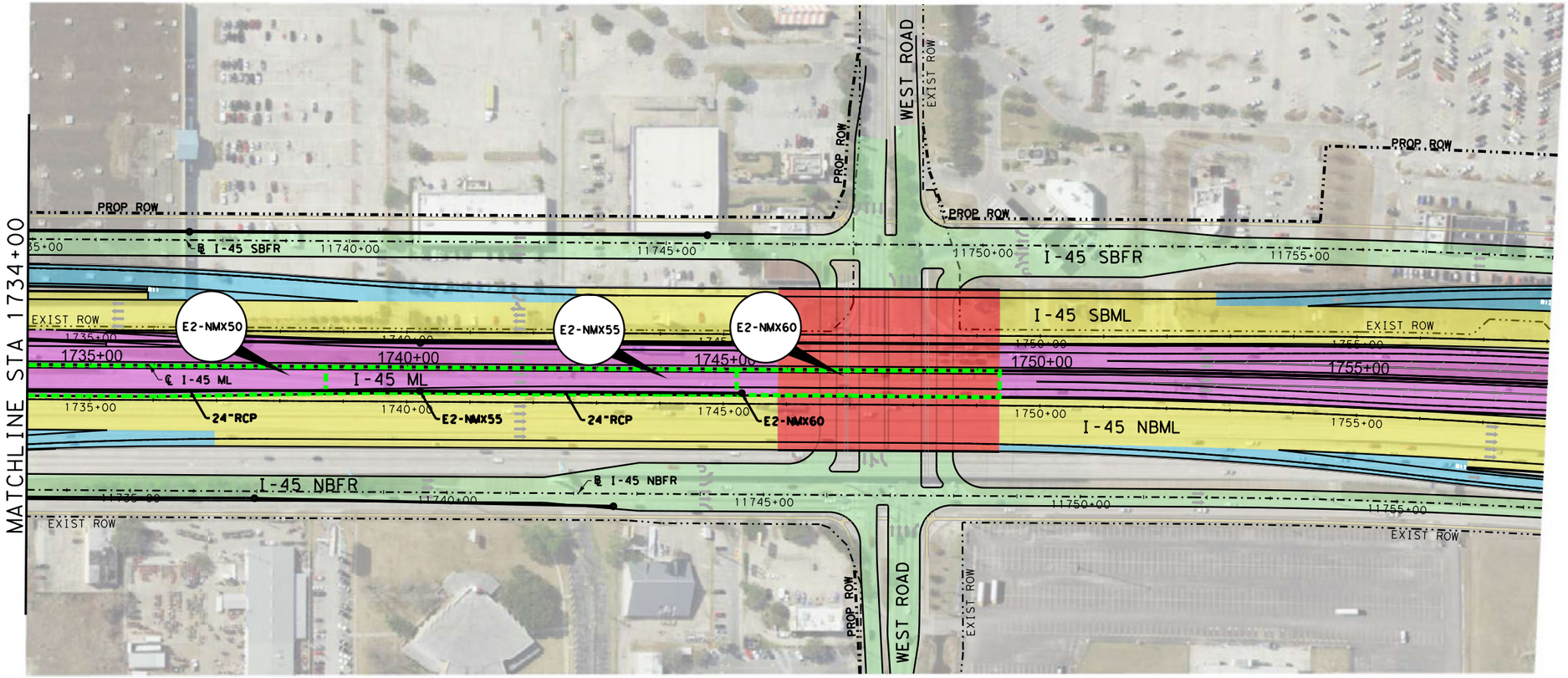

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
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CivilTech Engineering, Inc.
1.1821 Telge Road
Cypress, Texas 77429
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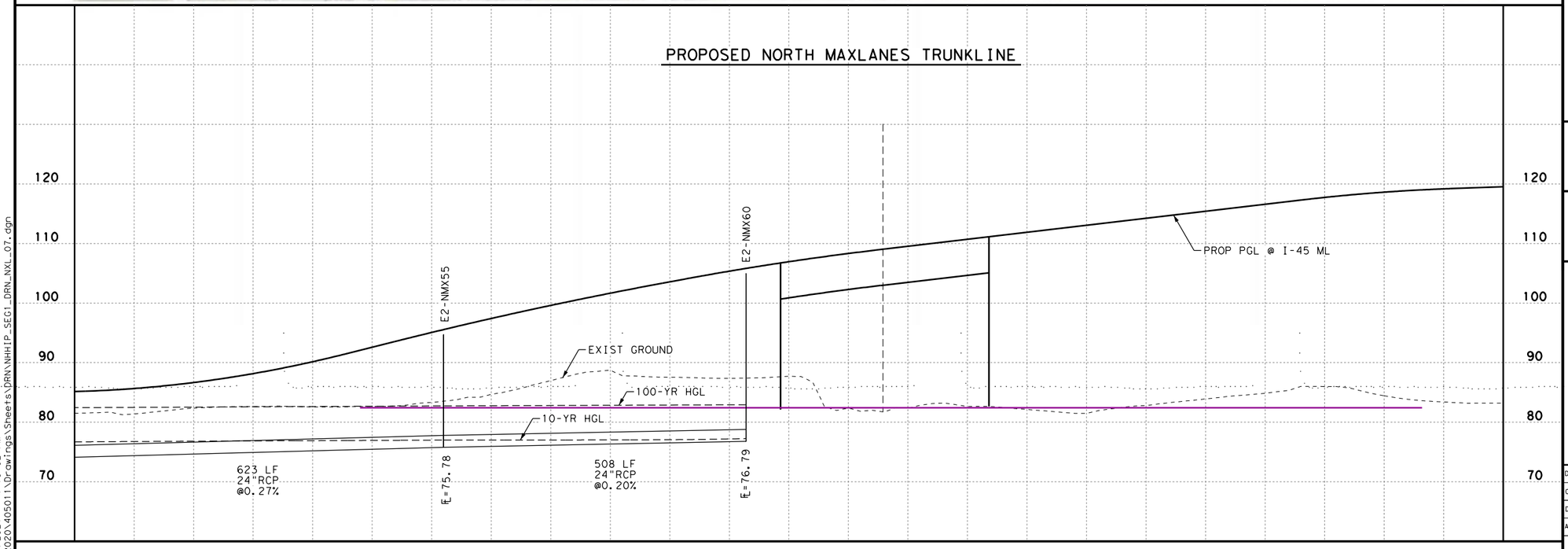
Texas Department of Transportation

NHHIP SEGMENT 1
I-45 NORTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1734+00 TO END
℄ I-45 MAXLANES

SHEET 7 OF 7

PROPOSED NORTH MAXLANES TRUNKLINE



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DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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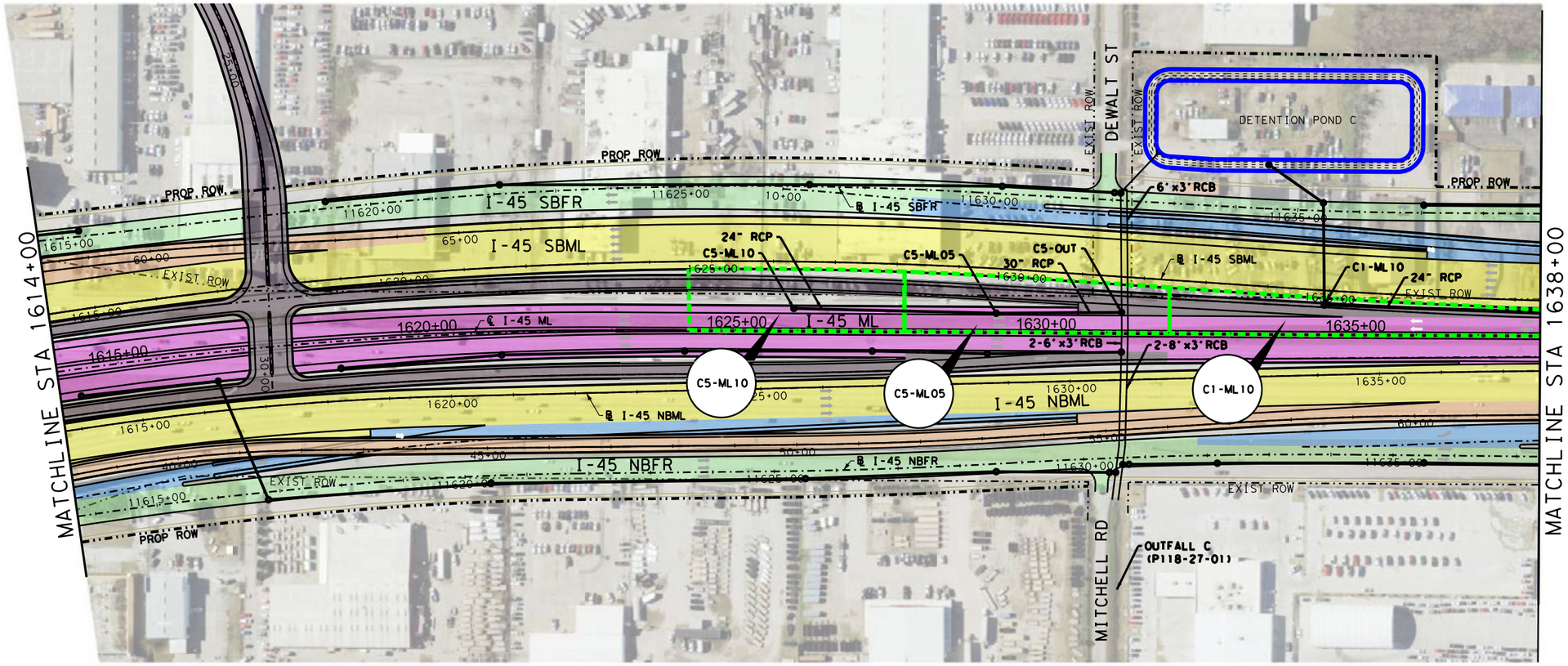

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
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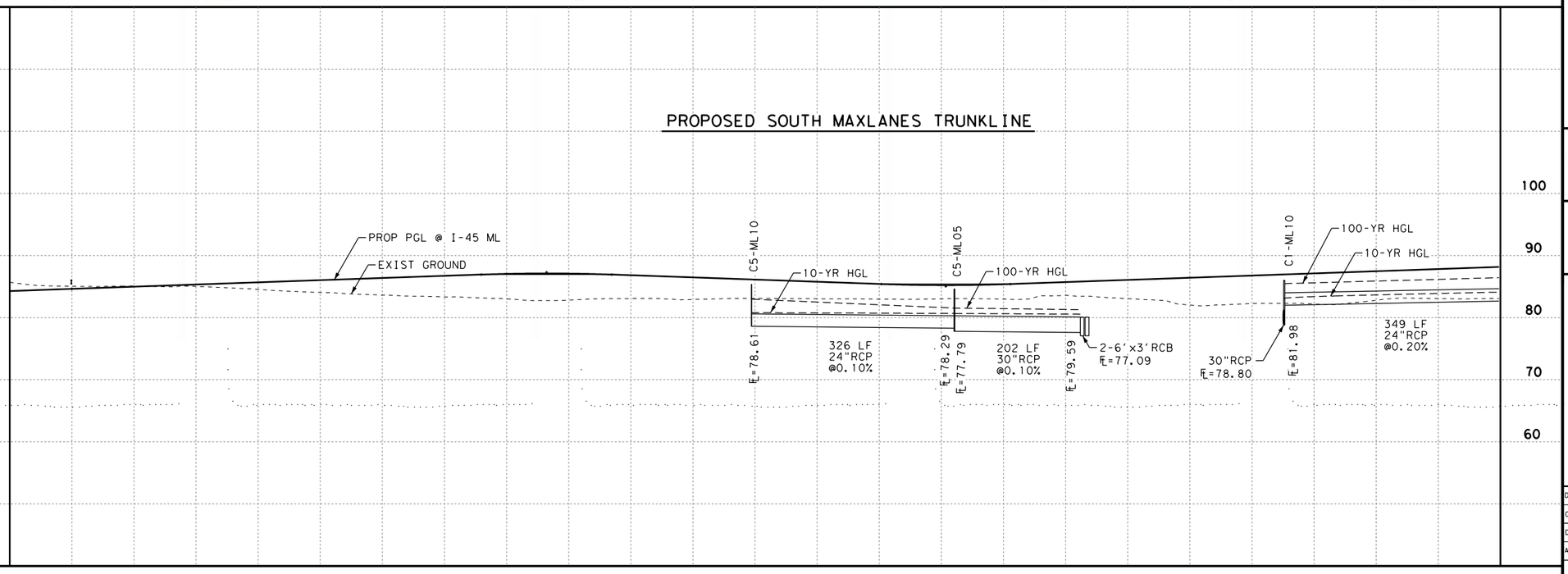
Firm Registration No. F-382

PROPOSED SOUTH MAXLANES TRUNKLINE



NHHIP SEGMENT 1
I-45 SOUTH MAXLANES STORM SEWER PLAN AND PROFILE
STA 1614+00 TO STA 1638+00
℄ I-45 MAXLANES

SHEET 1 OF 6

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-3
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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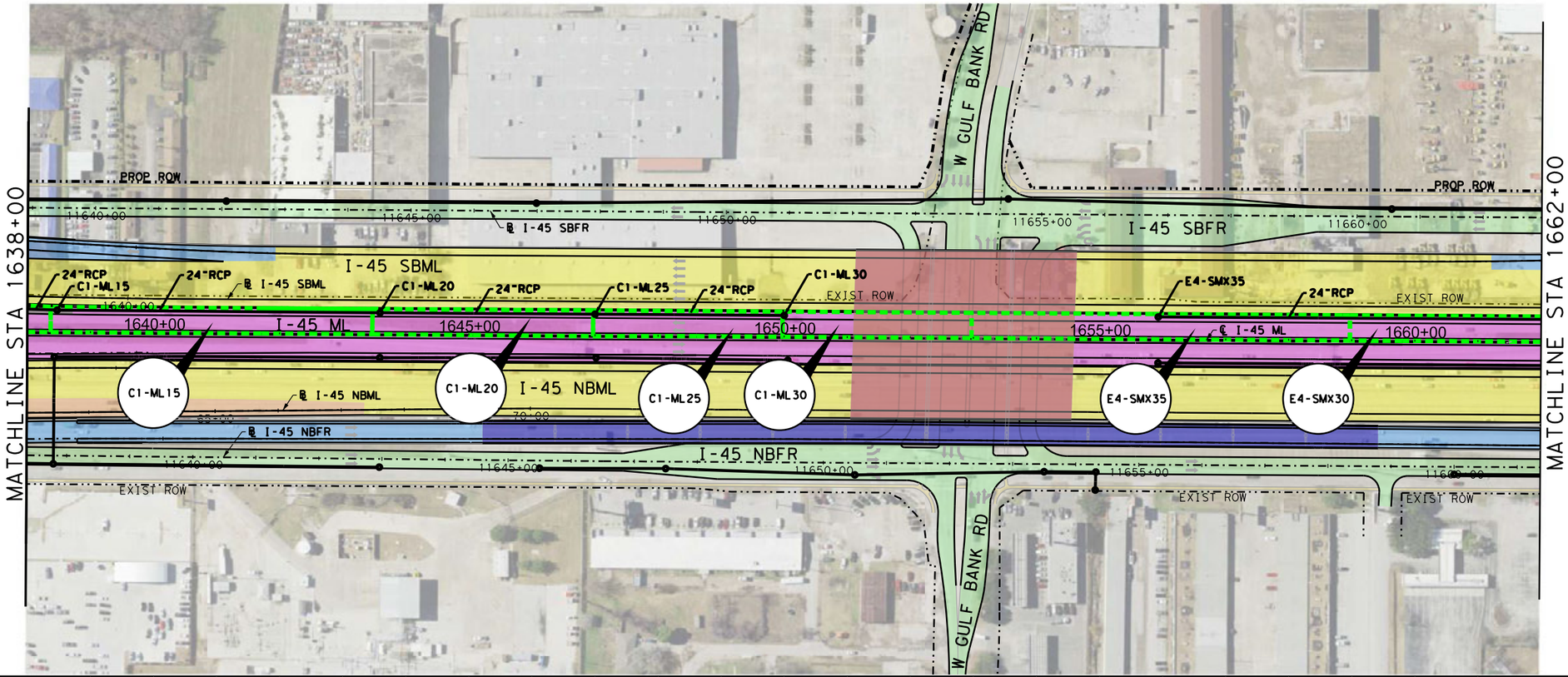

LEGEND

- PROP STORM SEWER NODE
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0 10 20 (V)

REV NO.	DATE	BY	REVISION

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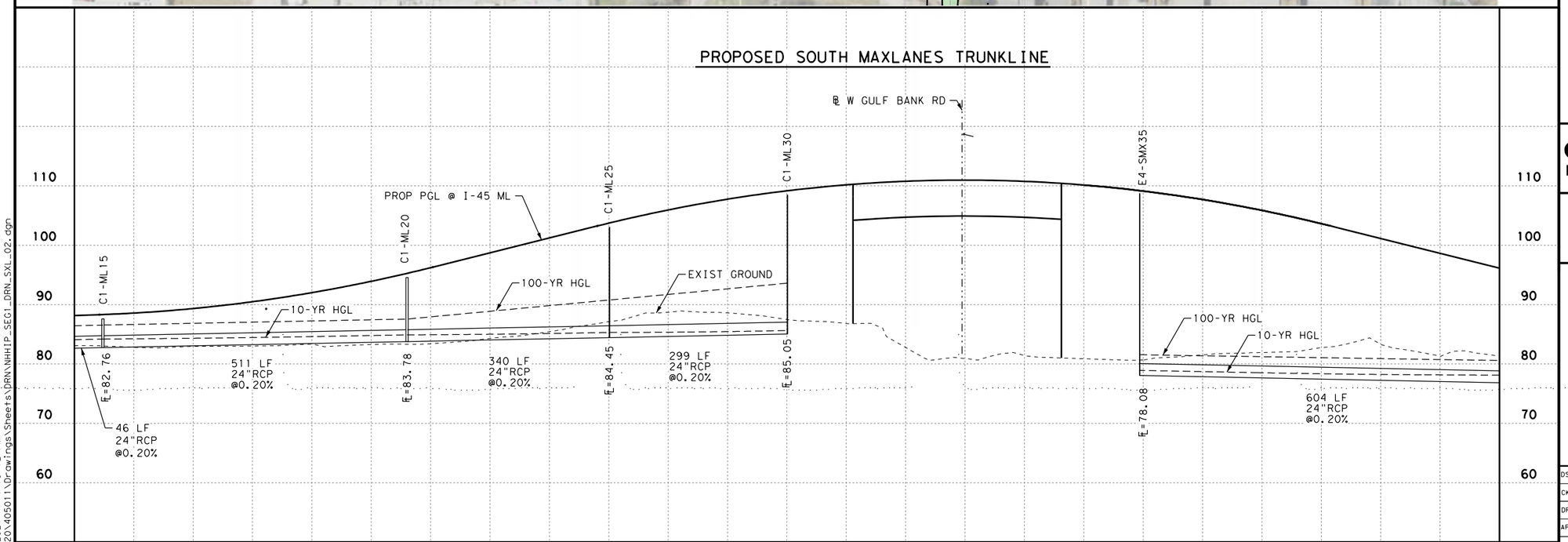
PRELIMINARY SUBJECT TO CHANGE



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Texas Department of Transportation

NHHIP SEGMENT 1
I-45 SOUTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1638+00 TO STA 1662+00
℄ I-45 MAXLANES

SHEET 2 OF 6

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-3
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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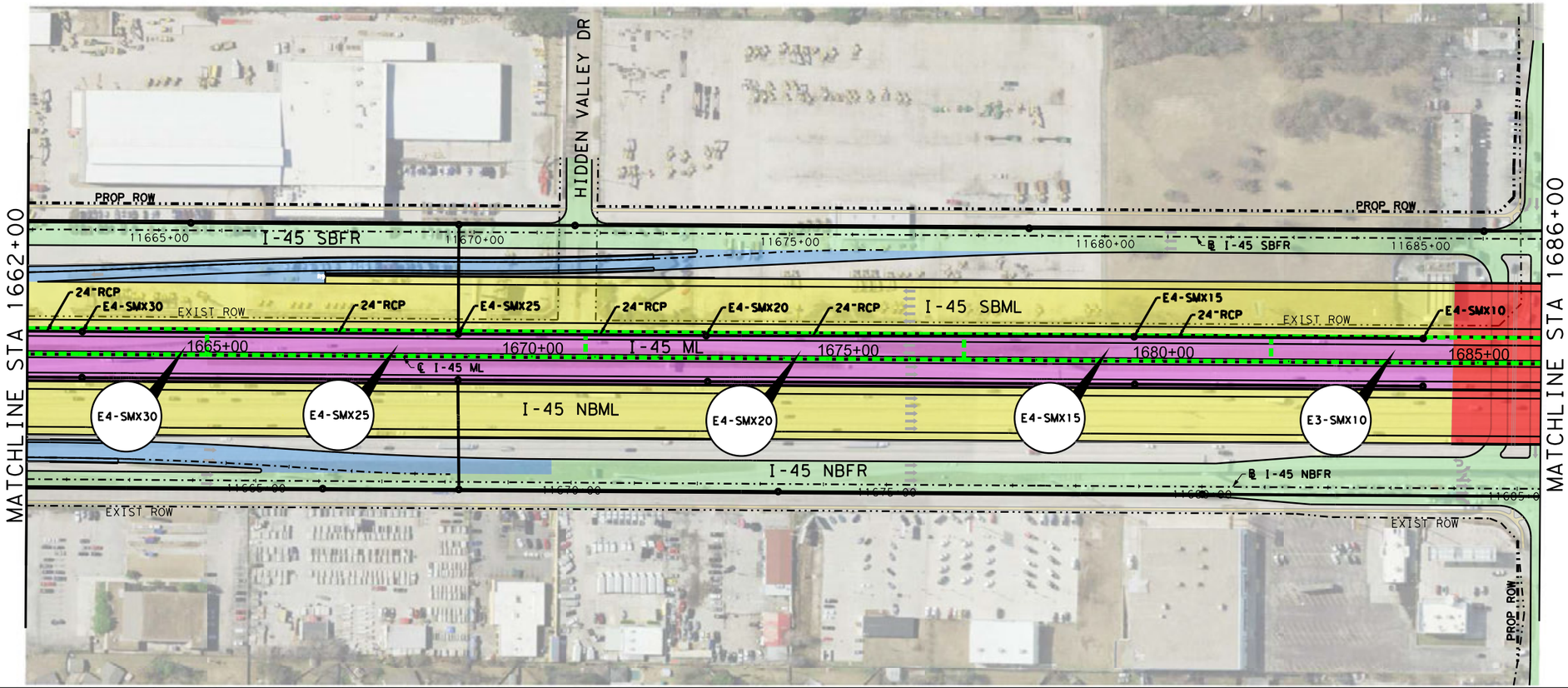

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

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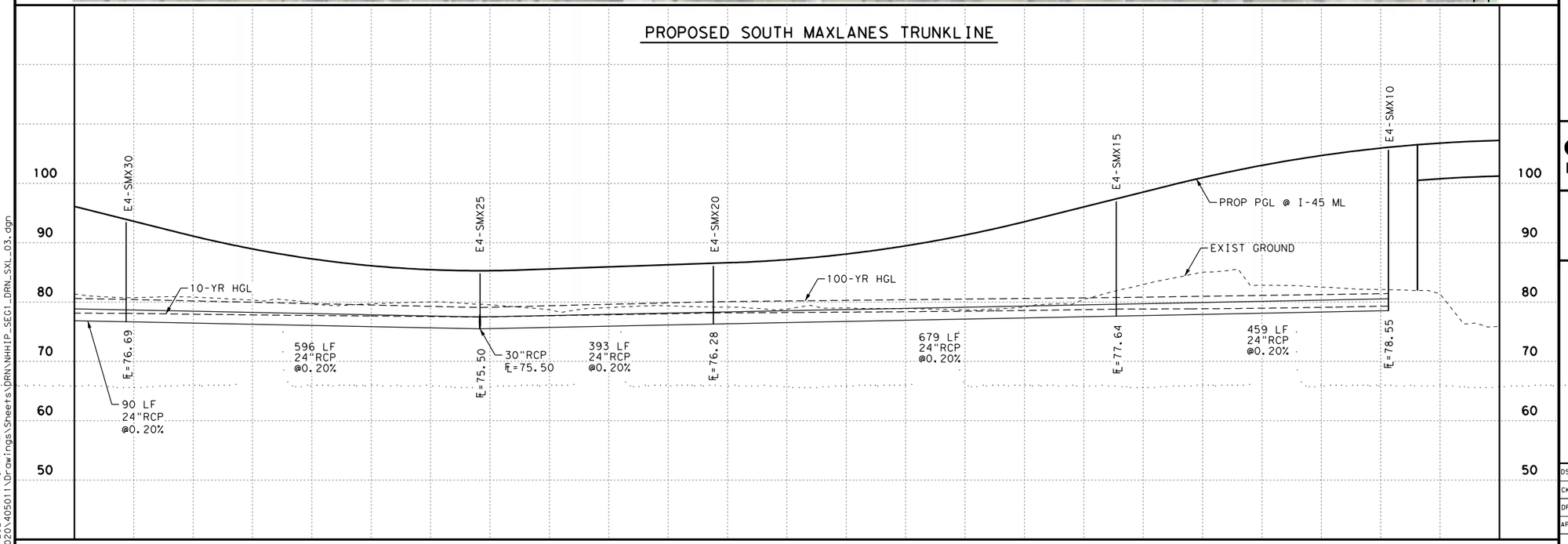

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NHHIP SEGMENT 1
I-45 SOUTH MAXLANES STORM SEWER PLAN AND PROFILE

STA 1662+00 TO STA 1686+00
℄ I-45 MAXLANES

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-3
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
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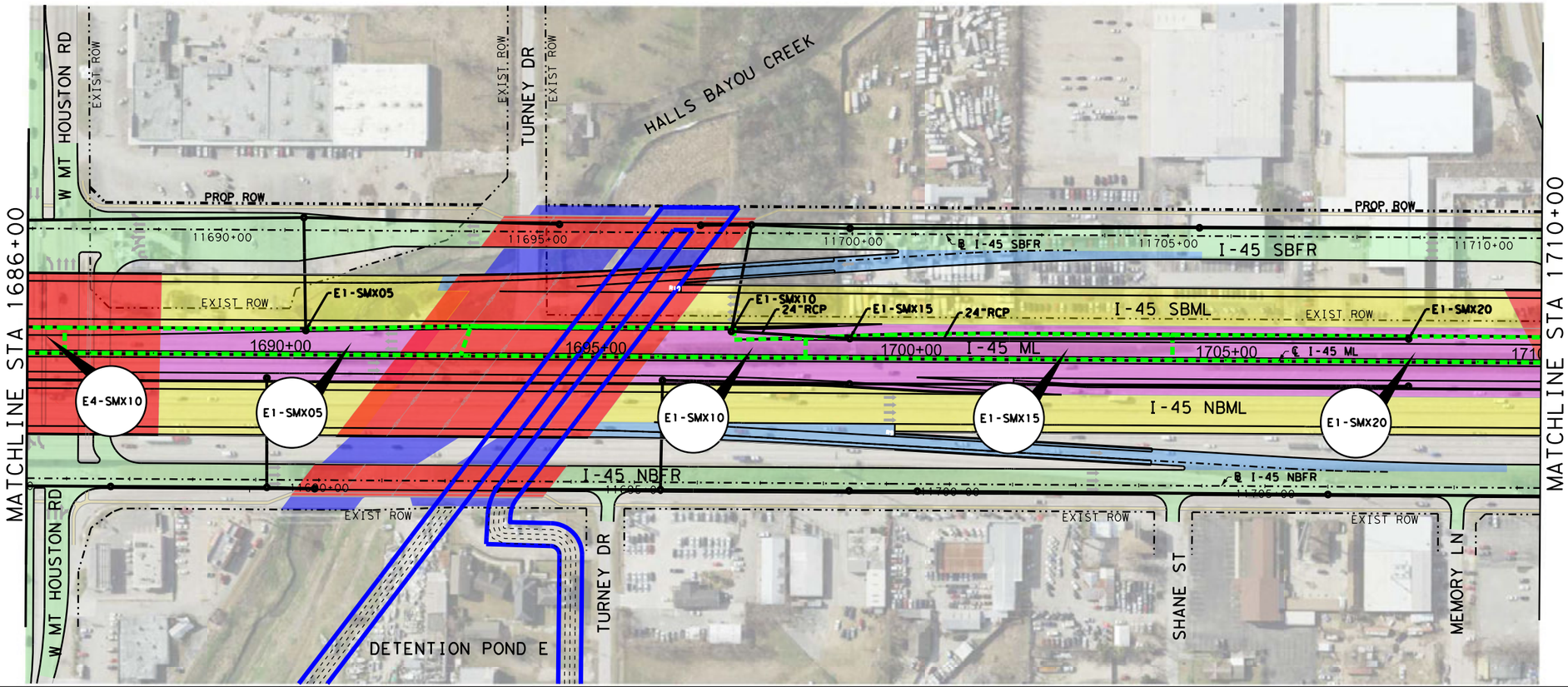

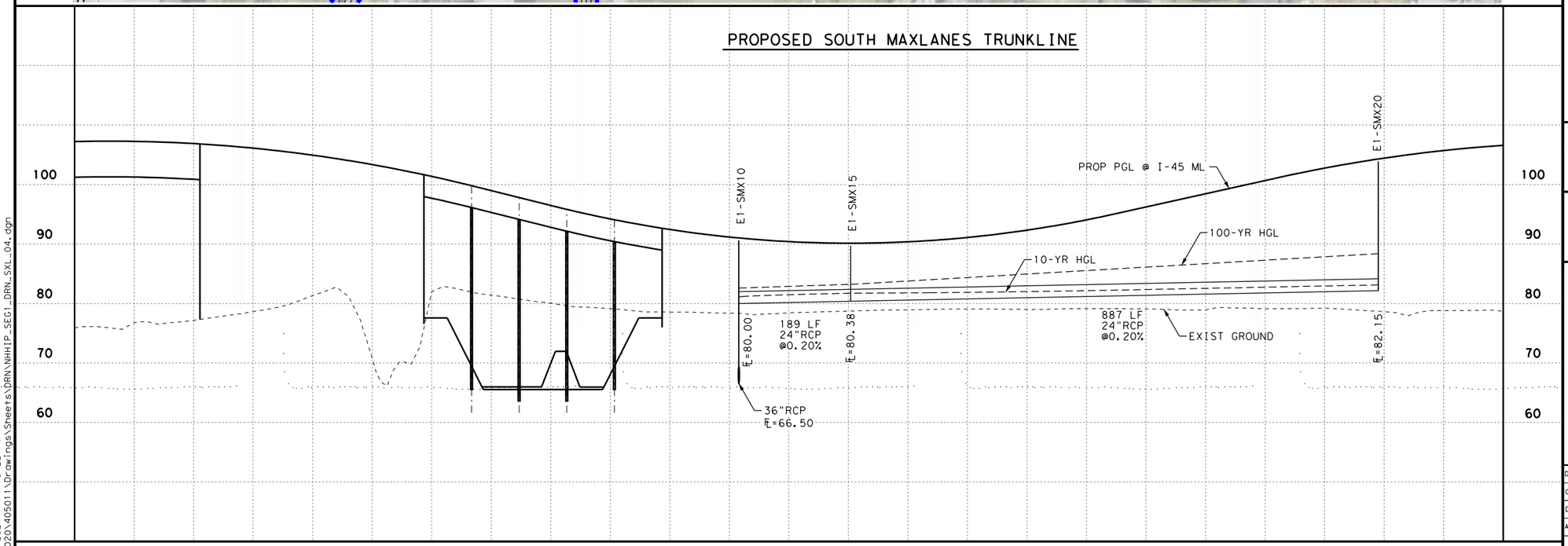

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
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NHHIP SEGMENT 1
I-45 SOUTH MAXLANES STORM SEWER PLAN AND PROFILE
STA 1686+00 TO STA 1710+00
℄ I-45 MAXLANES

SHEET 4 OF 6

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-3
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
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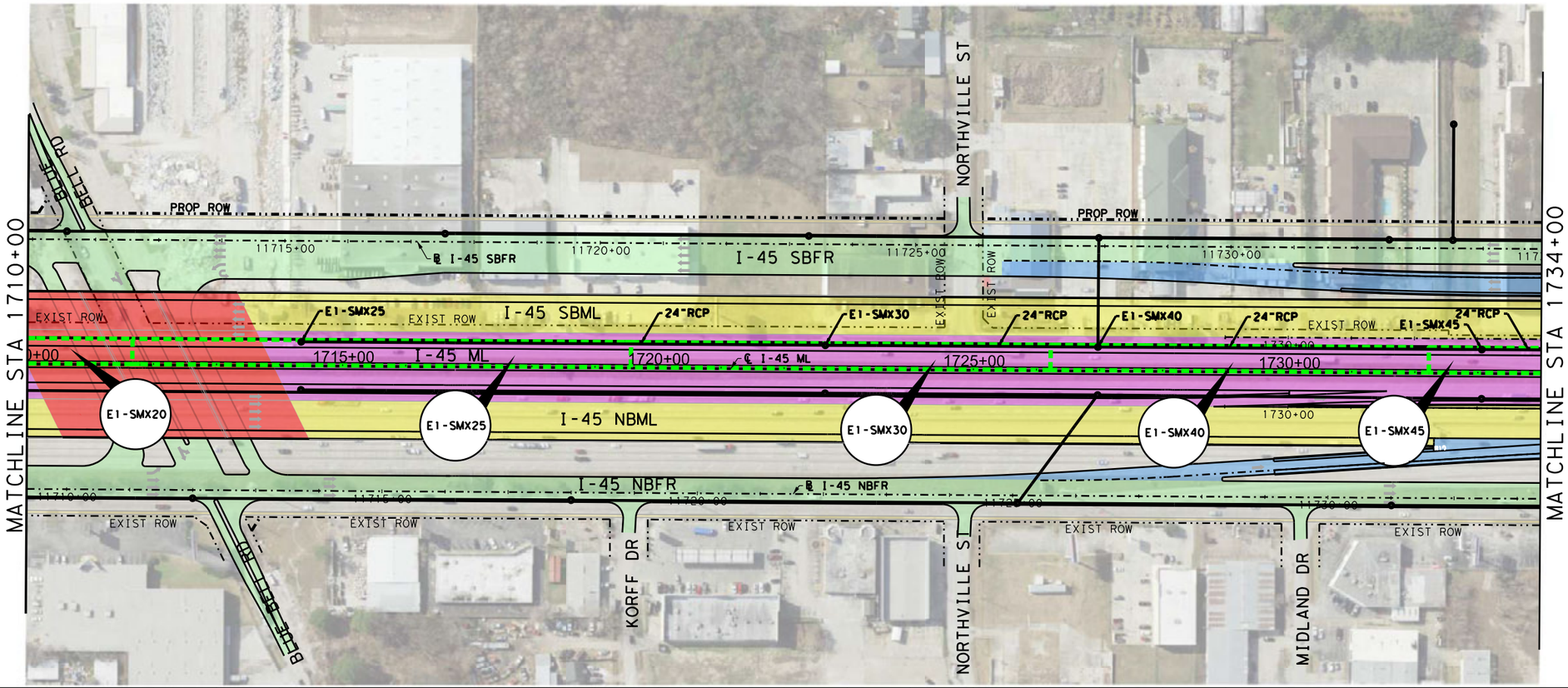

LEGEND

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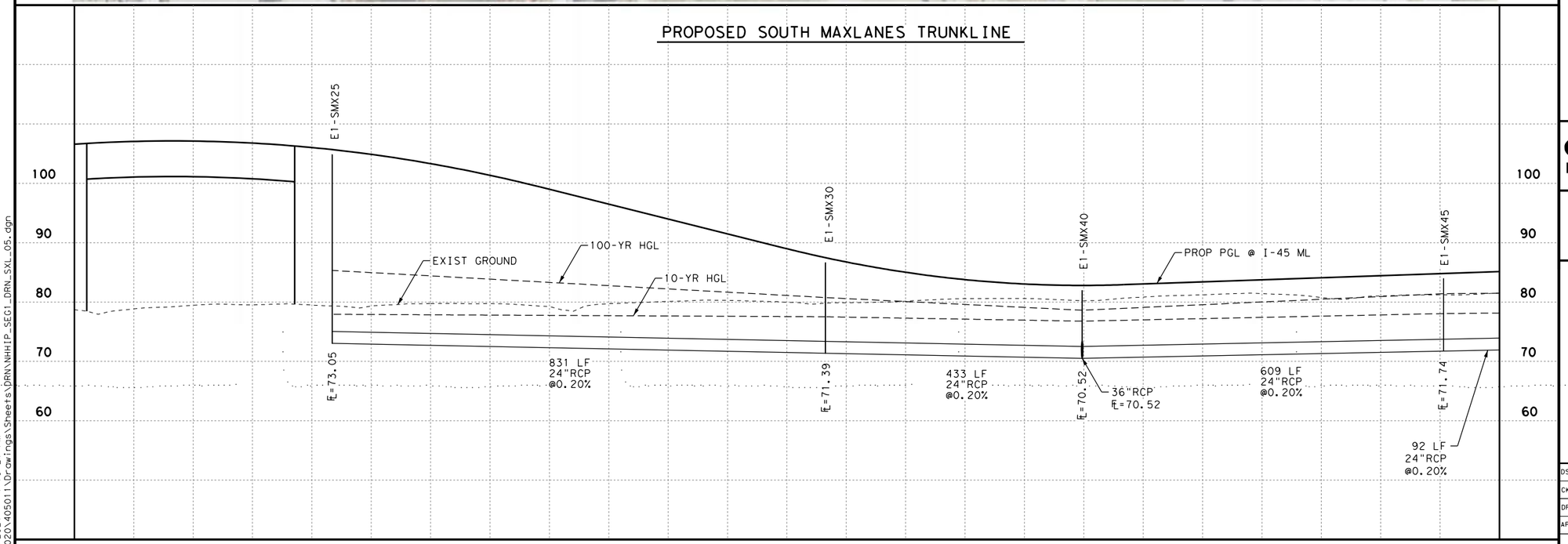
PROPOSED SOUTH MAXLANES TRUNKLINE



NHHIP SEGMENT 1
I-45 SOUTH MAXLANES STORM SEWER PLAN AND PROFILE
STA 1710+00 TO STA 1734+00
℄ I-45 MAXLANES

SHEET 5 OF 6

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-3
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
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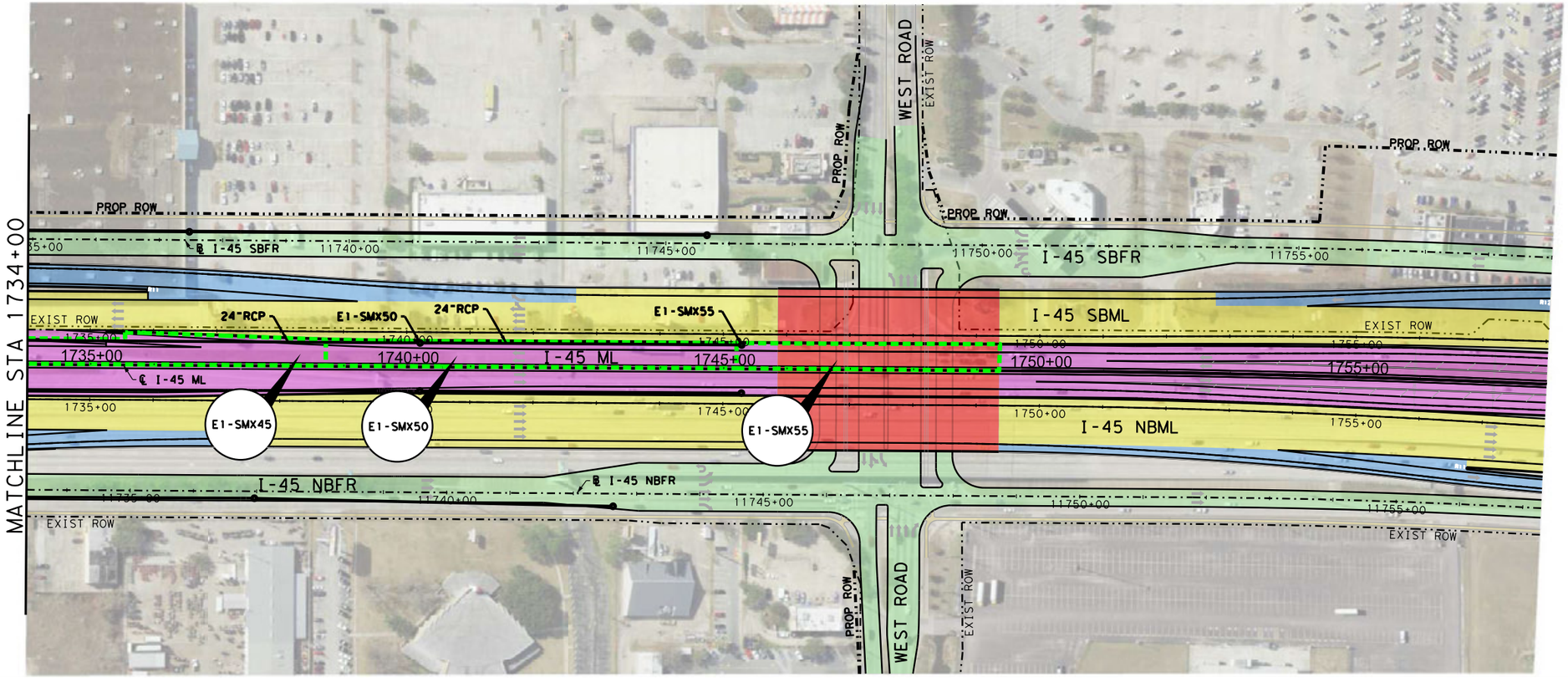

LEGEND

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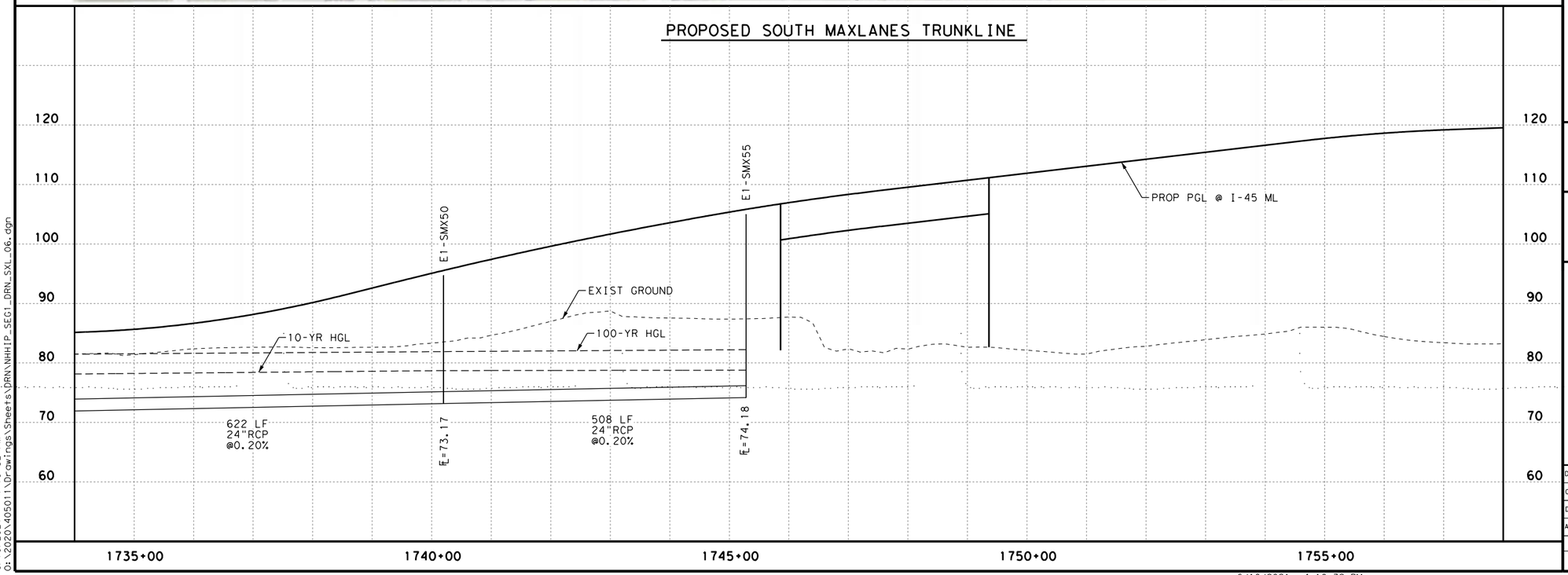

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NHHIP SEGMENT 1
I-45 SOUTH MAXLANES STORM SEWER PLAN AND PROFILE
STA 1734+00 TO END
℄ I-45 MAXLANES

SHEET 6 OF 6

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-3
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
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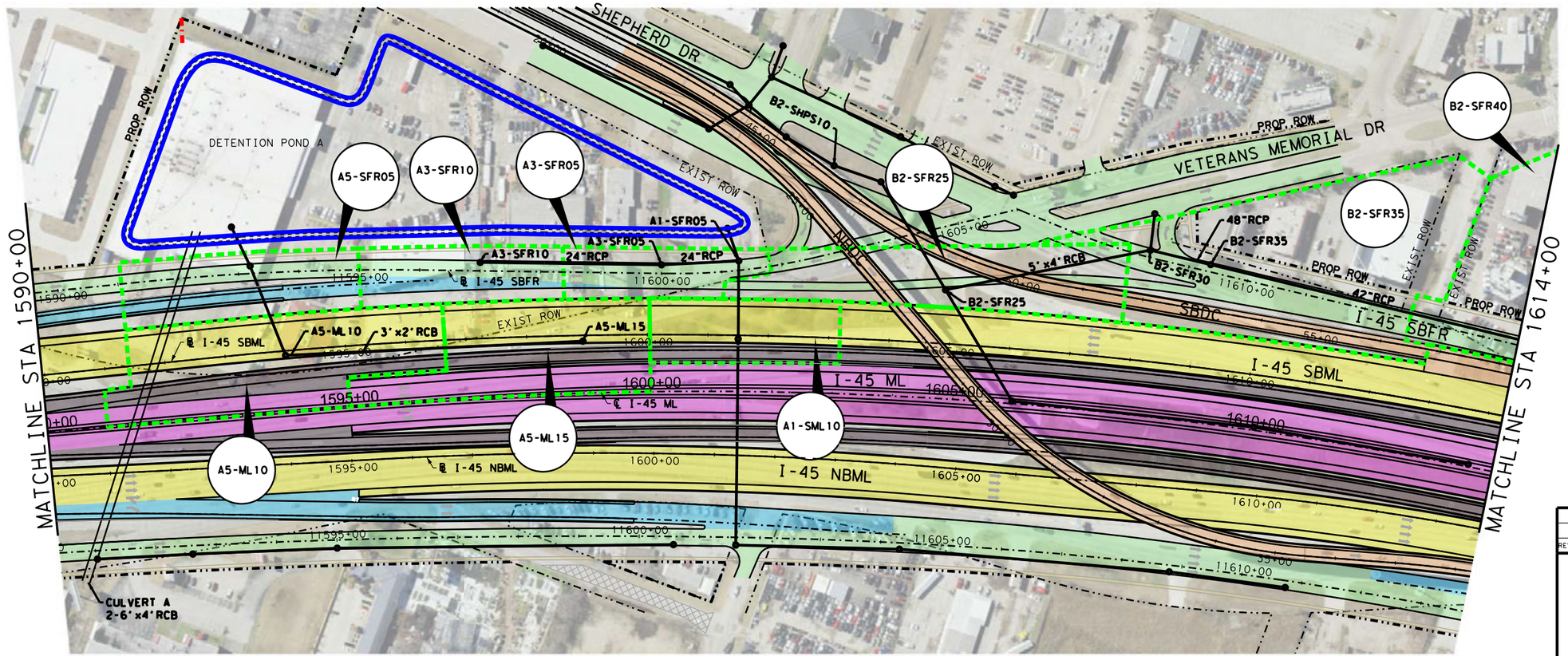

LEGEND

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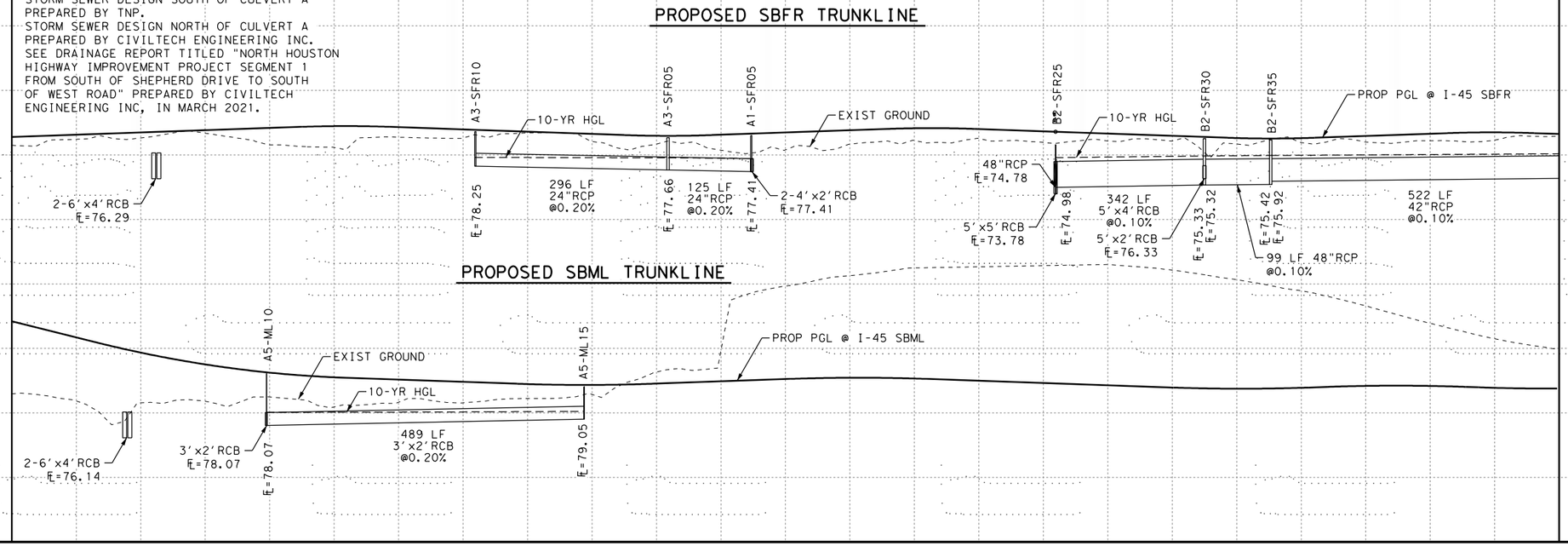
NOTE:
SYSTEM A SWMM MODEL PREPARED BY TNP.
STORM SEWER DESIGN SOUTH OF CULVERT A PREPARED BY TNP.
STORM SEWER DESIGN NORTH OF CULVERT A PREPARED BY CIVILTECH ENGINEERING INC.
SEE DRAINAGE REPORT TITLED "NORTH HOUSTON HIGHWAY IMPROVEMENT PROJECT SEGMENT 1 FROM SOUTH OF SHEPHERD DRIVE TO SOUTH OF WEST ROAD" PREPARED BY CIVILTECH ENGINEERING INC, IN MARCH 2021.



NHHIP SEGMENT 1

I-45 SBML AND SBFR STORM SEWER PLAN AND PROFILE

STA 1590+00 TO STA 1614+00
℄ I-45 MAXLANES

SHEET 1 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-4
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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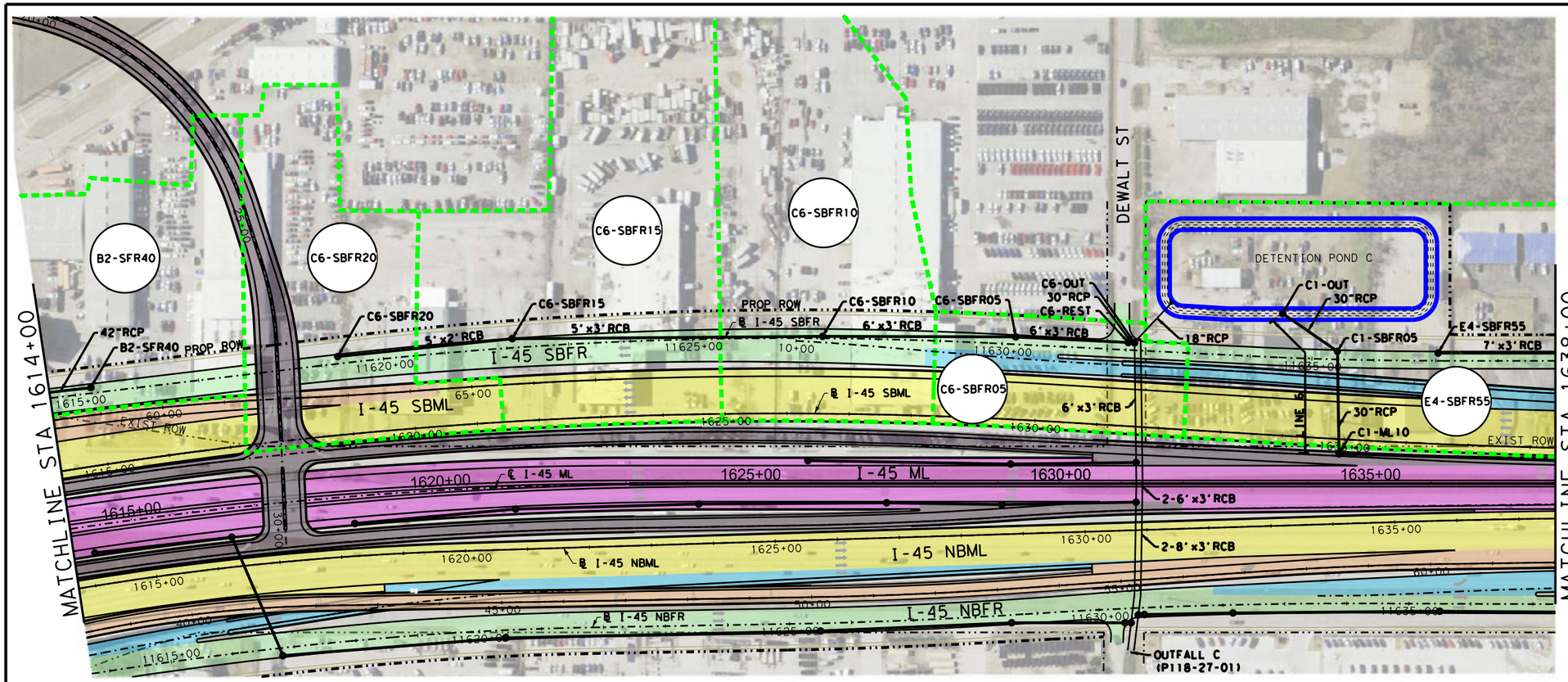

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
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REV NO.	DATE	BY	REVISION

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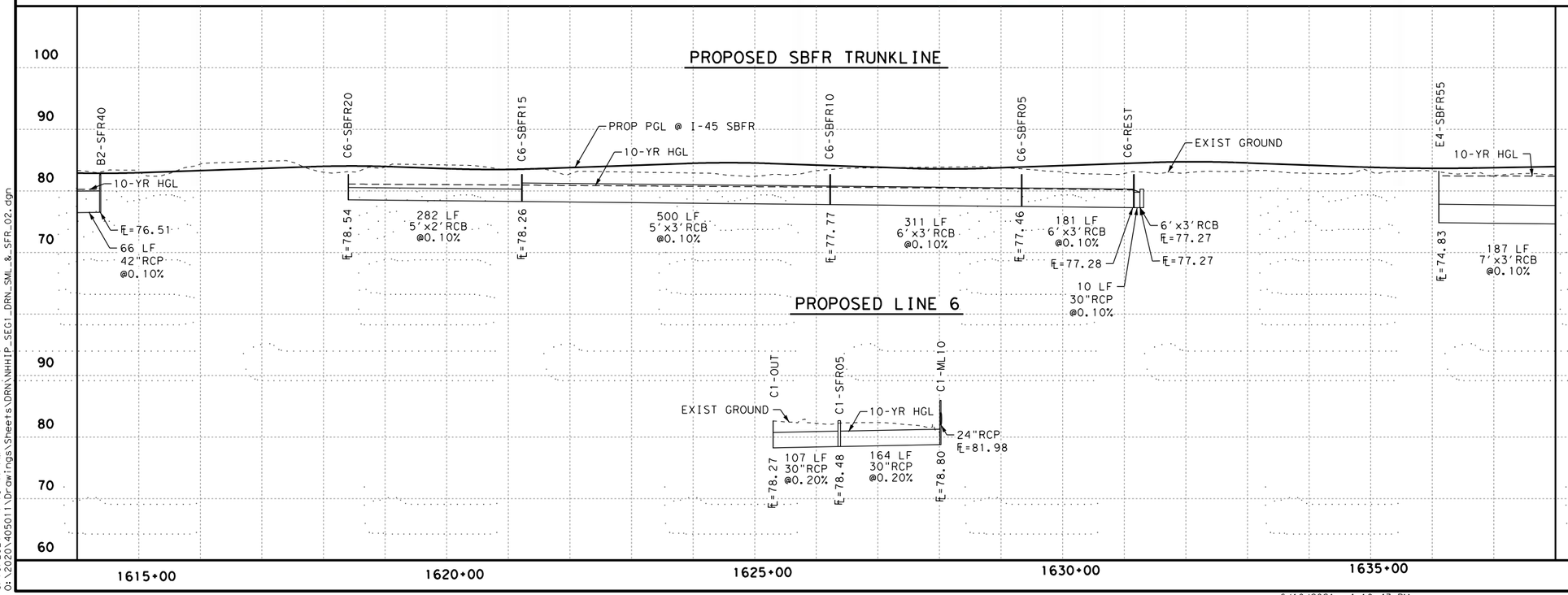
PRELIMINARY
SUBJECT TO CHANGE



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NHHIP SEGMENT 1
I-45 SBFR
STORM SEWER
PLAN AND PROFILE

STA 1614+00 TO STA 1638+00
℄ I-45 MAXLANES

SHEET 2 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-4
DRN: ES	STATE	DIST.	COUNTY	
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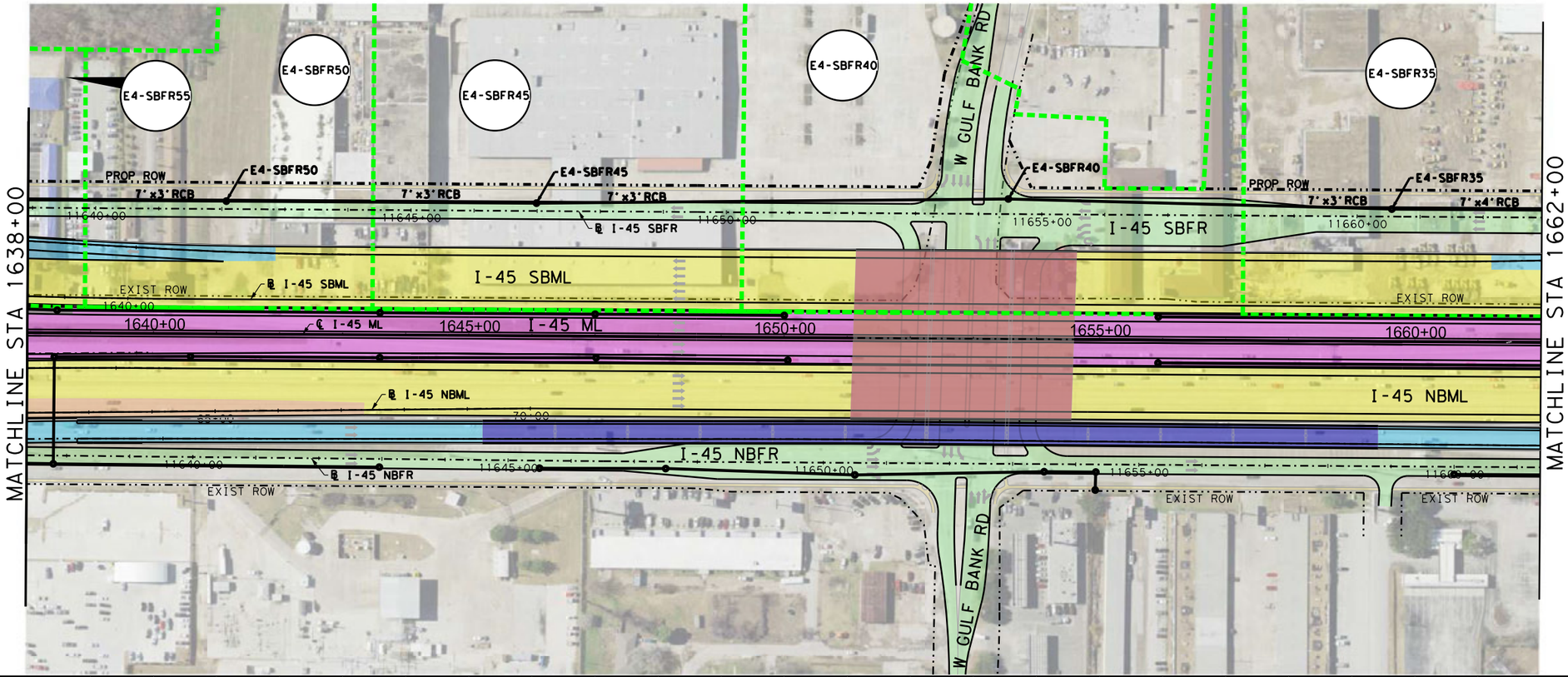

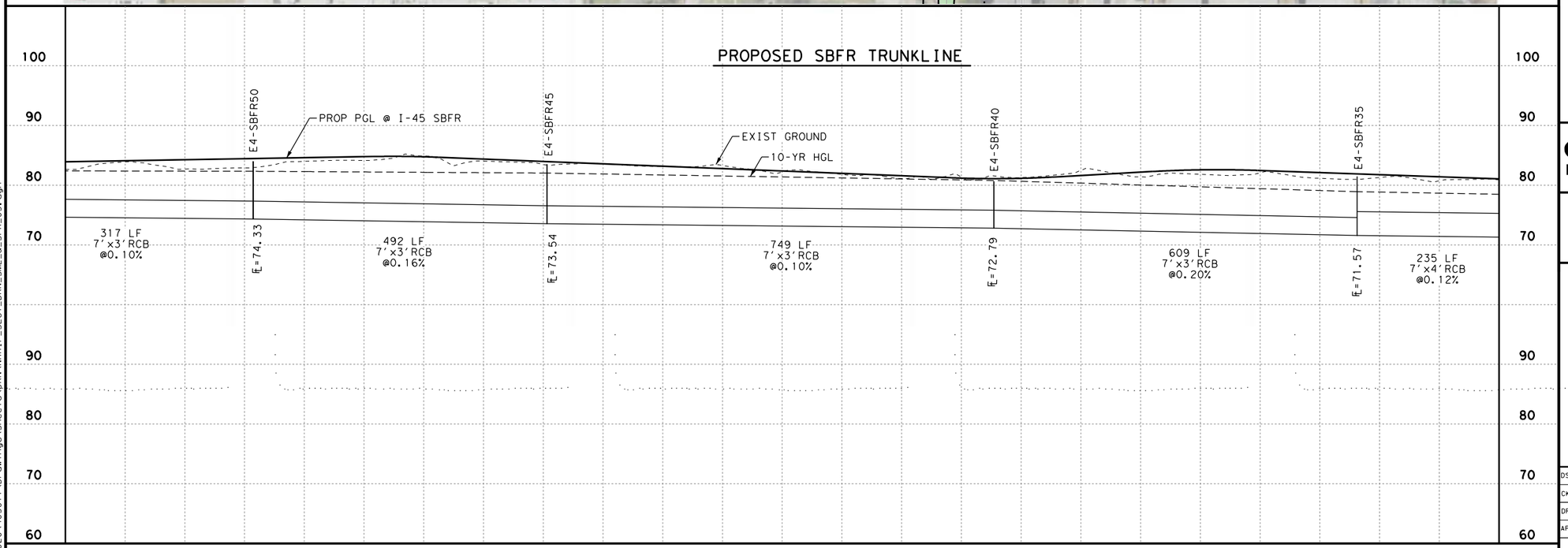

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
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NHHIP SEGMENT 1
I-45 SBFR STORM SEWER PLAN AND PROFILE

STA 1638+00 TO STA 1662+00
℄ I-45 MAXLANES

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-4
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
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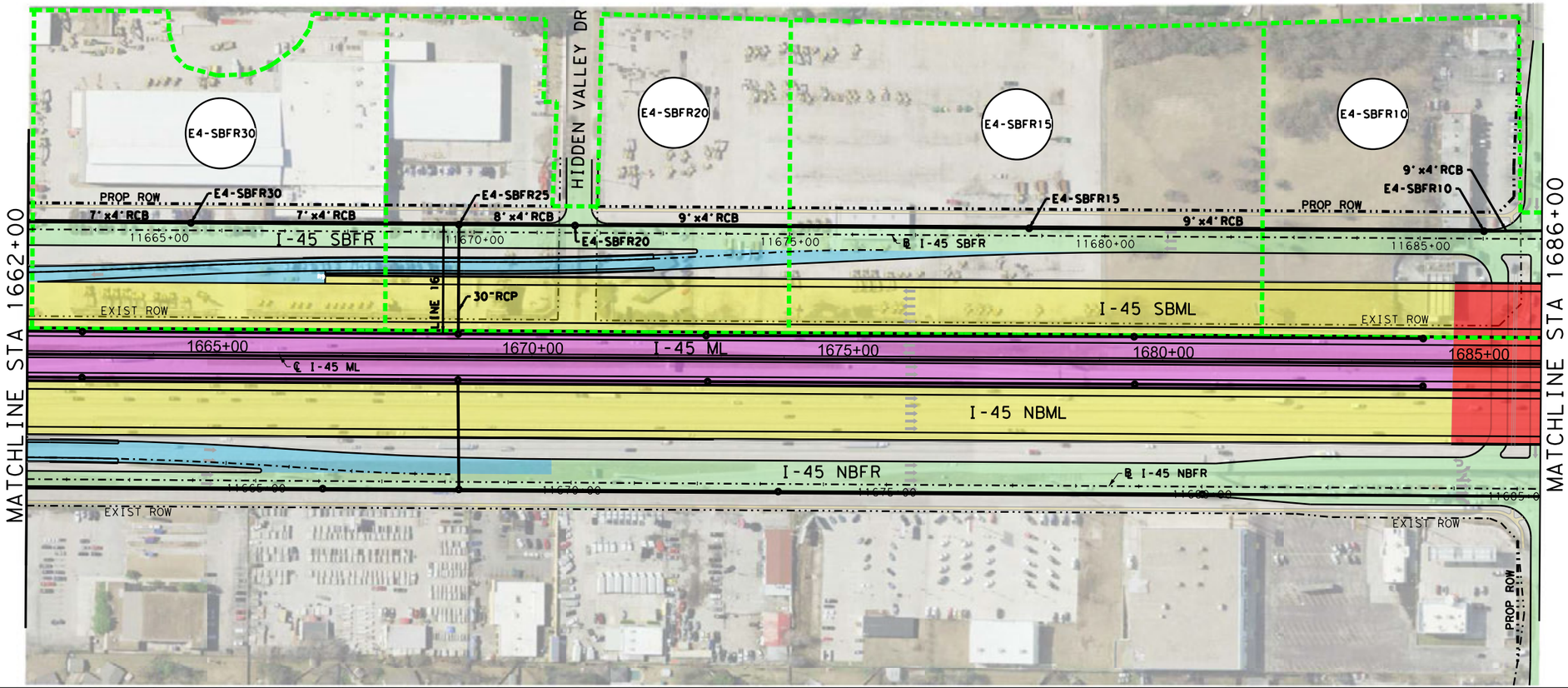

LEGEND

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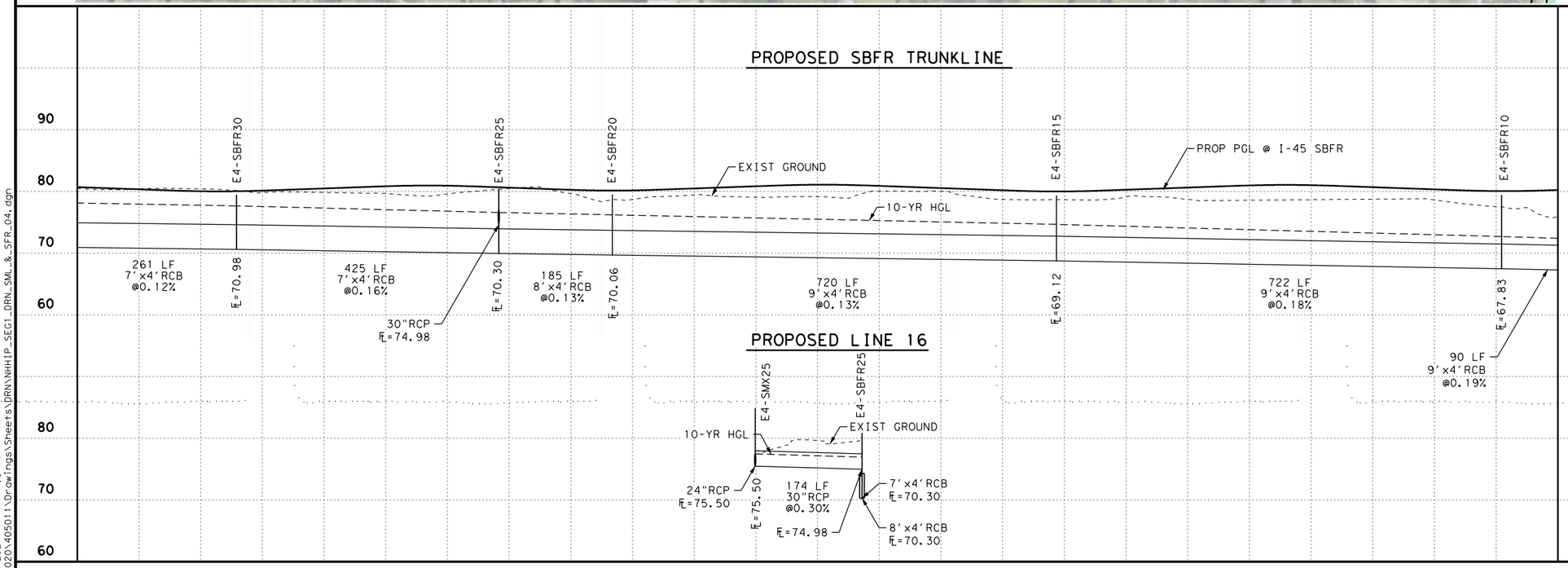

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NHHIP SEGMENT 1
I-45 SBFR STORM SEWER PLAN AND PROFILE

STA 1662+00 TO STA 1686+00
℄ I-45 MAXLANES

SHEET 4 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-4
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CONT.	SECT.	JOB	HIGHWAY NO.
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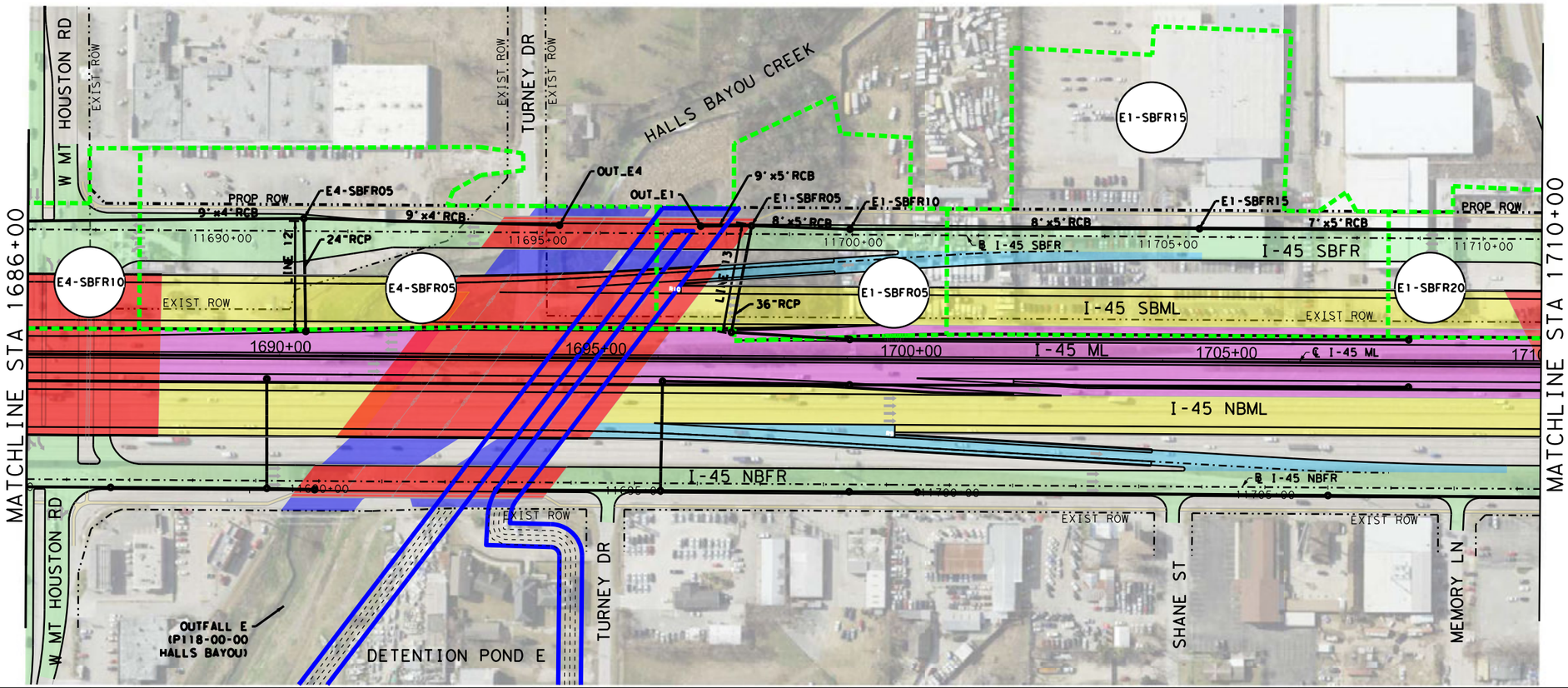

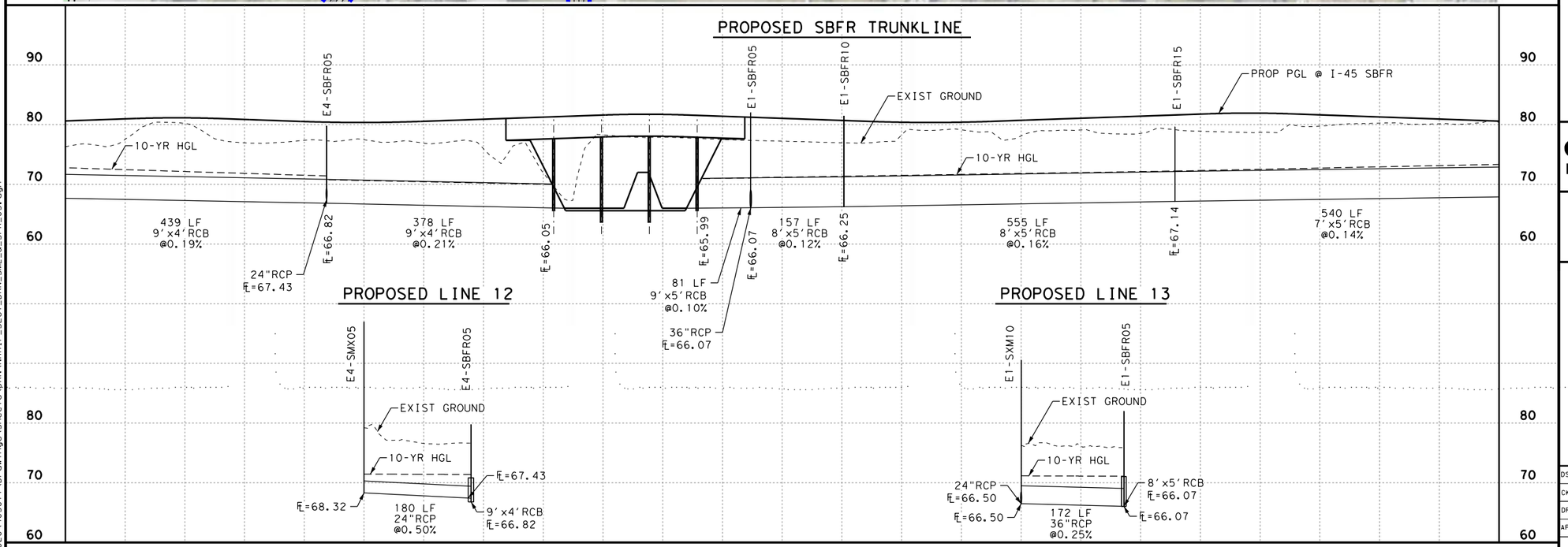

LEGEND

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NHHIP SEGMENT 1
I-45 SBFR STORM SEWER PLAN AND PROFILE
STA 1686+00 TO STA 1710+00
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SHEET 5 OF 7

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CONT.	SECT.	JOB	HIGHWAY NO.
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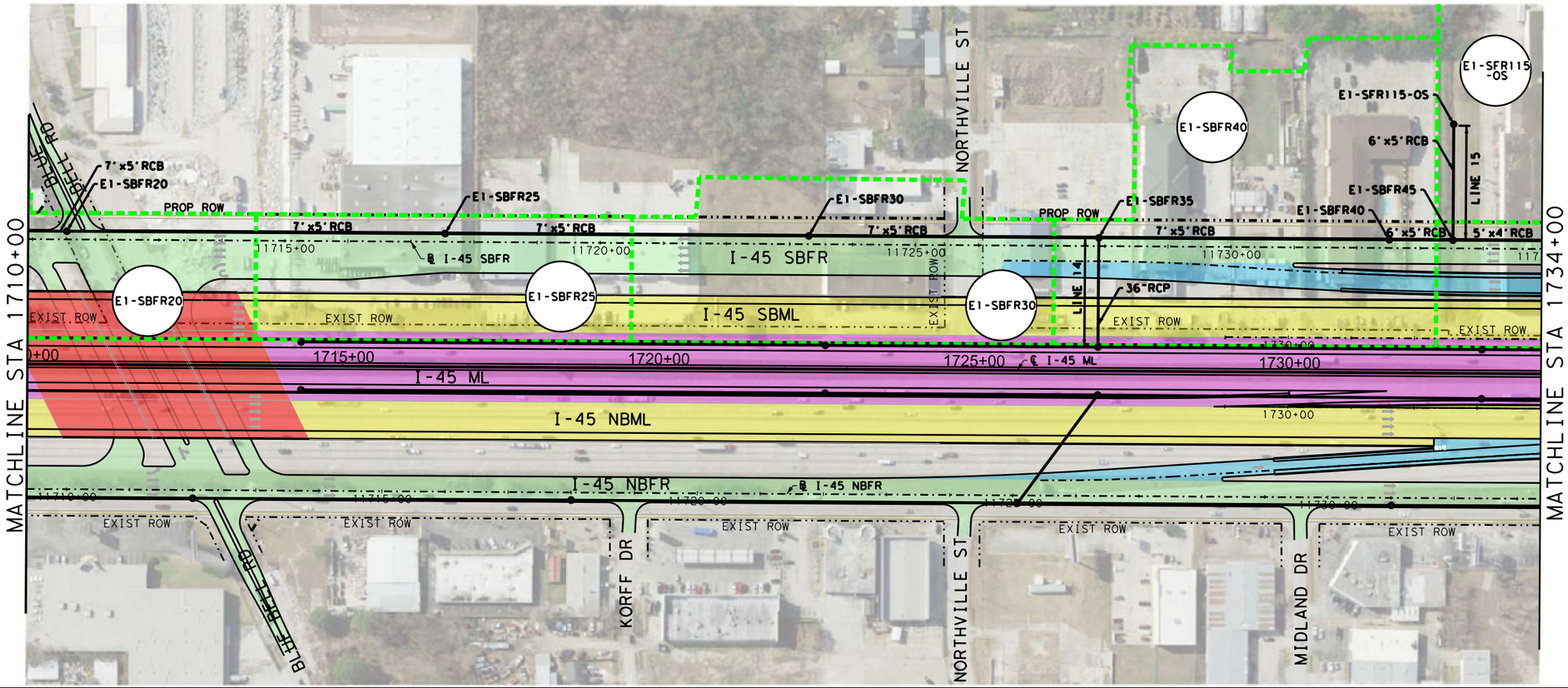

LEGEND

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Firm Registration No. F-382

Texas Department of Transportation

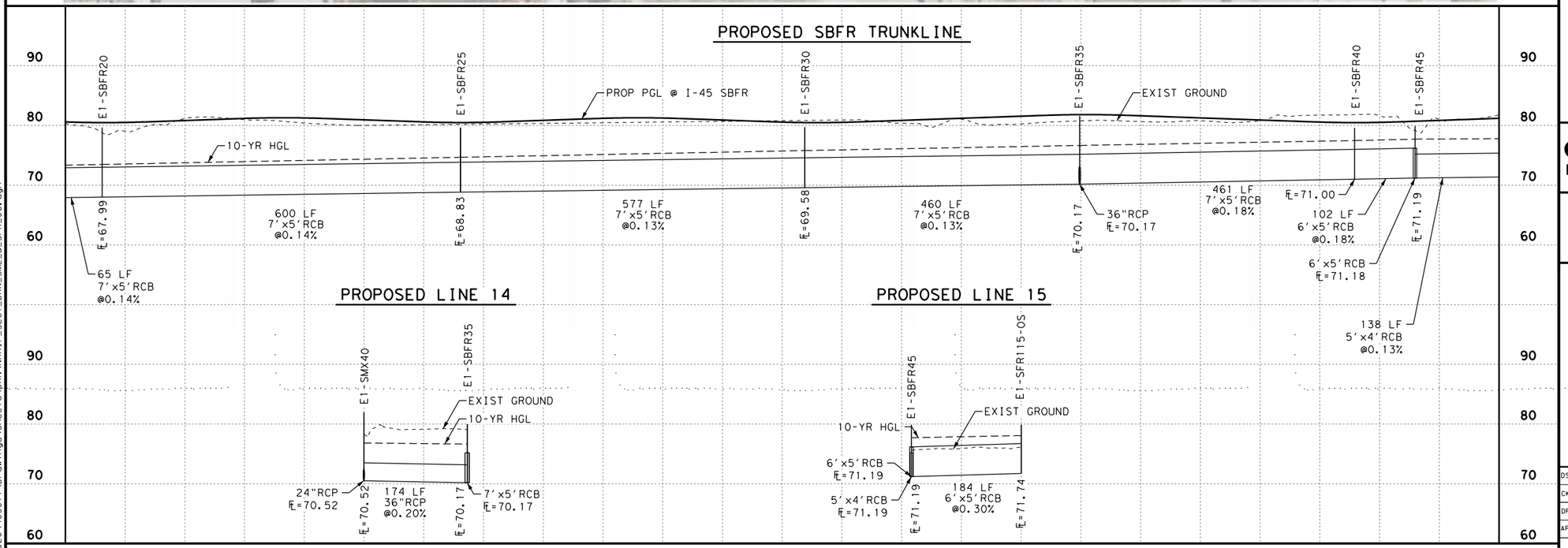
NHHIP SEGMENT 1
I-45 SBFR STORM SEWER PLAN AND PROFILE

STA 1710+00 TO STA 1734+00
℄ I-45 MAXLANES

SHEET 6 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-4
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

PROPOSED SBFR TRUNKLINE



PROPOSED LINE 14

PROPOSED LINE 15

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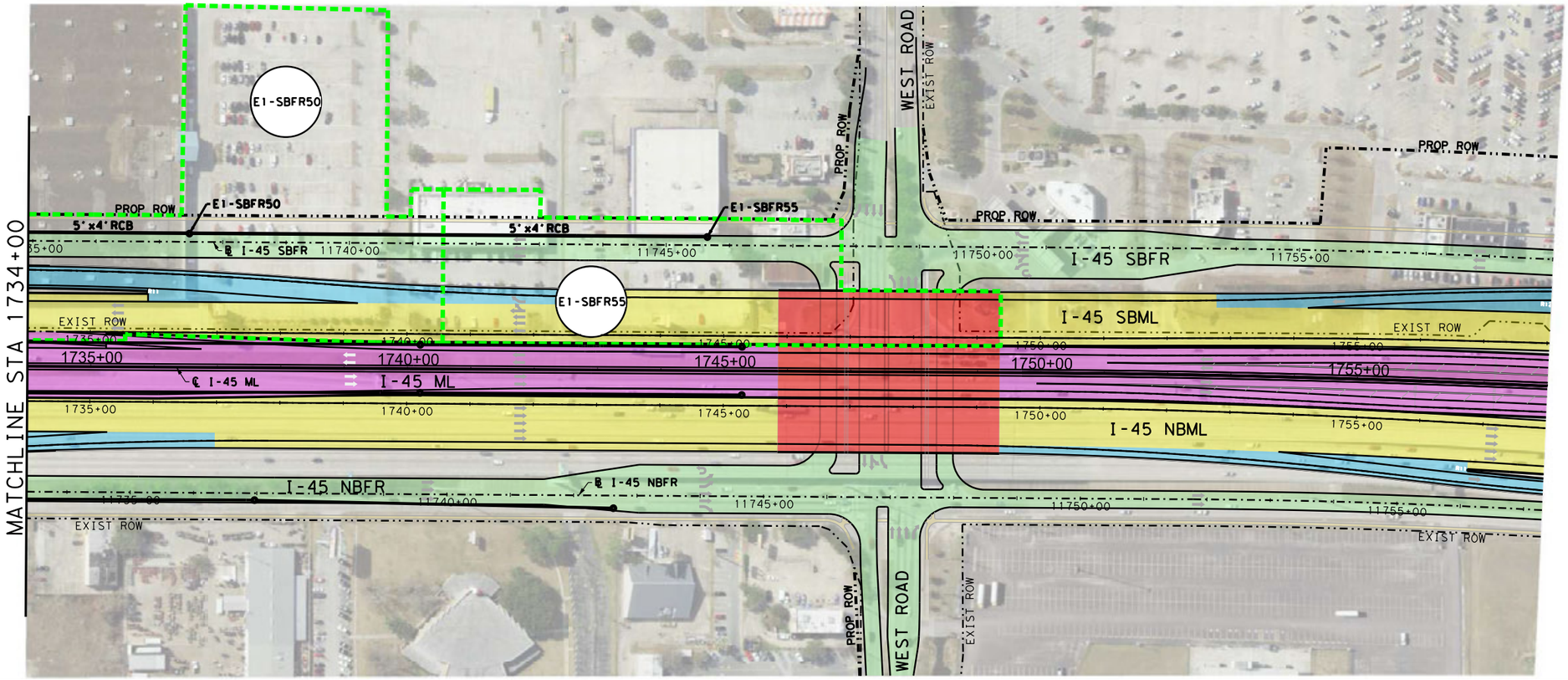

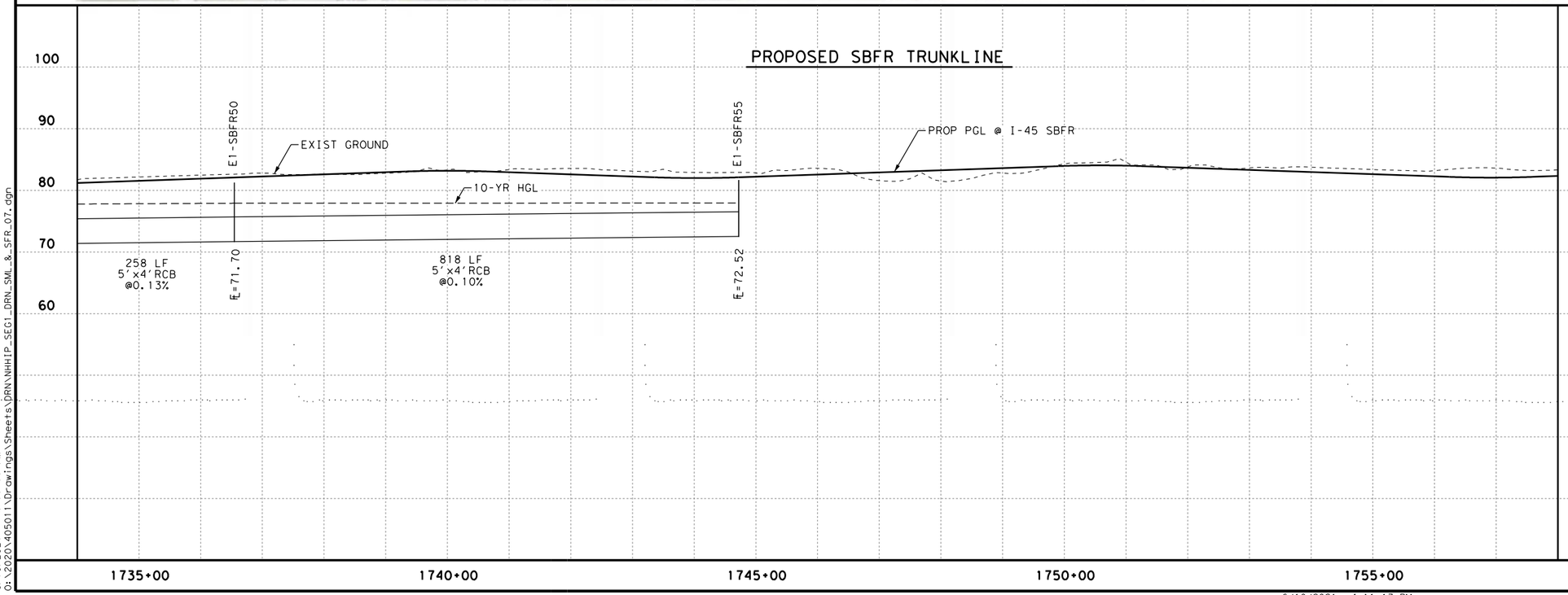

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
0 10 20 (V)

REV NO.	DATE	BY	REVISION

THIS INFORMATION IS PRESENTED FOR STUDY PURPOSES ONLY. IT IS NOT INTENDED TO BE USED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1
I-45 SBFR STORM SEWER PLAN AND PROFILE

STA 1734+00 TO END
℄ I-45 MAXLANES

SHEET 7 OF 7

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	4-4
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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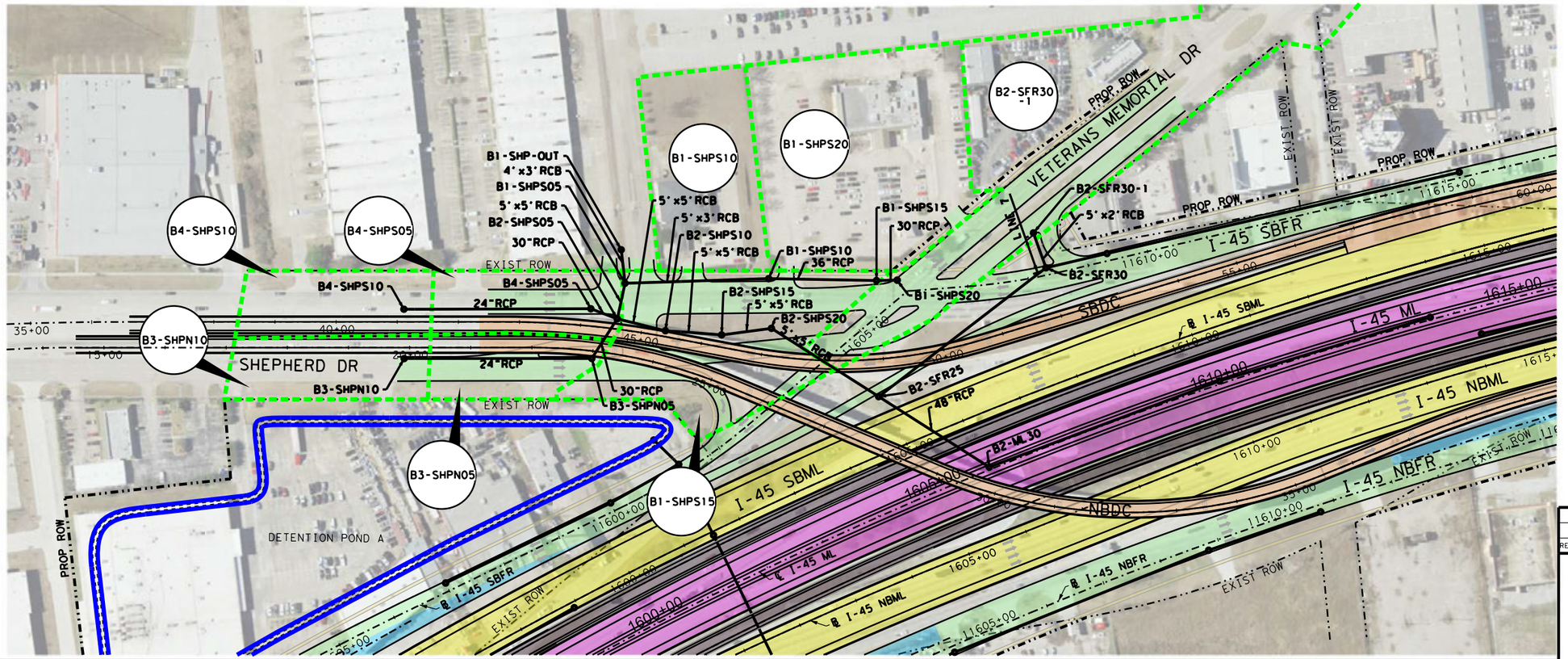

LEGEND

- PROP STORM SEWER NODE
- PROP STORM SEWER
- DIRECTION OF FLOW
- DRAINAGE AREA BOUNDARY
- DAM ID — DRAINAGE AREA ID
- HYDRAULIC GRADE LINE
- NATURAL GROUND

NOTES:

1. SEE RUNOFF COMPUTATIONS SHEET FOR ALL DRAINAGE AREA CALCULATIONS.
2. SEE OVERALL DRAINAGE AREA MAP SHEETS FOR FULL EXTENTS OF DRAINAGE AREA BOUNDARIES.

0 100 200 (H)
0 10 20 (V)

REV NO.	DATE	BY	REVISION

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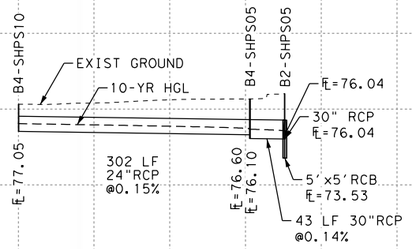
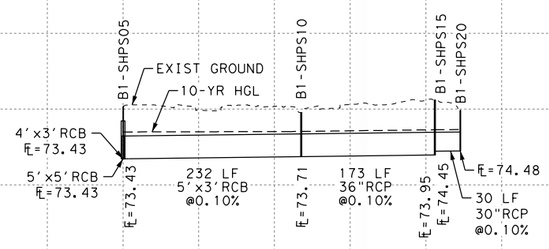
PRELIMINARY SUBJECT TO CHANGE

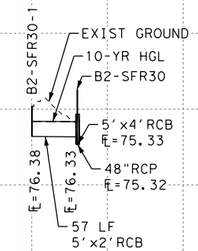
PROPOSED SHPS TRUNKLINE



PROPOSED SHPS TRUNKLINE



PROPOSED LINE 7



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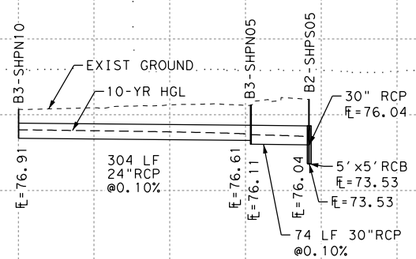
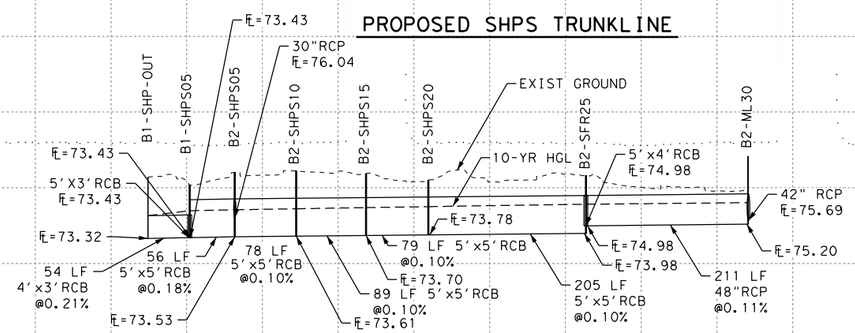


PROPOSED SHPS TRUNKLINE



CivilTech Engineering, Inc.
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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

SHEPHERD DR
STORM SEWER
PLAN AND PROFILE

SHEET 1 OF 1

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-01DP5012		4-5
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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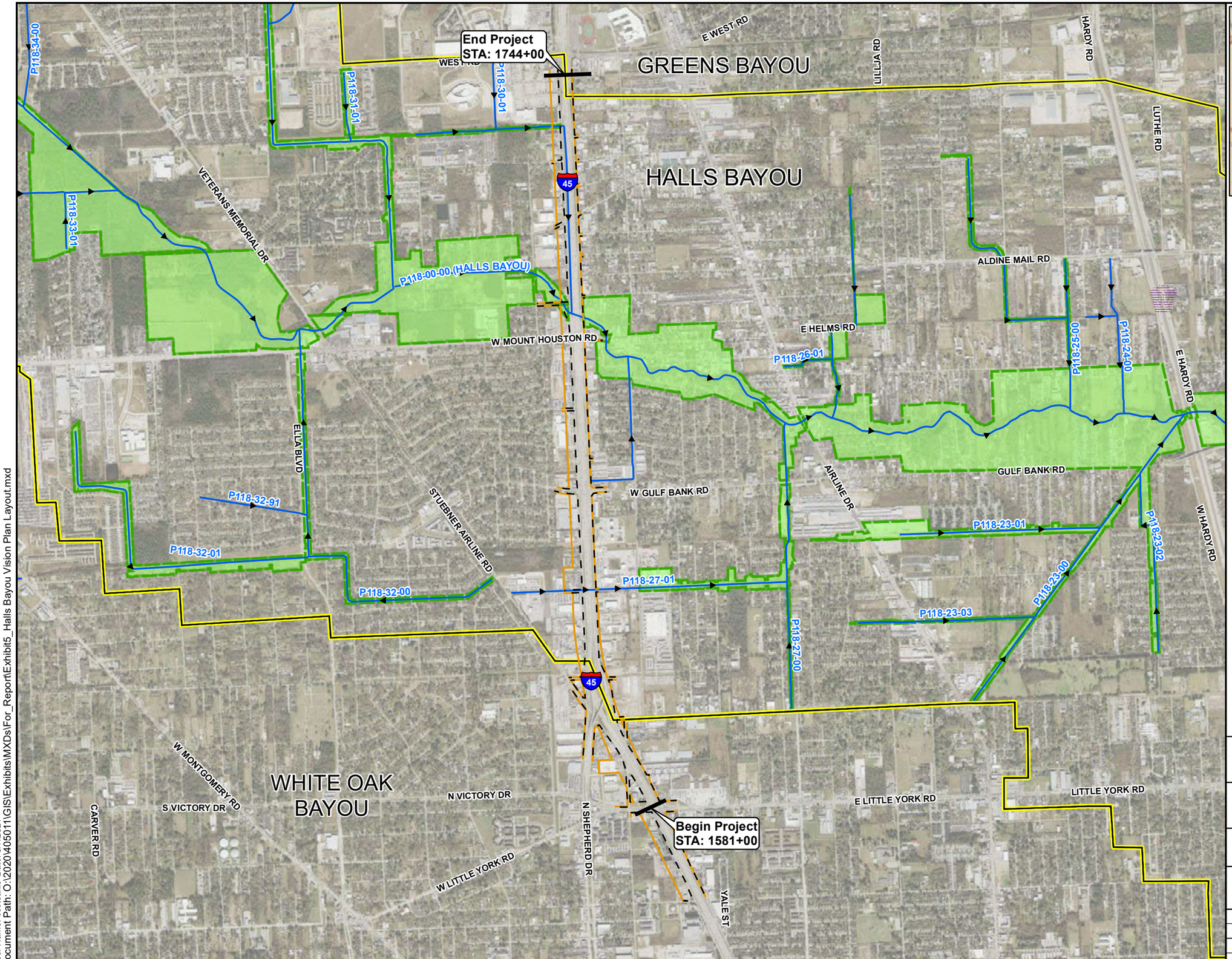

LEGEND

- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- HCFCD Watershed
- HCFCD Ultimate ROW

0 1,000 2,000

Aerial Source: H-GAC 2020

N

CivilTech Engineering, Inc.
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Fax: 281-304-0210

Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Halls Bayou Vision Plan Layout

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	5

User Name: ccotsakis Date: 5/7/2021
Document Path: O:\2020\405011\GIS\Exhibits\MXDs\For_ReportExhibit5_Halls Bayou Vision Plan Layout.mxd

HALLS BAYOU

1700+00

1695+00

1690+00

1685+00

45

TURNEY DR.

TURNEY DR.

W MOUNT HOUSTON RD

LEGEND

- Proposed Centerline
- Halls Bayou Existing Centerline
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Ultimate ROW
- Proposed Interim Channel
- Proposed Bridge
- Proposed Roadway

0 100 200

Aerial Source: H-GAC 2020

N

CivilTech Engineering, Inc.

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Fax: 281-304-0210

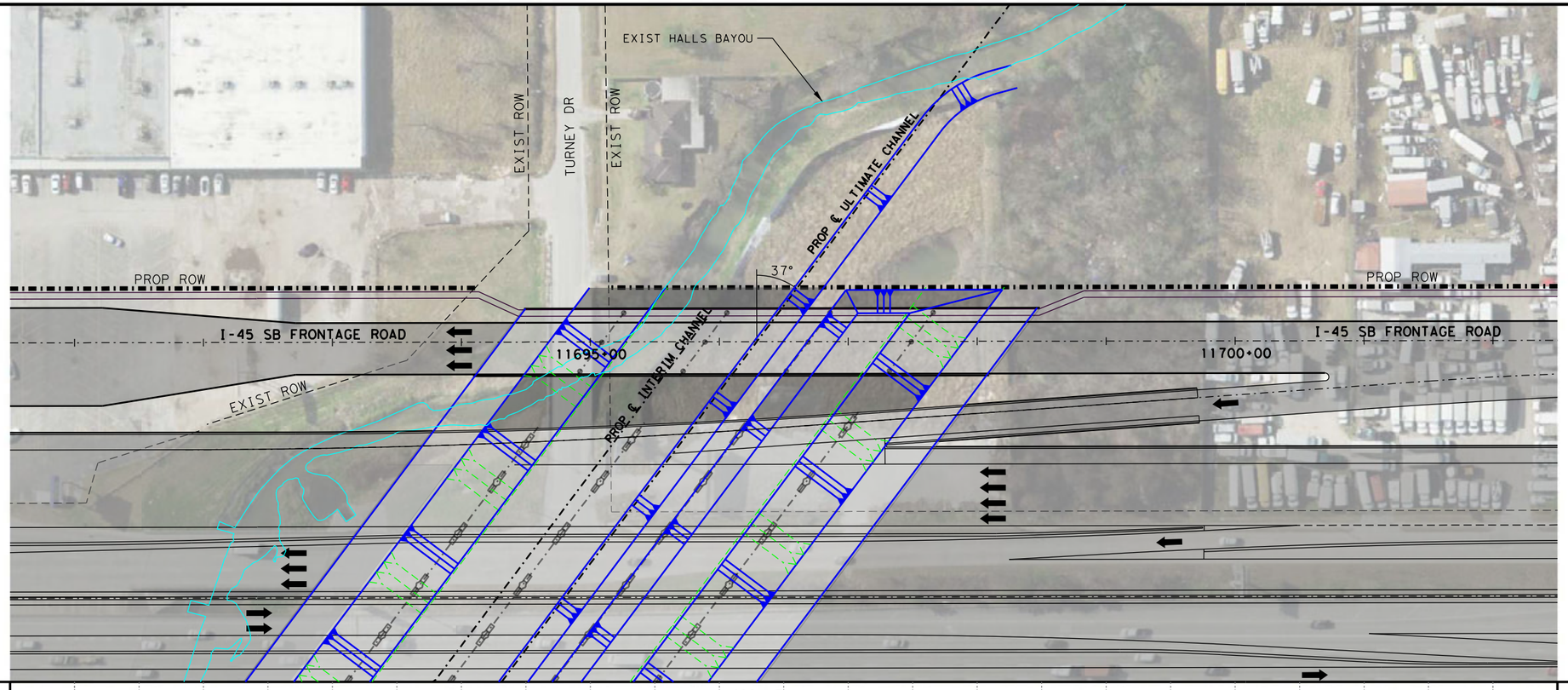
Texas Department of Transportation

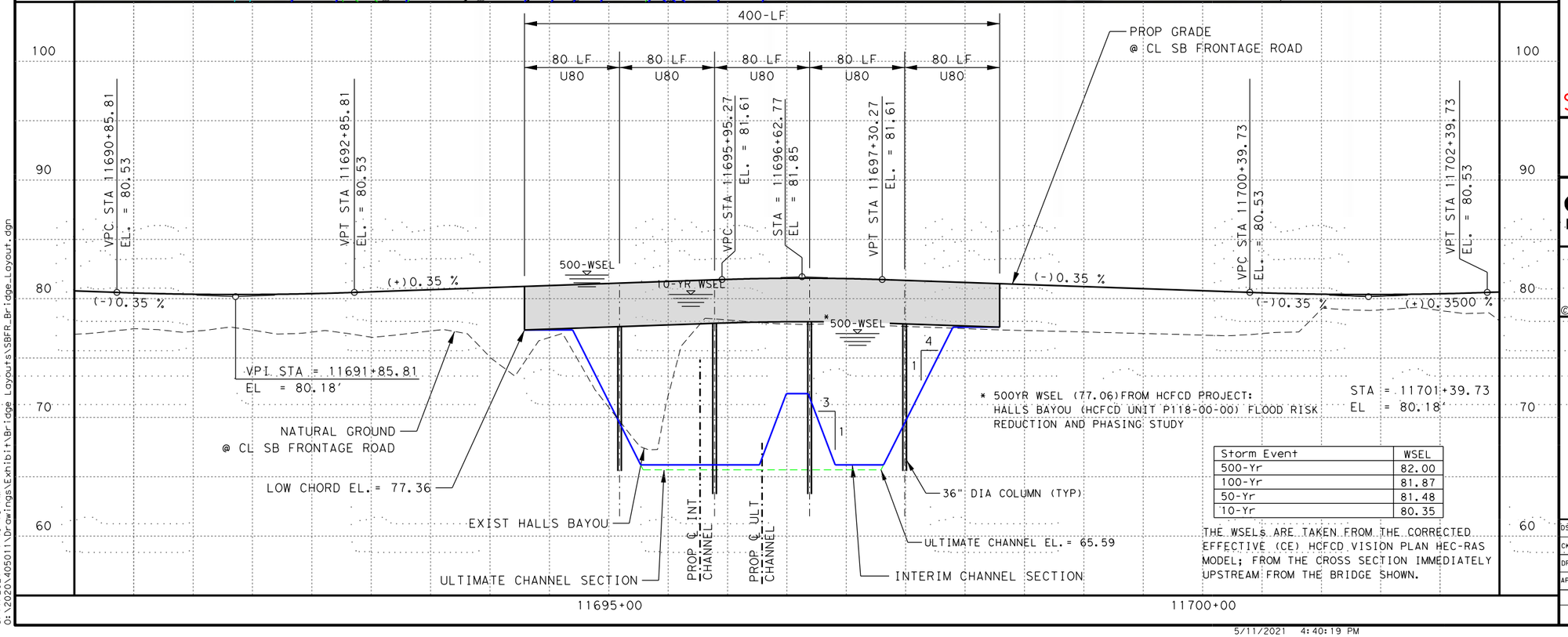
North Houston Highway Improvement Project
Segment 1 Drainage Study

Halls Bayou Proposed Bridge Layout and Channel Realignment

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	6

User Name: ccotsakis Date: 3/9/2021
Document Path: O:\2020\405011\GIS\Exhibits\MXDs\For_Report\Exhibit6_Halls Bayou Proposed Bridge Layout and Channel Realignment.mxd





* 500YR WSEL (77.06)FROM HCFCD PROJECT: HALLS BAYOU (HCFCD UNIT P118-00-00) FLOOD RISK REDUCTION AND PHASING STUDY

STA = 11701+39.73
EL = 80.18'

Storm Event	WSEL
500-Yr	82.00
100-Yr	81.87
50-Yr	81.48
10-Yr	80.35

THE WSELs ARE TAKEN FROM THE CORRECTED EFFECTIVE (CE) HCFCD VISION PLAN HEC-RAS MODEL; FROM THE CROSS SECTION IMMEDIATELY UPSTREAM FROM THE BRIDGE SHOWN.

LEGEND

- BRIDGE
- ROADWAY
- INTERIM CHANNEL & DETENTIO POND

0 50 100 (H)
0 5 10 (V)
SCALE IN FEET

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PRELIMINARY
SUBJECT TO CHANGE

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Cypress, Texas 77429
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Firm Registration No. F-382

NHHIP SEGMENT 1

I-45 SB FRONTAGE ROAD HALLS BAYOU BRIDGE LAYOUT

DSN: XX	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: XX	6	12-0IDP5012, WA 1	7-1
DRN: XX	STATE	DIST.	COUNTY
APPVD: XX	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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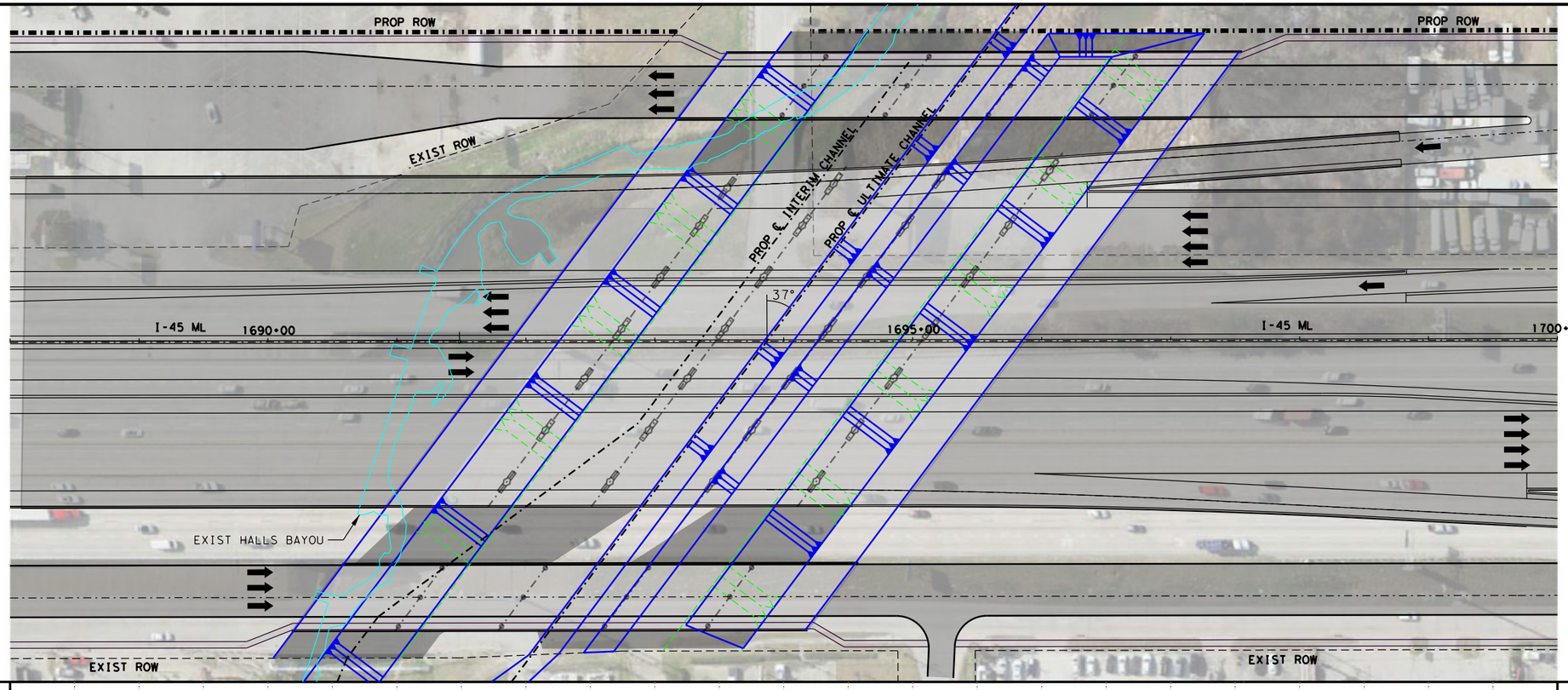

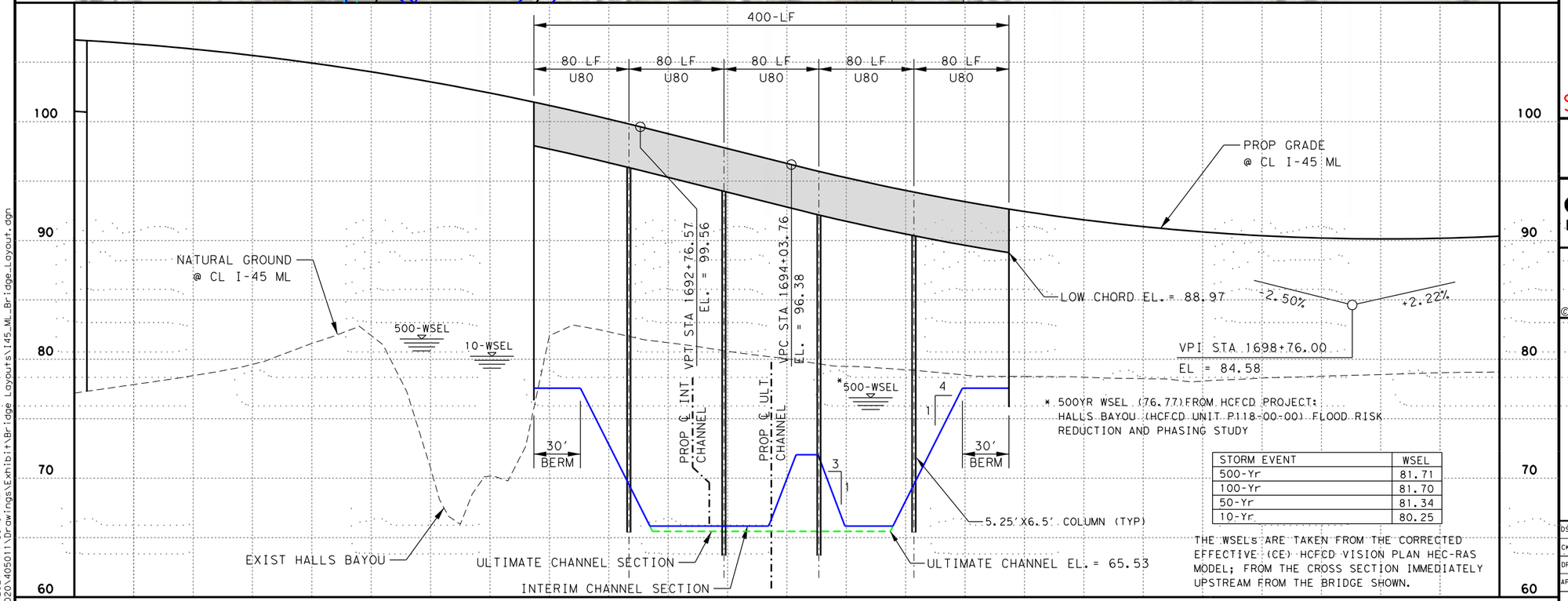

* 500YR WSEL (76.77) FROM HCFCD PROJECT: HALLS BAYOU (HCFCD UNIT P118-00-00) FLOOD RISK REDUCTION AND PHASING STUDY

STORM EVENT	WSEL
500-Yr	81.71
100-Yr	81.70
50-Yr	81.34
10-Yr	80.25

THE WSELS ARE TAKEN FROM THE CORRECTED EFFECTIVE (CE) HCFCD VISION PLAN HEC-RAS MODEL; FROM THE CROSS SECTION IMMEDIATELY UPSTREAM FROM THE BRIDGE SHOWN.

LEGEND

- BRIDGE
- ROADWAY
- INTERIM CHANNEL & DETENTIO POND

0 50 100 (H)
0 5 10 (V)
SCALE IN FEET

REV NO.	DATE	BY	REVISION

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

I-45 MAIN LANE HALLS BAYOU BRIDGE LAYOUT

DSN: XX	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: XX	6	12-0IDP5012, WA 1	7-2
DRN: XX	STATE	DIST.	COUNTY
APPVD: XX	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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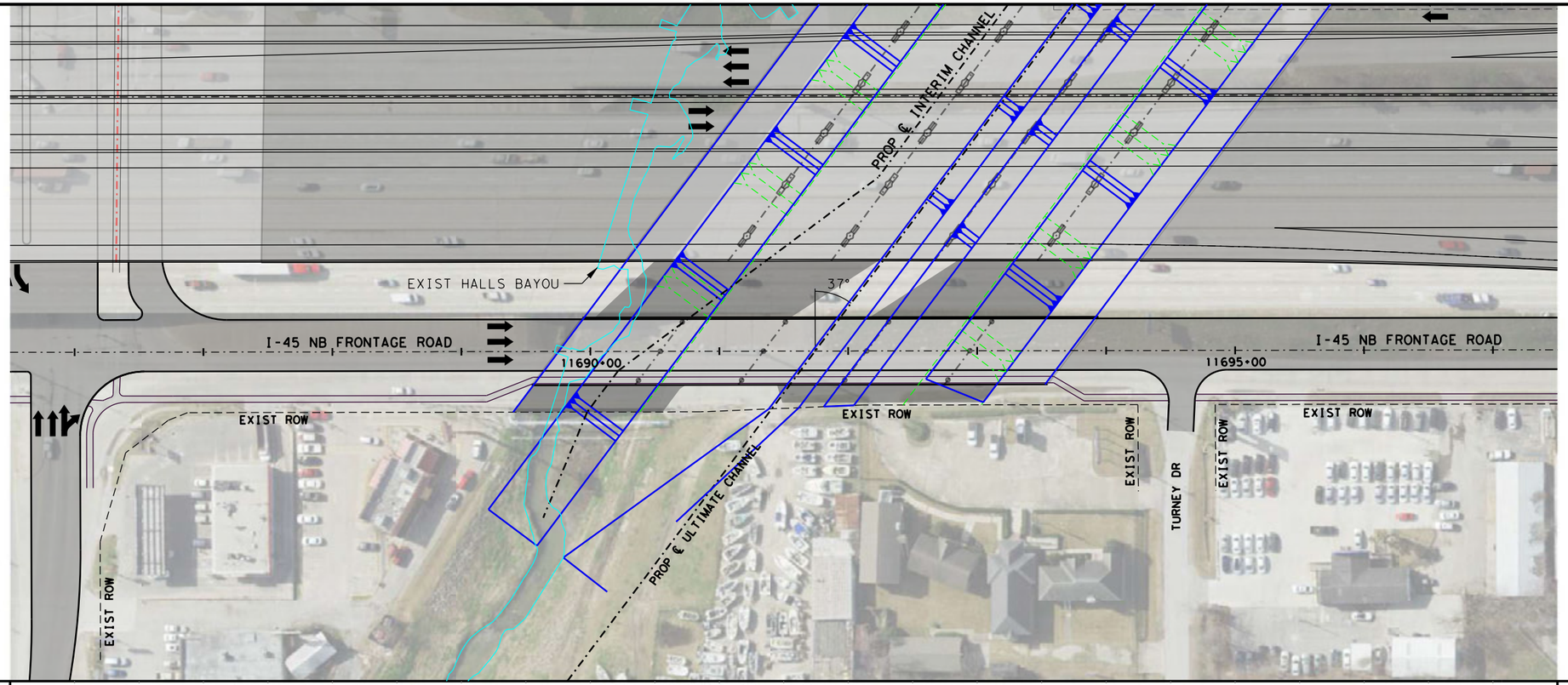

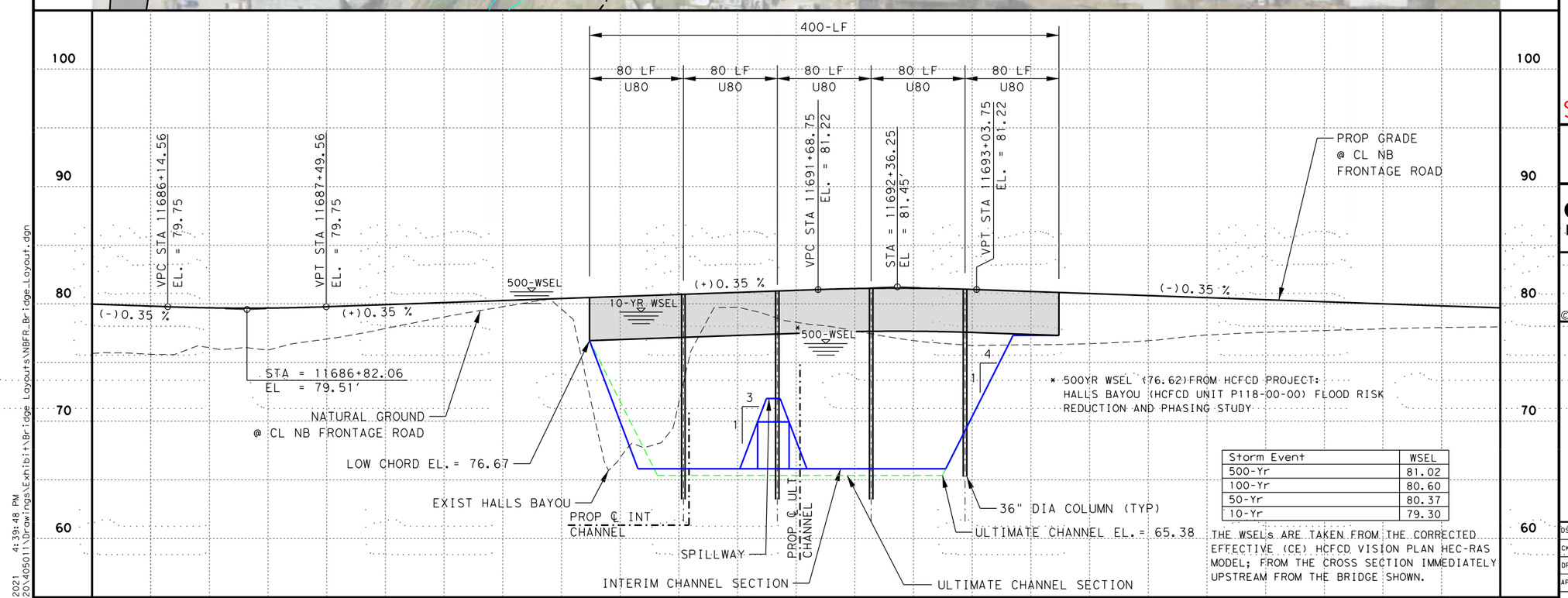

* 500YR WSEL (76.62) FROM HCFCD PROJECT: HALLS BAYOU (HCFCD UNIT P118-00-00) FLOOD RISK REDUCTION AND PHASING STUDY

Storm Event	WSEL
500-Yr	81.02
100-Yr	80.60
50-Yr	80.37
10-Yr	79.30

THE WSELs ARE TAKEN FROM THE CORRECTED EFFECTIVE (CE) HCFCD VISION PLAN HEC-RAS MODEL; FROM THE CROSS SECTION IMMEDIATELY UPSTREAM FROM THE BRIDGE SHOWN.

LEGEND

- BRIDGE
- ROADWAY
- INTERIM CHANNEL & DETENTIO POND

0 50 100 (H)
0 5 10 (V)
SCALE IN FEET

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
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Cypress, Texas 77429
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Firm Registration No. F-382

NHHIP SEGMENT 1

I-45 NB FRONTAGE ROAD HALLS BAYOU BRIDGE LAYOUT

DSN: XX	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: XX	6	12-01DP5012, WA 1	7-3
DRN: XX	STATE	DIST.	COUNTY
APPVD: XX	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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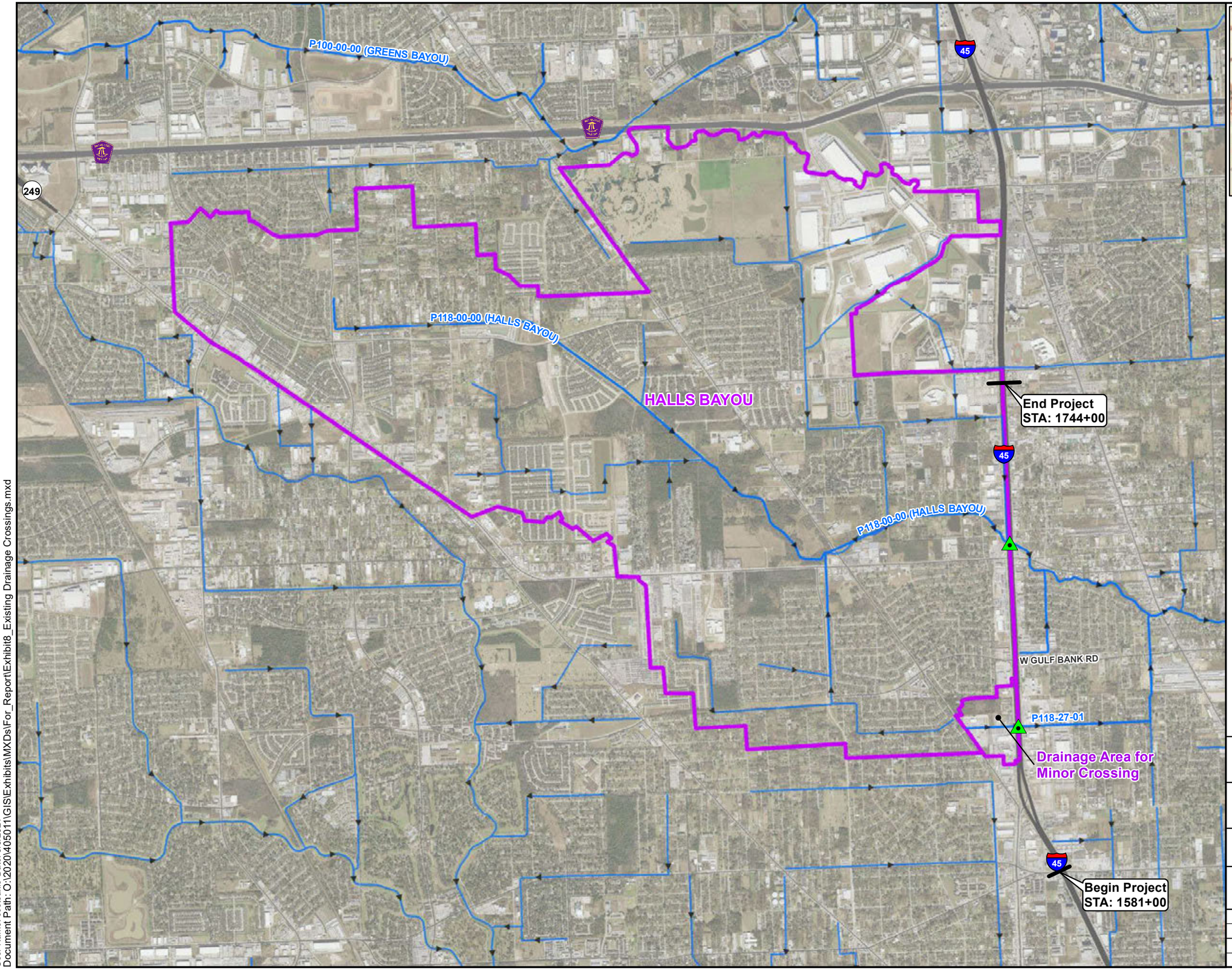

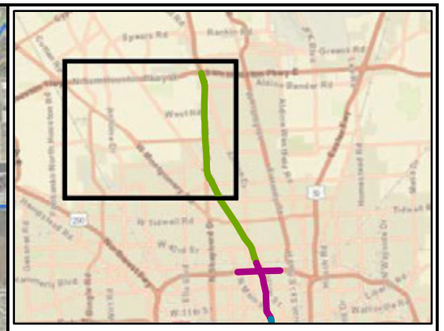

LEGEND

- Drainage Crossing
- Project Limit
- HCFCD Stream
- Crossing Drainage Area

0 1,500 3,000

Aerial Source: H-GAC 2020

N

CivilTech Engineering, Inc.
11750 Katy Fwy, Suite 1260
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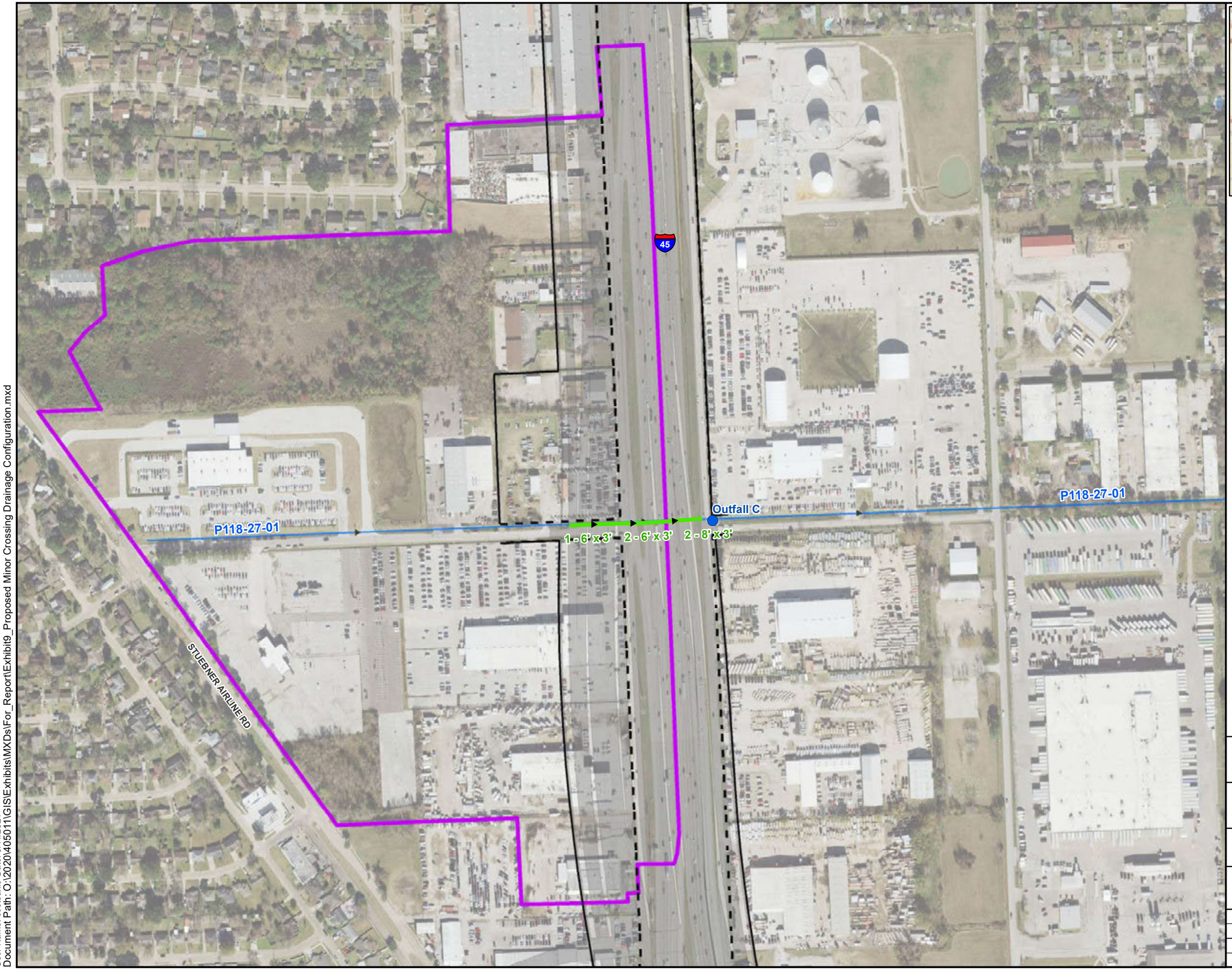
Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Drainage Crossings

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	8



LEGEND

- Outfall
- HCFCD Stream
- Existing TxDOT ROW
- Proposed TxDOT ROW
- P 118-27-01 Crossing
- Crossing Drainage Area
- Proposed Roadways

0 150 300

Aerial Source: H-GAC 2020

N

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Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Minor Crossing Drainage Configuration

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	9

User Name: ccotsakis Date: 3/11/2021
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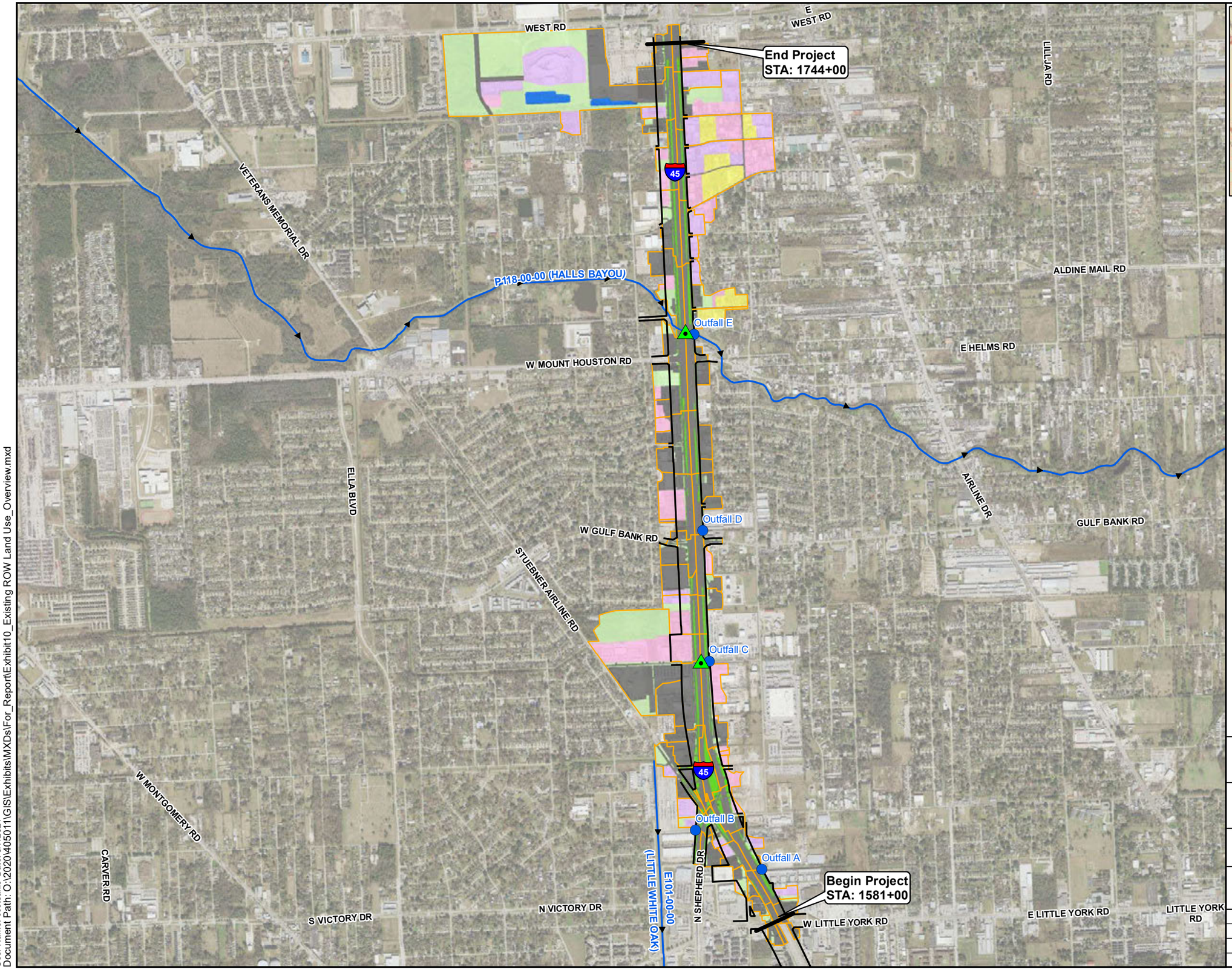

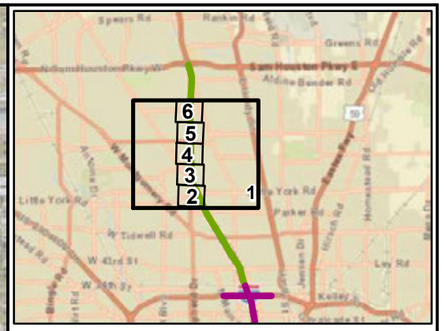

LEGEND

- Outfall
- Drainage Crossing
- Proposed TxDOT ROW
- Project Limit
- HCFCD Stream
- Existing Drainage Area

Existing Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped
- Open Water

N

0 1,000 2,000

Aerial Source: H-GAC 2020

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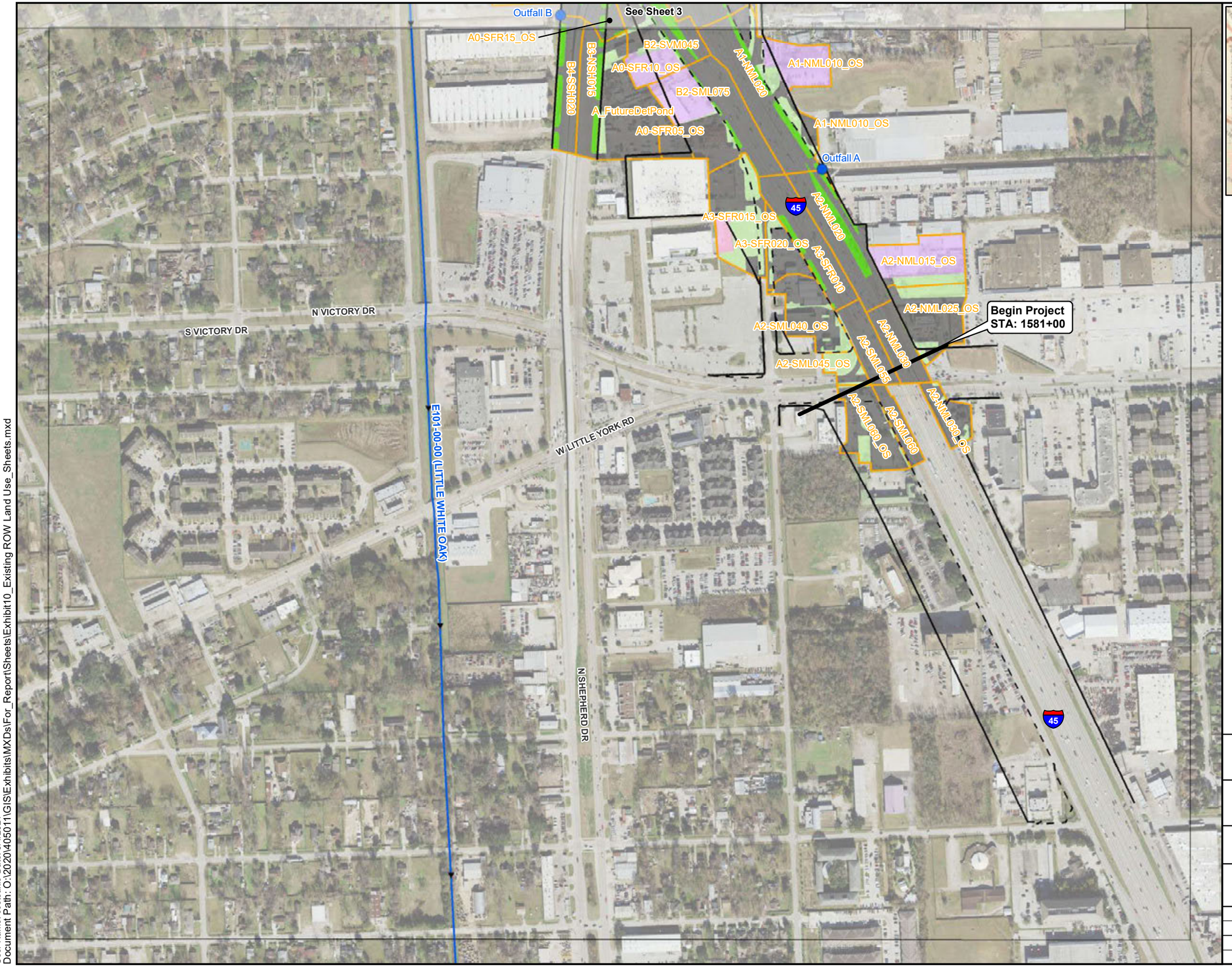
Texas Department of Transportation

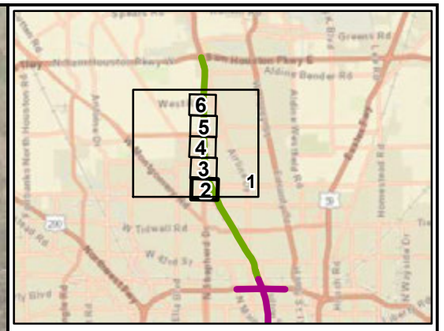
North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Land Use

Sheet 1 of 6

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	10





LEGEND

- Outfall
- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Existing Drainage Area

Existing Land Use

- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped

0 200 400

Aerial Source: H-GAC 2020

N

CivilTech Engineering, Inc.
11750 Katy Fwy, Suite 1260
Houston, Texas 77079
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Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Land Use

Sheet 2 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	10

User Name: ccotsakis Date: 3/4/2021
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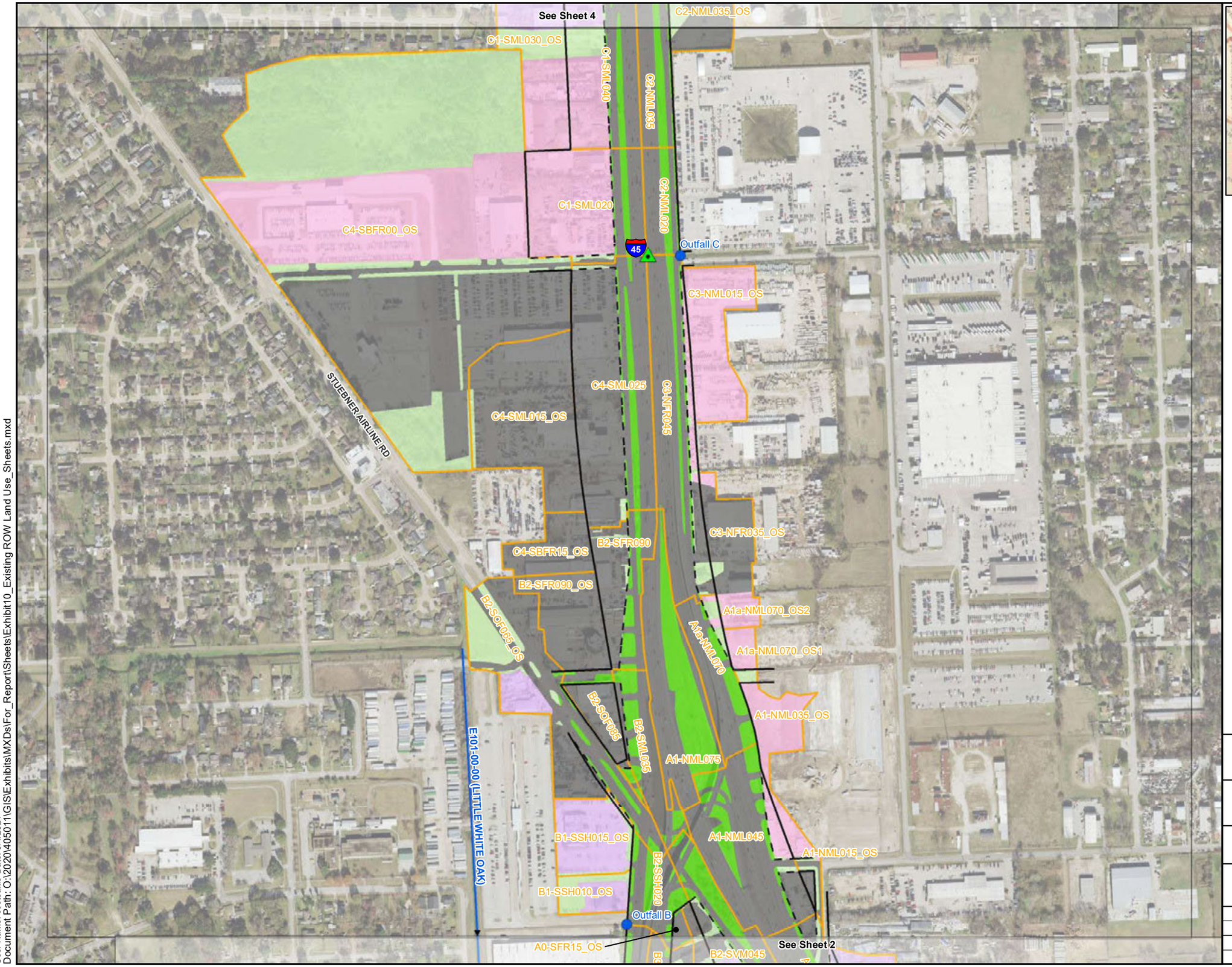

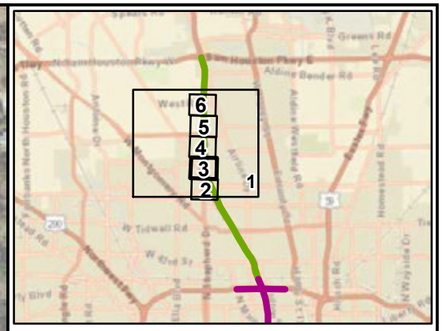

LEGEND

- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Existing Drainage Area

Existing Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped

0 200 400

Aerial Source: H-GAC 2020

N

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Fax: 281-304-0210

Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Land Use

Sheet 3 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	10

User Name: ccotsakis Date: 3/4/2021
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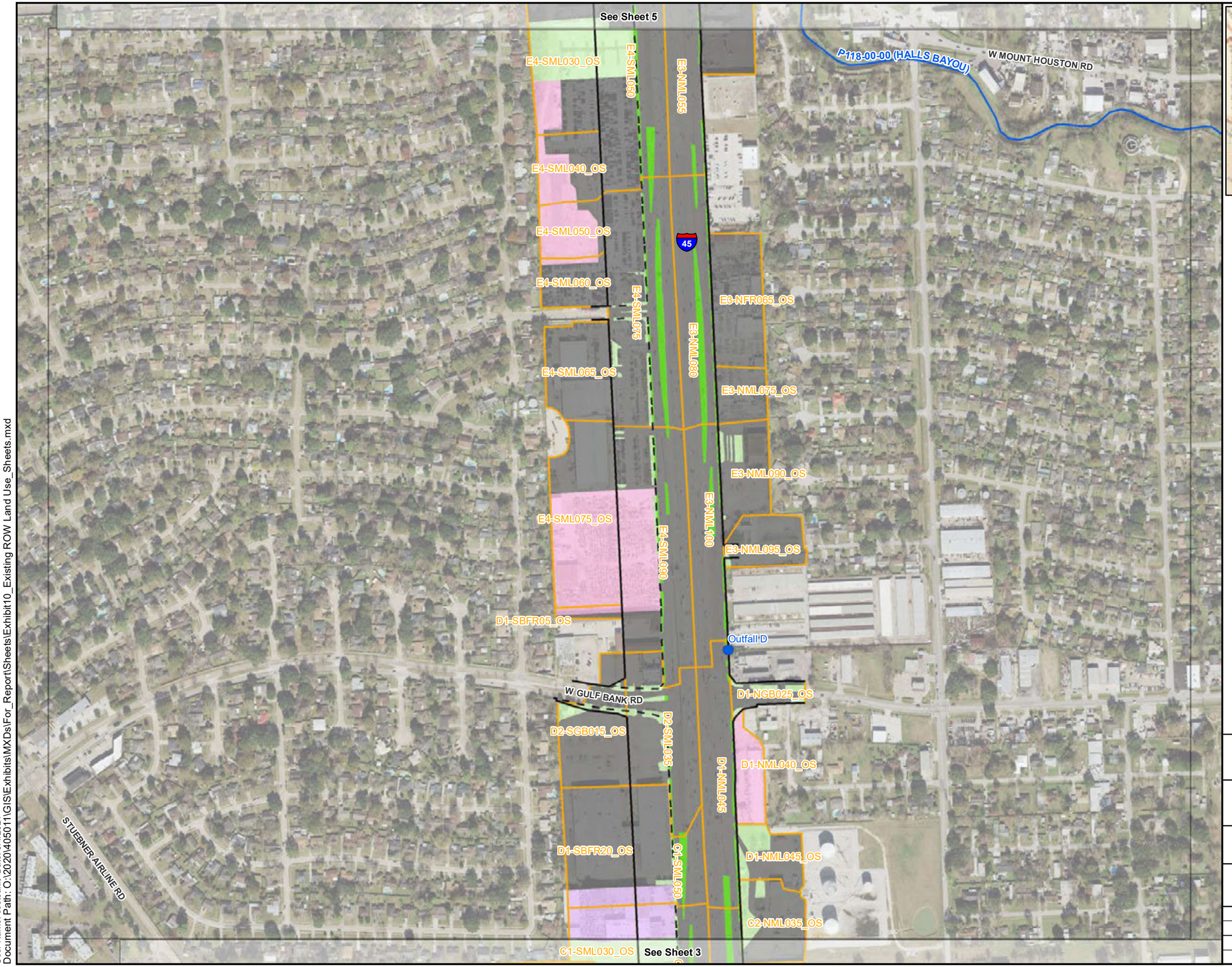

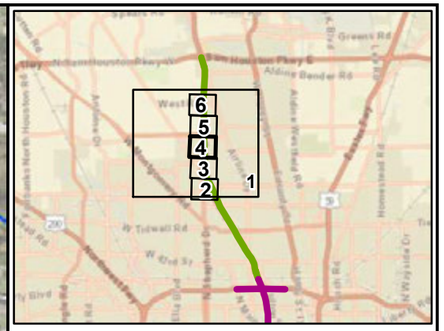

LEGEND

- Outfall
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Existing Drainage Area

Existing Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped

0 200 400

Aerial Source: H-GAC 2020

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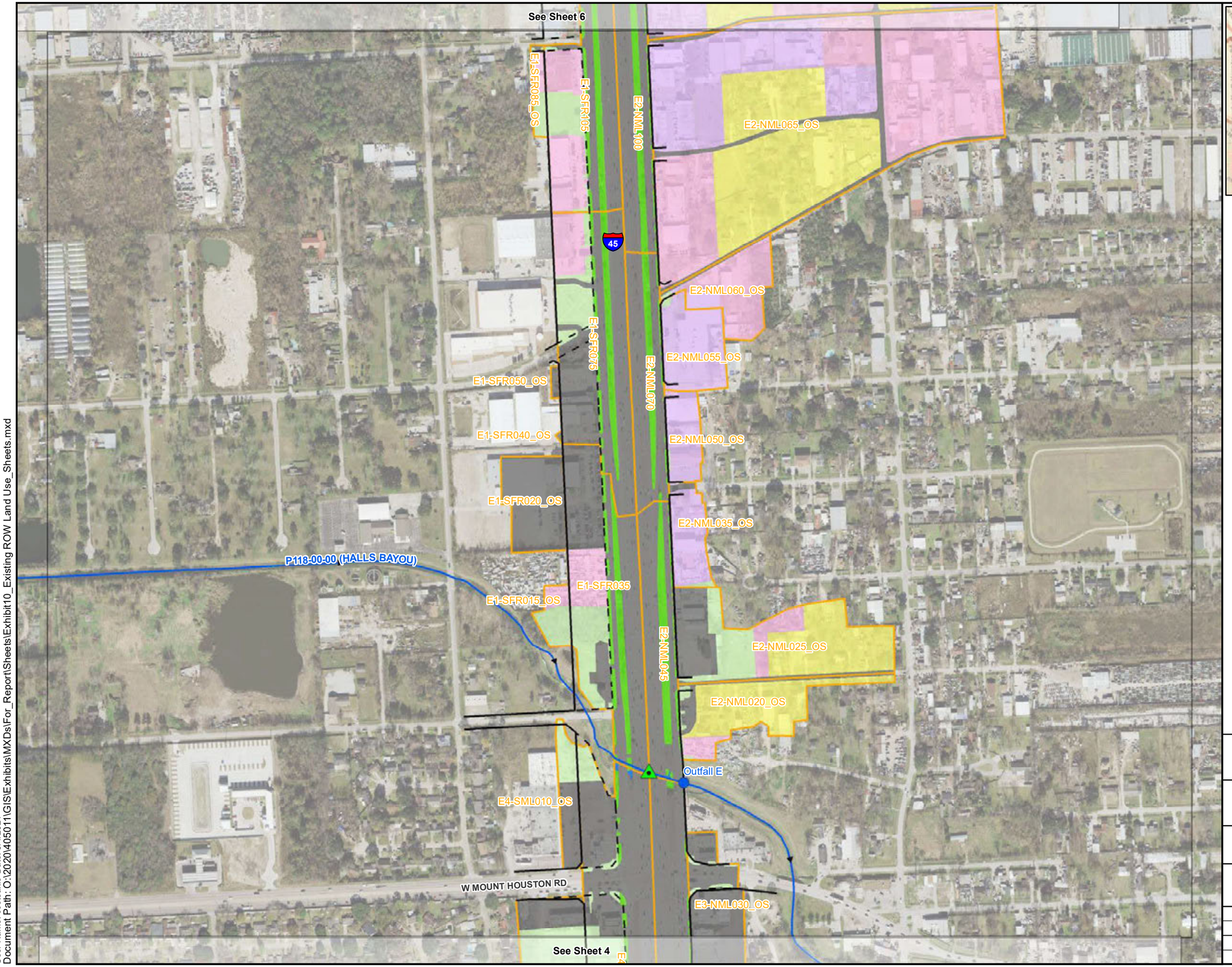
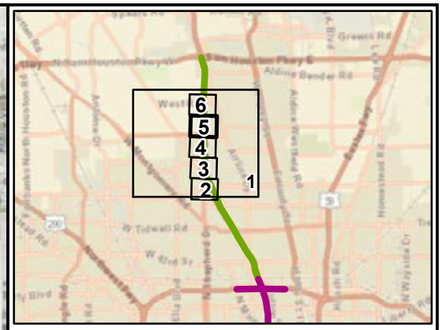
North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Land Use

Sheet 4 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	10





LEGEND

- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Existing Drainage Area

Existing Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped
- Open Water

0 200 400

Aerial Source: H-GAC 2020

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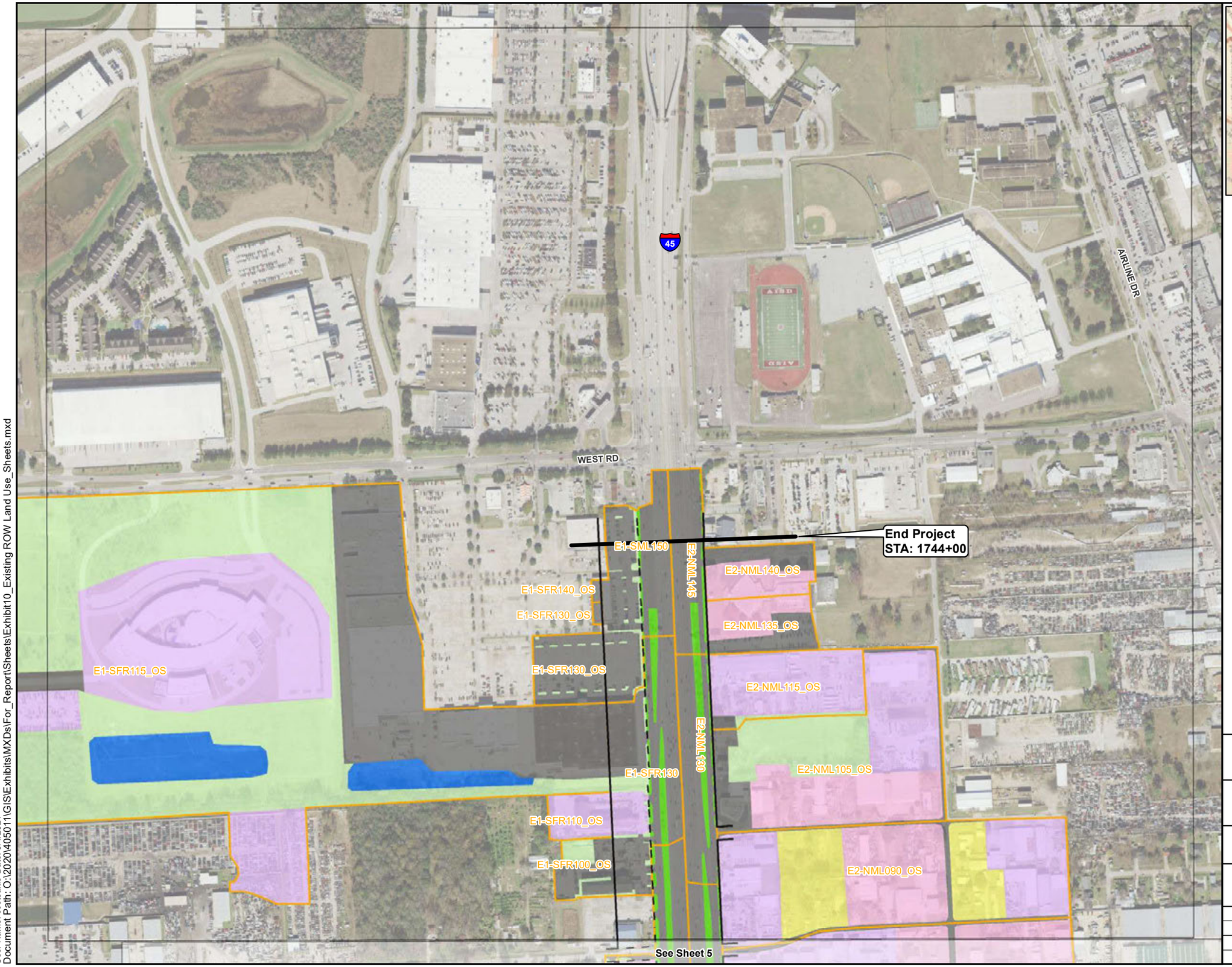
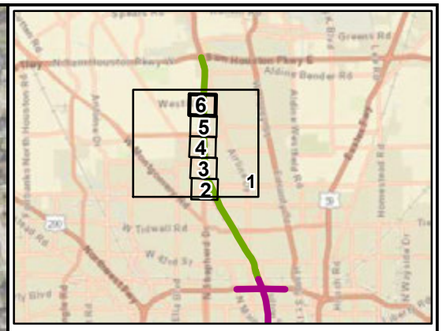
North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Land Use

Sheet 5 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	10





LEGEND

- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Existing Drainage Area

Existing Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped
- Open Water

0 200 400

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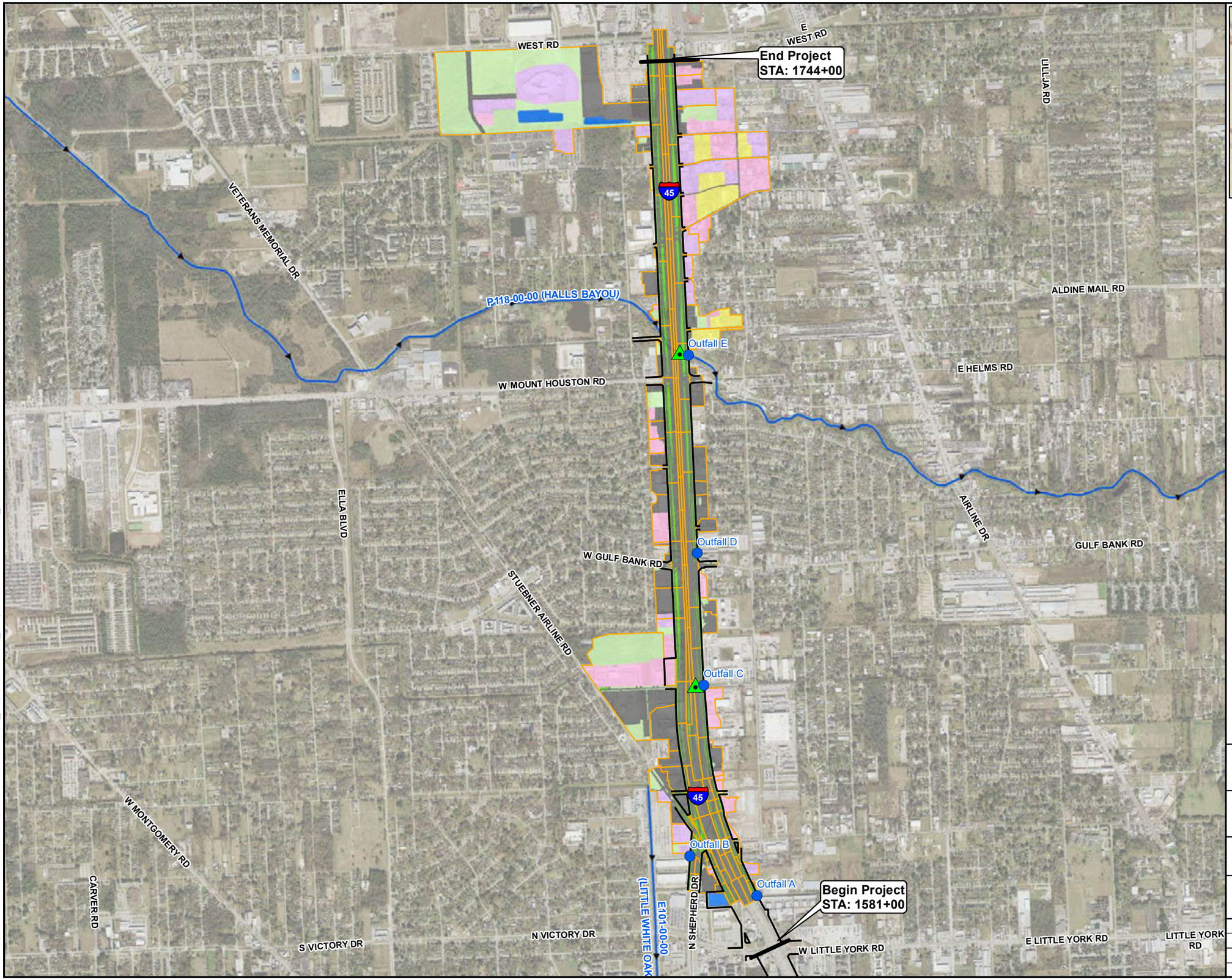
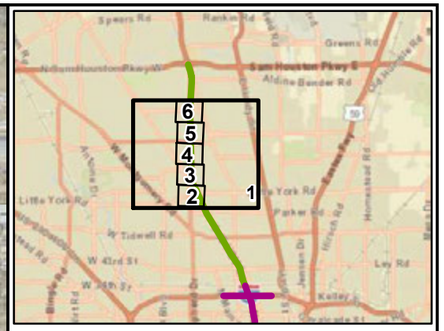
North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Land Use

Sheet 6 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	10





LEGEND

- Outfall
- Drainage Crossing
- Proposed TxDOT ROW
- Project Limit
- HCFCD Stream
- Proposed Drainage Area

Proposed Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
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- Open Water

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Land Use

Sheet 1 of 6

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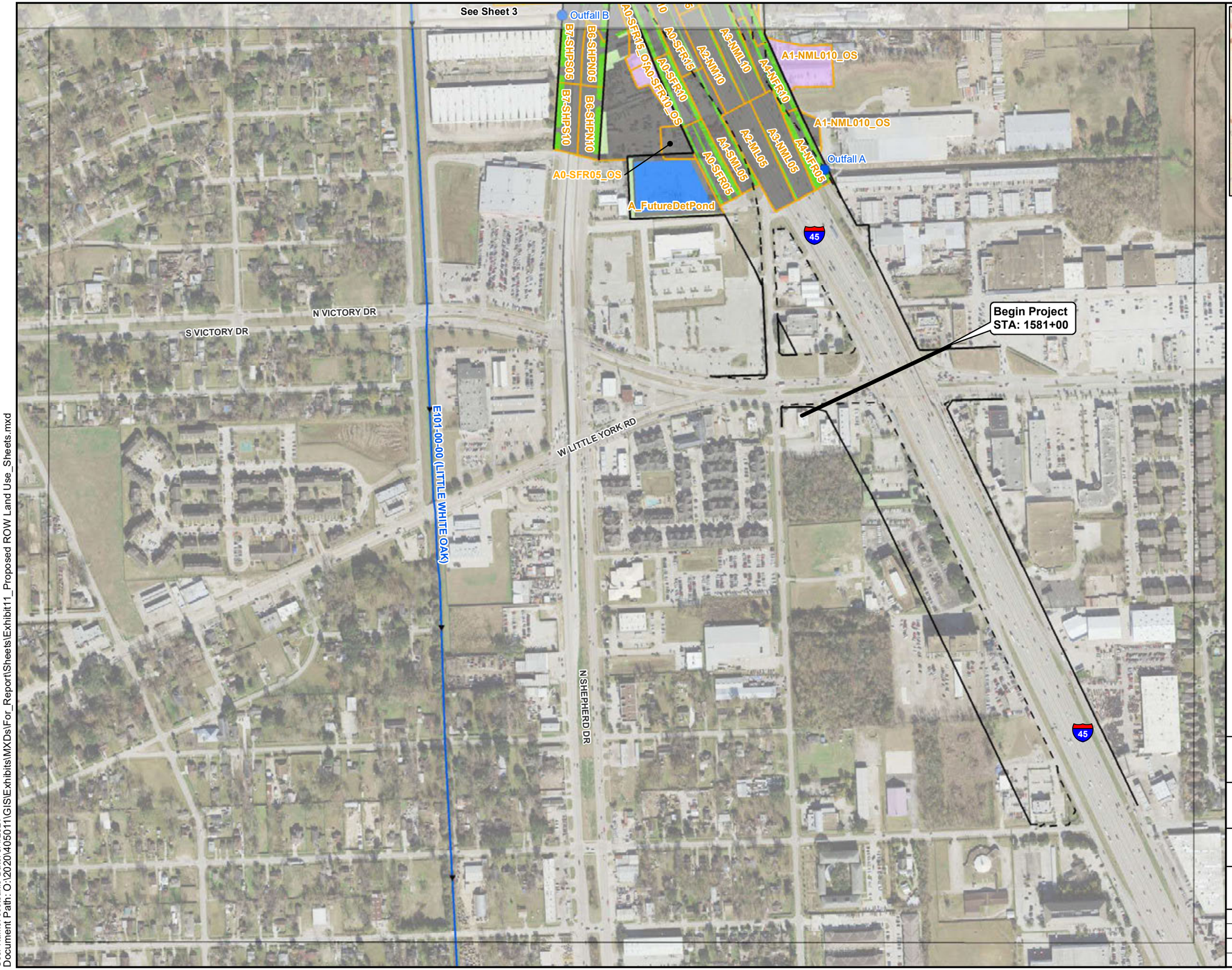
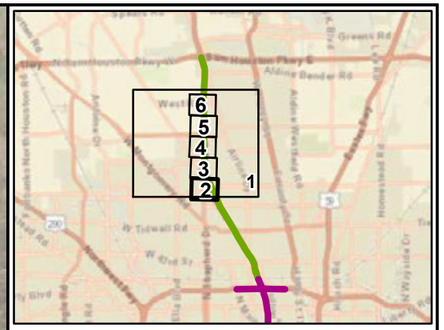
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	11





LEGEND

- Outfall
- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Proposed Drainage Area

Proposed Land Use

- High Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped
- Open Water

0 200 400

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Land Use

Sheet 2 of 6

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HOU	HARRIS	0110	06	139	11

User Name: ccotsakis Date: 3/4/2021
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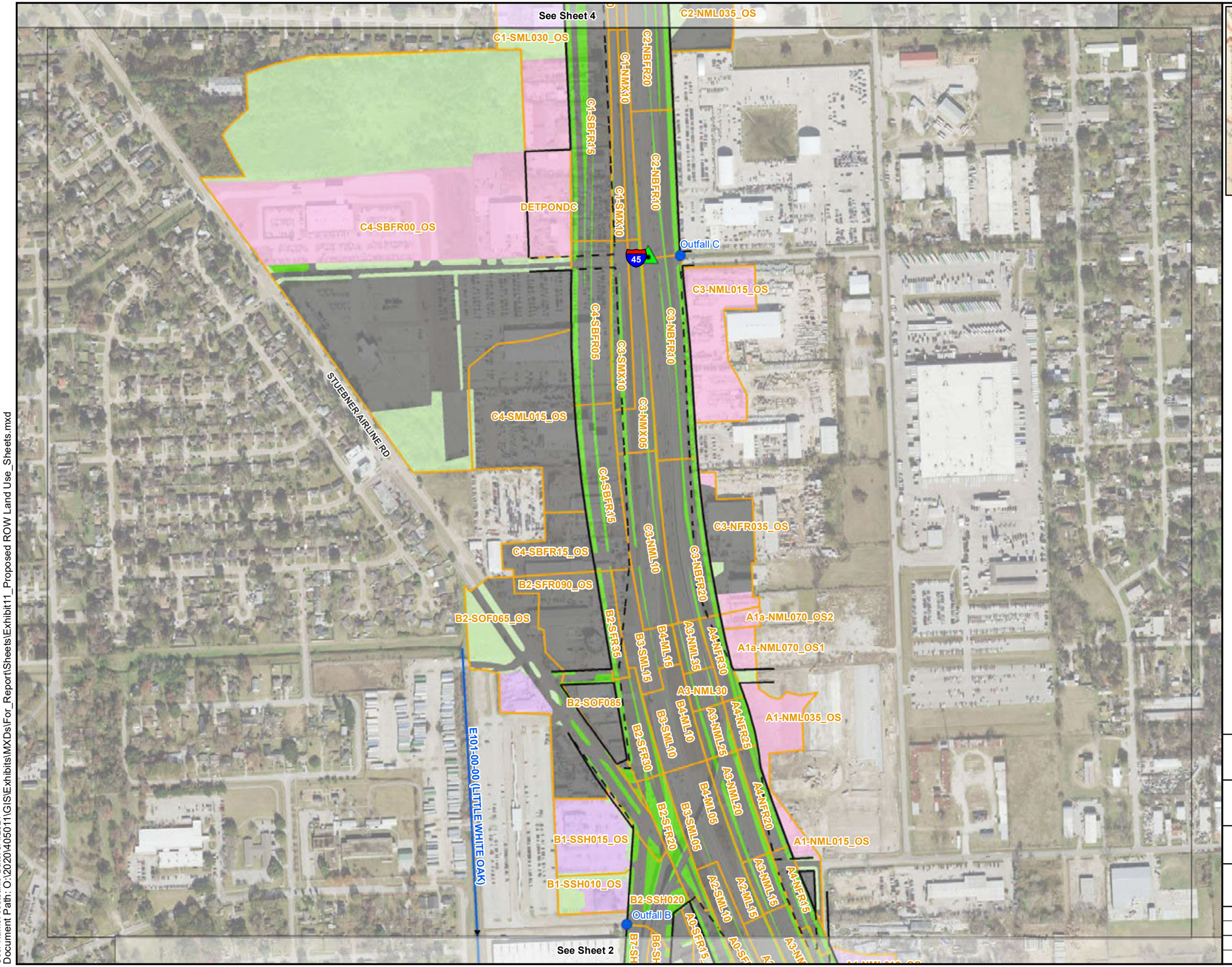

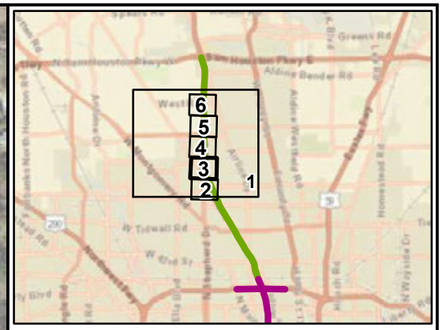

LEGEND

- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Proposed Drainage Area

Proposed Land Use

- Single-family Residential
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North Houston Highway Improvement Project
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Proposed Land Use

Sheet 3 of 6

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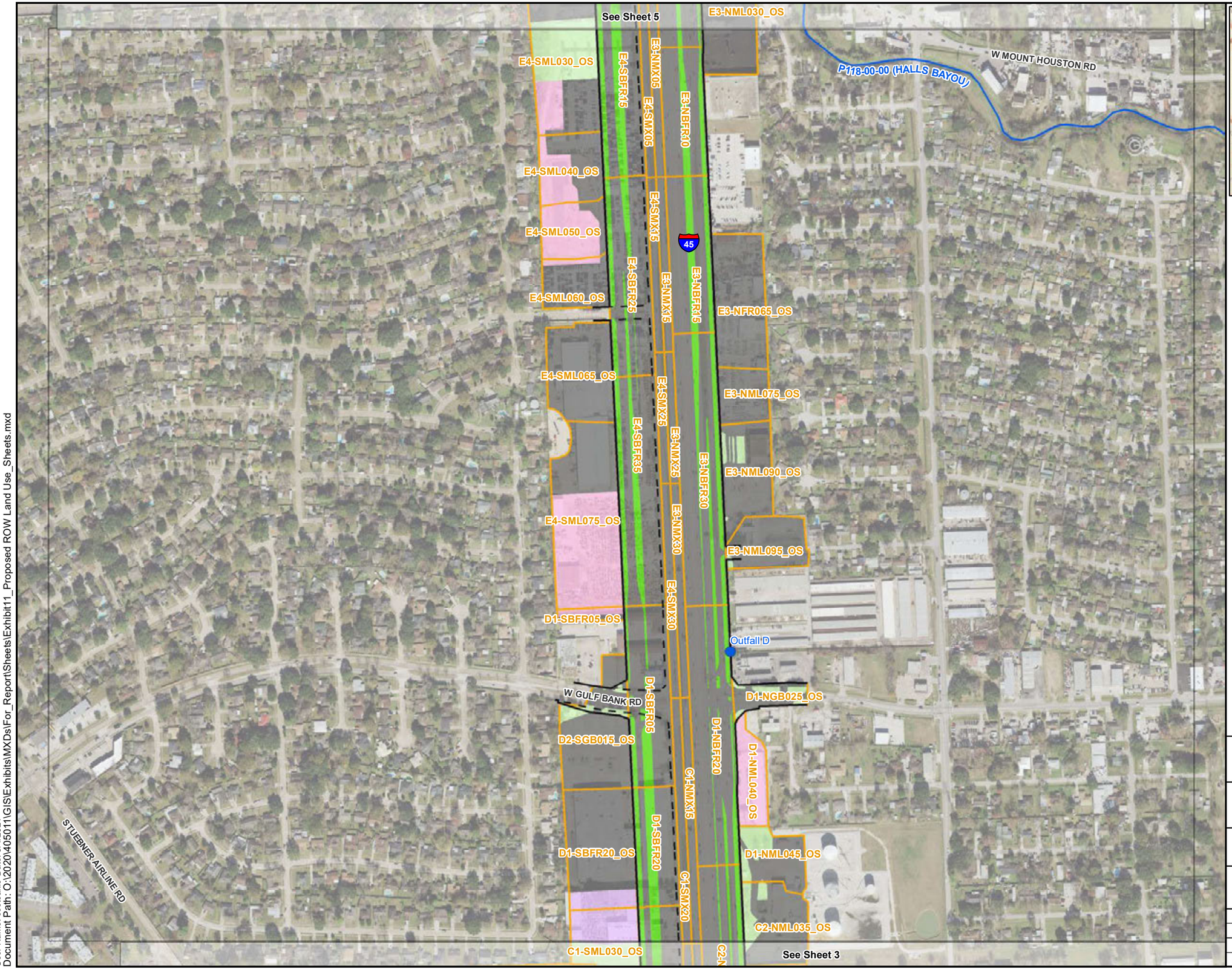
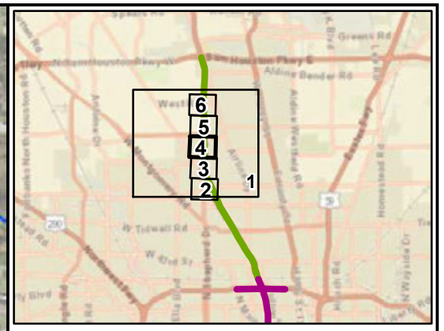
HOU	HARRIS	0110	06	139	11





LEGEND

- Outfall
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Proposed Drainage Area

Proposed Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped

0 200 400

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Land Use

Sheet 4 of 6

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HOU	HARRIS	0110	06	139	11

User Name: ccotsakis Date: 3/4/2021
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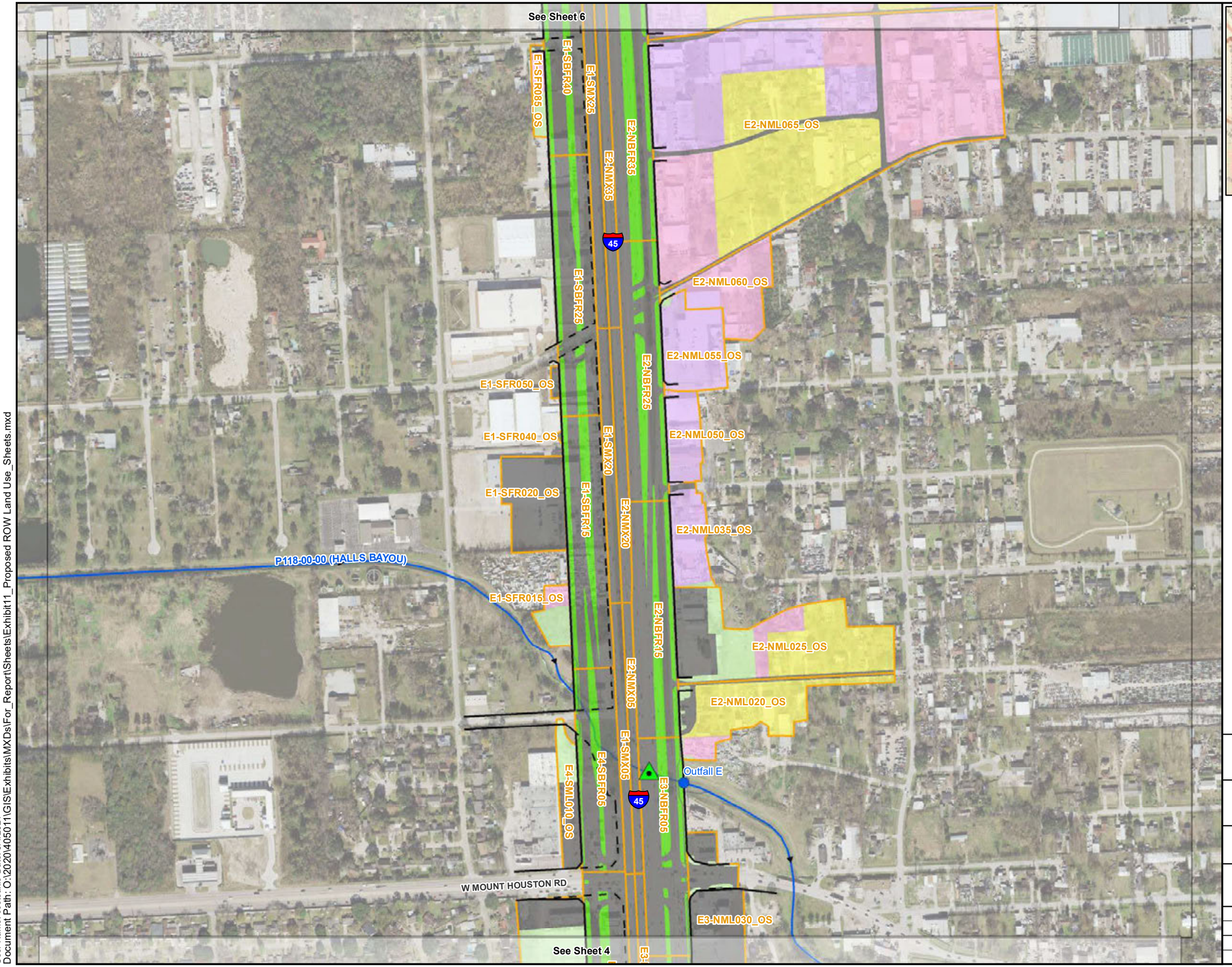

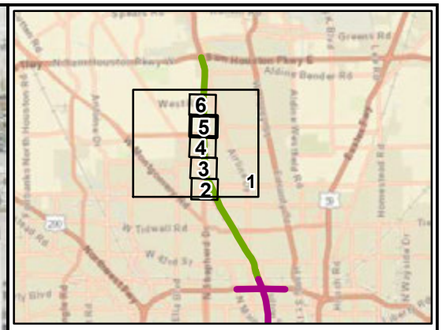

LEGEND

- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Proposed Drainage Area

Proposed Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped

0 200 400

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Aerial Source: H-GAC 2020

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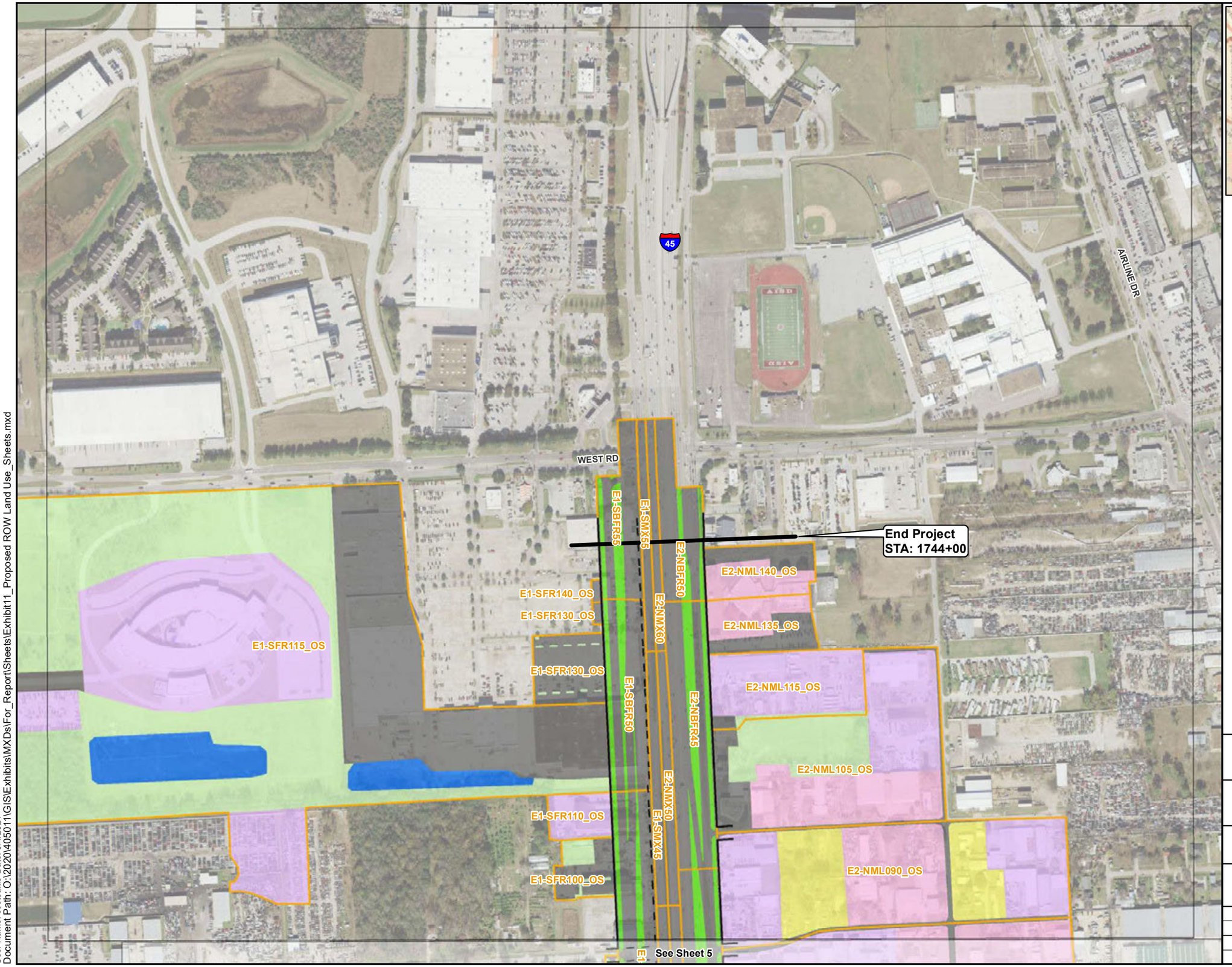
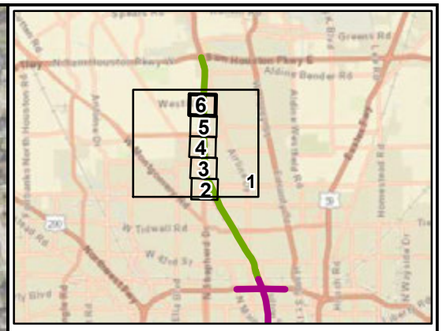
North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Land Use

Sheet 5 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	11





LEGEND

- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Drainage Area

Proposed Land Use

- Single-family Residential
- High Density Industrial/Commercial
- Low Density Industrial/Commercial
- Right-Of-Way Grasses
- Transportation
- Undeveloped
- Open Water

0 200 400

Aerial Source: H-GAC 2020

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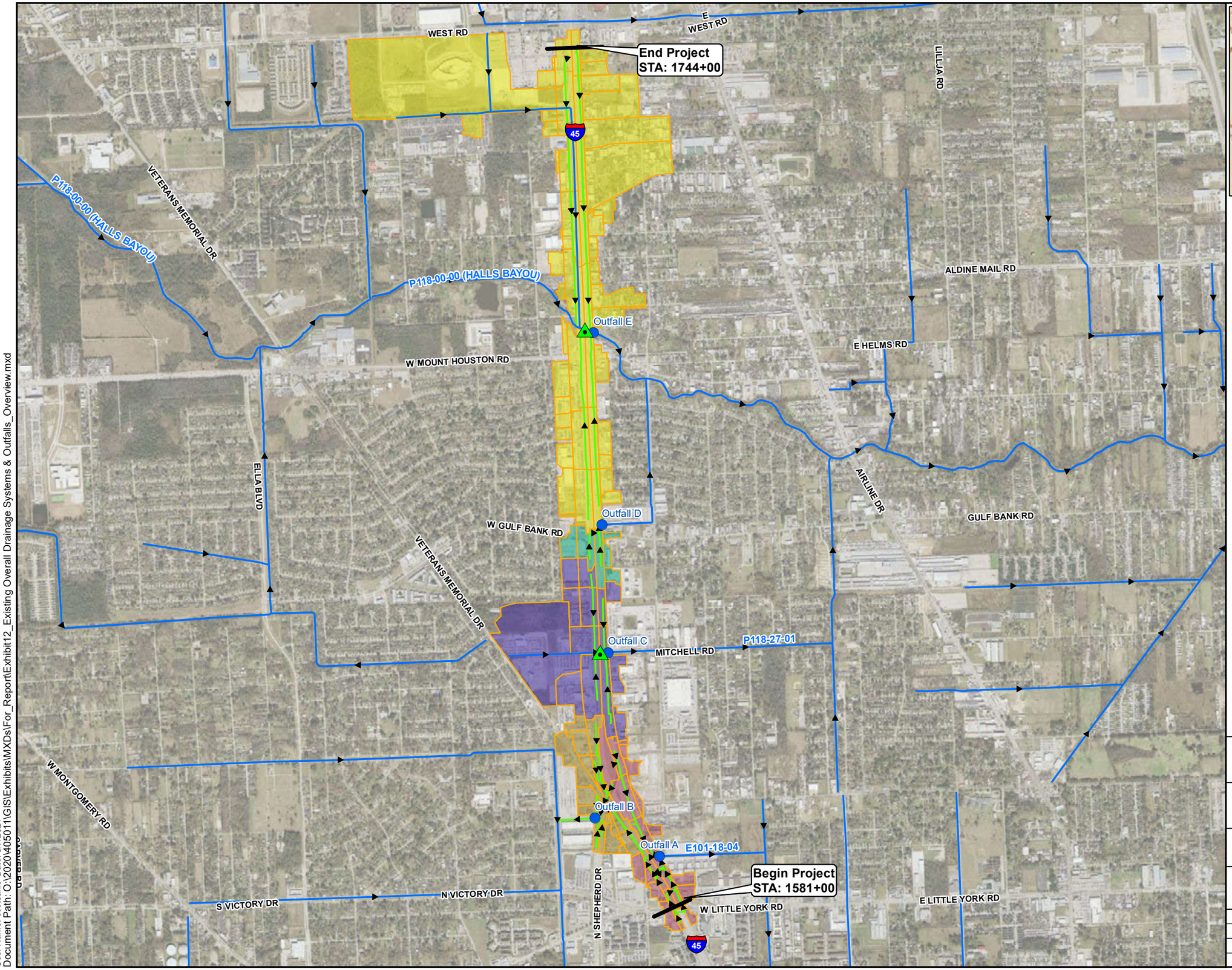
North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Land Use

Sheet 6 of 6

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	11



LEGEND

- Outfall
- Drainage Crossing
- Project Limit
- HCFCD Stream
- Existing Storm Sewer
- Existing Drainage Area

Existing Drainage Area Systems

- System A
- System B
- System C
- System D
- System E

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Aerial Source: H-GAC 2020

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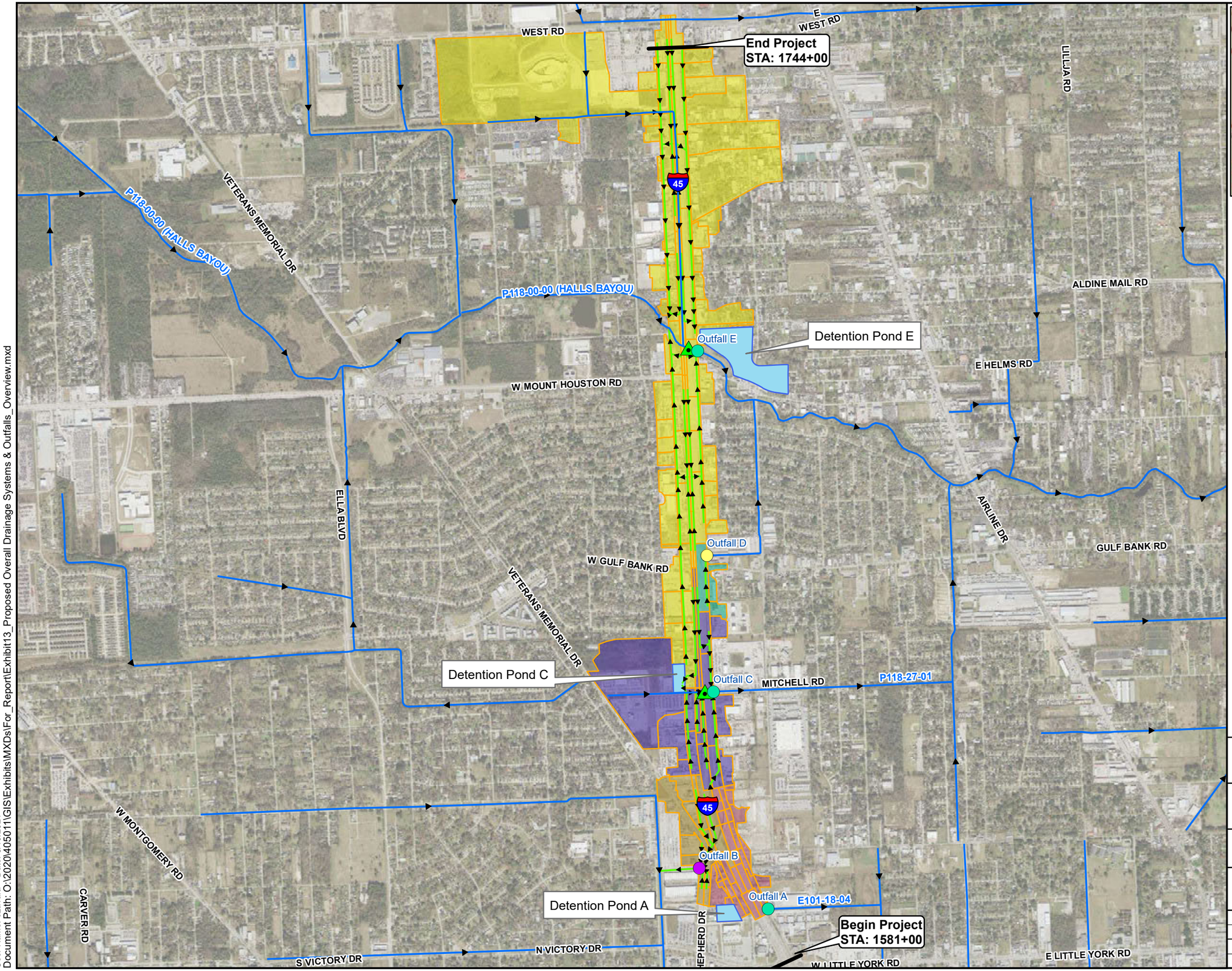
North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing Overall Drainage System & Outfalls

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	12



LEGEND

Outfall

- Off-line Storage
- In-line Storage
- Drainage Area Redirection
- Drainage Crossing
- Project Limit
- HCFCD Stream
- Proposed Storm Sewer
- Proposed Detention Pond
- Proposed Drainage Area

Proposed Drainage Area Systems

- System A
- System B
- System C
- System D
- System E

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Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Overall Drainage Systems & Outfalls

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	13

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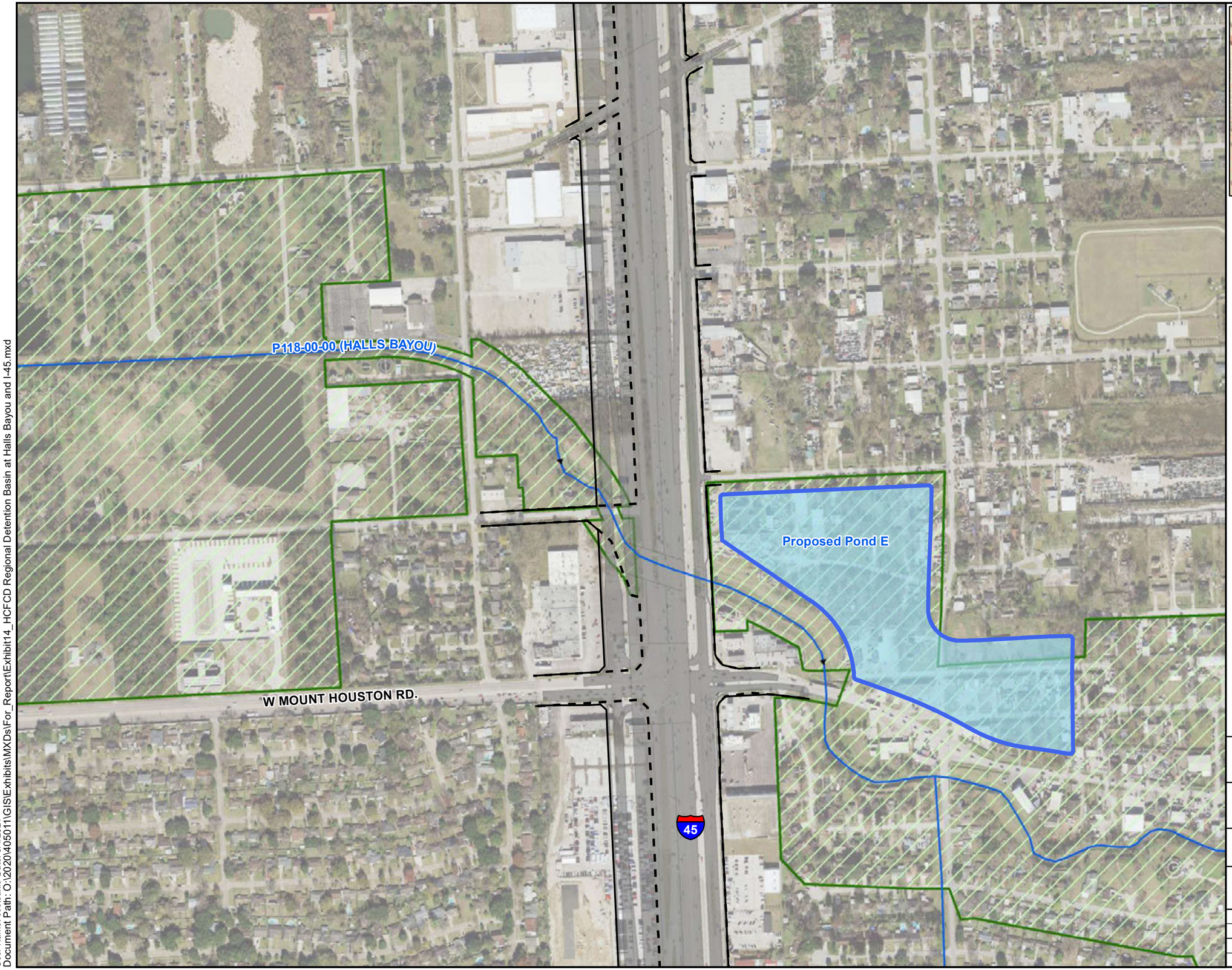

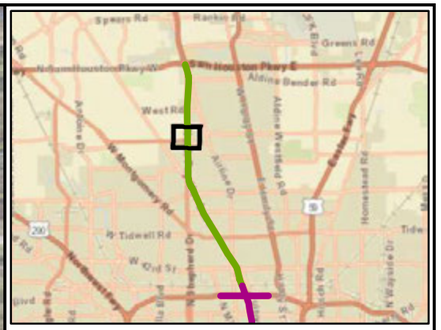

LEGEND

- HCFCD Stream
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Detention Basin
- HCFCD Ultimate ROW
- Proposed Roadway

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Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed Detention Basin E at Halls Bayou and I-45

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	14

User Name: ccotsakis Date: 3/4/2021
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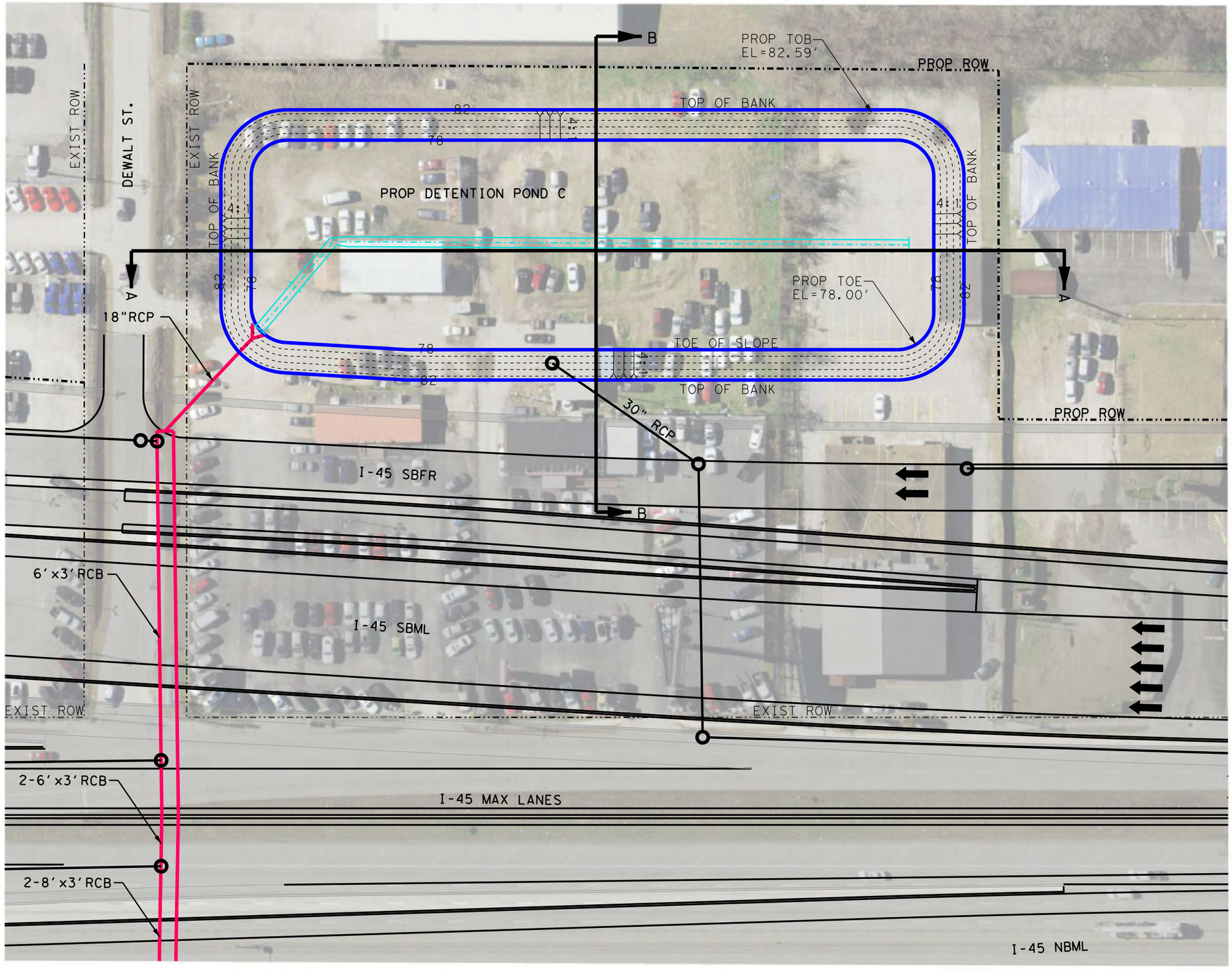

LEGEND

- PROP STORM SEWER
- PROP STORM SEWER NODE
- PROP OUTFALL CULVERT

NOTES:

1. REFER TO THE STORM SEWER PLANS FOR DETAILS ON THE STORM SEWER LAYOUT.

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REV NO.	DATE	BY	REVISION

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Cypress, Texas 77429
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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

PROPOSED DETENTION POND C PLAN

SHEET 1 OF 2

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		EXHIBIT NO.
CK: CW	6	12-0IDP5012		15-1
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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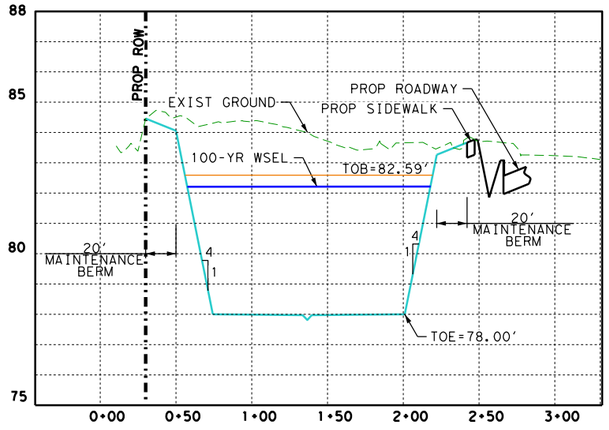
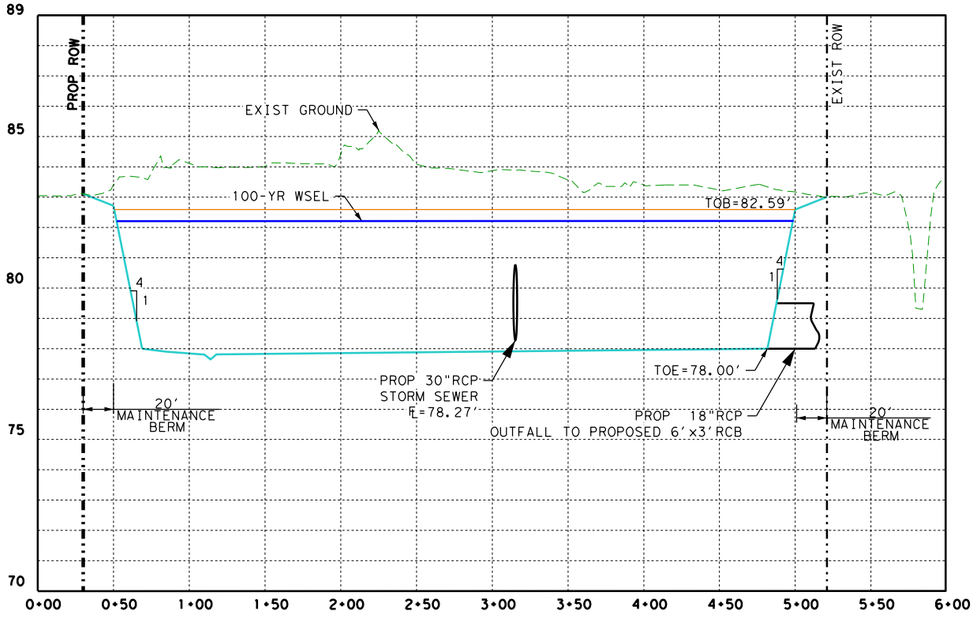
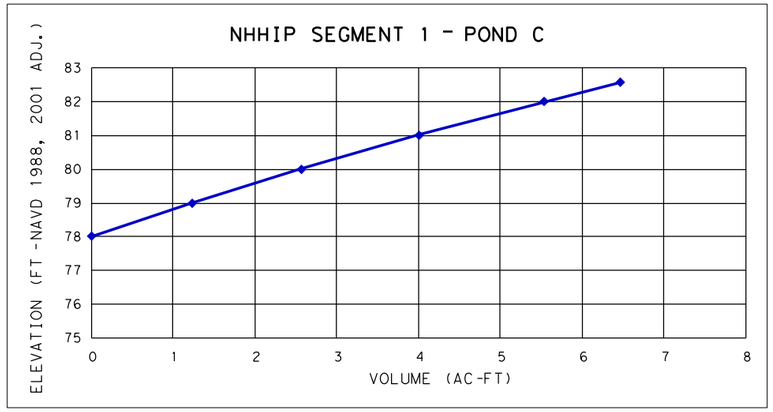


C SECTION B-B

Elevation (feet)	Stage (feet)	Surface Area (sq. ft.)	Incremental Volume (cu. ft.)	Cumulative Volume (cu. ft.)	Volume (ac-ft)	Pond Feature
78.00	0.00	51644	0	0	0.00	Outlet
79.00	1.00	55843	53744	53744	1.23	
80.00	2.00	60142	57992	111736	2.57	
81.00	3.00	64542	62342	174078	4.00	
82.00	4.00	69042	66792	240869	5.53	
82.59	4.59	69714	40933	281802	6.47	High Bank



C SECTION A-A



0 50 100 (H)
0 2.5 5 (V)

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PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

NHHIP SEGMENT 1

DETENTION POND C SECTIONS

SHEET 2 OF 2

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	15-1
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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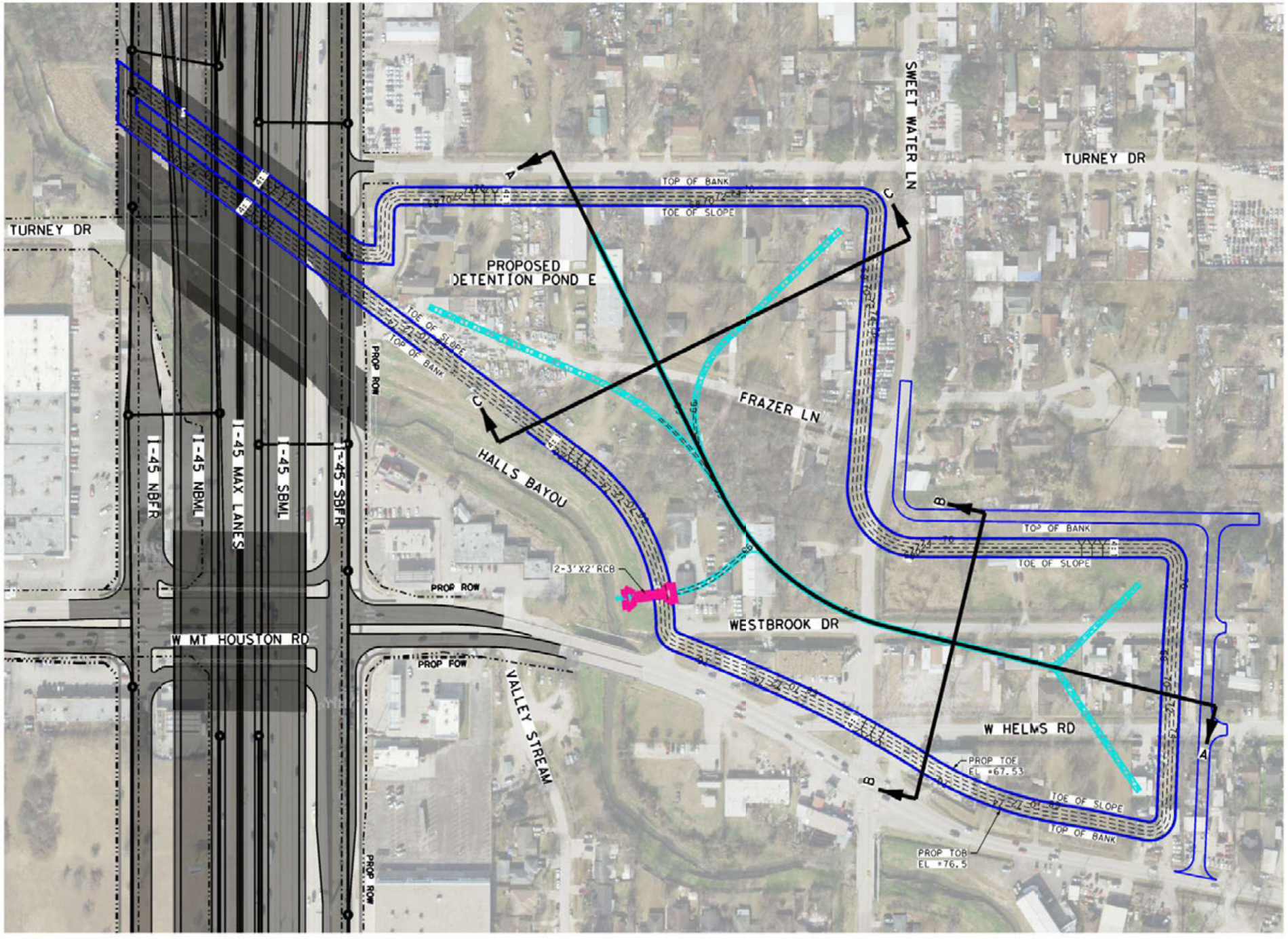

LEGEND

- PROP STORM SEWER
- PROP STORM SEWER NODE
- PROP OUTFALL CULVERT

NOTES:

1. REFER TO THE STORM SEWER PLANS FOR DETAILS ON THE STORM SEWER LAYOUT.

N

0 100 200

REV. NO.	DATE	BY	REVISION

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PRELIMINARY SUBJECT TO CHANGE

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Cypress, Texas 77429
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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

PROPOSED
DETENTION POND E
PLAN

SHEET 1 OF 2

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	15-2
DRN: ES	STATE	DIST.	COUNTY
APPVD: EV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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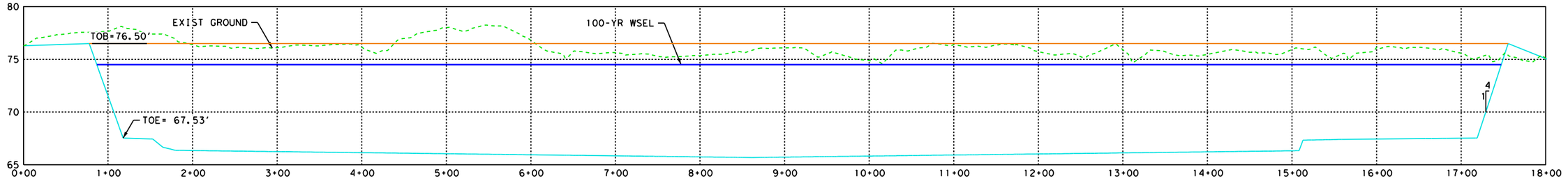
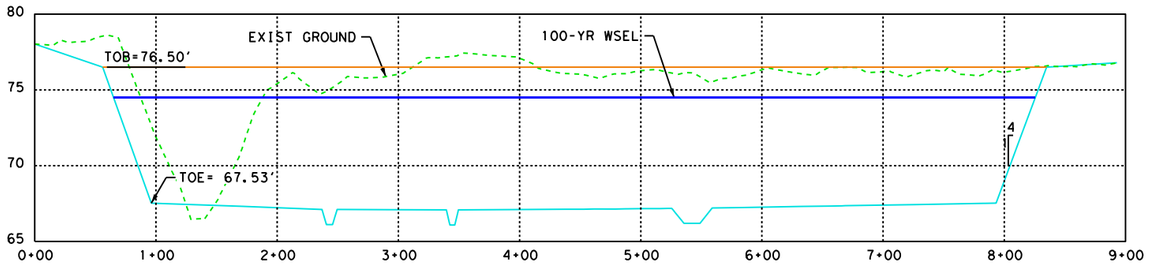


A SECTION A-A



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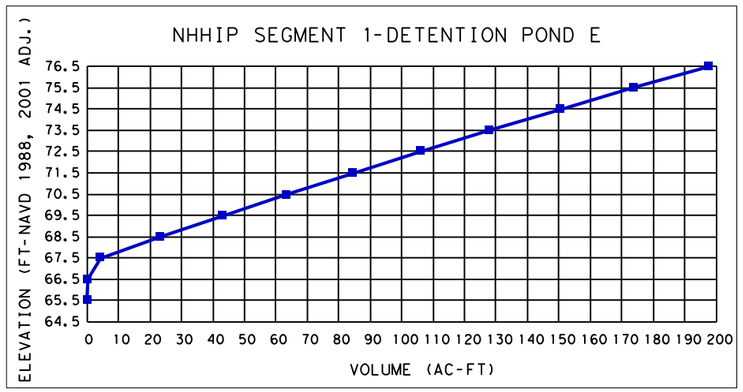

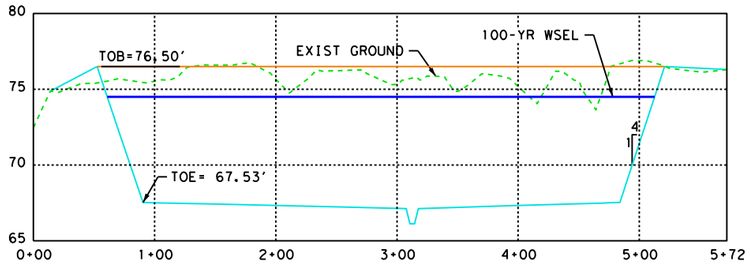

B SECTION B-B

Elevation (feet)	Stage (feet)	Surface Area (sq. ft.)	Incremental Volume (cu. ft.)	Cumulative Volume (cu. ft.)	Volume (ac-ft)	Pond Feature
65.50	0.00	981785	0	0	0.00	Outlet
66.50	1.00	987917	6594	6594	0.15	
67.50	2.00	994057	175775	182369	4.19	
68.50	3.00	1000205	836595	1018964	23.39	
69.50	4.00	1006360	863878	1882842	43.22	
70.50	5.00	1012523	887746	2770588	63.60	
71.50	6.00	1018694	911722	3682309	84.53	
72.50	7.00	1024872	935800	4618109	106.02	
73.50	8.00	1031056	959984	5578093	128.06	
74.50	9.00	1037252	984274	6562368	150.65	
75.50	10.00	1043453	1009446	7571814	173.82	
76.50	11.00	1046559	1034142	8605956	197.57	High Bank

0 40 80 (H)
0 2.5 5 (V)

REV NO.	DATE	BY	REVISION

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NHHIP SEGMENT 1

PROPOSED DETENTION POND E SECTIONS

SHEET 2 OF 2

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	EXHIBIT NO.
CK: CW	6	12-01DP5012	15-2
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

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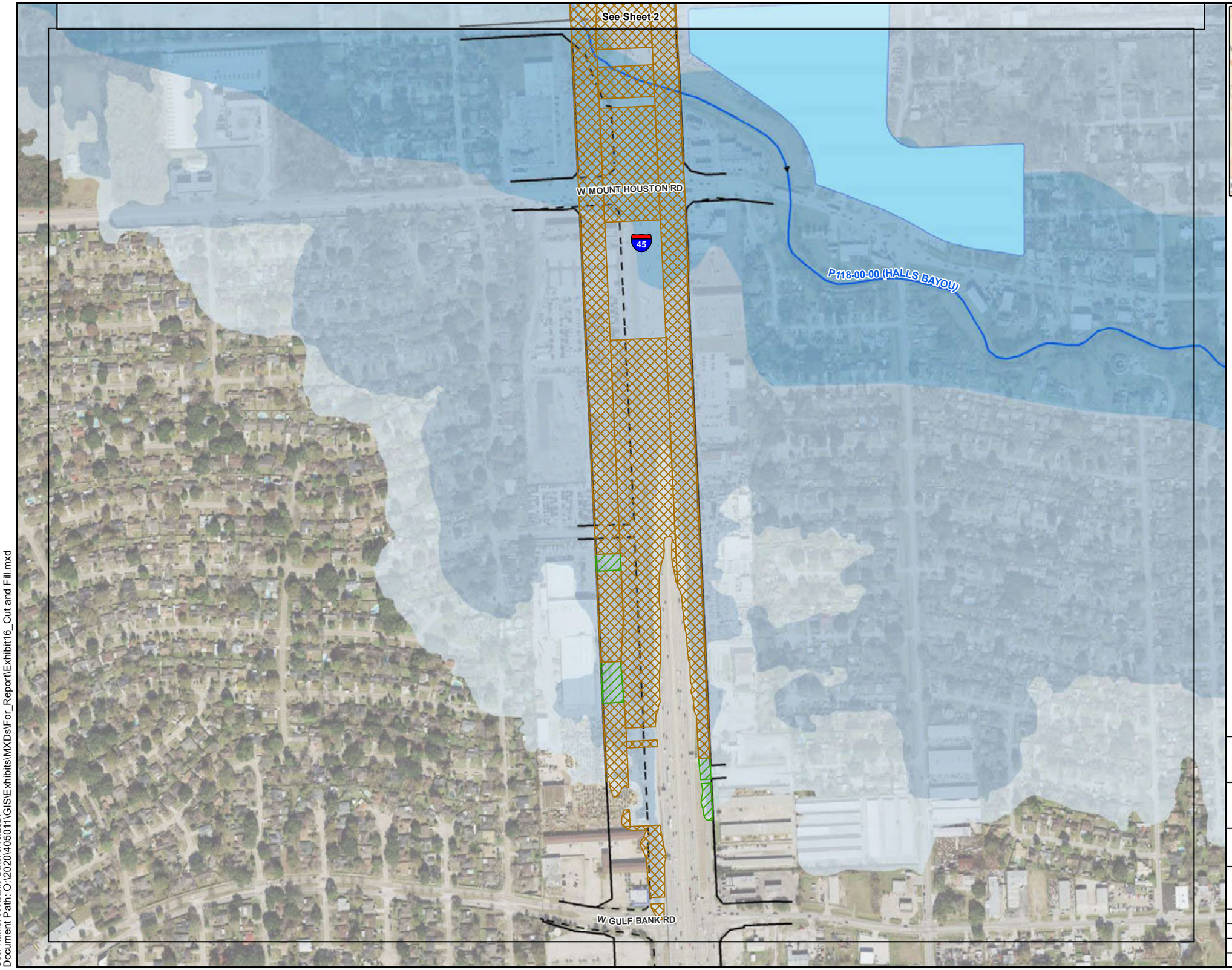

LEGEND

- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Proposed Detention Basin E

Approximate Cut & Fill

- Cut
- Fill

FEMA Flood Hazard Zones

- Regulatory Floodway
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard

Note: Fill volumes based on Halls Bayou Corrected Effective 500-Year WSE (Pre-Atlas 14)

0 200 400

N

Aerial Source: H-GAC 2020
Vertical Datum: NAVD 88 (2001 Adj)

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Floodplain Impact Analysis

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	16

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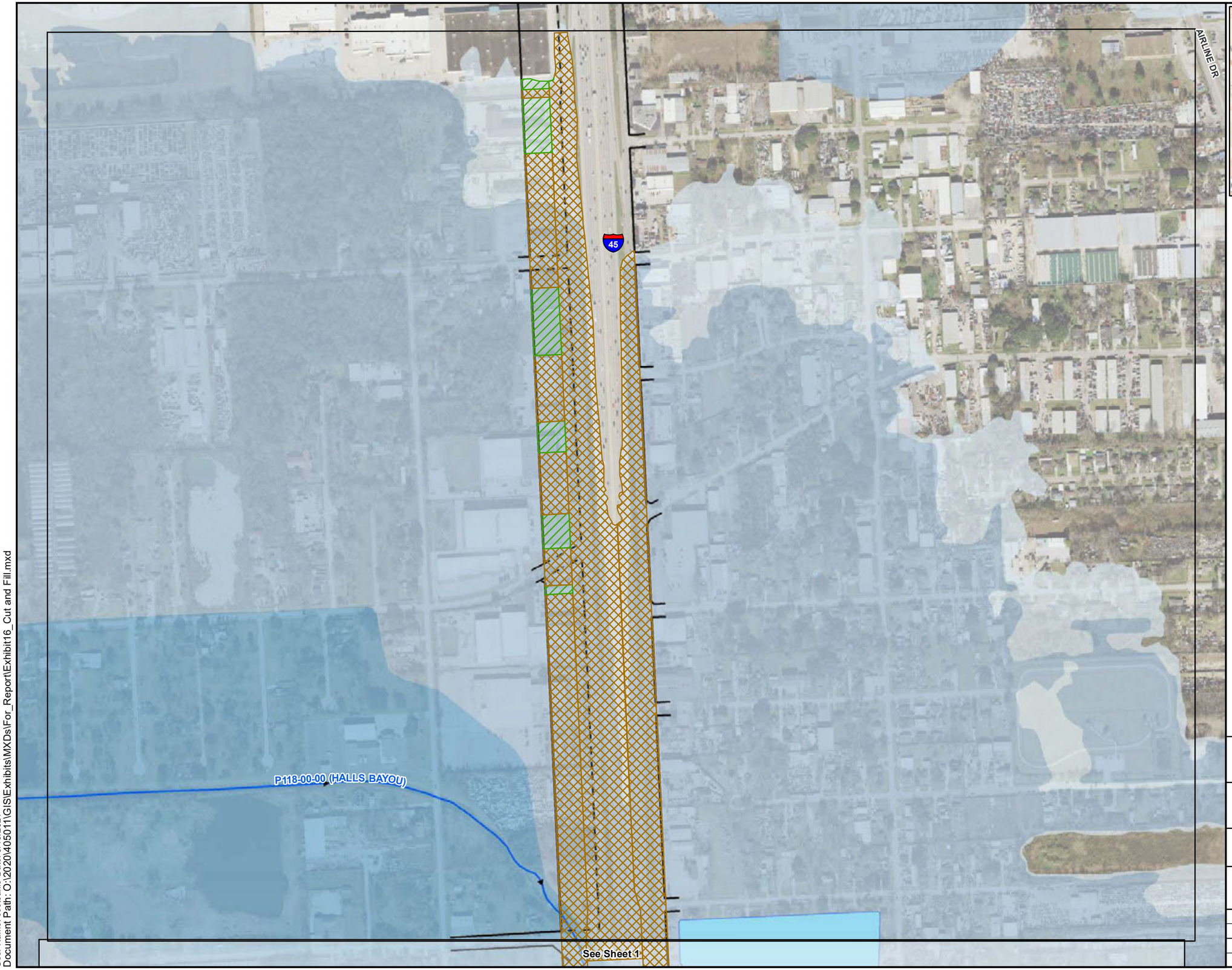

LEGEND

- Existing TxDOT ROW
- Proposed TxDOT ROW
- HCFCD Stream
- Proposed Detention Basin E

Approximate Cut & Fill

- Cut
- Fill

FEMA Flood Hazard Zones

- Regulatory Floodway
- 1% Annual Chance Flood Hazard
- 0.2% Annual Chance Flood Hazard

Note: Fill volumes based on Halls Bayou Corrected Effective 500-Year WSE (Pre-Atlas 14)

0 200 400

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Aerial Source: H-GAC 2020
Vertical Datum: NAVD 88 (2001 Adj)

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Floodplain Impact Analysis

Sheet 2 of 2

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	16

User Name: ccotsakis Date: 3/10/2021
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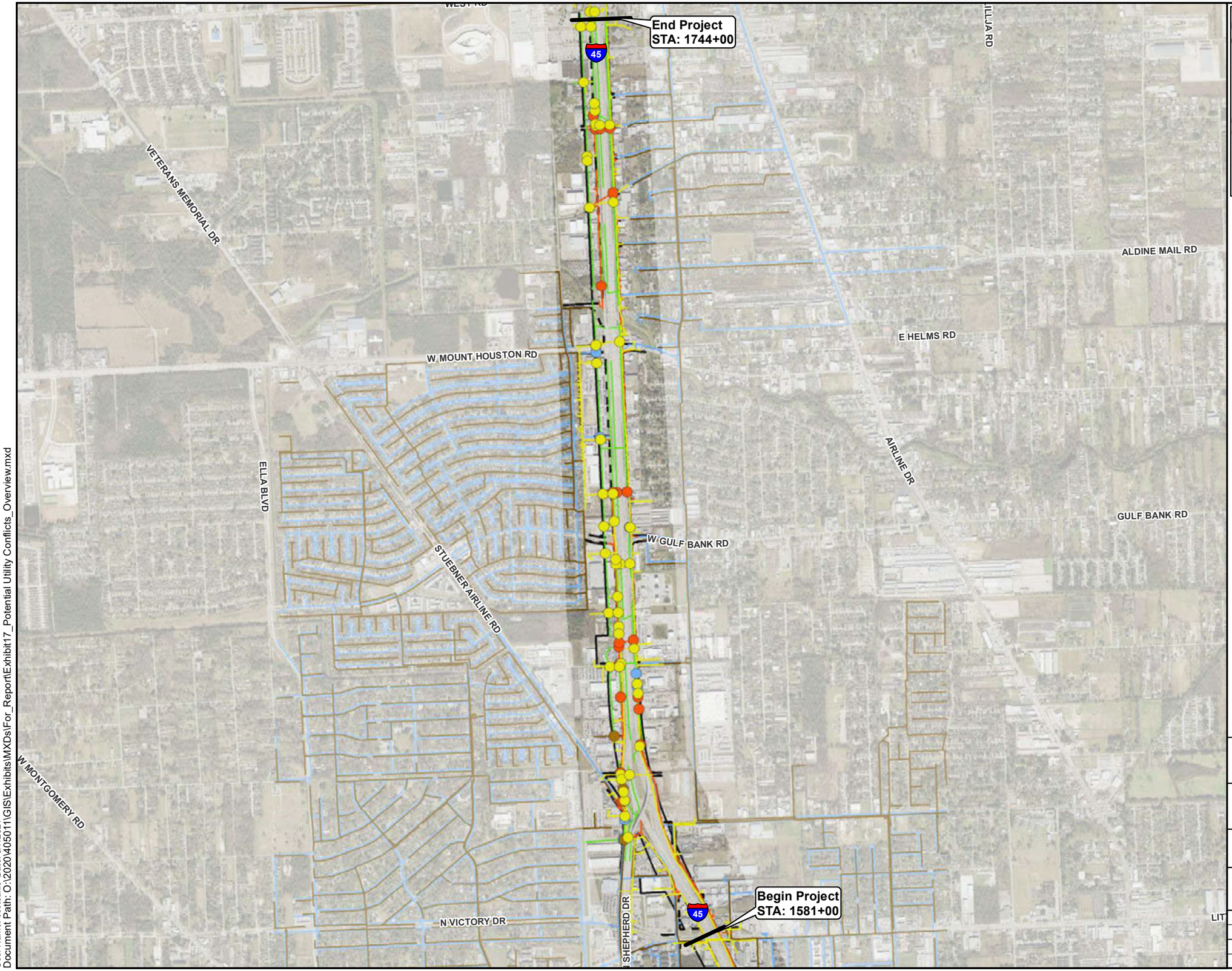

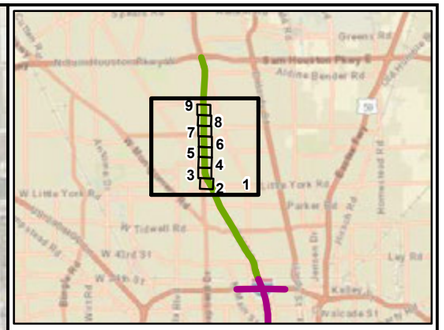

LEGEND

- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer

Utility Conflicts

- Electric Line Conflict
- Gas Line Conflict
- Waste Water Conflict
- Water Line Conflict

Utility Lines

- Electric Line
- Gas Line
- Waste Water Line
- Water Line

0 800 1,600

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 1 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17

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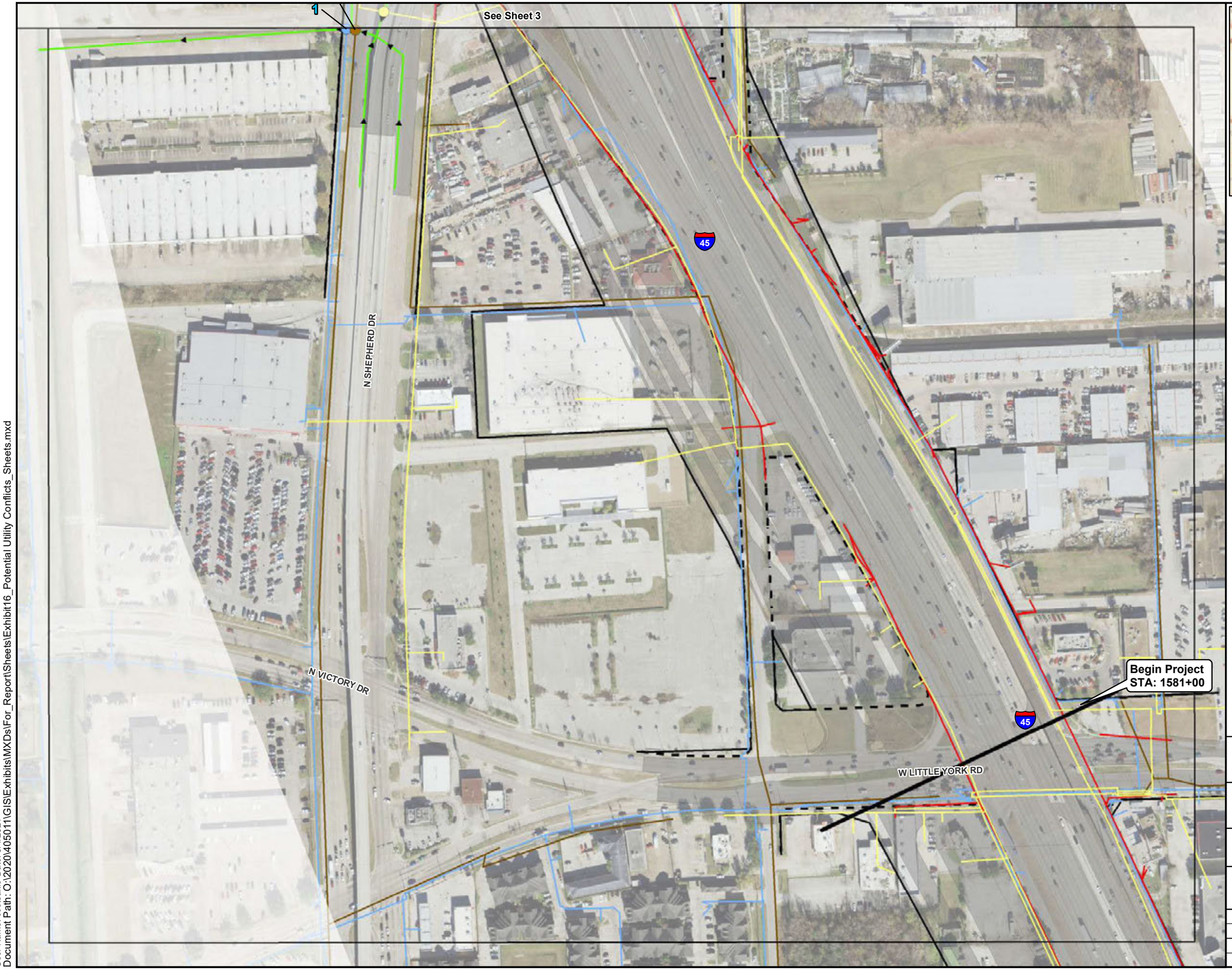

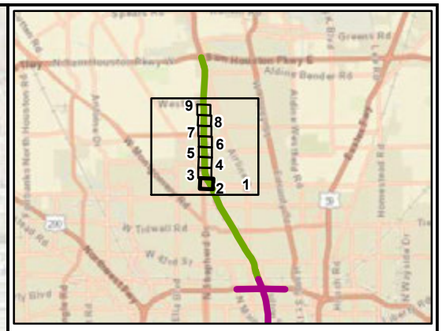

LEGEND

- Gas Line Conflict
- Waste Water Conflict
- Water Line Conflict
- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 2 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17

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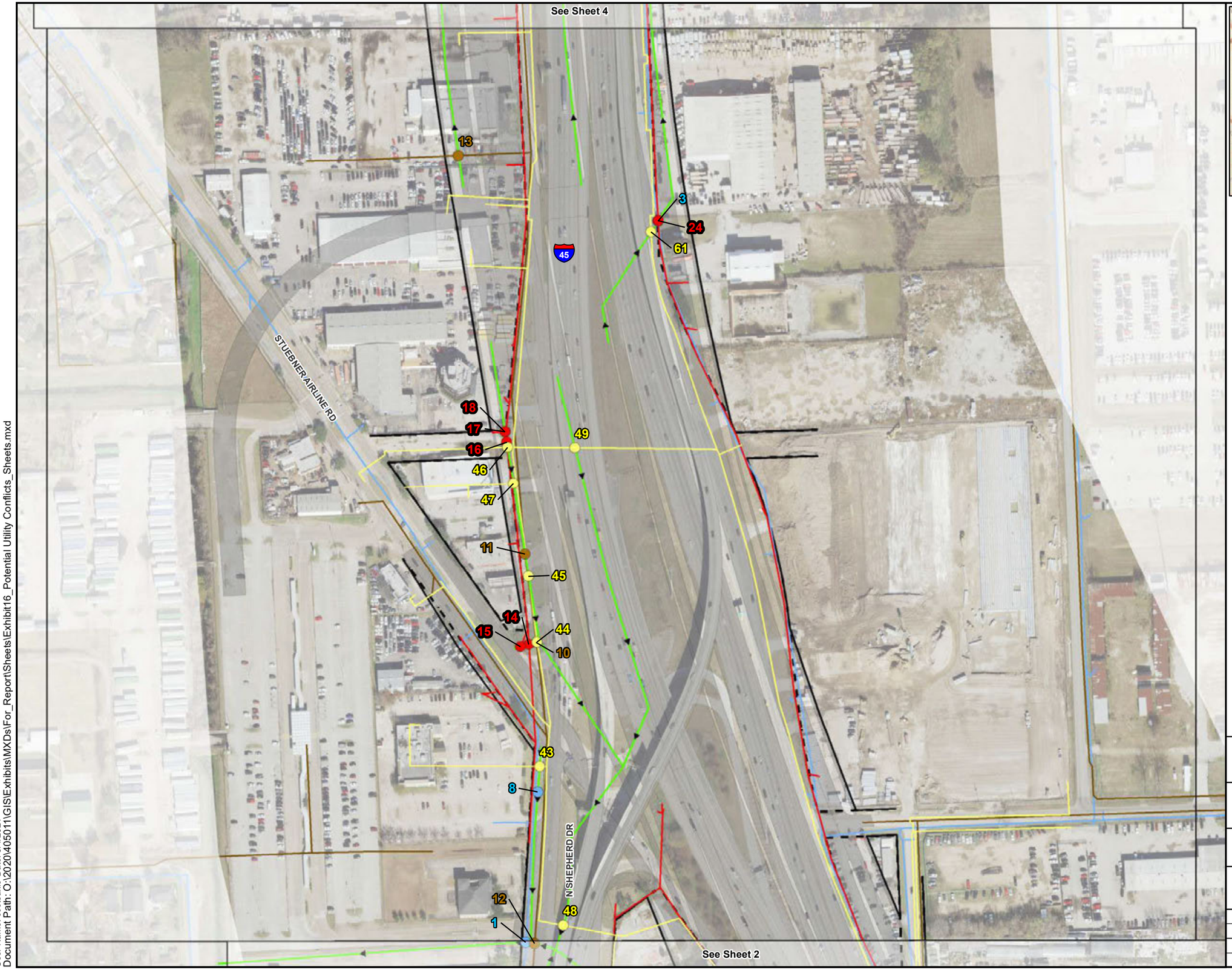

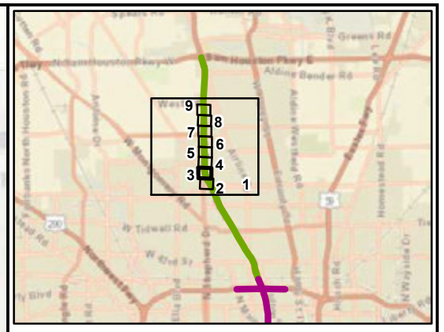

LEGEND

- Electric Line Conflict
- Gas Line Conflict
- Waste Water Conflict
- Water Line Conflict
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 3 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17

See Sheet 5

See Sheet 3

STUEBNER AIRLINE RD

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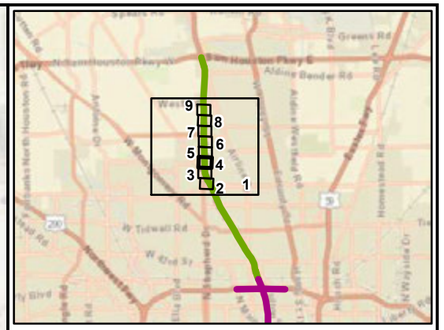

LEGEND

- Electric Line Conflict
- Gas Line Conflict
- Water Line Conflict
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

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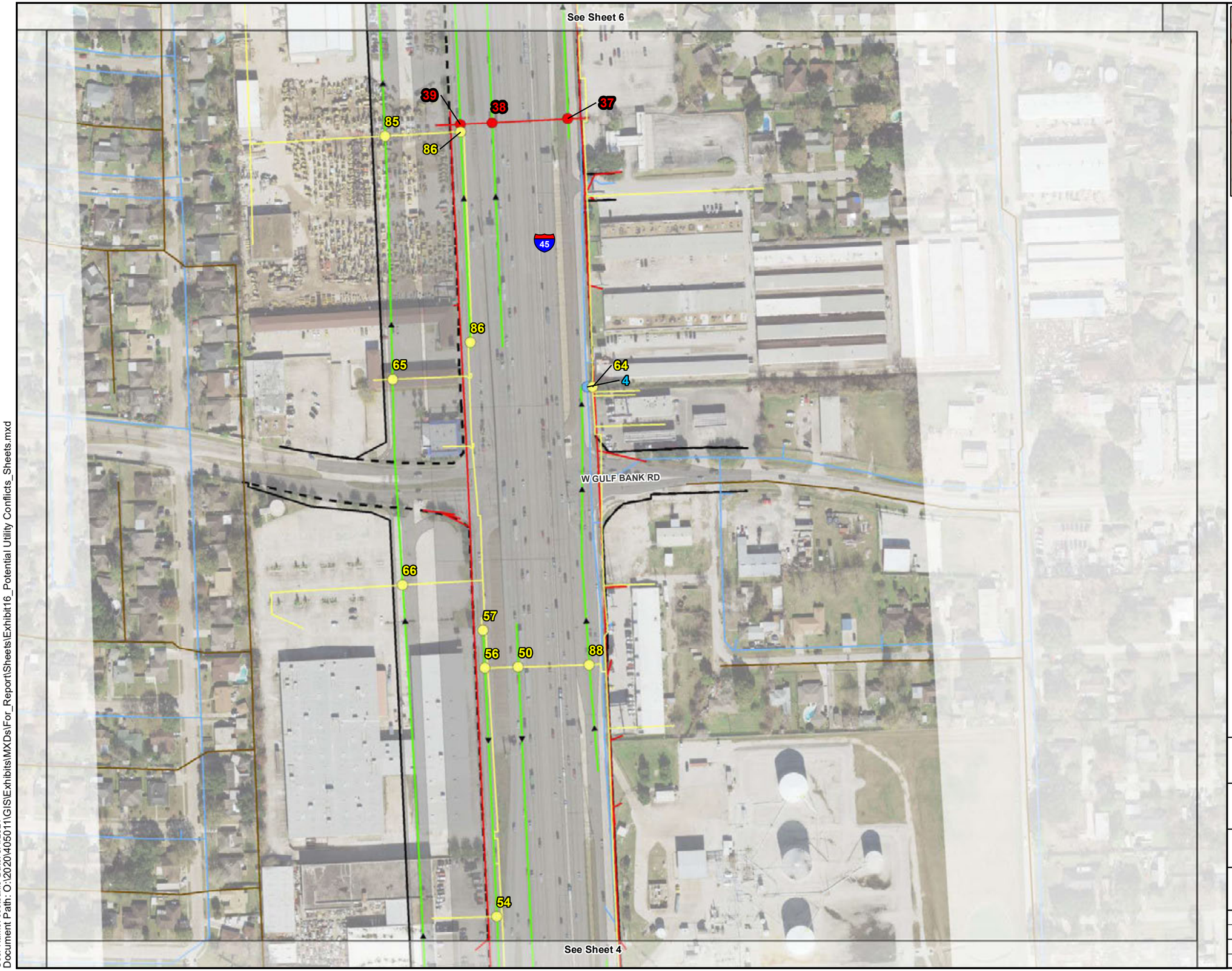
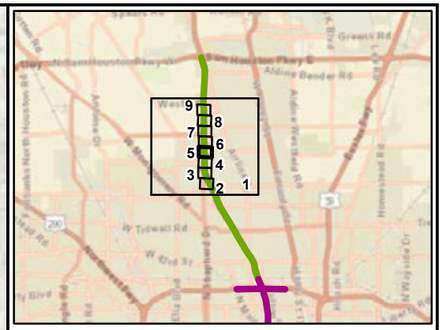
North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17





LEGEND

- Electric Line Conflict
- Gas Line Conflict
- Water Line Conflict
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

Aerial Source: H-GAC 2020

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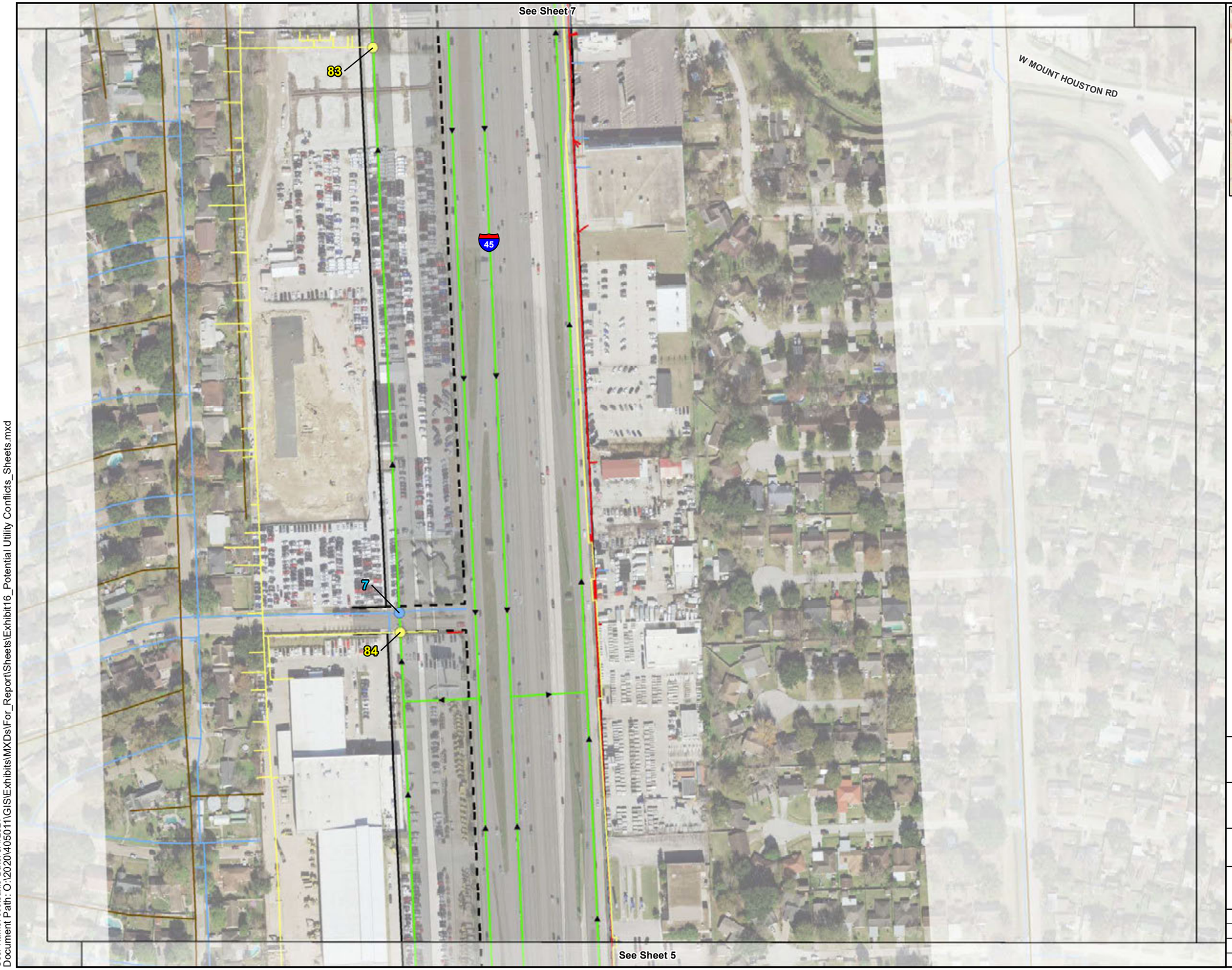
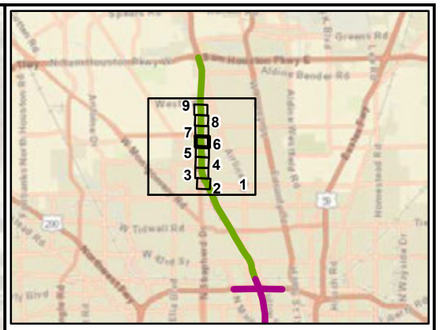
North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 5 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17





LEGEND

- Gas Line Conflict
- Water Line Conflict
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

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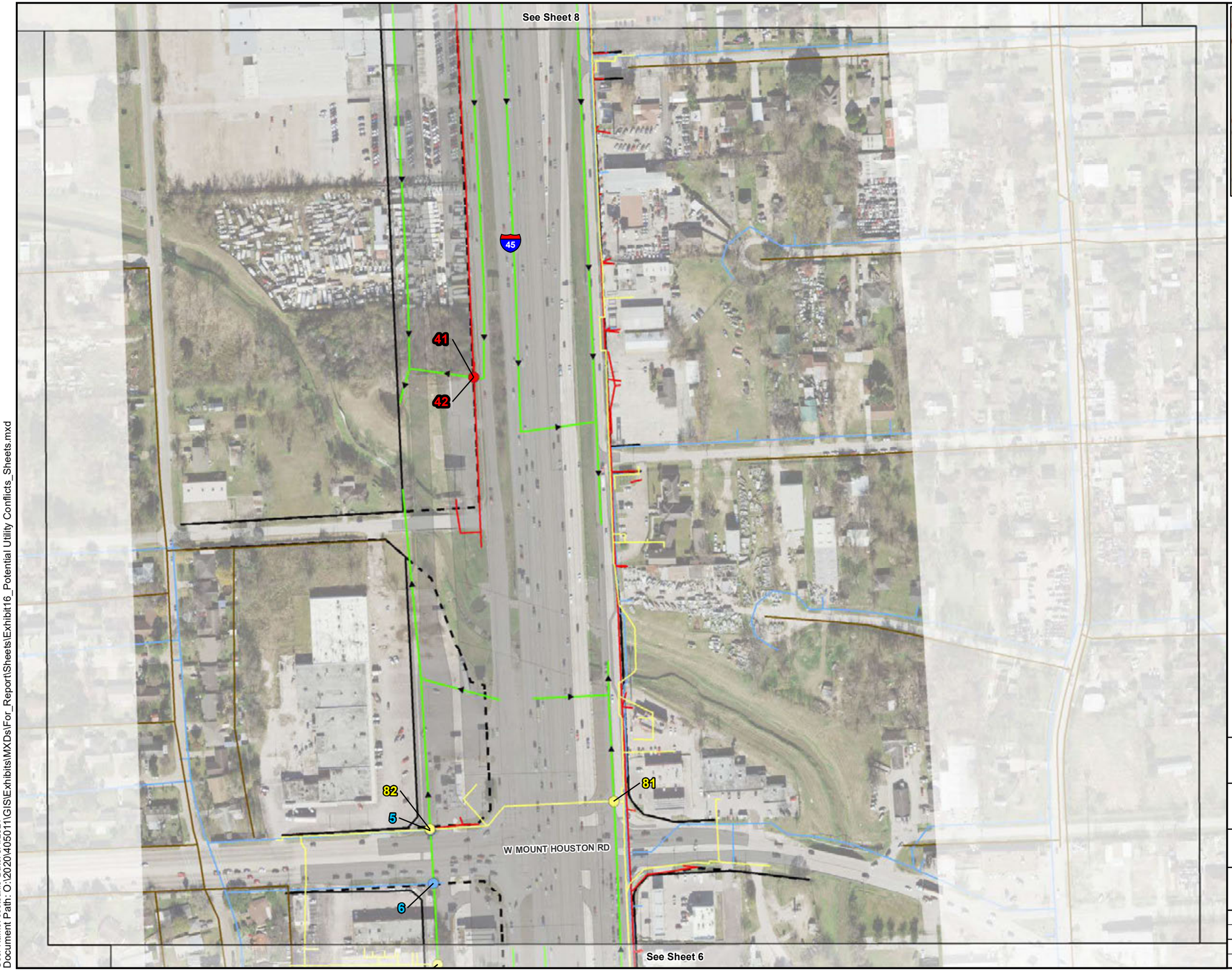
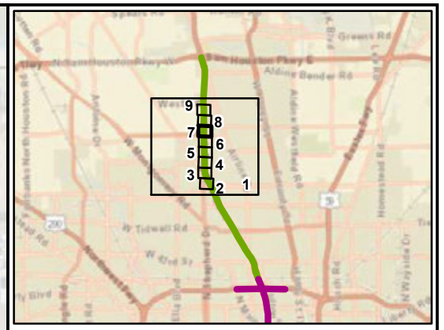
North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 6 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17





LEGEND

- Electric Line Conflict
- Gas Line Conflict
- Water Line Conflict
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

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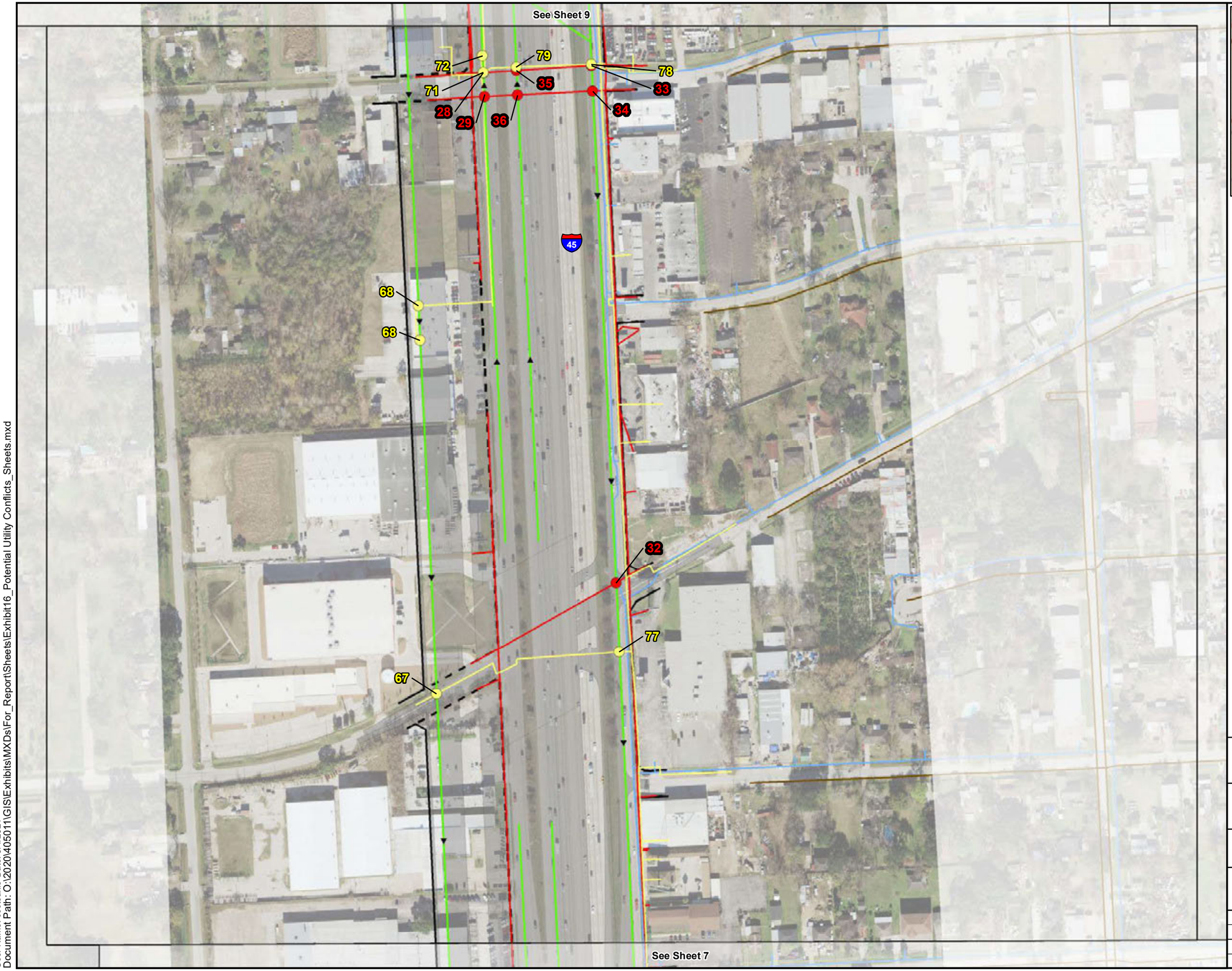
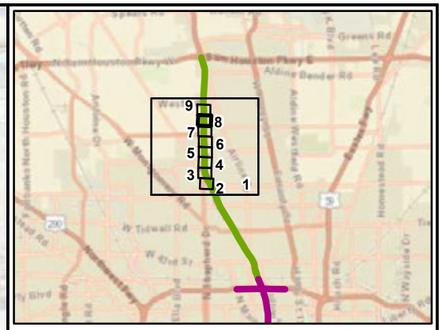
North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 7 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17





LEGEND

- Electric Line Conflict
- Gas Line Conflict
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 8 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17

User Name: ccotsakis Date: 3/4/2021
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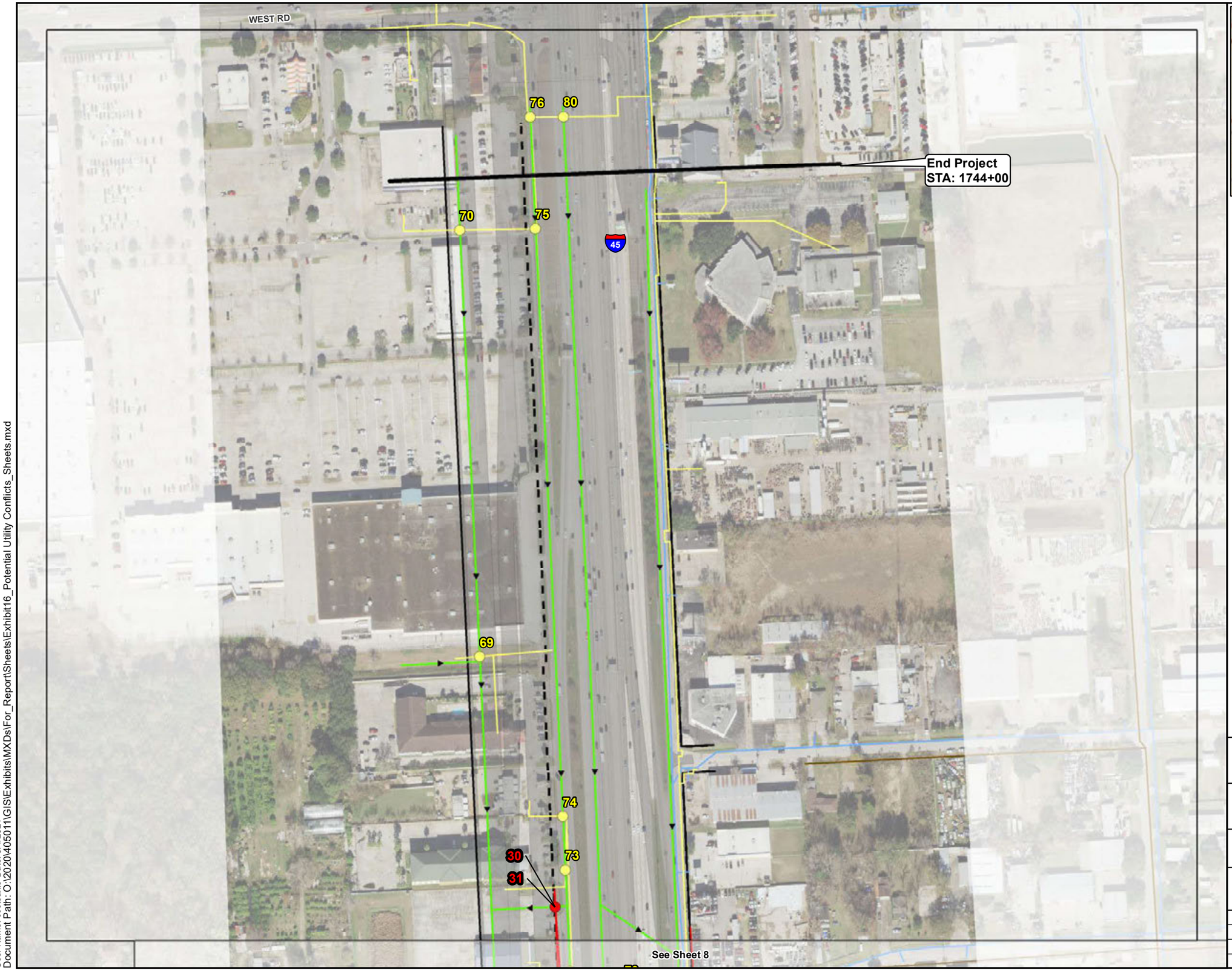

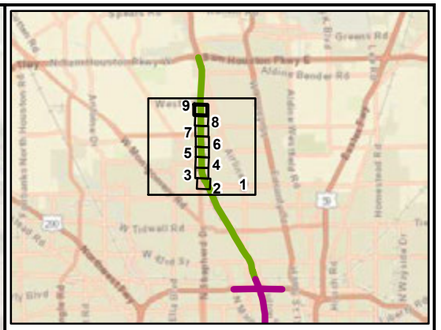

LEGEND

- Electric Line Conflict
- Gas Line Conflict
- Project Limit
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Electric Line
- Gas Line
- Waste Water Line
- Water Line
- Proposed Roadway

0 100 200

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Potential Utility Conflicts

Sheet 9 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
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STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	17

User Name: ccotsakis Date: 3/4/2021
Document Path: O:\2020\405011\GIS\Exhibits\MXDs\For_Report\Sheets\Exhibit16_Potential Utility Conflicts_Sheets.mxd

Appendix A

Project Correspondence and Criteria

- Meeting Minutes
- NHHIP I-45 Segment 1 Drainage Criteria
- Vertical Datum Adjustment from AECOM Study

Meeting Minutes

CivilTech
Engineering, Inc.

11821 Telge Road
Cypress, Texas 77429
Office: (281) 304-0200
Fax: (281) 304-0210
www.civiltecheng.com

Meeting Minutes
September 2, 2020

Meeting Date/Time/Location:
Date/Time: September 2, 2020/9:00 AM – 10:00 AM
Location: Teams Meeting (Teleconference)

Attendee: TxDOT: Elie Alkhoury, Thuy Luong
CivilTech: Mike McGovern, Barry Vanderwalt, Michelle Milliard, Jessica Sprague

Project/Limits/Contract/CSJ:
Project: North Houston Highway Improvement Project (NHHIP) Segment 1
Hwy: I-45
County: Harris
TxDOT Contract No. 12-0IDP5012; WA1
CSJ: 0110-06-139

Meeting Minutes:

1. Purpose of Meeting
    a. Progress meeting to discuss the preliminary corridor drainage plan, intersection layout and outstanding items.
2. Project Overview
    a. Mike McGovern gave an overview of the project.
        i. Limits of CivilTech's section is from South of Shepherd Drive to South of West Road.
        ii. There is one (1) major crossing within the project area – Halls Bayou. Halls Bayou has an expansive floodplain in the vicinity of I-45.
        iii. There is one (1) minor drainage crossing south of Halls Bayou.
3. Drainage Concept Plan
        i. Followed guidelines set forth by TxDOT and meeting minutes provided by TNP.
        ii. Proposed trunk lines on the outside of the frontage roads.
        iii. Place ditches in between the frontage roads and main lanes where enough space is available.
        iv. In super elevated area, may have inlet to capture runoff from managed lanes, inlet at retaining wall, and in ditch area. Have inlets line up to one another as much as possible.
        v. CivilTech will proceed forward with SWMM analysis and drainage design based on drainage concept plan

4. Halls Bayou Crossing
    a. A detention basin was proposed as part of the study completed by AECOM in 2016, west of the SBFR and south of Turney Drive that is not shown on the schematic.
        i. TxDOT's direction is to leave for now until further information is provided by HCFCD.
    b. CivilTech is proposing to realign the bridge crossing at Halls Bayou.
        i. TxDOT agrees with this.
    c. Turney Drive – will need to determine if access is needed to the SBFR once a decision has been made regarding the proposed detention basin.
    d. Further information regarding the proposed plans for Halls Bayou needs to be obtained from HCFCD. The profile analysis and floodplain fill mitigation should be based on proposed plans if information is available.
5. Frontage Road Profile
    a. Based on current schematic profile, there are profile issues from West Gulf Bank Road to Halls Bayou.
    b. The frontage road profiles should be reevaluated once information on Halls Bayou is provided by HFCD.
6. Intersection Layout
    a. TxDOT agrees with intersection layout provided.
    b. CivilTech to add inlets to outside lanes of frontage roads right before roadway intersection.
7. Other Items
    a. Main lanes need to be above the 500-year WSE. Current proposed profile should be sufficient.
    b. TxDOT to follow up on Vertical Datum for project area.
    c. Add inlets to ramps as needed.

Action Items:

- CivilTech and TxDOT – Mike McGovern and Elie Alkhoury to follow up with HCFCD to obtain latest information on Halls Bayou.

NORTH HOUSTON HIGHWAY IMPROVEMENT PROJECT (NHHIP) SEGMENT 1
TXDOT CONTRACT NO. 12-0IDP5012; WORK AUTHORIZATION NO. 1
CSJ: 0110-06-139

SIGN-IN-SHEET

MEETING DATE: 9/2/2020
MEETING TIME: 9:00 AM

ATTENDANCE (initial)	NAME	COMPANY/DEPARTMENT	TELEPHONE NUMBER	EMAIL ADDRESS
	TXDOT-HOU	Elie J. Alkhoury, P.E.	713-802-5508	elie.alkhoury@txdot.gov
	TXDOT-HOU	Thuy Luong, P.E., CTCM	713-802-5720	thuy.luong@txdot.com
	CivilTech Engineering, Inc.	Michael McGovern, P.E., CFM	832-653-6045	mmcgovern@civiltecheng.com
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	CivilTech Engineering, Inc.	Barry Vanderwalt, P.E.	832-653-3412	bvanderwalt@civiltecheng.com
	CivilTech Engineering, Inc.	Michelle Milliard	832-653-6023	mmilliard@civiltecheng.com
	CivilTech Engineering, Inc.	Jessica Sprague, P.E.	832-653-6049	jsprague@civiltecheng.com

NHHIP I-45 Segment 1 Drainage Criteria

engineers
surveyors
landscape architects

JUNE 2020

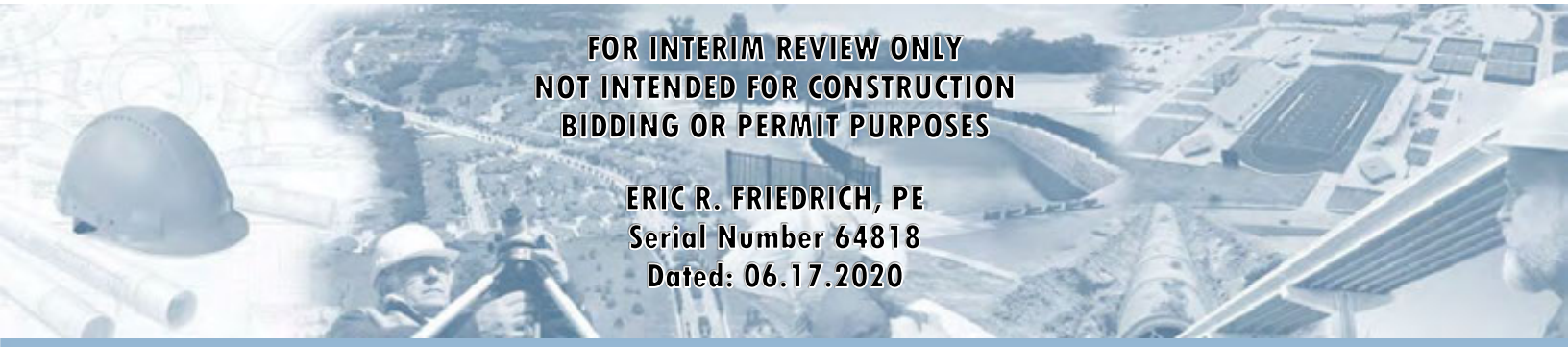
NHHIP I-45 Segment 1 Drainage Criteria

CSJ: 0500-03-596, 0500-03-446, 0110-06-139, and 0110-06-132

Harris County, Texas

Prepared for:

Texas Department of Transportation



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BIDDING OR PERMIT PURPOSES

ERIC R. FRIEDRICH, PE
Serial Number 64818
Dated: 06.17.2020

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TNP Firm Registrations
Texas Board of Professional Engineers, Firm No. F-230 | Georgia Board of Professional Engineers, Firm No. PEF007431
Texas Board of Professional Land Surveying, Firm No. 10011600 | 10194381 | 10011601

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1. DRAINAGE CRITERIA

1.1 General Requirements

Efficient performance of the drainage system is an integral part of the performance of the Project. Section Design Teams shall account for all sources of runoff that may reach the Project, whether originating within or outside the Project ROW, in the design of the drainage facilities.

If existing drainage patterns are revised during the Project design, then the Section Design Team shall design a solution that does not have adverse impact to property owners outside the ROW.

1.1.1 Project Specific Requirements

Section Design Teams shall incorporate the following requirements into the Project drainage design:

- No increase to existing water surface elevations at stream crossings outside the Project ROW and at any cross section along the streams. At its sole discretion, TxDOT may approve increases in existing water surface elevations if contained within drainage channels or storm drain systems and if no adverse impacts result to adjacent properties.

1.2 Administrative Requirements

1.2.1 Team Coordination

Each Section Design Team will prepare detailed drainage studies and reports for their section. **Table 1** shows the team's prime consultant, project limits, and corresponding TxDOT managers. Teague Nall & Perkins (TNP) will assist TxDOT with coordination and review of reports and PS&E for the overall corridor. Section Design Teams shall coordinate with adjacent teams on drainage and mitigation analysis and designs. TNP will maintain a comment/resolution log for submittal reviews and a decision log affecting corridor studies.

Table 1: Section Design Teams Drainage Study Limits

Section Design Team	Project Limits	TxDOT Hydraulic PM / Design Supervisor
Gauge Engineering	N OF AIRLINE TO N OF TIDWELL RD	Sarah Alvarez / Pat Nwachukwu
Teague Nall & Perkins	TIDWELL RD TO S OF SHEPHERD	Christen Specht / Alan Wang
CivilTech Engineering	S OF SHEPHERD DR TO S OF WEST RD	Thuy Luong / King Yuen
CobbFendley & Associates	S OF WEST RD TO SL 8	Fred Garcia / Stephen Wainaina

1.2.2 Coordination with Other Agencies

Section Design Teams shall coordinate all water resource issues with affected interests and regulatory agencies, and shall document the resolutions and decisions related to these issues.

The Section Design Team shall provide to the local floodplain administrators all information and technical data needed to file Conditional Letters of Map Revision (CLOMR) with FEMA, per HDM requirements.

1.3 Analysis and Design Requirements

Section Design Teams shall analyze and design all Elements of the drainage facilities in accordance with criteria in this document, the TxDOT Hydraulic Design Manual (September 2019), and applicable criteria in the Harris County Flood Control District Policy Criteria & Procedure Manual (October 2018). Any changes/deviations from TxDOT criteria need coordination with and approval by TxDOT Houston District.

Abbreviations used in this document including tables herein are defined as follows:

AEP	Annual Exceedance Probability	HGL	Hydraulic Grade Line
AHW	Allowable High Water	HOU	Houston District Practice
COH	City of Houston	JB	Junction Box
EOP	Edge of Pavement	L.P.	Low Point
FB	Freeboard	MH	Manhole
FEMA	Federal Emergency Management Agency	ML	Main Lanes
FHWA	Federal Highway Administration	P.I.	Point of Intersection
FIS	Flood Insurance Study	Q	Runoff, Discharge, Flowrate
FR	Frontage Road	RCB	Reinforced Concrete Box
HCFCD	Harris County Flood Control District	RCP	Reinforced Concrete Pipe
HDM	Hydraulic Design Manual (TxDOT)	ROW	Right of Way
HEC	Hydrologic Engineering Center (USACE) or Hydraulic Engineering Circular (FHWA)	SWMM	Storm Water Management Model (XP-, PC-, or EPA-SWMM)
HEC-HMS	USACE HEC Hydrologic Modeling System	USACE	U.S. Army Corps of Engineers
HEC-RAS	USACE HEC River Analysis System	WSEL	Water Surface Elevation

1.3.1 Design Frequencies

Section Design Teams shall use the design frequencies listed in **Table 2** below for hydrologic and hydraulic analysis and design of project drainage features and systems.

Table 2: Drainage Design Frequencies

(Any deviation requires TxDOT approval)

Design Element	Mainlanes	Ramp	Direct Connect.	Frontage Road	Arterial / Cross Street	Application Notes
Minimum Roadway Elevation	100-yr	25-yr	100-yr	10-yr	10-yr (No FB required)	Crossing or adjacent waterway WSEL, **plus 1' FB at low EOP**. Does not apply to storm drain or roadside ditch HGL.
Bridge Waterway Crossing	100-yr plus 2.5' FB	100-yr plus 1.5' FB	100-yr plus 2.5' FB	100-yr plus 1.5' FB	Match Exist.	Applies to WSEL at new location bridges. **For existing FR bridges,** use min 10-yr w/ Low chord > WSEL
Cross Drain Culverts	100-yr	25-yr	100-yr	10-yr	Match Exist.	Set maximum AHW at 1' below low EOP. Check for 100-year.
Storm Drain Inlets and Pavement Drainage	10-yr	10-yr	10-yr	10-yr	Match Exist. or better	Applies to ponded widths in gutter and inlet capacity.
Storm Drain Conduits	10-yr	10-yr	10-yr	10-yr	Match Exist. or better	Size conduit for non-pressure full flow; i.e. Design Q<= Full Flow Capacity Q. See HGL requirements below.
Storm Drain HGL	100-yr < EOP	25-yr < EOP	100-yr < EOP	10-yr: max 1-lane ponding	10-yr: max 1-lane ponding	Starting HGL at outfall: 25-yr if it works. Otherwise, base the starting HGL on hydrograph timing or top of pipe. Determine and report maximum frequency flood contained in ROW.
Depressed Roadway Storm Drain, Inlets and Pavement Drainage	100-yr	100-yr	100-yr	100-yr	100-yr	Depressed roadway occurs if water has nowhere to drain overland when curb height is exceeded. Size conduit for non-pressure full flow. Check for 100-yr HGL < EOP.
Storm Water Pumping Stations	100-yr	100-yr	100-yr	100-yr	100-yr	Design pump capacity >/= 100-yr Q + 25%. Check for 100-year < EOP.
Detention Ponds	100-year + 2' FB. Provide Detention Summary with Area Serviced, Detention Storage Volume Required, Detention Storage Volume Provided, Maximum Design WSEL, Maximum Outflow Rate Allowed, Maximum Outflow Rate Provided, and Restrictor Size.					Sample plans available from TxDOT upon request.
Outfall Ditches	Design for No Impact to 100-yr WSEL. Use TxDOT Houston District standard details for HCFCD Outfalls and other construction within HCFCD channels and ponds.					
Separation Ditches	10-yr	10-yr	10-yr	N/A	N/A	Separation Ditches are those in medians between adjacent roadways. AHW = 1' below EOP.
Roadside Ditches***	N/A	N/A	N/A	10-yr*	10-yr**	*If required outside curb line. **Or match existing capacity. *** Roadside ditches are those between the roadway and ROW

1.3.2 Hydrologic Analysis

Section Design Teams shall analyze and design drainage structure capacities for the frequencies and hydrologic conditions as described in **Table 2.** The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11 Version 2.0: Texas (Perica et al. 2018) shall be used as the rainfall depth-duration-frequency source in hydrologic studies.

Teams shall analyze drainage impacts and evaluate mitigation effectiveness using 100-yr and 10-yr frequencies. The pre-Atlas 14 500-year flow on FEMA studied streams may be used in lieu of the Atlas 14 100-year flow with TxDOT approval. The following Atlas 14 e, b, and d values shown in **Table 3** should be utilized for Rainfall Intensity calculations in the Rational Method, per the HDM and as presented in TxDOT's spreadsheet release, EBDLKUP-2019-vC6.2.10.

Table 3: Atlas 14 Rainfall Intensity Coefficients e, b, and d values

	50% (2-year)	20% (5-year)	10% (10-year)	4% (25-year)	2% (50-year)	1% (100-year)	0.2% (500-year)
e	0.8004	0.7652	0.7458	0.7247	0.7091	0.6963	0.6878
b	64.7650	75.5205	84.1543	95.8918	103.8089	113.6760	156.5886
d	12.8285	12.4064	12.3545	12.5119	12.6173	13.1642	17.3069

Section Design Team shall design the drainage system to accommodate increased runoff due to the roadway improvements within the Project ROW. Flood damage potential for the completed Project shall not exceed pre-Project conditions.

When determining flow for conduits from outside the right of way the flow shall be the greater of (a) the contributing drainage area at existing development conditions, or (b) the 150' development strip adjacent to the right of way using a runoff coefficient of 0.65. Peak flows from existing development with compensatory onsite stormwater detention should consider the flow reduction benefits of the stormwater detention. See also 'Inlet Drainage Area' and 'Conduit Drainage Area' provisions in **Table 4.**

1.3.3 Storm Sewer Systems

Where precluded from handling runoff with open channels by physical site constraints, or as directed in this document, Section Design Teams shall design enclosed storm sewer systems to collect and convey runoff to appropriate discharge points.

As part of the Drainage Design Report, the Section Design Team shall prepare a storm sewer study encompassing all storm sewer systems that contains, at a minimum, the following items:

a. Drainage area maps with pertinent data, such as boundaries of the drainage area, topographic contours, runoff coefficients, time of concentration, and land use with design curve number and/or design runoff coefficients, discharges, velocities, ponding, and hydraulic grade line data.

b. Location and tabulation of all existing and proposed pipe and cross drainage structures. These include size, class or gauge, catch basin spacing, detailed structure designs, and any special designs.

c. Complete pipe profiles, including pipe size, type, and gradient; station offsets from the centerline of the roadway; length of pipe; class/gauge of pipe; and numbered drainage structures with coordinate location and elevations.

Section Design Teams shall design all storm sewer systems such that the hydraulic grade line for the design frequency event is no higher than:

a. the level for 'Storm Drain HGL' in **Table 1**; and

b. one foot below the top of manhole cover (for standalone MH).

Section Design Team shall apply the design criteria listed in **Table 4** for design of drainage systems and related appurtenances.

Table 4: Drainage Design Criteria

(Any deviation requires TxDOT approval)

Design Element	Mainlanes	Ramp	Direct Connect.	Frontage Road	Arterial / Cross Street	Application Notes
Pavement Drainage						
Allowable Ponding Width/AHW	Shldr Width	Shldr Width + 2'	Shldr Width + 2'	Curb offset + 1 Lane	Curb offset + 1 Lane*	
Maximum Low Point Ponding Depth	Function of Allowable Ponding Width and Cross Slope					Provide flanking inlets to reduce hydroplaning potential.
Storm Drain Inlets						
Pavement Inlet Types	AZ, AZ2G, AZR, AZR2G, Trench Drains[1]	AZ, AZ2G, AZR, AZR2G, C or C1	AZ, AZ2G, AZR, AZR2G	C1 (typical)	C, C1	Use Trench Drains in ramp gores. Provide resultant slope of Trench Drain invert >/= 1%.
Ditch Inlet Types	Separation Ditches: AD, AAD, SET Side Road Ditches: A, AD, AAD, SET					Provide detail to add concrete riprap apron min 5'-wide around inlet perimeter.
Inlet Drainage Area	In general, contributing drainage area to the inlet from within and outside the right of way, with following clarifications: 1. For Frontage Road inlets Adjacent to **Undeveloped Areas Outside Right Of Way :** Contributing area within the right of way, plus 150' strip outside right of way at an assumed runoff coefficient 'C' = 0.65 2. For Frontage Road inlets Adjacent to **Developed Areas (with internal drainage system) Outside Right of Way:** Contributing areas within and outside right of way. 3. Drainage area for storm drain conduits may differ (see 'Conduit Drainage Area' below).					

Design Element	Mainlanes	Ramp	Direct Connect.	Frontage Road	Arterial / Cross Street	Application Notes
Inlet Locations	1. On-grade: Place inlets to keep gutter ponding within allowable ponding widths in this table. Carryover acceptable up to 1 cfs. 2. Low points: Verify inlet location is at sag of vertical curve, not at P.I. Place flanking inlets both sides of low point at a 25' - 100' spacing from L.P. 3. Redundant inlets: End of curb returns at intersection, and in separation ditches. 4. 100% flow interception: On pavement at end of retaining wall, at ramp gores, at intersections. 5. Provide detail for equalizer pipes to connect multiple boxes in trunkline at inlets.					
Bridge Deck Drainage	1. Drain free-fall through slots in rail, where falling water would not affect adjacent roadway/bridge or other features below. 2. Use Bridge Drain Inlets per Houston District Bridge Section details, where drainage through slots in rail would adversely affect adjacent roadway/bridge or other features below, including any traffic thereon. 3. Use slotted rail w/water blocks in sag locations. Limit height of water stop to 2" in sags. 4. Outfall deck drain pipe system directly into nearby storm drain inlet or manhole below grade, if available. Otherwise, outfall pipe from base of column into adjacent ditch collection system in a manner that prevents erosion. 5. Minimize exposed length of PVC drain pipe from inlet to bent cap. Hide PVC drain pipe inside cap and column.					
Storm Drain Conduits – General						
Conduit Drainage Area	In general, contributing drainage area to the conduit from within and outside the right of way, with following clarifications: 1. Flows to the conduit from areas outside the right of way are based on the higher of (1) contributing area at existing development conditions or (2) 150' strip adjacent to right of way at runoff coefficient 'C' = 0.65 2. 'Existing development conditions' in #1 should consider effect of any existing stormwater detention. 3. Drainage area for storm drain inlets may differ (see 'Inlet Drainage Area' above).					
Conduit Material/Type	Reinforced Concrete Pipe – RCP, or Reinforced Concrete Box - RCB					
Design Conduit Size	Full flow pipe capacity >= design Q					
Conduit Size Changes	Match soffits at conduit size changes, if possible. Matching flowlines is acceptable if grade is limited.					
Manholes/Junctions	Hou District Ty A or Ty B Manholes. Statewide Bridge Division Manhole PB, PJB, PDD, & PSL.. Manhole TY M signed and seal. All other JB's require special design.					No MH access on pavement. Provide MH spacing per TxDOT HDM.
Conduit Connections	1. Lateral stub-in boxes require 2' minimum size differential 2. Pipe to pipe stub-in requires 3' minimum size differential 3. Other connections require M/H, JB, or JB w/out riser 4. Provide detail for accommodating multiple (parallel) conduits at junctions – use equalizer openings 5. Bends acceptable up to 30° angle.					
Minimum Conduit Clearance (Cover)	1. Graded areas: 1 ft 2. Paved areas: the lower of (a) 2 ft below pavement surface, or (b) 0.5' below treated subgrade.					

Design Element	Mainlanes	Ramp	Direct Connect.	Frontage Road	Arterial / Cross Street	Application Notes
Location near Retaining Wall	1. Where possible, avoid placement of conduit parallel to MSE wall if located within wall backfill. 2. Preferred lateral placement is under wall, normal to wall alignment (see AZR and AZR2G inlet standards). 3. If conduits are outside of and parallel to a fill wall, offset conduit 15 ft minimum from face of wall, if possible.					
Storm Drain Conduits – Laterals						
Minimum Pipe Size	24"	24"	24"	24"	24"	18" allowed with TxDOT approval
Minimum Slope	0.2 % preferable, 0.1 % minimum					
Maximum Slope	3%					Deviations allowed with TxDOT approval
Minimum Velocity	2 ft/sec at full flow					
Maximum Velocity	12 ft/sec					
Storm Drain Conduits – Trunk Lines						
Minimum Pipe Size	24"	24"	24"	24"	24"	18" allowed with TxDOT approval
Minimum RCB Depth	3'	3'	3'	3'	3'	Deviations allowed with TxDOT approval
Minimum Slope	0.2 % preferable, 0.1 % minimum					
Maximum Slope	3%					Deviations allowed with TxDOT approval
Minimum Velocity	2 ft/sec at full flow					
Maximum Velocity	12 ft/sec					
Separation Ditches/Roadside Ditches						
Minimum Depth	Variable					
Maximum Depth	3'					
Minimum Slope	0.5 % if grass lined or pavers, 0.2 % if concrete lined					
Maximum Slope	Based on sheer stress of lining					
Side Slopes/Shape	Based on roadway design criteria and typical section max 4:1 front & back slope					Deviations allowed with TxDOT approval

1.3.4 Culverts

Section Design Teams shall analyze existing and proposed culverts and drainage-ways impacted, replaced, or created by the Project design, for any localized flooding problems.

If the culvert is located on an existing FEMA studied stream, then the effective model and version should be utilized for the analysis. If the culvert is located on an unstudied stream, then HEC-RAS 5.0.7 should be utilized; for minor crossings HY-8 may be used.

The hydraulic analysis should include a thorough investigation of field conditions and appropriate survey data to develop hydraulic models to evaluate water surface elevations, velocities, and floodplain boundaries. Where culvert design is influenced by upstream storage, the analysis of the storage shall be incorporated into the design of the culvert.

For all culverts, the maximum AHW for the design frequency shall not exceed one foot below the EOP elevation of the applicable roadway low point (See **Table 2**). Culverts extending underneath both ML and FR shall be designed to the ML design Q, while meeting AHW requirements of **Table 2** for each roadway. The maximum allowable velocity shall not surpass seven (7) FPS. If this value is exceeded, velocity protection devices shall be used to protect the channel from erosion damage.

See Section 1.3.1 for additional design requirements.

1.3.5 Bridges

All bridge hydraulic computations, designs, and recommendations shall be coordinated through TxDOT with HCFCD, and be consistent with past studies and projects in the area by the USACE and other State or federal agency studies and projects. For FEMA modeled crossings use the effective model version. For unstudied crossings model using HEC-RAS version 5.0.7.

Where bridge design is influenced by upstream storage, the analysis of the storage shall be considered in the design of the bridge.

Refer to Section 1.2.2 for the required coordination with the local Floodplain Administrator and FEMA compliance. See Section 1.3.1 for additional design requirements.

1.3.5.1 Method Used to Estimate Flows

Section Design Teams shall ensure that the selected hydrologic method is appropriate for the conditions in the watershed. For all crossings located within a FEMA Flood Insurance Study (FIS) with peak flow information, the Section Design Team shall gather and utilize, as appropriate, the flow information provided in the FIS and any subsequent Letters of Map Revision (LOMR) for estimating flow. For channel crossings within Harris County the Section Design Team shall obtain the effective hydrologic and hydraulic model, if available, from the HCFCD.

For crossings not located within a FEMA FIS, the Section Design Team shall select the appropriate method for calculating the design flows based on site conditions, and applicable design criteria in the TxDOT HDM and the HCFCD Policy Criteria & Procedure Manual.

1.3.5.2 Design Frequency

Bridge waterway crossings, bridges, culverts and storm drain systems shall be designed for the design-year frequency corresponding to the functional classification of the associated roadway based on **Table 2.**

Section Design Teams shall estimate the peak discharge, for both, existing and proposed condition; water surface profiles for design and check flood conditions will have to be determined. Higher freeboards may be required when the stream is prone to heavy debris loads, or to accommodate other clearance needs.

1.3.5.3 Hydraulic Analysis

The hydraulic analysis should include a thorough investigation of field conditions and appropriate survey data to develop hydraulic models to evaluate water surface elevations, velocities, and floodplain boundaries. The Section Design Team shall provide a scour analysis in accordance with TxDOT's Geotechnical Manual (Chapter 5 – Section 5 Scour), Bridge Division Geotechnical Branch guidance, and FHWA's HEC-18 for all new bridges. The Section Design Team shall evaluate bridges for contraction and pier scour concerns and, if necessary, provide countermeasures for any instability and scour problems in accordance with FHWA HEC No. 23 - Bridge and Scour and Stream Instability Countermeasures Experience Selection and Design Guidance.

The Section Design Team shall design riprap at abutments in accordance with the procedures outlined in HEC-23.

1.3.5.4 Bridge Deck Drainage

Runoff from bridge decks shall be carried off the bridge and into the adjacent roadway drainage system using bridge deck drains, slots in the rail, and/or captured in bridge approach drains to intercept gutter flow at each end of the bridge according to Bridge Deck Drainage criteria in Storm Drain Inlets section of **Table 4.**

2. DRAINAGE DOCUMENTATION

The Section Design Team shall provide drainage analysis and design documentation per the requirements of their TxDOT contract scope and shall deliver that documentation per the contract schedule and/or other requirements coordinated with TxDOT. This section highlights the major components of that documentation.

2.1 Drainage Impact Analysis Report

The Section Design Team shall prepare a Drainage Impact Analysis Report to include preliminary design of all components that will be included in the design plans. At a minimum, the Drainage Design Report shall include:

a) Drainage computations, both hydrologic and hydraulic, and all supporting data.
b) Hydrologic and hydraulic notes, models, and tabulations (where computer software is used, both pdf copies and electronic input and output files)
c) Tentative profile of roadway with WSEL plots at outfalls
d) SWMM link-node network exhibits
e) Mitigation & Pond designs
f) Floodplain cut and fill calculations

g) Drainage system data (location, type, material, size, and other pertinent information) in a suitable electronic format
h) Recommendations for preliminary type, size and location of culvert and bridge waterway crossings
i) Recommendations for preliminary storm sewer trunkline sizes and system layout

2.2 Bridge Hydraulics and Scour Report

The Section Design Team shall also prepare a report for each major stream crossing with a FEMA studied SFHA or requiring a bridge-class culvert. The report shall include the detailed calculations and electronic and printed copies of the computer software input and output files, as well as a discussion about hydrologic and hydraulic analysis and reasons for the design recommendations. At a minimum, for each crossing the study shall include:

FEMA Special Flood Hazard Area (SFHA)

a) Firmette
b) Discussion of SFHA and implications

Hydrology

a) Drainage area maps with watershed characteristics, hardcopy
b) Hydrologic calculations (where computer software is used, both hardcopy and electronic input and output files)
c) Historical or site data used to review computed flows

Hydraulics and Recommended Waterway Opening and/or Structure

a) Channel profiles
b) Photographs of Site
c) General plan, profile, and elevation of recommended waterway opening and/or structure
d) Calculations – pdf and electronic copies of input and output for all computer models used for final analysis or for permit request, as well as summary of the basis of the models
e) Cross-sections of channel at structure

Scour Analysis

a) Channel cross-sections at bridge showing predicted scour
b) Calculations and summary of calculations based on FHWA HEC-18, TxDOT Geotechnical Manual, and Bridge Division Geotechnical Branch Guidelines; clearly showing predicted scour and assumptions regarding bridge opening and piers used to calculate predicted scour
c) Discussion of review of long-term degradation/aggradation and effects
d) Recommendation for abutment protection, based on TxDOT requirements for abutment scour.
e) Form 2605

Preliminary PS&E Sheets

a) Preliminary Bridge Layout
b) Preliminary Bridge Hydraulic Data Sheets

Vertical Datum Adjustment from AECOM Study

Reference Exhibits E3, E4, F3, and F4 for roadway stationing

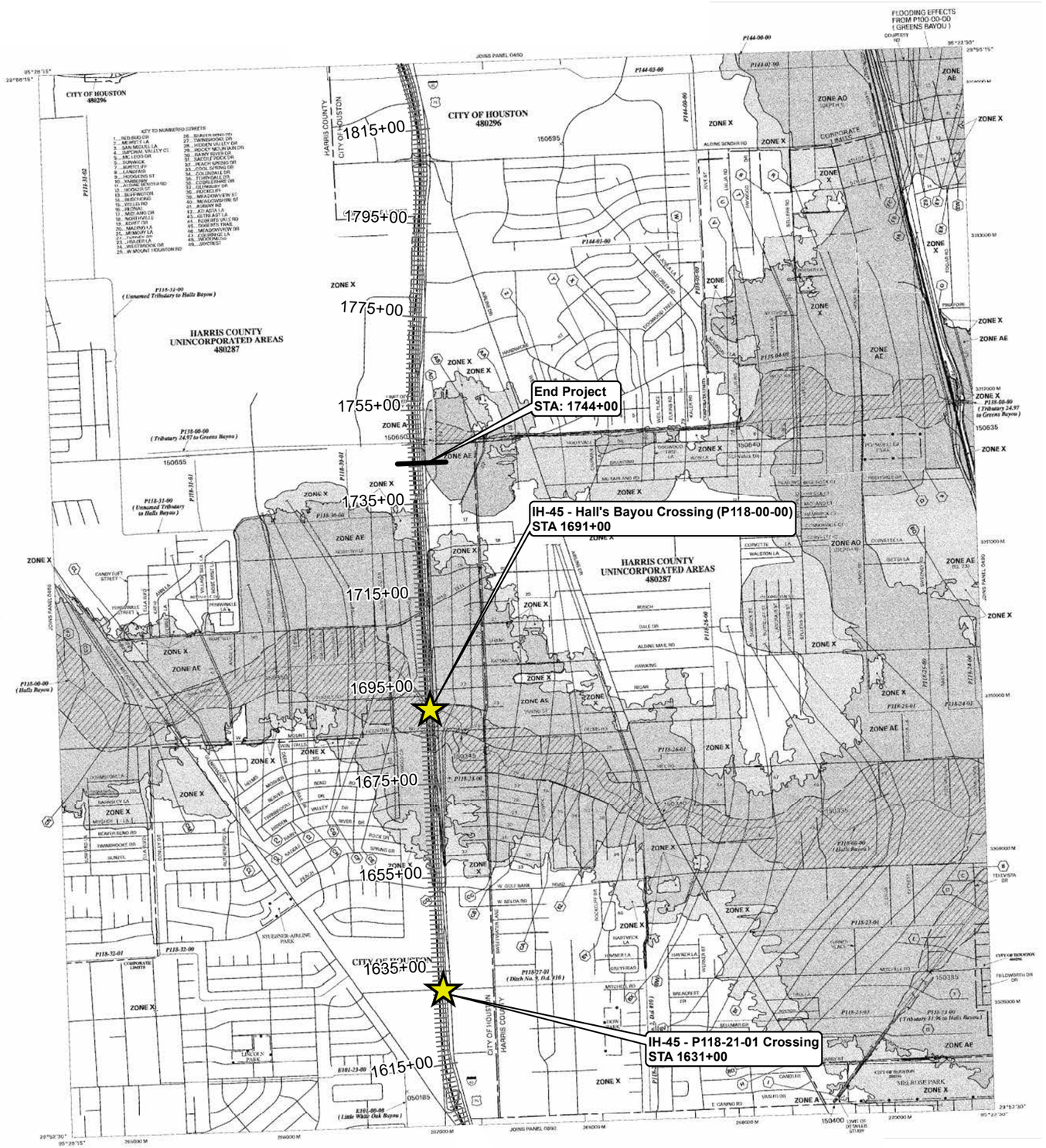
Segment	Drainage Study I-45 Station	Adjustment from NAVD 1988 to NAVD 1988, 2001 Adj	I-45 Intersection
-	590+00	-0.45	
-	600+00	-0.43	
Segment 1	605+50	-	BWY-8
	610+00	-0.39	
	620+00	-0.36	
	630+00	-0.32	
	640+00	-0.28	
	641+33	-	Aldine Bender Rd
	650+00	-0.25	
	660+00	-0.21	
	670+00	-0.17	
	680+00	-0.17	
	690+00	-0.17	
	700+00	-0.17	
	702+00	-	West Rd
	710+00	-0.17	
	720+00	-0.17	
	730+00	-0.27	
	740+00	-0.39	
	750+00	-0.43	
	760+00	-0.43	
	763+74	-	W. Mount Houston Rd
	770+00	-0.43	
	780+00	-0.43	
	790+00	-0.42	
	796+71	-	W Gulf Bank Rd
	800+00	-0.40	
	810+00	-0.38	
	820+00	-0.35	
	830+00	-0.33	
	840+00	-0.31	
	850+00	-0.29	
	860+00	-0.28	
	869+30	-	W Little York Rd
	870+00	-0.28	
	880+00	-0.28	
	890+00	-0.28	
	900+00	-0.28	
	910+00	-0.28	
	910+89	-	W Parker
	920+00	-0.28	
	930+00	-0.28	
	940+00	-0.28	
	950+00	-0.28	
	960+00	-0.28	
	970+00	-0.28	
	980+00	-0.28	E Tidwell Rd
	990+00	-0.28	
	1000+00	-0.27	
	1010+00	-0.24	
	1020+00	-0.21	
	1030+00	-0.20	
	1040+00	-0.20	
	1042+00	-	E Cross Timbers St
	1050+00	-0.20	
	1060+00	-0.20	
	1070+00	-0.20	

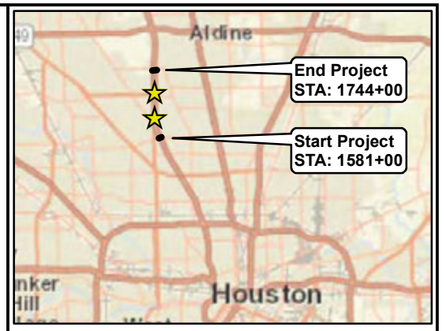
Appendix B

FEMA Effective Data

- FIRM Panel 48201C0470L and 48201C0660M
- FEMA FIS Profile for P118-00-00 (Halls Bayou)
- FEMA Floodway Data Table for P118-00-00 (Halls Bayou)

FIRM Panel 48201C0470L and 48201C0660M





LEGEND

- Drainage Crossings
- Project Limit
- Project Alignment

N

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0470L

FIRM
FLOOD INSURANCE RATE MAP
HARRIS COUNTY,
TEXAS
AND INCORPORATED AREAS

PANEL 470 OF 1150
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
HARRIS COUNTY, UNINCORPORATED AREAS	480287	0470	L
HOUSTON, CITY OF	480296	0470	L

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
48201C0470L

MAP REVISED:
JUNE 18, 2007

Federal Emergency Management Agency

Base Map: FEMA FIRM Map
Vertical Datum: NAVD88, 2001 adj.

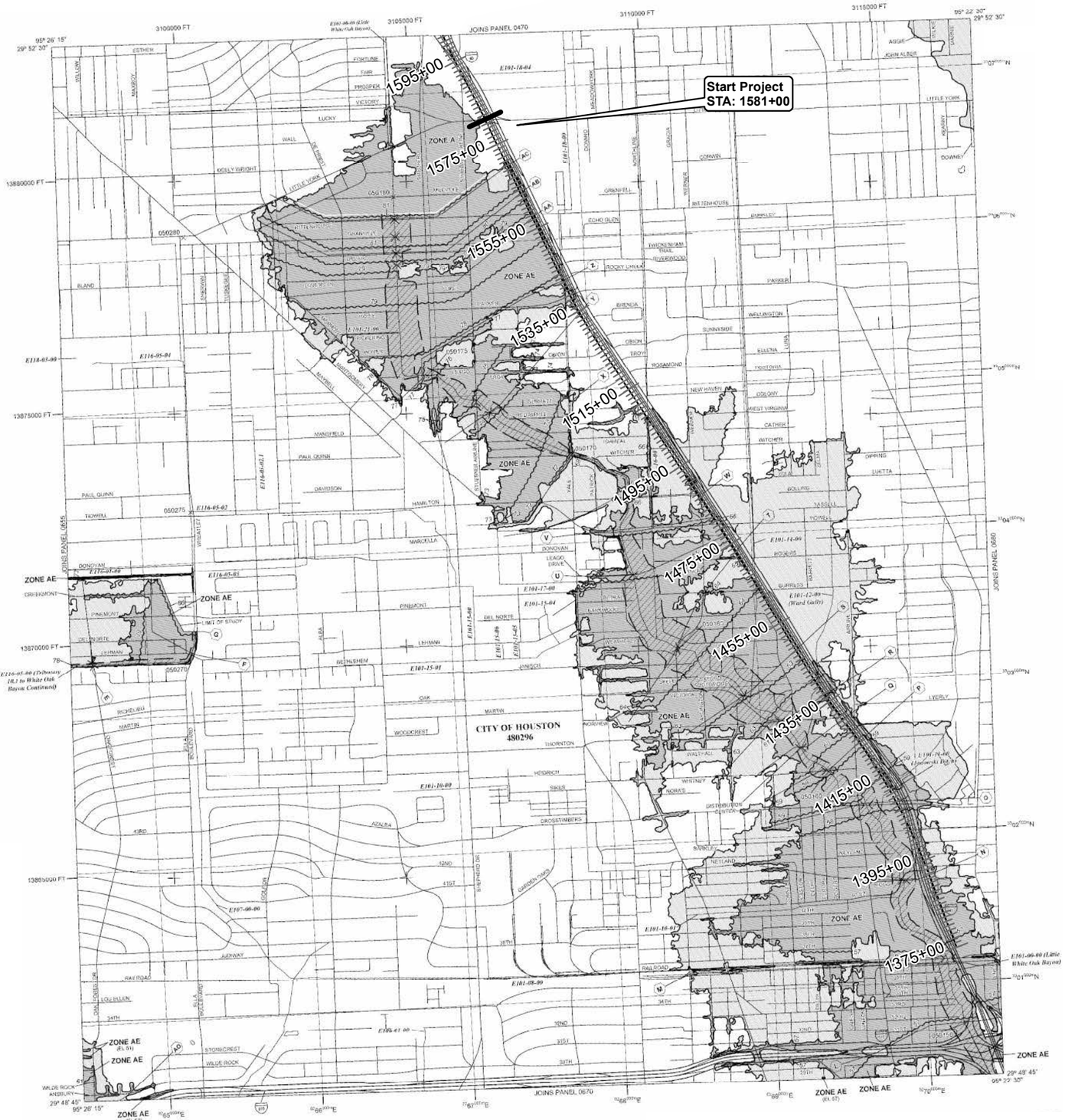
CivilTech Engineering, Inc.
11750 Katy Fwy, Suite 1260
Houston, Texas 77079
Tel: 346-409-2067
Fax: 281-304-0210

Texas Department of Transportation

Drainage Report for
NHHIP Segment 1

FEMA FIRM Map
NHHIP Segment 1

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	405011			IH-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	APPENDIX NO.
HOU	HARRIS	0110	06	139	B.1



N

LEGEND

- Drainage Crossings
- Project Limit
- Project Alignment

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0660M

FIRM

FLOOD INSURANCE RATE MAP

HARRIS COUNTY, TEXAS AND INCORPORATED AREAS

PANEL 660 OF 1150

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
HOUSTON, CITY OF	480296	0660	M

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
48201C0660M

MAP REVISED
JUNE 9, 2014

Federal Emergency Management Agency

Base Map: FEMA FIRM Map
Vertical Datum: NAVD88, 2001 adj.

CivilTech Engineering, Inc.
11750 Katy Fwy, Suite 1260
Houston, Texas 77079
Tel: 346-409-2067
Fax: 281-304-0210

Texas Department of Transportation

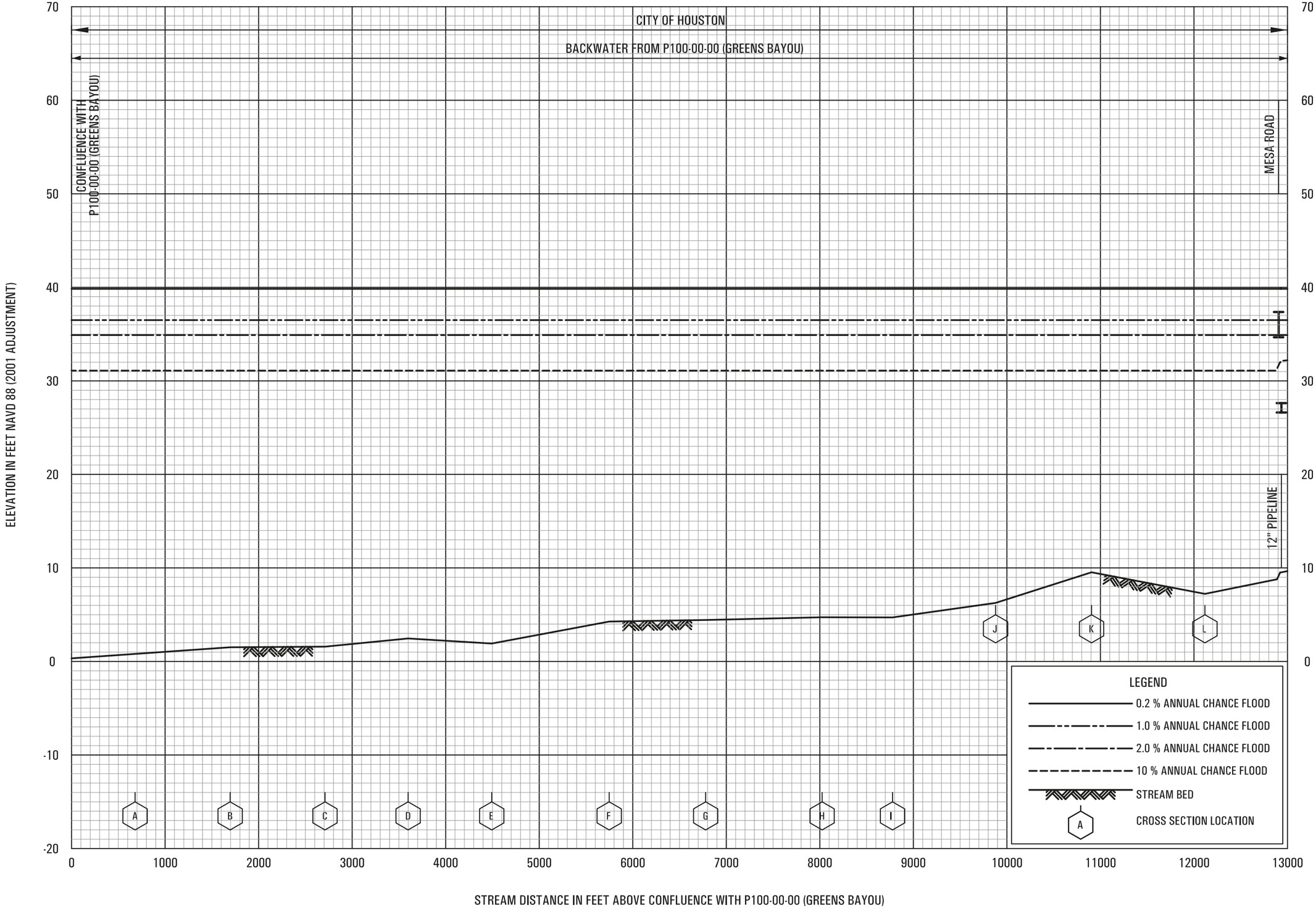
Drainage Report for
NHHIP Segment 1

FEMA FIRM Map
NHHIP Segment 1

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	405011			IH-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	APPENDIX NO.
HOU	HARRIS	0110	06	139	B.2

User Name: iholdemanDate: 3/2/2021
Document Path: \\server8\projects_3120201405011\GIS\Exhibits\MXDs\For_Report\Appendix B - FEMA FIRMS\Appendix B.2 - FEMA FIRM_South.mxd

FEMA FIS Profile for P118-00-00 (Halls Bayou)



FLOOD PROFILES

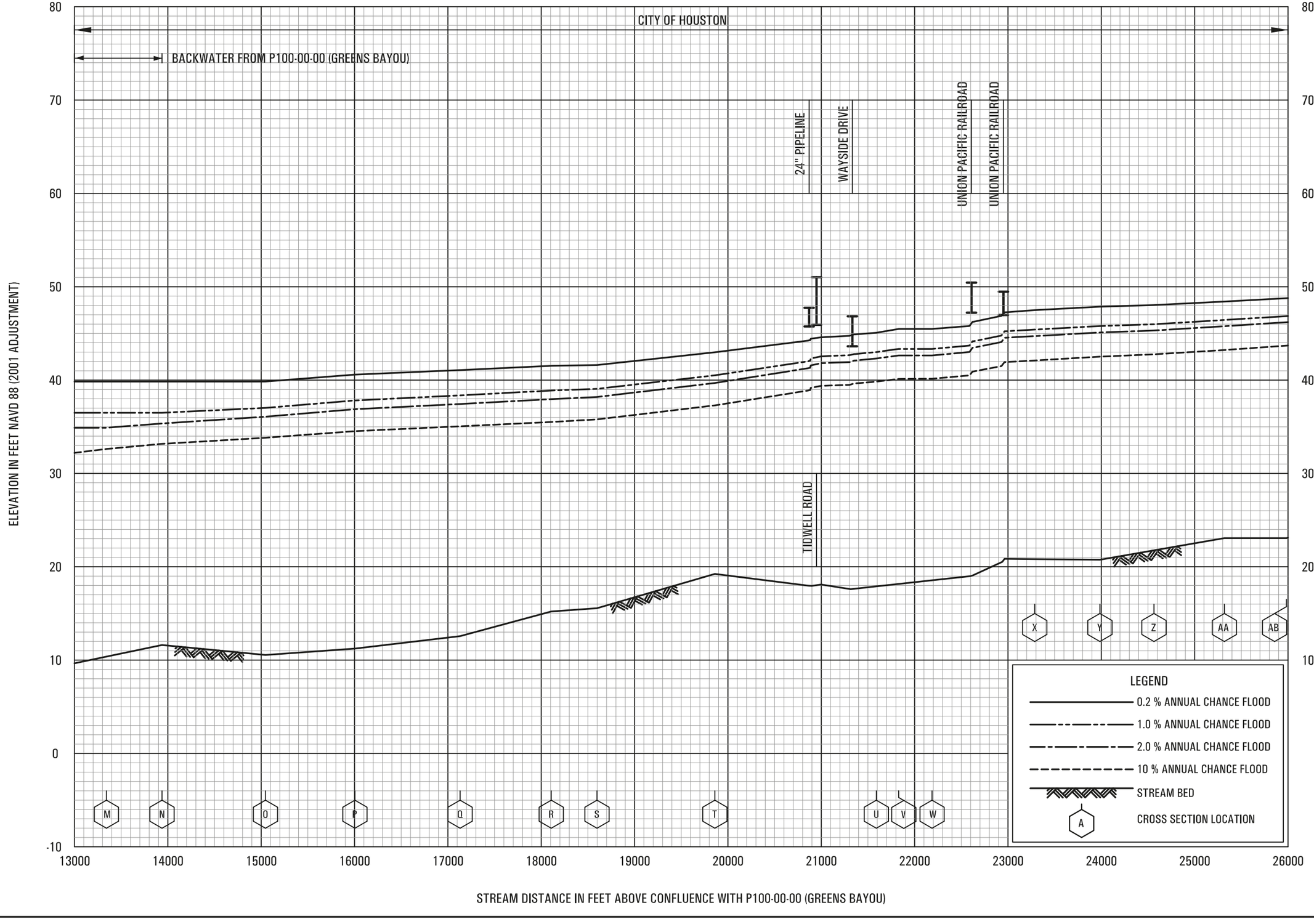
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P26P



FLOOD PROFILES

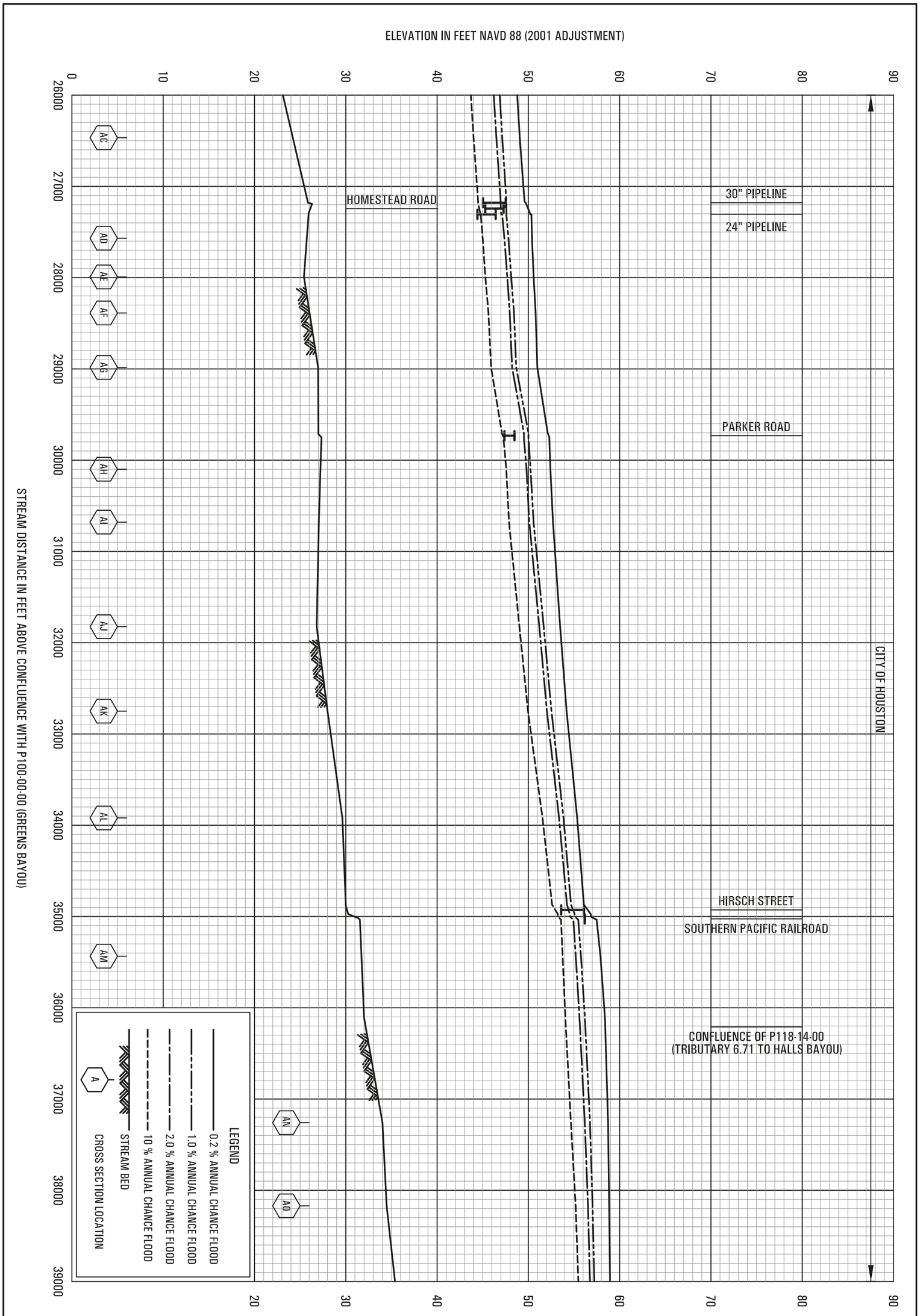
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P27P



P28P

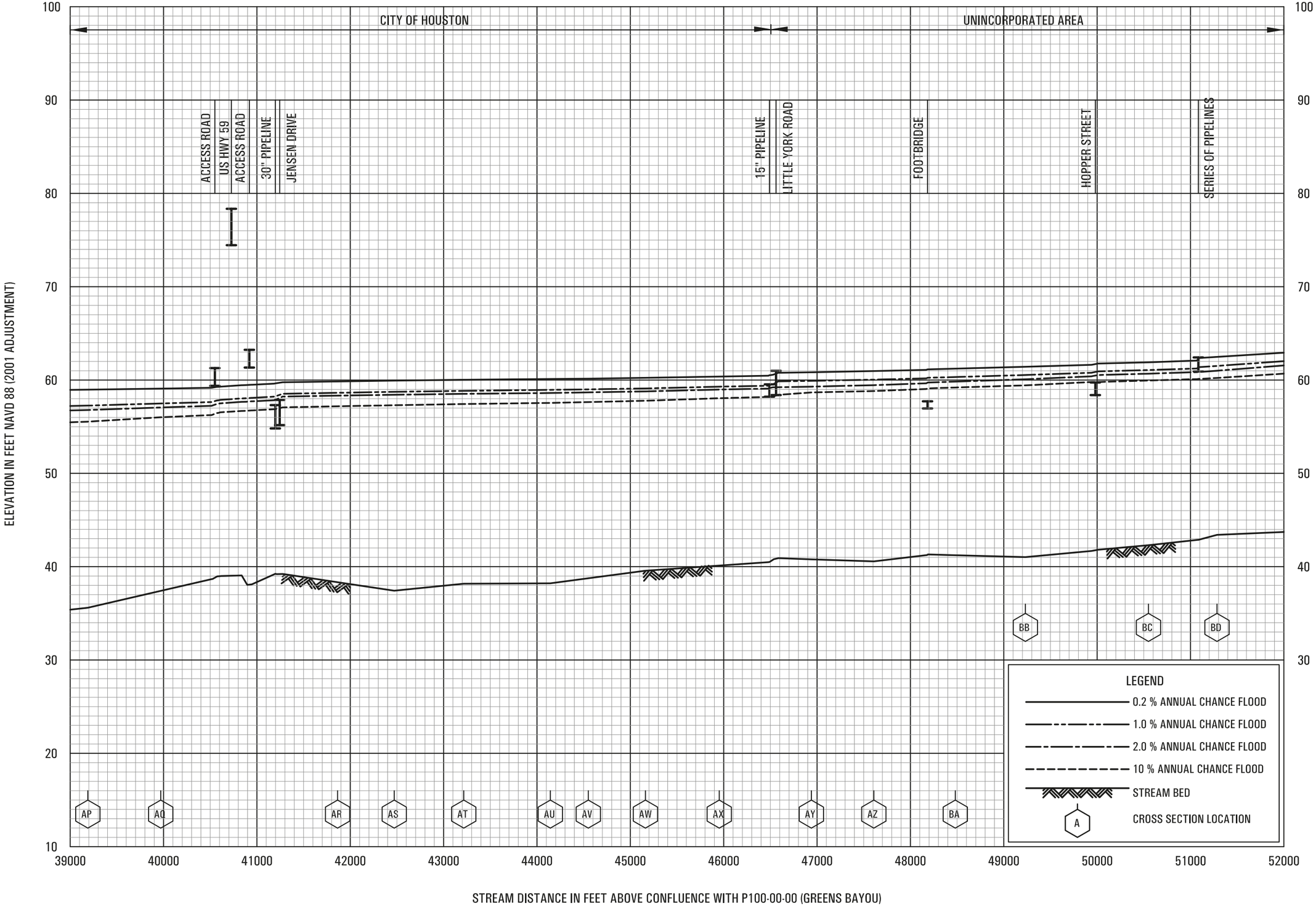
FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY,TX

AND INCORPORATED AREAS

FLOOD PROFILES

P118-00-00 (HALLS BAYOU)



FLOOD PROFILES

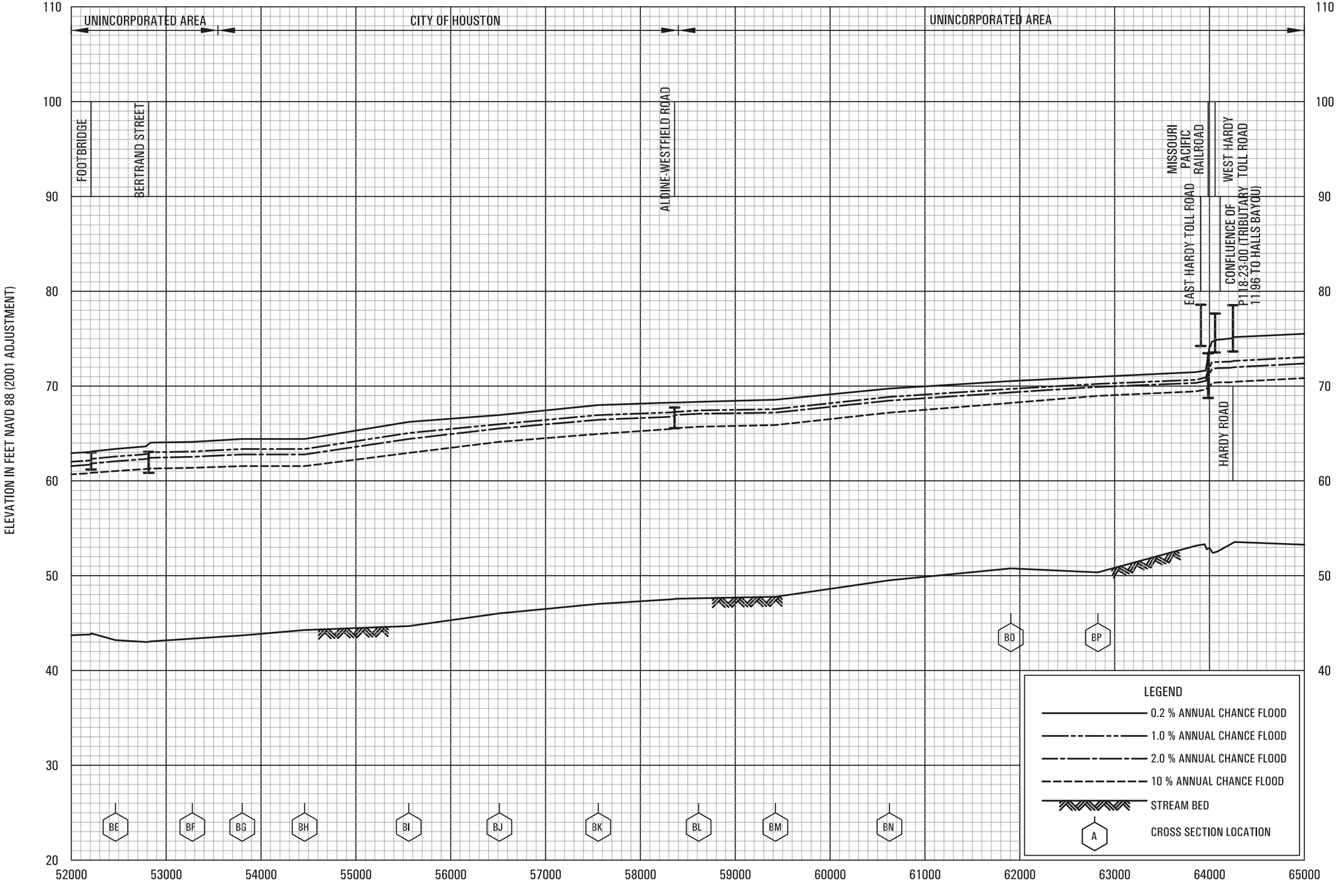
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P29P



FLOOD PROFILES

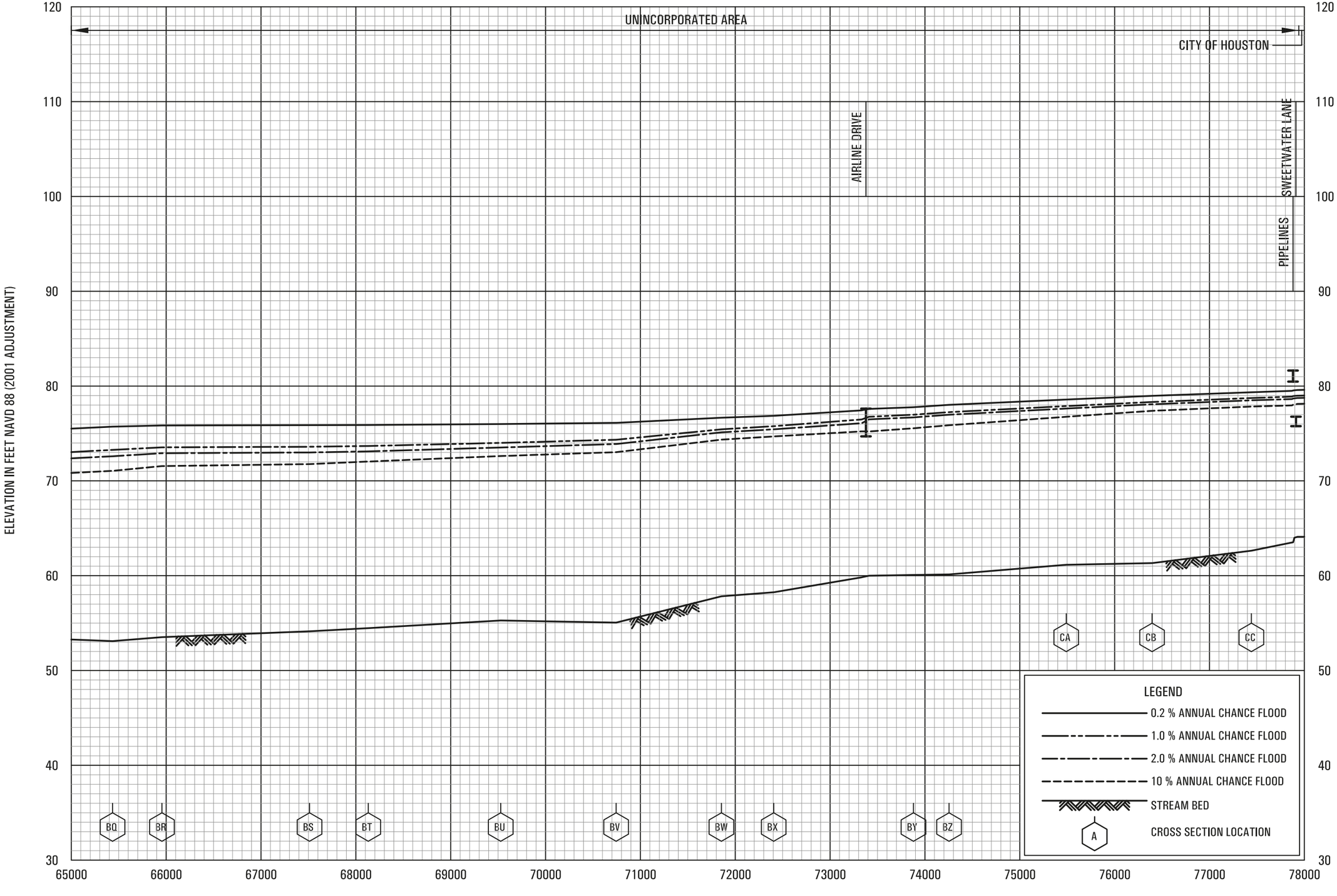
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P30P



FLOOD PROFILES

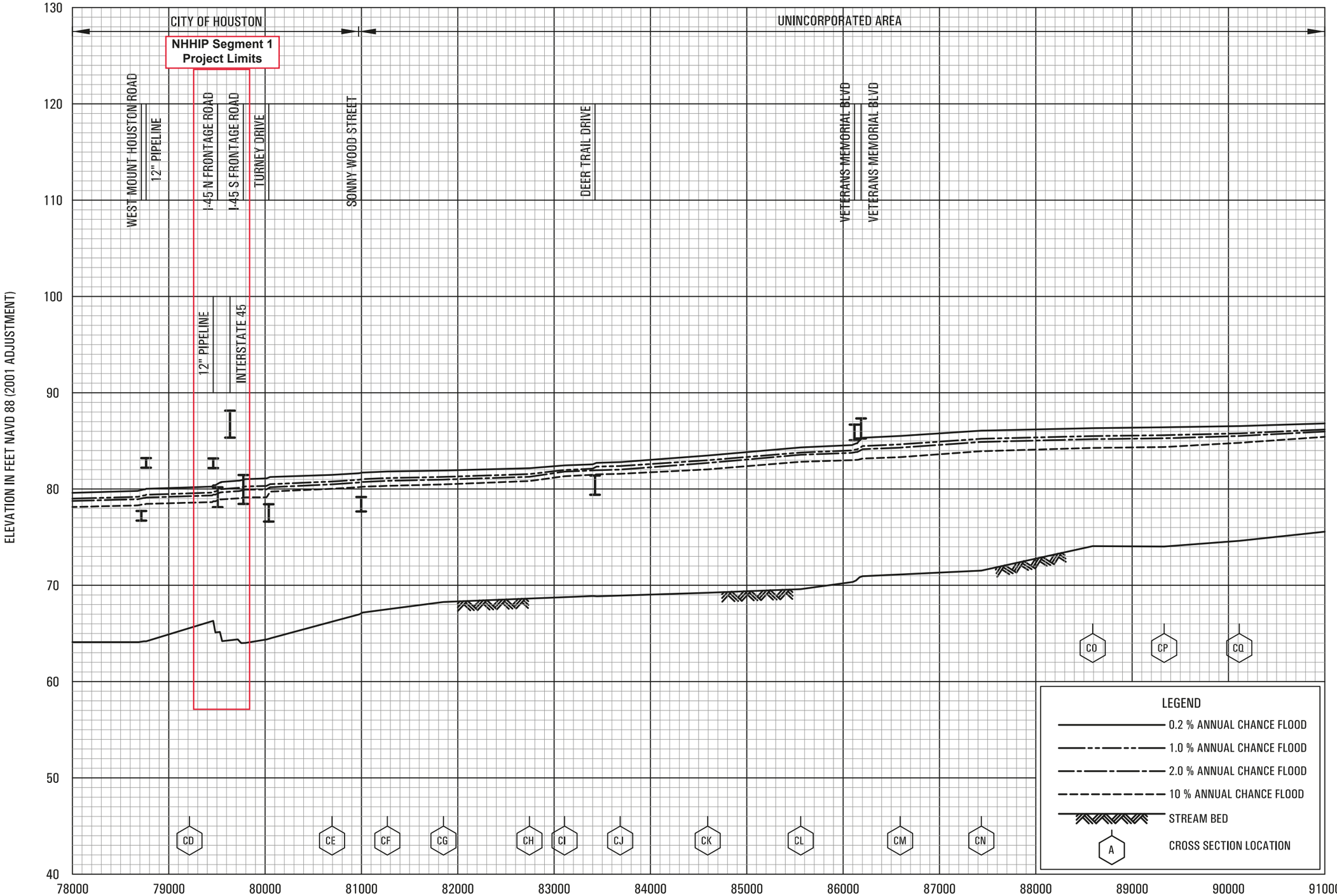
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P31P



FLOOD PROFILES

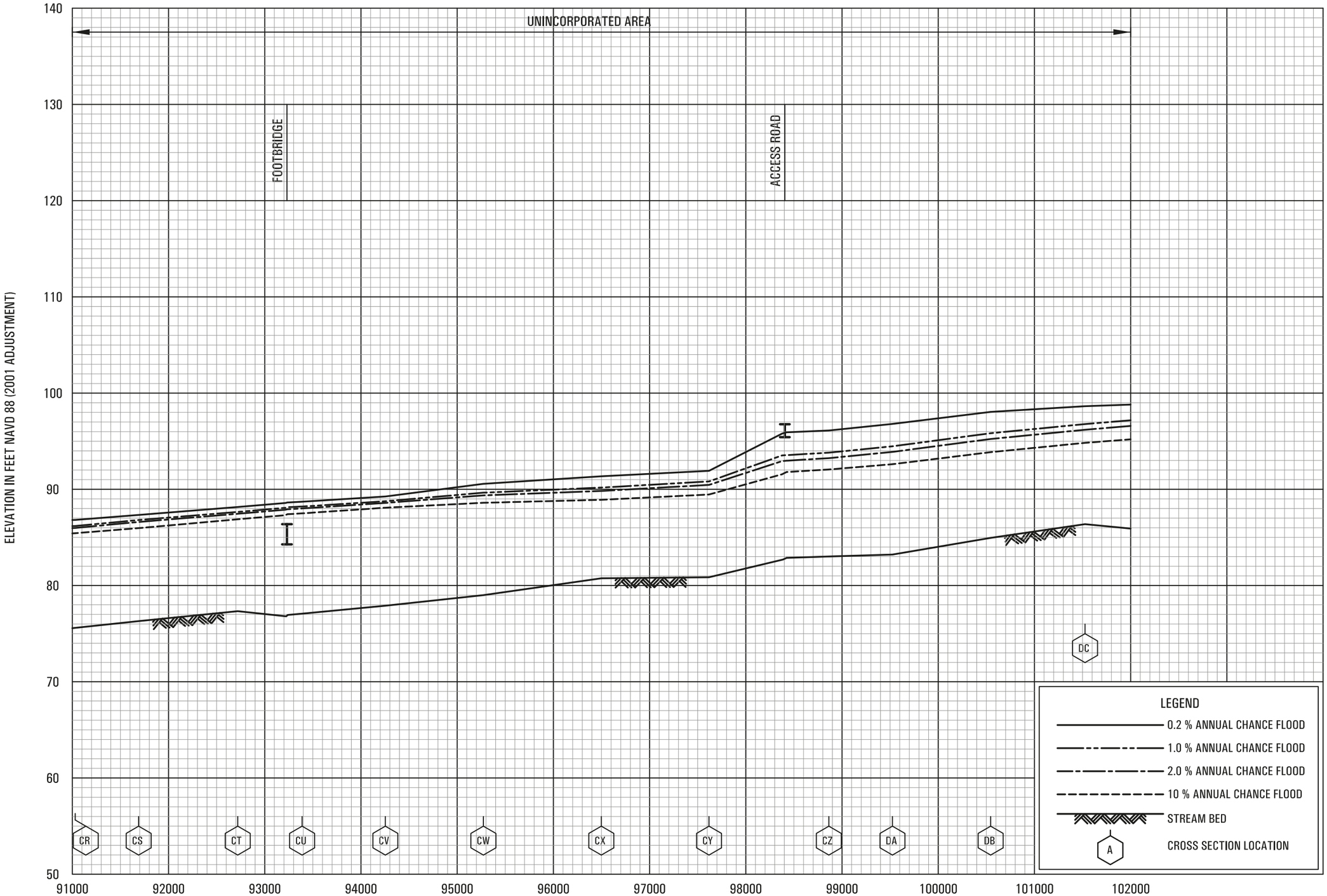
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P32P



FLOOD PROFILES

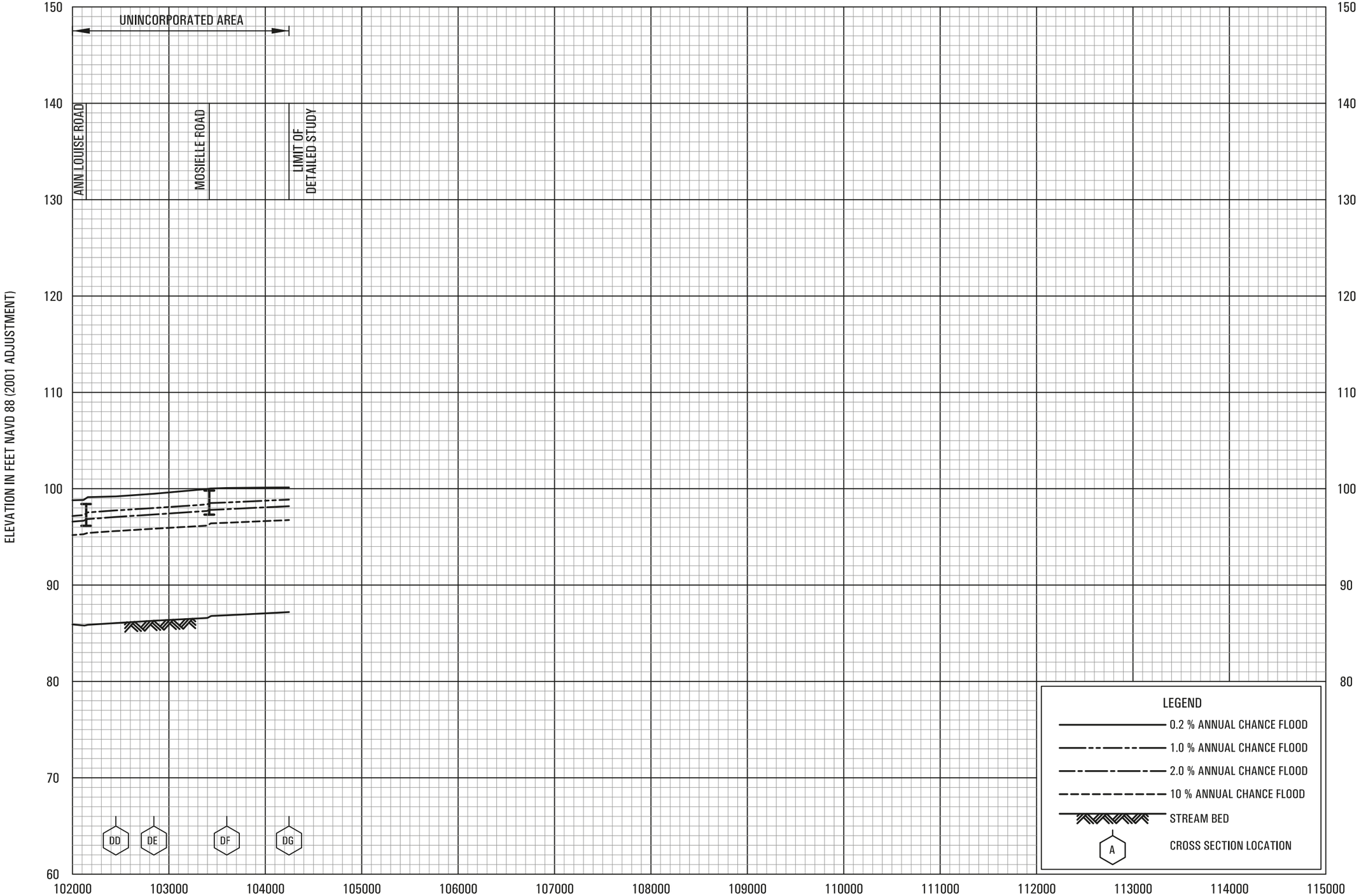
P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P33P



FLOOD PROFILES

P118-00-00 (HALLS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY

HARRIS COUNTY, TX

AND INCORPORATED AREAS

P34P

FEMA Floodway Data Table for P118-00-00 (Halls Bayou)

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					FEET (NAVD 88, 2001 Adjustment)			
P118-00-00 (Halls Bayou)								
CC	77,441	1,110	5,402	1.2	78.7	78.7	79.7	1.0
CD	79,215	965	4,148	1.5	79.6	79.6	80.4	0.8
CE	80,695	1,580	6,423	1.0	80.8	80.8	81.7	0.9
CF	81,269	2,100	6,940	0.9	81.1	81.1	81.9	0.8
CG	81,851	1,800	5,848	1.1	81.3	81.3	82.1	0.8
CH	82,744	1,490	3,916	1.6	81.6	81.6	82.5	0.9
CI	83,108	1,280	3,982	1.6	82.0	82.0	82.9	0.9
CJ	83,686	950	3,622	1.6	82.4	82.4	83.3	0.9
CK	84,594	750	2,518	2.3	83.0	83.0	83.7	0.7
CL	85,560	570	2,392	1.8	83.8	83.8	84.5	0.7
CM	86,592	700	2,156	1.8	84.6	84.6	85.1	0.5
CN	87,435	1,130	3,955	0.9	85.2	85.2	85.7	0.5
CO	88,591	1,400	5,568	0.6	85.5	85.5	86.0	0.5
CP	89,332	1,300	3,948	0.8	85.6	85.6	86.1	0.5
CQ	90,112	1,000	2,251	1.4	85.8	85.8	86.4	0.6
CR	91,030	1,000	2,414	1.2	86.2	86.2	86.9	0.7
CS	91,689	1,000	1,756	1.6	86.8	86.8	87.4	0.6
CT	92,719	1,085	1,982	1.3	87.6	87.6	88.6	1.0
CU	93,388	850	2,453	1.0	88.2	88.2	89.2	1.0
CV	94,254	450	1,000	2.3	88.8	88.8	89.7	0.9
CW	95,272	116	928	2.4	89.7	89.7	90.4	0.7
CX	96,498	115	774	2.7	90.2	90.2	90.8	0.6
CY	97,618	26	187	10.1	90.8	90.8	91.0	0.2
CZ	98,863	77	484	3.5	93.8	93.8	94.3	0.5
DA	99,524	68	385	4.2	94.5	94.5	94.8	0.3

NHHIP Segment 1 Project Limits

[1] Feet above confluence with P100-00-00 (Greens Bayou)

TABLE 8

FEDERAL EMERGENCY MANAGEMENT AGENCY
HARRIS COUNTY, TX
AND INCORPORATED AREAS

FLOODWAY DATA

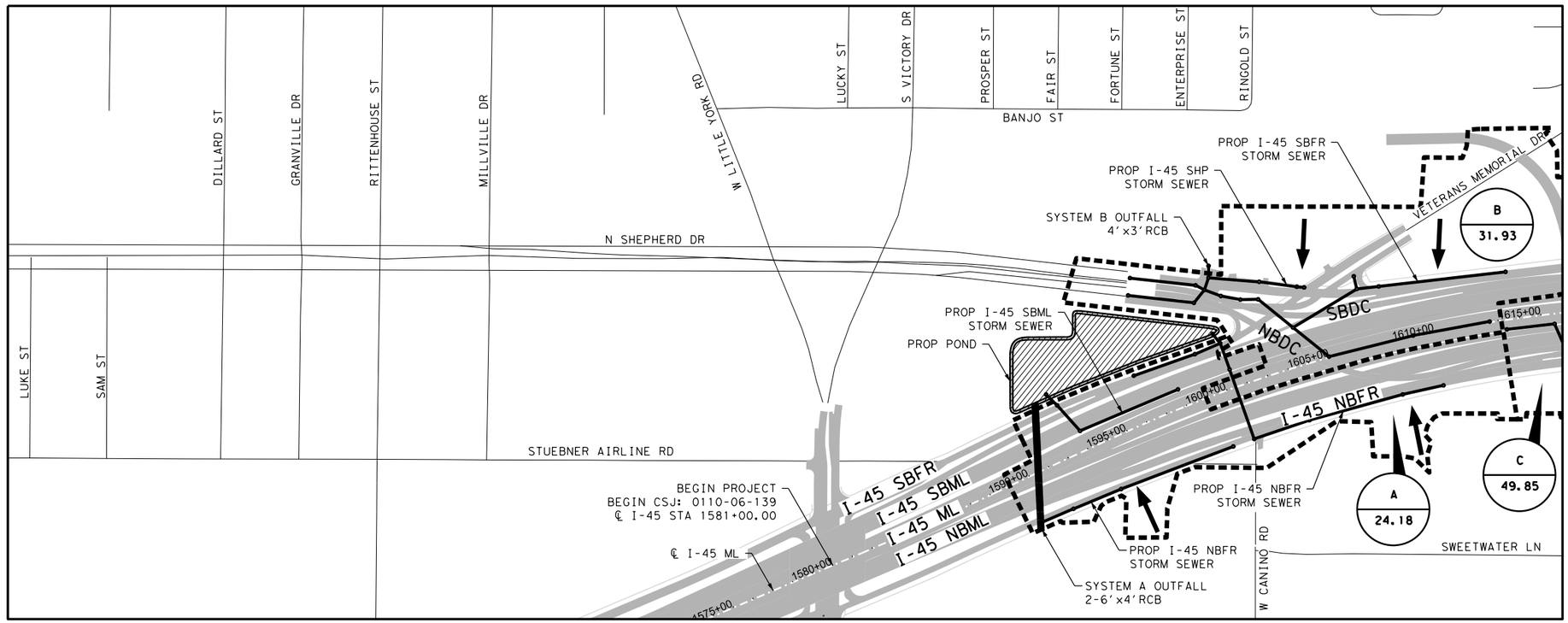
P118-00-00 (HALLS BAYOU)

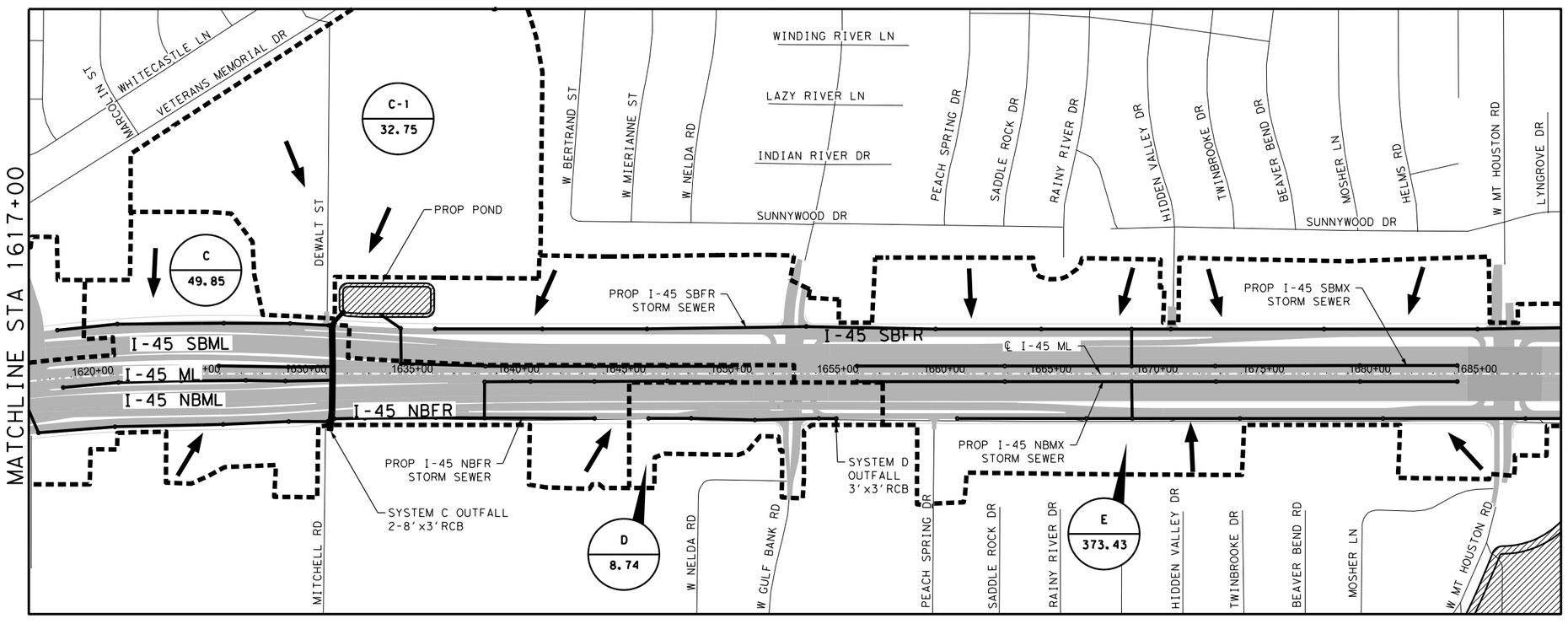
Appendix C

Proposed Drain Design Supporting Data

- Proposed Drain Design Sheets

Proposed Drain Design Sheets





LEGEND

- PROPOSED DRAINAGE AREA
- DIRECTION OF FLOW
- ID / 00.00 — DRAINAGE AREA ID / DRAINAGE AREA ACREAGE
- PROPOSED ROADWAY

0 300 600 (H)

REV NO.	DATE	BY	REVISION

THIS INFORMATION IS PRESENTED FOR STUDY PURPOSES ONLY. IT IS NOT INTENDED TO BE USED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

PRELIMINARY SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

NHHIP SEGMENT 1

OVERALL DRAINAGE AREA MAP

BEGIN TO STA 1689+00

SHEET 1 OF 2

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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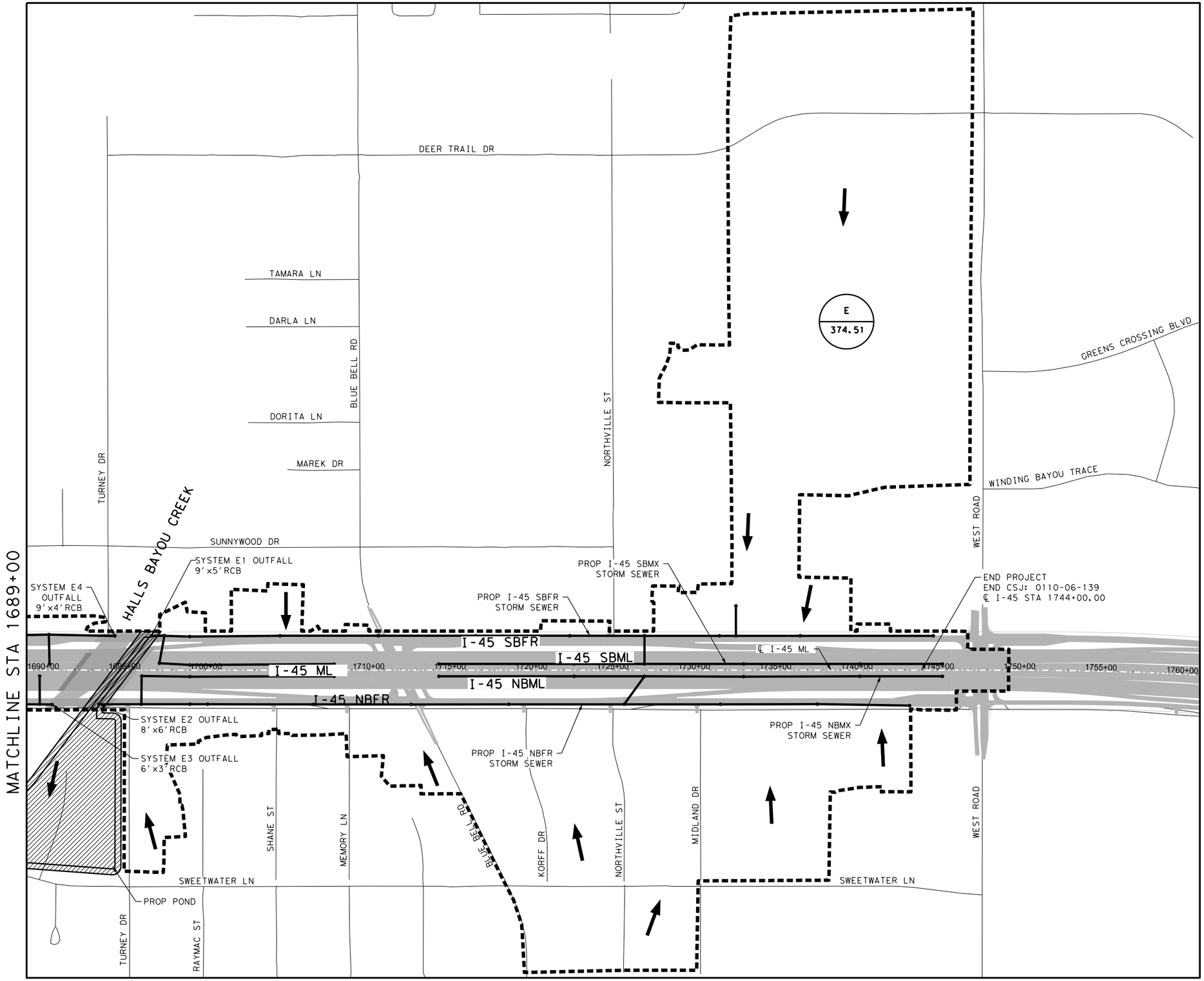

LEGEND

- PROPOSED DRAINAGE AREA
- DIRECTION OF FLOW
- ID / 00.00 — DRAINAGE AREA ID / DRAINAGE AREA ACREAGE
- PROPOSED ROADWAY

0 300 600 (H)

REV NO.	DATE	BY	REVISION

THIS INFORMATION IS PRESENTED FOR STUDY PURPOSES ONLY. IT IS NOT INTENDED TO BE USED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

PRELIMINARY SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

OVERALL DRAINAGE AREA MAP

STA 1689+00 TO END

SHEET 2 OF 2

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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6/11/2021 10:21:24 AM

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Runoff Computations for Design Frequency

SYSTEM A1						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
A1-SML10	0.88	0.76	3.66	10.00	8.39	5.61
A3-SFR05	0.68	0.59	3.44	10.00	8.39	3.42
A3-SFR10	0.68	0.73	6.92	10.00	8.39	4.12
A1-NFR15	0.72	3.35	7.84	10.00	8.39	20.33
A1-NFR20	0.69	2.47	7.80	10.00	8.39	14.33
A1-NFR25	0.74	3.23	10.00	10.00	8.39	20.00

SYSTEM A4						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
A4-NFR05	0.78	2.49	7.18	10.00	8.39	16.23
A4-NFR10	0.75	3.94	11.82	11.82	7.91	23.27
A4-NFR15	0.73	2.45	6.88	10.00	8.39	15.11

SYSTEM A5						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
A5-SFR05	0.65	0.97	6.81	10.00	8.39	5.31
A5-ML10	0.85	1.80	6.42	10.00	8.39	12.82
A5-ML15	0.88	1.40	8.82	10.00	8.39	10.30

SYSTEM B						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
B1-SHPS10	0.35	1.34	10.38	10.38	8.28	3.90
B1-SHPS15	0.71	1.95	7.52	10.00	8.39	11.60
B4-SHPS05	0.80	0.75	5.58	10.00	8.39	4.99
B3-SHPN05	0.79	0.63	5.80	10.00	8.39	4.18
B1-SHPS20	0.62	2.72	7.63	10.00	8.39	14.23
B4-SHPS10	0.76	0.78	5.78	10.00	8.39	4.94
B3-SHPN10	0.77	0.77	6.42	10.00	8.39	4.93
B2-SFR25	0.58	1.46	7.28	10.00	8.39	7.13
B2-ML30	0.88	2.97	13.14	13.14	7.61	19.82
B2-ML35	0.88	1.98	13.14	13.14	7.61	13.33
B2-SFR35	0.78	3.18	11.28	11.28	8.05	19.89
B2-SFR30-1	0.73	7.60	19.00	19.00	6.52	36.22
B2-ML40	0.89	1.91	13.14	13.14	7.61	12.89
B2-SFR40	0.86	3.89	11.16	11.16	8.08	26.92

SYSTEM C1						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
C1-ML10	0.84	0.83	7.82	10.00	8.39	5.85
C1-ML15	0.90	0.47	10.00	10.00	8.39	3.54
C1-ML20	0.90	0.33	6.78	10.00	8.39	2.46
C1-ML25	0.90	0.28	6.00	10.00	8.39	2.09
C1-ML30	0.90	0.28	5.96	10.00	8.39	2.08

REV NO.	DATE	BY	REVISION

THIS INFORMATION IS PRESENTED FOR STUDY PURPOSES ONLY. IT IS NOT INTENDED TO BE USED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
RUNOFF COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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6/11/2021 10:21:25 AM

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Runoff Computations for Design Frequency

SYSTEM C2						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
C2-NFR05	0.80	1.51	8.00	10.00	8.39	10.13
C2-NFR10	0.81	2.39	7.20	10.00	8.39	16.24
C2-NFR15	0.79	1.67	8.66	10.00	8.39	11.06
C2-NFR20	0.78	4.64	8.24	10.00	8.39	30.26
C2-ML20	0.90	0.49	10.10	10.10	8.36	3.70
C2-ML25	0.90	0.33	6.72	10.00	8.39	2.49
C2-ML30	0.90	0.29	5.98	10.00	8.39	2.17
C2-ML35	0.90	0.29	5.86	10.00	8.39	2.18

SYSTEM C3						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
C3-NFR05	0.72	3.79	7.64	10.00	8.39	23.04
C3-NFR10	0.73	4.05	9.30	10.00	8.39	24.81
C3-NFR15	0.78	2.02	7.70	10.00	8.39	13.21
C3-NFR20	0.83	3.85	7.42	10.00	8.39	26.74
C3-ML30	0.86	1.62	8.58	10.00	8.39	11.67

SYSTEM C4						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
C4-ML05	0.83	0.66	3.76	10.00	8.39	4.56
C4-ML10	0.83	0.63	6.00	10.00	8.39	4.41
C4-ML15	0.77	0.68	4.38	10.00	8.39	4.40
C4-ML20	0.78	0.63	4.00	10.00	8.39	4.13
C4-ML25	0.81	1.10	5.64	10.00	8.39	7.43

SYSTEM C5						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
C5-ML05	0.79	0.85	3.40	10.00	8.39	5.60
C5-ML10	0.73	0.79	4.00	10.00	8.39	4.87

SYSTEM C6						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
C6-SFR05	0.81	1.64	4.20	10.00	8.39	11.15
C6-SFR10	0.80	4.76	11.04	11.04	8.11	30.91
C6-SFR15	0.77	5.61	12.68	12.68	7.71	33.40
C6-SFR20	0.85	3.37	9.20	10.00	8.39	24.02

SYSTEM D						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
D1-NFR05	0.73	3.75	8.50	10.00	8.39	22.97
D1-NFR20	0.73	2.35	7.46	10.00	8.39	14.37
D1-NFR25	0.75	2.64	10.60	10.60	8.22	16.27

REV NO.	DATE	BY	REVISION

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
RUNOFF COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Runoff Computations for Design Frequency

SYSTEM E1						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
E1-SBFR05	0.72	2.97	2.82	10.00	8.39	18.04
E1-SXM10	0.90	0.53	2.71	10.00	8.39	3.99
E1-SBFR15	0.74	5.92	3.18	10.00	8.39	36.74
E1-SXM15	0.90	0.51	3.16	10.00	8.39	3.87
E1-SBFR20	0.76	2.89	2.58	10.00	8.39	18.48
E1-SXM20	0.90	0.69	2.39	10.00	8.39	5.21
E1-SBFR25	0.76	2.72	2.58	10.00	8.39	17.38
E1-SBFR30	0.74	3.66	2.93	10.00	8.39	22.56
E1-SMX40	0.90	0.55	3.29	10.00	8.39	4.16
E1-SBFR40	0.71	5.79	7.37	10.00	8.39	34.56
E1-SMX30	0.90	0.61	2.27	10.00	8.39	4.61
E1-SMX45	0.90	0.64	2.09	10.00	8.39	4.85
E1-SMX25	0.90	0.73	3.28	10.00	8.39	5.49
E1-SMX50	0.90	0.60	2.45	10.00	8.39	4.51
E1-SBFR50	0.77	6.18	1.40	10.00	8.39	40.00
E1-SFR115-OS	0.66	111.79	88.00	88.00	2.74	202.47
E1-SMX55	0.90	0.39	6.90	10.00	8.39	2.93
E1-SBFR55	0.74	3.54	9.92	10.00	8.39	22.11

SYSTEM E2						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
E2-NBFR05	0.74	5.28	17.87	17.87	6.70	26.22
E2-NMX10	0.90	0.51	1.95	10.00	8.39	3.85
E2-NMX15	0.90	0.62	3.19	10.00	8.39	4.64
E2-NBFR15	0.61	8.62	18.18	18.18	6.65	34.88
E2-NMX20	0.90	0.69	2.18	10.00	8.39	5.19
E2-NBFR20	0.70	5.13	6.64	10.00	8.39	30.10
E2-NBFR25	0.68	8.95	10.47	10.47	8.26	50.00
E2-NBFR30	0.60	22.87	29.13	29.13	5.29	72.28
E2-NBFR35	0.63	24.73	29.36	29.36	5.27	82.46
E2-NMX45	0.90	0.60	3.22	10.00	8.39	4.50
E2-NBFR40	0.67	19.20	28.86	28.86	5.32	68.64
E2-NMX40	0.90	0.61	1.89	10.00	8.39	4.61
E2-NMX50	0.90	0.70	2.35	10.00	8.39	5.26
E2-NBFR45	0.71	14.79	19.72	19.72	6.41	67.33
E2-NMX35	0.90	0.73	1.94	10.00	8.39	5.48
E2-NMX55	0.90	0.60	2.45	10.00	8.39	4.54
E2-NBFR50	0.78	5.81	9.41	10.00	8.39	37.77
E2-NMX60	0.90	0.39	6.90	10.00	8.39	2.92

REV NO.	DATE	BY	REVISION

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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
RUNOFF COMPUTATIONS

SHEET 3 OF 4

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Runoff Computations for Design Frequency

SYSTEM E3						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
E3-NMX05	0.90	0.57	5.25	10.00	8.39	4.30
E3-NBFR10	0.73	5.71	6.14	10.00	8.39	35.17
E3-NBFR15	0.76	5.07	6.72	10.00	8.39	32.49
E3-NBFR20	0.75	6.05	6.05	10.00	8.39	37.79
E3-NBFR30	0.75	5.99	5.87	10.00	8.39	37.78
E3-NMX25	0.90	0.55	2.52	10.00	8.39	4.16
E3-NBFR35	0.79	6.20	7.67	10.00	8.39	40.90
E3-NMX20	0.90	0.55	2.56	10.00	8.39	4.16
E3-NMX30	0.90	0.54	2.48	10.00	8.39	4.08
E3-NMX15	0.90	0.45	2.45	10.00	8.39	3.38
E3-NMX35	0.90	0.55	1.92	10.00	8.39	4.16
E3-NMX10	0.90	0.45	1.63	10.00	8.39	3.38

SYSTEM E4						
ID	Runoff (C)	Drainage Area (acres)	Time of Conc. (min)	Time Used (min)	Intensity (in/hr)	Discharge (cfs)
E4-SBFR05	0.74	4.82	3.99	10.00	8.39	29.75
E4-SMX05	0.90	0.60	3.62	10.00	8.39	4.56
E4-SBFR10	0.77	5.83	7.23	10.00	8.39	37.62
E4-SBFR15	0.75	8.47	7.37	10.00	8.39	53.48
E4-SBFR20	0.83	6.79	7.08	10.00	8.39	47.31
E4-SBFR30	0.83	6.04	7.10	10.00	8.39	42.26
E4-SMX25	0.90	0.55	2.53	10.00	8.39	4.16
E4-SBFR35	0.69	5.57	6.79	10.00	8.39	32.34
E4-SMX20	0.90	0.55	2.60	10.00	8.39	4.16
E4-SMX30	0.90	0.54	2.50	10.00	8.39	4.08
E4-SBFR40	0.78	7.29	7.84	10.00	8.39	47.66
E4-SMX15	0.90	0.45	1.47	10.00	8.39	3.38
E4-SMX35	0.90	0.55	1.94	10.00	8.39	4.16
E4-SBFR45	0.74	6.90	7.84	10.00	8.39	43.08
E4-SMX10	0.90	0.45	1.62	10.00	8.39	3.38
E4-SBFR50	0.65	4.87	4.09	10.00	8.39	26.68
E4-SBFR55	0.70	6.60	5.60	10.00	8.39	38.95

REV NO.	DATE	BY	REVISION

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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
RUNOFF COMPUTATIONS

SHEET 4 OF 4

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

6/11/2021 10:21:29 AM

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Configuration Data

SYSTEM A1											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert (ft)	Downstream Invert (ft)
A1-SFR05	A1-SFR05	A1-OUT	54.99	Box	2	2.00	4.00	0.012	0.09	77.41	77.36
A1-SML10	A1-SML10	A1-SFR05	125.10	Box	2	2.00	4.00	0.012	0.10	77.54	77.41
A3-SFR05	A3-SFR05	A1-SFR05	124.15	Circular	1	2.00	n/a	0.012	0.20	77.66	77.41
A1-NFR13	A1-NFR13	A1-SML10	337.09	Box	2	2.00	4.00	0.012	0.10	77.87	77.54
A3-SFR10	A3-SFR10	A3-SFR05	296.00	Circular	1	2.00	n/a	0.012	0.20	78.25	77.66
A1-NFR15	A1-NFR15	A1-NFR13	266.85	Box	2	2.00	4.00	0.012	0.10	78.14	77.87
A1-NFR20	A1-NFR20	A1-NFR15	443.77	Box	2	2.00	4.00	0.012	0.10	78.58	78.14
A1-NFR25	A1-NFR25	A1-NFR20	189.78	Box	1	2.00	4.00	0.012	0.10	78.77	78.58

SYSTEM A4											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
A4-NFR05	A4-NFR05	A4-NFR-OUT	163.16	Box	1	2.00	5.00	0.012	0.28	76.24	75.79
A4-NFR10	A4-NFR10	A4-NFR05	235.17	Box	1	2.00	5.00	0.012	0.15	76.59	76.24
A4-NFR15	A4-NFR15	A4-NFR10	552.31	Box	1	2.00	4.00	0.012	0.13	77.31	76.59

SYSTEM A5											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
A5-SFR05	A5-SFR05	A5-OUT	69.37	Box	1	2.00	3.00	0.012	0.20	77.76	77.62
A5-ML10	A5-ML10	A5-SFR05	155.19	Box	1	2.00	3.00	0.012	0.20	78.07	77.76
A5-ML15	A5-ML15	A5-ML10	488.60	Box	1	2.00	3.00	0.012	0.20	79.05	78.07

SYSTEM B											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
B1-REST	B1-SHPS05	B1-SHPS-OUT	54.49	Box	1	3.00	4.00	0.012	0.20	73.43	73.32
B1-SHPS10	B1-SHPS10	B1-SHPS05	233.98	Box	1	3.00	5.00	0.012	0.12	73.71	73.43
B2-SHPS05	B2-SHPS05	B1-SHPS05	58.17	Box	1	5.00	5.00	0.012	0.18	73.53	73.43
B1-SHPS15	B1-SHPS15	B1-SHPS10	174.98	Circular	1	3.00	n/a	0.012	0.14	73.95	73.71
B4-SHP05	B4-SHPS05	B2-SHPS05	44.91	Circular	1	2.50	n/a	0.012	0.14	76.10	76.04
B2-SHPS10	B2-SHPS10	B2-SHPS05	79.85	Box	1	5.00	5.00	0.012	0.10	73.61	73.53
B3-SHPN05	B3-SHPN05	B2-SHPS05	75.72	Circular	1	2.50	n/a	0.012	0.10	76.11	76.04
B1-SHPS20	B1-SHPS20	B1-SHPS15	32.66	Circular	1	2.50	n/a	0.012	0.09	74.48	74.45
B4-SHPS10	B4-SHPS10	B4-SHPS05	304.48	Circular	1	2.00	n/a	0.012	0.15	77.05	76.60
B2-SHPS15	B2-SHPS15	B2-SHPS10	90.94	Box	1	5.00	5.00	0.012	0.10	73.70	73.61
B3-SHPN10	B3-SHPN10	B3-SHPN05	305.74	Circular	1	2.00	n/a	0.012	0.10	76.91	76.61
B2-SHPS20	B2-SHPS20	B2-SHPS15	80.89	Box	1	5.00	5.00	0.012	0.10	73.78	73.70
B2-SFR25	B2-SFR25	B2-SHPS20	206.76	Box	1	5.00	5.00	0.012	0.10	73.98	73.78
B2-ML30	B2-ML30	B2-SFR25	213.17	Circular	1	4.00	n/a	0.012	0.11	75.20	74.98
B2-SFR30	B2-SFR30	B2-SFR25	343.98	Box	1	4.00	5.00	0.013	0.10	75.33	74.98
B2-ML35	B2-ML35	B2-ML30	400.86	Circular	1	3.50	n/a	0.012	0.10	76.09	75.69
B2-SFR35	B2-SFR35	B2-SFR30	101.32	Circular	1	4.00	n/a	0.012	0.10	75.42	75.32
B2-SFR30-1	B2-SFR30-1	B2-SFR30	59.27	Box	1	2.00	5.00	0.012	0.09	76.38	76.33
B2-ML40	B2-ML40	B2-ML35	358.89	Circular	1	2.50	n/a	0.012	0.10	77.45	77.09
B2-SFR40	B2-SFR40	B2-SFR35	590.16	Circular	1	3.50	n/a	0.012	0.10	76.51	75.92

SYSTEM C1											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
C1-SFR05	C1-SFR05	C1-OUT	106.76	Circular	1	2.50	n/a	0.012	0.20	78.48	78.27
C1-ML10	C1-ML10	C1-SFR05	163.91	Circular	1	2.50	n/a	0.012	0.20	78.80	78.48
C1-ML15	C1-ML15	C1-ML10	394.87	Circular	1	2.00	n/a	0.012	0.20	82.76	81.98
C1-ML20	C1-ML20	C1-ML15	510.69	Circular	1	2.00	n/a	0.012	0.20	83.78	82.76
C1-ML25	C1-ML25	C1-ML20	339.69	Circular	1	2.00	n/a	0.012	0.20	84.45	83.78
C1-ML30	C1-ML30	C1-ML25	298.69	Circular	1	2.00	n/a	0.012	0.20	85.05	84.45

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Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER COMPUTATIONS

SHEET 1 OF 9

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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6/11/2021 10:21:30 AM

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Configuration Data

SYSTEM C2											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
C2-REST	C2-REST	C2-OUT	9.33	Circular	1	2.50	n/a	0.012	0.05	76.77	76.77
C2-NFR05	C2-NFR05	C2-REST	141.49	Box	1	3.00	5.00	0.012	0.10	76.91	76.77
C2-NFR10	C2-NFR10	C2-NFR05	332.33	Box	1	3.00	5.00	0.012	0.10	77.24	76.91
C2-NFR15	C2-NFR15	C2-NFR10	227.69	Box	1	3.00	5.00	0.012	0.15	77.58	77.24
C2-ML15	C2-ML15	C2-NFR15	168.33	Circular	1	2.00	n/a	0.012	0.20	78.91	78.58
C2-NFR20	C2-NFR20	C2-NFR15	515.69	Box	1	2.00	4.00	0.012	0.10	79.09	78.58
C2-ML20	C2-ML20	C2-ML15	214.70	Circular	1	2.00	n/a	0.012	0.20	82.97	82.55
C2-ML25	C2-ML25	C2-ML20	298.69	Circular	1	2.00	n/a	0.012	0.20	83.57	82.97
C2-ML30	C2-ML30	C2-ML25	341.69	Circular	1	2.00	n/a	0.012	0.20	84.24	83.57
C2-ML35	C2-ML35	C2-ML30	302.69	Circular	1	2.00	n/a	0.012	0.20	84.84	84.24

SYSTEM C3											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
C3-REST	C3-REST	C3-OUT	7.98	Circular	1	2.00	n/a	0.012	0.13	76.76	76.75
C3-NFR05	C3-NFR05	C3-REST	178.96	Box	1	3.00	7.00	0.012	0.10	76.94	76.76
C3-NFR10	C3-NFR10	C3-NFR05	304.46	Box	1	3.00	6.00	0.012	0.10	77.24	76.94
C3-NFR15	C3-NFR15	C3-NFR10	504.72	Box	1	3.00	5.00	0.012	0.10	77.75	77.24
C3-NFR20	C3-NFR20	C3-NFR15	355.92	Box	1	2.00	5.00	0.012	0.10	78.10	77.75
C3-ML25	C3-ML25	C3-NFR20	204.01	Box	1	2.00	3.00	0.012	0.10	78.31	78.10
C3-ML30	C3-ML30	C3-ML25	218.44	Box	1	2.00	3.00	0.012	0.11	78.53	78.30

SYSTEM C4											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
C4-ML05	C4-ML05	C4-OUT	215.88	Box	1	2.00	5.00	0.012	0.20	78.39	77.96
C4-ML10	C4-ML10	C4-ML05	184.71	Box	1	2.00	4.00	0.012	0.10	78.57	78.39
C4-ML15	C4-ML15	C4-ML10	301.69	Box	1	2.00	4.00	0.012	0.10	78.87	78.57
C4-ML20	C4-ML20	C4-ML15	294.31	Box	1	2.00	4.00	0.012	0.10	79.16	78.87
C4-ML25	C4-ML25	C4-ML20	259.18	Circular	1	2.00	n/a	0.012	0.10	79.42	79.16

SYSTEM C5											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
C5-ML05	C5-ML05	C5-ML-OUT	201.86	Circular	1	2.50	n/a	0.012	0.10	77.79	77.59
C5-ML10	C5-ML10	C5-ML05	325.73	Circular	1	2.00	n/a	0.012	0.10	78.61	78.29

SYSTEM C6											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
C6-REST	C6-REST	C6-OUT	9.34	Circular	1	2.50	n/a	0.012	0.10	77.28	77.27
C6-SFR05	C6-SFR05	C6-REST	180.69	Box	1	3.00	6.00	0.012	0.10	77.46	77.28
C6-SFR10	C6-SFR10	C6-SFR05	310.08	Box	1	3.00	6.00	0.012	0.10	77.77	77.46
C6-SFR15	C6-SFR15	C6-SFR10	499.72	Box	1	3.00	5.00	0.012	0.10	78.26	77.77
C6-SFR20	C6-SFR20	C6-SFR15	281.48	Box	1	2.00	5.00	0.012	0.10	78.54	78.26

SYSTEM D											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
D1-NFR05	D1-NFR05	D1-OUT	26.57	Box	1	3.00	3.00	0.012	0.11	74.28	74.25
D1-NFR10	D1-NFR10	D1-NFR05	78.00	Box	1	3.00	3.00	0.012	0.09	74.35	74.28
D1-NFR15	D1-NFR15	D1-NFR10	296.08	Box	1	3.00	3.00	0.012	0.10	74.65	74.35
D1-NFR20	D1-NFR20	D1-NFR15	296.11	Box	1	3.00	3.00	0.012	0.10	74.95	74.65
D1-NFR25	D1-NFR25	D1-NFR20	196.05	Box	1	2.00	3.00	0.012	0.10	76.14	75.95

REV NO.	DATE	BY	REVISION

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
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Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Configuration Data

SYSTEM E1											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
E1-SBFR05	E1-SBFR05	OUT_E1	80.75	Box	1	5.00	9.00	0.013	0.10	66.07	65.99
E1-SBFR10	E1-SBFR10	E1-SBFR05	156.07	Box	1	5.00	8.00	0.012	0.12	66.25	66.07
E1-SMX10A	E1-SXM10	E1-SBFR05	171.88	Circular	1	3.00	n/a	0.012	0.25	66.50	66.07
E1-SBFR20	E1-SBFR15	E1-SBFR10	554.02	Box	1	5.00	8.00	0.012	0.16	67.14	66.25
E1-SMX10	E1-SXM15	E1-SXM10	188.03	Circular	1	2.00	n/a	0.012	0.20	80.38	80.00
E1-SBFR25	E1-SBFR20	E1-SBFR15	604.33	Box	1	5.00	7.00	0.012	0.14	67.99	67.14
E1-SMX15	E1-SXM20	E1-SXM15	886.25	Circular	1	2.00	n/a	0.012	0.20	82.15	80.38
E1-SBFR30	E1-SBFR25	E1-SBFR20	599.68	Box	1	5.00	7.00	0.012	0.14	68.83	67.99
E1-SBFR35	E1-SBFR30	E1-SBFR25	576.62	Box	1	5.00	7.00	0.012	0.13	69.58	68.83
E1-SBFR40	E1-SBFR35	E1-SBFR30	459.87	Box	1	5.00	7.00	0.012	0.13	70.17	69.58
E1-SMX40	E1-SMX40	E1-SBFR35	173.02	Circular	1	3.00	n/a	0.012	0.20	70.52	70.17
E1-SBFR45	E1-SBFR40	E1-SBFR35	460.36	Box	1	5.00	7.00	0.012	0.18	71.00	70.17
E1-SMX35	E1-SMX30	E1-SMX40	432.20	Circular	1	2.00	n/a	0.012	0.20	71.39	70.52
E1-SMX45	E1-SMX45	E1-SMX40	608.80	Circular	1	2.00	n/a	0.012	0.20	71.74	70.52
E1-SBFR50	E1-SBFR45	E1-SBFR40	101.05	Box	1	5.00	6.00	0.012	0.18	71.19	71.00
E1-SMX30	E1-SMX25	E1-SMX30	831.00	Circular	1	2.00	n/a	0.012	0.20	73.05	71.39
E1-SMX50	E1-SMX50	E1-SMX45	714.00	Circular	1	2.00	n/a	0.012	0.20	73.17	71.74
E1-SBFR55	E1-SBFR50	E1-SBFR45	395.41	Box	1	4.00	5.00	0.012	0.13	71.70	71.19
E1-SFR115-OS	E1-SFR115-OS	E1-SBFR45	183.74	Box	1	5.00	6.00	0.012	0.30	71.74	71.19
E1-SMX55	E1-SMX55	E1-SMX50	508.00	Circular	1	2.00	n/a	0.012	0.20	74.18	73.17
E1-SBFR60	E1-SBFR55	E1-SBFR50	817.68	Box	1	4.00	5.00	0.012	0.10	72.52	71.70

SYSTEM E2											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
E2-NBFR05	E2-NBFR05	E2_OUT	233.65	Box	1	6.00	8.00	0.012	0.13	66.29	65.98
E2-NMX05	E2-NMX10	E2-NBFR05	173.40	Circular	1	2.00	n/a	0.012	0.30	68.81	68.29
E2-NBFR10	E2-NBFR10	E2-NBFR05	299.19	Box	1	6.00	8.00	0.012	0.13	66.68	66.29
E2-NMX10	E2-NMX15	E2-NMX10	296.43	Circular	1	2.00	n/a	0.012	0.20	81.00	80.41
E2-NBFR15	E2-NBFR15	E2-NBFR10	108.09	Box	1	6.00	8.00	0.012	0.12	66.81	66.68
E2-NMX15	E2-NMX20	E2-NMX15	886.24	Circular	1	2.00	n/a	0.012	0.20	82.77	81.00
E2-NBFR20	E2-NBFR20	E2-NBFR15	651.06	Box	1	6.00	8.00	0.012	0.12	67.59	66.81
E2-NBFR25	E2-NBFR25	E2-NBFR20	599.95	Box	1	6.00	8.00	0.012	0.10	68.19	67.59
E2-NBFR30	E2-NBFR30	E2-NBFR25	600.05	Box	1	6.00	8.00	0.012	0.10	68.79	68.19
E2-NBFR35	E2-NBFR35	E2-NBFR30	708.18	Box	1	6.00	8.00	0.012	0.10	69.50	68.79
E2-NMX45	E2-NMX45	E2-NBFR35	212.91	Circular	1	2.50	n/a	0.012	0.35	72.65	71.91
E2-NBFR40	E2-NBFR40	E2-NBFR35	592.41	Box	1	5.00	8.00	0.012	0.10	71.08	70.49
E2-NMX40	E2-NMX40	E2-NMX45	432.20	Circular	1	2.00	n/a	0.012	0.20	73.52	72.65
E2-NMX50	E2-NMX50	E2-NMX45	608.80	Circular	1	2.00	n/a	0.012	0.20	73.87	72.65
E2-NBFR45	E2-NBFR45	E2-NBFR40	595.66	Box	1	5.00	8.00	0.012	0.10	71.68	71.08
E2-NMX35	E2-NMX35	E2-NMX40	831.00	Circular	1	2.00	n/a	0.012	0.20	75.18	73.52
E2-NMX55	E2-NMX55	E2-NMX50	714.00	Circular	1	2.00	n/a	0.012	0.27	75.78	73.87
E2-NBFR50	E2-NBFR50	E2-NBFR45	566.82	Box	1	2.00	4.00	0.012	0.20	72.81	71.68
E2-NMX60	E2-NMX60	E2-NMX55	508.00	Circular	1	2.00	n/a	0.012	0.20	76.79	75.78

REV NO.	DATE	BY	REVISION

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CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
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Firm Registration No. F-382

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

6/11/2021 10:21:32 AM

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Configuration Data

SYSTEM E3											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
E3-NBFR05	E3-NBFR05	OUT_E3	86.41	Box	1	3.00	7.00	0.012	0.33	66.27	65.98
E3-NMX05	E3-NMX05	E3-NBFR05	172.96	Circular	1	2.00	n/a	0.012	0.20	67.11	66.77
E3-NBFR10	E3-NBFR10	E3-NBFR05	247.67	Box	1	3.00	6.00	0.012	0.41	67.28	66.27
E3-NBFR15	E3-NBFR15	E3-NBFR10	669.29	Box	1	3.00	6.00	0.012	0.30	69.29	67.28
E3-NBFR20	E3-NBFR20	E3-NBFR15	672.37	Box	1	3.00	6.00	0.012	0.22	70.77	69.29
E3-NBFR25	E3-NBFR25	E3-NBFR20	506.27	Box	1	3.00	6.00	0.012	0.13	71.43	70.77
E3-NBFR30	E3-NBFR30	E3-NBFR25	215.95	Box	1	3.00	6.00	0.012	0.10	71.65	71.43
E3-NMX20A	E3-NMX25	E3-NBFR25	173.59	Circular	1	2.50	n/a	0.012	0.24	72.34	71.93
E3-NBFR35	E3-NBFR35	E3-NBFR30	605.39	Box	1	2.00	5.00	0.013	0.20	72.86	71.65
E3-NMX25	E3-NMX20	E3-NMX25	396.00	Circular	1	2.00	n/a	0.012	0.20	73.14	72.34
E3-NMX30	E3-NMX30	E3-NMX25	596.00	Circular	1	2.00	n/a	0.012	0.20	73.54	72.34
E3-NMX20	E3-NMX15	E3-NMX20	677.00	Circular	1	2.00	n/a	0.012	0.20	74.49	73.14
E3-NMX35	E3-NMX35	E3-NMX30	694.00	Circular	1	2.00	n/a	0.012	0.20	74.92	73.54
E3-NMX15	E3-NMX10	E3-NMX15	457.00	Circular	1	2.00	n/a	0.012	0.20	75.40	74.49

SYSTEM E4											
ID	Upstream ID	Downstream ID	Length (ft)	Shape	#	Rise (ft)	Span (ft)	n	Slope %	Upstream Invert	Downstream Invert (ft)
E4-SBFR05	E4-SBFR05	OUT_E4	377.06	Box	1	4.00	9.00	0.012	0.21	66.82	66.05
E4-SMX05	E4-SMX05	E4-SBFR05	179.05	Circular	1	2.00	n/a	0.012	0.50	68.32	67.43
E4-SBFR10	E4-SBFR10	E4-SBFR05	528.95	Box	1	4.00	9.00	0.012	0.19	67.83	66.82
E4-SBFR15	E4-SBFR15	E4-SBFR10	721.28	Box	1	4.00	9.00	0.012	0.18	69.12	67.83
E4-SBFR20	E4-SBFR20	E4-SBFR15	719.87	Box	1	4.00	9.00	0.012	0.13	70.06	69.12
E4-SBFR25	E4-SBFR25	E4-SBFR20	184.11	Box	1	4.00	8.00	0.012	0.13	70.30	70.06
E4-SBFR30	E4-SBFR30	E4-SBFR25	424.97	Box	1	4.00	7.00	0.012	0.16	70.98	70.30
E4-SMX20A	E4-SMX25	E4-SBFR25	173.29	Circular	1	2.50	n/a	0.012	0.30	75.50	74.98
E4-SBFR35	E4-SBFR35	E4-SBFR30	495.92	Box	1	4.00	7.00	0.012	0.12	71.57	70.98
E4-SMX20	E4-SMX20	E4-SMX25	393.00	Circular	1	2.00	n/a	0.012	0.20	76.28	75.50
E4-SMX25	E4-SMX30	E4-SMX25	596.00	Circular	1	2.00	n/a	0.012	0.20	76.69	75.50
E4-SBFR40	E4-SBFR40	E4-SBFR35	608.19	Box	1	3.00	7.00	0.012	0.20	72.79	71.57
E4-SMX15	E4-SMX15	E4-SMX20	678.68	Circular	1	2.00	n/a	0.012	0.20	77.64	76.28
E4-SMX30	E4-SMX35	E4-SMX30	694.00	Circular	1	2.00	n/a	0.012	0.20	78.08	76.69
E4-SBFR45	E4-SBFR45	E4-SBFR40	748.21	Box	1	3.00	7.00	0.012	0.10	73.54	72.79
E4-SMX10	E4-SMX10	E4-SMX15	458.22	Circular	1	2.00	n/a	0.012	0.20	78.55	77.64
E4-SBFR50	E4-SBFR50	E4-SBFR45	491.81	Box	1	3.00	7.00	0.012	0.16	74.33	73.54
E4-SBFR55	E4-SBFR55	E4-SBFR50	503.26	Box	1	3.00	7.00	0.012	0.10	74.83	74.33

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Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

SHEET 4 OF 9

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	APPENDIX NO.
CK: CW	6	12-01DP5012	C
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Hydraulic Computations

SYSTEM A1												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
A1-SFR05	A1-SFR05	A1-OUT	79.44	79.36	55.98	58.95	0.09	0.00	3.53	1.98	3.50	2.00
A1-SML10	A1-SML10	A1-SFR05	79.58	79.44	50.53	63.02	0.10	0.00	3.65	1.73	3.16	2.00
A3-SFR05	A3-SFR05	A1-SFR05	79.55	79.44	7.54	11.83	0.20	0.00	3.71	1.23	2.40	2.00
A1-NFR13	A1-NFR13	A1-SML10	79.92	79.58	47.76	61.17	0.10	0.00	3.71	1.61	2.99	2.00
A3-SFR10	A3-SFR10	A3-SFR05	79.61	79.55	4.12	11.77	0.20	0.00	3.24	0.85	1.34	1.89
A1-NFR15	A1-NFR15	A1-NFR13	80.21	79.92	49.51	62.18	0.10	0.00	3.57	1.73	3.09	2.00
A1-NFR20	A1-NFR20	A1-NFR15	80.37	80.21	33.28	61.56	0.10	0.00	3.36	1.24	2.08	2.00
A1-NFR25	A1-NFR25	A1-NFR20	80.47	80.37	20.00	30.93	0.10	0.00	3.37	1.48	2.80	1.79

SYSTEM A4												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
A4-NFR05	A4-NFR05	A4-NFR-OUT	78.28	77.79	53.68	68.81	0.28	0.00	6.43	1.67	5.37	2.00
A4-NFR10	A4-NFR10	A4-NFR05	78.66	78.28	39.75	50.55	0.15	0.00	4.76	1.67	3.97	2.00
A4-NFR15	A4-NFR15	A4-NFR10	78.87	78.66	17.46	35.29	0.13	0.00	3.71	1.18	2.18	2.00

SYSTEM A5												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
A5-SFR05	A5-SFR05	A5-OUT	79.81	79.62	27.06	29.73	0.20	0.00	4.86	1.86	4.51	2.00
A5-ML10	A5-ML10	A5-SFR05	80.09	79.81	22.40	29.58	0.20	0.00	4.64	1.61	3.73	2.00
A5-ML15	A5-ML15	A5-ML10	80.27	80.09	10.30	29.64	0.20	0.00	3.83	0.90	1.72	2.00

SYSTEM B												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
B1-REST	B1-SHPS05	B1-SHPS-OUT	76.98	76.32	146.26	74.44	0.20	0.00	12.31	3.00	12.19	3.00
B1-SHPS10	B1-SHPS10	B1-SHPS05	77.04	76.98	29.41	77.99	0.12	0.00	3.96	1.48	1.96	3.00
B2-SHPS05	B2-SHPS05	B1-SHPS05	77.09	76.98	125.10	182.50	0.18	0.00	6.74	3.71	7.06	3.55
B1-SHPS15	B1-SHPS15	B1-SHPS10	77.27	77.04	25.83	28.79	0.14	0.00	4.16	2.46	3.65	3.00
B4-SHP05	B4-SHPS05	B2-SHPS05	77.34	77.09	9.93	18.02	0.14	0.00	3.53	1.39	5.06	1.05
B2-SHPS10	B2-SHPS10	B2-SHPS05	77.23	77.09	111.90	138.42	0.10	0.00	5.17	4.33	6.28	3.56
B3-SHPN05	B3-SHPN05	B2-SHPS05	77.37	77.09	9.11	14.80	0.10	0.00	3.04	1.47	4.64	1.05
B1-SHPS20	B1-SHPS20	B1-SHPS15	77.30	77.27	14.23	14.49	0.09	0.00	2.97	2.35	2.90	2.50
B4-SHPS10	B4-SHPS10	B4-SHPS05	78.15	77.38	4.94	10.18	0.15	0.00	3.04	1.03	4.33	0.78
B2-SHPS15	B2-SHPS15	B2-SHPS10	77.38	77.23	112.63	137.28	0.10	0.00	5.20	4.33	6.22	3.62
B3-SHPN10	B3-SHPN10	B3-SHPN05	78.02	77.39	4.93	8.29	0.10	0.00	2.57	1.17	4.33	0.78
B2-SHPS20	B2-SHPS20	B2-SHPS15	77.51	77.38	113.28	137.49	0.10	0.00	5.23	4.33	6.15	3.68
B2-SFR25	B2-SFR25	B2-SHPS20	77.83	77.51	114.95	134.57	0.10	0.00	5.31	4.33	6.16	3.73
B2-ML30	B2-ML30	B2-SFR25	78.04	77.83	41.68	54.12	0.10	0.00	4.41	2.82	4.35	2.85
B2-SFR30	B2-SFR30	B2-SFR25	78.32	77.83	73.61	96.34	0.10	0.00	4.58	3.22	5.16	2.85
B2-ML35	B2-ML35	B2-ML30	78.37	78.04	24.87	37.16	0.10	0.00	3.79	2.26	3.63	2.35
B2-SFR35	B2-SFR35	B2-SFR30	78.41	78.32	43.61	53.30	0.10	0.00	4.61	2.82	4.32	3.00
B2-SFR30-1	B2-SFR30-1	B2-SFR30	78.38	78.32	36.22	38.95	0.09	0.00	3.90	1.86	3.65	1.99
B2-ML40	B2-ML40	B2-ML35	79.22	78.37	12.89	15.20	0.10	0.00	3.21	1.91	5.09	1.28
B2-SFR40	B2-SFR40	B2-SFR35	78.91	78.41	26.92	37.16	0.10	0.00	4.10	2.26	3.68	2.49

REV NO.	DATE	BY	REVISION

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Hydraulic Computations

SYSTEM C1												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
C1-SFR05	C1-SFR05	C1-OUT	80.86	80.77	14.09	21.33	0.20	0.00	4.44	1.54	2.87	2.50
C1-ML10	C1-ML10	C1-SFR05	80.99	80.86	14.35	21.30	0.20	0.00	4.40	1.58	2.97	2.38
C1-ML15	C1-ML15	C1-ML10	84.20	83.09	9.58	11.76	0.20	0.00	3.88	1.47	5.37	1.11
C1-ML20	C1-ML20	C1-ML15	84.91	84.20	6.63	11.81	0.20	0.00	3.68	1.11	2.74	1.44
C1-ML25	C1-ML25	C1-ML20	85.32	84.91	4.17	11.71	0.20	0.00	3.28	0.85	2.28	1.13
C1-ML30	C1-ML30	C1-ML25	85.68	85.32	2.08	11.82	0.20	0.00	2.70	0.59	1.59	0.87

SYSTEM C2												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
C2-REST	C2-REST	C2-OUT	79.48	79.27	64.93	10.70	0.05	0.00	13.57	2.50	13.23	2.50
C2-NFR05	C2-NFR05	C2-REST	79.63	79.48	64.93	71.60	0.10	0.00	4.66	2.78	4.79	2.71
C2-NFR10	C2-NFR10	C2-NFR05	79.90	79.63	58.12	71.33	0.10	0.00	4.47	2.60	4.28	2.72
C2-NFR15	C2-NFR15	C2-NFR10	80.00	79.90	44.44	87.64	0.15	0.00	5.04	1.76	3.34	2.66
C2-ML15	C2-ML15	C2-NFR15	80.16	80.00	6.66	11.77	0.20	0.00	3.70	1.11	2.80	1.42
C2-NFR20	C2-NFR20	C2-NFR15	81.15	80.00	30.26	30.82	0.10	0.00	3.82	1.98	5.34	1.42
C2-ML20	C2-ML20	C2-ML15	84.09	83.46	6.66	11.73	0.20	0.00	3.70	1.11	4.75	0.91
C2-ML25	C2-ML25	C2-ML20	84.71	84.09	6.84	11.87	0.20	0.00	3.68	1.14	3.79	1.12
C2-ML30	C2-ML30	C2-ML25	85.13	84.71	4.35	11.67	0.20	0.00	3.27	0.88	2.35	1.14
C2-ML35	C2-ML35	C2-ML30	85.49	85.13	2.18	11.74	0.20	0.00	2.74	0.60	1.61	0.89

SYSTEM C3												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
C3-REST	C3-REST	C3-OUT	79.94	78.75	84.59	9.33	0.13	0.00	27.62	2.00	26.92	2.00
C3-NFR05	C3-NFR05	C3-REST	80.12	79.94	84.59	112.00	0.10	0.00	5.01	2.41	4.03	3.00
C3-NFR10	C3-NFR10	C3-NFR05	80.40	80.12	67.00	90.46	0.10	0.00	4.63	2.41	3.72	3.00
C3-NFR15	C3-NFR15	C3-NFR10	80.77	80.40	47.91	71.66	0.10	0.00	4.30	2.23	3.19	3.00
C3-NFR20	C3-NFR20	C3-NFR15	81.28	80.77	37.34	41.09	0.10	0.00	4.02	1.86	3.73	2.00
C3-ML25	C3-ML25	C3-NFR20	81.38	81.28	11.67	21.23	0.10	0.00	3.14	1.24	1.94	2.00
C3-ML30	C3-ML30	C3-ML25	81.49	81.38	11.67	21.48	0.11	0.00	3.14	1.24	1.94	2.00

SYSTEM C4												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
C4-ML05	C4-ML05	C4-OUT	80.66	80.53	23.81	58.48	0.20	0.00	4.53	1.05	2.38	2.00
C4-ML10	C4-ML10	C4-ML05	80.79	80.66	20.03	30.51	0.10	0.00	3.37	1.48	2.50	2.00
C4-ML15	C4-ML15	C4-ML10	80.92	80.79	15.96	30.82	0.10	0.00	3.22	1.24	1.99	2.00
C4-ML20	C4-ML20	C4-ML15	80.97	80.92	11.56	30.68	0.10	0.00	2.92	0.99	1.45	2.00
C4-ML25	C4-ML25	C4-ML20	81.18	80.97	7.43	8.35	0.10	0.00	2.69	1.64	2.49	1.81

SYSTEM C5												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
C5-ML05	C5-ML05	C5-ML-OUT	80.67	80.56	10.47	15.05	0.10	0.00	3.12	1.61	2.13	2.50
C5-ML10	C5-ML10	C5-ML05	80.80	80.67	4.87	8.26	0.10	0.00	2.54	1.17	1.55	2.00

REV NO.	DATE	BY	REVISION

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Hydraulic Computations

SYSTEM C6												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
C6-REST	C6-REST	C6-OUT	80.16	79.77	87.69	15.12	0.10	0.00	18.33	2.50	17.86	2.50
C6-SFR05	C6-SFR05	C6-REST	80.35	80.16	87.69	92.15	0.10	0.00	4.92	2.97	5.07	2.88
C6-SFR10	C6-SFR10	C6-SFR05	80.60	80.35	80.56	91.52	0.10	0.00	4.82	2.78	4.65	2.89
C6-SFR15	C6-SFR15	C6-SFR10	80.94	80.60	55.48	70.79	0.10	0.00	4.60	2.41	3.92	2.83
C6-SFR20	C6-SFR20	C6-SFR15	81.11	80.94	24.02	41.32	0.10	0.00	3.53	1.36	2.40	2.00

SYSTEM D												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
D1-NFR05	D1-NFR05	D1-OUT	77.27	77.25	26.89	36.99	0.11	0.00	4.02	2.23	2.99	3.00
D1-NFR10	D1-NFR10	D1-NFR05	77.32	77.27	28.27	32.98	0.09	0.00	3.63	2.60	3.16	2.99
D1-NFR15	D1-NFR15	D1-NFR10	77.51	77.32	28.27	35.04	0.10	0.00	3.63	2.60	3.17	2.97
D1-NFR20	D1-NFR20	D1-NFR15	77.75	77.51	29.42	35.04	0.10	0.00	3.77	2.60	3.42	2.86
D1-NFR25	D1-NFR25	D1-NFR20	77.90	77.75	16.27	20.60	0.10	0.00	3.37	1.61	3.02	1.80

SYSTEM E1												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
E1-SBFR05	E1-SBFR05	OUT_E1	71.04	70.97	267.90	278.34	0.10	0.00	6.01	4.95	5.98	4.98
E1-SBFR10	E1-SBFR10	E1-SBFR05	71.18	71.04	261.01	288.42	0.12	0.00	7.03	4.64	6.56	4.97
E1-SMX10A	E1-SXM10	E1-SBFR05	71.10	71.04	13.07	38.86	0.25	0.00	4.67	1.25	1.85	3.00
E1-SBFR20	E1-SBFR15	E1-SBFR10	71.68	71.18	261.01	333.03	0.16	0.00	8.11	4.02	6.62	4.93
E1-SMX10	E1-SXM15	E1-SXM10	81.72	81.08	9.08	11.79	0.20	0.00	3.84	1.41	5.27	1.08
E1-SBFR25	E1-SBFR20	E1-SBFR15	72.69	71.68	252.00	259.11	0.14	0.00	7.27	4.95	7.94	4.54
E1-SMX15	E1-SXM20	E1-SXM15	83.12	81.72	5.21	11.79	0.20	0.00	3.46	0.97	2.31	1.35
E1-SBFR30	E1-SBFR25	E1-SBFR20	73.58	72.69	248.55	259.11	0.14	0.00	7.40	4.80	7.54	4.71
E1-SBFR35	E1-SBFR30	E1-SBFR25	74.39	73.58	245.41	249.68	0.13	0.00	7.08	4.95	7.38	4.75
E1-SBFR40	E1-SBFR35	E1-SBFR30	74.99	74.39	240.10	249.68	0.13	0.00	6.93	4.95	7.13	4.81
E1-SMX40	E1-SMX40	E1-SBFR35	75.16	74.99	22.58	34.76	0.20	0.00	4.94	1.85	3.19	3.00
E1-SBFR45	E1-SBFR40	E1-SBFR35	75.50	74.99	233.16	293.80	0.18	0.00	7.97	4.18	6.91	4.82
E1-SMX35	E1-SMX30	E1-SMX40	75.90	75.16	10.10	11.80	0.20	0.00	3.93	1.53	3.22	2.00
E1-SMX45	E1-SMX45	E1-SMX40	76.43	75.16	11.21	11.79	0.20	0.00	4.06	1.64	3.57	2.00
E1-SBFR50	E1-SBFR45	E1-SBFR40	75.72	75.50	222.25	236.67	0.18	0.00	7.98	4.64	8.24	4.49
E1-SMX30	E1-SMX25	E1-SMX30	76.31	75.90	5.49	11.79	0.20	0.00	3.51	1.00	1.75	2.00
E1-SMX50	E1-SMX50	E1-SMX45	77.09	76.43	7.43	11.79	0.20	0.00	3.77	1.20	2.37	2.00
E1-SBFR55	E1-SBFR50	E1-SBFR45	75.89	75.72	55.36	117.51	0.13	0.00	4.97	2.23	2.77	4.00
E1-SFR115-OS	E1-SFR115-OS	E1-SBFR45	75.89	75.72	202.47	305.53	0.30	0.00	9.48	3.56	7.45	4.53
E1-SMX55	E1-SMX55	E1-SMX50	77.16	77.09	2.93	11.79	0.20	0.00	2.96	0.70	0.93	2.00
E1-SBFR60	E1-SBFR55	E1-SBFR50	75.93	75.89	22.11	103.06	0.10	0.00	3.57	1.24	1.11	4.00

REV NO.	DATE	BY	REVISION

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Cypress, Texas 77429
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Firm Registration No. F-382

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

SHEET 7 OF 9

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.	APPENDIX NO.
CK: CW	6	12-0IDP5012	C
DRN: ES	STATE	DIST.	COUNTY
APPVD: BV	TEXAS	HOU	HARRIS
CONT.	SECT.	JOB	HIGHWAY NO.
0110	06	139	I-45

6/11/2021 10:21:37 AM

GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Hydraulic Computations

SYSTEM E2												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
E2-NBFR05	E2-NBFR05	E2_OUT	71.26	70.05	372.58	381.67	0.13	0.00	7.84	5.94	11.44	4.07
E2-NMX05	E2-NMX10	E2-NBFR05	71.80	71.26	13.69	14.44	0.30	0.00	4.81	1.70	4.36	2.00
E2-NBFR10	E2-NBFR10	E2-NBFR05	71.85	71.26	351.63	379.31	0.13	0.00	7.89	5.57	8.84	4.97
E2-NMX10	E2-NMX15	E2-NMX10	82.45	81.53	9.84	11.79	0.20	0.00	3.98	1.47	5.42	1.12
E2-NBFR15	E2-NBFR15	E2-NBFR10	72.05	71.85	351.63	364.43	0.12	0.00	7.40	5.94	8.50	5.17
E2-NMX15	E2-NMX20	E2-NMX15	83.91	82.45	5.19	11.79	0.20	0.00	3.45	0.97	2.13	1.45
E2-NBFR20	E2-NBFR20	E2-NBFR15	72.97	72.05	334.50	364.43	0.12	0.00	7.51	5.57	7.98	5.24
E2-NBFR25	E2-NBFR25	E2-NBFR20	73.73	72.97	324.83	332.68	0.10	0.00	6.84	5.94	7.54	5.38
E2-NBFR30	E2-NBFR30	E2-NBFR25	74.34	73.73	302.47	332.68	0.10	0.00	6.79	5.57	6.83	5.54
E2-NBFR35	E2-NBFR35	E2-NBFR30	74.76	74.34	241.49	332.68	0.10	0.00	6.50	4.64	5.44	5.55
E2-NMX45	E2-NMX45	E2-NBFR35	75.35	74.76	23.31	28.28	0.35	0.00	6.04	1.83	4.75	2.50
E2-NBFR40	E2-NBFR40	E2-NBFR35	75.02	74.76	148.46	263.29	0.10	0.00	5.71	3.25	4.34	4.27
E2-NMX40	E2-NMX40	E2-NMX45	76.08	75.35	10.09	11.79	0.20	0.00	3.92	1.53	3.21	2.00
E2-NMX50	E2-NMX50	E2-NMX45	76.74	75.35	11.70	11.80	0.20	0.00	3.82	1.88	3.72	2.00
E2-NBFR45	E2-NBFR45	E2-NBFR40	75.15	75.02	96.20	263.29	0.10	0.00	5.18	2.32	3.05	3.94
E2-NMX35	E2-NMX35	E2-NMX40	76.47	76.08	5.48	11.79	0.20	0.00	3.50	1.00	1.75	2.00
E2-NMX55	E2-NMX55	E2-NMX50	77.35	76.74	7.45	13.62	0.27	0.00	4.14	1.11	2.37	2.00
E2-NBFR50	E2-NBFR50	E2-NBFR45	76.57	75.15	37.77	43.71	0.20	0.00	5.26	1.79	4.72	2.00
E2-NMX60	E2-NMX60	E2-NMX55	77.58	77.35	2.92	11.79	0.20	0.00	2.95	0.70	1.10	1.57

SYSTEM E3												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
E3-NBFR05	E3-NBFR05	OUT_E3	69.03	68.72	182.14	204.18	0.33	0.00	9.50	2.74	9.50	2.74
E3-NMX05	E3-NMX05	E3-NBFR05	69.08	69.03	4.30	11.79	0.20	0.00	3.23	0.88	1.37	2.00
E3-NBFR10	E3-NBFR10	E3-NBFR05	70.28	69.88	180.42	184.53	0.41	0.00	10.29	2.92	10.02	3.00
E3-NBFR15	E3-NBFR15	E3-NBFR10	73.54	70.28	155.35	157.85	0.30	0.00	8.72	2.97	8.63	3.00
E3-NBFR20	E3-NBFR20	E3-NBFR15	75.88	73.54	131.71	135.17	0.22	0.00	7.63	2.88	7.32	3.00
E3-NBFR25	E3-NBFR25	E3-NBFR20	76.92	75.88	100.76	103.91	0.13	0.00	5.65	2.97	5.60	3.00
E3-NBFR30	E3-NBFR30	E3-NBFR25	77.19	76.92	78.69	91.13	0.10	0.00	5.05	2.60	4.37	3.00
E3-NMX20A	E3-NMX25	E3-NBFR25	77.40	76.92	23.31	23.42	0.24	0.00	4.87	2.35	4.75	2.50
E3-NBFR35	E3-NBFR35	E3-NBFR30	78.40	77.19	40.90	54.09	0.20	0.00	5.08	1.61	4.09	2.00
E3-NMX25	E3-NMX20	E3-NMX25	78.18	77.40	10.91	11.79	0.20	0.00	3.95	1.64	3.47	2.00
E3-NMX30	E3-NMX30	E3-NMX25	78.07	77.40	8.24	11.79	0.20	0.00	3.84	1.29	2.62	2.00
E3-NMX20	E3-NMX15	E3-NMX20	78.70	78.18	6.75	11.79	0.20	0.00	3.63	1.14	2.15	2.00
E3-NMX35	E3-NMX35	E3-NMX30	78.27	78.07	4.16	11.79	0.20	0.00	3.27	0.85	1.32	2.00
E3-NMX15	E3-NMX10	E3-NMX15	78.78	78.70	3.38	11.79	0.20	0.00	3.07	0.76	1.07	2.00

REV NO.	DATE	BY	REVISION

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PRELIMINARY
SUBJECT TO CHANGE

CivilTech Engineering, Inc.
11821 Telge Road
Cypress, Texas 77429
PH: (281) 304-0200 - FX: (281) 304-0210
Firm Registration No. F-382

Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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GEOPAK 2013 Drainage (STORM DRAIN DESIGN)
Project Name: NHHIP SEGMENT 1
Job Number: 405011
Project Description: Storm Sewer
Design Frequency: 10 Year
Measurement Unit: English
County: Harris
Conveyance Hydraulic Computations

SYSTEM E4												
ID	Upstream ID	Downstream ID	Upstream HGL (ft)	Downstream HGL (ft)	Discharge (cfs)	Capacity (cfs)	Slope %	Loss (ft)	Uniform		Actual	
									Velocity (ft/s)	Depth (ft)	Velocity (ft/s)	Depth (ft)
E4-SBFR05	E4-SBFR05	OUT_E4	70.76	69.97	326.29	328.78	0.21	0.00	9.16	3.96	9.24	3.92
E4-SMX05	E4-SMX05	E4-SBFR05	70.82	70.76	4.56	18.64	0.50	0.00	4.68	0.70	1.45	2.00
E4-SBFR10	E4-SBFR10	E4-SBFR05	71.71	70.76	307.16	316.11	0.19	0.00	8.90	3.84	8.67	3.93
E4-SBFR15	E4-SBFR15	E4-SBFR10	72.91	71.71	287.41	307.68	0.18	0.00	8.60	3.71	8.22	3.89
E4-SBFR20	E4-SBFR20	E4-SBFR15	73.91	72.91	254.91	261.48	0.13	0.00	7.15	3.96	7.49	3.78
E4-SBFR25	E4-SBFR25	E4-SBFR20	74.16	73.91	217.51	223.78	0.13	0.00	6.87	3.96	7.05	3.85
E4-SBFR30	E4-SBFR30	E4-SBFR25	74.86	74.16	202.90	207.51	0.16	0.00	7.32	3.96	7.51	3.86
E4-SMX20A	E4-SMX25	E4-SBFR25	77.41	76.62	23.31	26.18	0.30	0.00	5.59	1.98	6.81	1.64
E4-SBFR35	E4-SBFR35	E4-SBFR30	75.43	74.86	172.02	179.71	0.12	0.00	6.41	3.84	6.34	3.88
E4-SMX20	E4-SMX20	E4-SMX25	78.07	77.41	10.91	11.79	0.20	0.00	3.95	1.64	3.52	1.92
E4-SMX25	E4-SMX30	E4-SMX25	78.06	77.41	8.24	11.79	0.20	0.00	3.84	1.29	2.66	1.92
E4-SBFR40	E4-SBFR40	E4-SBFR35	77.29	75.43	148.59	157.94	0.20	0.00	7.38	2.88	7.08	3.00
E4-SMX15	E4-SMX15	E4-SMX20	78.79	78.07	6.75	11.79	0.20	0.00	3.63	1.14	2.28	1.79
E4-SMX30	E4-SMX35	E4-SMX30	78.93	78.06	4.16	11.79	0.20	0.00	3.27	0.85	1.81	1.38
E4-SBFR45	E4-SBFR45	E4-SBFR40	78.52	77.29	108.71	111.68	0.10	0.00	5.23	2.97	5.18	3.00
E4-SMX10	E4-SMX10	E4-SMX15	79.32	78.79	3.38	11.79	0.20	0.00	3.07	0.76	1.80	1.15
E4-SBFR50	E4-SBFR50	E4-SBFR45	78.81	78.52	65.63	141.26	0.16	0.00	5.46	1.72	3.13	3.00
E4-SBFR55	E4-SBFR55	E4-SBFR50	78.92	78.81	38.95	111.68	0.10	0.00	4.00	1.39	1.85	3.00

REV NO.	DATE	BY	REVISION

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Texas Department of Transportation

NHHIP SEGMENT 1

I-45
HYDRAULIC DATA SHEET
STORM SEWER
COMPUTATIONS

SHEET 9 OF 9

DSN: CR	FED.RD. DIV.NO.	CONTRACT NO.		APPENDIX NO.
CK: CW	6	12-01DP5012		C
DRN: ES	STATE	DIST.	COUNTY	
APPVD: BV	TEXAS	HOU	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0110	06	139	I-45	

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Appendix D

Drainage Crossing Analysis Supporting Data

- HEC-RAS Results
    - Halls Bayou Crossing Analysis – 10 Year Event
    - Halls Bayou Crossing Analysis – 50 Year Event
    - Halls Bayou Crossing Analysis – 100 Year Event
    - Halls Bayou Crossing Analysis – 500 Year Event

HEC-RAS Results

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
104245	679	679	0	96.79	96.75	-0.04	2.2	2.3	0.0
103601	715	715	0	96.51	96.47	-0.04	2.3	2.3	0.0
103446	715	715	0	96.43	96.40	-0.03	2.5	2.3	-0.2
103392	715	715	0	96.17	96.16	-0.01	2.5	2.3	-0.2
102844	749	749	0	95.84	95.84	0.00	2.7	2.7	0.0
102450	749	749	0	95.61	95.61	0.00	2.6	2.6	0.0
102169	783	783	0	95.42	95.42	0.00	2.8	2.8	0.0
102115	783	783	0	95.29	95.29	0.00	2.8	2.8	0.0
101526	838	838	0	94.83	94.83	0.00	3.0	3.0	0.0
100545	899	899	0	93.86	93.86	0.00	3.3	3.3	0.0
99524.3	940	940	0	92.61	92.61	0.00	3.6	3.6	0.0
98862.7	972	972	0	92.06	92.06	0.00	2.9	2.9	0.0
98434.7	1,024	1,024	0	91.80	91.80	0.00	2.5	2.5	0.0
98376.7	1,024	1,024	0	91.56	91.56	0.00	2.5	2.5	0.0
97617.6	1,106	1,106	0	89.46	89.46	0.00	6.7	6.7	0.0
96497.8	1,204	1,204	0	88.90	88.90	0.00	2.2	2.2	0.0
95272.1	1,291	1,291	0	88.59	88.59	0.00	1.8	1.8	0.0
94253.5	1,370	1,370	0	88.08	88.08	0.00	2.2	2.2	0.0
93387.8	1,435	1,435	0	87.49	87.49	0.00	0.7	0.7	0.0
93247.3	1,435	1,435	0	87.40	87.40	0.00	0.6	0.6	0.0
93213.9	1,435	1,435	0	87.30	87.30	0.00	0.6	0.6	0.0
92719.1	1,540	1,540	0	86.88	86.88	0.00	1.1	1.1	0.0
91689.3	1,611	1,611	0	85.94	85.94	0.00	1.1	1.1	0.0
91029.5	1,716	1,716	0	85.43	85.43	0.00	1.3	1.3	0.0
90112.3	1,811	1,811	0	84.84	84.84	0.00	1.1	1.1	0.0
89332.1	1,906	1,906	0	84.37	84.37	0.00	0.9	0.9	0.0
88590.5	2,063	2,063	0	84.31	84.31	0.00	0.4	0.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
87434.8	2,186	2,186	0	83.98	83.98	0.00	1.0	1.0	0.0
86591.9	2,263	2,263	0	83.32	83.31	-0.01	1.5	1.5	0.0
86213.8	2,347	2,347	0	83.17	83.16	-0.01	1.5	1.5	0.0
86159.8	2,347	2,347	0	83.06	83.05	-0.01	1.4	1.4	0.0
86145.4	2,347	2,347	0	83.04	83.03	-0.01	2.1	2.1	0.0
86091.4	2,347	2,347	0	83.00	82.99	-0.01	2.0	2.0	0.0
85559.7	2,508	2,508	0	82.83	82.82	-0.01	1.3	1.4	0.0
84594.2	3,634	3,634	0	82.05	82.01	-0.04	1.9	1.9	0.1
83685.6	3,634	3,634	0	81.61	81.55	-0.06	1.4	1.4	0.1
83450.7	4,153	4,153	0	81.54	81.48	-0.06	1.0	1.0	0.0
83398.7	4,153	4,153	0	81.51	81.45	-0.06	1.0	1.1	0.0
83108.1	4,153	4,153	0	81.37	81.28	-0.09	0.8	0.9	0.1
82744.1	4,153	4,153	0	81.01	80.74	-0.27	1.3	1.6	0.4
81851.2	4,153	4,153	0	80.79	80.24	-0.55	0.5	0.7	0.2
81268.8	4,153	4,153	0	80.70	80.02	-0.68	0.4	0.7	0.2
81023.3	4,153	4,153	0	80.64	79.90	-0.74	0.6	0.9	0.2
80971.3	4,153	4,153	0	80.60	79.82	-0.78	0.6	0.8	0.2
80695	4,153	4,153	0	80.52	79.60	-0.92	0.8	1.2	0.4
80155	see note	4,153	see note	see note	79.57	see note	see note	1.4	see note
79975	see note	4,153	see note	see note	79.36	see note	see note	1.6	see note
79960	see note	4,153	see note	see note	79.37	see note	see note	1.5	see note
79578	see note	4,153	see note	see note	79.31	see note	see note	1.4	see note
79572	see note	4,153	see note	see note	79.29	see note	see note	1.7	see note
79482	see note	4,153	see note	see note	79.09	see note	see note	1.8	see note
79462	4,153	4,153	0	78.83	78.84	0.01	3.9	3.8	-0.1
79459	4,153	4,153	0	78.79	78.79	0.00	3.9	3.9	0.0
79432	4,153	4,153	0	78.78	78.78	0.00	3.0	3.0	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
79206	4,153	4,153	0	78.61	78.61	0.00	2.5	2.5	0.0
78762	4,153	4,153	0	78.54	78.54	0.00	1.0	1.0	0.0
78747	4,153	4,153	0	78.50	78.50	0.00	1.0	1.0	0.0
78738	4,153	4,153	0	78.46	78.46	0.00	1.0	1.0	0.0
78666	4,153	4,153	0	78.31	78.31	0.00	1.0	1.0	0.0
77938.5	4,153	4,153	0	78.14	78.14	0.00	0.8	0.8	0.0
77884.5	4,153	4,153	0	78.05	78.05	0.00	0.7	0.7	0.0
77869.4	4,153	4,153	0	77.97	77.97	0.00	0.8	0.8	0.0
77441.3	4,153	4,153	0	77.85	77.85	0.00	0.8	0.8	0.0
76394.4	4,153	4,153	0	77.40	77.40	0.00	0.9	0.9	0.0
75489.4	4,153	4,153	0	76.77	76.77	0.00	1.3	1.3	0.0
74253.7	4,153	4,153	0	75.89	75.89	0.00	1.5	1.5	0.0
73879.2	4,153	4,153	0	75.56	75.56	0.00	2.1	2.1	0.0
73423.3	4,484	4,484	0	75.18	75.18	0.00	2.6	2.6	0.0
73332.3	4,484	4,484	0	75.23	75.23	0.00	2.1	2.1	0.0
72405.2	4,484	4,484	0	74.71	74.71	0.00	2.1	2.1	0.0
71854.2	4,484	4,484	0	74.36	74.36	0.00	1.6	1.6	0.0
70744.2	4,484	4,484	0	73.08	73.08	0.00	1.7	1.7	0.0
69527.2	4,484	4,484	0	72.66	72.66	0.00	1.5	1.5	0.0
68131	4,484	4,484	0	72.11	72.11	0.00	1.1	1.1	0.0
67511.6	4,484	4,484	0	71.86	71.86	0.00	0.8	0.8	0.0
65955.8	4,484	4,484	0	71.63	71.63	0.00	0.3	0.3	0.0
65434.6	4,484	4,484	0	71.17	71.17	0.00	1.8	1.8	0.0
64273.7	5,125	5,125	0	70.64	70.64	0.00	2.3	2.3	0.0
64220.7	5,125	5,125	0	70.42	70.42	0.00	2.3	2.3	0.0
64094	5,125	5,125	0	70.39	70.39	0.00	2.8	2.8	0.0
64024	5,125	5,125	0	70.32	70.32	0.00	2.9	2.9	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
64010.4	5,125	5,125	0	70.07	70.07	0.00	4.1	4.1	0.0
63960.4	5,125	5,125	0	69.50	69.50	0.00	4.6	4.6	0.0
63959.7	5,125	5,125	0	69.61	69.61	0.00	3.2	3.2	0.0
63856.7	5,125	5,125	0	69.44	69.44	0.00	3.2	3.2	0.0
62823.2	5,125	5,125	0	68.98	68.98	0.00	1.4	1.4	0.0
61905.2	5,125	5,125	0	68.20	68.20	0.00	2.0	2.0	0.0
60625.3	5,371	5,371	0	67.19	67.19	0.00	2.7	2.7	0.0
59423.1	5,371	5,371	0	65.88	65.88	0.00	4.7	4.7	0.0
58613.7	5,371	5,371	0	65.70	65.70	0.00	2.4	2.4	0.0
58387.5	5,371	5,371	0	65.57	65.57	0.00	3.8	3.8	0.0
58331.5	5,371	5,371	0	65.47	65.47	0.00	3.9	3.9	0.0
57555.5	5,371	5,371	0	64.94	64.94	0.00	2.1	2.1	0.0
56513.3	5,371	5,371	0	64.14	64.14	0.00	4.4	4.4	0.0
55557.7	5,597	5,597	0	62.97	62.97	0.00	4.8	4.8	0.0
54459.2	5,597	5,597	0	61.57	61.57	0.00	6.6	6.6	0.0
53801.7	5,597	5,597	0	61.59	61.59	0.00	3.3	3.3	0.0
53275.7	5,597	5,597	0	61.41	61.41	0.00	3.6	3.6	0.0
52844.3	5,597	5,597	0	61.33	61.33	0.00	3.2	3.2	0.0
52786.3	5,597	5,597	0	61.27	61.27	0.00	3.2	3.2	0.0
52465.7	5,597	5,597	0	61.06	61.06	0.00	3.9	3.9	0.0
52221.3	5,597	5,597	0	60.87	60.87	0.00	4.4	4.4	0.0
52194.3	5,597	5,597	0	60.83	60.83	0.00	4.3	4.3	0.0
51283.9	5,597	5,597	0	60.24	60.24	0.00	3.7	3.7	0.0
51096.9	5,835	5,835	0	60.14	60.14	0.00	3.4	3.4	0.0
51070.9	5,835	5,835	0	60.11	60.11	0.00	3.4	3.4	0.0
50549.6	5,835	5,835	0	59.95	59.95	0.00	2.7	2.7	0.0
50021.9	5,835	5,835	0	59.80	59.80	0.00	1.9	1.9	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

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	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
49939.9	5,835	5,835	0	59.80	59.80	0.00	1.7	1.7	0.0
49231.7	5,835	5,835	0	59.44	59.44	0.00	1.8	1.8	0.0
48480.5	5,835	5,835	0	59.21	59.21	0.00	1.3	1.3	0.0
48196.5	5,835	5,835	0	59.13	59.13	0.00	1.2	1.2	0.0
48169.5	5,835	5,835	0	59.07	59.07	0.00	1.2	1.2	0.0
47607.9	5,835	5,835	0	58.85	58.85	0.00	1.1	1.1	0.0
46939	5,835	5,835	0	58.72	58.72	0.00	0.8	0.8	0.0
46594.8	5,969	5,969	0	58.47	58.47	0.00	3.7	3.7	0.0
46526.8	5,969	5,969	0	58.32	58.32	0.00	3.7	3.7	0.0
46499.9	5,969	5,969	0	58.27	58.27	0.00	3.9	3.9	0.0
46478.9	5,969	5,969	0	58.22	58.22	0.00	3.9	3.9	0.0
45952.3	5,969	5,969	0	58.10	58.10	0.00	0.8	0.8	0.0
45161.4	5,969	5,969	0	57.82	57.82	0.00	0.7	0.7	0.0
44549.9	5,969	5,969	0	57.65	57.65	0.00	0.7	0.7	0.0
44143.3	6,604	6,604	0	57.55	57.55	0.00	0.7	0.7	0.0
43215.5	6,604	6,604	0	57.42	57.42	0.00	0.6	0.6	0.0
42471	6,604	6,604	0	57.30	57.30	0.00	0.7	0.7	0.0
41863.8	6,604	6,604	0	57.17	57.17	0.00	0.8	0.8	0.0
41285.4	6,604	6,604	0	57.08	57.08	0.00	0.9	0.9	0.0
41202.4	6,604	6,604	0	56.91	56.91	0.00	1.0	1.0	0.0
41185.7	6,604	6,604	0	56.86	56.86	0.00	0.8	0.8	0.0
40951.8	6,604	6,604	0	56.73	56.73	0.00	1.1	1.1	0.0
40886.8	6,604	6,604	0	56.62	56.62	0.00	1.1	1.1	0.0
40846.9	6,604	6,604	0	56.62	56.62	0.00	1.1	1.1	0.0
40605.5	6,604	6,604	0	56.47	56.47	0.00	1.1	1.1	0.0
40584.6	6,604	6,604	0	56.39	56.39	0.00	1.3	1.3	0.0
40515.6	6,604	6,604	0	56.26	56.26	0.00	1.2	1.2	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
39969.8	6,604	6,604	0	56.04	56.04	0.00	1.0	1.0	0.0
39188.6	6,604	6,604	0	55.58	55.58	0.00	1.0	1.0	0.0
38170.2	6,604	6,604	0	55.17	55.17	0.00	1.2	1.2	0.0
37258.6	6,604	6,604	0	54.65	54.65	0.00	1.6	1.6	0.0
36107.2	7,578	7,578	0	54.06	54.06	0.00	2.2	2.2	0.0
35434.7	7,578	7,578	0	53.76	53.76	0.00	3.3	3.3	0.0
35045.7	7,578	7,578	0	53.59	53.59	0.00	3.9	3.9	0.0
35006.1	7,578	7,578	0	53.31	53.31	0.00	3.8	3.8	0.0
34984.3	7,578	7,578	0	53.25	53.25	0.00	3.7	3.7	0.0
34870.3	7,578	7,578	0	52.62	52.62	0.00	3.7	3.7	0.0
33920.1	7,578	7,578	0	51.55	51.55	0.00	4.2	4.2	0.0
32749.8	7,578	7,578	0	49.96	49.96	0.00	5.1	5.1	0.0
31824.3	7,578	7,578	0	49.02	49.02	0.00	4.3	4.3	0.0
30679.1	7,578	7,578	0	47.87	47.87	0.00	4.8	4.8	0.0
30099.1	7,578	7,578	0	47.58	47.58	0.00	3.7	3.7	0.0
29757.8	8,019	8,019	0	47.27	47.27	0.00	4.7	4.7	0.0
29704.8	8,019	8,019	0	47.12	47.12	0.00	4.6	4.6	0.0
28983.7	8,019	8,019	0	45.94	45.94	0.00	6.3	6.3	0.0
28387.3	8019	8019	0	45.64	45.64	0.00	3.9	3.9	0.0
27992	8019	8019	0	45.30	45.30	0.00	3.2	3.2	0.0
27567.7	8019	8019	0	45.02	45.02	0.00	3.5	3.5	0.0
27317	8019	8019	0	44.82	44.82	0.00	4.3	4.3	0.0
27304.8	8019	8019	0	44.74	44.74	0.00	4.3	4.3	0.0
27180.8	8019	8019	0	44.50	44.50	0.00	4.4	4.4	0.0
27167.5	8019	8019	0	44.51	44.51	0.00	4.1	4.1	0.0
26466.1	8019	8019	0	44.01	44.01	0.00	4.4	4.4	0.0
25982.8	8019	8019	0	43.70	43.70	0.00	4.1	4.1	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
25318.4	8019	8019	0	43.23	43.23	0.00	4.0	4.0	0.0
24564.2	8019	8019	0	42.76	42.76	0.00	4.1	4.1	0.0
23984.6	8019	8019	0	42.52	42.52	0.00	2.9	2.9	0.0
23286.2	8041	8041	0	42.11	42.11	0.00	4.2	4.2	0.0
22973.4	8285	8285	0	41.94	41.94	0.00	4.1	4.1	0.0
22929.4	8285	8285	0	41.50	41.50	0.00	4.1	4.1	0.0
22630.3	8285	8285	0	40.92	40.92	0.00	5.8	5.8	0.0
22587.7	8285	8285	0	40.51	40.51	0.00	6.0	6.0	0.0
22186.8	8285	8285	0	40.17	40.17	0.00	5.1	5.1	0.0
21829	8285	8285	0	40.13	40.13	0.00	3.5	3.5	0.0
21589.8	8285	8285	0	39.85	39.85	0.00	4.1	4.1	0.0
21362	8285	8285	0	39.66	39.66	0.00	4.7	4.7	0.0
21304	8285	8285	0	39.51	39.51	0.00	4.7	4.7	0.0
21010.4	8285	8285	0	39.43	39.43	0.00	3.0	3.0	0.0
20887.4	8285	8285	0	39.21	39.21	0.00	3.1	3.1	0.0
20880.6	8285	8285	0	38.94	38.94	0.00	3.8	3.8	0.0
20858.6	8285	8285	0	38.89	38.89	0.00	3.8	3.8	0.0
19860	8506	8506	0	37.31	37.31	0.00	6.4	6.4	0.0
18597.4	8506	8506	0	35.81	35.81	0.00	4.9	4.9	0.0
18107.1	8506	8506	0	35.48	35.48	0.00	4.5	4.5	0.0
17130.3	8599	8599	0	35.05	35.05	0.00	3.7	3.7	0.0
16004	8857	8857	0	34.53	34.53	0.00	3.9	3.9	0.0
15045.6	8857	8857	0	33.82	33.82	0.00	4.7	4.7	0.0
13937.2	8857	8857	0	33.16	33.16	0.00	3.0	3.0	0.0
13341.9	8857	8857	0	32.61	32.61	0.00	3.6	3.6	0.0
12945.5	9031	9031	0	32.16	32.16	0.00	4.5	4.5	0.0
12931.7	9031	9031	0	32.01	32.01	0.00	4.9	4.9	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
12877.9	9031	9031	0	31.10	31.10	0.00	4.9	4.9	0.0
12117.3	9031	9031	0	30.83	30.83	0.00	3.5	3.5	0.0
10905.1	9218	9218	0	29.99	29.99	0.00	4.5	4.5	0.0
9879.2	9218	9218	0	28.77	28.77	0.00	4.6	4.6	0.0
8777	9491	9491	0	28.45	28.45	0.00	1.8	1.8	0.0
8024.4	9491	9491	0	28.10	28.10	0.00	2.5	2.5	0.0
6779.3	9491	9491	0	27.39	27.39	0.00	3.3	3.3	0.0
5748.4	9690	9690	0	25.96	25.96	0.00	4.6	4.6	0.0
4492	9690	9690	0	24.95	24.95	0.00	4.2	4.2	0.0
3597.9	9966	9966	0	24.18	24.18	0.00	3.4	3.4	0.0
2709.4	9966	9966	0	23.37	23.37	0.00	3.1	3.1	0.0
1695.9	9966	9966	0	22.19	22.19	0.00	3.7	3.7	0.0
678.7	9966	9966	0	19.75	19.75	0.00	7.1	7.1	0.0

1. Cross sections added surrounding the proposed I-45 bridge

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
104245	1,007	1,007	0	98.25	98.20	-0.05	2.6	2.6	0.0
103601	1,061	1,061	0	97.95	97.88	-0.07	2.5	2.5	0.0
103446	1,061	1,061	0	97.86	97.82	-0.04	2.1	2.0	-0.2
103392	1,061	1,061	0	97.71	97.70	-0.01	2.0	1.9	-0.2
102844	1,112	1,112	0	97.34	97.34	0.00	3.0	3.0	0.0
102450	1,112	1,112	0	97.09	97.09	0.00	2.9	2.9	0.0
102169	1,162	1,162	0	96.89	96.89	0.00	3.0	3.0	0.0
102115	1,162	1,162	0	96.71	96.71	0.00	3.1	3.1	0.0
101526	1,243	1,243	0	96.22	96.22	0.00	3.4	3.4	0.0
100545	1,333	1,333	0	95.29	95.29	0.00	3.6	3.6	0.0
99524.3	1,396	1,396	0	94.00	94.00	0.00	4.1	4.1	0.0
98862.7	1,443	1,443	0	93.40	93.40	0.00	3.4	3.4	0.0
98434.7	1,520	1,520	0	93.17	93.17	0.00	2.7	2.7	0.0
98376.7	1,520	1,520	0	92.94	92.94	0.00	2.7	2.7	0.0
97617.6	1,642	1,642	0	90.46	90.46	0.00	7.7	7.7	0.0
96497.8	1,787	1,787	0	89.83	89.83	0.00	2.7	2.7	0.0
95272.1	1,917	1,917	0	89.36	89.36	0.00	2.4	2.4	0.0
94253.5	2,034	2,034	0	88.57	88.57	0.00	2.0	2.0	0.0
93387.8	2,130	2,130	0	88.01	88.01	0.00	0.5	0.5	0.0
93247.3	2,130	2,130	0	87.94	87.94	0.00	0.5	0.5	0.0
93213.9	2,130	2,130	0	87.87	87.87	0.00	0.5	0.5	0.0
92719.1	2,286	2,286	0	87.45	87.45	0.00	0.8	0.8	0.0
91689.3	2,393	2,393	0	86.56	86.56	0.00	0.8	0.8	0.0
91029.5	2,549	2,549	0	85.99	85.99	0.00	1.0	1.0	0.0
90112.3	2,689	2,689	0	85.54	85.54	0.00	0.7	0.7	0.0
89332.1	2,830	2,830	0	85.26	85.26	0.00	0.6	0.6	0.0
88590.5	3,064	3,064	0	85.19	85.18	-0.01	0.4	0.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
87434.8	3,247	3,247	0	84.90	84.89	-0.01	0.9	0.9	0.0
86591.9	3,361	3,361	0	84.21	84.19	-0.02	1.4	1.4	0.0
86213.8	3,486	3,486	0	84.02	83.99	-0.03	1.6	1.6	0.0
86159.8	3,486	3,486	0	83.96	83.92	-0.04	1.5	1.5	0.0
86145.4	3,486	3,486	0	83.88	83.85	-0.03	2.3	2.3	0.0
86091.4	3,486	3,486	0	83.80	83.76	-0.04	2.2	2.2	0.0
85559.7	3,726	3,726	0	83.60	83.56	-0.04	1.2	1.3	0.0
84594.2	5,268	5,268	0	82.87	82.72	-0.15	1.5	1.7	0.1
83685.6	5,268	5,268	0	82.38	82.03	-0.35	1.1	1.4	0.3
83450.7	5,617	5,617	0	82.33	81.96	-0.37	1.0	1.1	0.2
83398.7	5,617	5,617	0	82.18	81.94	-0.24	1.0	1.1	0.1
83108.1	5,617	5,617	0	82.09	81.82	-0.27	0.7	0.8	0.1
82744.1	5,617	5,617	0	81.91	81.41	-0.50	0.8	1.1	0.4
81851.2	5,617	5,617	0	81.78	81.15	-0.63	0.4	0.6	0.1
81268.8	5,617	5,617	0	81.72	81.04	-0.68	0.4	0.5	0.1
81023.3	5,617	5,617	0	81.67	80.94	-0.73	0.6	0.8	0.2
80971.3	5,617	5,617	0	81.64	80.89	-0.75	0.6	0.7	0.1
80695	5,617	5,617	0	81.61	80.77	-0.84	0.3	1.0	0.6
80155	see note	5,617	see note	see note	80.73	see note	see note	1.5	see note
79975	see note	5,617	see note	see note	80.33	see note	see note	1.7	see note
79960	see note	5,617	see note	see note	80.34	see note	see note	1.7	see note
79578	see note	5,617	see note	see note	80.28	see note	see note	1.6	see note
79572	see note	5,617	see note	see note	80.25	see note	see note	2.0	see note
79482	see note	5,617	see note	see note	79.85	see note	see note	2.2	see note
79462	5,617	5,617	0	79.51	79.53	0.02	4.6	4.4	-0.2
79459	5,617	5,617	0	79.45	79.45	0.00	4.7	4.7	0.0
79432	5,617	5,617	0	79.42	79.42	0.00	3.5	3.5	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
79206	5,617	5,617	0	79.21	79.21	0.00	2.9	2.9	0.0
78762	5,617	5,617	0	79.16	79.16	0.00	1.0	1.0	0.0
78747	5,617	5,617	0	79.10	79.10	0.00	1.0	1.0	0.0
78738	5,617	5,617	0	79.07	79.07	0.00	1.0	1.0	0.0
78666	5,617	5,617	0	78.95	78.95	0.00	1.0	1.0	0.0
77938.5	5,617	5,617	0	78.78	78.78	0.00	0.8	0.8	0.0
77884.5	5,617	5,617	0	78.73	78.73	0.00	0.7	0.7	0.0
77869.4	5,617	5,617	0	78.65	78.65	0.00	0.8	0.8	0.0
77441.3	5,617	5,617	0	78.52	78.52	0.00	0.7	0.7	0.0
76394.4	5,617	5,617	0	78.11	78.11	0.00	0.8	0.8	0.0
75489.4	5,617	5,617	0	77.66	77.66	0.00	0.9	0.9	0.0
74253.7	5,617	5,617	0	77.01	77.01	0.00	1.0	1.0	0.0
73879.2	5,617	5,617	0	76.74	76.74	0.00	1.3	1.3	0.0
73423.3	5,828	5,828	0	76.52	76.52	0.00	1.1	1.1	0.0
73332.3	5,828	5,828	0	76.10	76.10	0.00	1.3	1.3	0.0
72405.2	5,828	5,828	0	75.47	75.47	0.00	1.8	1.8	0.0
71854.2	5,828	5,828	0	75.13	75.13	0.00	1.3	1.3	0.0
70744.2	5,828	5,828	0	73.98	73.98	0.00	1.3	1.3	0.0
69527.2	5,828	5,828	0	73.57	73.57	0.00	1.0	1.0	0.0
68131	5,828	5,828	0	73.18	73.18	0.00	0.7	0.7	0.0
67511.6	5,840	5,840	0	73.08	73.08	0.00	0.5	0.5	0.0
65955.8	5,852	5,852	0	72.98	72.98	0.00	0.2	0.2	0.0
65434.6	5,852	5,852	0	72.67	72.67	0.00	1.2	1.2	0.0
64273.7	6,788	6,788	0	72.16	72.16	0.00	2.3	2.3	0.0
64220.7	6,788	6,788	0	71.94	71.94	0.00	2.3	2.3	0.0
64094	6,788	6,788	0	71.90	71.90	0.00	3.2	3.2	0.0
64024	6,788	6,788	0	71.79	71.79	0.00	3.2	3.2	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
64010.4	6,788	6,788	0	71.47	71.47	0.00	4.6	4.6	0.0
63960.4	6,788	6,788	0	70.37	70.37	0.00	5.4	5.4	0.0
63959.7	6,788	6,788	0	70.53	70.53	0.00	3.8	3.8	0.0
63856.7	6,788	6,788	0	70.32	70.32	0.00	3.9	3.9	0.0
62823.2	6,788	6,788	0	69.93	69.93	0.00	1.2	1.2	0.0
61905.2	6,788	6,788	0	69.30	69.30	0.00	1.3	1.3	0.0
60625.3	7,004	7,004	0	68.45	68.45	0.00	1.5	1.5	0.0
59423.1	7,004	7,004	0	67.19	67.19	0.00	2.5	2.5	0.0
58613.7	7,004	7,004	0	67.06	67.06	0.00	1.5	1.5	0.0
58387.5	7,004	7,004	0	66.94	66.94	0.00	1.6	1.6	0.0
58331.5	7,004	7,004	0	66.74	66.74	0.00	1.8	1.8	0.0
57555.5	7,004	7,004	0	66.41	66.41	0.00	1.2	1.2	0.0
56513.3	7,004	7,004	0	65.56	65.56	0.00	2.5	2.5	0.0
55557.7	7,200	7,200	0	64.50	64.50	0.00	2.5	2.5	0.0
54459.2	7,200	7,200	0	62.86	62.86	0.00	5.6	5.6	0.0
53801.7	7,200	7,200	0	62.93	62.93	0.00	2.8	2.8	0.0
53275.7	7,200	7,200	0	62.70	62.70	0.00	3.2	3.2	0.0
52844.3	7,200	7,200	0	62.61	62.61	0.00	3.6	3.6	0.0
52786.3	7,200	7,200	0	62.47	62.47	0.00	3.6	3.6	0.0
52465.7	7,200	7,200	0	62.25	62.25	0.00	3.0	3.0	0.0
52221.3	7,200	7,200	0	62.04	62.04	0.00	3.4	3.4	0.0
52194.3	7,200	7,200	0	61.90	61.90	0.00	3.6	3.6	0.0
51283.9	7,200	7,200	0	61.31	61.31	0.00	1.9	1.9	0.0
51096.9	7,404	7,404	0	61.20	61.20	0.00	1.7	1.7	0.0
51070.9	7,404	7,404	0	60.86	60.86	0.00	2.4	2.4	0.0
50549.6	7,404	7,404	0	60.69	60.69	0.00	1.8	1.8	0.0
50021.9	7,404	7,404	0	60.55	60.55	0.00	1.2	1.2	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
49939.9	7,404	7,404	0	60.41	60.41	0.00	1.2	1.2	0.0
49231.7	7,404	7,404	0	60.09	60.09	0.00	1.1	1.1	0.0
48480.5	7,404	7,404	0	59.84	59.84	0.00	1.0	1.0	0.0
48196.5	7,404	7,404	0	59.76	59.76	0.00	0.9	0.9	0.0
48169.5	7,404	7,404	0	59.67	59.67	0.00	0.9	0.9	0.0
47607.9	7,404	7,404	0	59.48	59.48	0.00	0.9	0.9	0.0
46939	7,404	7,404	0	59.33	59.33	0.00	0.7	0.7	0.0
46594.8	7,517	7,517	0	59.27	59.27	0.00	0.6	0.6	0.0
46526.8	7,517	7,517	0	59.27	59.27	0.00	0.5	0.5	0.0
46499.9	7,517	7,517	0	59.21	59.21	0.00	0.6	0.6	0.0
46478.9	7,517	7,517	0	59.16	59.16	0.00	0.6	0.6	0.0
45952.3	7,517	7,517	0	59.06	59.06	0.00	0.6	0.6	0.0
45161.4	7,517	7,517	0	58.87	58.87	0.00	0.6	0.6	0.0
44549.9	7,517	7,517	0	58.74	58.74	0.00	0.6	0.6	0.0
44143.3	8,703	8,703	0	58.66	58.66	0.00	0.6	0.6	0.0
43215.5	8,703	8,703	0	58.55	58.55	0.00	0.5	0.5	0.0
42471	8,703	8,703	0	58.45	58.45	0.00	0.6	0.6	0.0
41863.8	8,703	8,703	0	58.34	58.34	0.00	0.8	0.8	0.0
41285.4	8,703	8,703	0	58.26	58.26	0.00	0.8	0.8	0.0
41202.4	8,703	8,703	0	57.92	57.92	0.00	0.9	0.9	0.0
41185.7	8,703	8,703	0	57.86	57.86	0.00	0.8	0.8	0.0
40951.8	8,703	8,703	0	57.73	57.73	0.00	1.1	1.1	0.0
40886.8	8,703	8,703	0	57.61	57.61	0.00	1.1	1.1	0.0
40846.9	8,703	8,703	0	57.61	57.61	0.00	1.1	1.1	0.0
40605.5	8,703	8,703	0	57.45	57.45	0.00	1.2	1.2	0.0
40584.6	8,703	8,703	0	57.39	57.39	0.00	1.2	1.2	0.0
40515.6	8,703	8,703	0	57.27	57.27	0.00	1.2	1.2	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
39969.8	8,703	8,703	0	57.11	57.11	0.00	0.9	0.9	0.0
39188.6	8,703	8,703	0	56.84	56.84	0.00	0.7	0.7	0.0
38170.2	8,703	8,703	0	56.51	56.51	0.00	0.9	0.9	0.0
37258.6	8,703	8,703	0	56.16	56.16	0.00	1.1	1.1	0.0
36107.2	9,853	9,853	0	55.61	55.61	0.00	1.6	1.6	0.0
35434.7	9,853	9,853	0	55.21	55.21	0.00	3.3	3.3	0.0
35045.7	9,853	9,853	0	54.96	54.96	0.00	4.6	4.6	0.0
35006.1	9,853	9,853	0	54.64	54.64	0.00	4.5	4.5	0.0
34984.3	9,853	9,853	0	54.58	54.58	0.00	4.3	4.3	0.0
34870.3	9,853	9,853	0	54.26	54.26	0.00	4.1	4.1	0.0
33920.1	9,853	9,853	0	53.38	53.38	0.00	2.6	2.6	0.0
32749.8	9,853	9,853	0	52.05	52.05	0.00	3.1	3.1	0.0
31824.3	9,853	9,853	0	51.23	51.23	0.00	3.0	3.0	0.0
30679.1	9,853	9,853	0	50.13	50.13	0.00	3.6	3.6	0.0
30099.1	9,853	9,853	0	49.84	49.84	0.00	3.1	3.1	0.0
29757.8	10,614	10,614	0	49.54	49.54	0.00	3.2	3.2	0.0
29704.8	10,614	10,614	0	49.56	49.56	0.00	2.8	2.8	0.0
28983.7	10,614	10,614	0	48.28	48.28	0.00	5.8	5.8	0.0
28387.3	10614	10614	0	48.04	48.04	0.00	4.0	4.0	0.0
27992	10614	10614	0	47.77	47.77	0.00	3.0	3.0	0.0
27567.7	10614	10614	0	47.46	47.46	0.00	3.2	3.2	0.0
27317	10614	10614	0	47.19	47.19	0.00	3.6	3.6	0.0
27304.8	10614	10614	0	47.08	47.08	0.00	3.7	3.7	0.0
27180.8	10614	10614	0	46.96	46.96	0.00	3.9	3.9	0.0
27167.5	10614	10614	0	46.97	46.97	0.00	3.7	3.7	0.0
26466.1	10614	10614	0	46.50	46.50	0.00	4.4	4.4	0.0
25982.8	10614	10614	0	46.20	46.20	0.00	4.2	4.2	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
25318.4	10614	10614	0	45.77	45.77	0.00	4.0	4.0	0.0
24564.2	10614	10614	0	45.30	45.30	0.00	4.2	4.2	0.0
23984.6	10614	10614	0	45.10	45.10	0.00	2.6	2.6	0.0
23286.2	10652	10652	0	44.70	44.70	0.00	4.0	4.0	0.0
22973.4	11049	11049	0	44.53	44.53	0.00	4.4	4.4	0.0
22929.4	11049	11049	0	44.08	44.08	0.00	4.5	4.5	0.0
22630.3	11049	11049	0	43.46	43.46	0.00	6.3	6.3	0.0
22587.7	11049	11049	0	43.01	43.01	0.00	6.4	6.4	0.0
22186.8	11049	11049	0	42.65	42.65	0.00	5.1	5.1	0.0
21829	11049	11049	0	42.65	42.65	0.00	3.8	3.8	0.0
21589.8	11049	11049	0	42.32	42.32	0.00	4.3	4.3	0.0
21362	11049	11049	0	42.10	42.10	0.00	5.0	5.0	0.0
21304	11049	11049	0	41.93	41.93	0.00	5.1	5.1	0.0
21010.4	11049	11049	0	41.85	41.85	0.00	3.3	3.3	0.0
20887.4	11049	11049	0	41.61	41.61	0.00	3.4	3.4	0.0
20880.6	11049	11049	0	41.32	41.32	0.00	4.0	4.0	0.0
20858.6	11049	11049	0	41.28	41.28	0.00	4.1	4.1	0.0
19860	11409	11409	0	39.71	39.71	0.00	5.9	5.9	0.0
18597.4	11409	11409	0	38.20	38.20	0.00	5.2	5.2	0.0
18107.1	11409	11409	0	37.92	37.92	0.00	4.8	4.8	0.0
17130.3	11560	11560	0	37.44	37.44	0.00	4.2	4.2	0.0
16004	11985	11985	0	36.89	36.89	0.00	4.4	4.4	0.0
15045.6	11985	11985	0	36.09	36.09	0.00	5.3	5.3	0.0
13937.2	11985	11985	0	35.37	35.37	0.00	3.1	3.1	0.0
13341.9	11985	11985	0	34.74	34.74	0.00	3.9	3.9	0.0
12945.5	12274	12274	0	34.16	34.16	0.00	4.9	4.9	0.0
12931.7	12274	12274	0	33.93	33.93	0.00	5.4	5.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
12877.9	12274	12274	0	33.81	33.81	0.00	5.1	5.1	0.0
12117.3	12274	12274	0	33.54	33.54	0.00	3.8	3.8	0.0
10905.1	12584	12584	0	32.61	32.61	0.00	4.9	4.9	0.0
9879.2	12584	12584	0	31.26	31.26	0.00	5.0	5.0	0.0
8777	13040	13040	0	31.10	31.10	0.00	1.8	1.8	0.0
8024.4	13040	13040	0	30.70	30.70	0.00	2.7	2.7	0.0
6779.3	13040	13040	0	29.99	29.99	0.00	3.2	3.2	0.0
5748.4	13373	13373	0	28.52	28.52	0.00	4.5	4.5	0.0
4492	13373	13373	0	27.51	27.51	0.00	4.3	4.3	0.0
3597.9	13840	13840	0	26.76	26.76	0.00	3.5	3.5	0.0
2709.4	13840	13840	0	25.94	25.94	0.00	3.3	3.3	0.0
1695.9	13840	13840	0	24.68	24.68	0.00	3.9	3.9	0.0
678.7	13840	13840	0	22.05	22.05	0.00	7.2	7.2	0.0

1. Cross sections added surrounding the proposed I-45 bridge

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
104245	1,172	1,172	0	98.93	98.88	-0.05	2.6	2.6	0.0
103601	1,234	1,234	0	98.65	98.59	-0.06	1.8	1.9	0.1
103446	1,234	1,234	0	98.58	98.53	-0.05	1.6	1.5	-0.1
103392	1,234	1,234	0	98.40	98.39	-0.01	1.6	1.4	-0.1
102844	1,292	1,292	0	98.03	98.03	0.00	3.1	3.1	0.0
102450	1,292	1,292	0	97.78	97.78	0.00	2.9	2.9	0.0
102169	1,349	1,349	0	97.59	97.59	0.00	3.0	3.0	0.0
102115	1,349	1,349	0	97.31	97.31	0.00	3.1	3.1	0.0
101526	1,442	1,442	0	96.82	96.82	0.00	3.6	3.6	0.0
100545	1,545	1,545	0	95.90	95.90	0.00	3.7	3.7	0.0
99524.3	1,616	1,616	0	94.59	94.59	0.00	4.4	4.4	0.0
98862.7	1,670	1,670	0	93.97	93.97	0.00	3.6	3.6	0.0
98434.7	1,758	1,758	0	93.76	93.76	0.00	2.7	2.7	0.0
98376.7	1,758	1,758	0	93.52	93.52	0.00	2.8	2.8	0.0
97617.6	1,897	1,897	0	90.81	90.81	0.00	8.1	8.1	0.0
96497.8	2,061	2,061	0	90.18	90.18	0.00	2.9	2.9	0.0
95272.1	2,209	2,209	0	89.64	89.64	0.00	2.6	2.6	0.0
94253.5	2,342	2,342	0	88.73	88.73	0.00	2.0	2.0	0.0
93387.8	2,451	2,451	0	88.20	88.20	0.00	0.5	0.5	0.0
93247.3	2,451	2,451	0	88.13	88.13	0.00	0.5	0.5	0.0
93213.9	2,451	2,451	0	88.07	88.07	0.00	0.5	0.5	0.0
92719.1	2,628	2,628	0	87.64	87.64	0.00	0.8	0.8	0.0
91689.3	2,748	2,748	0	86.76	86.76	0.00	0.7	0.7	0.0
91029.5	2,924	2,924	0	86.19	86.19	0.00	1.0	1.0	0.0
90112.3	3,083	3,083	0	85.80	85.79	-0.01	0.6	0.6	0.0
89332.1	3,242	3,242	0	85.57	85.56	-0.01	0.6	0.6	0.0
88590.5	3,506	3,506	0	85.49	85.48	-0.01	0.4	0.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
XS	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
87434.8	3,713	3,713	0	85.20	85.19	-0.01	0.9	0.9	0.0
86591.9	3,841	3,841	0	84.50	84.48	-0.02	1.4	1.5	0.0
86213.8	3,982	3,982	0	84.29	84.27	-0.02	1.6	1.6	0.0
86159.8	3,982	3,982	0	84.24	84.21	-0.03	1.6	1.6	0.0
86145.4	3,982	3,982	0	84.14	84.12	-0.02	2.4	2.4	0.0
86091.4	3,982	3,982	0	84.04	84.01	-0.03	2.3	2.3	0.0
85559.7	4,251	4,251	0	83.83	83.80	-0.03	1.2	1.2	0.0
84594.2	5,888	5,888	0	83.10	83.01	-0.09	1.5	1.6	0.1
83685.6	5,888	5,888	0	82.62	82.44	-0.18	1.1	1.2	0.1
83450.7	6,309	6,309	0	82.56	82.37	-0.19	1.0	1.1	0.1
83398.7	6,309	6,309	0	82.45	82.17	-0.28	1.0	1.2	0.1
83108.1	6,309	6,309	0	82.38	82.06	-0.32	0.7	0.8	0.1
82744.1	6,309	6,309	0	82.23	81.78	-0.45	0.7	0.9	0.2
81851.2	6,309	6,309	0	82.11	81.58	-0.53	0.4	0.5	0.1
81268.8	6,309	6,309	0	82.07	81.50	-0.57	0.3	0.5	0.1
81023.3	6,309	6,309	0	82.01	81.42	-0.59	0.7	0.8	0.1
80971.3	6,309	6,309	0	81.98	81.37	-0.61	0.6	0.7	0.1
80695	6,309	6,309	0	81.96	81.28	-0.68	0.3	0.9	0.6
80155	see note	6,309	see note	see note	81.23	see note	see note	1.6	see note
79975	see note	6,309	see note	see note	80.77	see note	see note	1.8	see note
79960	see note	6,309	see note	see note	80.77	see note	see note	1.8	see note
79578	see note	6,309	see note	see note	80.71	see note	see note	1.7	see note
79572	see note	6,309	see note	see note	80.68	see note	see note	2.2	see note
79482	see note	6,309	see note	see note	80.17	see note	see note	2.4	see note
79462	6,309	6,309	0	79.78	79.81	0.03	4.9	4.7	-0.2
79459	6,309	6,309	0	79.72	79.72	0.00	5.0	5.0	0.0
79432	6,309	6,309	0	79.68	79.68	0.00	3.7	3.7	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
79206	6,309	6,309	0	79.45	79.45	0.00	3.0	3.0	0.0
78762	6,309	6,309	0	79.41	79.41	0.00	1.0	1.0	0.0
78747	6,309	6,309	0	79.35	79.35	0.00	1.0	1.0	0.0
78738	6,309	6,309	0	79.30	79.30	0.00	1.0	1.0	0.0
78666	6,309	6,309	0	79.19	79.19	0.00	1.0	1.0	0.0
77938.5	6,309	6,309	0	79.03	79.03	0.00	0.8	0.8	0.0
77884.5	6,309	6,309	0	78.97	78.97	0.00	0.7	0.7	0.0
77869.4	6,309	6,309	0	78.90	78.90	0.00	0.8	0.8	0.0
77441.3	6,309	6,309	0	78.76	78.76	0.00	0.7	0.7	0.0
76394.4	6,309	6,309	0	78.36	78.36	0.00	0.8	0.8	0.0
75489.4	6,309	6,309	0	77.93	77.93	0.00	0.9	0.9	0.0
74253.7	6,309	6,309	0	77.30	77.30	0.00	0.9	0.9	0.0
73879.2	6,309	6,309	0	77.02	77.02	0.00	1.3	1.3	0.0
73423.3	6,566	6,566	0	76.79	76.79	0.00	1.1	1.1	0.0
73332.3	6,566	6,566	0	76.50	76.50	0.00	1.2	1.2	0.0
72405.2	6,566	6,566	0	75.82	75.82	0.00	1.7	1.7	0.0
71854.2	6,566	6,566	0	75.47	75.47	0.00	1.2	1.2	0.0
70744.2	6,566	6,566	0	74.48	74.48	0.00	1.1	1.1	0.0
69527.2	6,566	6,566	0	74.12	74.12	0.00	0.8	0.8	0.0
68131	6,566	6,566	0	73.82	73.82	0.00	0.6	0.6	0.0
67511.6	6,576	6,576	0	73.75	73.75	0.00	0.4	0.4	0.0
65955.8	6,586	6,586	0	73.68	73.68	0.00	0.2	0.2	0.0
65434.6	6,586	6,586	0	73.44	73.44	0.00	1.1	1.1	0.0
64273.7	7,681	7,681	0	72.94	72.94	0.00	2.3	2.3	0.0
64220.7	7,681	7,681	0	72.72	72.72	0.00	2.3	2.3	0.0
64094	7,681	7,681	0	72.67	72.67	0.00	3.3	3.3	0.0
64024	7,681	7,681	0	72.52	72.52	0.00	3.4	3.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
64010.4	7,681	7,681	0	72.15	72.15	0.00	4.9	4.9	0.0
63960.4	7,681	7,681	0	70.68	70.68	0.00	5.9	5.9	0.0
63959.7	7,681	7,681	0	70.87	70.87	0.00	4.2	4.2	0.0
63856.7	7,681	7,681	0	70.66	70.66	0.00	4.3	4.3	0.0
62823.2	7,681	7,681	0	70.25	70.25	0.00	1.2	1.2	0.0
61905.2	7,681	7,681	0	69.67	69.67	0.00	1.2	1.2	0.0
60625.3	7,871	7,871	0	68.84	68.84	0.00	1.3	1.3	0.0
59423.1	7,871	7,871	0	67.55	67.55	0.00	2.2	2.2	0.0
58613.7	7,871	7,871	0	67.40	67.40	0.00	1.4	1.4	0.0
58387.5	7,871	7,871	0	67.26	67.26	0.00	1.6	1.6	0.0
58331.5	7,871	7,871	0	67.19	67.19	0.00	1.6	1.6	0.0
57555.5	7,871	7,871	0	66.89	66.89	0.00	1.1	1.1	0.0
56513.3	7,871	7,871	0	65.99	65.99	0.00	2.2	2.2	0.0
55557.7	8,042	8,042	0	65.05	65.05	0.00	1.9	1.9	0.0
54459.2	8,042	8,042	0	63.27	63.27	0.00	4.6	4.6	0.0
53801.7	8,042	8,042	0	63.35	63.35	0.00	2.5	2.5	0.0
53275.7	8,042	8,042	0	63.09	63.09	0.00	2.8	2.8	0.0
52844.3	8,042	8,042	0	63.00	63.00	0.00	2.6	2.6	0.0
52786.3	8,042	8,042	0	62.80	62.80	0.00	2.8	2.8	0.0
52465.7	8,042	8,042	0	62.57	62.57	0.00	2.7	2.7	0.0
52221.3	8,042	8,042	0	62.33	62.33	0.00	3.0	3.0	0.0
52194.3	8,042	8,042	0	62.15	62.15	0.00	3.2	3.2	0.0
51283.9	8,042	8,042	0	61.49	61.49	0.00	1.7	1.7	0.0
51096.9	8,219	8,219	0	61.38	61.38	0.00	1.6	1.6	0.0
51070.9	8,219	8,219	0	61.25	61.25	0.00	1.7	1.7	0.0
50549.6	8,219	8,219	0	61.08	61.08	0.00	1.4	1.4	0.0
50021.9	8,219	8,219	0	60.95	60.95	0.00	0.9	0.9	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
49939.9	8,219	8,219	0	60.79	60.79	0.00	1.0	1.0	0.0
49231.7	8,219	8,219	0	60.55	60.55	0.00	0.9	0.9	0.0
48480.5	8,219	8,219	0	60.33	60.33	0.00	0.8	0.8	0.0
48196.5	8,219	8,219	0	60.27	60.27	0.00	0.7	0.7	0.0
48169.5	8,219	8,219	0	60.19	60.19	0.00	0.7	0.7	0.0
47607.9	8,219	8,219	0	60.05	60.05	0.00	0.7	0.7	0.0
46939	8,219	8,219	0	59.93	59.93	0.00	0.6	0.6	0.0
46594.8	8,316	8,316	0	59.88	59.88	0.00	0.5	0.5	0.0
46526.8	8,316	8,316	0	59.56	59.56	0.00	0.5	0.5	0.0
46499.9	8,316	8,316	0	59.51	59.51	0.00	0.6	0.6	0.0
46478.9	8,316	8,316	0	59.45	59.45	0.00	0.6	0.6	0.0
45952.3	8,316	8,316	0	59.35	59.35	0.00	0.6	0.6	0.0
45161.4	8,316	8,316	0	59.17	59.17	0.00	0.5	0.5	0.0
44549.9	8,316	8,316	0	59.04	59.04	0.00	0.6	0.6	0.0
44143.3	9,539	9,539	0	58.96	58.96	0.00	0.6	0.6	0.0
43215.5	9,539	9,539	0	58.85	58.85	0.00	0.5	0.5	0.0
42471	9,539	9,539	0	58.75	58.75	0.00	0.6	0.6	0.0
41863.8	9,539	9,539	0	58.64	58.64	0.00	0.8	0.8	0.0
41285.4	9,539	9,539	0	58.56	58.56	0.00	0.9	0.9	0.0
41202.4	9,539	9,539	0	58.30	58.30	0.00	0.9	0.9	0.0
41185.7	9,539	9,539	0	58.24	58.24	0.00	0.8	0.8	0.0
40951.8	9,539	9,539	0	58.11	58.11	0.00	1.1	1.1	0.0
40886.8	9,539	9,539	0	57.99	57.99	0.00	1.1	1.1	0.0
40846.9	9,539	9,539	0	57.99	57.99	0.00	1.1	1.1	0.0
40605.5	9,539	9,539	0	57.83	57.83	0.00	1.2	1.2	0.0
40584.6	9,539	9,539	0	57.77	57.77	0.00	1.2	1.2	0.0
40515.6	9,539	9,539	0	57.66	57.66	0.00	1.1	1.1	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
39969.8	9,539	9,539	0	57.52	57.52	0.00	0.8	0.8	0.0
39188.6	9,539	9,539	0	57.29	57.29	0.00	0.7	0.7	0.0
38170.2	9,539	9,539	0	57.01	57.01	0.00	0.8	0.8	0.0
37258.6	9,539	9,539	0	56.72	56.72	0.00	0.9	0.9	0.0
36107.2	10,699	10,699	0	56.20	56.20	0.00	1.5	1.5	0.0
35434.7	10,699	10,699	0	55.76	55.76	0.00	3.2	3.2	0.0
35045.7	10,699	10,699	0	55.49	55.49	0.00	4.8	4.8	0.0
35006.1	10,699	10,699	0	55.16	55.16	0.00	4.7	4.7	0.0
34984.3	10,699	10,699	0	55.09	55.09	0.00	4.5	4.5	0.0
34870.3	10,699	10,699	0	54.70	54.70	0.00	4.2	4.2	0.0
33920.1	10,699	10,699	0	53.85	53.85	0.00	2.4	2.4	0.0
32749.8	10,699	10,699	0	52.53	52.53	0.00	2.9	2.9	0.0
31824.3	10,699	10,699	0	51.67	51.67	0.00	2.8	2.8	0.0
30679.1	10,699	10,699	0	50.55	50.55	0.00	3.2	3.2	0.0
30099.1	10,699	10,699	0	50.22	50.22	0.00	3.0	3.0	0.0
29757.8	11,271	11,271	0	49.96	49.96	0.00	2.9	2.9	0.0
29704.8	11,271	11,271	0	49.99	49.99	0.00	2.5	2.5	0.0
28983.7	11,271	11,271	0	48.64	48.64	0.00	5.7	5.7	0.0
28387.3	11271	11271	0	48.40	48.40	0.00	4.1	4.1	0.0
27992	11271	11271	0	48.08	48.08	0.00	3.0	3.0	0.0
27567.7	11271	11271	0	47.77	47.77	0.00	3.1	3.1	0.0
27317	11271	11271	0	47.52	47.52	0.00	3.4	3.4	0.0
27304.8	11271	11271	0	47.52	47.52	0.00	3.4	3.4	0.0
27180.8	11271	11271	0	47.50	47.50	0.00	3.3	3.3	0.0
27167.5	11271	11271	0	47.60	47.60	0.00	3.2	3.2	0.0
26466.1	11271	11271	0	47.14	47.14	0.00	4.3	4.3	0.0
25982.8	11271	11271	0	46.84	46.84	0.00	4.1	4.1	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
25318.4	11271	11271	0	46.44	46.44	0.00	3.9	3.9	0.0
24564.2	11271	11271	0	45.98	45.98	0.00	4.2	4.2	0.0
23984.6	11271	11271	0	45.79	45.79	0.00	2.5	2.5	0.0
23286.2	11300	11300	0	45.41	45.41	0.00	3.8	3.8	0.0
22973.4	11828	11828	0	45.23	45.23	0.00	4.5	4.5	0.0
22929.4	11828	11828	0	44.77	44.77	0.00	4.6	4.6	0.0
22630.3	11828	11828	0	44.15	44.15	0.00	6.4	6.4	0.0
22587.7	11828	11828	0	43.70	43.70	0.00	6.5	6.5	0.0
22186.8	11828	11828	0	43.34	43.34	0.00	5.1	5.1	0.0
21829	11828	11828	0	43.34	43.34	0.00	3.9	3.9	0.0
21589.8	11828	11828	0	43.01	43.01	0.00	4.3	4.3	0.0
21362	11828	11828	0	42.79	42.79	0.00	5.1	5.1	0.0
21304	11828	11828	0	42.67	42.67	0.00	5.1	5.1	0.0
21010.4	11828	11828	0	42.58	42.58	0.00	3.4	3.4	0.0
20887.4	11828	11828	0	42.34	42.34	0.00	3.4	3.4	0.0
20880.6	11828	11828	0	42.07	42.07	0.00	4.1	4.1	0.0
20858.6	11828	11828	0	42.03	42.03	0.00	4.1	4.1	0.0
19860	12311	12311	0	40.53	40.53	0.00	5.6	5.6	0.0
18597.4	12311	12311	0	39.08	39.08	0.00	5.1	5.1	0.0
18107.1	12311	12311	0	38.84	38.84	0.00	4.8	4.8	0.0
17130.3	12517	12517	0	38.37	38.37	0.00	4.2	4.2	0.0
16004	13094	13094	0	37.83	37.83	0.00	4.4	4.4	0.0
15045.6	13094	13094	0	37.04	37.04	0.00	5.4	5.4	0.0
13937.2	13094	13094	0	36.34	36.34	0.00	3.1	3.1	0.0
13341.9	13094	13094	0	35.75	35.75	0.00	3.8	3.8	0.0
12945.5	13489	13489	0	35.15	35.15	0.00	5.0	5.0	0.0
12931.7	13489	13489	0	34.89	34.89	0.00	5.4	5.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
12877.9	13489	13489	0	34.87	34.87	0.00	5.1	5.1	0.0
12117.3	13489	13489	0	34.61	34.61	0.00	3.9	3.9	0.0
10905.1	13917	13917	0	33.66	33.66	0.00	4.9	4.9	0.0
9879.2	13917	13917	0	32.28	32.28	0.00	5.1	5.1	0.0
8777	14550	14550	0	32.19	32.19	0.00	1.8	1.8	0.0
8024.4	14550	14550	0	31.78	31.78	0.00	2.7	2.7	0.0
6779.3	14550	14550	0	31.08	31.08	0.00	3.2	3.2	0.0
5748.4	15017	15017	0	29.62	29.62	0.00	4.4	4.4	0.0
4492	15017	15017	0	28.63	28.63	0.00	4.3	4.3	0.0
3597.9	15674	15674	0	27.89	27.89	0.00	3.5	3.5	0.0
2709.4	15674	15674	0	27.01	27.01	0.00	3.4	3.4	0.0
1695.9	15674	15674	0	25.73	25.73	0.00	4.0	4.0	0.0
678.7	15674	15674	0	23.02	23.02	0.00	7.3	7.3	0.0

1. Cross sections added surrounding the proposed I-45 bridge

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
104245	2,023	2,023	0	100.16	100.13	-0.03	3.4	3.4	0.0
103601	2,109	2,109	0	100.12	100.08	-0.04	0.3	0.3	0.0
103446	2,109	2,109	0	100.06	100.03	-0.03	0.3	0.3	0.0
103392	2,109	2,109	0	99.99	99.97	-0.02	0.3	0.2	0.0
102844	2,189	2,189	0	99.48	99.48	0.00	1.9	1.9	0.0
102450	2,189	2,189	0	99.21	99.21	0.00	1.3	1.3	0.0
102169	2,269	2,269	0	99.13	99.13	0.00	0.6	0.6	0.0
102115	2,269	2,269	0	98.84	98.84	0.00	0.8	0.8	0.0
101526	2,395	2,395	0	98.65	98.65	0.00	0.3	0.3	0.0
100545	2,534	2,534	0	98.05	98.05	0.00	0.5	0.5	0.0
99524.3	2,628	2,628	0	96.80	96.80	0.00	3.4	3.4	0.0
98862.7	2,699	2,699	0	96.12	96.12	0.00	4.3	4.3	0.0
98434.7	2,815	2,815	0	95.94	95.94	0.00	3.1	3.1	0.0
98376.7	2,815	2,815	0	95.80	95.80	0.00	3.0	3.0	0.0
97617.6	2,994	2,994	0	91.92	91.92	0.00	10.0	10.0	0.0
96497.8	3,204	3,204	0	91.36	91.36	0.00	3.6	3.6	0.0
95272.1	3,389	3,389	0	90.57	90.57	0.00	3.2	3.2	0.0
94253.5	3,555	3,555	0	89.22	89.22	0.00	2.1	2.1	0.0
93387.8	3,689	3,689	0	88.70	88.70	0.00	0.6	0.6	0.0
93247.3	3,689	3,689	0	88.63	88.63	0.00	0.5	0.5	0.0
93213.9	3,689	3,689	0	88.58	88.58	0.00	0.5	0.5	0.0
92719.1	3,904	3,904	0	88.15	88.15	0.00	0.7	0.7	0.0
91689.3	4,049	4,049	0	87.30	87.30	0.00	0.7	0.7	0.0
91029.5	4,259	4,259	0	86.85	86.85	0.00	0.7	0.7	0.0
90112.3	4,447	4,447	0	86.59	86.59	0.00	0.5	0.5	0.0
89332.1	4,633	4,633	0	86.44	86.44	0.00	0.5	0.5	0.0
88590.5	4,938	4,938	0	86.36	86.36	0.00	0.4	0.4	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
87434.8	5,173	5,173	0	86.12	86.12	0.00	0.8	0.8	0.0
86591.9	5,318	5,318	0	85.53	85.53	0.00	1.2	1.2	0.0
86213.8	5,476	5,476	0	85.34	85.34	0.00	1.3	1.3	0.0
86159.8	5,476	5,476	0	84.94	84.94	0.00	1.4	1.4	0.0
86145.4	5,476	5,476	0	84.75	84.75	0.00	2.7	2.7	0.0
86091.4	5,476	5,476	0	84.58	84.57	-0.01	2.6	2.6	0.0
85559.7	5,776	5,776	0	84.35	84.35	0.00	1.1	1.1	0.0
84594.2	7,723	7,723	0	83.53	83.53	0.00	1.5	1.5	0.0
83685.6	7,723	7,723	0	82.93	82.92	-0.01	1.2	1.2	0.0
83450.7	8,137	8,137	0	82.85	82.84	-0.01	1.1	1.1	0.0
83398.7	8,137	8,137	0	82.72	82.71	-0.01	1.2	1.2	0.0
83108.1	8,137	8,137	0	82.63	82.61	-0.02	0.8	0.8	0.0
82744.1	8,137	8,137	0	82.47	82.43	-0.04	0.7	0.8	0.1
81851.2	8,137	8,137	0	82.31	82.27	-0.04	0.4	0.4	0.0
81268.8	8,137	8,137	0	82.25	82.21	-0.04	0.4	0.4	0.0
81023.3	8,137	8,137	0	82.23	82.12	-0.11	0.4	0.8	0.4
80971.3	8,137	8,137	0	82.17	82.08	-0.09	0.8	0.8	0.0
80695	8,137	8,137	0	82.14	82.04	-0.10	0.4	0.4	0.0
80155	see note	8,137	see note	see note	81.96	see note	see note	1.8	see note
79975	see note	8,137	see note	see note	81.37	see note	see note	2.1	see note
79960	see note	8,137	see note	see note	81.37	see note	see note	2.1	see note
79578	see note	8,137	see note	see note	81.28	see note	see note	0.3	see note
79572	see note	8,137	see note	see note	81.28	see note	see note	0.3	see note
79482	see note	8,137	see note	see note	81.02	see note	see note	0.3	see note
79462	8,137	8,137	0	81.02	81.02	0.00	0.3	0.3	0.0
79459	8,137	8,137	0	81.02	81.02	0.00	0.4	0.4	0.0
79432	8,137	8,137	0	80.27	80.27	0.00	4.2	4.2	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
79206	8,137	8,137	0	80.02	80.02	0.00	3.4	3.4	0.0
78762	8,137	8,137	0	80.02	80.02	0.00	1.0	1.0	0.0
78747	8,137	8,137	0	79.95	79.95	0.00	1.0	1.0	0.0
78738	8,137	8,137	0	79.90	79.90	0.00	1.1	1.1	0.0
78666	8,137	8,137	0	79.78	79.78	0.00	1.1	1.1	0.0
77938.5	8,137	8,137	0	79.61	79.61	0.00	0.7	0.7	0.0
77884.5	8,137	8,137	0	79.56	79.56	0.00	0.6	0.6	0.0
77869.4	8,137	8,137	0	79.52	79.52	0.00	0.7	0.7	0.0
77441.3	8,137	8,137	0	79.38	79.38	0.00	0.7	0.7	0.0
76394.4	8,137	8,137	0	79.01	79.01	0.00	0.8	0.8	0.0
75489.4	8,137	8,137	0	78.61	78.61	0.00	0.8	0.8	0.0
74253.7	8,137	8,137	0	78.06	78.06	0.00	0.8	0.8	0.0
73879.2	8,137	8,137	0	77.80	77.80	0.00	1.0	1.0	0.0
73423.3	8,386	8,386	0	77.61	77.61	0.00	0.8	0.8	0.0
73332.3	8,386	8,386	0	77.44	77.44	0.00	0.8	0.8	0.0
72405.2	8,386	8,386	0	76.88	76.88	0.00	1.1	1.1	0.0
71854.2	8,386	8,386	0	76.65	76.65	0.00	0.8	0.8	0.0
70744.2	8,386	8,386	0	76.13	76.13	0.00	0.7	0.7	0.0
69527.2	8,386	8,386	0	75.97	75.97	0.00	0.5	0.5	0.0
68131	8,386	8,386	0	75.86	75.86	0.00	0.3	0.3	0.0
67511.6	8,547	8,547	0	75.83	75.83	0.00	0.3	0.3	0.0
65955.8	8,724	8,724	0	75.80	75.80	0.00	0.2	0.2	0.0
65434.6	8,724	8,724	0	75.66	75.66	0.00	0.9	0.9	0.0
64273.7	10,335	10,335	0	75.18	75.18	0.00	2.4	2.4	0.0
64220.7	10,335	10,335	0	75.02	75.02	0.00	2.4	2.4	0.0
64094	10,335	10,335	0	74.91	74.91	0.00	3.7	3.7	0.0
64024	10,335	10,335	0	74.68	74.68	0.00	3.7	3.7	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
64010.4	10,335	10,335	0	74.21	74.21	0.00	5.4	5.4	0.0
63960.4	10,335	10,335	0	71.32	71.32	0.00	7.3	7.3	0.0
63959.7	10,335	10,335	0	71.62	71.62	0.00	5.2	5.2	0.0
63856.7	10,335	10,335	0	71.47	71.47	0.00	5.4	5.4	0.0
62823.2	10,335	10,335	0	71.00	71.00	0.00	1.3	1.3	0.0
61905.2	10,335	10,335	0	70.49	70.49	0.00	1.0	1.0	0.0
60625.3	10,556	10,556	0	69.71	69.71	0.00	0.9	0.9	0.0
59423.1	10,556	10,556	0	68.51	68.51	0.00	1.3	1.3	0.0
58613.7	10,556	10,556	0	68.28	68.28	0.00	1.2	1.2	0.0
58387.5	10,556	10,556	0	68.21	68.21	0.00	1.0	1.0	0.0
58331.5	10,556	10,556	0	68.21	68.21	0.00	1.0	1.0	0.0
57555.5	10,556	10,556	0	67.93	67.93	0.00	1.0	1.0	0.0
56513.3	10,556	10,556	0	66.98	66.98	0.00	1.6	1.6	0.0
55557.7	10,754	10,754	0	66.23	66.23	0.00	1.3	1.3	0.0
54459.2	10,754	10,754	0	64.46	64.46	0.00	2.3	2.3	0.0
53801.7	10,754	10,754	0	64.44	64.44	0.00	1.8	1.8	0.0
53275.7	10,754	10,754	0	64.14	64.14	0.00	2.0	2.0	0.0
52844.3	10,754	10,754	0	64.05	64.05	0.00	1.5	1.5	0.0
52786.3	10,754	10,754	0	63.65	63.65	0.00	1.9	1.9	0.0
52465.7	10,754	10,754	0	63.39	63.39	0.00	2.1	2.1	0.0
52221.3	10,754	10,754	0	63.13	63.13	0.00	2.2	2.2	0.0
52194.3	10,754	10,754	0	63.03	63.03	0.00	2.2	2.2	0.0
51283.9	10,754	10,754	0	62.46	62.46	0.00	1.0	1.0	0.0
51096.9	10,958	10,958	0	62.35	62.35	0.00	0.9	0.9	0.0
51070.9	10,958	10,958	0	62.09	62.09	0.00	1.1	1.1	0.0
50549.6	10,958	10,958	0	61.90	61.90	0.00	0.9	0.9	0.0
50021.9	10,958	10,958	0	61.78	61.78	0.00	0.7	0.7	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
49939.9	10,958	10,958	0	61.64	61.64	0.00	0.7	0.7	0.0
49231.7	10,958	10,958	0	61.44	61.44	0.00	0.7	0.7	0.0
48480.5	10,958	10,958	0	61.24	61.24	0.00	0.6	0.6	0.0
48196.5	10,958	10,958	0	61.19	61.19	0.00	0.6	0.6	0.0
48169.5	10,958	10,958	0	61.12	61.12	0.00	0.6	0.6	0.0
47607.9	10,958	10,958	0	61.00	61.00	0.00	0.5	0.5	0.0
46939	10,958	10,958	0	60.89	60.89	0.00	0.5	0.5	0.0
46594.8	11,071	11,071	0	60.84	60.84	0.00	0.4	0.4	0.0
46526.8	11,071	11,071	0	60.64	60.64	0.00	0.4	0.4	0.0
46499.9	11,071	11,071	0	60.60	60.60	0.00	0.5	0.5	0.0
46478.9	11,071	11,071	0	60.56	60.56	0.00	0.5	0.5	0.0
45952.3	11,071	11,071	0	60.48	60.48	0.00	0.5	0.5	0.0
45161.4	11,071	11,071	0	60.35	60.35	0.00	0.5	0.5	0.0
44549.9	11,071	11,071	0	60.24	60.24	0.00	0.5	0.5	0.0
44143.3	12,194	12,194	0	60.18	60.18	0.00	0.5	0.5	0.0
43215.5	12,340	12,340	0	60.09	60.09	0.00	0.5	0.5	0.0
42471	12,340	12,340	0	60.01	60.01	0.00	0.6	0.6	0.0
41863.8	12,340	12,340	0	59.91	59.91	0.00	0.8	0.8	0.0
41285.4	12,340	12,340	0	59.84	59.84	0.00	0.9	0.9	0.0
41202.4	12,340	12,340	0	59.74	59.74	0.00	0.9	0.9	0.0
41185.7	12,340	12,340	0	59.69	59.69	0.00	0.8	0.8	0.0
40951.8	12,340	12,340	0	59.57	59.57	0.00	1.0	1.0	0.0
40886.8	12,340	12,340	0	59.47	59.47	0.00	1.1	1.1	0.0
40846.9	12,340	12,340	0	59.47	59.47	0.00	1.1	1.1	0.0
40605.5	12,340	12,340	0	59.32	59.32	0.00	1.1	1.1	0.0
40584.6	12,340	12,340	0	59.29	59.29	0.00	1.1	1.1	0.0
40515.6	12,340	12,340	0	59.19	59.19	0.00	1.0	1.0	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
39969.8	12,340	12,340	0	59.11	59.11	0.00	0.7	0.7	0.0
39188.6	12,340	12,340	0	58.99	58.99	0.00	0.5	0.5	0.0
38170.2	12,340	12,340	0	58.86	58.86	0.00	0.6	0.6	0.0
37258.6	12,340	12,340	0	58.74	58.74	0.00	0.6	0.6	0.0
36107.2	13,748	13,748	0	58.42	58.42	0.00	1.0	1.0	0.0
35434.7	13,748	13,748	0	57.94	57.94	0.00	3.0	3.0	0.0
35045.7	13,748	13,748	0	57.54	57.54	0.00	5.4	5.4	0.0
35006.1	13,748	13,748	0	56.94	56.94	0.00	5.4	5.4	0.0
34984.3	13,748	13,748	0	56.89	56.89	0.00	5.0	5.0	0.0
34870.3	13,748	13,748	0	56.11	56.11	0.00	4.4	4.4	0.0
33920.1	13,748	13,748	0	55.37	55.37	0.00	2.0	2.0	0.0
32749.8	13,748	13,748	0	54.22	54.22	0.00	2.3	2.3	0.0
31824.3	13,748	13,748	0	53.50	53.50	0.00	2.0	2.0	0.0
30679.1	13,748	13,748	0	52.71	52.71	0.00	1.7	1.7	0.0
30099.1	13,748	13,748	0	52.42	52.42	0.00	1.6	1.6	0.0
29757.8	13,792	13,792	0	52.31	52.31	0.00	1.3	1.3	0.0
29704.8	13,792	13,792	0	52.13	52.13	0.00	1.3	1.3	0.0
28983.7	13,792	13,792	0	51.00	51.00	0.00	3.0	3.0	0.0
28387.3	13792	13792	0	50.81	50.81	0.00	2.3	2.3	0.0
27992	13792	13792	0	50.58	50.58	0.00	2.2	2.2	0.0
27567.7	13792	13792	0	50.40	50.40	0.00	1.8	1.8	0.0
27317	13792	13792	0	50.35	50.35	0.00	1.4	1.4	0.0
27304.8	13792	13792	0	50.19	50.19	0.00	1.5	1.5	0.0
27180.8	13792	13792	0	49.71	49.71	0.00	1.7	1.7	0.0
27167.5	13792	13792	0	49.58	49.58	0.00	1.8	1.8	0.0
26466.1	13792	13792	0	49.05	49.05	0.00	3.3	3.3	0.0
25982.8	13792	13792	0	48.76	48.76	0.00	3.6	3.6	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
25318.4	13792	13792	0	48.40	48.40	0.00	3.0	3.0	0.0
24564.2	13792	13792	0	48.04	48.04	0.00	2.3	2.3	0.0
23984.6	13792	13792	0	47.85	47.85	0.00	2.0	2.0	0.0
23286.2	13794	13794	0	47.50	47.50	0.00	2.9	2.9	0.0
22973.4	14563	14563	0	47.25	47.25	0.00	4.9	4.9	0.0
22929.4	14563	14563	0	46.88	46.88	0.00	5.0	5.0	0.0
22630.3	14563	14563	0	46.25	46.25	0.00	6.6	6.6	0.0
22587.7	14563	14563	0	45.79	45.79	0.00	6.8	6.8	0.0
22186.8	14563	14563	0	45.45	45.45	0.00	4.4	4.4	0.0
21829	14563	14563	0	45.47	45.47	0.00	3.3	3.3	0.0
21589.8	14563	14563	0	45.06	45.06	0.00	3.8	3.8	0.0
21362	14563	14563	0	44.89	44.89	0.00	4.5	4.5	0.0
21304	14563	14563	0	44.75	44.75	0.00	4.7	4.7	0.0
21010.4	14563	14563	0	44.62	44.62	0.00	3.1	3.1	0.0
20887.4	14563	14563	0	44.47	44.47	0.00	3.2	3.2	0.0
20880.6	14563	14563	0	44.27	44.27	0.00	4.0	4.0	0.0
20858.6	14563	14563	0	44.24	44.24	0.00	4.0	4.0	0.0
19860	15271	15271	0	42.99	42.99	0.00	4.6	4.6	0.0
18597.4	15271	15271	0	41.62	41.62	0.00	5.1	5.1	0.0
18107.1	15271	15271	0	41.50	41.50	0.00	4.6	4.6	0.0
17130.3	15573	15573	0	41.08	41.08	0.00	3.8	3.8	0.0
16004	16429	16429	0	40.60	40.60	0.00	3.7	3.7	0.0
15045.6	16429	16429	0	39.86	39.86	0.00	5.1	5.1	0.0
13937.2	16429	16429	0	39.27	39.27	0.00	2.8	2.8	0.0
13341.9	16429	16429	0	38.74	38.74	0.00	3.6	3.6	0.0
12945.5	17019	17019	0	38.63	38.63	0.00	2.8	2.8	0.0
12931.7	17019	17019	0	38.47	38.47	0.00	2.8	2.8	0.0

Hall's Bayou Crossing Analysis
Corrective Effective vs. Proposed Interim Conditions

XS	Flow (cfs)			WSE (ft.)			Velocity (ft/sec)		
	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)	Corrected Effective	Proposed Interim	Difference (Prop - Exist)
12877.9	17019	17019	0	37.59	37.59	0.00	2.8	2.8	0.0
12117.3	17019	17019	0	37.19	37.19	0.00	3.9	3.9	0.0
10905.1	17661	17661	0	36.15	36.15	0.00	4.9	4.9	0.0
9879.2	17661	17661	0	34.70	34.70	0.00	5.3	5.3	0.0
8777	18617	18617	0	34.74	34.74	0.00	1.8	1.8	0.0
8024.4	18617	18617	0	34.29	34.29	0.00	2.9	2.9	0.0
6779.3	18617	18617	0	33.59	33.59	0.00	3.2	3.2	0.0
5748.4	19327	19327	0	32.11	32.11	0.00	4.3	4.3	0.0
4492	19327	19327	0	31.14	31.14	0.00	4.3	4.3	0.0
3597.9	20334	20334	0	30.36	30.36	0.00	3.5	3.5	0.0
2709.4	20334	20334	0	29.50	29.50	0.00	3.5	3.5	0.0
1695.9	20334	20334	0	28.14	28.14	0.00	4.2	4.2	0.0
678.7	20334	20334	0	25.26	25.26	0.00	7.5	7.5	0.0

1. Cross sections added surrounding the proposed I-45 bridge

Appendix E

Roadway Impact Analysis Supporting Data

- E.1 Hydrologic Calculations
  - Onsite Land Use and Runoff Coefficient "C" – Existing Condition
  - Onsite Imperviousness (%) – Existing Condition
  - Onsite Land Use and Runoff Coefficient "C" – Proposed Condition
  - Onsite Imperviousness (%) – Proposed Condition
  - Offsite Land Use Data

- E.2 Hydrologic Calculations
  - TxDOT Rational Method Calculation – Existing Onsite Drainage Area
  - TxDOT Rational Method Calculation – Proposed Onsite Drainage Area
  - TxDOT Rational Method Calculation – Offsite Drainage Area

- E.3 Hydraulic Calculations: PCSWMM Results
  - PCSWMM - Existing Results
  - PCSWMM - Proposed Results

- E.4 PC-SWMM Model Setup
  - Existing Conditions
  - Proposed Conditions

E.1 Hydrologic Calculations

Onsite Land Use and Runoff Coefficient "C"

Drainage Area ID	Area (acres)	High Density Commercial	Low Density Commercial	Single Family Residential	Right-of-way Grasses	Pavement	Unimproved	Water	Weighted Runoff Coefficient "C"
		0.75	0.6	0.4	0.35	0.9	0.25	1	
A1a-NML070	2.88	0.00	0.09	0.00	0.69	1.88	0.21	0.00	0.71
A1-NML020	3.84	0.12	0.00	0.00	0.40	2.81	0.50	0.00	0.75
A1-NML045	6.78	0.00	0.44	0.00	1.25	5.01	0.07	0.00	0.77
A1-NML075	5.64	0.00	0.00	0.00	2.37	3.27	0.00	0.00	0.67
A2-NML020	2.45	0.00	0.00	0.00	0.61	1.84	0.00	0.00	0.76
A2-NML030	1.19	0.00	0.00	0.00	0.02	1.17	0.00	0.00	0.89
A2-SML055	1.16	0.00	0.00	0.00	0.01	1.11	0.04	0.00	0.87
A2-SML060	0.63	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.90
A3-SFR010	2.08	0.00	0.00	0.00	0.24	1.84	0.00	0.00	0.84
B2-SFR090	3.40	0.00	0.00	0.00	0.61	2.69	0.11	0.00	0.78
B2-SML035	2.60	0.00	0.00	0.00	0.73	1.87	0.00	0.00	0.74
B2-SML075	3.77	0.88	0.00	0.00	0.13	2.67	0.09	0.00	0.83
B2-SSH020	1.95	0.00	0.00	0.00	0.76	1.19	0.00	0.00	0.68
B2-SVM045	2.92	0.33	0.00	0.00	1.01	1.35	0.23	0.00	0.64
B3-NSH015	1.40	0.00	0.00	0.00	0.31	1.08	0.00	0.00	0.78
B4-SSH020	1.52	0.00	0.00	0.00	0.37	1.16	0.00	0.00	0.77
C1-SML020	6.24	0.00	4.42	0.00	0.42	1.30	0.09	0.00	0.64
C1-SML040	5.39	0.64	1.76	0.00	0.49	1.90	0.60	0.00	0.66
C1-SML050	3.48	0.34	0.00	0.00	0.22	2.78	0.14	0.00	0.82
C2-NML020	1.76	0.00	0.00	0.00	0.55	1.21	0.00	0.00	0.73
C2-NML035	2.44	0.00	0.00	0.00	0.71	1.72	0.00	0.00	0.74
C3-NFR045	6.83	0.00	0.51	0.00	0.72	5.29	0.30	0.00	0.79
C4-SML025	9.62	0.00	0.00	0.00	0.93	8.56	0.13	0.00	0.84
D1-NML045	4.17	0.00	0.00	0.00	0.34	3.82	0.00	0.00	0.85
D2-SML035	4.82	0.00	0.00	0.00	0.17	4.28	0.38	0.00	0.83
E1-SFR035	9.03	0.00	1.06	0.00	1.21	5.53	1.22	0.00	0.70
E1-SFR075	8.98	0.00	0.98	0.00	1.17	5.73	1.11	0.00	0.72
E1-SFR105	7.66	0.00	2.11	0.00	1.29	3.38	0.88	0.00	0.65
E1-SFR130	6.93	0.74	0.00	0.00	0.77	4.88	0.54	0.00	0.77
E1-SML150	5.74	0.00	0.00	0.00	0.25	5.08	0.38	0.00	0.83
E2-NML045	4.39	0.00	0.00	0.00	1.11	3.27	0.00	0.01	0.76
E2-NML070	4.07	0.00	0.00	0.00	0.89	3.18	0.00	0.00	0.78
E2-NML100	4.46	0.00	0.00	0.00	1.10	3.36	0.00	0.00	0.76
E2-NML130	3.67	0.00	0.00	0.00	0.78	2.89	0.00	0.00	0.78
E2-NML145	2.98	0.00	0.00	0.00	0.37	2.61	0.00	0.00	0.83
E3-NML055	5.22	0.00	0.00	0.00	0.23	4.99	0.00	0.00	0.88
E3-NML080	4.35	0.00	0.00	0.00	0.76	3.59	0.00	0.00	0.80
E3-NML100	3.72	0.00	0.00	0.00	0.42	3.31	0.00	0.00	0.84
E4-SML050	11.03	0.00	0.00	0.00	0.62	8.91	1.46	0.03	0.78
E4-SML075	8.07	0.00	0.00	0.00	0.87	6.80	0.40	0.00	0.81
E4-SML090	8.12	0.00	2.23	0.00	0.32	5.37	0.19	0.00	0.78

Onsite Imperviousness (%)

Drainage Area ID	Area (acres)	High Density Commercial	Low Density Commercial	Single Family Residential	Right-of-way Grasses	Pavement	Unimproved	Water	Weighted Imperviousness (%)
		85%	72%	38%	0%	100%	0%	100%	
A1a-NML070	2.88	0.00	0.09	0.00	0.69	1.88	0.21	0.00	67.80
A1-NML020	3.84	0.12	0.00	0.00	0.40	2.81	0.50	0.00	75.90
A1-NML045	6.78	0.00	0.44	0.00	1.25	5.01	0.07	0.00	78.65
A1-NML075	5.64	0.00	0.00	0.00	2.37	3.27	0.00	0.00	58.03
A2-NML020	2.45	0.00	0.00	0.00	0.61	1.84	0.00	0.00	74.98
A2-NML030	1.19	0.00	0.00	0.00	0.02	1.17	0.00	0.00	98.16
A2-SML055	1.16	0.00	0.00	0.00	0.01	1.11	0.04	0.00	95.98
A2-SML060	0.63	0.00	0.00	0.00	0.00	0.63	0.00	0.00	99.86
A3-SFR010	2.08	0.00	0.00	0.00	0.24	1.84	0.00	0.00	88.61
B2-SFR090	3.40	0.00	0.00	0.00	0.61	2.69	0.11	0.00	78.98
B2-SML035	2.60	0.00	0.00	0.00	0.73	1.87	0.00	0.00	71.77
B2-SML075	3.77	0.88	0.00	0.00	0.13	2.67	0.09	0.00	90.84
B2-SSH020	1.95	0.00	0.00	0.00	0.76	1.19	0.00	0.00	60.91
B2-SVM045	2.92	0.33	0.00	0.00	1.01	1.35	0.23	0.00	55.85
B3-NSH015	1.40	0.00	0.00	0.00	0.31	1.08	0.00	0.00	77.60
B4-SSH020	1.52	0.00	0.00	0.00	0.37	1.16	0.00	0.00	75.99
C1-SML020	6.24	0.00	4.42	0.00	0.42	1.30	0.09	0.00	71.95
C1-SML040	5.39	0.64	1.76	0.00	0.49	1.90	0.60	0.00	68.71
C1-SML050	3.48	0.34	0.00	0.00	0.22	2.78	0.14	0.00	88.20
C2-NML020	1.76	0.00	0.00	0.00	0.55	1.21	0.00	0.00	68.91
C2-NML035	2.44	0.00	0.00	0.00	0.71	1.72	0.00	0.00	70.74
C3-NFR045	6.83	0.00	0.51	0.00	0.72	5.29	0.30	0.00	82.88
C4-SML025	9.62	0.00	0.00	0.00	0.93	8.56	0.13	0.00	88.99
D1-NML045	4.17	0.00	0.00	0.00	0.34	3.82	0.00	0.00	91.73
D2-SML035	4.82	0.00	0.00	0.00	0.17	4.28	0.38	0.00	88.66
E1-SFR035	9.03	0.00	1.06	0.00	1.21	5.53	1.22	0.00	69.74
E1-SFR075	8.98	0.00	0.98	0.00	1.17	5.73	1.11	0.00	71.60
E1-SFR105	7.66	0.00	2.11	0.00	1.29	3.38	0.88	0.00	63.97
E1-SFR130	6.93	0.74	0.00	0.00	0.77	4.88	0.54	0.00	79.43
E1-SML150	5.74	0.00	0.00	0.00	0.25	5.08	0.38	0.00	88.63
E2-NML045	4.39	0.00	0.00	0.00	1.11	3.27	0.00	0.01	74.75
E2-NML070	4.07	0.00	0.00	0.00	0.89	3.18	0.00	0.00	78.17
E2-NML100	4.46	0.00	0.00	0.00	1.10	3.36	0.00	0.00	75.32
E2-NML130	3.67	0.00	0.00	0.00	0.78	2.89	0.00	0.00	78.81
E2-NML145	2.98	0.00	0.00	0.00	0.37	2.61	0.00	0.00	87.44
E3-NML055	5.22	0.00	0.00	0.00	0.23	4.99	0.00	0.00	95.59
E3-NML080	4.35	0.00	0.00	0.00	0.76	3.59	0.00	0.00	82.50
E3-NML100	3.72	0.00	0.00	0.00	0.42	3.31	0.00	0.00	88.74
E4-SML050	11.03	0.00	0.00	0.00	0.62	8.91	1.46	0.03	81.06
E4-SML075	8.07	0.00	0.00	0.00	0.87	6.80	0.40	0.00	84.27
E4-SML090	8.12	0.00	2.23	0.00	0.32	5.37	0.19	0.00	85.98

Onsite Land Use and Runoff Coefficient "C"

Drainage Area ID	Area (acres)	High Density Commercial	Low Density Commercial	Single Family Residential	Right-of-way Grasses	Pavement	Unimproved	Water	Weighted Runoff Coefficient "C"
		0.75	0.6	0.4	0.35	0.9	0.25	1	
B2-ML30	1.08	0.00	0.00	0.00	0.01	1.07	0.00	0.00	0.90
B2-ML35	0.86	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.90
B2-ML40	1.46	0.00	0.00	0.00	0.02	1.44	0.00	0.00	0.89
B2-SFR25	1.46	0.00	0.00	0.00	0.84	0.61	0.00	0.00	0.59
B2-SFR35	1.44	0.00	0.00	0.00	0.46	0.97	0.00	0.00	0.72
B2-SFR40	0.83	0.00	0.00	0.00	0.29	0.53	0.00	0.00	0.71
B2-SHPS20	1.95	0.00	0.00	0.00	0.76	1.19	0.00	0.00	0.69
B3-SHPN05	0.63	0.00	0.00	0.00	0.13	0.50	0.00	0.00	0.79
B3-SHPN10	0.77	0.00	0.00	0.00	0.19	0.58	0.00	0.00	0.77
B4-SHPS05	0.75	0.00	0.00	0.00	0.17	0.58	0.00	0.00	0.78
B4-SHPS10	0.78	0.00	0.00	0.00	0.20	0.58	0.00	0.00	0.76
C1-ML15	1.16	0.00	0.00	0.00	0.09	1.06	0.00	0.00	0.86
C1-ML30	1.11	0.00	0.00	0.00	0.00	1.11	0.00	0.00	0.90
C2-ML15	1.06	0.00	0.00	0.00	0.07	0.99	0.00	0.00	0.86
C2-ML25	1.11	0.00	0.00	0.00	0.00	1.11	0.00	0.00	0.90
C2-NFR10	2.92	0.00	0.00	0.00	0.52	2.39	0.00	0.00	0.80
C2-NFR20	3.30	0.00	0.00	0.00	0.66	2.64	0.00	0.00	0.79
C3-ML30	0.44	0.00	0.00	0.00	0.02	0.42	0.00	0.00	0.87
C3-NFR10	4.00	0.00	0.00	0.00	0.70	3.29	0.00	0.00	0.80
C3-NFR20	3.24	0.00	0.00	0.00	0.58	2.65	0.00	0.00	0.80
C4-ML05	2.11	0.00	0.00	0.00	0.36	1.75	0.00	0.00	0.81
C4-ML20	3.17	0.00	0.00	0.00	0.39	2.75	0.00	0.00	0.83
C5-ML10	1.64	0.00	0.00	0.00	0.41	1.22	0.00	0.00	0.76
C6-SFR05	3.13	0.00	0.00	0.00	0.58	2.55	0.00	0.00	0.80
C6-SFR20	3.09	0.00	0.00	0.00	0.58	2.50	0.00	0.00	0.80
D1-NFR20	5.43	0.00	0.00	0.00	0.80	4.63	0.00	0.00	0.82
E1-SBFR15	4.96	0.00	0.00	0.00	1.59	3.36	0.00	0.00	0.72
E1-SBFR25	5.10	0.00	0.00	0.00	1.35	3.75	0.00	0.00	0.75
E1-SBFR40	5.38	0.00	0.00	0.00	1.45	3.93	0.00	0.00	0.75
E1-SBFR50	3.86	0.00	0.00	0.00	0.98	2.88	0.00	0.00	0.76
E1-SBFR55	2.64	0.00	0.00	0.00	0.84	1.79	0.00	0.00	0.72
E1-SMX20	1.60	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.90
E1-SMX25	1.93	0.00	0.00	0.00	0.00	1.93	0.00	0.00	0.90
E1-SMX45	1.39	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.90
E1-SMX55	0.85	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.90
E2-NBFR15	4.81	0.00	0.00	0.00	1.45	3.36	0.00	0.00	0.73
E2-NBFR25	5.10	0.00	0.00	0.00	1.58	3.52	0.00	0.00	0.73
E2-NBFR35	5.51	0.00	0.00	0.00	2.17	3.33	0.00	0.00	0.68
E2-NBFR45	5.39	0.00	0.00	0.00	1.69	3.70	0.00	0.00	0.73
E2-NBFR50	2.48	0.00	0.00	0.00	0.57	1.90	0.00	0.00	0.77
E2-NMX20	1.56	0.00	0.00	0.00	0.00	1.56	0.00	0.00	0.90
E2-NMX35	1.93	0.00	0.00	0.00	0.00	1.93	0.00	0.00	0.90
E2-NMX50	1.38	0.00	0.00	0.00	0.00	1.38	0.00	0.00	0.90
E2-NMX60	0.80	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.90
E3-NBFR10	4.64	0.00	0.00	0.00	1.17	3.47	0.00	0.00	0.76
E3-NBFR15	2.68	0.00	0.00	0.00	0.68	1.99	0.00	0.00	0.76
E3-NBFR20	3.26	0.00	0.00	0.00	0.90	2.35	0.00	0.00	0.75
E3-NBFR35	5.65	0.00	0.00	0.00	1.26	4.39	0.00	0.00	0.78
E3-NMX05	1.23	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.90
E3-NMX10	0.96	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.90
E3-NMX20	0.79	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.90
E3-NMX30	0.60	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.90
E3-NMX35	0.97	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.90
E4-SBFR05	4.16	0.00	0.00	0.00	0.99	3.17	0.00	0.00	0.77
E4-SBFR15	4.44	0.00	0.00	0.00	1.30	3.14	0.00	0.00	0.74
E4-SBFR25	4.13	0.00	0.00	0.00	0.90	3.23	0.00	0.00	0.78
E4-SBFR35	4.76	0.00	0.00	0.00	1.16	3.60	0.00	0.00	0.77
E4-SBFR40	3.76	0.00	0.00	0.00	0.68	3.08	0.00	0.00	0.80
E4-SBFR45	2.48	0.00	0.00	0.00	0.84	1.64	0.00	0.00	0.71
E4-SBFR50	5.06	0.00	0.00	0.00	1.40	3.66	0.00	0.00	0.75
E4-SMX05	1.35	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.90
E4-SMX10	0.96	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.90
E4-SMX20	0.79	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.90
E4-SMX30	0.59	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.90
E4-SMX35	0.97	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.90

Onsite Imperviousness (%)

Drainage Area ID	Area (acres)	High Density Commercial	Low Density Commercial	Single Family Residential	Right-of-way Grasses	Pavement	Unimproved	Water	Weighted Imperviousness (%)
		85%	72%	38%	0%	100%	0%	100%	
B2-ML30	1.08	0.00	0.00	0.00	0.01	1.07	0.00	0.00	99.27
B2-ML35	0.86	0.00	0.00	0.00	0.01	0.85	0.00	0.00	99.41
B2-ML40	1.46	0.00	0.00	0.00	0.03	1.44	0.00	0.00	98.50
B2-SFR25	1.46	0.00	0.00	0.00	0.84	0.62	0.00	0.00	42.56
B2-SFR35	1.44	0.00	0.00	0.00	0.47	0.97	0.00	0.00	67.61
B2-SFR40	0.83	0.00	0.00	0.00	0.30	0.54	0.00	0.00	64.59
B2-SHPS20	1.95	0.00	0.00	0.00	0.76	1.19	0.00	0.00	60.93
B3-SHPN05	0.63	0.00	0.00	0.00	0.13	0.50	0.00	0.00	80.00
B3-SHPN10	0.77	0.00	0.00	0.00	0.19	0.58	0.00	0.00	75.63
B4-SHPS05	0.75	0.00	0.00	0.00	0.17	0.58	0.00	0.00	77.72
B4-SHPS10	0.78	0.00	0.00	0.00	0.20	0.58	0.00	0.00	74.39
C1-ML15	1.16	0.00	0.00	0.00	0.09	1.06	0.00	0.00	92.16
C1-ML30	1.11	0.00	0.00	0.00	0.00	1.11	0.00	0.00	100.00
C2-ML15	1.06	0.00	0.00	0.00	0.07	0.99	0.00	0.00	93.01
C2-ML25	1.11	0.00	0.00	0.00	0.00	1.11	0.00	0.00	100.00
C2-NFR10	2.92	0.00	0.00	0.00	0.52	2.39	0.00	0.00	82.05
C2-NFR20	3.30	0.00	0.00	0.00	0.66	2.64	0.00	0.00	79.88
C3-ML30	0.44	0.00	0.00	0.00	0.02	0.42	0.00	0.00	95.00
C3-NFR10	4.00	0.00	0.00	0.00	0.70	3.29	0.00	0.00	82.31
C3-NFR20	3.24	0.00	0.00	0.00	0.58	2.65	0.00	0.00	81.98
C4-ML05	2.11	0.00	0.00	0.00	0.36	1.75	0.00	0.00	82.90
C4-ML20	3.17	0.00	0.00	0.00	0.40	2.77	0.00	0.00	87.31
C5-ML10	1.64	0.00	0.00	0.00	0.41	1.22	0.00	0.00	74.72
C6-SFR05	3.13	0.00	0.00	0.00	0.58	2.55	0.00	0.00	81.45
C6-SFR20	3.09	0.00	0.00	0.00	0.59	2.50	0.00	0.00	81.04
D1-NFR20	5.43	0.00	0.00	0.00	0.80	4.63	0.00	0.00	85.29
E1-SBFR15	4.96	0.00	0.00	0.00	1.59	3.36	0.00	0.00	67.82
E1-SBFR25	5.10	0.00	0.00	0.00	1.35	3.75	0.00	0.00	73.60
E1-SBFR40	5.38	0.00	0.00	0.00	1.45	3.93	0.00	0.00	73.08
E1-SBFR50	3.86	0.00	0.00	0.00	0.98	2.88	0.00	0.00	74.64
E1-SBFR55	2.64	0.00	0.00	0.00	0.84	1.79	0.00	0.00	67.90
E1-SMX20	1.60	0.00	0.00	0.00	0.00	1.60	0.00	0.00	100.00
E1-SMX25	1.93	0.00	0.00	0.00	0.00	1.93	0.00	0.00	100.00
E1-SMX45	1.39	0.00	0.00	0.00	0.00	1.39	0.00	0.00	100.00
E1-SMX55	0.85	0.00	0.00	0.00	0.00	0.85	0.00	0.00	99.99
E2-NBFR15	4.81	0.00	0.00	0.00	1.45	3.36	0.00	0.00	69.87
E2-NBFR25	5.10	0.00	0.00	0.00	1.58	3.52	0.00	0.00	69.03
E2-NBFR35	5.51	0.00	0.00	0.00	2.17	3.33	0.00	0.00	60.53
E2-NBFR45	5.39	0.00	0.00	0.00	1.69	3.70	0.00	0.00	68.71
E2-NBFR50	2.48	0.00	0.00	0.00	0.57	1.90	0.00	0.00	76.81
E2-NMX20	1.56	0.00	0.00	0.00	0.00	1.56	0.00	0.00	100.00
E2-NMX35	1.93	0.00	0.00	0.00	0.00	1.93	0.00	0.00	100.00
E2-NMX50	1.38	0.00	0.00	0.00	0.00	1.38	0.00	0.00	100.00
E2-NMX60	0.80	0.00	0.00	0.00	0.00	0.80	0.00	0.00	100.00
E3-NBFR10	4.64	0.00	0.00	0.00	1.17	3.47	0.00	0.00	74.84
E3-NBFR15	2.68	0.00	0.00	0.00	0.68	1.99	0.00	0.00	74.43
E3-NBFR20	3.26	0.00	0.00	0.00	0.90	2.35	0.00	0.00	72.22
E3-NBFR35	5.65	0.00	0.00	0.00	1.26	4.39	0.00	0.00	77.70
E3-NMX05	1.23	0.00	0.00	0.00	0.00	1.23	0.00	0.00	100.00
E3-NMX10	0.96	0.00	0.00	0.00	0.00	0.96	0.00	0.00	100.00
E3-NMX20	0.79	0.00	0.00	0.00	0.00	0.79	0.00	0.00	100.00
E3-NMX30	0.60	0.00	0.00	0.00	0.00	0.60	0.00	0.00	100.00
E3-NMX35	0.97	0.00	0.00	0.00	0.00	0.97	0.00	0.00	100.00
E4-SBFR05	4.16	0.00	0.00	0.00	0.99	3.17	0.00	0.00	76.13
E4-SBFR15	4.44	0.00	0.00	0.00	1.30	3.14	0.00	0.00	70.67
E4-SBFR25	4.13	0.00	0.00	0.00	0.90	3.23	0.00	0.00	78.19
E4-SBFR35	4.76	0.00	0.00	0.00	1.16	3.60	0.00	0.00	75.52
E4-SBFR40	3.76	0.00	0.00	0.00	0.68	3.08	0.00	0.00	81.85
E4-SBFR45	2.48	0.00	0.00	0.00	0.84	1.64	0.00	0.00	66.08
E4-SBFR50	5.06	0.00	0.00	0.00	1.40	3.66	0.00	0.00	72.34
E4-SMX05	1.35	0.00	0.00	0.00	0.00	1.35	0.00	0.00	100.00
E4-SMX10	0.96	0.00	0.00	0.00	0.00	0.96	0.00	0.00	100.00
E4-SMX20	0.79	0.00	0.00	0.00	0.00	0.79	0.00	0.00	100.00
E4-SMX30	0.59	0.00	0.00	0.00	0.00	0.59	0.00	0.00	100.00
E4-SMX35	0.97	0.00	0.00	0.00	0.00	0.97	0.00	0.00	100.00

Offsite Land Use Data

Drainage Area ID	Area (acres)	Weighted Runoff Coefficient "C"	Weighted Imperviousness (%)
A_FutureDetPond	2.76	0.84	90.42
A0-SFR05_OS	0.62	0.85	95.46
A0-SFR10_OS	0.77	0.76	83.17
A0-SFR15_OS	0.26	0.84	89.05
A1a-NML070_OS1	0.70	0.54	58.63
A1a-NML070_OS2	0.32	0.60	71.69
A1-NML010_OS	1.30	0.76	85.95
A1-NML015_OS	0.98	0.63	67.62
A1-NML035_OS	1.68	0.60	72.00
A2-NML015_OS	1.97	0.66	70.24
A2-NML025_OS	2.05	0.73	73.21
A2-NML030_OS	0.87	0.85	91.56
A2-SML040_OS	1.73	0.80	84.65
A2-SML045_OS	0.57	0.43	27.17
A2-SML060_OS	1.81	0.79	83.68
A3-SFR015_OS	2.59	0.56	50.09
A3-SFR020_OS	0.97	0.79	83.61
B1-SSH010_OS	1.34	0.51	44.36
B1-SSH015_OS	2.72	0.70	76.68
B2-SFR090_OS	3.06	0.90	100.00
B2-SOF065_OS	7.62	0.73	74.21
B2-SOF085	1.74	0.82	84.74
C1-SML030_OS	4.04	0.56	59.71
C2-NML035_OS	2.45	0.78	82.16
C3-NFR035_OS	2.62	0.83	91.89
C3-NML015_OS	3.85	0.60	72.00
C4-SBFR00_OS	46.62	0.55	50.64
C4-SBFR15_OS	2.02	0.90	100.00
C4-SML015_OS	7.21	0.89	97.76
D1-NGB025_OS	0.88	0.73	73.52
D1-NML040_OS	1.38	0.60	71.67
D1-NML045_OS	1.69	0.70	68.91
D1-SBFR05_OS	0.39	0.72	83.17
D1-SBFR20_OS	3.97	0.88	97.78
D2-SGB015_OS	3.52	0.83	89.56
E1-SFR015_OS	0.83	0.36	22.60
E1-SFR020_OS	2.70	0.90	100.00
E1-SFR040_OS	0.02	0.90	100.00
E1-SFR050_OS	0.13	0.90	100.00
E1-SFR085_OS	0.60	0.44	37.09
E1-SFR100_OS	1.62	0.69	67.70
E1-SFR110_OS	1.40	0.74	82.67
E1-SFR115_OS	111.79	0.52	42.40
E1-SFR130_OS	2.53	0.88	96.32

Offsite Land Use Data

Drainage Area ID	Area (acres)	Weighted Runoff Coefficient "C"	Weighted Imperviousness (%)
E1-SFR140_OS	0.10	0.90	100.00
E2-NML020_OS	3.97	0.48	47.78
E2-NML025_OS	7.16	0.52	50.17
E2-NML035_OS	1.79	0.74	82.53
E2-NML050_OS	1.50	0.74	83.27
E2-NML055_OS	2.63	0.74	83.73
E2-NML060_OS	2.78	0.63	74.36
E2-NML065_OS	31.37	0.59	66.47
E2-NML090_OS	17.77	0.61	68.25
E2-NML105_OS	14.56	0.59	60.70
E2-NML115_OS	5.07	0.73	81.36
E2-NML135_OS	2.86	0.74	84.60
E2-NML140_OS	2.75	0.72	83.24
E3-NFR065_OS	3.31	0.90	100.00
E3-NML030_OS	3.52	0.87	95.72
E3-NML075_OS	1.33	0.90	100.00
E3-NML090_OS	2.39	0.84	90.80
E3-NML095_OS	1.83	0.89	97.81
E4-SML010_OS	1.30	0.65	62.30
E4-SML030_OS	4.54	0.58	53.85
E4-SML040_OS	2.10	0.78	88.39
E4-SML050_OS	1.75	0.65	76.71
E4-SML060_OS	1.57	0.87	97.18
E4-SML065_OS	3.00	0.90	100.00
E4-SML075_OS	5.64	0.70	81.68

1. Offsite drainage areas remain unchanged between existing and proposed conditions

E.2 Hydrologic Calculations

TxDOT Rational Method Calculation - Existing Onsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
A1a-NML070	0.6644	0.0010	0.75	10.00	8.39	12.75	17.1	26.1
A1-NML020	0.4538	0.0007	0.79	10.00	8.39	12.75	24.2	36.8
A1-NML045	0.7216	0.0011	0.57	10.00	8.09	12.34	42.3	64.5
A1-NML075	0.5268	0.0008	0.88	10.00	8.39	12.75	31.6	48.1
A2-NML020	0.2769	0.0004	0.85	10.00	8.39	12.75	15.7	23.8
A2-NML030	0.7775	0.0012	0.86	10.00	8.39	12.75	8.9	13.5
A2-SML055	1.3084	0.0020	0.67	10.00	8.39	12.75	8.5	12.9
A2-SML060	0.9702	0.0015	0.59	10.00	8.39	12.75	4.8	7.3
A3-SFR010	0.9896	0.0015	0.59	10.00	8.39	12.75	14.6	22.1
B2-SFR090	1.0049	0.0016	0.75	10.00	8.39	12.75	22.3	33.9
B2-SML035	0.6505	0.0010	0.71	10.00	8.39	12.75	16.2	24.7
B2-SML075	1.8184	0.0028	0.61	10.00	8.39	12.75	26.3	39.9
B2-SSH020	0.3955	0.0006	0.88	10.00	8.39	12.75	11.2	17.1
B2-SVM045	2.9362	0.0046	0.72	10.00	8.39	12.75	15.7	23.9
B3-NSH015	1.7851	0.0028	0.72	10.00	7.12	10.98	7.7	11.9
B4-SSH020	0.5335	0.0008	0.83	10.00	8.39	12.75	9.8	14.9
C1-SML020	0.5924	0.0009	0.85	10.00	8.39	12.75	33.5	50.9
C1-SML040	1.7725	0.0028	0.75	10.00	8.39	12.75	29.9	45.4
C1-SML050	1.8548	0.0029	0.66	10.00	8.39	12.75	24.0	36.5
C2-NML020	2.1194	0.0033	0.63	10.00	8.39	12.75	10.8	16.3
C2-NML035	1.8650	0.0029	0.78	10.00	8.39	12.75	15.1	22.9
C3-NFR045	2.6339	0.0041	0.69	10.00	7.78	11.91	42.0	64.3
C4-SML025	1.7578	0.0027	0.72	10.00	6.85	10.61	55.2	85.5
D1-NML045	3.5070	0.0055	0.69	10.00	8.39	12.75	29.9	45.4
D2-SML035	1.8329	0.0029	0.64	10.00	8.39	12.75	33.6	51.0
E1-SFR035	2.3370	0.0037	0.56	10.00	8.39	12.75	53.2	80.9
E1-SFR075	1.0075	0.0016	0.75	10.00	8.39	12.75	53.9	81.9
E1-SFR105	0.9730	0.0015	0.64	10.00	8.39	12.75	41.8	63.5
E1-SFR130	1.5421	0.0024	0.75	10.00	8.39	12.75	44.9	68.2
E1-SML150	1.0747	0.0017	0.50	10.00	8.39	12.75	39.9	60.7
E2-NML045	4.0117	0.0063	0.63	10.00	8.39	12.75	28.0	42.6
E2-NML070	2.1412	0.0033	0.75	10.00	8.39	12.75	26.7	40.5
E2-NML100	4.6882	0.0073	0.70	10.00	8.39	12.75	28.6	43.4
E2-NML130	2.7380	0.0043	0.86	10.00	8.39	12.75	24.1	36.7
E2-NML145	4.4447	0.0069	0.87	10.00	8.39	12.75	20.8	31.6
E3-NML055	1.8335	0.0029	0.84	10.00	8.39	12.75	38.4	58.3

TxDOT Rational Method Calculation - Existing Onsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
E3-NML080	3.3434	0.0052	0.67	10.00	8.39	12.75	29.3	44.5
E3-NML100	0.2382	0.0004	0.81	10.00	8.39	12.75	26.2	39.8
E4-SML050	2.9506	0.0046	0.54	10.00	8.39	12.75	72.4	110.0
E4-SML075	0.8771	0.0014	0.74	10.00	8.39	12.75	54.8	83.2
E4-SML090	0.3998	0.0006	0.85	10.00	8.39	12.75	53.1	80.8

TxDOT Rainfall Intensity-Duration-Frequency Coefficient for Harris County Zone 1		
Coefficient[1]	10-yr	100-yr
b (in)	84.7764	156.589
d (min)	12.36	17.307
e	0.7445	0.688

[1] e, b, d = coefficients for specific frequencies for watersheds in Harris County Region 2, from *Atlas 14 IDF Curves* , Assistance with NOAA Atlas 14 Updates to the Harris County Flood Control District Policy Criteria & Procedures Manual (PCPM), May 2019.

TxDOT Rational Method Calculation - Proposed Onsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
B2-ML30	1.08	0.00	0.90	10.00	8.39	12.75	8.10	12.31
B2-ML35	0.86	0.00	0.90	10.00	8.39	12.75	6.47	9.84
B2-ML40	1.46	0.00	0.89	10.00	8.39	12.75	10.96	16.65
B2-SFR25	1.46	0.00	0.59	10.00	8.39	12.75	7.16	10.89
B2-SFR35	1.44	0.00	0.72	10.00	8.39	12.75	8.71	13.24
B2-SFR40	0.83	0.00	0.71	10.00	8.39	12.75	4.92	7.48
B2-SHPS20	1.95	0.00	0.69	10.00	8.39	12.75	11.23	17.06
B3-SHPN05	0.63	0.00	0.79	10.00	8.39	12.75	4.18	6.35
B3-SHPN10	0.77	0.00	0.77	10.00	8.39	12.75	4.92	7.48
B4-SHPS05	0.75	0.00	0.78	10.00	8.39	12.75	4.87	7.40
B4-SHPS10	0.78	0.00	0.76	10.00	8.39	12.75	4.94	7.50
C1-ML15	1.16	0.00	0.86	10.00	8.39	12.75	8.30	12.62
C1-ML30	1.11	0.00	0.90	10.00	8.39	12.75	8.37	12.72
C2-ML15	1.06	0.00	0.86	10.00	8.39	12.75	7.69	11.69
C2-ML25	1.11	0.00	0.90	10.00	8.39	12.75	8.39	12.75
C2-NFR10	2.92	0.00	0.80	10.00	8.39	12.75	19.59	29.78
C2-NFR20	3.30	0.01	0.79	10.00	8.39	12.75	21.87	33.24
C3-ML30	0.44	0.00	0.87	10.00	8.39	12.75	3.21	4.88
C3-NFR10	4.00	0.01	0.80	10.00	8.39	12.75	26.91	40.89
C3-NFR20	3.24	0.01	0.80	10.00	8.39	12.75	21.75	33.05
C4-ML05	2.11	0.00	0.81	10.00	8.39	12.75	14.27	21.68
C4-ML20	3.17	0.00	0.83	10.00	8.39	12.75	22.06	33.52
C5-ML10	1.64	0.00	0.76	10.00	8.39	12.75	10.44	15.87
C6-SFR05	3.13	0.00	0.80	10.00	8.39	12.75	20.92	31.80
C6-SFR20	3.09	0.00	0.80	10.00	8.39	12.75	20.61	31.33
D1-NFR20	5.43	0.01	0.82	10.00	8.39	12.75	37.33	56.73
E1-SBFR15	4.96	0.01	0.72	10.00	8.39	12.75	30.05	45.67
E1-SBFR25	5.10	0.01	0.75	10.00	8.39	12.75	32.27	49.04
E1-SBFR40	5.38	0.01	0.75	10.00	8.39	12.75	33.94	51.59
E1-SBFR50	3.86	0.01	0.76	10.00	8.39	12.75	24.61	37.39
E1-SBFR55	2.64	0.00	0.72	10.00	8.39	12.75	15.99	24.30
E1-SMX20	1.60	0.00	0.90	10.00	8.39	12.75	12.07	18.34
E1-SMX25	1.93	0.00	0.90	10.00	8.39	12.75	14.58	22.15
E1-SMX45	1.39	0.00	0.90	10.00	8.39	12.75	10.52	15.99
E1-SMX55	0.85	0.00	0.90	10.00	8.39	12.75	6.42	9.76
E2-NBFR15	4.81	0.01	0.73	10.00	8.39	12.75	29.65	45.06

TxDOT Rational Method Calculation - Proposed Onsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
E2-NBFR25	5.10	0.01	0.73	10.00	8.39	12.75	31.19	47.40
E2-NBFR35	5.51	0.01	0.68	10.00	8.39	12.75	31.54	47.93
E2-NBFR45	5.39	0.01	0.73	10.00	8.39	12.75	32.92	50.03
E2-NBFR50	2.48	0.00	0.77	10.00	8.39	12.75	16.05	24.39
E2-NMX20	1.56	0.00	0.90	10.00	8.39	12.75	11.81	17.95
E2-NMX35	1.93	0.00	0.90	10.00	8.39	12.75	14.59	22.17
E2-NMX50	1.38	0.00	0.90	10.00	8.39	12.75	10.40	15.80
E2-NMX60	0.80	0.00	0.90	10.00	8.39	12.75	6.08	9.23
E3-NBFR10	4.64	0.01	0.76	10.00	8.39	12.75	29.65	45.06
E3-NBFR15	2.68	0.00	0.76	10.00	8.39	12.75	17.05	25.92
E3-NBFR20	3.26	0.01	0.75	10.00	8.39	12.75	20.41	31.01
E3-NBFR35	5.65	0.01	0.78	10.00	8.39	12.75	36.83	55.97
E3-NMX05	1.23	0.00	0.90	10.00	8.39	12.75	9.29	14.12
E3-NMX10	0.96	0.00	0.90	10.00	8.39	12.75	7.26	11.03
E3-NMX20	0.79	0.00	0.90	10.00	8.39	12.75	5.98	9.08
E3-NMX30	0.60	0.00	0.90	10.00	8.39	12.75	4.49	6.83
E3-NMX35	0.97	0.00	0.90	10.00	8.39	12.75	7.32	11.13
E4-SBFR05	4.16	0.01	0.77	10.00	8.39	12.75	26.82	40.76
E4-SBFR15	4.44	0.01	0.74	10.00	8.39	12.75	27.49	41.77
E4-SBFR25	4.13	0.01	0.78	10.00	8.39	12.75	27.03	41.09
E4-SBFR35	4.76	0.01	0.77	10.00	8.39	12.75	30.57	46.46

TxDOT Rational Method Calculation - Proposed Onsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
E4-SBFR40	3.76	0.01	0.80	10.00	8.39	12.75	25.24	38.35
E4-SBFR45	2.48	0.00	0.71	10.00	8.39	12.75	14.85	22.56
E4-SBFR50	5.06	0.01	0.75	10.00	8.39	12.75	31.74	48.23
E4-SMX05	1.35	0.00	0.90	10.00	8.39	12.75	10.20	15.50
E4-SMX10	0.96	0.00	0.90	10.00	8.39	12.75	7.26	11.03
E4-SMX20	0.79	0.00	0.90	10.00	8.39	12.75	5.97	9.07
E4-SMX30	0.59	0.00	0.90	10.00	8.39	12.75	4.49	6.82
E4-SMX35	0.97	0.00	0.90	10.00	8.39	12.75	7.34	11.16

TxDOT Rainfall Intensity-Duration-Frequency Coefficient for Harris County Zone 1

Coefficient[1]	10-yr	100-yr
b (in)	84.7764	156.589
d (min)	12.36	17.307
e	0.7445	0.688

[1] e, b, d = coefficients for specific frequencies for watersheds in Harris County Region 2, from *Atlas 14 IDF Curves* , Assistance with NOAA Atlas 14 Updates to the Harris County Flood Control District Policy Criteria & Procedures Manual (PCPM), May 2019.

TxDOT Rational Method Calculation - Offsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
A_FutureDetPond	2.7556	0.0043	0.84	17.56	6.75	10.47	15.6	24.2
A0-SFR05_OS	2.3635	0.0037	0.70	10.00	8.39	12.75	4.4	6.7
A0-SFR10_OS	3.2362	0.0051	0.75	10.00	8.39	12.75	5.0	7.5
A0-SFR15_OS	2.1810	0.0034	0.67	10.00	8.39	12.75	1.9	2.8
A1a-NML070_OS1	0.3305	0.0005	0.82	10.00	8.39	12.75	3.2	4.8
A1a-NML070_OS2	0.6578	0.0010	0.56	10.00	8.39	12.75	1.6	2.5
A1-NML010_OS	2.7093	0.0042	0.80	10.00	8.39	12.75	8.3	12.7
A1-NML015_OS	2.6526	0.0041	0.78	10.00	8.39	12.75	5.2	7.8
A1-NML035_OS	0.3802	0.0006	0.90	10.00	8.39	12.75	8.5	12.9
A2-NML015_OS	0.4034	0.0006	0.90	10.00	8.39	12.75	11.0	16.7
A2-NML025_OS	0.3555	0.0006	0.88	10.00	8.39	12.75	12.5	19.0
A2-NML030_OS	1.5532	0.0024	0.56	10.00	8.39	12.75	6.2	9.4
A2-SML040_OS	0.5950	0.0009	0.90	10.00	8.39	12.75	11.6	17.7
A2-SML045_OS	2.9544	0.0046	0.70	10.00	8.39	12.75	2.0	3.1
A2-SML060_OS	0.7888	0.0012	0.63	10.00	8.39	12.75	12.1	18.4
A3-SFR015_OS	1.1242	0.0018	0.62	10.00	7.88	12.04	11.5	17.6
A3-SFR020_OS	1.0470	0.0016	0.61	10.00	8.39	12.75	6.4	9.8
B1-SSH010_OS	1.3331	0.0021	0.63	10.00	6.97	10.77	4.8	7.4
B1-SSH015_OS	1.8308	0.0029	0.62	10.00	4.72	7.55	9.0	14.4
B2-SFR090_OS	0.9886	0.0015	0.66	10.00	8.39	12.75	23.1	35.1
B2-SOF065_OS	0.9035	0.0014	0.60	10.00	8.39	12.75	46.9	71.2
B2-SOF085	2.0073	0.0031	0.67	10.00	8.39	12.75	11.9	18.1
C1-SML030_OS	0.9344	0.0015	0.84	10.00	8.39	12.75	19.1	29.1
C2-NML035_OS	2.6411	0.0041	0.76	10.00	8.39	12.75	16.1	24.5
C3-NFR035_OS	1.6715	0.0026	0.59	10.00	8.39	12.75	18.2	27.6
C3-NML015_OS	2.6637	0.0042	0.74	10.00	8.39	12.75	19.4	29.5
C4-SBFR00_OS	0.8854	0.0014	0.88	10.00	4.03	6.52	102.5	165.9
C4-SBFR15_OS	1.1819	0.0018	0.78	10.00	8.39	12.75	15.2	23.1
C4-SML015_OS	1.5359	0.0024	0.73	10.00	8.39	12.75	53.5	81.4
D1-NGB025_OS	2.3459	0.0037	0.68	10.00	8.39	12.75	5.4	8.2
D1-NML040_OS	0.6816	0.0011	0.90	10.00	7.11	10.97	5.9	9.0
D1-NML045_OS	1.2503	0.0020	0.62	10.00	8.39	12.75	9.9	15.0
D1-SBFR05_OS	1.3300	0.0021	0.69	10.00	8.39	12.75	2.4	3.6
D1-SBFR20_OS	3.6157	0.0056	0.55	10.00	8.28	12.59	28.8	43.9
D2-SGB015_OS	1.8196	0.0028	0.64	10.00	8.39	12.75	24.6	37.3
E1-SFR015_OS	3.9668	0.0062	0.67	10.00	7.34	11.30	2.2	3.4

TxDOT Rational Method Calculation - Offsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
E1-SFR020_OS	2.4629	0.0038	0.49	10.00	8.39	12.75	20.4	31.0
E1-SFR040_OS	0.6235	0.0010	0.83	10.00	8.39	12.75	0.2	0.2
E1-SFR050_OS	0.9872	0.0015	0.80	10.00	8.39	12.75	1.0	1.5
E1-SFR085_OS	0.8596	0.0013	0.80	10.00	8.39	12.75	2.2	3.4
E1-SFR100_OS	1.5459	0.0024	0.64	10.00	7.74	11.85	8.7	13.3
E1-SFR110_OS	2.0469	0.0032	0.60	10.00	7.77	11.89	8.0	12.3
E1-SFR115_OS	0.7237	0.0011	0.47	10.00	2.92	4.83	168.8	279.8
E1-SFR130_OS	0.9616	0.0015	0.46	10.00	8.39	12.75	18.6	28.2
E1-SFR140_OS	1.3217	0.0021	0.54	10.00	8.39	12.75	0.8	1.2
E2-NML020_OS	4.7439	0.0074	0.58	10.00	7.94	12.13	15.1	23.0
E2-NML025_OS	0.8338	0.0013	0.43	10.00	6.13	9.58	22.8	35.6
E2-NML035_OS	0.3368	0.0005	0.62	10.00	8.39	12.75	11.1	16.8
E2-NML050_OS	0.6901	0.0011	0.70	10.00	8.39	12.75	9.3	14.1
E2-NML055_OS	4.6541	0.0073	0.71	10.00	6.69	10.38	13.1	20.3
E2-NML060_OS	4.8790	0.0076	0.70	10.00	7.07	10.92	12.4	19.1
E2-NML065_OS	4.9750	0.0078	0.72	10.00	6.56	10.20	122.2	190.0
E2-NML090_OS	2.2742	0.0036	0.79	10.00	6.24	9.74	67.9	106.1
E2-NML105_OS	7.6678	0.0120	0.78	10.00	6.66	10.34	57.3	89.0
E2-NML115_OS	6.0827	0.0095	0.82	10.00	7.64	11.72	28.3	43.4
E2-NML135_OS	2.8436	0.0044	0.87	10.00	6.98	10.79	14.7	22.7
E2-NML140_OS	1.2508	0.0020	0.86	10.00	8.39	12.75	16.6	25.2

TxDOT Rational Method Calculation - Offsite Drainage Area

Drainage Area ID	Area		Weighted Runoff Coefficient "C"	Time of Concentration (minimum 10 minutes)	Rainfall Intensity		Peak Flow Rates	
					$I_{10\text{-YR}}$	$I_{100\text{-YR}}$	$Q_{10\text{-YR}}$	$Q_{100\text{-YR}}$
	(acre)	(sq. mi.)	(--)	(min)	(in/hr)	(in/hr)	(cfs)	(cfs)
E3-NFR065_OS	1.9704	0.0031	0.56	10.00	8.39	12.75	25.0	38.0
E3-NML030_OS	1.5852	0.0025	0.73	10.00	8.39	12.75	25.8	39.2
E3-NML075_OS	2.5777	0.0040	0.73	10.00	8.39	12.75	10.0	15.2
E3-NML090_OS	0.3172	0.0005	0.83	10.00	8.39	12.75	16.9	25.6
E3-NML095_OS	0.9322	0.0015	0.51	10.00	8.39	12.75	13.6	20.6
E4-SML010_OS	2.7566	0.0043	0.81	10.00	8.39	12.75	7.1	10.8
E4-SML030_OS	1.6762	0.0026	0.62	10.00	8.39	12.75	22.2	33.8
E4-SML040_OS	3.9663	0.0062	0.58	10.00	8.39	12.75	13.7	20.8
E4-SML050_OS	1.4459	0.0023	0.56	10.00	8.39	12.75	9.5	14.5
E4-SML060_OS	3.7811	0.0059	0.52	10.00	8.39	12.75	11.5	17.4
E4-SML065_OS	0.6113	0.0010	0.72	10.00	8.39	12.75	22.6	34.4
E4-SML075_OS	0.4931	0.0008	0.82	10.00	7.36	11.33	29.2	45.0

TxDOT Rainfall Intensity-Duration-Frequency Coefficient for Harris County Zone 1		
Coefficient[1]	10-yr	100-yr
b (in)	84.7764	156.589
d (min)	12.36	17.307
e	0.7445	0.688

[1] e, b, d = coefficients for specific frequencies for watersheds in Harris County Region 2, from *Atlas 14 IDF Curves* , Assistance with NOAA Atlas 14 Updates to the Harris County Flood Control District Policy Criteria & Procedures Manual (PCPM), May 2019.

E.3 Hydraulic Calculations: PCSWMM Results

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
A1a-NML020	A1-NML015	76.8	76.6	70	0.001	1	0.0	1.0	CIRCULAR	84.0	80.9	14.8	80.8	80.7	19.5	81.5	81.5
A1a-NML070	A1-NML065	77.4	77.4	230	0.000	1	0.0	1.5	CIRCULAR	82.5	81.5	7.2	82.4	82.7	8.3	83.4	83.5
A1-NFR006	A-NFR005	76.0	75.4	115	0.002	1	4.0	2.0	RECT_CLOSED	79.6	76.7	81.5	79.2	79.1	108.8	79.9	79.5
A1-NFR008	A1-NFR006	76.1	75.8	40	0.002	1	4.0	2.0	RECT_CLOSED	82.0	79.6	26.1	79.2	79.2	37.6	80.0	79.9
A1-NML010	A1-NFR008	76.5	76.0	300	0.001	1	0.0	2.0	CIRCULAR	81.6	82.0	26.3	80.1	79.2	37.7	80.7	80.0
A1-NML015	A1-NML010	76.8	76.1	300	0.001	1	0.0	2.0	CIRCULAR	80.9	81.6	13.6	80.7	80.1	14.8	81.5	80.7
A1-NML020	A1-NML015	76.8	76.6	100	0.001	1	0.0	1.5	CIRCULAR	81.2	80.9	14.8	82.1	80.7	19.5	84.1	81.5
A1-NML025	A1-NML020	76.9	76.8	100	0.001	1	0.0	1.5	CIRCULAR	81.6	81.2	24.2	81.3	82.1	36.8	81.5	84.1
A1-NML030	A1-NML025	77.2	76.8	100	0.002	1	0.0	1.5	CIRCULAR	85.5	81.6	15.0	81.6	81.3	23.7	82.0	81.5
A1-NML035	A1-NML030	77.2	76.9	280	0.000	1	0.0	1.5	CIRCULAR	92.0	85.5	6.6	82.7	81.6	7.8	83.4	82.0
A1-NML040	A1-NML035	77.3	77.2	325	0.000	1	0.0	1.5	CIRCULAR	81.7	92.0	17.1	82.7	82.7	23.1	83.4	83.4
A1-NML045	A1-NML040	77.4	77.2	45	0.000	1	0.0	1.5	CIRCULAR	81.2	81.7	5.1	82.7	82.7	5.3	83.4	83.4
A1-NML050	A1-NML045	77.4	77.3	80	0.000	1	0.0	1.5	CIRCULAR	81.5	81.2	42.3	82.7	82.7	64.5	83.4	83.4
A1-NML055	A1-NML050	77.4	77.4	50	0.000	1	0.0	1.5	CIRCULAR	81.6	81.5	7.2	82.7	82.7	7.9	83.4	83.4
A1-NML060	A1-NML055	77.4	77.4	50	0.000	1	0.0	1.5	CIRCULAR	82.3	81.6	7.2	82.7	82.7	7.9	83.5	83.4
A1-NML065	A1-NML060	77.4	77.4	30	0.000	1	0.0	1.5	CIRCULAR	81.5	82.3	7.2	82.7	82.7	7.9	83.5	83.5
A2a-NML025	A2-NML020	75.7	76.0	5	0.002	1	0.0	2.0	CIRCULAR	81.3	79.9	19.7	81.2	81.2	23.8	82.0	82.0
A2a-NML030	A2a-NML025	75.8	75.7	20	0.002	1	0.0	2.0	CIRCULAR	90.9	81.3	5.7	81.2	81.2	5.8	82.0	82.0
A2-NML007	A-NFR005	75.9	75.4	100	0.001	1	4.0	2.0	RECT_CLOSED	80.0	76.7	81.5	79.3	79.1	108.8	79.7	79.5
A2-NML010	A2-NML007	76.0	75.9	100	0.001	1	0.0	2.0	CIRCULAR	80.1	80.0	25.8	81.0	79.3	28.6	81.6	79.7
A2-NML015	A2-NML010	76.0	75.9	240	0.000	1	0.0	2.0	CIRCULAR	80.2	80.1	25.7	81.1	81.0	28.5	81.9	81.6
A2-NML020	A2-NML015	76.1	76.0	200	0.001	1	0.0	2.0	CIRCULAR	79.9	80.2	19.9	81.2	81.1	19.8	82.0	81.9
A2-NML025	A2-NML020	76.2	76.0	100	0.001	1	0.0	2.0	CIRCULAR	79.6	79.9	19.7	81.2	81.2	23.8	81.9	82.0
A2-NML030	A2-NML025	76.4	76.1	330	0.001	1	0.0	1.5	CIRCULAR	80.2	79.6	12.0	81.1	81.2	13.9	82.0	81.9
A2-SFR045	A2-SML040	75.9	76.1	150	0.001	1	0.0	1.5	CIRCULAR	82.6	81.9	9.3	81.1	81.1	6.7	82.0	82.0
A2-SFR050	A2-SFR045	76.5	75.7	100	0.005	1	0.0	1.0	CIRCULAR	81.9	82.6	6.0	81.2	81.1	5.5	82.1	82.0
A2-SFR065	A2-SML060	77.1	80.0	220	0.000	1	0.0	1.5	CIRCULAR	91.0	80.1	17.5	81.2	81.1	20.9	82.0	82.0
A2-SML035	A2a-NML030	76.1	75.7	130	0.002	1	0.0	2.0	CIRCULAR	92.1	90.9	5.7	81.2	81.2	5.8	82.0	82.0
A2-SML040	A2-SML035	76.1	75.8	25	0.002	1	0.0	2.0	CIRCULAR	81.9	92.1	5.7	81.1	81.2	5.8	82.0	82.0
A2-SML055	A2-SFR050	76.8	76.0	50	0.005	1	0.0	1.5	CIRCULAR	80.1	81.9	3.5	81.2	81.2	3.7	82.1	82.1
A2-SML060	A2-SML055	80.2	76.5	178	0.001	1	165.0	1.0	TRAPEZOIDAL	80.1	80.1	8.5	81.1	81.2	12.9	82.0	82.1
A3-SFR010	A-NFR005	75.5	75.4	280	0.000	3	0.0	3.0	CIRCULAR	80.0	76.7	81.5	79.2	79.1	108.8	79.7	79.5
A3-SFR015	A3-SFR010	75.7	75.5	80	0.002	1	0.0	2.0	CIRCULAR	81.9	80.0	34.9	81.6	79.2	48.2	82.2	79.7
A3-SFR020	A3-SFR015	76.1	75.5	140	0.002	1	0.0	2.0	CIRCULAR	81.5	81.9	27.7	82.1	81.6	31.7	82.3	82.2

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
A3-SFR025	A3-SFR020	76.8	75.7	180	0.004	1	0.0	2.0	CIRCULAR	81.3	81.5	36.1	81.0	82.1	32.1	81.7	82.3
A3-SFR025	A2-NML010	76.8	75.9	180	0.004	1	0.0	2.0	CIRCULAR	81.3	80.1	25.7	81.0	81.0	28.5	81.7	81.6
A3-SFR025	A2-NML010	76.8	75.9	180	0.004	1	0.0	2.0	CIRCULAR	81.3	80.1	25.7	81.0	81.0	28.5	81.7	81.6
A3-SFR030	A3-SFR025	77.5	76.1	160	0.004	1	0.0	2.0	CIRCULAR	80.0	81.3	21.9	81.1	81.0	24.5	82.0	81.7
B1-SSH010	Ba-SSH005	76.2	73.5	238	0.006	1	0.0	3.0	CIRCULAR	80.3	80.7	461.5	82.7	82.7	707.8	83.0	83.3
B1-SSH015	B1-SSH010	76.9	74.7	191	0.004	1	0.0	2.0	CIRCULAR	81.1	80.3	27.0	82.7	82.7	26.6	83.0	83.0
B1-SSH020	B1-SSH015	77.0	76.2	27	0.004	1	0.0	2.0	CIRCULAR	80.5	81.1	26.2	82.8	82.7	35.2	83.1	83.0
B2a-SML035	B2-SML030	76.0	74.8	65	0.003	1	0.0	2.0	CIRCULAR	80.1	80.3	63.4	82.8	82.8	67.8	83.1	83.1
B2a-SML040	B2a-SML035	76.6	75.8	69	0.009	1	0.0	2.0	CIRCULAR	80.4	80.1	17.2	82.8	82.8	19.2	83.2	83.1
B2a-SML045	B2a-SML040	76.7	76.0	96	0.001	1	0.0	1.5	CIRCULAR	81.3	80.4	17.1	82.7	82.8	19.2	83.4	83.2
B2a-SML055	B2-SML050	75.6	75.4	42	0.003	1	0.0	3.5	CIRCULAR	80.3	80.6	49.1	82.8	82.8	51.2	83.1	83.1
B2a-SSH020	B2-SSH015	81.7	73.9	20	0.010	1	0.0	0.0	IRREGULAR	79.6	80.8	110.9	82.7	82.7	113.6	83.0	83.0
B2-SFR050	B2-SVM045	76.0	75.9	110	0.000	1	5.0	3.0	RECT_CLOSED	80.7	80.7	35.7	82.4	82.4	43.6	82.6	82.7
B2-SFR055	B2-SFR050	76.4	75.9	110	0.004	1	5.0	3.0	RECT_CLOSED	80.4	80.7	35.7	82.3	82.4	43.6	82.5	82.6
B2-SFR060	B2-SFR055	83.3	76.0	20	0.010	1	0.0	0.0	IRREGULAR	80.3	80.4	35.7	82.1	82.3	43.6	82.3	82.5
B2-SFR065	B2-SFR060	76.9	83.1	80	0.002	1	0.0	2.0	CIRCULAR	80.5	80.3	44.2	82.3	82.1	53.2	82.5	82.3
B2-SFR070	B2-SML065	76.3	75.7	71	0.001	1	0.0	3.0	CIRCULAR	82.1	82.0	14.4	82.8	82.8	28.3	83.1	83.1
B2-SFR075	B2-SFR070	76.5	76.2	232	0.001	1	0.0	3.0	CIRCULAR	81.0	82.1	14.4	82.8	82.8	28.3	83.1	83.1
B2-SFR080	B2-SFR075	76.7	76.3	116	0.001	1	0.0	3.0	CIRCULAR	81.9	81.0	14.4	82.8	82.8	28.3	83.0	83.1
B2-SFR085	B2-SFR080	76.8	76.5	108	0.001	1	0.0	3.0	CIRCULAR	82.0	81.9	29.2	83.0	82.8	34.7	83.2	83.0
B2-SFR090	B2-SFR085	77.0	76.7	163	0.001	1	0.0	3.0	CIRCULAR	81.5	82.0	29.2	83.3	83.0	34.7	83.6	83.2
B2-SML025	B2-SSH020	74.8	74.2	162	0.004	1	0.0	3.5	CIRCULAR	80.8	82.2	87.4	82.7	82.7	90.1	83.0	83.0
B2-SML030	B2-SML025	74.9	74.2	43	0.002	1	0.0	3.5	CIRCULAR	80.3	80.8	84.2	82.8	82.7	98.1	83.1	83.0
B2-SML035	B2-SML030	75.2	74.8	46	0.003	1	0.0	3.5	CIRCULAR	80.0	80.3	63.4	82.8	82.8	67.8	83.1	83.1
B2-SML040	B2-SML035	75.2	75.0	25	0.002	1	0.0	3.5	CIRCULAR	80.1	80.0	50.0	82.8	82.8	52.5	83.1	83.1
B2-SML045	B2-SML040	75.4	75.2	52	0.003	1	0.0	3.5	CIRCULAR	80.7	80.1	49.1	82.8	82.8	51.2	83.1	83.1
B2-SML050	B2-SML045	75.5	75.2	27	0.003	1	0.0	3.5	CIRCULAR	80.6	80.7	49.1	82.8	82.8	51.2	83.1	83.1
B2-SML060	B2a-SML055	75.7	75.5	83	0.002	1	0.0	3.5	CIRCULAR	81.7	80.3	49.1	82.8	82.8	51.2	83.1	83.1
B2-SML065	B2-SML060	76.2	75.6	407	0.001	1	0.0	3.0	CIRCULAR	82.0	81.7	49.1	82.8	82.8	51.2	83.1	83.1
B2-SML070	B2-SFR065	77.0	76.8	135	0.000	1	0.0	1.5	CIRCULAR	81.9	80.5	10.1	83.6	82.3	9.9	83.6	82.5
B2-SML075	B2-SML070	83.6	76.9	20	0.010	1	0.0	0.0	IRREGULAR	82.1	81.9	10.1	83.8	83.6	9.9	83.8	83.6
B2-SOF065	B2-SML060	77.4	75.6	50	0.006	3	0.0	2.0	CIRCULAR	79.8	81.7	49.1	82.8	82.8	51.2	83.1	83.1
B2-SOF070	B2-SOF065	77.7	77.1	36	0.006	1	0.0	2.0	CIRCULAR	80.6	79.8	44.2	82.7	82.8	25.4	83.0	83.1
B2-SOF075	B2-SOF070	78.0	77.4	132	0.003	1	0.0	2.0	CIRCULAR	80.9	80.6	11.6	82.6	82.7	11.3	83.0	83.0
B2-SOF080	B2-SOF075	78.3	77.7	127	0.003	1	0.0	2.0	CIRCULAR	80.7	80.9	10.2	82.6	82.6	10.6	83.0	83.0

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
B2-SOF085_1	B2-SOF080	79.1	78.0	99	0.003	1	0.0	1.5	CIRCULAR	80.4	80.7	0.5	82.7	82.6	0.5	83.0	83.0
B2-SSH010	Bb-SSH005	73.9	73.6	80	0.002	1	0.0	5.0	CIRCULAR	82.2	82.0	112.4	82.7	82.7	116.4	83.0	83.0
B2-SSH015	B2-SSH010	74.2	73.7	151	0.002	1	0.0	5.0	CIRCULAR	80.8	82.2	110.9	82.7	82.7	113.6	83.0	83.0
B2-SSH020	B2-SSH015	74.2	73.9	55	0.001	1	0.0	3.5	CIRCULAR	82.2	80.8	110.9	82.7	82.7	113.6	83.0	83.0
B2-SVM025	B2a-SSH020	74.4	81.5	104	0.001	1	5.0	3.0	RECT_CLOSED	79.8	79.6	36.7	82.6	82.7	45.8	82.9	83.0
B2-SVM030	B2-SVM025	75.1	74.3	70	0.001	1	5.0	3.0	RECT_CLOSED	79.9	79.8	36.7	82.6	82.6	37.9	82.9	82.9
B2-SVM035	B2-SVM030	75.8	75.0	125	0.006	1	5.0	3.0	RECT_CLOSED	80.1	79.9	36.3	82.5	82.6	37.6	82.8	82.9
B2-SVM040	B2-SVM035	75.9	75.1	165	0.001	1	5.0	3.0	RECT_CLOSED	80.6	80.1	34.3	82.5	82.5	34.8	82.7	82.8
B2-SVM045	B2-SVM040	75.9	75.8	90	0.000	1	5.0	3.0	RECT_CLOSED	80.7	80.6	34.3	82.4	82.5	34.7	82.7	82.7
B3-NSH010	Bb-SSH005	74.3	73.6	79	0.002	1	0.0	2.0	CIRCULAR	81.2	82.0	112.4	82.2	82.7	116.4	82.4	83.0
B3-NSH015	B3-NSH010	76.1	74.1	308	0.006	1	0.0	2.0	CIRCULAR	81.0	81.2	14.9	80.8	82.2	16.2	80.9	82.4
B4-SSH010	Bb-SSH005	82.3	73.6	20	0.010	1	0.0	0.0	IRREGULAR	81.2	82.0	112.4	82.3	82.7	116.4	82.4	83.0
B4-SSH015	B4-SSH010	81.0	82.1	20	0.010	1	0.0	0.0	IRREGULAR	80.5	81.2	12.7	81.3	82.3	14.7	81.4	82.4
B4-SSH020	B4-SSH015	77.7	80.8	198	0.006	1	0.0	1.5	CIRCULAR	81.2	80.5	20.6	83.1	81.3	27.0	85.5	81.4
Ba-SSH005	B-SSH005	73.5	72.8	20	0.001	1	0.0	5.0	CIRCULAR	80.7	81.8	137.8	82.7	82.8	151.0	83.3	83.1
Bb-SSH005	Ba-SSH005	73.7	73.5	62	0.002	1	0.0	5.0	CIRCULAR	82.0	80.7	461.5	82.7	82.7	707.8	83.0	83.3
B-SSH005	OUT_B	73.5	72.8	693	0.001	1	0.0	5.0	CIRCULAR	81.8	77.8	137.9	82.8	83.6	151.1	83.1	83.6
C1-SML010	C-SML005	83.6	78.2	20	0.010	1	0.0	0.0	IRREGULAR	81.5	82.6	119.3	82.4	82.4	136.1	82.9	82.9
C1-SML015	C1-SML010	78.5	83.4	225	0.001	1	6.0	3.0	RECT_CLOSED	81.9	81.5	46.9	82.5	82.4	52.1	82.9	82.9
C1-SML020	C1-SML015	78.6	78.3	80	0.001	1	6.0	3.0	RECT_CLOSED	82.4	81.9	46.9	82.5	82.5	52.1	82.9	82.9
C1-SML025	C1-SML020	78.7	78.5	120	0.001	1	6.0	3.0	RECT_CLOSED	82.5	82.4	47.1	82.6	82.5	52.2	83.5	82.9
C1-SML030	C1-SML025	83.7	78.6	20	0.010	1	0.0	0.0	IRREGULAR	81.9	82.5	24.4	82.6	82.6	19.8	83.0	83.5
C1-SML035	C1-SML030	79.1	83.5	300	0.001	1	3.0	3.0	RECT_CLOSED	82.9	81.9	24.4	82.6	82.6	20.4	83.1	83.0
C1-SML040	C1-SML035	79.1	78.8	80	0.001	1	3.0	3.0	RECT_CLOSED	82.4	82.9	16.3	82.6	82.6	18.0	83.1	83.1
C1-SML045	C1-SML040	83.8	79.1	20	0.010	1	0.0	0.0	IRREGULAR	82.5	82.4	29.9	82.6	82.6	45.4	83.0	83.1
C1-SML050	C1-SML045	79.3	83.6	115	0.000	1	0.0	1.5	CIRCULAR	81.9	82.5	25.3	83.3	82.6	45.2	87.0	83.0
C2-NML010	C-NML005	77.9	77.6	190	0.001	1	4.0	2.0	RECT_CLOSED	81.3	82.0	135.7	82.1	82.1	165.3	82.5	82.6
C2-NML015	C2-NML010	78.1	77.6	152	0.001	1	3.0	2.0	RECT_CLOSED	82.1	81.3	7.8	82.0	82.1	9.0	82.4	82.5
C2-NML020	C2-NML015	78.2	77.9	144	0.001	1	3.0	2.0	RECT_CLOSED	82.2	82.1	7.8	82.0	82.0	9.0	82.4	82.4
C2-NML025	C2-NML020	78.3	78.1	64	0.001	1	3.0	2.0	RECT_CLOSED	81.6	82.2	10.8	82.0	82.0	16.3	82.4	82.4
C2-NML030	C2-NML025	78.5	78.2	182	0.001	1	0.0	2.0	CIRCULAR	82.1	81.6	8.8	81.7	82.0	10.6	82.0	82.4
C2-NML035	C2-NML030	78.7	78.3	288	0.001	1	0.0	2.0	CIRCULAR	81.9	82.1	8.8	81.5	81.7	10.6	81.8	82.0
C3-NFR035	C3-NML030	79.2	78.9	36	0.003	1	0.0	1.5	CIRCULAR	80.3	81.1	6.8	82.7	82.6	6.9	83.4	83.3
C3-NFR040	C3-NFR035	79.3	79.1	65	0.002	1	0.0	1.5	CIRCULAR	80.5	80.3	6.8	82.6	82.7	8.5	83.4	83.4
C3-NFR045	C3-NFR040	80.5	79.2	20	0.010	1	0.0	0.0	IRREGULAR	79.8	80.5	4.2	82.4	82.6	3.8	83.4	83.4

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
C3-NML010	C-NML005	77.8	77.6	85	0.001	1	4.0	3.0	RECT_CLOSED	81.3	82.0	135.7	86.1	82.1	165.3	82.7	82.6
C3-NML015	C3-NML010	78.0	77.7	325	0.001	1	3.0	3.0	RECT_CLOSED	81.2	81.3	33.4	82.4	86.1	34.9	83.3	82.7
C3-NML020	C3-NML015	78.1	77.8	160	0.001	1	4.0	3.0	RECT_CLOSED	80.5	81.2	33.4	82.3	82.4	34.9	83.2	83.3
C3-NML025	C3-NML020	78.4	78.0	397	0.001	1	0.0	3.0	CIRCULAR	81.0	80.5	7.0	82.4	82.3	7.3	83.3	83.2
C3-NML030	C3-NML025	79.1	78.1	186	0.001	1	0.0	2.0	CIRCULAR	81.1	81.0	6.8	82.6	82.4	7.0	83.3	83.3
C4-SML010	C-SML005	78.5	78.2	380	0.001	1	5.0	3.0	RECT_CLOSED	81.6	82.6	119.3	82.6	82.4	136.1	83.0	82.9
C4-SML015	C4-SML010	78.7	78.2	180	0.001	1	5.0	3.0	RECT_CLOSED	80.9	81.6	41.0	82.7	82.6	47.1	83.2	83.0
C4-SML020	C4-SML015	78.8	78.5	195	0.001	1	3.0	3.0	RECT_CLOSED	82.2	80.9	42.5	83.0	82.7	49.2	83.4	83.2
C4-SML025	C4-SML020	78.9	78.7	115	0.001	1	3.0	3.0	RECT_CLOSED	81.8	82.2	37.0	83.3	83.0	35.3	83.6	83.4
C-ML005	C-NML005	78.2	77.6	88	0.000	2	6.0	3.0	RECT_CLOSED	83.9	82.0	135.7	82.2	82.1	165.3	82.7	82.6
C-NML005	C-NFR005	77.7	76.4	86	0.001	2	7.0	3.0	RECT_CLOSED	82.0	81.8	128.1	82.1	82.0	156.8	82.6	82.3
C-SML005	C-ML005	78.2	78.2	78	0.000	2	6.0	3.0	RECT_CLOSED	82.6	83.9	119.3	82.4	82.2	136.1	82.9	82.7
D1-NFR010	D1-NFR005	76.6	73.8	13	0.039	1	6.0	3.0	RECT_CLOSED	79.1	77.5	93.8	79.1	79.2	106.5	79.4	79.4
D1-NGB020	D1-NML015	76.8	76.6	157	0.001	1	6.0	3.0	RECT_CLOSED	80.8	83.1	93.8	80.5	79.5	106.7	81.2	79.8
D1-NGB025	D1-NGB020	76.8	76.6	9	0.001	1	4.0	3.0	RECT_CLOSED	80.2	80.8	93.8	80.6	80.5	105.2	81.2	81.2
D1-NGB030	D1-NGB025	76.9	76.8	102	0.001	1	4.0	3.0	RECT_CLOSED	79.9	80.2	53.7	80.8	80.6	71.7	81.4	81.2
D1-NGB035	D1-NGB030	76.9	76.8	45	0.001	1	4.0	3.0	RECT_CLOSED	80.5	79.9	49.4	80.9	80.8	49.6	81.5	81.4
D1-NML015	D1-NFR010	76.6	76.1	32	0.001	1	6.0	3.0	RECT_CLOSED	83.1	79.1	93.8	79.5	79.1	106.5	79.8	79.4
D1-NML040	D1-NGB035	77.1	76.9	219	0.001	1	4.0	3.0	RECT_CLOSED	79.5	80.5	49.4	81.3	80.9	49.5	81.8	81.5
D1-NML045	D1-NML040	77.3	76.9	258	0.001	1	0.0	3.0	CIRCULAR	82.7	79.5	49.4	81.4	81.3	49.8	81.8	81.8
D2-SGB005	D1-NGB020	76.8	76.6	89	0.001	1	3.0	3.0	RECT_CLOSED	81.1	80.8	93.8	81.1	80.5	105.2	81.6	81.2
D2-SGB010	D2-SGB005	76.9	76.8	87	0.001	1	3.0	3.0	RECT_CLOSED	80.4	81.1	43.0	81.6	81.1	44.3	81.9	81.6
D2-SGB015	D2-SGB010	76.9	76.8	9	0.001	1	3.0	3.0	RECT_CLOSED	80.1	80.4	50.3	81.8	81.6	48.2	82.2	81.9
D2-SGB020	D2-SGB015	77.0	76.9	102	0.001	1	3.0	3.0	RECT_CLOSED	79.6	80.1	47.6	82.0	81.8	70.9	82.8	82.2
D2-SML025	D2-SGB020	77.1	76.9	70	0.001	1	3.0	3.0	RECT_CLOSED	80.5	79.6	43.7	82.6	82.0	70.9	83.5	82.8
D2-SML030	D2-SML025	77.2	77.0	225	0.001	1	3.0	3.0	RECT_CLOSED	81.7	80.5	43.7	83.0	82.6	70.9	85.9	83.5
D2-SML035	D2-SML030	77.3	77.1	90	0.001	1	3.0	3.0	RECT_CLOSED	81.7	81.7	43.7	83.3	83.0	70.9	87.0	85.9
E1-SFR005	OUT_E1	68.7	67.5	14	0.002	1	8.0	6.0	RECT_CLOSED	77.7	73.5	228.4	78.5	78.5	317.1	78.5	78.5
E1-SFR010	E1-SFR005	79.4	68.7	20	0.010	1	0.0	0.0	IRREGULAR	78.2	77.7	228.5	78.5	78.5	317.1	78.7	78.5
E1-SFR015	E1-SFR010	69.5	79.2	60	0.005	1	8.0	6.0	RECT_CLOSED	76.2	78.2	229.3	78.5	78.5	316.7	78.7	78.7
E1-SFR020	E1-SFR015	79.5	69.2	20	0.010	1	0.0	0.0	IRREGULAR	76.4	76.2	230.1	78.5	78.5	319.2	78.9	78.7
E1-SFR025	E1-SFR020	70.4	79.3	140	0.001	1	8.0	6.0	RECT_CLOSED	77.2	76.4	230.5	78.5	78.5	315.9	79.0	78.9
E1-SFR030	E1-SFR025	70.4	70.2	30	0.001	1	8.0	6.0	RECT_CLOSED	77.1	77.2	213.7	78.5	78.5	286.7	79.0	79.0
E1-SFR035	E1-SFR030	80.0	70.4	20	0.010	1	0.0	0.0	IRREGULAR	77.9	77.1	214.4	78.5	78.5	286.5	79.1	79.0
E1-SFR040	E1-SFR035	70.8	79.8	139	0.001	1	8.0	6.0	RECT_CLOSED	77.3	77.9	215.6	78.5	78.5	287.6	79.1	79.1

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
E1-SFR045	E1-SFR040	80.2	70.6	20	0.010	1	0.0	0.0	IRREGULAR	78.0	77.3	179.7	78.5	78.5	209.2	79.2	79.1
E1-SFR050	E1-SFR045	71.3	80.0	200	0.001	1	8.0	6.0	RECT_CLOSED	77.9	78.0	180.2	78.5	78.5	215.5	79.3	79.2
E1-SFR055	E1-SFR050	71.4	71.0	96	0.001	1	8.0	6.0	RECT_CLOSED	77.6	77.9	191.5	78.5	78.5	220.6	79.4	79.3
E1-SFR060	E1-SFR055	73.5	71.3	70	0.001	1	11.0	4.0	RECT_CLOSED	78.6	77.6	191.1	78.5	78.5	221.8	79.5	79.4
E1-SFR065	E1-SFR060	73.7	73.4	160	0.001	1	11.0	4.0	RECT_CLOSED	78.5	78.6	180.4	78.6	78.5	226.8	79.6	79.5
E1-SFR070	E1-SFR065	73.8	73.5	125	0.001	1	11.0	4.0	RECT_CLOSED	78.2	78.5	180.6	78.6	78.6	231.4	79.7	79.6
E1-SFR075	E1-SFR070	74.0	73.7	218	0.001	1	11.0	4.0	RECT_CLOSED	78.6	78.2	181.1	78.7	78.6	237.7	79.9	79.7
E1-SFR080	E1-SFR075	74.1	73.8	132	0.001	1	11.0	4.0	RECT_CLOSED	78.8	78.6	181.5	78.8	78.7	244.0	83.0	79.9
E1-SFR085	E1-SFR080	74.5	74.0	400	0.001	1	11.0	4.0	RECT_CLOSED	78.4	78.8	154.5	79.0	78.8	179.5	80.3	83.0
E1-SFR090	E1-SFR085	74.8	74.1	205	0.001	1	11.0	4.0	RECT_CLOSED	79.9	78.4	154.5	79.1	79.0	185.0	83.2	80.3
E1-SFR095	E1-SFR090	75.0	74.5	245	0.001	1	11.0	4.0	RECT_CLOSED	79.7	79.9	153.7	79.2	79.1	186.6	80.7	83.2
E1-SFR100	E1-SFR095	75.1	74.8	110	0.001	1	11.0	4.0	RECT_CLOSED	79.7	79.7	154.2	79.3	79.2	189.1	80.8	80.7
E1-SFR105	E1-SFR100	75.3	75.0	178	0.001	1	11.0	4.0	RECT_CLOSED	80.8	79.7	154.7	79.4	79.3	191.1	81.5	80.8
E1-SFR110	E1-SFR105	75.4	75.1	147	0.001	1	11.0	4.0	RECT_CLOSED	81.1	80.8	151.6	79.5	79.4	182.9	81.0	81.5
E1-SFR115	E1-SFR110	82.9	75.3	20	0.010	1	0.0	0.0	IRREGULAR	79.8	81.1	144.5	79.5	79.5	183.1	81.3	81.0
E1-SFR120	E1-SFR115	75.8	82.7	167	0.001	1	0.0	4.0	CIRCULAR	80.0	79.8	144.0	79.6	79.5	415.6	81.3	81.3
E1-SFR125	E1-SFR120	76.6	75.6	360	0.001	1	0.0	3.5	CIRCULAR	82.2	80.0	74.3	81.1	79.6	74.5	81.7	81.3
E1-SFR130	E1-SFR125	76.7	76.3	134	0.001	1	0.0	3.5	CIRCULAR	81.9	82.2	74.3	81.8	81.1	74.8	82.3	81.7
E1-SFR135	E1-SFR130	76.9	76.6	186	0.001	1	0.0	3.5	CIRCULAR	82.2	81.9	76.6	82.0	81.8	104.0	82.6	82.3
E1-SFR140	E1-SFR135	77.0	76.7	5	0.026	1	0.0	3.0	CIRCULAR	81.1	82.2	27.3	82.2	82.0	37.1	83.0	82.6
E1-SML145	E1-SFR140	77.3	76.9	35	0.007	1	0.0	2.5	CIRCULAR	79.3	81.1	27.4	82.6	82.2	37.0	83.7	83.0
E1-SML150	E1-SML145	84.2	77.0	20	0.010	1	0.0	0.0	IRREGULAR	90.4	79.3	26.6	85.4	82.6	36.0	88.8	83.7
E2-NML005	OUT_E2	66.6	66.5	23	0.001	1	6.0	5.0	RECT_CLOSED	77.9	71.5	187.0	78.4	78.4	255.6	78.4	78.4
E2-NML010	E2-NML005	66.7	66.6	82	0.001	1	6.0	5.0	RECT_CLOSED	78.4	77.9	187.0	78.4	78.4	255.6	78.4	78.4
E2-NML015	E2-NML010	66.8	66.6	143	0.001	1	6.0	5.0	RECT_CLOSED	76.2	78.4	419.5	78.4	78.4	575.4	78.4	78.4
E2-NML020	E2-NML015	66.9	66.7	105	0.001	1	6.0	5.0	RECT_CLOSED	75.7	76.2	142.8	78.4	78.4	160.6	78.4	78.4
E2-NML025	E2-NML020	67.1	66.8	160	0.001	1	6.0	5.0	RECT_CLOSED	77.8	75.7	143.2	78.4	78.4	160.8	78.4	78.4
E2-NML030	E2-NML025	67.3	66.9	190	0.001	1	6.0	5.0	RECT_CLOSED	76.8	77.8	144.5	78.4	78.4	163.6	78.5	78.4
E2-NML035	E2-NML030	67.4	67.1	185	0.001	1	6.0	5.0	RECT_CLOSED	77.5	76.8	129.9	78.4	78.4	152.7	78.4	78.5
E2-NML040	E2-NML035	67.6	67.3	185	0.001	1	6.0	5.0	RECT_CLOSED	77.9	77.5	130.5	78.4	78.4	153.3	78.4	78.4
E2-NML045	E2-NML040	67.7	67.4	110	0.001	1	5.0	5.0	RECT_CLOSED	78.0	77.9	128.5	78.4	78.4	137.7	78.4	78.4
E2-NML050	E2-NML045	67.9	67.6	200	0.001	1	5.0	5.0	RECT_CLOSED	79.0	78.0	129.6	78.4	78.4	138.6	78.4	78.4
E2-NML055	E2-NML050	68.3	67.7	390	0.001	1	5.0	5.0	RECT_CLOSED	77.4	79.0	126.6	78.4	78.4	133.7	78.5	78.4
E2-NML060	E2-NML055	68.6	67.9	358	0.001	1	5.0	5.0	RECT_CLOSED	79.2	77.4	128.9	79.0	78.4	151.0	79.4	78.5
E2-NML065	E2-NML060	68.6	68.3	50	0.001	2	3.0	5.0	RECT_CLOSED	79.5	79.2	128.9	79.0	79.0	151.0	79.5	79.4

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
E2-NML070	E2-NML065	70.4	68.6	177	0.002	1	0.0	4.5	CIRCULAR	79.9	79.5	93.2	79.1	79.0	109.8	79.6	79.5
E2-NML075	E2-NML070	70.6	70.0	118	0.002	1	0.0	4.5	CIRCULAR	80.0	79.9	93.2	79.1	79.1	109.8	79.6	79.6
E2-NML080	E2-NML075	71.2	70.4	370	0.002	1	0.0	4.5	CIRCULAR	78.7	80.0	83.6	79.2	79.1	103.7	79.8	79.6
E2-NML085	E2-NML080	71.4	70.6	160	0.001	1	0.0	4.5	CIRCULAR	80.3	78.7	88.4	79.4	79.2	104.2	79.9	79.8
E2-NML090	E2-NML085	71.7	71.2	290	0.001	1	0.0	4.5	CIRCULAR	79.0	80.3	88.4	79.8	79.4	86.3	80.0	79.9
E2-NML095	E2-NML090	72.6	71.4	160	0.002	1	0.0	4.0	CIRCULAR	80.3	79.0	88.6	80.0	79.8	86.5	80.1	80.0
E2-NML100	E2-NML095	72.8	72.2	110	0.002	1	0.0	4.0	CIRCULAR	80.3	80.3	63.7	80.0	80.0	55.5	80.2	80.1
E2-NML105	E2-NML100	73.2	72.6	280	0.002	1	0.0	4.0	CIRCULAR	80.6	80.3	63.7	80.1	80.0	55.5	80.3	80.2
E2-NML110	E2-NML105	73.4	72.8	230	0.001	1	0.0	4.0	CIRCULAR	80.7	80.6	59.7	80.2	80.1	68.5	80.3	80.3
E2-NML115	E2-NML110	74.2	73.2	250	0.001	1	0.0	3.5	CIRCULAR	80.9	80.7	32.5	80.4	80.2	30.5	80.5	80.3
E2-NML120	E2-NML115	74.3	73.9	50	0.002	1	0.0	3.5	CIRCULAR	80.6	80.9	32.7	80.4	80.4	32.6	80.6	80.5
E2-NML125	E2-NML120	74.5	74.2	175	0.001	1	0.0	3.5	CIRCULAR	81.8	80.6	32.9	80.6	80.4	32.6	80.8	80.6
E2-NML130	E2-NML125	74.5	74.3	15	0.001	1	0.0	3.5	CIRCULAR	81.8	81.8	32.9	80.6	80.6	32.6	80.8	80.8
E2-NML135	E2-NML130	75.2	74.5	210	0.001	1	0.0	3.0	CIRCULAR	80.2	81.8	32.9	80.7	80.6	36.7	80.8	80.8
E2-NML140	E2-NML135	75.9	75.0	110	0.002	1	0.0	2.5	CIRCULAR	83.5	80.2	20.8	80.8	80.7	23.5	81.1	80.8
E2-NML145	E2-NML140	76.8	75.7	220	0.002	1	0.0	2.0	CIRCULAR	82.7	83.5	32.1	85.4	80.8	41.4	88.8	81.1
E3-NFR065	E3-NML060	72.3	71.6	400	0.001	1	0.0	4.5	CIRCULAR	78.0	77.5	67.5	78.5	78.5	73.4	78.7	78.6
E3-NML005	OUT_E3	68.3	66.4	20	0.003	1	0.0	5.0	CIRCULAR	82.0	71.4	127.3	78.4	78.4	139.9	78.4	78.4
E3-NML010	E3-NML005	68.8	68.3	156	0.003	1	0.0	5.0	CIRCULAR	78.3	82.0	127.3	78.4	78.4	140.0	78.5	78.4
E3-NML015	E3-NML010	68.9	68.3	99	0.002	1	0.0	5.0	CIRCULAR	76.1	78.3	127.3	78.4	78.4	140.0	78.6	78.5
E3-NML020	E3-NML015	69.0	68.8	86	0.001	1	0.0	5.0	CIRCULAR	75.1	76.1	127.3	78.5	78.4	140.0	78.5	78.6
E3-NML025	E3-NML020	69.2	68.9	102	0.001	1	0.0	5.0	CIRCULAR	75.7	75.1	128.5	78.5	78.5	141.7	78.5	78.5
E3-NML030	E3-NML025	69.2	69.0	50	0.001	1	0.0	5.0	CIRCULAR	75.9	75.7	118.9	78.5	78.5	129.4	78.5	78.5
E3-NML035	E3-NML030	69.4	69.2	215	0.001	1	0.0	5.0	CIRCULAR	75.0	75.9	100.9	78.5	78.5	110.8	78.5	78.5
E3-NML040	E3-NML035	69.6	69.2	180	0.001	1	0.0	5.0	CIRCULAR	77.0	75.0	101.3	78.5	78.5	111.1	78.5	78.5
E3-NML045	E3-NML040	70.7	69.4	140	0.001	1	0.0	5.0	CIRCULAR	78.9	77.0	101.3	78.5	78.5	111.1	78.5	78.5
E3-NML050	E3-NML045	70.9	70.6	160	0.001	1	0.0	5.0	CIRCULAR	79.2	78.9	101.5	78.5	78.5	111.5	78.5	78.5
E3-NML055	E3-NML050	71.6	70.7	160	0.001	1	0.0	4.5	CIRCULAR	78.2	79.2	101.8	78.5	78.5	111.8	78.6	78.5
E3-NML060	E3-NML055	71.8	71.4	160	0.001	1	0.0	4.5	CIRCULAR	77.5	78.2	101.8	78.5	78.5	111.8	78.6	78.6
E3-NML070	E3-NFR065	73.1	71.8	320	0.001	1	0.0	4.0	CIRCULAR	78.9	78.0	66.9	78.8	78.5	72.7	79.1	78.7
E3-NML075	E3-NML070	73.3	72.8	150	0.001	1	0.0	4.0	CIRCULAR	78.3	78.9	54.1	78.8	78.8	53.6	79.3	79.1
E3-NML080	E3-NML075	73.9	73.1	140	0.001	1	0.0	3.5	CIRCULAR	79.5	78.3	53.2	78.9	78.8	53.6	79.3	79.3
E3-NML085	E3-NML080	74.0	73.8	60	0.001	1	0.0	3.5	CIRCULAR	80.1	79.5	45.9	78.9	78.9	45.4	79.4	79.3
E3-NML090	E3-NML085	74.9	73.9	280	0.002	1	0.0	3.0	CIRCULAR	80.9	80.1	30.9	78.9	78.9	27.5	79.3	79.4
E3-NML095	E3-NML090	75.8	74.5	250	0.002	1	0.0	2.5	CIRCULAR	79.8	80.9	30.5	79.2	78.9	29.8	79.7	79.3

Hydraulic Calculations: PCSWMM - Existing Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
E3-NML100	E3-NML095	76.0	75.4	90	0.002	1	0.0	2.5	CIRCULAR	80.5	79.8	26.1	79.3	79.2	34.6	79.9	79.7
E4-SML005	OUT_E4	85.3	68.3	20	0.010	1	0.0	0.0	IRREGULAR	77.3	68.3	123.9	78.5	78.5	137.5	78.5	78.5
E4-SML010	E4-SML005	68.9	85.1	390	0.000	1	5.0	5.0	RECT_CLOSED	75.5	77.3	124.5	78.5	78.5	138.1	78.5	78.5
E4-SML015	E4-SML010	69.0	68.8	102	0.001	1	5.0	5.0	RECT_CLOSED	75.6	75.5	136.8	78.5	78.5	154.0	78.5	78.5
E4-SML020	E4-SML015	69.1	68.9	85	0.001	1	5.0	5.0	RECT_CLOSED	75.3	75.6	160.8	78.5	78.5	168.6	78.5	78.5
E4-SML025	E4-SML020	83.4	69.0	20	0.010	1	0.0	0.0	IRREGULAR	76.1	75.3	160.8	78.5	78.5	168.6	78.5	78.5
E4-SML030	E4-SML025	69.5	83.2	160	0.001	1	5.0	5.0	RECT_CLOSED	76.6	76.1	161.2	78.5	78.5	168.7	78.5	78.5
E4-SML035	E4-SML030	69.6	69.3	90	0.001	1	5.0	5.0	RECT_CLOSED	77.3	76.6	165.6	78.5	78.5	172.1	78.5	78.5
E4-SML040	E4-SML035	69.8	69.5	160	0.001	1	5.0	5.0	RECT_CLOSED	76.7	77.3	162.5	78.5	78.5	169.7	78.9	78.5
E4-SML045	E4-SML040	79.6	69.6	20	0.010	1	0.0	0.0	IRREGULAR	78.5	76.7	162.5	78.7	78.5	169.7	79.2	78.9
E4-SML050	E4-SML045	70.0	79.4	70	0.001	1	5.0	5.0	RECT_CLOSED	78.2	78.5	163.4	78.9	78.7	170.4	79.4	79.2
E4-SML055	E4-SML050	70.3	70.0	280	0.001	1	5.0	5.0	RECT_CLOSED	78.2	78.2	167.3	79.1	78.9	176.1	79.6	79.4
E4-SML060	E4-SML055	80.0	70.0	20	0.010	1	0.0	0.0	IRREGULAR	78.3	78.2	100.8	79.4	79.1	95.8	79.8	79.6
E4-SML065	E4-SML060	72.1	79.8	170	0.001	1	0.0	5.0	CIRCULAR	79.2	78.3	102.3	79.6	79.4	114.3	80.0	79.8
E4-SML070	E4-SML065	72.3	71.9	265	0.001	1	0.0	5.0	CIRCULAR	79.3	79.2	103.5	79.8	79.6	115.7	80.2	80.0
E4-SML075	E4-SML070	81.0	72.1	20	0.010	1	0.0	0.0	IRREGULAR	80.1	79.3	82.1	79.8	79.8	87.8	80.2	80.2
E4-SML080	E4-SML075	73.0	80.8	86	0.001	1	0.0	4.5	CIRCULAR	80.3	80.1	82.2	79.8	79.8	88.2	80.3	80.2
E4-SML085	E4-SML080	73.3	72.9	350	0.001	1	0.0	4.5	CIRCULAR	79.7	80.3	60.2	79.9	79.8	46.2	80.4	80.3
E4-SML087	E4-SML085	74.4	73.0	150	0.001	1	0.0	3.5	CIRCULAR	81.2	79.7	60.2	80.1	79.9	46.2	80.5	80.4
E4-SML090	E4-SML087	76.4	74.3	340	0.002	1	0.0	2.0	CIRCULAR	79.6	81.2	56.7	81.6	80.1	45.7	81.9	80.5

Hydraulic Calculations: PCSWMM - Proposed Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
B1-SHPS05	B1-SHPS-OUT	73.4	73.3	53	0.002	1	4.0	3.0	RECT_CLOSED	81.0	81.4	141.4	82.2	82.9	148.4	82.3	82.9
B1-SHPS10	B1-SHPS05	73.7	73.4	231	0.001	1	8.0	3.0	RECT_CLOSED	79.5	81.0	140.6	82.2	82.2	199.3	89.5	82.3
B1-SHPS15	B1-SHPS10	74.0	73.7	172	0.001	1	0.0	3.0	CIRCULAR	81.2	79.5	43.9	82.2	82.2	42.8	82.2	89.5
B1-SHPS20	B1-SHPS15	74.5	74.5	30	0.001	1	0.0	2.5	CIRCULAR	79.8	81.2	42.3	82.2	82.2	41.3	82.2	82.2
B1-SHPS-OUT	OUT_B	73.3	72.8	662	0.001	1	0.0	5.0	CIRCULAR	81.4	77.8	141.4	82.9	83.6	148.3	82.9	83.6
B2-ML30	B2-SFR25	75.2	75.0	213	0.001	1	0.0	4.0	CIRCULAR	84.2	81.6	81.0	86.7	82.2	101.6	92.4	82.2
B2-ML35	B2-ML30	76.1	75.7	401	0.001	1	0.0	3.5	CIRCULAR	82.9	84.2	50.5	82.2	86.7	76.4	82.6	92.4
B2-ML40	B2-ML35	77.5	77.1	359	0.001	1	0.0	2.5	CIRCULAR	84.0	82.9	28.8	82.2	82.2	43.6	83.6	82.6
B2-SFR25	B2-SHPS20	74.0	73.8	204	0.001	1	5.0	5.0	RECT_CLOSED	81.6	82.1	84.2	82.2	82.2	84.5	82.2	82.2
B2-SFR30	B2-SFR25	75.3	75.0	341	0.001	1	5.0	4.0	RECT_CLOSED	82.5	81.6	81.0	82.2	82.2	101.6	82.2	82.2
B2-SFR30-1	B2-SFR30	76.4	76.3	57	0.001	1	5.0	2.0	RECT_CLOSED	82.5	82.5	71.2	82.2	82.2	70.1	82.2	82.2
B2-SFR35	B2-SFR30	75.4	75.3	99	0.001	1	0.0	4.0	CIRCULAR	82.3	82.5	71.2	82.2	82.2	70.1	82.3	82.2
B2-SFR40	B2-SFR35	76.5	75.9	587	0.001	1	0.0	3.5	CIRCULAR	82.7	82.3	23.0	82.2	82.2	21.4	82.3	82.3
B2-SHPS05	B1-SHPS05	73.5	73.4	58	0.002	1	5.0	5.0	RECT_CLOSED	82.0	81.0	140.6	82.2	82.2	199.3	82.2	82.3
B2-SHPS10	B2-SHPS05	73.6	73.5	77	0.001	1	5.0	5.0	RECT_CLOSED	82.2	82.0	88.0	82.2	82.2	88.6	82.2	82.2
B2-SHPS15	B2-SHPS10	73.7	73.6	88	0.001	1	5.0	5.0	RECT_CLOSED	82.2	82.2	86.0	82.2	82.2	86.0	82.2	82.2
B2-SHPS20	B2-SHPS15	73.8	73.7	78	0.001	1	5.0	5.0	RECT_CLOSED	82.1	82.2	85.8	82.2	82.2	86.0	82.2	82.2
B3-SHPN05	B2-SHPS05	76.1	76.0	73	0.001	1	0.0	2.5	CIRCULAR	81.3	82.0	88.0	82.2	82.2	88.6	82.2	82.2
B3-SHPN10	B3-SHPN05	76.9	76.6	303	0.001	1	0.0	2.0	CIRCULAR	80.7	81.3	9.2	82.2	82.2	13.7	82.3	82.2
B4-SHPS05	B2-SHPS05	76.1	76.0	42	0.001	1	0.0	2.5	CIRCULAR	81.3	82.0	88.0	82.2	82.2	88.6	82.2	82.2
B4-SHPS10	B4-SHPS05	77.1	76.6	302	0.001	1	0.0	2.0	CIRCULAR	80.6	81.3	9.7	82.2	82.2	14.8	82.3	82.2
C1-ML05	C1-SFR05	78.8	78.5	161	0.002	1	0.0	2.5	CIRCULAR	86.0	82.7	14.3	80.4	80.0	20.2	81.9	81.9
C1-ML15	C1-ML05	82.8	82.0	392	0.002	1	0.0	2.0	CIRCULAR	87.6	86.0	14.3	85.1	80.4	20.3	86.7	81.9
C1-ML20	C1-ML15	83.8	82.8	508	0.002	1	0.0	2.0	CIRCULAR	94.6	87.6	14.6	85.5	85.1	21.1	87.7	86.7
C1-ML30	C1-ML20	85.1	83.8	633	0.002	1	0.0	2.0	CIRCULAR	108.5	94.6	8.3	86.8	85.5	11.2	89.0	87.7
C1-SFR05	DETPONDC	78.5	78.3	105	0.002	1	0.0	2.5	CIRCULAR	82.7	80.8	25.7	80.0	80.0	37.4	81.9	81.9
C2-ML15	C2-NFR15	78.9	78.6	166	0.002	1	0.0	2.0	CIRCULAR	87.6	83.0	15.3	82.2	81.4	23.1	83.6	81.9
C2-ML25	C2-ML15	83.6	82.6	508	0.002	1	0.0	2.0	CIRCULAR	94.5	87.6	15.3	84.9	82.2	23.4	85.4	83.6
C2-ML35	C2-ML25	84.8	83.6	639	0.002	1	0.0	2.0	CIRCULAR	108.5	94.5	8.4	85.3	84.9	12.7	85.5	85.4
C2-NFR05	C2-REST	76.9	76.8	139	0.001	1	5.0	3.0	RECT_CLOSED	83.8	83.9	21.6	81.1	80.9	31.2	81.5	81.3
C2-NFR10	C2-NFR05	77.2	76.9	330	0.001	1	5.0	3.0	RECT_CLOSED	82.4	83.8	21.6	81.4	81.1	31.2	81.9	81.5
C2-NFR15	C2-NFR10	77.6	77.2	225	0.002	1	5.0	3.0	RECT_CLOSED	83.0	82.4	22.1	81.4	81.4	31.3	81.9	81.9
C2-NFR20	C2-NFR15	79.1	77.6	513	0.003	1	4.0	2.0	RECT_CLOSED	83.1	83.0	15.3	81.5	81.4	23.1	81.8	81.9
C2-OUT	C3-OUT	76.8	76.8	5	0.004	1	0.0	2.5	CIRCULAR	83.9	83.9	124.1	80.8	79.9	146.2	81.2	79.9
C2-REST	C2-OUT	76.8	76.8	10	0.001	1	0.0	2.5	CIRCULAR	83.9	83.9	109.3	80.9	80.8	124.2	81.3	81.2

Hydraulic Calculations: PCSWMM - Proposed Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
C3-ML25	C3-NFR20	78.3	78.1	204	0.001	1	3.0	2.0	RECT_CLOSED	83.8	82.2	25.4	81.2	81.2	33.0	81.5	81.5
C3-ML30	C3-ML25	78.5	78.3	218	0.001	2	3.0	2.0	RECT_CLOSED	83.1	83.8	1.3	81.2	81.2	1.1	81.5	81.5
C3-NFR05	C3-REST	76.9	76.8	184	0.001	1	7.0	3.0	RECT_CLOSED	83.3	83.6	27.1	80.6	80.4	35.9	80.9	80.7
C3-NFR10	C3-NFR05	77.2	76.9	309	0.001	1	6.0	3.0	RECT_CLOSED	82.3	83.3	27.1	80.9	80.6	36.0	81.4	80.9
C3-NFR15	C3-NFR10	77.8	77.2	508	0.001	1	5.0	3.0	RECT_CLOSED	83.4	82.3	27.0	81.0	80.9	42.1	81.4	81.4
C3-NFR20	C3-NFR15	78.1	77.8	360	0.001	1	5.0	2.0	RECT_CLOSED	82.2	83.4	12.2	81.2	81.0	11.7	81.5	81.4
C3-OUT	OUT_C	76.8	76.7	20	0.001	2	8.0	3.0	RECT_CLOSED	83.9	79.7	124.2	79.9	79.8	146.1	79.9	79.8
C3-REST	C3-OUT	76.8	76.8	10	0.001	1	0.0	2.0	CIRCULAR	83.6	83.9	124.1	80.4	79.9	146.2	80.7	79.9
C4-ML05	C4-OUT	78.4	78.0	215	0.002	1	5.0	2.0	RECT_CLOSED	84.2	84.8	105.9	81.3	80.9	122.2	82.2	81.3
C4-ML10	C4-ML05	78.6	78.4	182	0.001	1	4.0	2.0	RECT_CLOSED	85.1	84.2	35.4	81.5	81.3	53.8	82.8	82.2
C4-ML15	C4-ML10	78.9	78.6	299	0.001	1	4.0	2.0	RECT_CLOSED	86.3	85.1	21.9	83.4	81.5	33.3	83.7	82.8
C4-ML20	C4-ML15	79.2	78.9	292	0.001	1	4.0	2.0	RECT_CLOSED	85.7	86.3	21.9	83.9	83.4	33.3	84.5	83.7
C4-ML25	C4-ML20	79.4	79.2	256	0.001	1	0.0	2.0	CIRCULAR	84.6	85.7	22.0	82.4	83.9	33.4	84.5	84.5
C4-OUT	C2-OUT	77.0	76.8	55	0.003	2	8.0	3.0	RECT_CLOSED	84.8	83.9	109.3	80.9	80.8	124.2	81.3	81.2
C5-ML05	C5-ML-OUT	77.8	77.6	201	0.001	1	0.0	2.5	CIRCULAR	84.6	84.8	102.7	81.0	80.9	117.4	81.6	81.3
C5-ML10	C5-ML05	78.6	78.3	323	0.001	1	0.0	2.0	CIRCULAR	85.4	84.6	10.4	81.7	81.0	15.8	83.2	81.6
C5-ML-OUT	C4-OUT	77.1	77.0	30	0.004	2	6.0	3.0	RECT_CLOSED	84.8	84.8	105.9	80.9	80.9	122.2	81.3	81.3
C6-OUT	C5-ML-OUT	77.3	77.1	165	0.001	1	6.0	3.0	RECT_CLOSED	82.7	84.8	102.7	81.7	80.9	117.4	82.4	81.3
C6-REST	C6-OUT	77.3	77.3	10	0.001	1	0.0	2.5	CIRCULAR	82.7	82.7	101.7	82.0	81.7	116.4	82.4	82.4
C6-SFR05	C6-REST	77.5	77.3	178	0.001	1	6.0	3.0	RECT_CLOSED	82.7	82.7	57.1	82.2	82.0	65.5	82.7	82.4
C6-SFR10	C6-SFR05	77.8	77.5	307	0.001	1	6.0	3.0	RECT_CLOSED	82.7	82.7	58.1	82.2	82.2	66.2	82.7	82.7
C6-SFR15	C6-SFR10	78.3	77.8	500	0.001	1	5.0	3.0	RECT_CLOSED	82.7	82.7	14.6	82.2	82.2	9.4	82.7	82.7
C6-SFR20	C6-SFR15	78.5	78.3	279	0.001	1	5.0	2.0	RECT_CLOSED	82.7	82.7	31.5	82.6	82.2	33.7	83.2	82.7
D1-NFR05	OUT_D	74.3	74.3	28	0.001	1	3.0	3.0	RECT_CLOSED	79.5	77.3	74.5	77.4	77.3	91.4	77.5	77.3
D1-NFR10	D1-NFR05	74.4	74.3	78	0.001	1	3.0	3.0	RECT_CLOSED	79.6	79.5	74.4	77.8	77.4	91.4	78.9	77.5
D1-NFR15	D1-NFR10	74.7	74.4	296	0.001	1	3.0	3.0	RECT_CLOSED	80.4	79.6	74.5	79.4	77.8	91.5	80.2	78.9
D1-NFR20	D1-NFR15	75.0	74.7	300	0.001	1	3.0	3.0	RECT_CLOSED	81.6	80.4	50.2	81.0	79.4	49.4	81.6	80.2
D1-NFR25	D1-NFR20	76.1	76.0	200	0.001	1	3.0	2.0	RECT_CLOSED	82.3	81.6	62.8	81.2	81.0	64.7	81.6	81.6
DETPONDC_OUT	C6-OUT	77.5	77.3	78	0.003	1	0.0	1.5	CIRCULAR	83.5	82.7	101.7	80.0	81.7	116.4	81.9	82.4
E1-SBFR05	OUT_E1	66.1	66.0	81	0.001	1	9.0	5.0	RECT_CLOSED	82.0	71.0	184.8	71.3	71.0	251.5	71.5	71.0
E1-SBFR10	E1-SBFR05	66.3	66.1	156	0.001	1	8.0	5.0	RECT_CLOSED	81.5	82.0	184.8	71.4	71.3	251.6	71.5	71.5
E1-SBFR15	E1-SBFR10	67.1	66.3	554	0.002	1	8.0	5.0	RECT_CLOSED	79.7	81.5	174.8	72.2	71.4	236.7	73.2	71.5
E1-SBFR20	E1-SBFR15	68.0	67.1	604	0.001	1	7.0	5.0	RECT_CLOSED	79.6	79.7	174.6	73.2	72.2	236.2	74.8	73.2
E1-SBFR25	E1-SBFR20	68.8	68.0	600.0	0.001	1	7.0	5.0	RECT_CLOSED	79.6	79.6	131.7	74.0	73.2	168.4	76.4	74.8
E1-SBFR30	E1-SBFR25	69.6	68.8	577	0.001	1	7.0	5.0	RECT_CLOSED	79.7	79.6	132.7	74.6	74.0	170.9	77.4	76.4

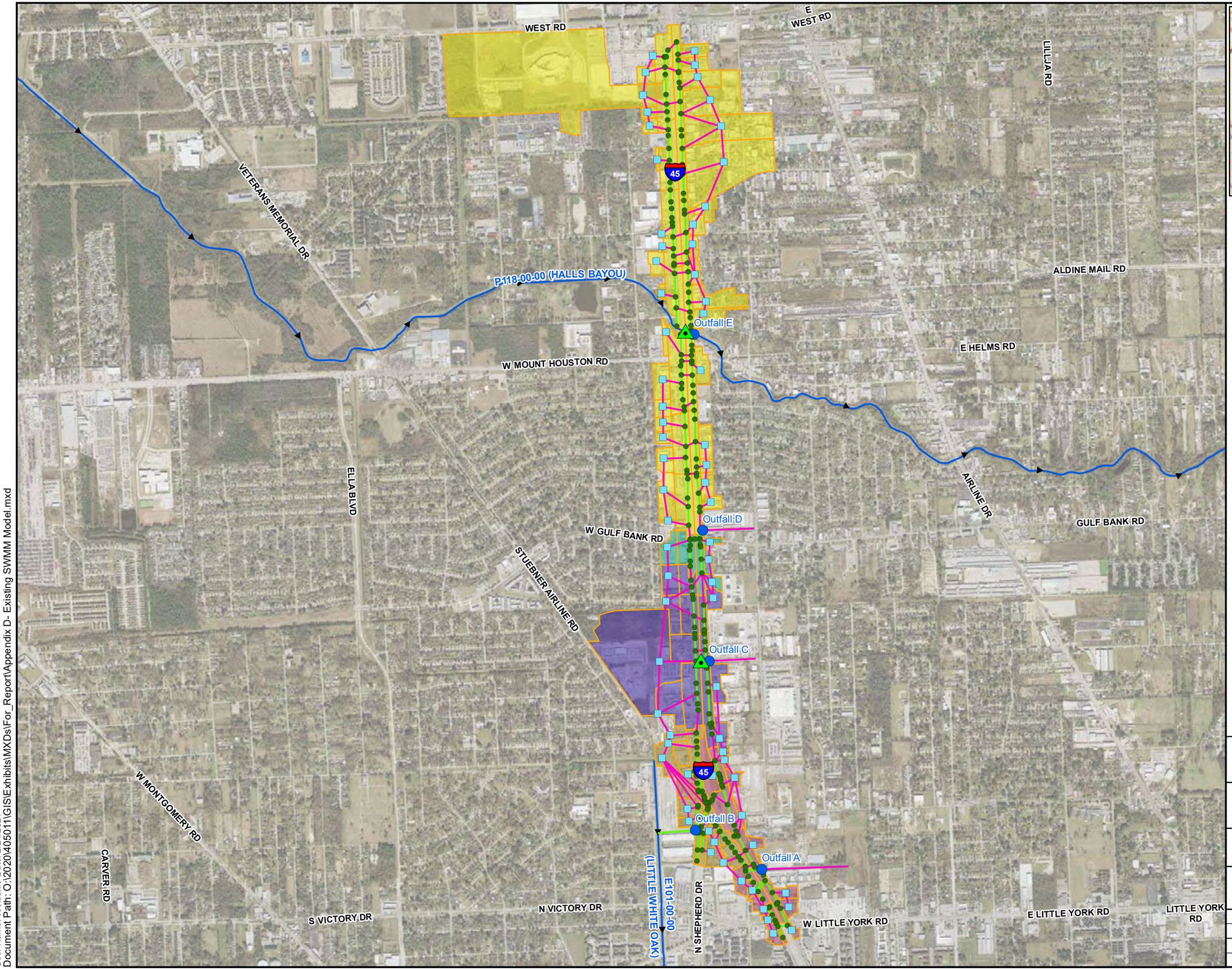
Hydraulic Calculations: PCSWMM - Proposed Results

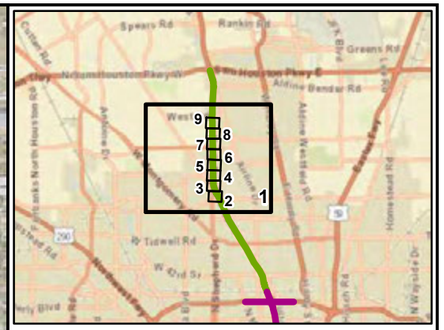
SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
E1-SBFR35	E1-SBFR30	70.2	69.6	460	0.001	1	7.0	5.0	RECT_CLOSED	81.6	79.7	125.8	74.9	74.6	154.4	78.6	77.4
E1-SBFR40	E1-SBFR35	71.0	70.2	460	0.002	1	7.0	5.0	RECT_CLOSED	79.6	81.6	125.0	75.2	74.9	153.1	79.8	78.6
E1-SBFR45	E1-SBFR40	71.2	71.0	101	0.002	1	6.0	5.0	RECT_CLOSED	79.9	79.6	123.4	75.4	75.2	158.1	89.9	79.8
E1-SBFR50	E1-SBFR45	71.7	71.2	395	0.001	1	5.0	4.0	RECT_CLOSED	81.2	79.9	118.6	75.4	75.4	133.8	80.2	89.9
E1-SBFR55	E1-SBFR50	72.5	71.7	818	0.001	1	5.0	4.0	RECT_CLOSED	81.7	81.2	58.8	75.4	75.4	87.1	80.2	80.2
E1-SFR115-OS	E1-SBFR45	71.7	71.2	181	0.003	1	6.0	5.0	RECT_CLOSED	79.9	79.9	118.6	77.6	75.4	133.8	80.5	89.9
E1-SMX10	E1-SBFR05	66.3	66.1	156.0	0.001	1	9.0	5.0	RECT_CLOSED	92.4	82.0	184.8	71.2	71.3	251.6	71.3	71.5
E1-SMX15	E1-SMX10	80.4	80.0	188.0	0.002	1	0.0	0.0	IRREGULAR	89.7	92.4	11.3	83.0	71.2	16.2	83.2	71.3
E1-SMX20	E1-SMX15	82.2	80.4	886.0	0.002	1	0.0	0.0	IRREGULAR	103.8	89.7	11.4	86.0	83.0	16.3	88.4	83.2
E1-SMX25	E1-SMX30	73.1	71.4	831.0	0.0	1	0.0	2.0	CIRCULAR	104.9	86.7	12.8	78.2	75.9	18.8	85.4	80.8
E1-SMX30	E1-SMX40	71.4	70.5	432	0.002	1	0.0	2.0	CIRCULAR	86.7	82.0	25.6	75.9	75.0	36.9	80.8	78.7
E1-SMX40	E1-SBFR35	71.0	70.2	460.0	0.002	1	7.0	5.0	RECT_CLOSED	82.0	81.6	125.0	75.0	74.9	153.1	78.7	78.6
E1-SMX45	E1-SMX40	71.4	70.5	432.0	0.002	1	0.0	0.0	IRREGULAR	84.0	82.0	25.6	76.7	75.0	36.9	82.1	78.7
E1-SMX50	E1-SMX45	73.2	71.7	714.0	0.002	1	0.0	0.0	IRREGULAR	94.7	84.0	14.6	77.1	76.7	21.8	82.9	82.1
E1-SMX55	E1-SMX50	74.2	73.2	508.0	0.002	1	0.0	0.0	IRREGULAR	105.0	94.7	7.0	77.4	77.1	10.5	83.5	82.9
E2-NBFR05	OUT_E2	66.3	66.0	260	0.001	1	8.0	6.0	RECT_CLOSED	80.2	72.0	308.9	72.6	72.0	380.5	73.0	72.0
E2-NBFR10	E2-NBFR05	66.7	66.3	300	0.001	1	8.0	6.0	RECT_CLOSED	78.9	80.2	311.1	73.4	72.6	631.1	74.0	73.0
E2-NBFR15	E2-NBFR10	66.8	66.7	108	0.001	1	8.0	6.0	RECT_CLOSED	78.7	78.9	257.4	73.7	73.4	287.6	74.4	74.0
E2-NBFR20	E2-NBFR15	67.6	66.8	651	0.001	1	8.0	6.0	RECT_CLOSED	78.8	78.7	258.5	75.3	73.7	289.5	76.2	74.4
E2-NBFR25	E2-NBFR20	68.2	67.6	600	0.001	1	8.0	6.0	RECT_CLOSED	79.0	78.8	251.5	76.7	75.3	280.1	78.0	76.2
E2-NBFR30	E2-NBFR25	68.8	68.2	600	0.001	1	8.0	6.0	RECT_CLOSED	78.8	79.0	257.6	77.9	76.7	328.1	79.0	78.0
E2-NBFR35	E2-NBFR30	69.5	68.8	708	0.001	1	8.0	6.0	RECT_CLOSED	79.2	78.8	218.6	78.5	77.9	238.2	79.7	79.0
E2-NBFR40	E2-NBFR35	71.1	70.5	592	0.001	1	8.0	5.0	RECT_CLOSED	79.1	79.2	222.0	78.8	78.5	240.2	80.1	79.7
E2-NBFR45	E2-NBFR40	71.7	71.1	596	0.001	1	8.0	5.0	RECT_CLOSED	78.9	79.1	137.7	78.8	78.8	154.6	80.2	80.1
E2-NBFR50	E2-NBFR45	72.8	71.7	567	0.002	1	4.0	2.0	RECT_CLOSED	81.3	78.9	66.2	79.3	78.8	89.3	80.7	80.2
E2-NMX10	E2-NBFR05	68.8	68.3	173	0.003	1	0.0	2.0	CIRCULAR	91.8	80.2	311.1	73.0	72.6	631.1	73.8	73.0
E2-NMX15	E2-NMX10	81.0	80.4	300	0.002	1	0.0	2.0	CIRCULAR	89.7	91.8	11.0	82.6	73.0	15.5	83.4	73.8
E2-NMX20	E2-NMX15	82.8	81.0	886	0.002	1	0.0	2.0	CIRCULAR	103.5	89.7	11.4	84.7	82.6	15.9	87.7	83.4
E2-NMX35	E2-NMX40	75.2	73.5	831	0.002	1	0.0	2.0	CIRCULAR	104.9	86.7	12.1	78.9	78.7	18.3	86.2	82.3
E2-NMX40	E2-NMX45	72.7	71.9	213.0	0.0	1	0.0	2.5	CIRCULAR	86.7	82.0	20.5	78.7	78.6	34.6	82.3	80.6
E2-NMX45	E2-NBFR35	72.7	71.9	213	0.003	1	0.0	2.5	CIRCULAR	82.0	79.2	222.0	78.6	78.5	240.2	80.6	79.7
E2-NMX50	E2-NMX45	73.9	72.7	609	0.002	1	0.0	2.0	CIRCULAR	84.0	82.0	20.5	78.8	78.6	34.6	83.1	80.6
E2-NMX55	E2-NMX50	75.8	73.9	714	0.003	1	0.0	2.0	CIRCULAR	94.7	84.0	13.2	78.8	78.8	20.5	83.7	83.1
E2-NMX60	E2-NMX55	76.8	75.8	508	0.002	1	0.0	2.0	CIRCULAR	105.0	94.7	6.5	78.9	78.8	9.7	84.1	83.7
E3-NBFR05	OUT_E3	66.3	66.0	77	0.004	1	7.0	3.0	RECT_CLOSED	80.6	69.0	131.8	69.5	69.0	131.8	69.6	69.0

Hydraulic Calculations: PCSWMM - Proposed Results

SWMM NODES		Storm Sewer Geometry										10-Year Results			100-Year Results		
From Node	To Node	Upstream Flowline	Downstream Flowline	Conduit Length	Conduit Slope	No. Barrel	Conduit Width	Conduit Height/ Diameter	Conduit Shape	US Node Natural Ground Elev.	DS Node Natural Ground Elev.	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)	Flow (cfs)	HGL US Elev (ft)	HGL DS Elev (ft)
(-)	(-)	(ft)	(ft)	(ft)	(%)	(-)	(ft)	(ft)	(-)	(ft)	(ft)	(cfs)	(ft)	(ft)	(cfs)	(ft)	(ft)
E3-NBFR10	E3-NBFR05	67.3	66.3	248	0.004	1	6.0	3.0	RECT_CLOSED	79.2	80.6	131.8	71.0	69.5	131.8	72.1	69.6
E3-NBFR15	E3-NBFR10	69.3	67.3	669	0.003	1	6.0	3.0	RECT_CLOSED	78.8	79.2	103.4	73.3	71.0	128.0	75.2	72.1
E3-NBFR20	E3-NBFR15	70.8	69.3	672	0.002	1	6.0	3.0	RECT_CLOSED	78.7	78.8	80.9	75.1	73.3	89.7	77.5	75.2
E3-NBFR25	E3-NBFR20	71.4	70.8	506	0.001	1	6.0	3.0	RECT_CLOSED	79.6	78.7	73.9	76.1	75.1	78.4	78.6	77.5
E3-NBFR30	E3-NBFR25	71.7	71.4	216	0.001	1	6.0	3.0	RECT_CLOSED	79.0	79.6	63.3	76.3	76.1	74.7	78.9	78.6
E3-NBFR35	E3-NBFR30	72.9	71.7	606	0.002	1	5.0	2.0	RECT_CLOSED	79.2	79.0	45.9	78.4	76.3	47.6	79.0	78.9
E3-NMX05	E3-NBFR05	67.1	66.8	172	0.002	1	0.0	2.0	CIRCULAR	104.7	80.6	131.8	69.6	69.5	131.8	70.1	69.6
E3-NMX10	E3-NMX15	75.4	74.5	457	0.002	1	0.0	2.0	CIRCULAR	108.7	96.6	6.2	76.9	76.8	9.8	80.7	80.4
E3-NMX15	E3-NMX20	74.5	73.1	677.0	0.0	1	0.0	2.0	CIRCULAR	96.6	86.1	10.0	76.8	76.6	15.9	80.4	79.9
E3-NMX20	E3-NMX25	73.1	72.3	396.0	0.0	1	0.0	2.0	CIRCULAR	86.1	84.5	18.5	76.6	76.3	28.9	79.9	79.0
E3-NMX25	E3-NBFR25	72.3	71.9	174	0.002	1	0.0	2.5	CIRCULAR	84.5	79.6	63.3	76.3	76.1	74.7	79.0	78.6
E3-NMX30	E3-NMX25	73.5	72.3	596	0.002	1	0.0	2.0	CIRCULAR	93.5	84.5	18.5	76.7	76.3	28.9	80.2	79.0
E3-NMX35	E3-NMX30	74.9	73.5	694	0.002	1	0.0	2.0	CIRCULAR	108.7	93.5	10.1	76.9	76.7	15.9	80.8	80.2
E4-SBFR05	OUT_E4	66.8	66.0	405	0.002	1	9.0	4.0	RECT_CLOSED	79.6	70.0	208.3	71.2	70.0	245.6	71.9	70.0
E4-SBFR10	E4-SBFR05	67.8	66.8	529	0.002	1	9.0	4.0	RECT_CLOSED	79.8	79.6	211.5	72.4	71.2	251.0	74.1	71.9
E4-SBFR15	E4-SBFR10	69.1	67.8	721	0.002	1	9.0	4.0	RECT_CLOSED	79.7	79.8	183.9	74.0	72.4	208.6	76.5	74.1
E4-SBFR20	E4-SBFR15	70.1	69.1	720	0.001	1	9.0	4.0	RECT_CLOSED	79.8	79.7	175.9	75.2	74.0	201.3	78.2	76.5
E4-SBFR25	E4-SBFR20	70.3	70.1	184	0.001	1	8.0	4.0	RECT_CLOSED	80.8	79.8	155.1	75.5	75.2	195.4	78.6	78.2
E4-SBFR30	E4-SBFR25	71.0	70.3	425	0.002	1	7.0	4.0	RECT_CLOSED	79.8	80.8	128.0	76.0	75.5	148.2	79.3	78.6
E4-SBFR35	E4-SBFR30	71.6	71.0	496	0.001	1	7.0	4.0	RECT_CLOSED	81.4	79.8	105.3	76.7	76.0	111.0	80.2	79.3
E4-SBFR40	E4-SBFR35	72.8	71.6	610	0.002	1	7.0	3.0	RECT_CLOSED	80.6	81.4	108.2	77.6	76.7	130.5	81.3	80.2
E4-SBFR45	E4-SBFR40	73.5	72.8	748	0.001	1	7.0	3.0	RECT_CLOSED	83.5	80.6	76.5	78.1	77.6	105.9	82.1	81.3
E4-SBFR50	E4-SBFR45	74.3	73.5	491	0.002	1	7.0	3.0	RECT_CLOSED	84.0	83.5	61.1	78.1	78.1	84.8	82.2	82.1
E4-SBFR55	E4-SBFR50	74.8	74.3	503	0.001	1	7.0	3.0	RECT_CLOSED	83.2	84.0	37.4	78.2	78.1	72.9	82.3	82.2
E4-SMX05	E4-SBFR05	67.8	66.8	529.0	0.002	1	9.0	4.0	RECT_CLOSED	104.4	79.6	211.5	82.4	71.2	251.0	82.6	71.9
E4-SMX10	E4-SMX15	78.6	77.6	457.0	0.002	1	0.0	0.0	IRREGULAR	105.2	92.3	7.3	79.8	78.9	9.9	81.5	80.8
E4-SMX15	E4-SMX20	77.6	76.3	680.0	0.002	1	0.0	0.0	IRREGULAR	92.3	85.7	12.6	78.9	78.3	14.8	80.8	80.1
E4-SMX20	E4-SMX25	76.3	75.5	393.0	0.002	1	0.0	0.0	IRREGULAR	85.7	84.5	19.5	78.3	77.4	27.2	80.1	79.1
E4-SMX25	E4-SBFR25	71.0	70.3	425.0	0.002	1	8.0	4.0	RECT_CLOSED	84.5	80.8	128.0	77.4	75.5	148.2	79.1	78.6
E4-SMX30	E4-SMX25	76.3	75.5	393.0	0.002	1	0.0	0.0	IRREGULAR	93.1	84.5	19.5	78.5	77.4	27.2	80.4	79.1
E4-SMX35	E4-SMX30	78.1	76.7	694.0	0.002	1	0.0	0.0	IRREGULAR	108.4	93.1	11.6	79.3	78.5	15.2	81.5	80.4

E.4 Existing SWMM Model Setup





LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
- Existing Storm Sewer
- Transect
- HCFCD Stream
- Existing Drainage Area

Existing Drainage Area Systems

- System A
- System B
- System C
- System D
- System E

0 1,000 2,000

Aerial Source: H-GAC 2020

N

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Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 1 of 9

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

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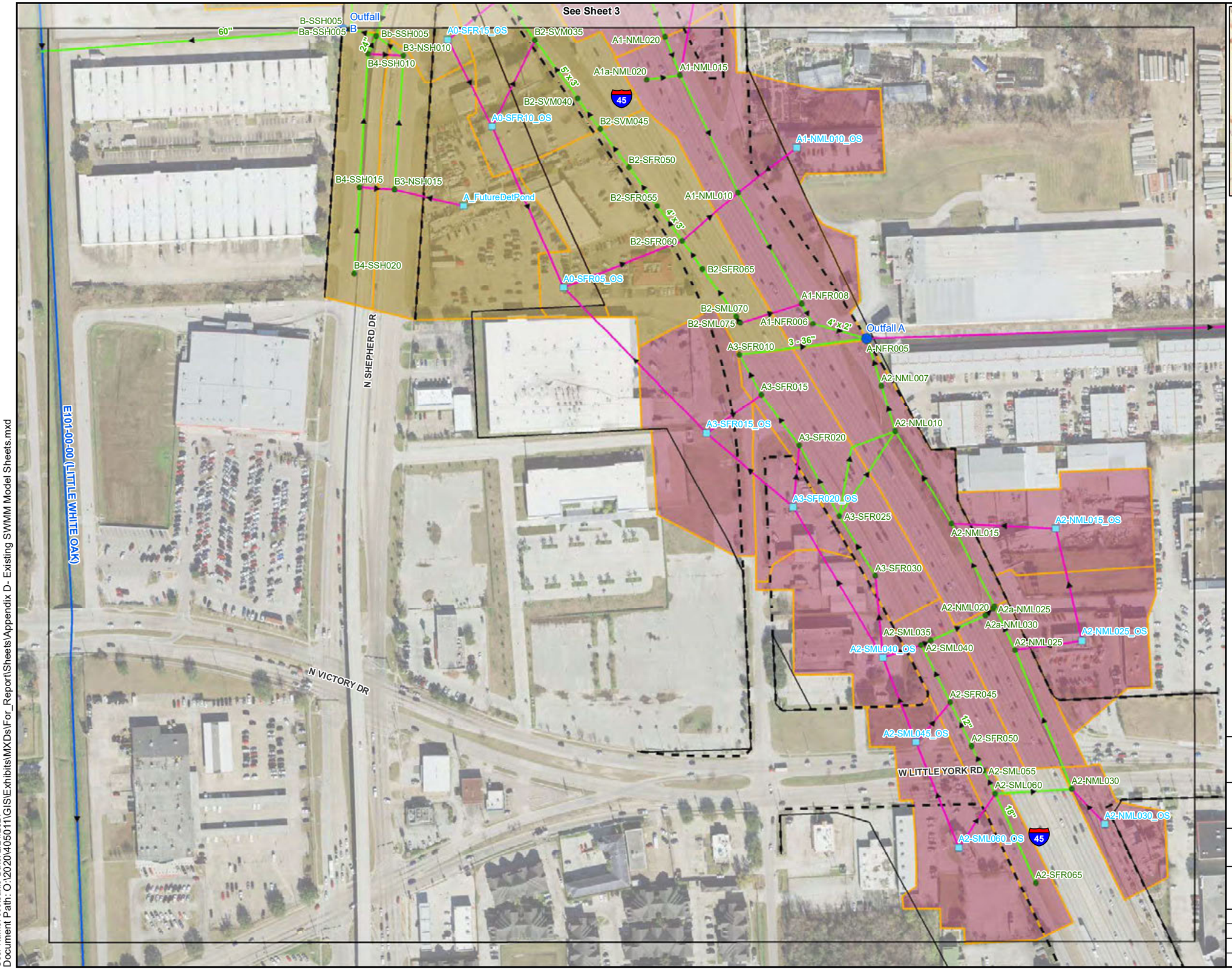

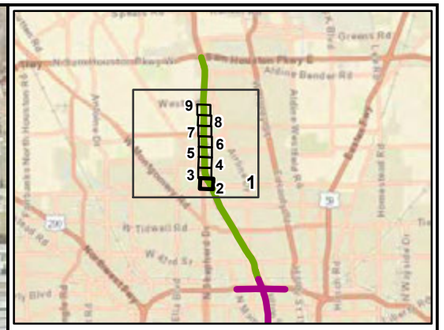

LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Existing Storm Sewer
- Transect
- HCFCD Stream
- Existing Drainage Area

Existing Drainage Area Systems

- System A
- System B
- System C
- System D
- System E

0 100 200

Aerial Source: H-GAC 2020

N

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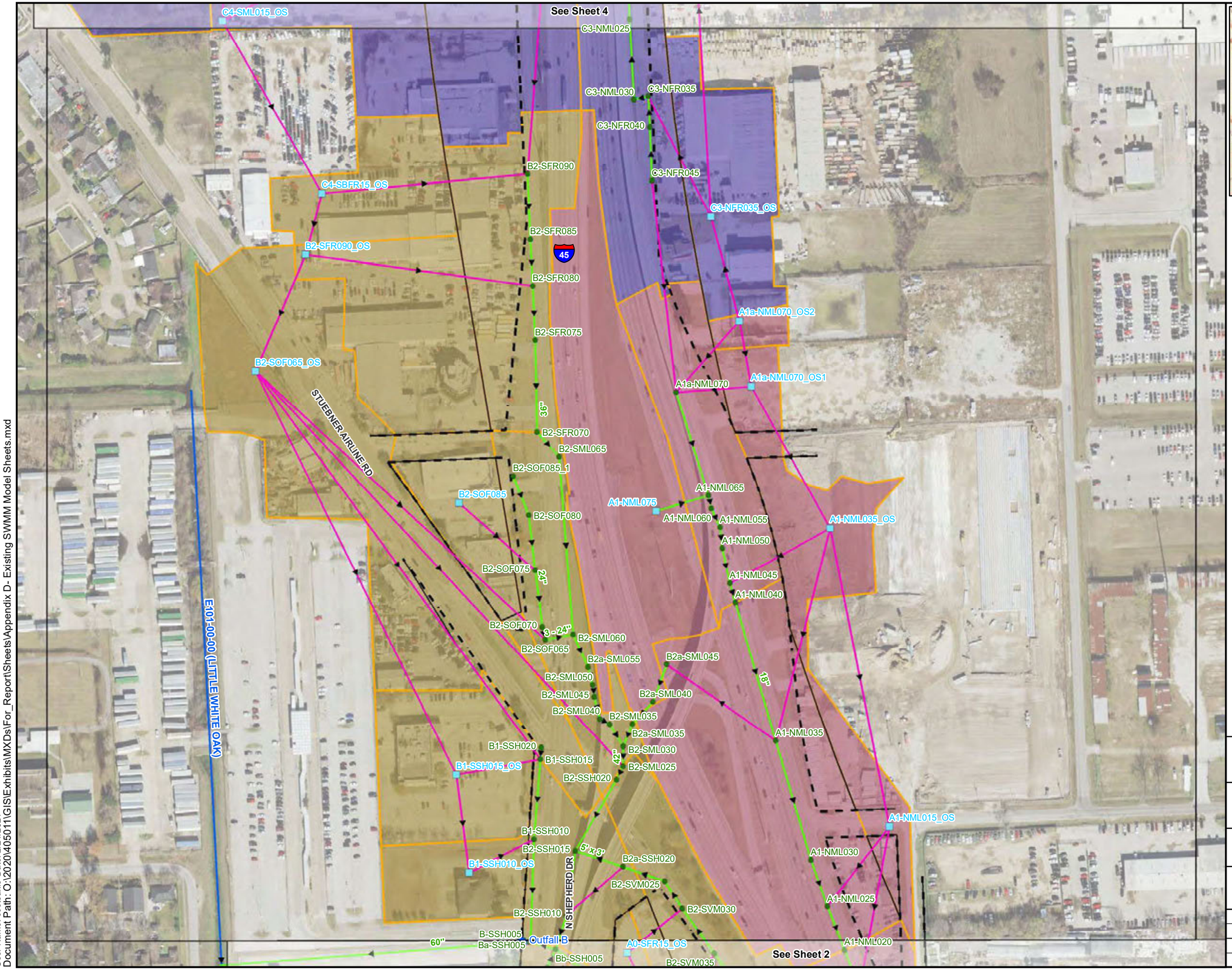
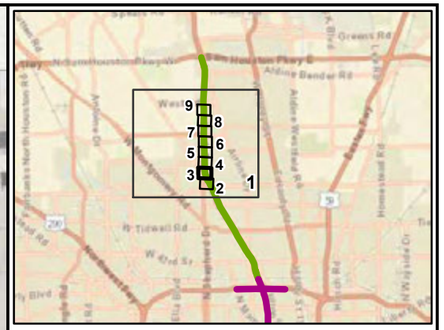
North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 2 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4





LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Existing Storm Sewer
- Transect
- HCFCD Stream
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Existing Drainage Area Systems

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Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
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Existing SWMM Model Setup

Sheet 3 of 9

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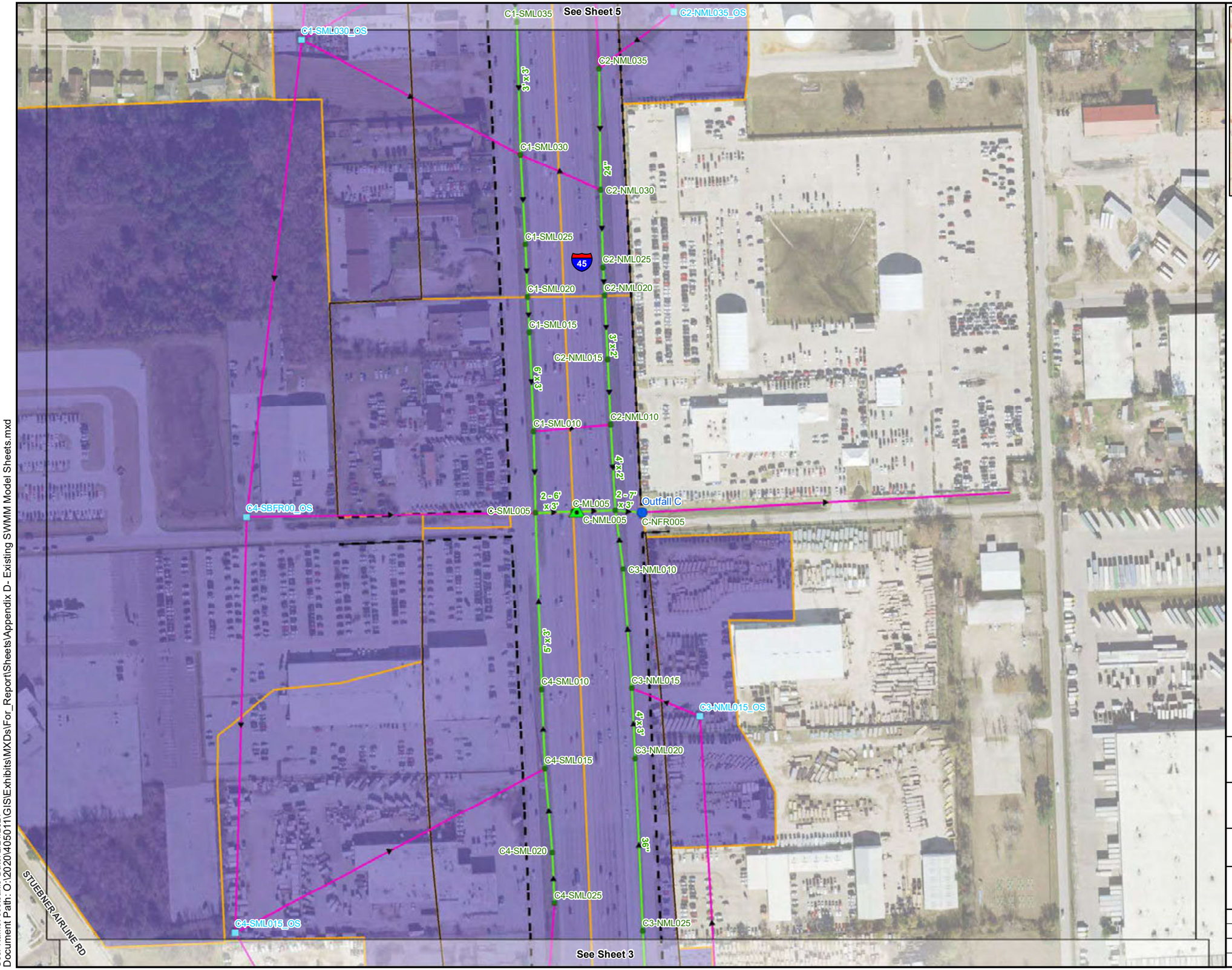
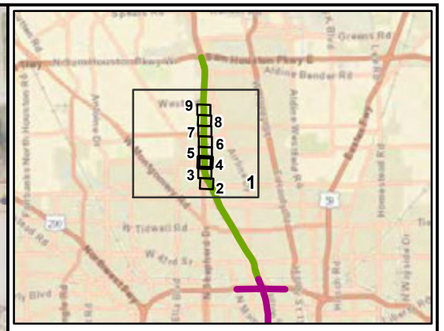
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4





LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Existing Storm Sewer
- Transect
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Existing SWMM Model Setup

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STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
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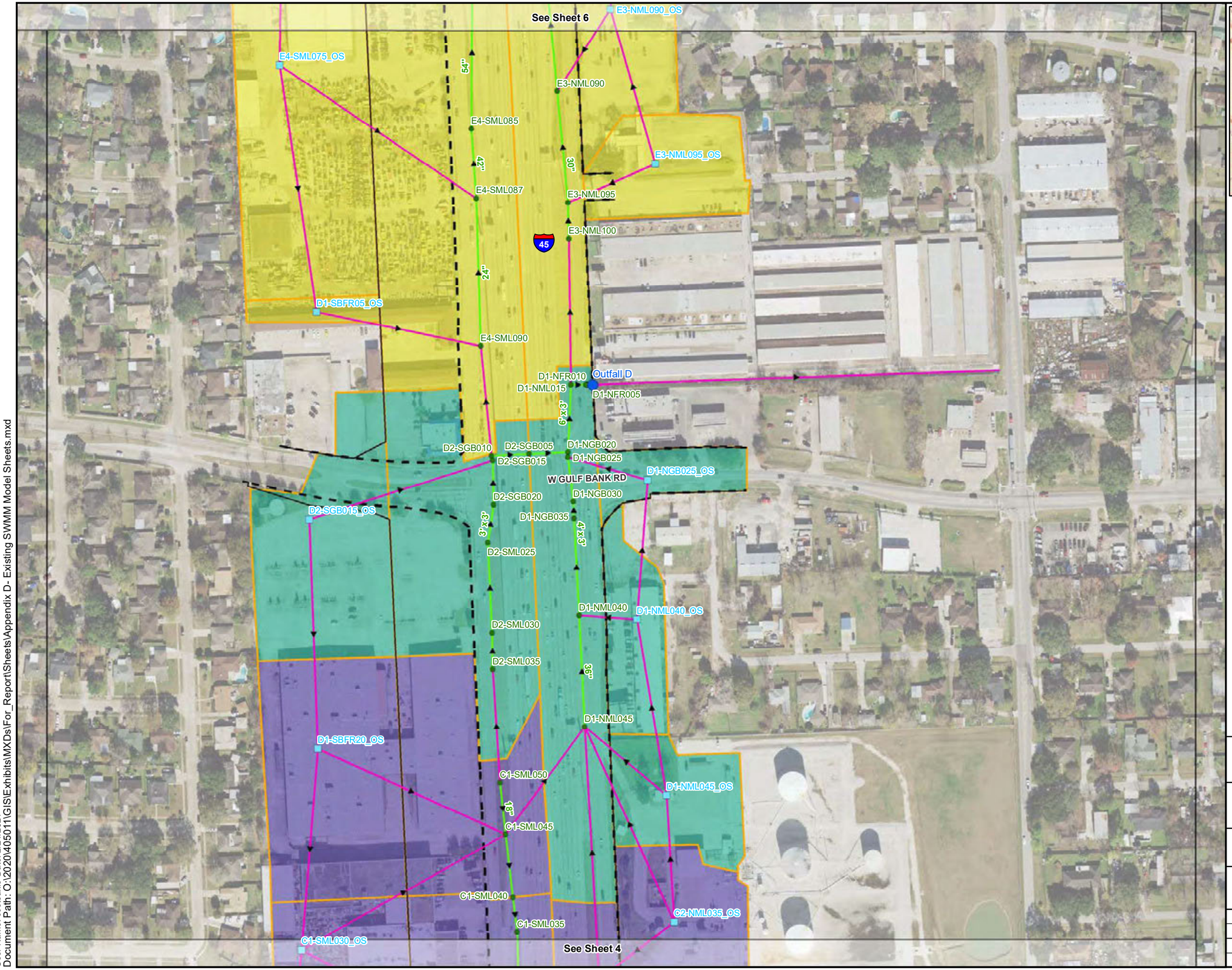

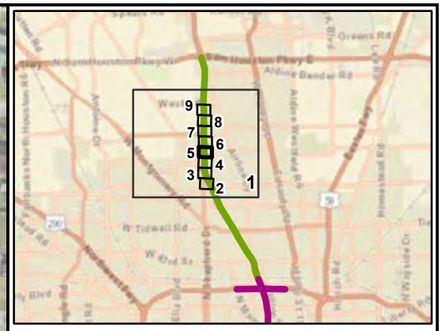

LEGEND

- Junction
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- Proposed TxDOT ROW
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Existing Drainage Area Systems

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Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 5 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
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STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

User Name: ccotsakis Date: 2/24/2021
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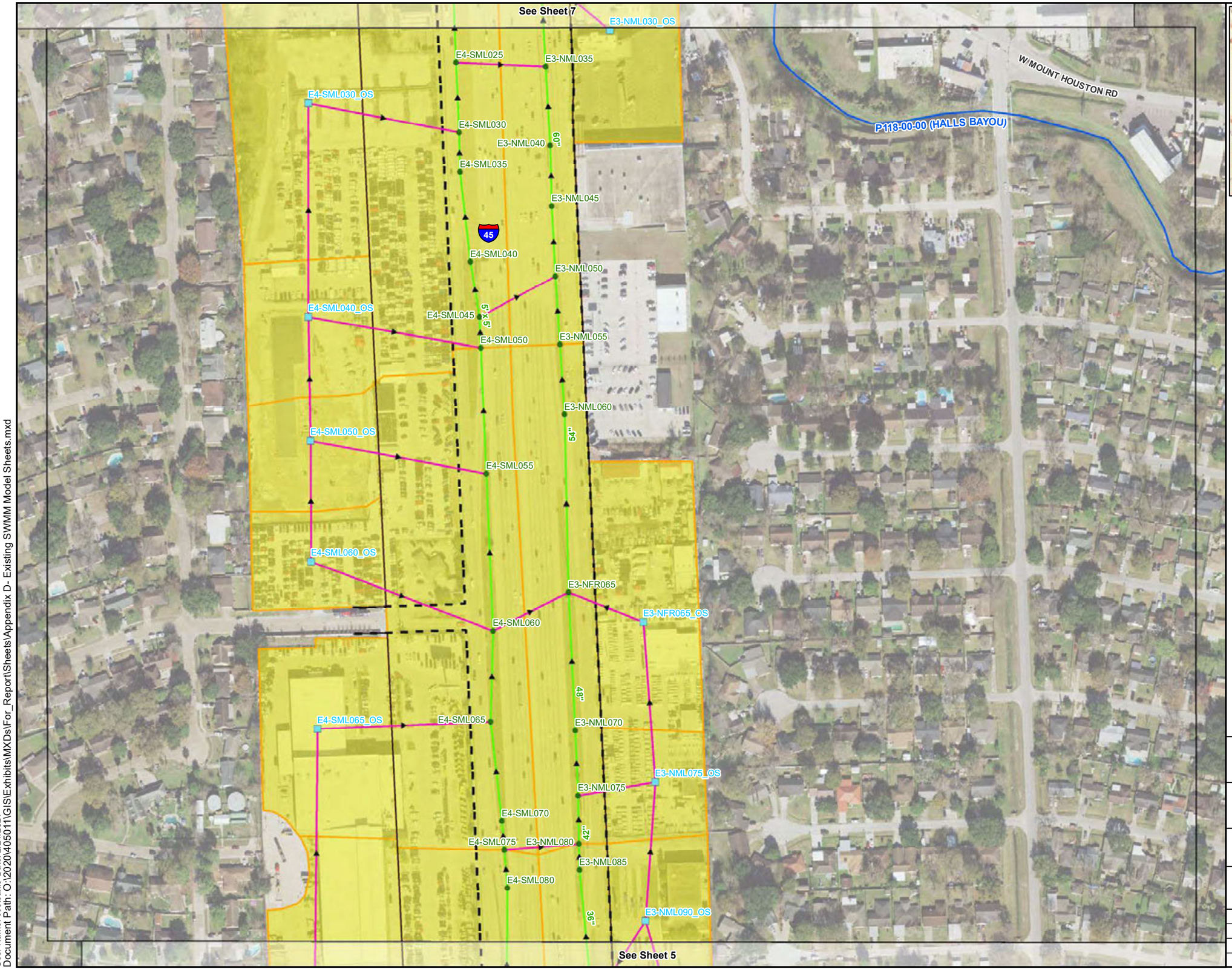

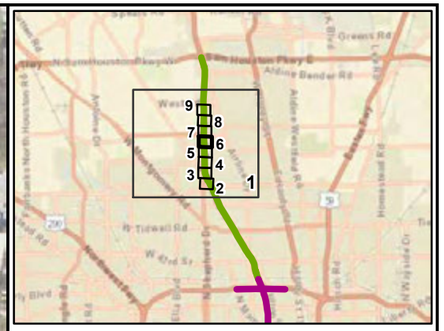

LEGEND

- Junction
- Storage
- Outfall
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- Existing TxDOT ROW
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Existing Drainage Area Systems

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Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 6 of 9

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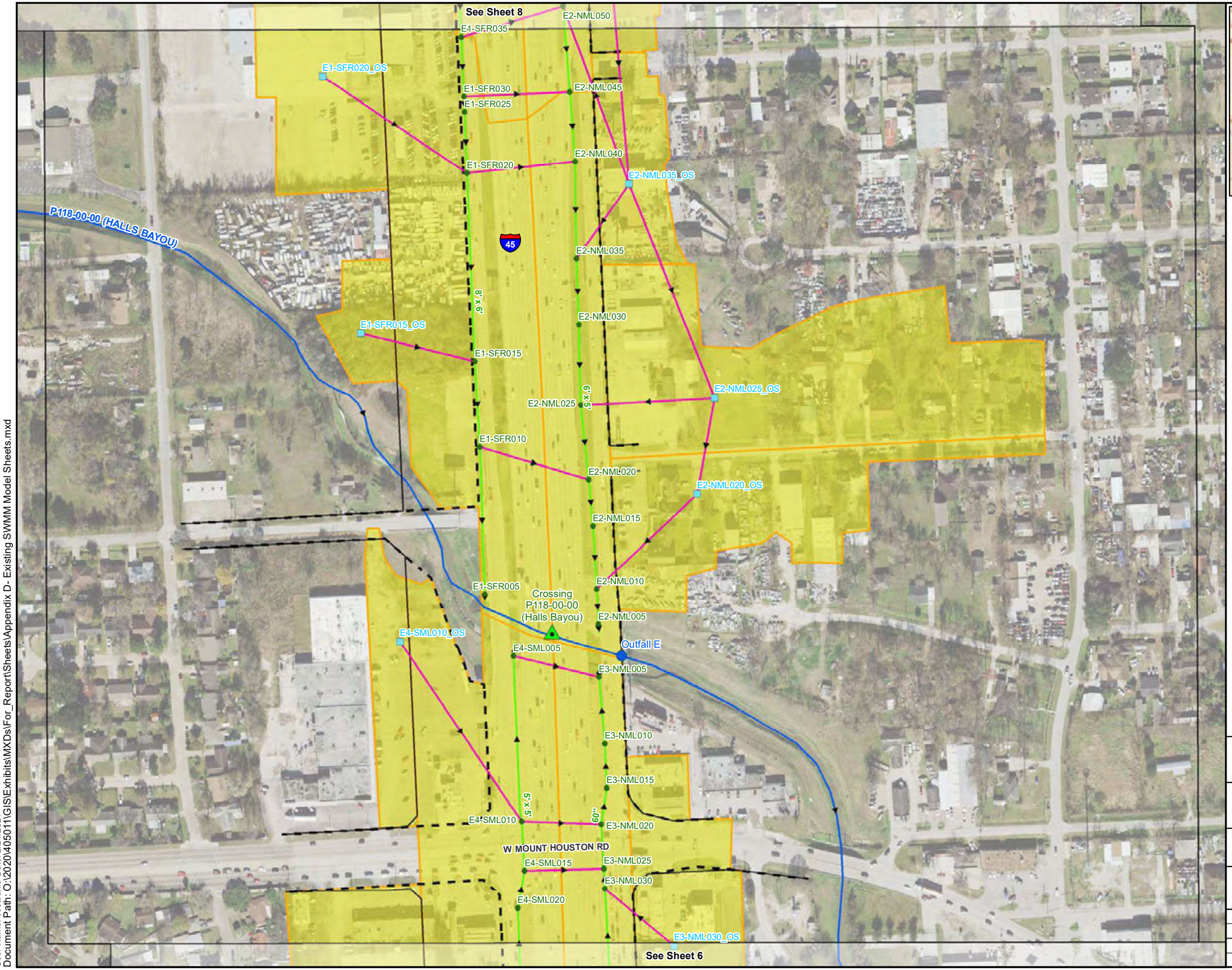
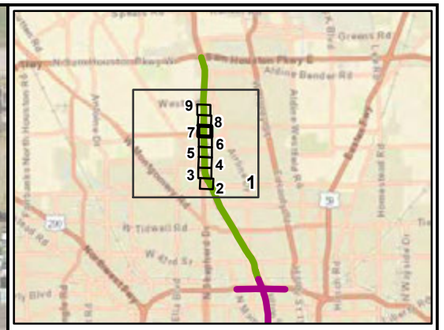
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4





LEGEND

- Junction
- Storage
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Existing Drainage Area Systems

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0 100 200

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Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 7 of 9

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STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

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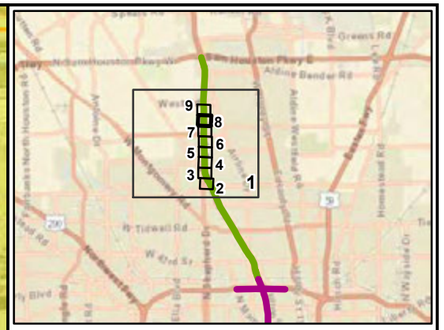
See Sheet 9

E1-SFR090
E2-NML090
48"
E1-SFR085_OS
E1-SFR085
E2-NML085
45
E2-NML065_OS
E2-NML080
11'x 4'
54"
E1-SFR080
E1-SFR075
E2-NML075
E2-NML070
E1-SFR070
E1-SFR065
E2-NML065
2 - 3'x5'
E2-NML060_OS
E2-NML060
E1-SFR060
E1-SFR055
E2-NML055_OS
E1-SFR050
E1-SFR050_OS
E2-NML055
E1-SFR045
8'x6'
5'x5'
E2-NML050_OS
E1-SFR040_OS
E1-SFR040
E2-NML050
E1-SFR035

See Sheet 7



LEGEND

- Junction
- Storage
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- Existing TxDOT ROW
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Existing Drainage Area Systems

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 8 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
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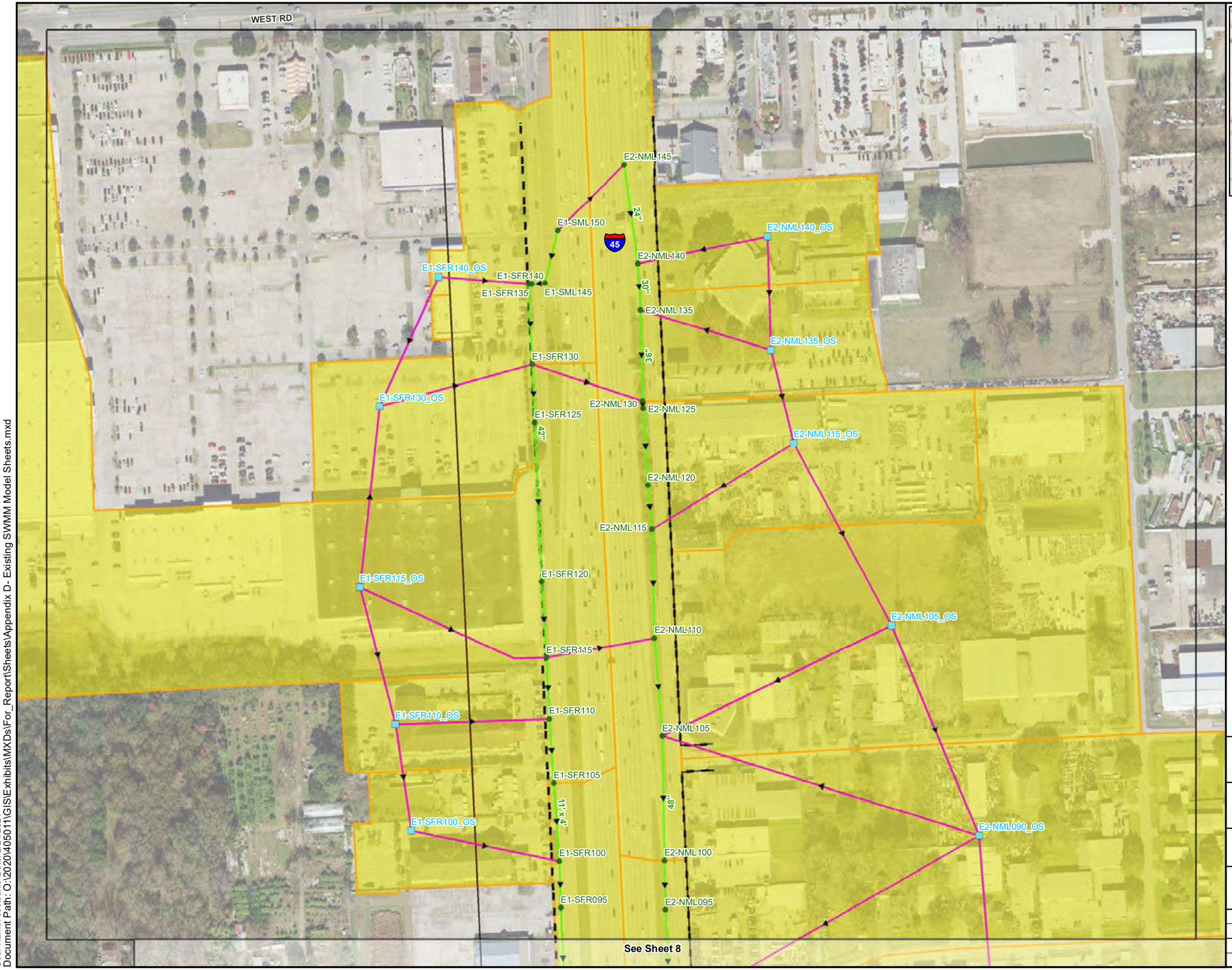

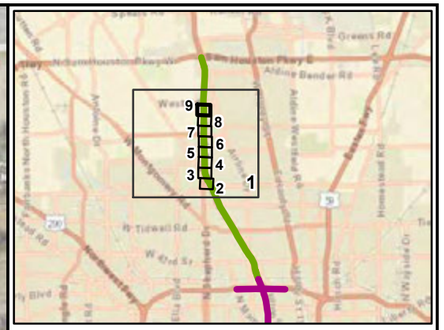

LEGEND

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- Existing TxDOT ROW
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Existing Drainage Area Systems

- System A
- System B
- System C
- System D
- System E

0 100 200

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Existing SWMM Model Setup

Sheet 9 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
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STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

User Name: ccotsakis Date: 2/24/2021
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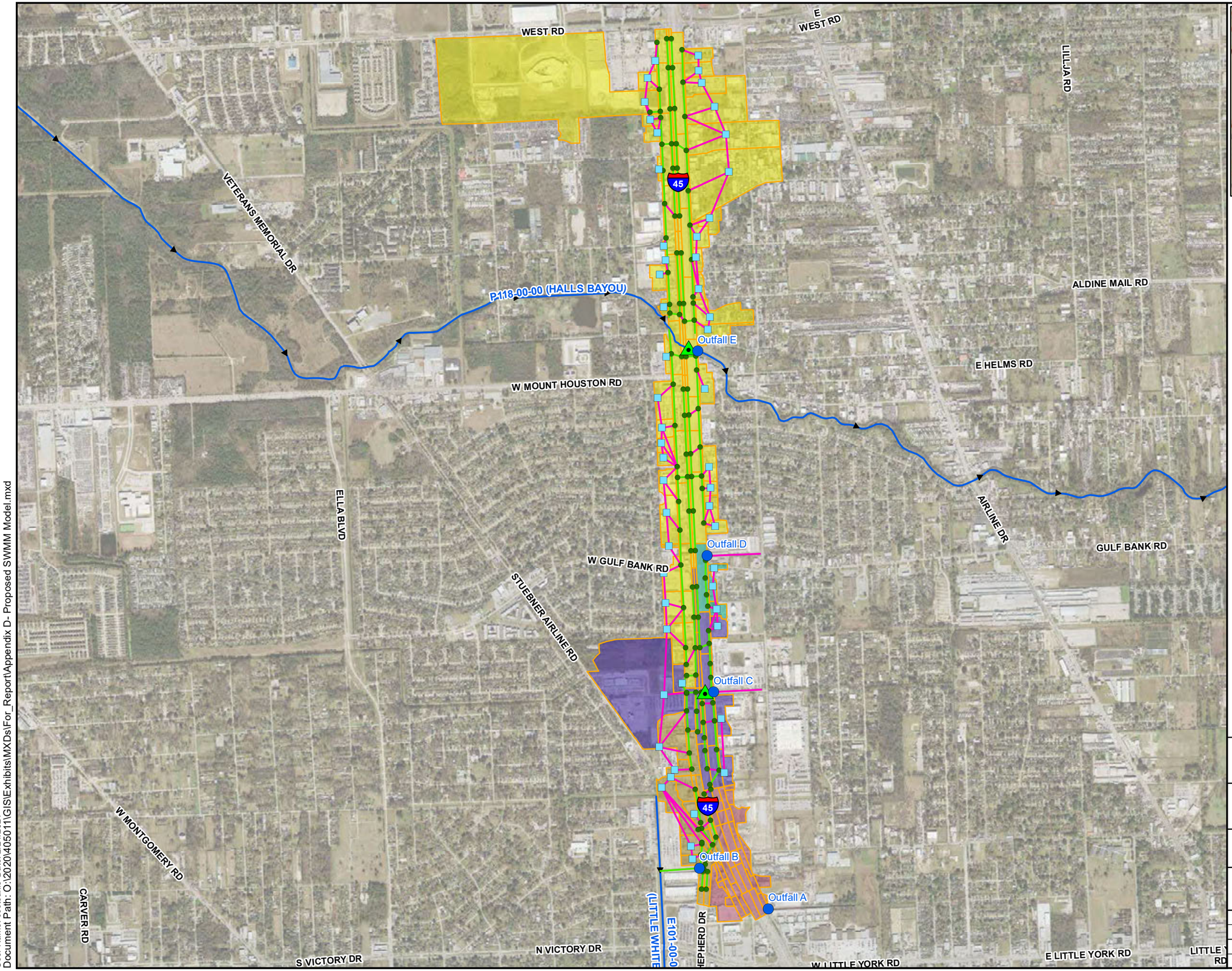
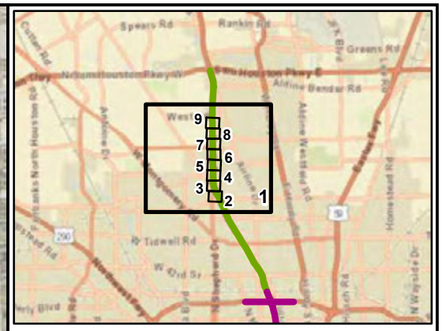
E.4 Proposed SWMM Model Setup





LEGEND

- Junction
- Storage
- Outfall
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Proposed Drainage Area Systems

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0 800 1,600

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed SWMM Model Setup

Sheet 1 of 9

FED. RD. DIV. NO.	STATE	TxDOT Contract No.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
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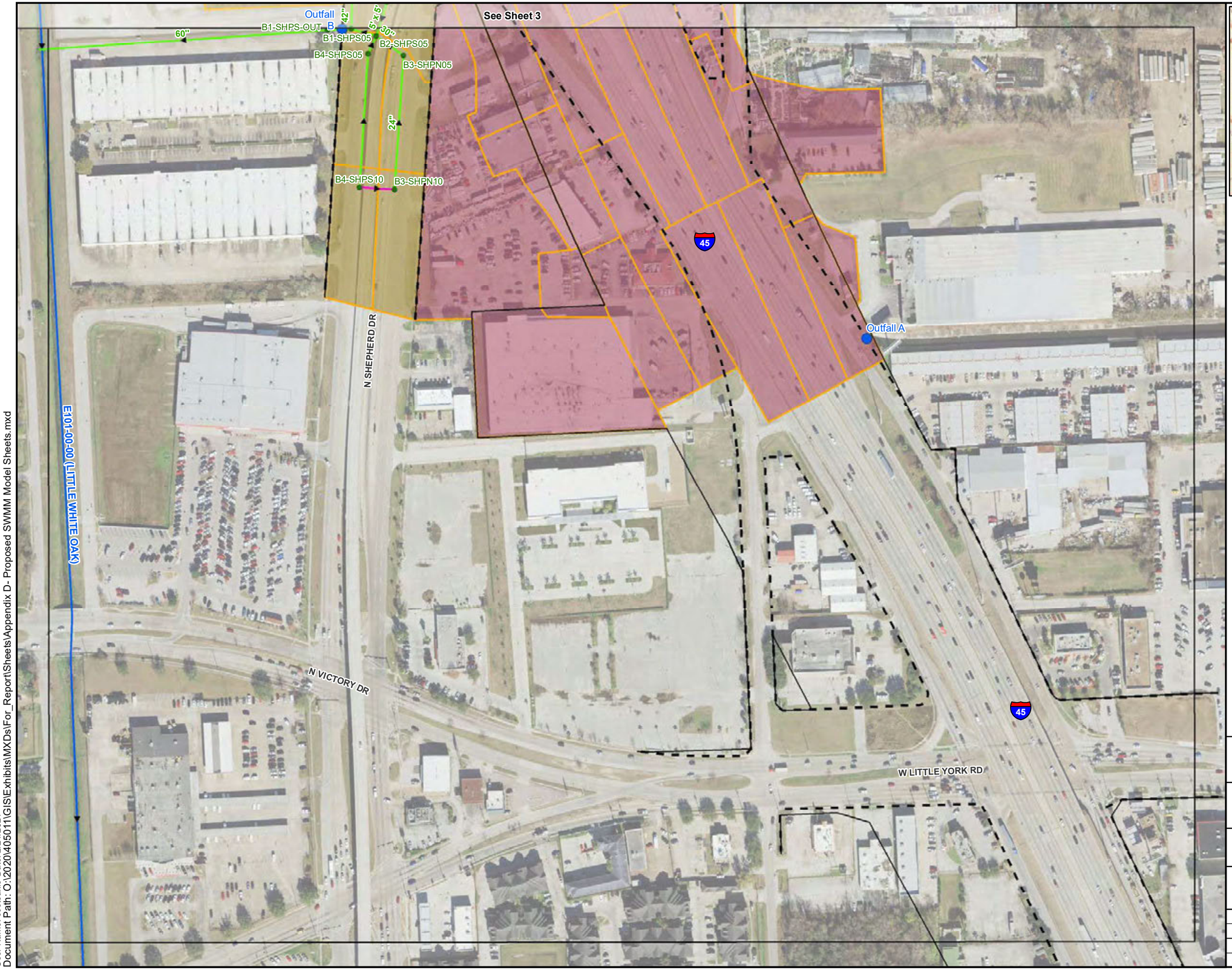

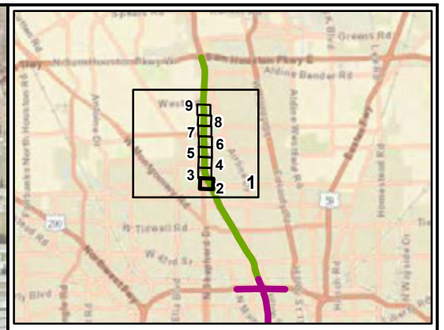

LEGEND

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- Outfall
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0 100 200

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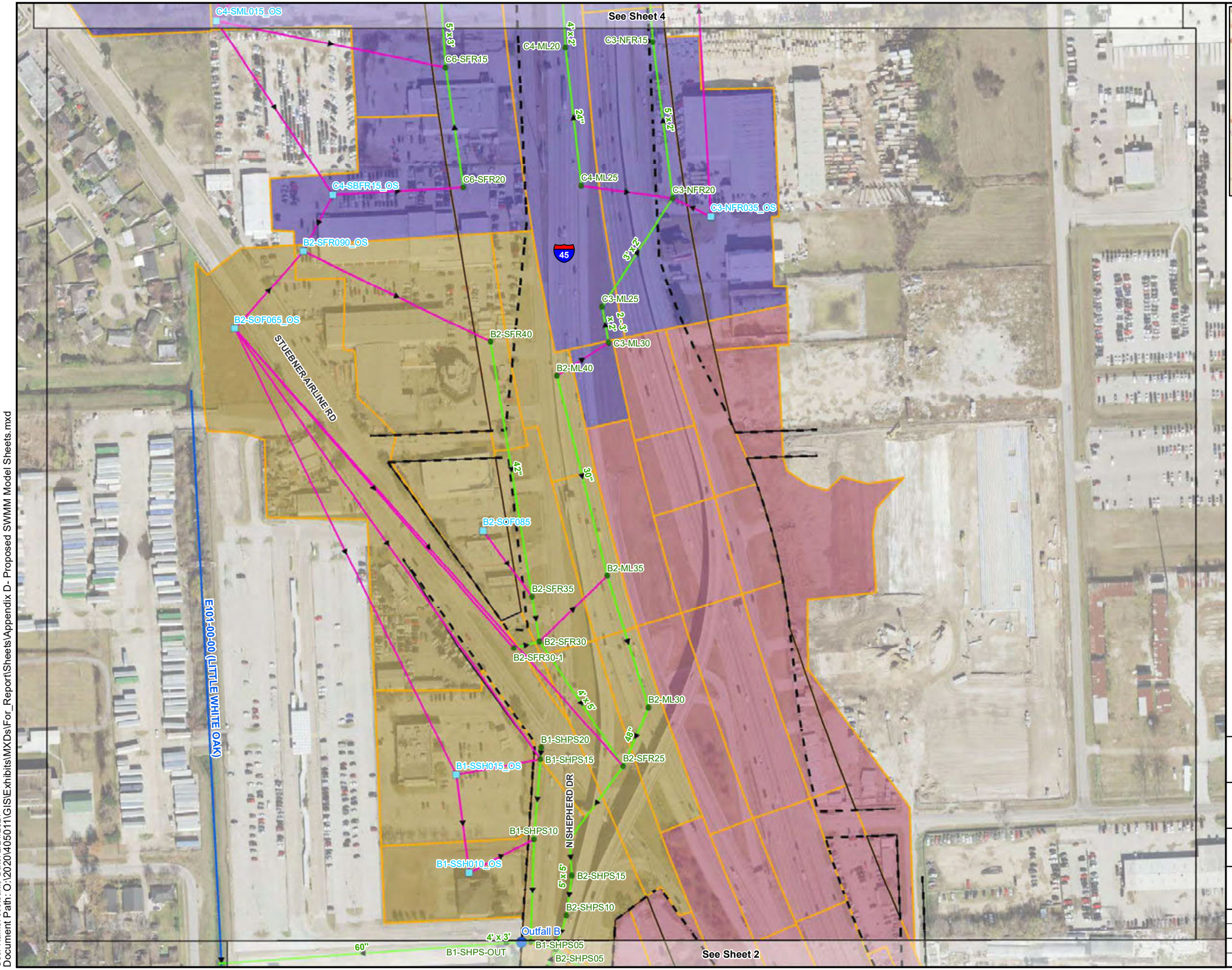

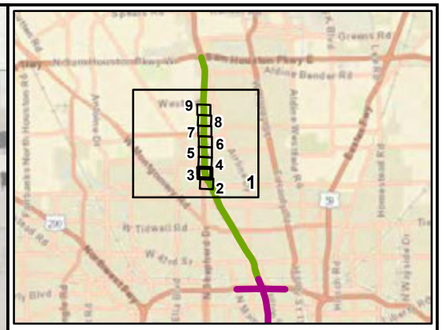

LEGEND

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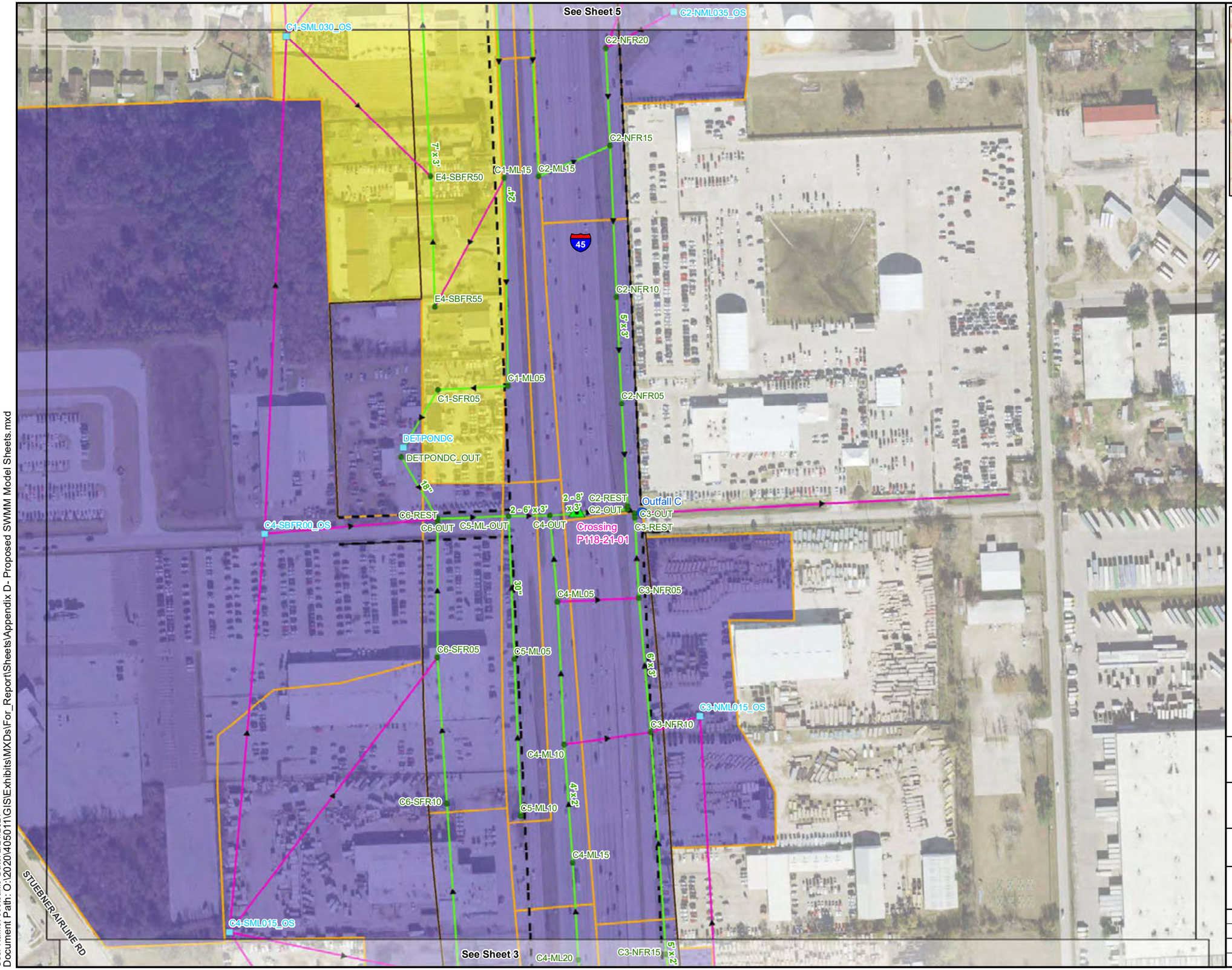

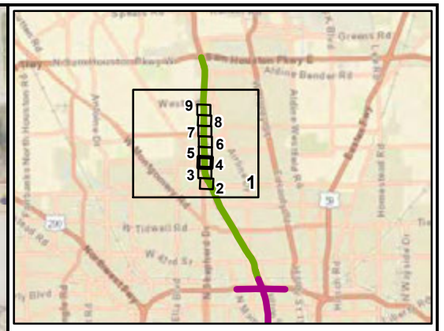

LEGEND

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Sheet 4 of 9

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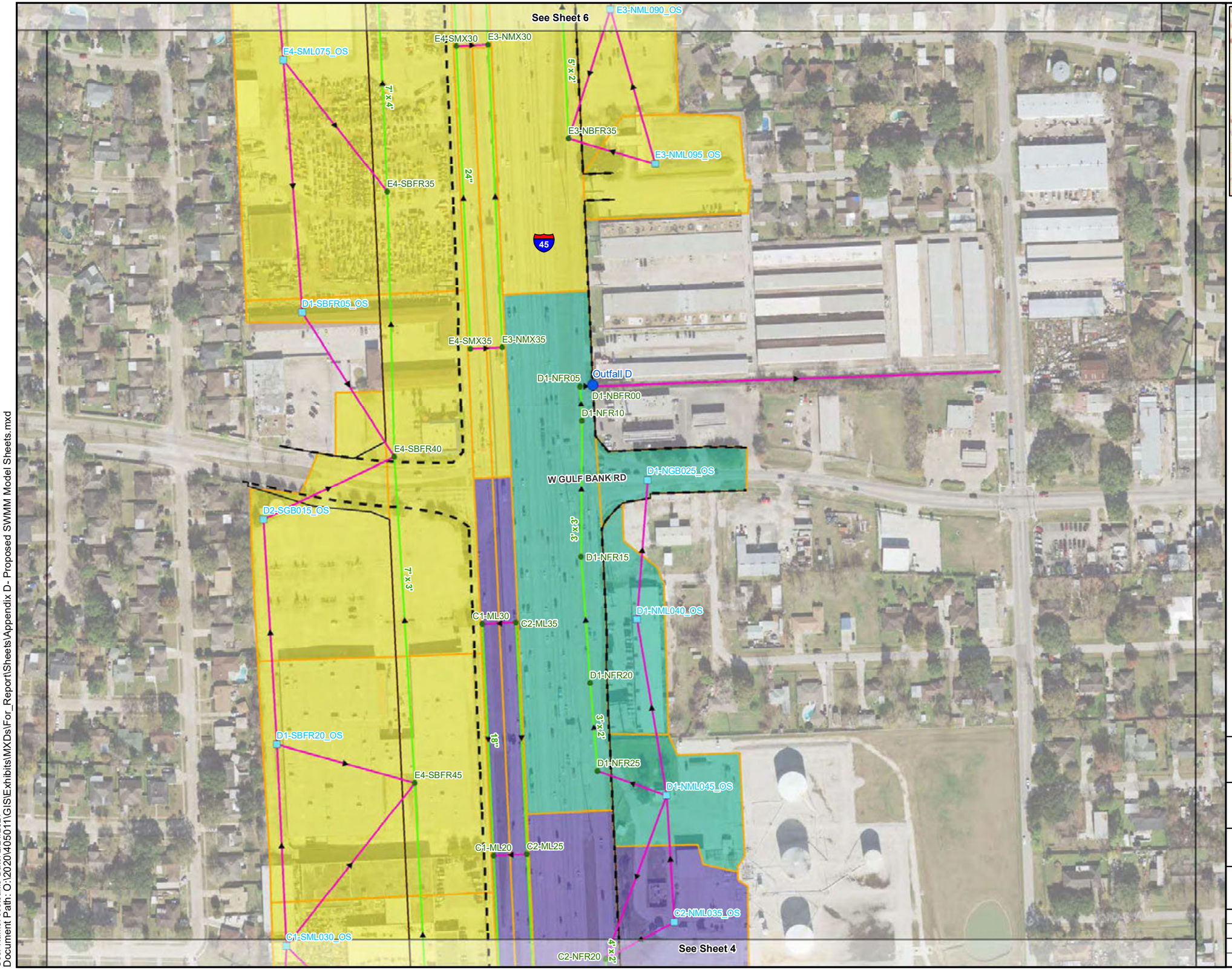

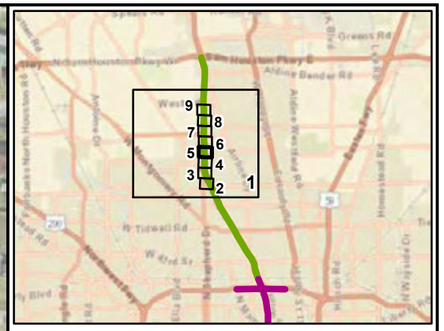

LEGEND

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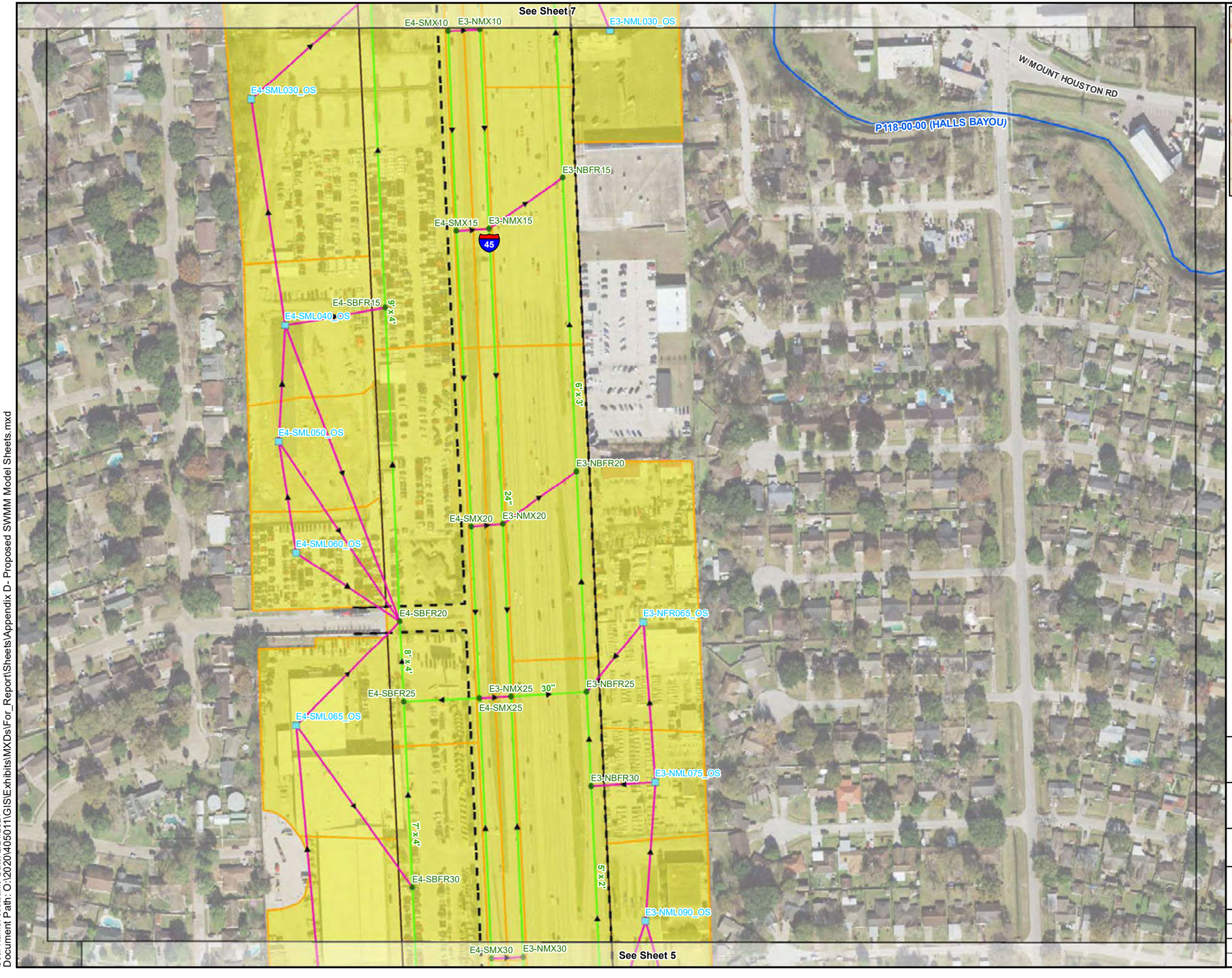

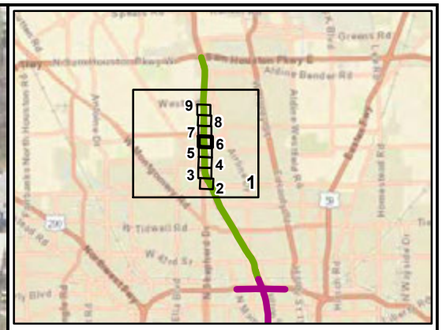

LEGEND

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- Proposed TxDOT ROW
- Proposed Storm Sewer
- Transect
- HCFCD Stream
- Proposed Drainage Area

Proposed Drainage Area Systems

- System A
- System B
- System C
- System D
- System E

0 100 200

Aerial Source: H-GAC 2020

N

CivilTech Engineering, Inc.
11750 Katy Fwy, Suite 1260
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Tel: 346-409-2067
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Texas Department of Transportation

North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed SWMM Model Setup

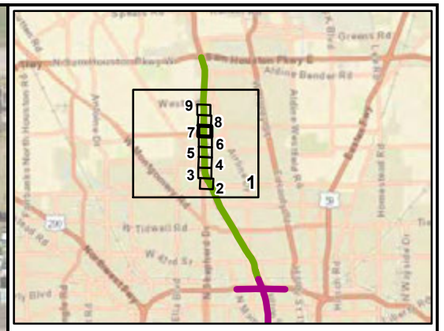
Sheet 6 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

See Sheet 8

P118-00-00 (HALLS BAYOU)

E1-SFR020_OS
E1-SBFR15
7' x 5'
8' x 5'
E1-SFR015_OS
E1-SBFR10
E1-SMX15
E2-NMX15
E1-SBFR05
36"
E1-SMX10
E2-NMX10
24"
8' x 6'
E2-NML035_OS
E2-NBFR15
E2-NBFR10
E2-NML025_OS
E2-NBFR05
E2-NML020_OS
45
8' x 4'
Crossing
P118-00-00
(Halls Bayou)
Outfall E
E4-SBFR05
E4-SML010_OS
E4-SMX05
E3-NMX05
E3-NBFR05
E3-NBFR10
6' x 3'
9' x 4'
W MOUNT HOUSTON RD
E4-SBFR10
E4-SMX10
E3-NMX10
E3-NML030_OS
See Sheet 6



LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Transect
- HCFCD Stream
- Proposed Drainage Area

Proposed Drainage Area Systems

- System A
- System B
- System C
- System D
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0 100 200

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Proposed SWMM Model Setup

Sheet 7 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

User Name: ccotsakis Date: 2/24/2021
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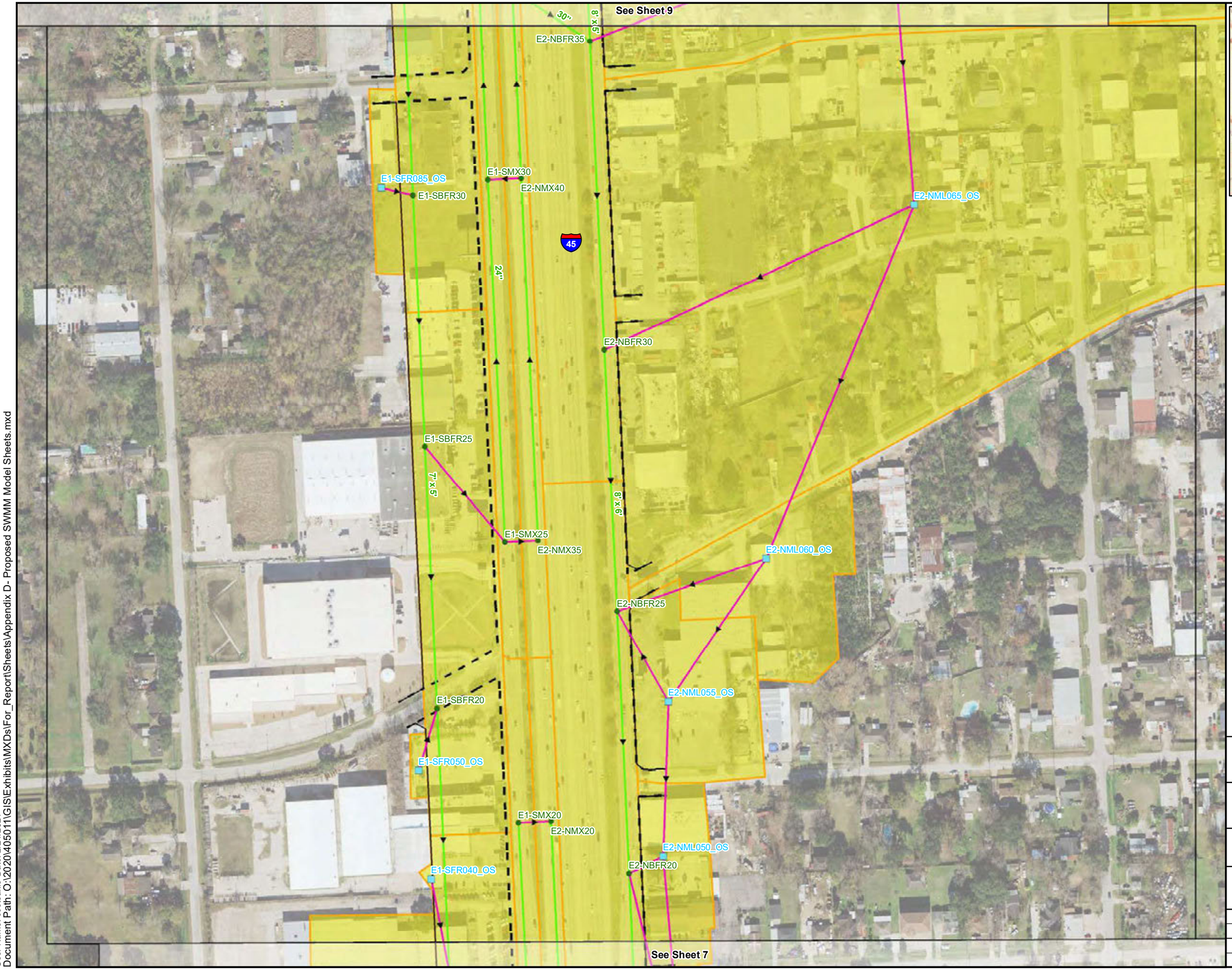

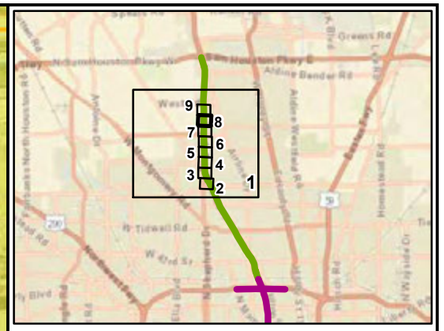

LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
- Existing TxDOT ROW
- Proposed TxDOT ROW
- Proposed Storm Sewer
- Transect
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- Proposed Drainage Area

Proposed Drainage Area Systems

- System A
- System B
- System C
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0 100 200

Aerial Source: H-GAC 2020

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North Houston Highway Improvement Project
Segment 1 Drainage Study

Proposed SWMM Model Setup

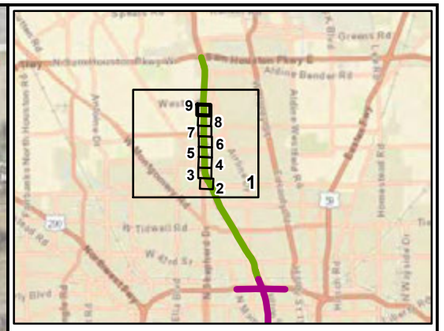
Sheet 8 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

User Name: ccotsakis Date: 2/24/2021
Document Path: O:\2020\4050111\GIS\Exhibits\MXDs\For_Report\Sheets\Appendix D- Proposed SWMM Model Sheets.mxd

WEST RD

E1-SMX55
E2-NMX60
E1-SBFR55
E2-NBFR50
E2-NML140_OS
45
E1-SFR140_OS
E1-SMX50
E2-NMX55
41" x 2'
E2-NML135_OS
E1-SFR130_OS
5' x 4'
E2-NBFR45
E2-NML115_OS
E1-SBFR50
24"
E1-SFR115_OS
E2-NML105_OS
E1-SMX45
E2-NMX50
E1-SFR115-OS
6' x 5'
E1-SBFR45
E2-NBFR40
8' x 5'
E1-SBFR40
E1-SFR110_OS
E1-SFR100_OS
7' x 5'
E2-NML090_OS
E1-SBFR35
36"
E1-SMX40
E2-NMX45
30"
E2-NBFR35
8' x 6'
See Sheet 8



LEGEND

- Junction
- Storage
- Outfall
- Drainage Crossing
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Segment 1 Drainage Study

Proposed SWMM Model Setup

Sheet 9 of 9

FED. RD. DIV. NO.	STATE	CEI PROJECT NO.			HIGHWAY NO.
6	TEXAS	12-0IDP5012, WA 1			I-45
STATE DISTRICT	COUNTY	CONTROL NO.	SECTION NO.	JOB NO.	EXHIBIT NO.
HOU	HARRIS	0110	06	139	Appendix E.4

Appendix F

Floodplain Impact Analysis Supporting Data

- Cut and Fill Volume Calculations – Southbound Frontage Road
- Cut and Fill Volume Calculations – Mainlanes
- Cut and Fill Volume Calculations – Northbound Frontage Road

Cut and Fill Volume Calculations
- Southbound Frontage Road

SOUTHBOUND FRONTAGE ROAD CUT & FILL VOLUMES

BASELINE STA.	WIDTH (ROW + ROADWAY)	Fill Area	Cut Area	Fill Volume	Cut Volume
(-)	(FT.)	(SQFT)	(SQFT)	(CY)	(CY)
1658+00.00	21	26.4	0.0	20.3	0.0
1659+00.00	82	44.3	0.0	135.2	0.0
1660+00.00	99	81.1	0.0	298.4	0.0
1661+00.00	99	48.2	0.0	177.3	0.0
1662+00.00	99	25.5	0.0	93.3	0.0
1663+00.00	97	17.0	1.2	61.0	4.5
1664+00.00	93	0.0	31.3	0.0	108.3
1665+00.00	88	4.3	20.7	14.1	67.7
1666+00.00	85	24.9	0.0	78.0	0.0
1667+00.00	83	74.9	0.0	230.0	0.0
1668+00.00	82	130.5	0.0	396.9	0.0
1669+00.00	82	43.1	0.9	131.1	2.6
1670+00.00	81	10.1	19.8	30.3	59.7
1671+00.00	84	123.5	0.0	385.7	0.0
1672+00.00	76	92.7	0.0	260.5	0.0
1673+00.00	111	129.0	0.0	531.9	0.0
1674+00.00	111	167.3	0.0	689.7	0.0
1675+00.00	111	138.8	0.0	572.3	0.0
1676+00.00	111	44.4	0.0	183.2	0.0
1677+00.00	111	97.1	0.0	400.4	0.0
1678+00.00	111	118.4	0.0	488.1	0.0
1679+00.00	111	118.5	0.0	488.5	0.0
1680+00.00	111	123.3	0.0	508.4	0.0
1681+00.00	111	207.1	0.0	853.8	0.0
1682+00.00	111	220.9	0.0	910.7	0.0
1683+00.00	111	191.9	0.0	791.3	0.0
1684+00.00	111	152.2	0.0	627.5	0.0
1685+00.00	112	203.3	0.0	841.9	0.0
1686+00.00	140	327.2	0.0	1697.7	0.0
1687+00.00	134	388.0	0.0	1931.9	0.0
1688+00.00	112	92.8	0.0	384.2	0.0
1689+00.00	111	286.4	0.0	1180.9	0.0
1690+00.00	111	334.5	0.0	1378.8	0.0
1691+00.00	111	281.0	0.0	1158.4	0.0
1692+00.00	111	329.6	0.0	1358.7	0.0
1693+00.00	111	385.0	0.0	1578.9	0.0
1694+00.00	108	532.3	0.0	2133.5	0.0
1695+00.00	104	733.0	0.0	2819.1	0.0
1696+00.00	98	376.1	0.0	1366.6	0.0

SOUTHBOUND FRONTAGE ROAD CUT & FILL VOLUMES

BASELINE STA.	WIDTH (ROW + ROADWAY)	Fill Area	Cut Area	Fill Volume	Cut Volume
(-)	(FT.)	(SQFT)	(SQFT)	(CY)	(CY)
1697+00.00	91	386.5	0.0	1305.2	0.0
1698+00.00	84	386.6	0.0	1197.5	0.0
1699+00.00	123	377.4	0.0	1723.5	0.0
1700+00.00	123	325.8	0.0	1488.0	0.0
1701+00.00	123	102.6	0.0	468.5	0.0
1702+00.00	123	152.9	0.0	698.2	0.0
1703+00.00	123	54.6	0.0	249.2	0.0
1704+00.00	123	108.1	0.0	493.7	0.0
1705+00.00	123	90.8	0.0	414.7	0.0
1706+00.00	123	158.6	0.0	724.2	0.0
1707+00.00	123	123.7	0.0	564.7	0.0
1708+00.00	123	78.2	0.0	357.0	0.0
1709+00.00	123	52.5	0.0	239.9	0.0
1710+00.00	124	16.8	9.3	77.1	42.6
1711+00.00	137	79.9	0.0	405.4	0.0
1712+00.00	124	28.0	16.6	128.1	76.1
1713+00.00	124	0.0	59.5	0.0	272.7
1714+00.00	123	18.9	0.0	86.3	0.0
1715+00.00	123	55.2	0.0	252.1	0.0
1716+00.00	123	25.5	0.0	116.5	0.0
1717+00.00	123	0.1	8.1	0.5	36.8
1718+00.00	123	3.1	2.8	14.3	12.6
1719+00.00	123	24.1	0.0	110.2	0.0
1720+00.00	123	34.0	0.0	155.3	0.0
1721+00.00	123	6.7	4.9	30.6	22.2
1722+00.00	123	0.0	43.7	0.0	199.6
1723+00.00	123	0.0	68.6	0.0	313.1
1724+00.00	123	9.4	25.5	43.0	116.6
1725+00.00	125	64.3	0.0	296.7	0.0
1726+00.00	124	130.4	0.0	597.4	0.0
1727+00.00	124	105.7	0.0	484.4	0.0
1728+00.00	124	59.2	0.0	271.1	0.0
1729+00.00	124	34.0	0.0	155.7	0.0
1730+00.00	124	10.3	5.5	47.4	25.0
1731+00.00	124	0.0	127.7	0.0	584.9
1732+00.00	124	0.0	167.7	0.0	768.2
1733+00.00	124	35.8	51.3	163.8	235.0
1733+28.23	124	0.0	7.9	0.0	36.1

Fill Volume (ac-ft)	**25.1**
Cut Volume (ac-ft)	**1.8**

CivilTech Engineering, Inc.

Cut and Fill Volume Calculations
- Mainlanes

MAINLANES CUT & FILL VOLUMES

BASELINE STA.	WIDTH (MAINLANES + MAX LANES)	Fill Area	Fill Volume
(-)	(FT.)	(SQFT)	(CY)
1652+84.84	8	10.9	3.1
1653+00.00	33	39.4	48.9
1654+00.00	66	63.6	155.4
1655+00.00	77	97.9	280.9
1656+00.00	98	53.8	195.7
1657+00.00	139	1.7	8.5
1658+00.00	133	0.0	0.0
1659+00.00	130	0.0	0.0
1660+00.00	133	4.2	20.5
1661+00.00	139	7.5	38.8
1662+00.00	141	78.1	407.6
1663+00.00	166	86.4	532.3
1664+00.00	173	112.2	719.8
1665+00.00	188	148.0	1031.0
1666+00.00	197	219.4	1597.1
1667+00.00	202	183.2	1368.4
1668+00.00	213	190.0	1498.7
1669+00.00	231	257.2	2199.0
1670+00.00	250	299.3	2766.0
1671+00.00	289	243.2	2607.6
1672+00.00	292	248.4	2688.7
1673+00.00	257	278.9	2658.6
1674+00.00	257	262.4	2501.7
1675+00.00	257	279.5	2664.4
1676+00.00	257	292.1	2785.0
1677+00.00	257	287.7	2743.1
1678+00.00	257	204.4	1948.5
1679+00.00	257	29.7	283.4
1680+00.00	257	0.0	0.0
1681+00.00	257	0.0	0.0
1682+00.00	257	0.0	0.0
1683+00.00	257	0.0	0.0
1684+00.00	257	2.0	19.4
1685+00.00	256	451.2	4285.1
1686+00.00	256	568.4	5398.1
1687+00.00	244	487.7	4414.7
1688+00.00	256	382.9	3636.4
1689+00.00	257	197.5	1883.0
1690+00.00	257	206.2	1966.4

MAINLANES CUT & FILL VOLUMES

BASELINE STA.	WIDTH (MAINLANES + MAX LANES)	Fill Area	Fill Volume
(-)	(FT.)	(SQFT)	(CY)
1691+00.00	257	1139.7	10845.1
1692+00.00	257	3.9	37.1
1693+00.00	258	100.5	959.1
1694+00.00	260	223.1	2149.9
1695+00.00	265	296.8	2911.7
1696+00.00	271	323.1	3247.8
1697+00.00	282	342.8	3578.7
1698+00.00	292	313.3	3387.9
1699+00.00	257	285.7	2723.9
1700+00.00	262	269.2	2614.7
1701+00.00	267	266.5	2639.9
1702+00.00	233	265.1	2291.7
1703+00.00	233	259.6	2244.2
1704+00.00	233	274.8	2375.5
1705+00.00	233	249.9	2160.4
1706+00.00	233	256.4	2216.2
1707+00.00	233	278.2	2405.2
1708+00.00	233	320.8	2773.5
1709+00.00	233	288.0	2490.0
1710+00.00	233	326.1	2813.4
1711+00.00	232	255.6	2200.4
1712+00.00	232	213.6	1839.2
1713+00.00	187	210.8	1462.7
1714+00.00	179	244.5	1621.5
1715+00.00	170	211.7	1330.3
1716+00.00	164	196.9	1195.0
1717+00.00	160	218.1	1293.5
1718+00.00	156	260.1	1503.3
1719+00.00	152	179.7	1010.3
1720+00.00	152	146.8	826.2
1721+00.00	152	156.8	884.1
1722+00.00	152	189.3	1067.4
1723+00.00	147	174.9	954.3
1724+00.00	142	131.8	694.6
1725+00.00	137	112.3	568.9
1726+00.00	132	129.3	631.0
1727+00.00	126	121.4	567.4
1728+00.00	121	65.3	293.3
1729+00.00	116	33.1	142.5

MAINLANES CUT & FILL VOLUMES

BASELINE STA.	WIDTH (MAINLANES + MAX LANES)	Fill Area	Fill Volume
(-)	(FT.)	(SQFT)	(CY)
1730+00.00	115	53.9	228.9
1731+00.00	121	100.1	448.8
1732+00.00	118	55.4	242.6
1733+00.00	117	40.5	176.1
1734+00.00	77	20.2	57.9
1735+00.00	65	5.3	12.9
1735+78.22	32	0.0	0.0

Fill Volume (ac-ft)	**82.7**
Cut Volume (ac-ft)	**-**

Cut and Fill Volume Calculations
- Northbound Frontage Road

NORTHBOUND FRONTAGE ROAD CUT & FILL VOLUMES

BASELINE STA.	WIDTH (ROW + ROADWAY)	Fill Area	Cut Area	Fill Volume	Cut Volume
(-)	(FT.)	(SQFT)	(SQFT)	(CY)	(CY)
1657+27.63	41	0.0	12.6	0.0	19.1
1658+00.00	48	0.0	27.5	0.0	49.2
1659+00.00	45	0.0	20.3	0.0	33.8
1660+00.00	52	0.2	11.6	0.4	22.2
1661+00.00	54	27.4	0.0	54.5	0.0
1662+00.00	54	94.9	0.0	189.1	0.0
1663+00.00	67	72.7	0.0	181.6	0.0
1664+00.00	74	72.2	0.0	196.5	0.0
1665+00.00	80	95.2	0.0	282.4	0.0
1666+00.00	85	103.0	0.0	325.4	0.0
1667+00.00	94	93.2	0.0	323.4	0.0
1668+00.00	108	107.7	0.0	432.3	0.0
1669+00.00	112	112.2	0.0	464.6	0.0
1670+00.00	112	112.4	0.0	465.2	0.0
1671+00.00	112	139.1	0.0	575.9	0.0
1672+00.00	112	142.0	0.0	587.9	0.0
1673+00.00	111	77.7	0.0	320.3	0.0
1674+00.00	111	44.1	0.0	181.8	0.0
1675+00.00	111	126.2	0.0	520.2	0.0
1676+00.00	111	133.7	0.0	551.1	0.0
1677+00.00	111	194.5	0.0	801.9	0.0
1678+00.00	111	249.0	0.0	1026.3	0.0
1679+00.00	111	226.7	0.0	934.5	0.0
1680+00.00	111	208.6	0.0	859.8	0.0
1681+00.00	111	266.4	0.0	1098.4	0.0
1682+00.00	111	377.2	0.0	1554.1	0.0
1683+00.00	116	464.1	0.0	1999.2	0.0
1684+00.00	116	497.8	0.0	2146.6	0.0
1685+00.00	117	460.7	0.0	1996.9	0.0
1686+00.00	117	423.8	0.0	1836.9	0.0
1687+00.00	148	361.1	0.0	1984.3	0.0
1688+00.00	117	275.0	0.0	1189.3	0.0
1689+00.00	116	124.0	0.0	534.1	0.0
1690+00.00	116	401.6	0.0	1729.8	0.0
1691+00.00	117	824.4	0.0	3566.2	0.0
1692+00.00	115	244.2	0.0	1037.9	0.0
1693+00.00	112	407.1	0.0	1685.0	0.0
1694+00.00	112	448.1	0.0	1854.8	0.0
1695+00.00	112	379.4	0.0	1574.4	0.0

NORTHBOUND FRONTAGE ROAD CUT & FILL VOLUMES

BASELINE STA.	WIDTH (ROW + ROADWAY)	Fill Area	Cut Area	Fill Volume	Cut Volume
(-)	(FT.)	(SQFT)	(SQFT)	(CY)	(CY)
1696+00.00	111	279.4	0.0	1143.5	0.0
1697+00.00	108	214.0	0.0	857.6	0.0
1698+00.00	104	162.4	0.0	627.7	0.0
1699+00.00	99	111.8	0.0	410.9	0.0
1700+00.00	95	82.7	0.0	289.5	0.0
1701+00.00	89	116.4	0.0	384.8	0.0
1702+00.00	123	139.8	0.0	638.5	0.0
1703+00.00	123	152.5	0.0	696.6	0.0
1704+00.00	125	152.9	0.0	708.6	0.0
1705+00.00	123	92.0	0.0	420.2	0.0
1706+00.00	123	21.6	0.0	98.5	0.0
1707+00.00	123	46.9	0.0	214.1	0.0
1708+00.00	123	114.1	0.0	520.8	0.0
1709+00.00	136	183.2	0.0	921.2	0.0
1710+00.00	123	161.0	0.0	735.0	0.0
1711+00.00	124	109.1	0.0	500.2	0.0
1712+00.00	124	96.5	0.0	442.5	0.0
1713+00.00	115	78.9	0.0	335.3	0.0
1714+00.00	122	96.9	0.0	439.6	0.0
1715+00.00	114	139.0	0.0	585.9	0.0
1716+00.00	105	154.8	0.0	603.8	0.0
1717+00.00	94	95.7	0.0	332.2	0.0
1718+00.00	90	42.3	0.0	140.9	0.0
1719+00.00	86	45.2	0.0	144.4	0.0
1720+00.00	83	91.4	0.0	279.5	0.0
1721+00.00	80	91.9	0.0	273.1	0.0
1722+00.00	78	68.5	0.0	197.7	0.0
1723+00.00	74	45.7	0.0	125.9	0.0
1724+00.00	70	36.9	0.0	95.2	0.0
1725+21.23	34	6.5	0.0	8.1	0.0

Fill Volume (ac-ft)	**29.9**
Cut Volume (ac-ft)	**0.1**

Appendix G

Utility Conflict Data

- Potential Utility Conflicts

Potential Utility Conflicts

POTENTIAL UTILITY CONFLICTS

CONFLICT ID	UTILITY	CONFLICT DESCRIPTION	EXHIBIT
1	Water Line	Proposed 4ft by 3ft Box conflicts with existing Water Pump Pressure Main.	Sheet 3 of 9
2	Water Line	Proposed 6ft by 3 ft Box conflicts with existing Water Pump Pressure Main.	Sheet 4 of 9
3	Water Line	Proposed 3ft by 2 ft Box conflicts with existing Water Pump Pressure Main.	Sheet 3 of 9
4	Water Line	Proposed 3ft by 3ft Box conflicts with existing Water Pump Pressure Main.	Sheet 5 of 9
5	Water Line	Proposed 9ft by 4ft Box conflicts with existing Water Pump Pressure Main.	Sheet 7 of 9
6	Water Line	Proposed 9ft by 4ft Box conflicts with existing Water Pump Pressure Main.	Sheet 7 of 9
7	Water Line	Proposed 9ft by 4ft Box conflicts with existing Water Pump Pressure Main.	Sheet 6 of 9
8	Water Line	Proposed 42 inch pipe conflicts with existing Water Lateral Service Line.	Sheet 3 of 9
9	Water Line	Proposed 7ft by 3ft Box conflicts with existing Water Lateral Service Line.	Sheet 4 of 9
10	Waste Water Line	Proposed 5ft by 2ft Box conflicts with existing Waste Water Gravity Main.	Sheet 3 of 9
11	Waste Water Line	Proposed 42 inch pipe conflicts with existing Waste Water Gravity Main.	Sheet 3 of 9
12	Waste Water Line	Proposed 60 inch pipe conflicts with existing Waste Water Gravity Main.	Sheet 3 of 9
13	Waste Water Line	Proposed 3 ft by 2ft Box conflicts with existing Waste Water Gravity Main.	Sheet 3 of 9
14	Electric Line	Proposed 5ft by 2ft Box conflicts with existing Electric Line.	Sheet 3 of 9
15	Electric Line	Proposed 5ft by 2ft Box conflicts with existing Electric Line.	Sheet 3 of 9
16	Electric Line	Proposed 42 inch pipe conflicts with existing Electric Line.	Sheet 3 of 9
17	Electric Line	Proposed 42 inch pipe conflicts with existing Electric Line.	Sheet 3 of 9
18	Electric Line	Proposed 42 inch pipe conflicts with existing Electric Line.	Sheet 3 of 9
19	Electric Line	Proposed 30 inch pipe conflicts with existing Electric Line.	Sheet 4 of 9
20	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 4 of 9
21	Electric Line	Proposed 5ft by 3ft Box conflicts with existing Electric Line.	Sheet 4 of 9
22	Electric Line	Proposed 5ft by 3 ft Box conflicts with existing Electric Line.	Sheet 4 of 9
23	Electric Line	Proposed 5ft by 3ft Box conflicts with existing Electric Line.	Sheet 4 of 9
24	Electric Line	Proposed 3ft by 2ft Box conflicts with existing Electric Line.	Sheet 3 of 9
25	Electric Line	Proposed 2 - 6ft by 3ft Box conflicts with existing Electric Line.	Sheet 4 of 9
26	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 4 of 9
27	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 4 of 9
28	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 8 of 9
29	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 8 of 9
30	Electric Line	Proposed 36 inch pipe conflicts with existing Electric Line.	Sheet 9 of 9
31	Electric Line	Proposed 36 inch pipe conflicts with existing Electric Line.	Sheet 9 of 9
32	Electric Line	Proposed 8ft by 6ft Box conflicts with existing Electric Line.	Sheet 8 of 9
33	Electric Line	Proposed 8ft by 6ft Box conflicts with existing Electric Line.	Sheet 8 of 9
34	Electric Line	Proposed 8ft by 6ft Box conflicts with existing Electric Line.	Sheet 8 of 9
35	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 8 of 9
36	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 8 of 9
37	Electric Line	Proposed 5ft by 2ft Box conflicts with existing Electric Line.	Sheet 5 of 9
38	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 5 of 9
39	Electric Line	Proposed 24 inch pipe conflicts with existing Electric Line.	Sheet 5 of 9
40	Electric Line	Proposed 30 inch pipe conflicts with existing Electric Line.	Sheet 4 of 9
41	Electric Line	Proposed 36 inch pipe conflicts with existing Electric Line.	Sheet 7 of 9
42	Electric Line	Proposed 36 inch pipe conflicts with existing Electric Line.	Sheet 7 of 9
43	Gas Line	Proposed 42 inch pipe conflicts with existing Gas Line.	Sheet 3 of 9
44	Gas Line	Proposed 5ft by 2ft Box conflicts with existing Gas Line.	Sheet 3 of 9
45	Gas Line	Proposed 42 inch pipe conflicts with existing Gas Line.	Sheet 3 of 9
46	Gas Line	Proposed 42 inch pipe conflicts with existing Gas Line.	Sheet 3 of 9
47	Gas Line	Proposed 42 inch pipe conflicts with existing Gas Line.	Sheet 3 of 9
48	Gas Line	Proposed 5ft by 5ft Box conflicts with existing Gas Line.	Sheet 3 of 9
49	Gas Line	Proposed 30 inch pipe conflicts with existing Gas Line.	Sheet 3 of 9
50	Gas Line	Proposed 18 inch pipe conflicts with existing Gas Line.	Sheet 5 of 9
51	Gas Line	Proposed 7ft by 3ft Box conflicts with existing Gas Line.	Sheet 4 of 9
52	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 4 of 9
53	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 4 of 9
54	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 5 of 9
55	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 4 of 9
56	Gas Line	Proposed 18 inch pipe conflicts with existing Gas Line.	Sheet 5 of 9
57	Gas Line	Proposed 18 inch pipe conflicts with existing Gas Line.	Sheet 5 of 9
58	Gas Line	Proposed 5ft by 3ft Box conflicts with existing Gas Line.	Sheet 4 of 9
59	Gas Line	Proposed 6ft by 3ft Box conflicts with existing Gas Line.	Sheet 4 of 9
60	Gas Line	Proposed 5ft by 3ft Box conflicts with existing Gas Line.	Sheet 4 of 9
61	Gas Line	Proposed 3ft by 2ft Box conflicts with existing Gas Line.	Sheet 3 of 9
62	Gas Line	Proposed 2 - 6ft by 3ft Box conflicts with existing Gas Line.	Sheet 4 of 9
63	Gas Line	Proposed 6ft by 3ft Box conflicts with existing Gas Line.	Sheet 4 of 9

POTENTIAL UTILITY CONFLICTS

CONFLICT ID	UTILITY	CONFLICT DESCRIPTION	EXHIBIT
64	Gas Line	Proposed 3ft by 3ft Box conflicts with existing Gas Line.	Sheet 5 of 9
65	Gas Line	Proposed 7ft by 3ft Box conflicts with existing Gas Line.	Sheet 5 of 9
66	Gas Line	Proposed 7ft by 3ft Box conflicts with existing Gas Line.	Sheet 5 of 9
67	Gas Line	Proposed 7ft by 5ft Box conflicts with existing Gas Line.	Sheet 8 of 9
68	Gas Line	Proposed 7ft by 5ft Box conflicts with existing Gas Line.	Sheet 8 of 9
69	Gas Line	Proposed 5ft by 4ft Box conflicts with existing Gas Line.	Sheet 9 of 9
70	Gas Line	Proposed 5ft by 4ft Box conflicts with existing Gas Line.	Sheet 9 of 9
71	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 8 of 9
72	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 8 of 9
73	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 9 of 9
74	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 9 of 9
75	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 9 of 9
76	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 9 of 9
77	Gas Line	Proposed 8ft by 6ft Box conflicts with existing Gas Line.	Sheet 8 of 9
78	Gas Line	Proposed 8ft by 6ft Box conflicts with existing Gas Line.	Sheet 8 of 9
79	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 8 of 9
80	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 9 of 9
81	Gas Line	Proposed 6ft by 3ft Box conflicts with existing Gas Line.	Sheet 7 of 9
82	Gas Line	Proposed 9ft by 4ft Box conflicts with existing Gas Line.	Sheet 7 of 9
83	Gas Line	Proposed 9ft by 4ft Box conflicts with existing Gas Line.	Sheet 6 of 9
84	Gas Line	Proposed 8ft by 4ft Box conflicts with existing Gas Line.	Sheet 6 of 9
85	Gas Line	Proposed 7ft by 4ft Box conflicts with existing Gas Line.	Sheet 5 of 9
86	Gas Line	Proposed 24 inch pipe conflicts with existing Gas Line.	Sheet 5 of 9
87	Gas Line	Proposed 30 inch pipe conflicts with existing Gas Line.	Sheet 4 of 9
88	Gas Line	Proposed 3ft by 3ft Box conflicts with existing Gas Line.	Sheet 5 of 9

Appendix H

Preliminary Drainage Cost Data

- Cost Estimate with Schematic Halls Bayou Bridge
- Cost Estimate with Ultimate HCFCD Halls Bayou Bridge

Cost Estimate with Schematic Halls Bayou Bridge

NHHIP SEGMENT 1
DRAINAGE COST SUMMARY WITH SCHEMATIC HALLS BAYOU BRIDGE

DRAINAGE COMPONENT	COST
Storm Sewer Systems	$22,274,395
Detention Ponds	$11,380,759
Bridge Deck Drains	$151,024
Storm Sewer Removal	$2,000,000
Cross Culverts	$323,379
Sub Total	**$36,129,558**
ROADWAY COMPONENTS	**COST**
Schematic Bridge at Halls Bayou	$6,849,781
Sub Total	**$6,849,781**
HALLS BAYOU CHANNEL COMPONENTS	**COST**
Halls Bayou Channel Widening	$1,352,182
Sub Total	**$1,352,182**
Total	**$44,331,520**

NHHIP Segment 1 Storm Sewer Systems					
Bid Item	**Item**	**Units**	**Unit Price**	**Total Quantity**	**Cost**
0400 6002	STRUCT EXCAV (BOX)	CY	$6.94	122924	$853,093
0400 6005	CEM STABIL BKFL	CY	$37.53	38004	$1,426,290
0402 6001	TRENCH EXCAVATION PROTECTION	LF	$1.63	43037	$70,150
0462 6001	CONC BOX CULV (3 FT X 2 FT)	LF	$153.74	1336	$205,397
0462 6002	CONC BOX CULV (3 FT X 3 FT)	LF	$200.33	799	$160,064
0462 6003	CONC BOX CULV (4 FT X 2 FT)	LF	$166.30	5065	$842,310
0462 6004	CONC BOX CULV (4 FT X 3 FT)	LF	$224.49	54	$12,122
0462 6006	CONC BOX CULV (5 FT X 2 FT)	LF	$201.07	1916	$385,250
0462 6007	CONC BOX CULV (5 FT X 3 FT)	LF	$282.42	1931	$545,353
0462 6008	CONC BOX CULV (5 FT X 4 FT)	LF	$324.20	1556	$504,455
0462 6009	CONC BOX CULV (5 FT X 5 FT)	LF	$333.36	507	$169,014
0462 6010	CONC BOX CULV (6 FT X 3 FT)	LF	$346.55	3111	$1,078,117
0462 6012	CONC BOX CULV (6 FT X 5 FT)	LF	$452.53	286	$129,424
0462 6014	CONC BOX CULV (7 FT X 3 FT)	LF	$348.24	2620	$912,389
0462 6015	CONC BOX CULV (7 FT X 4 FT)	LF	$486.50	921	$448,067
0462 6016	CONC BOX CULV (7 FT X 5 FT)	LF	$557.35	2703	$1,506,517
0462 6019	CONC BOX CULV (8 FT X 4 FT)	LF	$584.65	185	$108,160
0462 6020	CONC BOX CULV (8 FT X 5 FT)	LF	$546.86	1901	$1,039,581
0462 6021	CONC BOX CULV (8 FT X 6 FT)	LF	$623.15	3205	$1,997,196
0462 6159	CONC BOX CULV (9 FT X 4 FT)	LF	$698.80	2349	$1,641,481
0462 6024	CONC BOX CULV (9 FT X 5 FT)	LF	$850.00	81	$68,850
0464 6003	RC PIPE (CL III)(18 IN)	LF	$65.35	1273	$83,191
0464 6005	RC PIPE (CL III)(24 IN)	LF	$70.22	17806	$1,250,337
0464 6007	RC PIPE (CL III)(30 IN)	LF	$84.30	1545	$130,244
0464 6008	RC PIPE (CL III)(36 IN)	LF	$100.22	519	$52,014
0464 6009	RC PIPE (CL III)(42 IN)	LF	$112.99	987	$111,521
0464 6010	RC PIPE (CL III)(48 IN)	LF	$150.30	310	$46,593
0465 6167	INLET (COMPL)(TY AD)	EA	$4,628.72	56	$259,208
0465 6170	INLET (COMPL)(TY AZ)	EA	$4,135.40	124	$512,790
0465 6171	INLET (COMPL)(TY AZR)	EA	$6,885.61	14	$96,399
0465 6172	INLET (COMPL)(TY AZR2G)	EA	$10,325.26	25	$258,132
0465 6173	MANH (COMPL)(TY A)	EA	$6,749.09	10	$67,491
0465 6176	INLET (COMPL)(CURB)(TY C1)	EA	$6,352.26	170	$1,079,884
0465 6177	INLET (COMPL)(TY AZ2G)	EA	$9,173.83	6	$55,043
0465 6341	INLET (COMPL) (EXT) (TY CI)	EA	$1,404.98	300	$421,494
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	EA	$2,864.87	12	$34,378
Subtotal					**$18,561,996**
20% Contingency					$3,712,399
Total Segment					**$22,274,395**

NHHIP Segment 1 Detention Ponds					
Bid Item	**Item**	**Units**	**Unit Price**	**Quantity**	**Cost**
Proposed Detention Pond C					
0158 6005	Specialized Excavation Work	CY	$28.26	11,266	$318,410
	Landscaping	SF	$2.00	76,046	$152,092
0464 6003	Outfall 18" RCP	LF	$65.35	78	$5,097
	Headwalls	EA	$8,500.00	2	$17,000
				Total Cost Detention Pond C -->	**$492,599**
Detention Basin at Halls Bayou					
0158 6005	Specialized Excavation Work	CY	$28.26	243,051	$6,869,222
	Landscaping	SF	$2.00	1,043,453	$2,086,906
0462 6006	Outfall 2-5'x2' RCB	LF	$260.56	70	$18,239
	Headwalls	EA	$8,500.00	2	$17,000
				Total Cost Regional Detention Basin at Halls Bayou -->	**$8,991,367**
Subtotal					**$9,483,966**
20% Contingency					$1,896,793
Total Segment					**$11,380,759**

NHHIP Segment 1 Bridge Drainage

Bid Item	Item	Bridge - Segment Name	Units	Unit Price	Quantity	Cost
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Halls Bayou Main Lanes	EA	$6,991.87	2	$13,984
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Halls Bayou NFFR	EA	$6,991.87	2	$13,984
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Halls Bayou SBFR	EA	$6,991.87	2	$13,984
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Gulf Bank Rd Overpass	EA	$6,991.87	4	$27,967
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	MT Houston Rd Overpass	EA	$6,991.87	4	$27,967
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Blue Bell Rd Overpass	EA	$6,991.87	4	$27,967
Subtotal						**$125,854**
20% Contingency						$25,171
Total Segment						**$151,024**

NHHIP Segment 1 Cross Culverts					
Bid Item	**Item**	**Units**	**Unit Price**	**Quantity**	**Cost**
	Cross Culvert C				
0462 6010	1-6'x3' RCBs (*)	LF	$423.84	200	$84,768
0462 6010	2-6'x3' RCBs (*)	LF	$571.77	65	$37,165
0462 60xx	2-8'x3' RCBs (*)	LF	$614.79	240	$147,550
Subtotal					**$269,483**
20% Contingency					$53,897
Total Segment					**$323,379**

Notes

Note: Unit Cost includes "Structural Excavation - Box" (0400-6002), cost of box (0462-xxxx) and "Trench Excavation Protection" (0402-6001) per LF of box installation.

NHHIP Segment 1 Schematic Bridge Area						
Bid Item	**Item**	**Bridge-Segment Name**	**Units**	**Unit Price**	**Quantity**	**Cost**
BRIDGE	CONCRETE TX GIRDER	Main Lane Halls Bayou	SF	$120.00	5,200	$624,000
BRIDGE	CONCRETE TX GIRDER	Halls Bayou NBFR	SF	$120.00	35,487	$4,258,469
BRIDGE	CONCRETE TX GIRDER	Halls Bayou SBFR	SF	$120.00	6,881	$825,682
Sub Total						**$5,708,151**
20% Contingency						$1,141,630
Total Segment						**$6,849,781**

NHHIP Seg 1 Halls Bayou Interim Channel					
BID ITEM	**Item**	**Units**	**Unit Price**	**Quantity**	**Cost**
	HALLS BAYOU INTERIM CHANNEL EXCAVATION	CY	$9.00	125,202	$1,126,818
Subtotal					**$1,126,818**
20% Contingency					$225,364
Total Segment					**$1,352,182**

Cost Estimate with Ultimate HCFCD Halls Bayou Bridge

NHHIP SEGMENT 1
DRAINAGE COST SUMMARY WITH ULTIMATE HALLS BAYOU BRIDGE

DRAINAGE COMPONENT	COST
Storm Sewer Systems	$22,274,395
Detention Ponds	$11,380,759
Bridge Deck Drains	$151,024
Storm Sewer Removal	$2,000,000
Cross Culverts	$323,379
Sub Total	**$36,129,558**
ROADWAY COMPONENTS	**COST**
Ultimate (HCFCD) Halls Bayou Bridge[1]	$14,644,656
Sub Total	**$14,644,656**
HALLS BAYOU CHANNEL COMPONENTS	**COST**
Halls Bayou Channel Widening	$1,352,182
Additional Channel Excavation Under Bridges[2]	$1,032,815
Sub Total	**$2,384,996**
Total	**$53,159,210**

1. Additional Bridge Design Being Done in Coordination with Harris County Flood Control District to accommodate the Halls Bayou ultimate channel section at I-45

2. Additional mitigation volume being provided as part of the NHHIP

NHHIP Segment 1 Storm Sewer Systems					
Bid Item	**Item**	**Units**	**Unit Price**	**Total Quantity**	**Cost**
0400 6002	STRUCT EXCAV (BOX)	CY	$6.94	122924	$853,093
0400 6005	CEM STABIL BKFL	CY	$37.53	38004	$1,426,290
0402 6001	TRENCH EXCAVATION PROTECTION	LF	$1.63	43037	$70,150
0462 6001	CONC BOX CULV (3 FT X 2 FT)	LF	$153.74	1336	$205,397
0462 6002	CONC BOX CULV (3 FT X 3 FT)	LF	$200.33	799	$160,064
0462 6003	CONC BOX CULV (4 FT X 2 FT)	LF	$166.30	5065	$842,310
0462 6004	CONC BOX CULV (4 FT X 3 FT)	LF	$224.49	54	$12,122
0462 6006	CONC BOX CULV (5 FT X 2 FT)	LF	$201.07	1916	$385,250
0462 6007	CONC BOX CULV (5 FT X 3 FT)	LF	$282.42	1931	$545,353
0462 6008	CONC BOX CULV (5 FT X 4 FT)	LF	$324.20	1556	$504,455
0462 6009	CONC BOX CULV (5 FT X 5 FT)	LF	$333.36	507	$169,014
0462 6010	CONC BOX CULV (6 FT X 3 FT)	LF	$346.55	3111	$1,078,117
0462 6012	CONC BOX CULV (6 FT X 5 FT)	LF	$452.53	286	$129,424
0462 6014	CONC BOX CULV (7 FT X 3 FT)	LF	$348.24	2620	$912,389
0462 6015	CONC BOX CULV (7 FT X 4 FT)	LF	$486.50	921	$448,067
0462 6016	CONC BOX CULV (7 FT X 5 FT)	LF	$557.35	2703	$1,506,517
0462 6019	CONC BOX CULV (8 FT X 4 FT)	LF	$584.65	185	$108,160
0462 6020	CONC BOX CULV (8 FT X 5 FT)	LF	$546.86	1901	$1,039,581
0462 6021	CONC BOX CULV (8 FT X 6 FT)	LF	$623.15	3205	$1,997,196
0462 6159	CONC BOX CULV (9 FT X 4 FT)	LF	$698.80	2349	$1,641,481
0462 6024	CONC BOX CULV (9 FT X 5 FT)	LF	$850.00	81	$68,850
0464 6003	RC PIPE (CL III)(18 IN)	LF	$65.35	1273	$83,191
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0464 6007	RC PIPE (CL III)(30 IN)	LF	$84.30	1545	$130,244
0464 6008	RC PIPE (CL III)(36 IN)	LF	$100.22	519	$52,014
0464 6009	RC PIPE (CL III)(42 IN)	LF	$112.99	987	$111,521
0464 6010	RC PIPE (CL III)(48 IN)	LF	$150.30	310	$46,593
0465 6167	INLET (COMPL)(TY AD)	EA	$4,628.72	56	$259,208
0465 6170	INLET (COMPL)(TY AZ)	EA	$4,135.40	124	$512,790
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0465 6173	MANH (COMPL)(TY A)	EA	$6,749.09	10	$67,491
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0465 6177	INLET (COMPL)(TY AZ2G)	EA	$9,173.83	6	$55,043
0465 6341	INLET (COMPL) (EXT) (TY CI)	EA	$1,404.98	300	$421,494
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	EA	$2,864.87	12	$34,378
Subtotal					**$18,561,996**
20% Contingency					$3,712,399
Total Segment					**$22,274,395**

NHHIP Segment 1 Detention Ponds					
Bid Item	**Item**	**Units**	**Unit Price**	**Quantity**	**Cost**
Proposed Detention Pond C					
0158 6005	Specialized Excavation Work	CY	$28.26	11,266	$318,410
	Landscaping	SF	$2.00	76,046	$152,092
0464 6003	Outfall 18" RCP	LF	$65.35	78	$5,097
	Headwalls	EA	$8,500.00	2	$17,000
				Total Cost Detention Pond C -->	**$492,599**
Detention Basin at Halls Bayou					
0158 6005	Specialized Excavation Work	CY	$28.26	243,051	$6,869,222
	Landscaping	SF	$2.00	1,043,453	$2,086,906
0462 6006	Outfall 2-5'x2' RCB	LF	$260.56	70	$18,239
	Headwalls	EA	$8,500.00	2	$17,000
				Total Cost Regional Detention Basin at Halls Bayou -->	**$8,991,367**
Subtotal					**$9,483,966**
20% Contingency					$1,896,793
Total Segment					**$11,380,759**

NHHIP Segment 1 Bridge Drainage

Bid Item	Item	Bridge - Segment Name	Units	Unit Price	Quantity	Cost
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Halls Bayou Main Lanes	EA	$6,991.87	2	$13,984
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Halls Bayou NFFR	EA	$6,991.87	2	$13,984
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Halls Bayou SBFR	EA	$6,991.87	2	$13,984
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Gulf Bank Rd Overpass	EA	$6,991.87	4	$27,967
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	MT Houston Rd Overpass	EA	$6,991.87	4	$27,967
0471 6007	GRATE AND FRAME (BRIDGE DRAIN)	Blue Bell Rd Overpass	EA	$6,991.87	4	$27,967
Subtotal						**$125,854**
20% Contingency						$25,171
Total Segment						**$151,024**

NHHIP Segment 1 Cross Culverts					
Bid Item	**Item**	**Units**	**Unit Price**	**Quantity**	**Cost**
	Cross Culvert C				
0462 6010	1-6'x3' RCBs (*)	LF	$423.84	200	$84,768
0462 6010	2-6'x3' RCBs (*)	LF	$571.77	65	$37,165
0462 60xx	2-8'x3' RCBs (*)	LF	$614.79	240	$147,550
Subtotal					**$269,483**
20% Contingency					$53,897
Total Segment					**$323,379**

Notes

Note: Unit Cost includes "Structural Excavation - Box" (0400-6002), cost of box (0462-xxxx) and "Trench Excavation Protection" (0402-6001) per LF of box installation.

NHHIP Segment 1 Ultimate (HCFCD) Halls Bayou Bridge						
Bid Item	**Item**	**Bridge-Segment Name**	**Units**	**Unit Price**	**Quantity**	**Cost**
BRIDGE	CONCRETE TX GIRDER	Main Lane Halls Bayou	SF	$120.00	71,256	$8,550,720
BRIDGE	CONCRETE TX GIRDER	Halls Bayou NBFR	SF	$120.00	15,440	$1,852,800
BRIDGE	CONCRETE TX GIRDER	Halls Bayou SBFR	SF	$120.00	15,003	$1,800,360
Sub Total						**$12,203,880**
20% Contingency						$2,440,776
Total Segment						**$14,644,656**

Notes

Note: Bridge area not included in original schematic design but included to accommodate ultimate Halls Bayou channel.

NHHIP Seg 1 Halls Bayou Interim Channel					
BID ITEM	**Item**	**Units**	**Unit Price**	**Quantity**	**Cost**
	HALLS BAYOU INTERIM CHANNEL EXCAVATION	CY	$9.00	125,202	$1,126,818
	HALLS BAYOU INTERIM BASIN EXCAVATION	CY	$9.00	95,631	$860,679
Subtotal					**$1,987,497**
20% Contingency					$397,499
Total Segment					**$2,384,996**

Appendix I

GeoPAK & Microstation Files (USB Only)

GeoPAK & Microstation Files (USB Only)

Appendix J

H&H Models (USB Only)

- HEC-HMS (V.4.6.1)
- HEC-RAS (V.5.0.7)
- PC-SWMM (V.7.3.3095)

H&H Models (USB Only)