Buffalo Speedway Improvements

Bissonnet Street to Holcombe Boulevard

Drainage Preliminary Engineering Report

Prepared by HDR Engineering, Inc.

CSJ: 0912-72-360

City of West University Place

Harris County, Texas

May 1, 2020

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1 Executive Summary

Buffalo Speedway is a four lane curb-and-gutter street that passes through the City of West University Place, in Harris County. The existing storm sewer drainage system ranges from a single 66-inch RCP at the upstream end of the proposed project at Bissonnet Street to dual 66-inch RCPs at the outfall at Poor Farm Ditch. The current storm sewer system does not have sufficient capacity to convey a City of Houston 2-year design storm. HDR Engineering, Inc. was contracted to develop drainage improvements for the project.

Rational method calculations were performed to determine peak flows from each sub-area. The proposed system was designed using peak discharge rates for a City of Houston 2-year design storm. The design analysis shows that the 2-year Hydraulic Grade Line (HGL) is below the Proposed Grade Line (PGL). A plot of the design analysis HGL is included in **Exhibit 10**. This analysis was carried out in addition to the impact analysis because the City of Houston methodology to calculate the time of concentration does not account for travel time in the system, and therefore aggregates the peaks from all sub-areas to occur at the same time. This is a very conservative approach. To better estimate the HGL elevations, a traditional approach was used by setting the tailwater at top of outfall pipe and back calculating the elevations at each intersection by calculating head loss using typical loss coefficients. A table of calculations for this design analysis is included in **Appendix A** of this report.

The impact analysis was carried out for the 2-, 10-, and 100-year storm events using XP-SWMM stormwater modeling software. A HEC-HMS model was developed with Clark Unit Hydrograph method, and the storage coefficient (R) was iterated to match the peak flows generated with the rational method. The City of Houston methodology to calculate time of concentration was used, as described in section 3. The latest NOAA ATLAS 14 Point Precipitation Frequency Estimates were used for computations. Flow hydrographs developed from HEC-HMS were used as input for a XP-SWMM 1D/2D model. The HGL plots for the 2- and 100-year storm events impact analysis is also included in **Exhibit 10**.

Proposed storm sewer sizes range from a single 6’x5’ Reinforced Concrete Box (RCB) at Wroxton Road to dual 8’ x 8’ RCB culverts at the outfall at Poor Farm Ditch. The outfall pipes south of Holcombe are proposed to be removed or abandoned and replaced with dual 8’ x 8’ RCBs. Connectors between existing and proposed storm sewers along Buffalo Speedway are proposed to allow storm water to equalize in the existing and proposed storm sewers. In order to manage the discharge into Poor Farm Ditch, flow restrictors are proposed at various locations throughout the proposed drainage system. These restrictors are modeled as 48-inch pipes for ease of modeling, but actual restrictors should be designed using masonry walls that allow restrictors to be adjusted or removed as downstream channel capacity is increased or detention becomes available.

The results from the impact analysis are shown in section 6. Street ponding is significantly reduced for all storm events, with a maximum reduction of up to 1.5 ft for the 100-year storm event. Ponding still occurs at the upstream end of the project for the 2-year event, and along the entire corridor for the 100-year storm event. Peak discharge rates are slightly higher for the 2-year storm, however, mitigation is not needed as Poor Farm Ditch has sufficient capacity to convey the 2-year storm.

2 Project Introduction

This engineering report describes the drainage system upgrades associated with proposed roadway improvements to Buffalo Speedway, from Bissonnet Street to Holcombe Boulevard, within the City of West University Place (West U), Texas, and south in the City of Houston (see Exhibit 1A – drainage area map). The following sections provide descriptions of the hydrologic methodology for computing peak discharges and runoff hydrographs for the existing drainage system, discuss the proposed plan for roadway and drainage improvements to Buffalo Speedway, and provide the results of the hydraulic analysis of the existing and proposed drainage system.

Figure 1: Typical Configuration of the Existing Buffalo Speedway in West University Place

Buffalo Speedway is a four-lane, curb-and-gutter roadway with storm sewer drainage. It passes through the east-central portion of West U from north to south, entering West U from the City of Houston to the north and exiting into the City of Houston to the south. The Buffalo Speedway drainage system outfalls into Poor Farm Ditch a short distance south of Holcombe Boulevard through an existing easement in St. Vincent De Paul School. **Exhibit 1A** is a drainage area map for the Buffalo Speedway storm sewer system. Storm sewers along Buffalo Speedway drain storm runoff from a total drainage area of approximately 541 acres, including approximately 177 acres from the City of Houston.

The existing drainage system of Buffalo Speedway consists of a single 66-inch RCP storm sewer between Bissonnet and Georgetown, a single 72-inch RCP between Georgetown and Amherst, and dual 66-inch RCPs between Amherst and the system outfall to Poor Farm Ditch. The alignments and extents of the existing trunk line storm sewers are illustrated on **Exhibit 1B**.

Various lateral pipes empty into the Buffalo Speedway system from the east and west, and connectors are provided between the existing dual 66-inch RCPs to allow water to equalize in the proposed pipes. The existing system does not have sufficient capacity to convey the City of Houston standard 2-year storm design event, and the lack of storm sewer capacity causes significant street ponding within the project area during periods of heavy rainfall.

The City of West U proposes to complete paving improvements to Buffalo Speedway from Bissonnet Street southward to the Poor Farm Ditch outfall. The City has secured Transportation Improvement Program (TIP) funding for the paving portion for a section of the project from Bissonnet Street to Holcombe Boulevard. The general extents of the Buffalo Speedway project are shown in **Figure 3** on page 3 of this report. Storm sewer sizing for the preliminary drainage design is based on the assumption that the existing single 66-inch storm sewer at Bissonnet

Street remains in place, serving as a flow regulator and maintaining existing flow rates into West U from the 131-acre City of Houston drainage area to the north.

Proposed storm sewer sizes range from a single 6'x5' Reinforced Concrete Box (RCB) at Wroxton Road to dual 8' x 8' RCB culverts at the outfall at Poor Farm Ditch. **Exhibit 2** illustrates the proposed storm sewer sizes along Buffalo Speedway required to pass the 2-year storm design storm event with average velocity of 3 feet per second.

Figure 2: Route of Existing Dual 66" Storm Sewer Across the St. Vincent de Paul Campus

Existing storm sewers along Buffalo Speedway, consisting mainly of single 66-inch to 72-inch pipes or dual 66-inch pipes, are assumed to remain in place to provide in-line detention storage from Holcombe Blvd. north to Bissonnet St. The existing dual 66-inch storm sewer pipes between Holcombe Blvd. and Poor Farm Ditch (see Figure 2) are assumed to be replaced with dual 8' x 8' box culverts. Regulating structures are provided at intervals along the Buffalo Speedway system to make full use of system storage. No increases in downstream flow rates are proposed for the 100-year (1% annual chance) storm event. Flow rates are increased a nominal amount for the 2-year (50% annual chance event), but both Poor Farm Ditch and Brays Bayou provide sufficient capacity to accommodate peak runoff rates for the 2-year event.

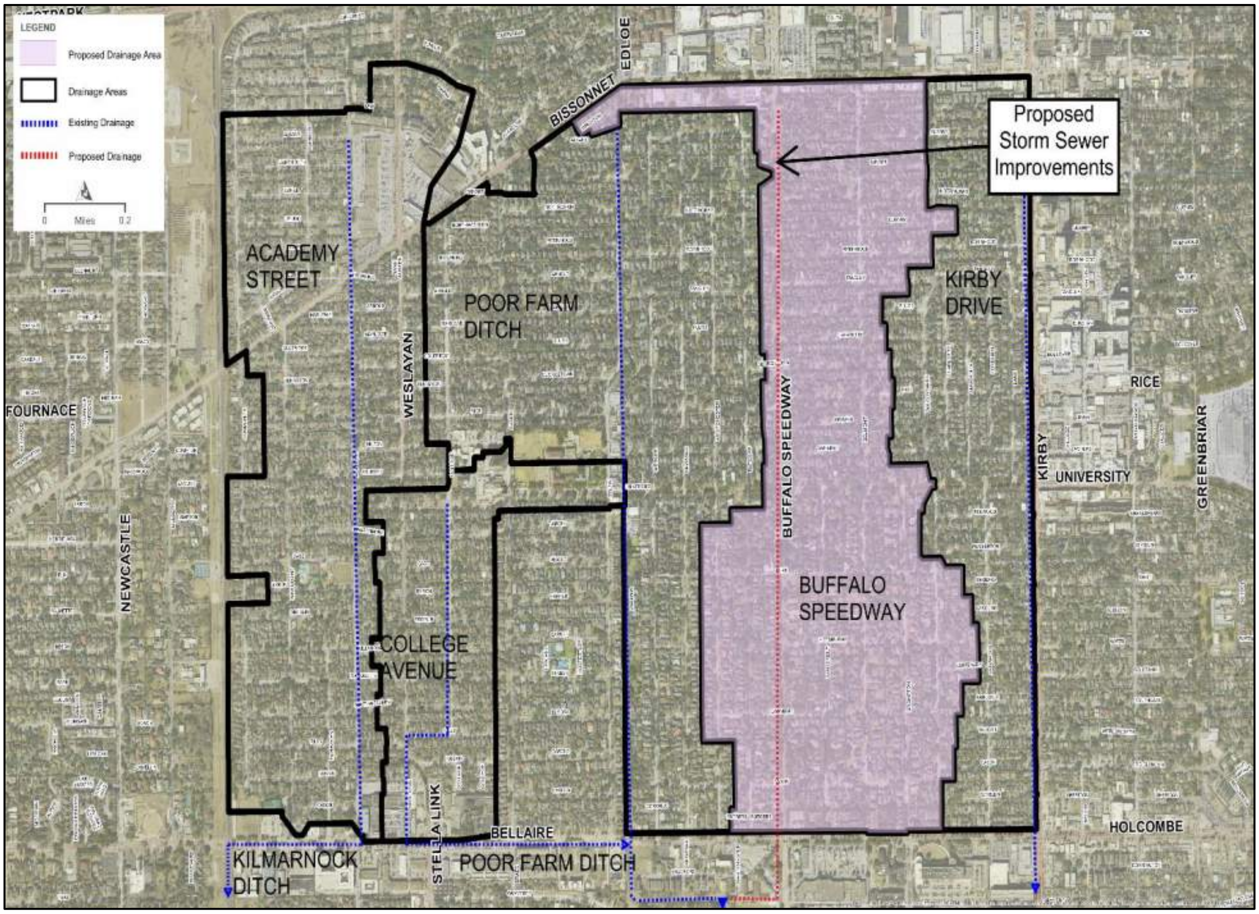


Figure 3: General Extents of Buffalo Speedway Drainage Improvements

A set of images provided in Appendix C to this report offer a “virtual tour” of the Buffalo Speedway project area, with a separate image at each intersection starting at Bissonnet and extending southward to Holcombe Boulevard, with supplemental information on the outfall to Poor Farm Ditch. These images provide background information on the existing roadway, cross-streets, signals, sidewalks, and other infrastructure, as well as trees and other features.

3 Hydrologic Methodology

Flow Hydrographs for the areas draining toward Buffalo Speedway were computed using HEC-HMS. The time of concentration was computed using the method described in the City of Houston's Infrastructure Design Manual, as the City of West U has adopted the City of Houston standards as design criteria, using the equation shown below:

$$T_c = 10A^{0.1761} + 15$$

Where T_C = time of concentration in minutes, and A = subarea in acres.

The storm sewer was designed for the City of Houston 2-year storm event. The rainfall intensity for each drainage area was computed using the equation shown below.

$$i = \frac{b}{T_c + d)^e}$$

The e, b, and d values required to compute rainfall intensities were taken from the latest version of the City of Houston Infrastructure Design Manual.

3.1 NOAA Atlas 14 Analysis

For more comprehensive analysis, the proposed storm sewer system was analyzed using the rainfall intensity values taken from the latest NOAA ATLAS 14 Point Precipitation Frequency Estimates, by using the calculated Time of concentration as the duration for each drainage area. Rainfall intensities were calculated by dividing rainfall depths by durations. Due to the fact that NOAA ATLAS 14 data has higher intensities compared to the City of Houston 2-year event, and the likelihood that the latest NOAA ATLAS 14 data will be accepted as the new design event, the findings in this report are results utilizing the NOAA ATLAS 14 data. Table 1 shows the NOAA ATLAS 14 rainfall depth (inches) for various durations for the 2-year, 10-year, and 100-year frequency storm events.

Table 1 – NOAA ATLAS 14 Rainfall Depths

Duration	Rainfall Depth (inches)		
	2-Year	10-Year	100-Year
5 minutes	0.588	0.844	1.27
15 minutes	1.18	1.69	2.52
60 minutes	2.25	3.23	4.84
2 hours	2.81	4.25	6.98
3 hours	3.15	4.92	8.58
6 hours	3.76	6.13	11.4
12 hours	4.41	7.37	14.1
24 hours	5.12	8.73	17

Runoff hydrographs for each sub-basin were created using the HEC-HMS software program. The Green-Ampt loss function was used to simulate the runoff losses within the drainage area, and the Clark Unit Hydrograph method was used to develop the hydrographs. The storage coefficient used in the Clark Unit Hydrograph method was iterated such that the peak discharge rate of the hydrograph was equal to the peak discharge rate computed with the Rational Method. **Table 2** shows the rational method calculations.

Table 2 – Summary of Rational Method Calculation

Area ID	Area (acres)	Intensity (in.hr)			Runoff Coefficient (C)	Peak Discharge (cfs)		
		$I_{2\text{-}YR}$	$I_{10\text{-}YR}$	$I_{100\text{-}YR}$		2-Year	10-Year	100-Year
COH N	131.21	2.94	4.06	5.79	0.80	309	426	608
BSWT 1A	21.27	3.27	4.45	6.30	0.55	38	52	74
BSW 01	10.00	3.40	4.60	6.49	0.55	19	25	36
BSW 02	9.98	3.40	4.60	6.50	0.55	19	25	36
BSW 03	10.25	3.39	4.60	6.49	0.55	19	26	37
BSWT 2A	6.32	3.47	4.69	6.61	0.55	12	16	23
BSW 04	10.21	3.39	4.60	6.49	0.55	19	26	36
BSW 05 N	4.72	3.52	4.74	6.67	0.55	9	12	17
BSW 05 S	25.64	3.24	4.42	6.25	0.55	46	62	88
BSWT 3A	18.47	3.29	4.48	6.34	0.55	33	46	64
BSW 06 N	19.23	3.29	4.47	6.33	0.55	35	47	67
BSW 06 S	13.23	3.35	4.55	6.42	0.55	24	33	47
BSW 12	15.00	3.33	4.52	6.39	0.55	27	37	53
BSWT 4A	10.52	3.39	4.59	6.48	0.55	20	27	37
BSW 07	19.58	3.28	4.47	6.32	0.55	35	48	68
BSW 13	10.06	3.40	4.60	6.49	0.55	19	25	36
BSWT 5A	8.80	3.42	4.63	6.53	0.55	17	22	32
BSW 08	27.51	3.23	4.40	6.23	0.55	49	67	94
BSW 14	11.71	3.37	4.57	6.46	0.55	22	29	42
BSWT 6A	5.48	3.50	4.72	6.64	0.55	11	14	20
BSW 09	32.57	3.20	4.37	6.19	0.55	57	78	111
BSW 15	8.69	3.42	4.63	6.53	0.55	16	22	31
BSWT 7A	5.26	3.50	4.72	6.65	0.55	10	14	19
BSW 10	24.71	3.24	4.42	6.26	0.55	44	60	85
BSWT 8A	7.30	3.45	4.66	6.57	0.55	14	19	26
BSW 11	28.62	3.22	4.39	6.22	0.55	51	69	98
COH S	45.57	3.14	4.29	6.09	0.69	98	135	191

$\sum$ A= 541.9 acres

Those runoff hydrographs were then applied to the XP-SWMM 1D/2D model of the Buffalo Speedway drainage system. **Appendix B** provides corresponding nodes in the XP-SWMM model. All hydrographs were developed for rainfall events with 24-hour duration.

Table 3 below provides a summary of the drainage areas, their times of concentration, and the storage coefficient (R) computed using the NOAA ATLAS 14 data for the 2-year, 10-year, and 100-year storm events. **Exhibit 1A** and **1B** provides a drainage area map of the Buffalo Speedway drainage system. The boundaries of each of the drainage area listed in **Table 3** are illustrated on the exhibit.

Table 3 – Summary of Computed Storage Coefficients

Area ID	Area (acres)	Time of Concentration (hours)	Storage Coefficient R (hours)		
			2-Year	10-Year	100-Year
COH N	131.21	0.64	0.44	0.50	0.40
BSWT 1A	21.27	0.54	0.79	0.94	0.85
BSW 01	10.00	0.50	0.74	0.89	0.80
BSW 02	9.98	0.50	0.74	0.89	0.80
BSW 03	10.25	0.50	0.74	0.89	0.80
BSWT 2A	6.32	0.48	0.72	0.86	0.78
BSW 04	10.21	0.50	0.74	0.89	0.80
BSW 05N	4.72	0.47	0.71	0.85	0.77
BSW 05 S	25.64	0.55	0.80	0.95	0.86
BSWT 3A	18.47	0.53	0.78	0.93	0.84
BSW 06 N	19.23	0.53	0.78	0.93	0.84
BSW06 S	13.23	0.51	0.75	0.91	0.82
BSW 12	15.00	0.52	0.76	0.92	0.82
BSWT 4A	10.52	0.50	0.74	0.89	0.80
BSW 07	19.58	0.53	0.78	0.94	0.84
BSW13	10.06	0.50	0.74	0.89	0.80
BSWT 5A	8.80	0.49	0.74	0.88	0.79
BSW 08	27.51	0.55	0.81	0.96	0.86
BSW 14	11.71	0.51	0.75	0.90	0.81
BSWT 6A	5.48	0.48	0.72	0.86	0.77
BSW 09	32.57	0.56	0.82	0.97	0.87
BSW 15	8.69	0.49	0.73	0.88	0.79
BSWT 7A	5.26	0.47	0.71	0.85	0.77
BSW 10	24.71	0.54	0.80	0.95	0.86
BSWT 8A	7.30	0.49	0.73	0.87	0.78
BSW 11	28.62	0.55	0.81	0.96	0.87
COH S	45.57	0.58	0.55	0.65	0.55

4 Proposed Drainage Plan

A preliminary design was developed for the proposed storm sewer based on the peak discharge rates for the 2-year (50% annual chance) storm event using City of Houston 2-Year design storm including the new Atlas 14 data. Detailed modeling of the existing and proposed storm sewers is described in the next section of this report.

4.1 Proposed Storm Sewer Sizing & Layout

Proposed storm sewer sizes range from a single 6'x5' Reinforced Concrete Box (RCB) at Wroxton Road to dual 8' x 8' RCB culverts at the outfall at Poor Farm Ditch. The outfall pipes south of Holcombe are proposed to be removed or abandoned and replaced with dual 8' x 8' RCBs. Connectors between existing and proposed storm sewers along Buffalo Speedway will be provided in order to allow storm water to equalize in the existing and proposed storm sewers. In order to meter the discharge into Poor Farm Ditch, short segments of 48-inch RCP are proposed at various locations throughout the proposed drainage system. These short segments of pipe serve as flow control devices to allow the velocity of flow through the proposed system to mimic the velocity of flow in the existing system. Note that these 48-inch pipes are proposed for ease of modeling, but actual restrictors should be designed using masonry walls that allow restrictors to be adjusted or removed as downstream channel capacity is increased or detention becomes available. **Table 4** provides a summary of the existing storm sewer and the proposed storm sewer improvements.

Table 4 – Summary of Proposed Storm Sewer Improvements

Cross-Street	Existing Storm Sewer Pipes				Proposed Storm Sewer RCB					Difference	
	Number	Diameter (inches)	Max flow 2-YR (cfs)	Max flow 100-YR (cfs)	Number	Span/Dia (ft)	Rise (ft)	Max flow 2-YR (cfs)	Max flow 100-YR (cfs)	2-Year (cfs)	100-Year (cfs)
Bissonnet	1	66	93.39	119.95	1	6	5	42.50	48.68	-50.89	71.26
Wroxton	1	66	95.01	76.47	1	6	5	120.75	104.69	25.74	28.22
Albans	1	66	88.07	77.25	1	8	5	154.61	120.79	66.55	43.54
Nottingham	1	66	101.42	95.39	1	8	6	187.47	179.04	86.05	83.66
Quenby	1	66	102.02	89.21	1	10	6	183.51	185.90	81.49	96.69
Tangley	1	66	124.48	120.33	1	11	6	227.06	239.14	102.59	118.81
Georgetown	1	72	144.27	145.23	1	12	6	229.71	264.61	85.45	119.37
Amherst	2	66	129.40	131.32	2	8	5	202.74	253.99	73.34	122.68
University	2	66	137.09	142.71	2	8	5	202.74	253.99	65.65	111.29
Duke	2	66	161.77	168.84	2	8	6	249.06	336.13	87.29	167.29
Pittsburgh	2	66	184.85	197.25	2	8	7	130.92	203.39	-53.94	6.15
Carnegie	2	66	211.14	225.64	2	8	7	209.50	321.07	-1.64	95.43
Cason	2	66	253.62	284.09	2	8	8	287.96	362.32	34.35	78.23
Holcombe	2	66	314.86	368.16	2	8	8	461.60	583.75	146.74	215.60
Outfall	2	66	312.46	377.90	2	8	8	427.92	521.41	115.46	143.51

Table 5 provides a comparison of in-line storage volumes available for both the existing system as well as the proposed system. The existing system is proposed to be left in place to provide additional in-line storage, with the exception of the existing dual 66" RCP from Holcombe to the outfall which is proposed to be abandoned or removed. The total volume available for storage will be approximately 22.19 ac-ft.

Table 5 – Comparison of In-line Storage Volumes

		EXISTING SYSTEM					PROPOSED SYSTEM				
From	**To**	**Count**	**Length**	**Diameter**	**Area**	**Volume**	**Count**	**Length**	**RCB Size**	**Area**	**Volume**
Street	Street		ft	ft	sq-ft	ac-ft		ft	ft x ft	sq-ft	ac-ft
Bissonnet	Wroxton	1	290	5.5	23.768	0.16	1	166	6x5	30	0.11
Wroxton	Albans	1	261	5.5	23.768	0.14	1	258	6x5	30	0.18
Albans	Nottingham	1	544	5.5	23.768	0.30	1	545	8x5	40	0.50
Nottingham	Quenbv	1	265	5.5	23.768	0.14	1	268	8x6	48	0.30
Quenby	Tangley	1	524	5.5	23.768	0.29	1	528	10x6	60	0.73
Tangley	Georgetown	1	762	5.5	23.768	0.42	1	772	11x6	66	1.17
Georgetown	Amherst	1	724	6	28.286	0.47	1	720	12x6	72	1.19
Amherst	University	2	410	5.5	23.768	0.45	2	402	8x5	40	0.74
University	Duke	2	775	5.5	23.768	0.85	2	788	8x5	40	1.45
Duke	Pittsburgh	2	653	5.5	23.768	0.71	2	645	8x6	48	1.42
Pittsburgh	Carnegie	2	643	5.5	23.768	0.70	2	650	8x7	56	1.67
Carnegie	Cason	2	655	5.5	23.768	0.71	2	650	8x7	56	1.67
Cason	Holcombe	2	529	5.5	23.768	0.58	2	497	8x8	64	1.46
							2	1257	8x8	64	3.69
					TOTAL	**5.91**				**TOTAL**	**16.28**

Exhibit 2 provides a layout of the existing and proposed storm sewer systems with sizing. The total length of the Buffalo Speedway storm sewer system from Bissonnet Street to Poor Farm Ditch is approximately 8,450 feet.

Figures 4 and 5 illustrate the general approach recommended for constructing the storm sewers within the existing Buffalo Speedway right-of-way. In both figures, solid black lines represent existing storm sewers, while dashed black lines represent proposed storm sewers. North of Amherst, the existing 66-inch to 72-inch storm sewers consists of a single line on the west side of the road. Therefore, from Wroxton southward to Amherst, the new storm sewer is proposed to be constructed on the east side of the road as indicated on **Figure 4**.

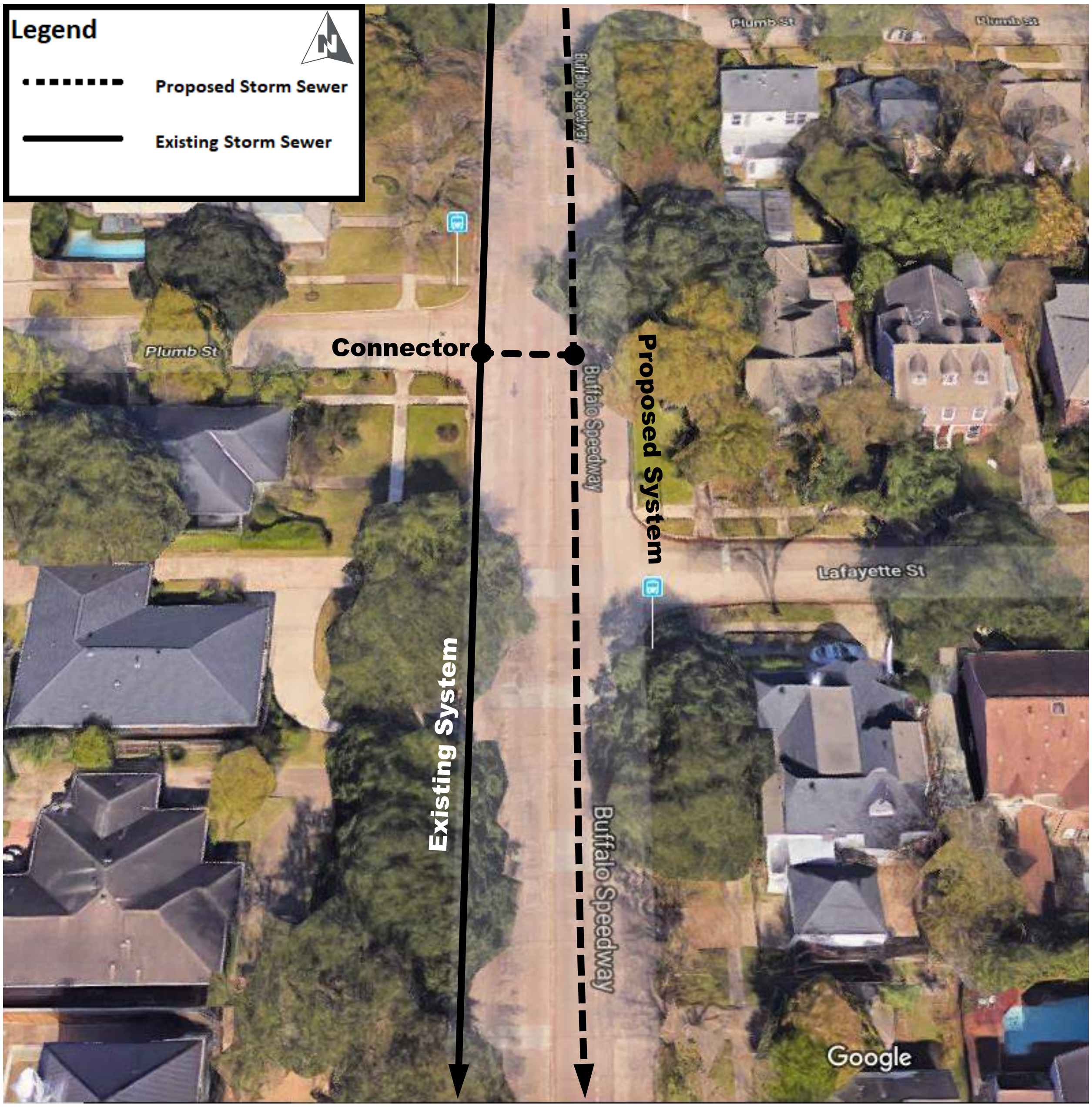


Figure 4: Proposed Storm Sewer Arrangement North of Amherst

South of Amherst, existing dual 66-inch storm sewer pipes are located adjacent to both curbs, so it is recommended that the proposed storm sewers be constructed "inside" of the existing pipes, as indicated on **Figure 5**.

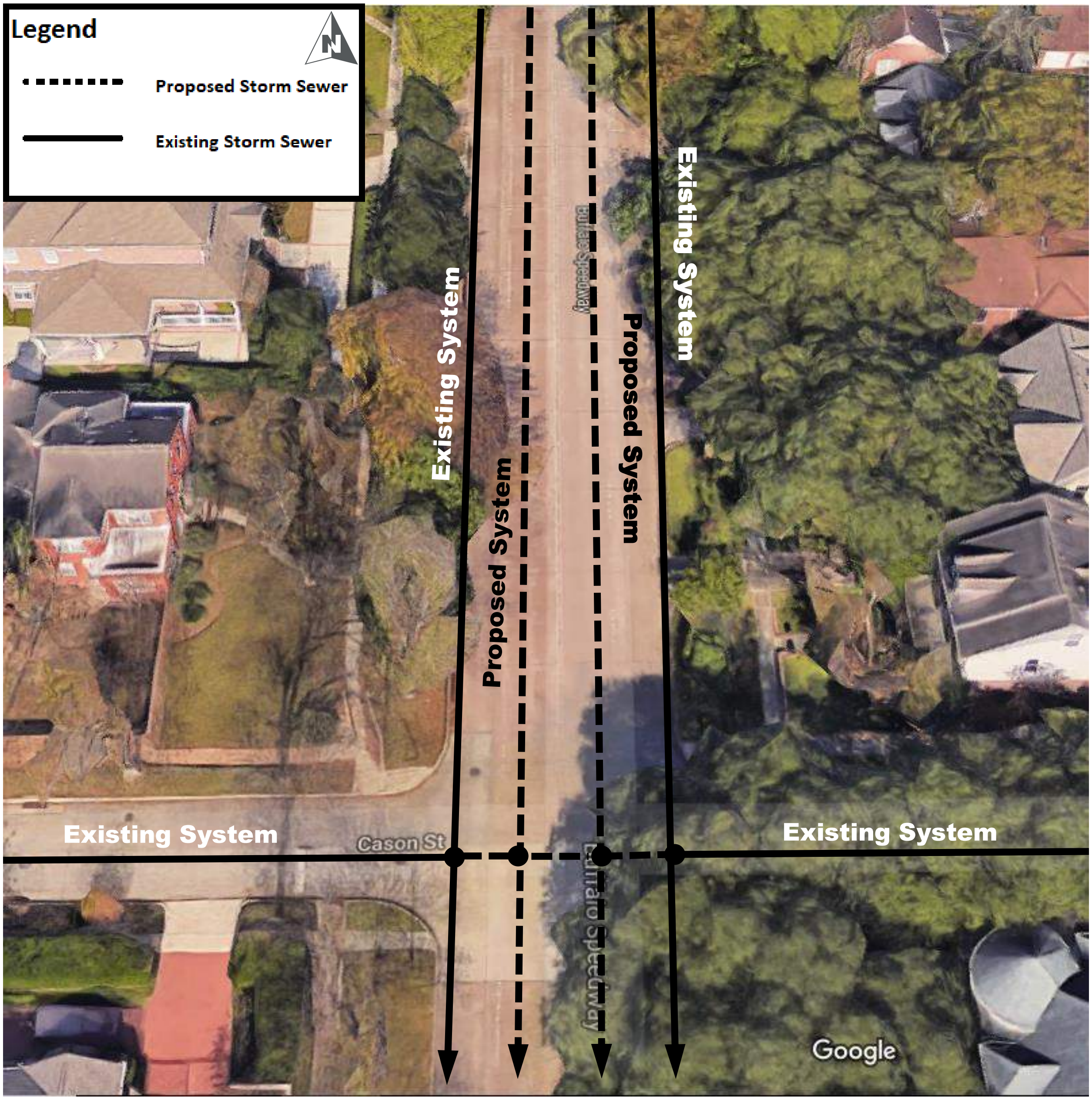


Figure 5: Proposed Storm Sewer Arrangement South of Amherst

This approach allows for improved traffic control, as in addition to two traffic lanes on one side of the road, an outside lane can be made available on the other side of the road for access to existing driveways. **Figure 6** illustrates this approach to traffic control, which has been successfully utilized on recent construction projects.

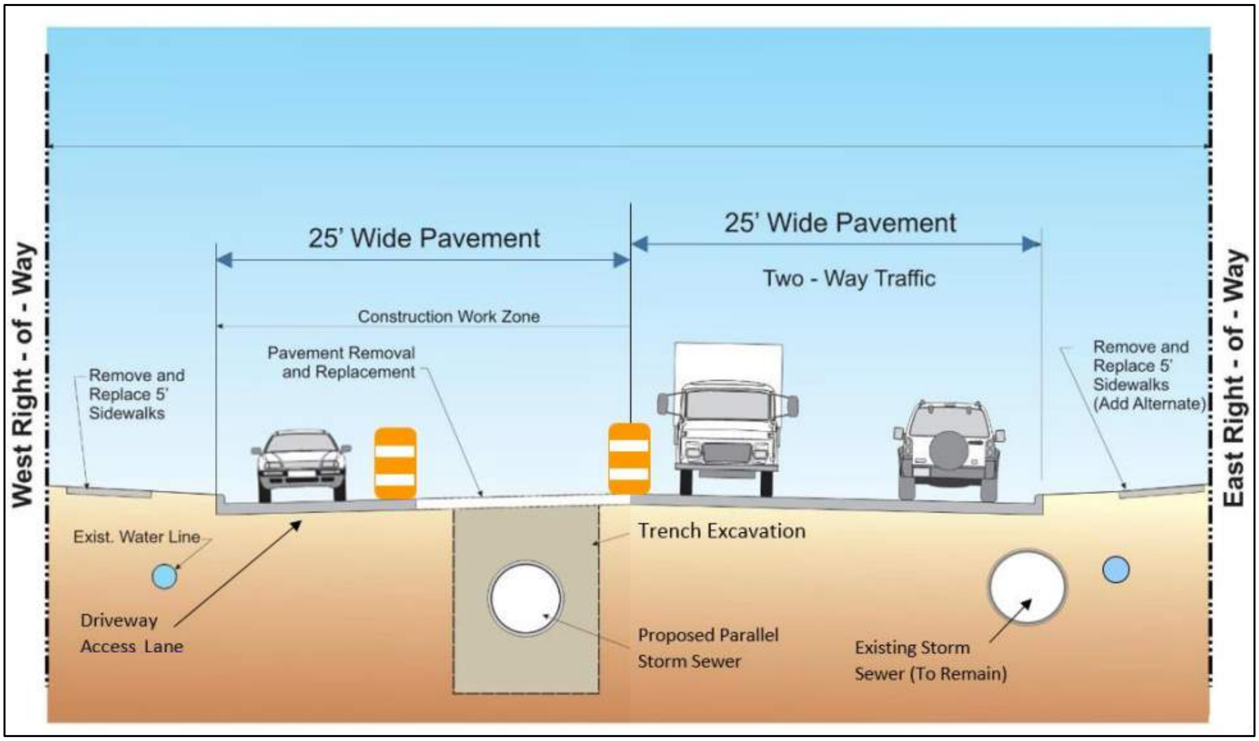


Figure 6: Possible Traffic Control Approach for Buffalo Speedway

4.2 Crossing the St. Vincent de Paul Church Property

Hydraulic modeling results indicate that the existing dual 66-inch storm sewer south of the Holcombe intersection could, in terms of capacity, be left in place to regulate flows to Poor Farm Ditch. However, information provided by the West U indicates that the existing pipes are in less than satisfactory condition and should be replaced. The replacement storm sewer will take the form of dual 8' x 8' box culvert storm sewers per the design summary presented on **Exhibit 2**. Items included as part of the project are stated below:

- Provides capacity for possible future condition where detention is provided downstream.
- Must negotiate an alignment easement with the church.
- Can remove the existing dual 66-inch pipes, and replace with 2 – 8' x 8' RCBs.
- Construct a new outfall at Poor Farm Ditch due to the depth of the proposed system.
- The cost estimate developed for the project includes an estimated cost for the new outfall structure.

Figure 7 illustrates the configuration described above.

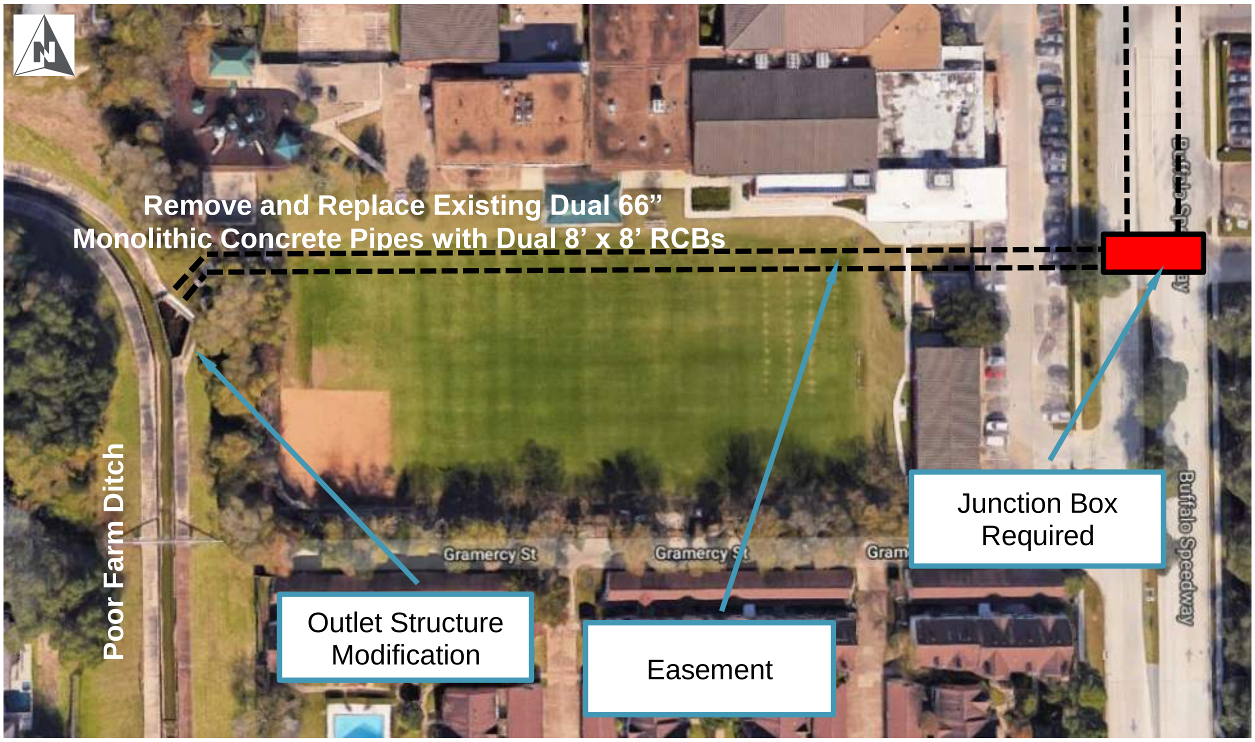


Figure 7: Storm Sewer Configuration Across the St. Vincent de Paul Campus

As indicated, utilizing the proposed 8' x 8' RCBs will create the need for additional easement, and will require that the existing outfall structure be replaced. The outfall structure at Poor Farm Ditch was repaired in 2014. Construction documents prepared for that project by HDR Engineering, Inc. in 2014 are attached to this report as **Appendix D**.

4.3 Tying Into Existing Monolithic Concrete Storm Sewers

The existing storm sewers along Buffalo Speedway were constructed during World War II, and due to rationing of steel during the war, the storm sewers were constructed as monolithic concrete pipes with no reinforcements. **Figure 8** to at right illustrates a typical section of the existing storm sewers. The prescribed wall thickness for the 66-inch and 72-inch pipes along Buffalo Speedway was 8 inches to $8^{1/2}$ inches. A copy of the construction plans for the original West U storm sewer system is attached to this report as **Appendix E**. The plans, which were completed in 1942, include storm sewer layouts, details, and the design of the original outfall structure at the Buffalo Speedway outfall to Poor Farm Ditch.

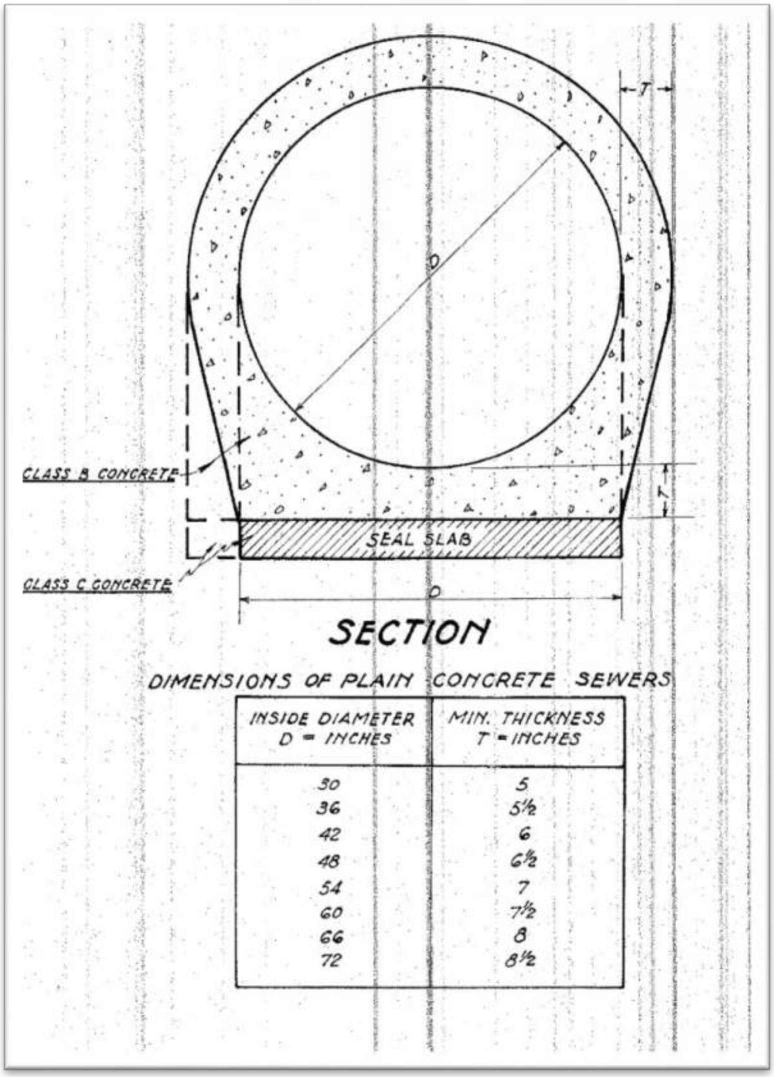


Figure 8: Typical Section, Monolithic Concrete Storm Sewer

The construction of new box culvert storm sewers under the inner lanes of Buffalo Speedway will require that flow be transferred from the existing 66-inch and 72-inch storm sewers on the outside of the roadway to the new box culverts. In order to achieve the required transfer of storm water, physical connections between the existing monolithic concrete storm sewers and the proposed box culvert storm sewers will be required. **Figure 9** below provides a possible means of making the required connections. This detail was detailed in connection with past roadway rehabilitation projects involving drainage improvements at intersections of Buffalo Speedway with various cross-streets.

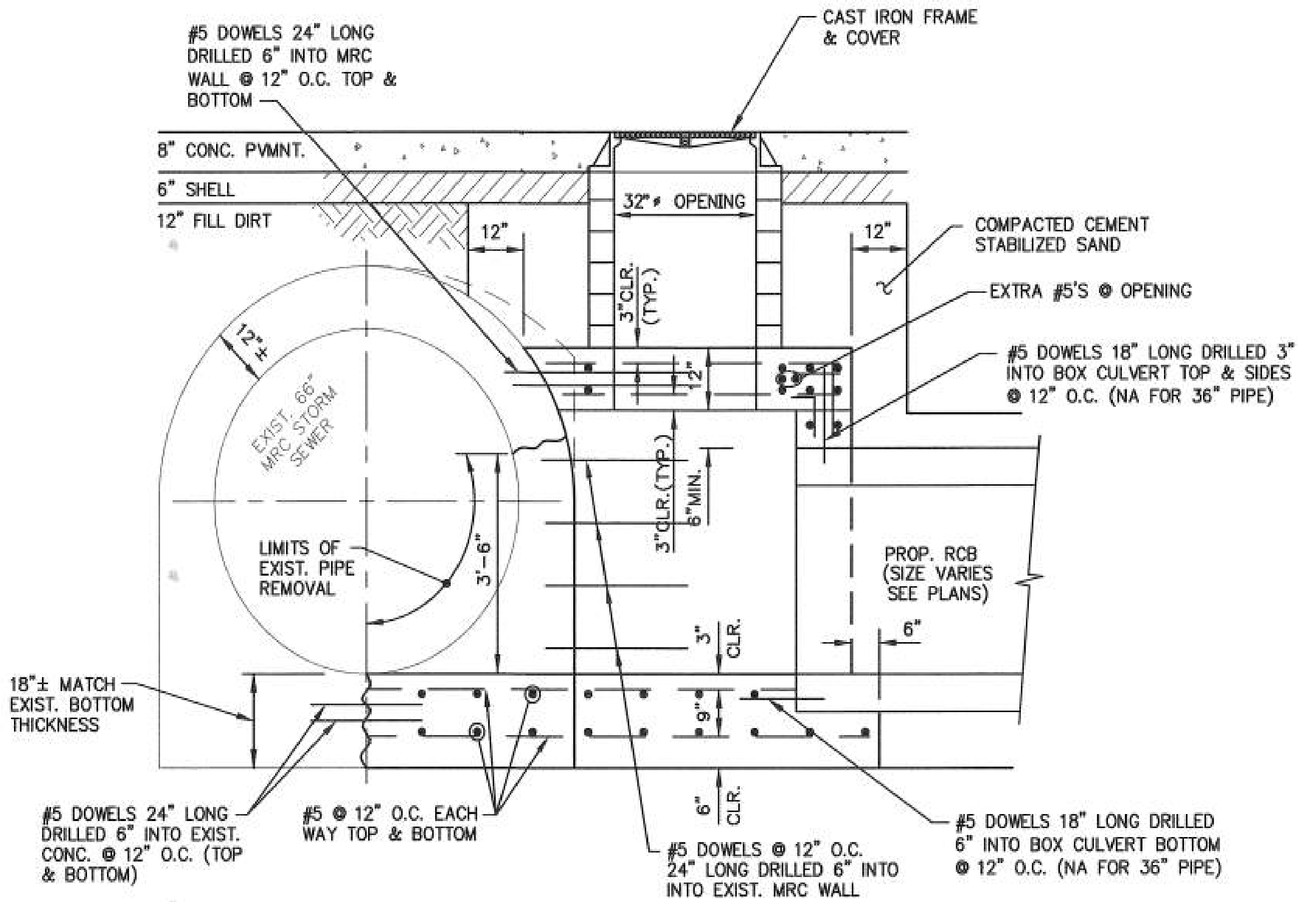


Figure 9: Detail for Connecting to Monolithic Concrete Storm Sewers

Appendix F contains excerpts from construction plans developed by Claunch & Miller, Inc. in 2002 for Priority Area 10 improvements and for Priority Area 11B, which involved side street drainage pipe connections to the existing monolithic concrete storm sewers on Buffalo Speedway.

4.4 Flow Regulation at Bissonnet Street

As indicated previously in this report, it is proposed that the existing single 66-inch storm sewer pipe that enters West University Place from the City of Houston, north of Bissonnet Street, be left in place to serve as a flow regulator. **Figure 10** provides a basic approach to the manner in which this is proposed to be accomplished.

Figure 10: Flow Regulation at Bissonnet Street

As indicated in **Figure 10**, the existing City of Houston storm sewer is left in place between Bissonnet Street and Wroxton Road. The Buffalo Speedway design calculations call for a new 66-inch storm sewer on the east side of Buffalo Speedway. In the interim, however, that 66-inch storm sewer will be omitted from West U's Buffalo Speedway improvement plan. Under this scenario, proposed storm sewer improvements would begin at the intersection of Buffalo Speedway and Wroxton Road and extend southward from that location. This would leave only the existing single 66-inch storm sewer in place between Bissonnet and Wroxton Road, with the possibility of adding the second 66-inch storm sewer along the east side of Buffalo Speedway in the future. This plan achieves the goal of regulating flows from the north while preserving the ability to make future improvements.

4.5 Flow Regulation along Buffalo Speedway

Due to the lack of available detention, the existing 66-inch and 72-inch storm sewers along Buffalo Speedway are proposed to be left in place from Wroxton to Holcombe to provide in-line detention storage. Proposed box culvert storm sewers are designed to accommodate the existing conditions 2-year flow from the area north of Bissonnet as well as 2-year flows from areas within the City of West University Place and contributing areas in the City of Houston south of Holcombe Boulevard. However, the proposed new storm sewers are significantly larger than the existing storm sewers, they have a much greater flow capacity than the existing storm sewers, and the detention storage made available by leaving existing storm sewer pipes in place along Buffalo Speedway is not sufficient to fully mitigate potential increases in 10-year and 100-year flow rates. In order to regulate the flow conveyed in the proposed storm sewer system, the proposed storm sewers are to be regulated to provide additional in-line storage until such time as downstream capacity along Brays Bayou is sufficient to accept the full-capacity flow from the proposed storm sewers or detention is provided at a downstream location in the future.

In the proposed conditions XPSWMM models of the Buffalo Speedway drainage system, a total of five (5) flow regulators are represented at intervals along the new storm sewer. **Table 6** shows the location and sizing information for these regulators. These regulators are modeled as 48-inch pipes, but the actual physical configuration of the regulators may take a number of forms.

Table 6 – Location and sizes of Flow Restrictors

STATION	LOCATION	SIZE
33+65	North of Duke	4ft x 3ft
27+15	North of Pittsburgh	4ft x 3ft
20+65	North of Carnegie	4ft x 3ft
14+15	North of Cason	4ft x 3ft
2+78	Upstream of St. Vincent de Paul Catholic Church Property	4ft x 3ft

The selected means of achieving the required degree of flow regulation should be simple, cost-effective, long-lasting, require little maintenance, and allow for modification or removal of regulators. A simple masonry wall structure can be constructed in manholes or junction boxes to limit flow openings at regulator locations to roughly the equivalent of a 48-inch pipe.

Figure 11 represents the basic approach to the construction of a masonry wall that is strong enough to withstand hydraulic pressure but also represents a modular system that can be removed without undue difficulty.

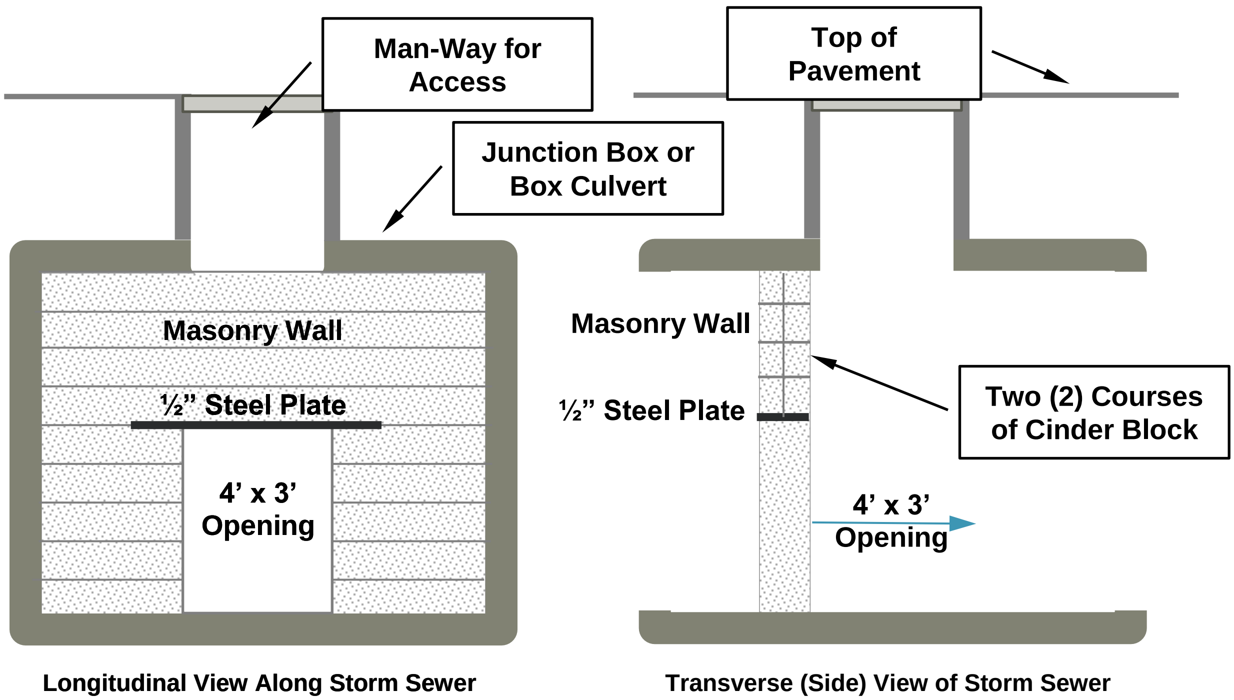


Figure 11: General Form of Masonry Flow Regulator

4.6 Utility Concerns

In constructing the proposed new storm sewers, care must be exercised to avoid existing utilities along Buffalo Speedway. **Figure 12** is representative of the water line layout for the entire length of the proposed Buffalo Speedway improvements project. The traffic control plan described in the foregoing section of this report minimizes potential conflicts with existing utilities, including sanitary sewers and existing water lines, the latter of which are located on both sides of the roadway, by constructing the storm sewers in the middle portion of the roadway, away from the curb lines and the area immediately behind the curbs where utilities are located.

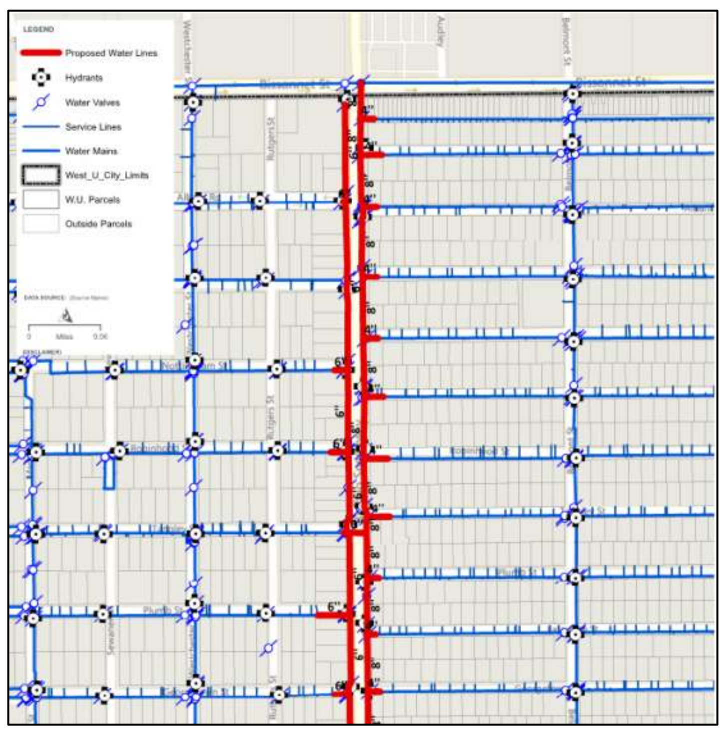


Figure 12: Typical Water Line Arrangement along Buffalo Speedway

5 Hydraulic Analysis

5.1 Existing Conditions

The existing conditions hydraulic model is a 1D/2D coupled XP-SWMM model created by HDR. The storm sewer elevation data was obtained from field survey provided by West Belt Surveying, Inc. **Appendix G** contains collected survey data and field notes taken in the project limit. The 2D domain of the model was created using the 2008 LiDAR data obtained by the Houston-Galveston Area Council. The runoff hydrographs described in Section 2 of this report were inserted using the “User Inflow” setting at computation points along the system. The model only includes the storm sewer trunk line(s) and does not include the inlet level calculations, as under the TIP funding program the roadway design engineer is responsible for designing storm sewer inlets and providing sufficient inlet capacity, while the storm sewer design engineer is responsible for the sizing and arrangement of storm sewer pipes. The model includes the 2-year, 10-year, and 100-year storm events. The tailwater condition was set to a stage discharge relationship calculated with a HEC-RAS model for Poor Farm Ditch.

The results of the existing conditions hydraulic analysis indicate that the storm sewer trunk line does not have sufficient capacity to convey the 2-year peak discharge. Storm water ponding is expected along the entire corridor of Buffalo Speedway, and storm water flows eastward toward Belmont Street and then outside the extents of the 2D domain on the east, west and south boundaries of the 2D domain. The runoff which exits the 2D domain is calculated via a 2D flow line along the boundary within the hydraulic model.

The runoff hydrographs from the storm sewers and 2D flow lines are shown below in **Figure 13**. As shown, the combined peak discharge from the system via all routes (including overland routes as well as the Poor Farm Ditch outfall) is approximately 335 cfs. The discharge at the storm sewer outfall to Poor Farm Ditch is approximately 310 cfs.

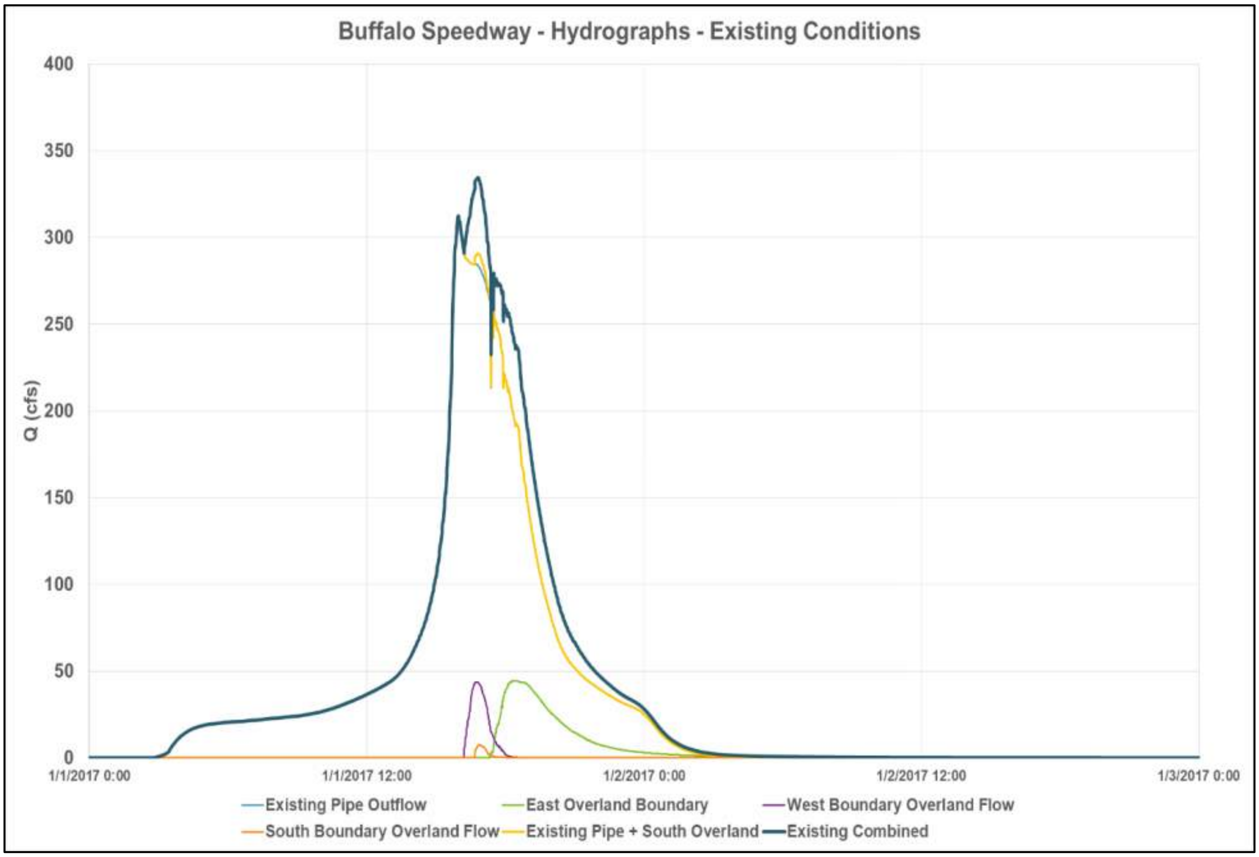


Figure 13: Existing Conditions 2-Year Runoff Hydrographs

The 10-year runoff hydrographs for the existing conditions are shown below in **Figure 14**. As shown, the combined peak discharge from the system (via all routes) is approximately 505 cfs. The discharge at the storm sewer outfall to Poor Farm Ditch is approximately 320 cfs.

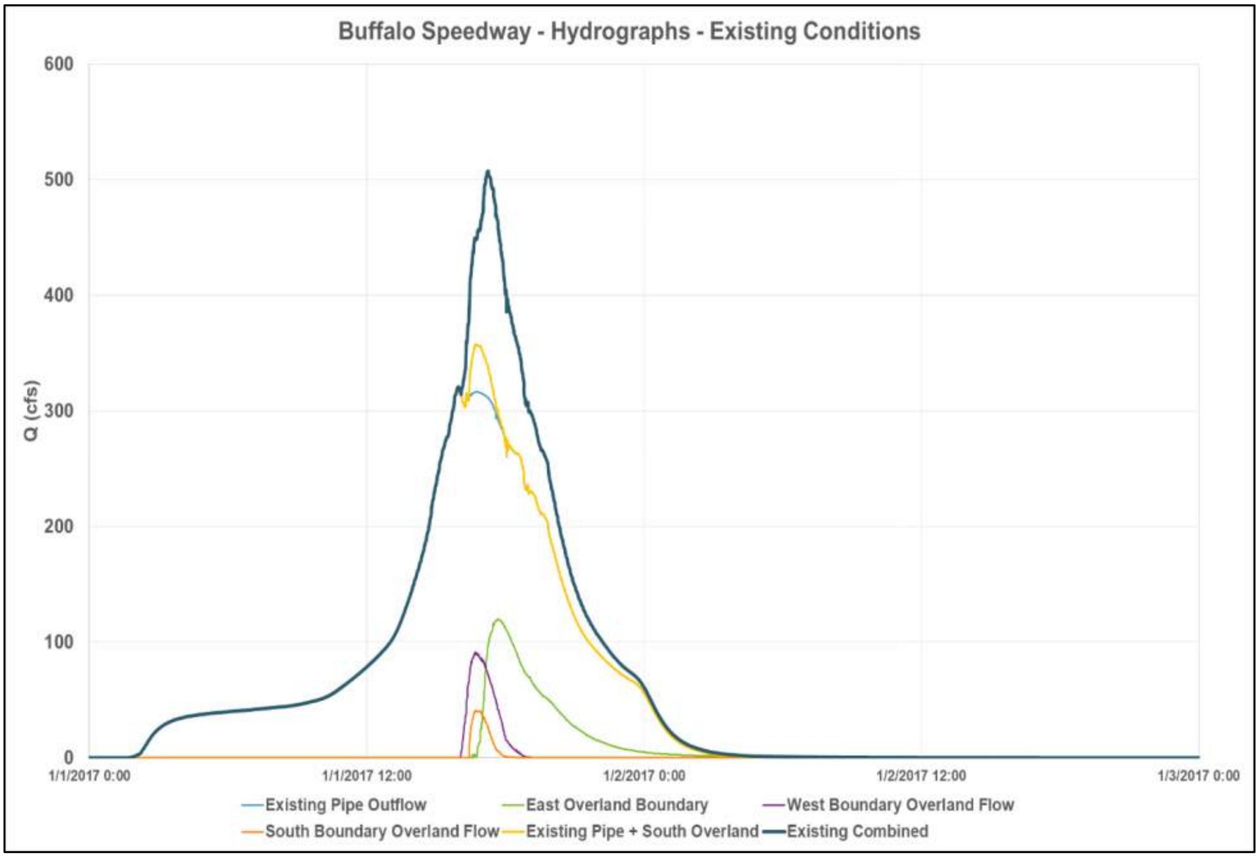


Figure 14: Existing Conditions 10-year Runoff Hydrographs

The 100-year runoff hydrographs for the existing conditions are provided below in **Figure 15**. As shown, the combined peak discharge (via all routes) is approximately 1065 cfs. The discharge at the Poor Farm Ditch outfall is approximately 380 cfs.

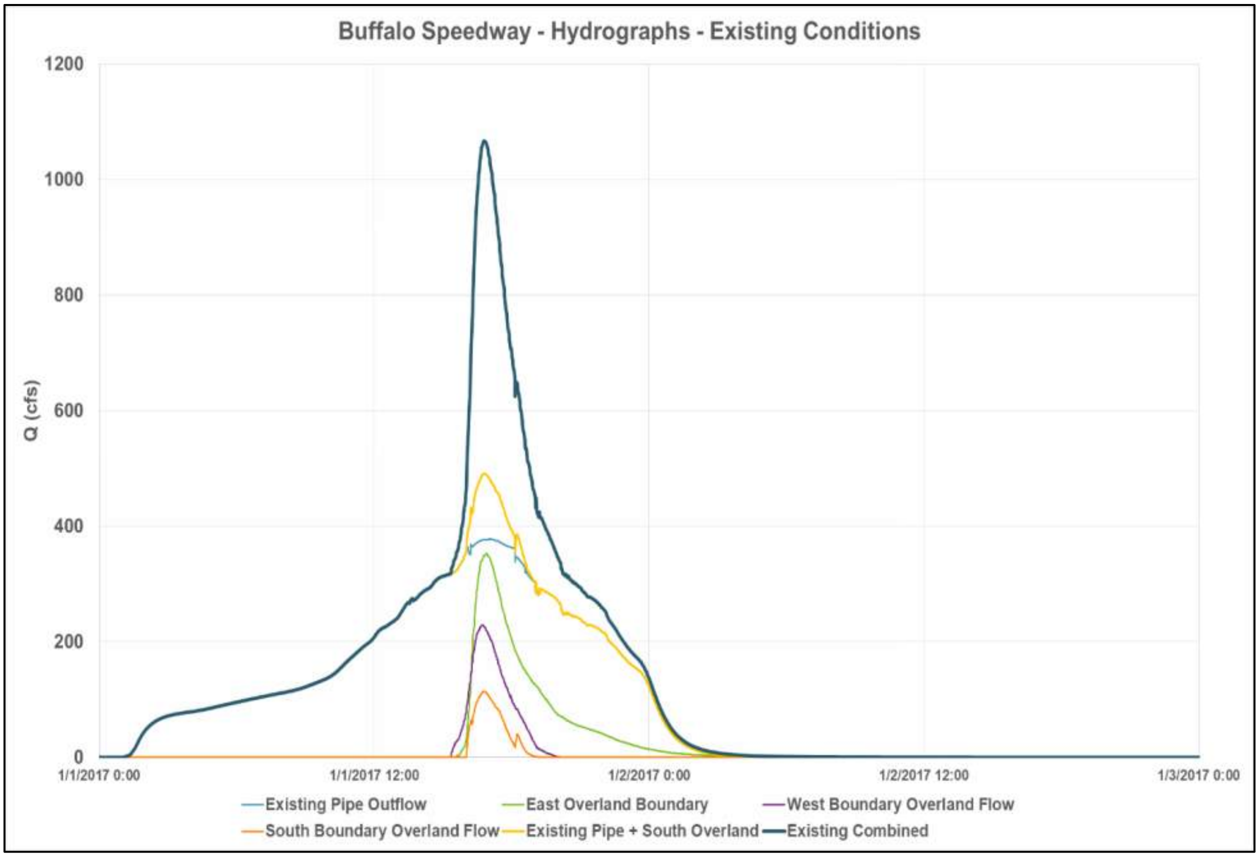


Figure 15: Existing Conditions 100-Year Runoff Hydrographs

Flooding depth grids of the 2-year, 10-year, and 100-year storm events are provided in **Exhibits 4, 5, and 6**, respectively.

5.2 Proposed Conditions

The existing conditions hydraulic model was modified to include the proposed storm sewer. The proposed storm sewer sizes range from a single 6'x5' RCB at Wroxton Road to dual 8'x8' box culverts near the outfall. The proposed conditions model results indicate significant reductions in street ponding along Buffalo Speedway for the 2-year storm event. There is still significant ponding in the upper portions of the system, and storm water flows eastward toward Belmont Street during the 2-year storm event. For the 100-year storm event, street ponding is significantly reduced in the proposed conditions.

The runoff hydrographs from the storm sewers and 2D flow lines are shown below in **Figure 16**. As shown, the proposed combined peak discharge from the system is approximately 425 cfs, which is an increase of approximately 90 cfs above the existing discharge rate at Poor Farm Ditch outfall. Based on that increase and evaluation of existing and proposed conditions 2-year discharge hydrographs, approximately 5 acre-feet of detention storage would be required to mitigate impacts for the 2-year storm event. However, due to the fact that Poor Farm Ditch has sufficient capacity to convey the 2-year storm, it will not be necessary to provide detention to mitigate potential increases in peak discharge from the Buffalo Speedway system if no impacts are computed for 10-year and 100-year events.

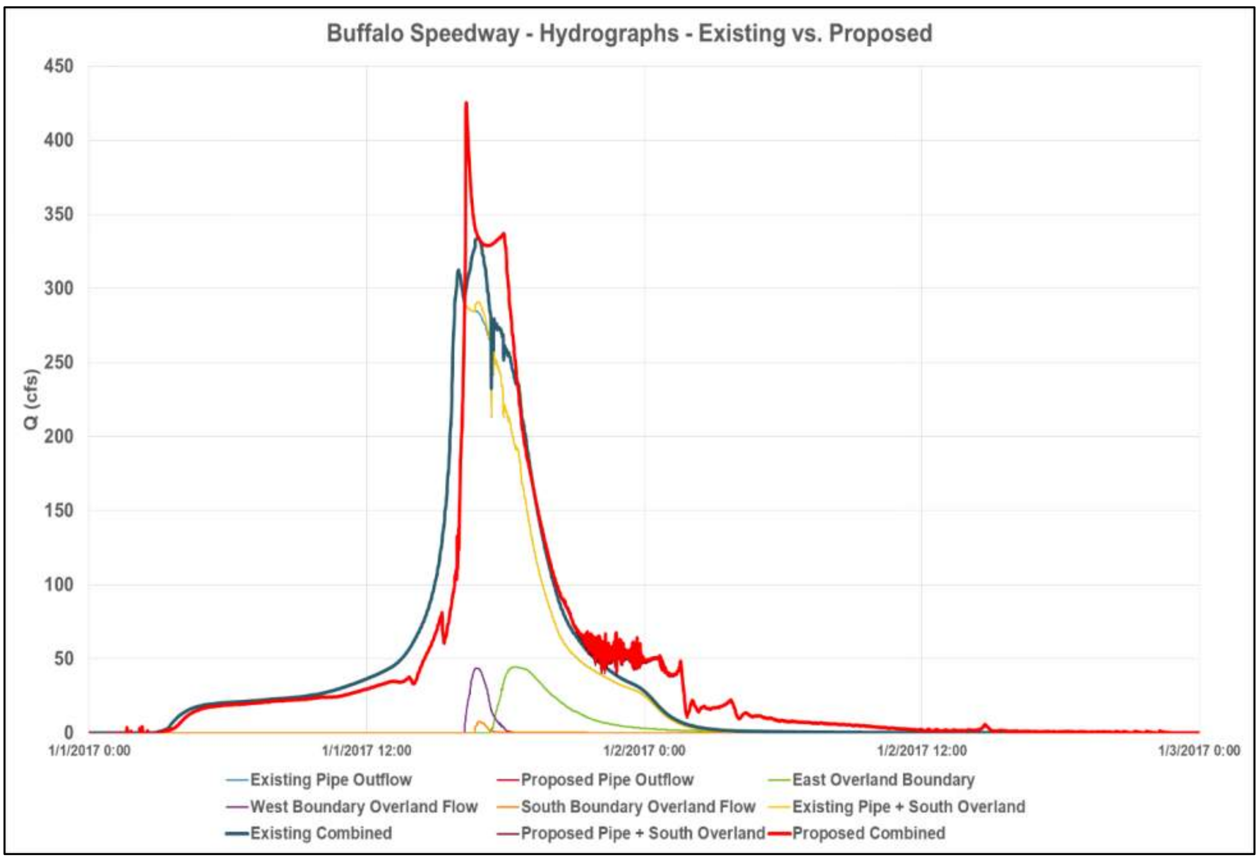


Figure 16: Existing Conditions vs. Proposed Conditions 2-Year Runoff Hydrographs

The 10-year runoff hydrographs for the proposed conditions are provided below in **Figure 17**. The combined peak discharge to Poor Farm Ditch, approximately 460 cfs, is less than the combined existing conditions discharge of 505 cfs to Poor Farm Ditch. XPSWMM results indicate that overland sheet flow to locations outside of the 2D domain was eliminated for the 10-year storm event, leaving only the storm sewer and overland route to Poor Farm Ditch.

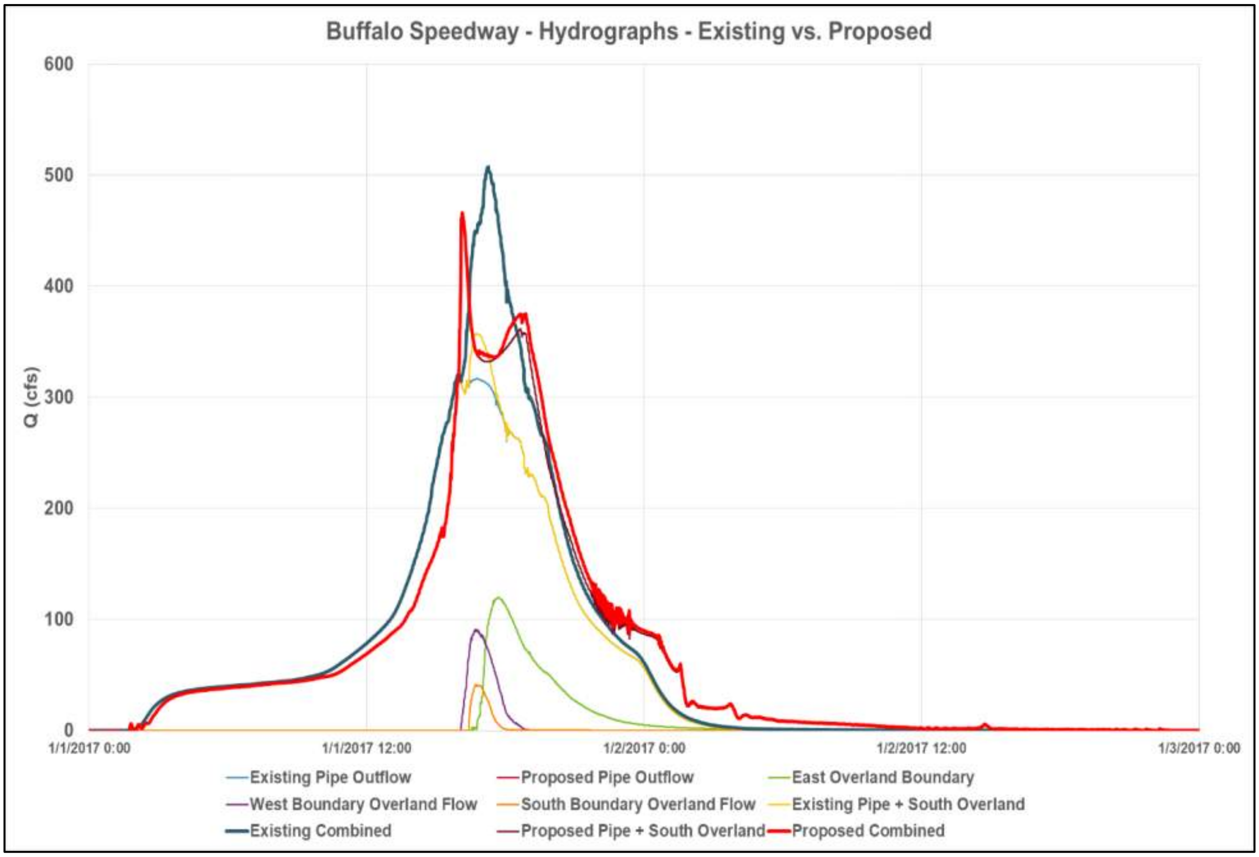


Figure 17: Existing Conditions vs. Proposed Conditions 10-Year Runoff Hydrographs

The 100-year runoff hydrographs for the proposed conditions are provided below in **Figure 18**. As shown, the combined peak discharge is approximately 520 cfs, which is much reduced in comparison to the existing conditions combined peak discharge of almost 1065 cfs. The proposed combined pipe and south overland flow is also reduced in comparison to the existing combined pipe and south overland flow. Storage within streets and storm sewer system meters flow out the system to broaden the hydrograph to reduce the peak discharge rates.

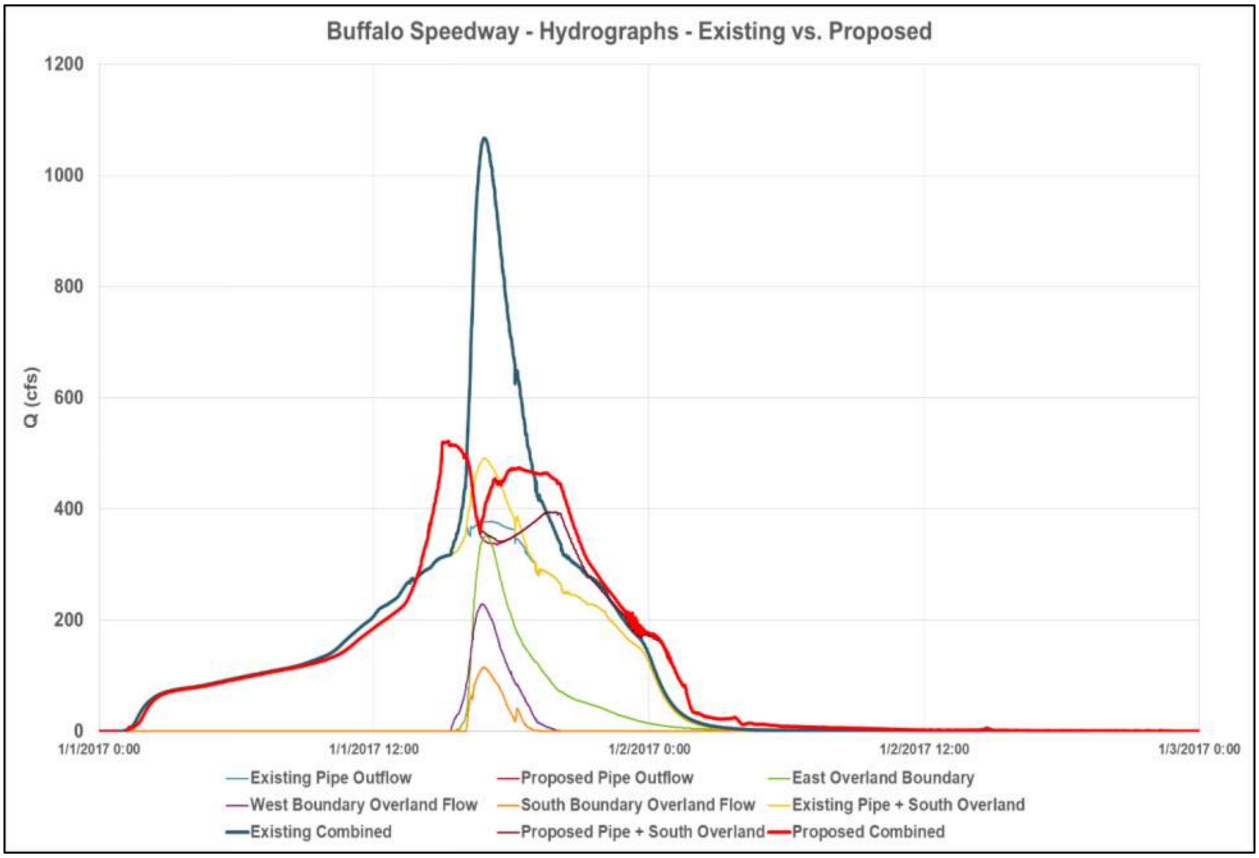


Figure 18: Existing Conditions vs. Proposed Conditions 100-Year Runoff Hydrographs

While there is an increase in the 2-year peak flow rate to Poor Farm Ditch, there is no mitigation required as the receiving channel has 100 year capacity. Flooding depth grids from the impact analysis of the 2-year, 10-year, and 100-year storm events are provided on **Exhibits 7, 8, and 9**, respectively.

5.3 Comparison of Ponding Depths along Buffalo Speedway

Table 7 below provides a summary of maximum flood depths at street intersections for each storm frequency based on the results of the XP-SWMM model. During a 2-year storm, street flooding is expected along Buffalo Speedway between Nottingham St. and Bissonnet St. and between Tangley St. and University Blvd. During a 10-year event, flooding is expected between Bissonnet St. and Duke St. Finally, during a 100-year storm event, street flooding is expected along the entire stretch of Buffalo Speedway between Bissonnet St. and Holcombe Blvd.

Storm sewer improvements associated with the proposed improvements to Buffalo Speedway reduce ponding depths along Buffalo Speedway in the southern portions of the project limits. During a 100-year storm event, the proposed improvements provide a reduction in ponding depths as much as 1.5 feet along Buffalo Speedway.

Table 7 – Comparison of Ponding Depths along Buffalo Speedway

Station	Location	2-Year			10-Year			100-Year		
		Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
79+19.57	Buffalo Speedway @ Bissonnet	1.58	1.43	-0.15	1.79	1.66	-0.13	2.22	2.11	-0.11
76+36.00	Buffalo Speedway @ Wroxton	1.71	1.44	-0.27	1.99	1.72	-0.27	2.40	2.24	-0.16
74+19.91	Buffalo Speedway @ Albans W	1.75	1.46	-0.29	2.04	1.74	-0.30	2.45	2.30	-0.15
73+76.38	Buffalo Speedway @ Albans E	1.48	1.18	-0.30	1.78	1.47	-0.31	2.20	2.05	-0.15
71+00.71	Buffalo Speedway @ Sunset E	0.71	0.42	-0.29	0.96	0.66	-0.30	1.35	1.21	-0.14
70+50.11	Buffalo Speedway @ Sunset W	0.66	0.43	-0.23	0.91	0.62	-0.29	1.27	1.09	-0.18
68+30.89	Buffalo Speedway @ Nottingham E	0.94	0.61	-0.33	1.20	0.88	-0.33	1.56	1.37	-0.19
66+90.12	Buffalo Speedway @ Nottingham W	0.67	0.00	-0.67	0.87	0.62	-0.25	1.21	1.04	-0.17
65+66.38	Buffalo Speedway @ Quenby	0.86	0.12	-0.74	1.10	0.78	-0.32	1.45	1.29	-0.16
63+30.66	Buffalo Speedway @ Robinhood W	0.11	0.00	-0.11	0.38	0.08	-0.30	0.67	0.51	-0.17
63+01.47	Buffalo Speedway @ Robinhood E	0.00	0.00	0.00	0.61	0.00	-0.61	0.92	0.75	-0.16
60+36.09	Buffalo Speedway @ Tangley E	0.55	0.32	-0.24	0.73	0.50	-0.23	1.06	0.92	-0.15
59+70.29	Buffalo Speedway @ Tangley W	0.32	0.11	-0.21	0.48	0.27	-0.20	0.80	0.64	-0.16
57+71.25	Buffalo Speedway @ Plumb E	0.99	0.73	-0.26	1.18	0.94	-0.24	1.47	1.32	-0.15
56+09.90	Buffalo Speedway @ Plumb W	1.03	0.77	-0.26	1.20	0.96	-0.24	1.48	1.35	-0.14
55+15.57	Buffalo Speedway @ Lafayette	0.90	0.64	-0.26	1.07	0.83	-0.23	1.35	1.21	-0.14
52+64.69	Buffalo Speedway @ Georgetown E	0.71	0.43	-0.28	0.88	0.60	-0.28	1.17	0.97	-0.20
52+49.41	Buffalo Speedway @ Georgetown W	0.62	0.24	-0.38	0.78	0.51	-0.27	1.06	0.87	-0.19
49+99.73	Buffalo Speedway @ Rice E	0.39	0.07	-0.32	0.50	0.26	-0.24	0.76	0.56	-0.20
48+90.26	Buffalo Speedway @ Rice W	0.45	0.00	-0.45	0.55	0.06	-0.49	0.78	0.59	-0.19
47+34.48	Buffalo Speedway @ Jarrard	0.05	0.00	-0.05	0.43	0.00	-0.43	0.83	0.63	-0.21
45+31.07	Buffalo Speedway @ Amherst W	0.01	0.00	-0.01	0.02	0.00	-0.02	0.31	0.06	-0.24
44+74.75	Buffalo Speedway @ Amherst E	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.21	-0.42
41+49.95	Buffalo Speedway @ University	0.79	0.29	-0.51	0.94	0.45	-0.49	1.16	0.83	-0.32
33+53.65	Buffalo Speedway @ Duke	1.71	1.04	-0.67	1.86	1.16	-0.70	2.14	1.39	-0.75
27+05.07	Buffalo Speedway @ Pittsburgh	1.28	0.28	-1.00	1.49	0.47	-1.01	1.87	0.76	-1.11
20+54.66	Buffalo Speedway @ Carnegie	0.93	0.00	-0.93	1.11	0.00	-1.11	1.50	0.00	-1.50
14+04.91	Buffalo Speedway @ Cason	1.08	0.40	-0.68	1.44	0.79	-0.65	1.90	0.90	-1.00
9+20.49	Buffalo Speedway @ Bellaire	1.08	0.74	-0.35	1.56	0.86	-0.70	2.16	1.07	-1.09

5.4 Comparison of Water Surface Elevations along Buffalo Speedway

Table 8 below provides a summary of maximum water surface elevations at street intersections for each storm frequency based on the results of the XP-SWMM model.

Table 8 – Comparison of Water Surface Elevations along Buffalo Speedway

Station	Location	2-Year			10-Year			100-Year		
		Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
79+19.57	Buffalo Speedway @ Bissonet	50.41	50.28	-0.14	50.67	50.54	-0.10	51.13	51.02	-0.11
76+36.00	Buffalo Speedway @ Wroxton	50.20	49.97	-0.23	50.48	50.22	-0.26	50.89	50.73	-0.16
74+19.91	Buffalo Speedway @ Albans W	50.06	49.76	-0.30	50.34	50.04	-0.31	50.77	50.61	-0.14
73+76.38	Buffalo Speedway @ Albans E	50.06	49.76	-0.30	50.34	50.04	-0.31	50.77	50.61	-0.16
71+00.71	Buffalo Speedway @ Sunset E	50.00	49.70	-0.41	50.26	49.95	-0.31	50.63	50.49	-0.14
70+50.11	Buffalo Speedway @ Sunset W	49.96	49.70	-0.26	50.19	49.91	-0.27	50.55	50.38	-0.17
68+30.89	Buffalo Speedway @ Nottingham E	49.82	49.62	-0.21	50.07	49.76	-0.32	50.44	50.24	-0.20
66+90.12	Buffalo Speedway @ Nottingham W	49.75	-	-	49.99	49.69	-0.30	50.33	50.15	-0.19
65+66.38	Buffalo Speedway @ Quenby	49.65	49.24	-0.41	49.84	49.61	-0.31	50.19	50.03	-0.16
63+30.66	Buffalo Speedway @ Robinhood W	49.19	-	-	49.44	49.16	-0.27	49.74	49.57	-0.17
63+01.47	Buffalo Speedway @ Robinhood E	-	-	-	49.43	-	-	49.73	49.57	-0.16
60+36.09	Buffalo Speedway @ Tangley E	49.17	48.91	-0.26	49.33	49.09	-0.24	49.68	49.51	-0.14
59+70.29	Buffalo Speedway @ Tangley W	49.08	48.81	-0.27	49.25	49.03	-0.23	49.58	49.43	-0.15
57+71.25	Buffalo Speedway @ Plumb E	49.02	48.75	-0.42	49.21	48.96	-0.25	49.51	49.35	-0.15
56+09.90	Buffalo Speedway @ Plumb W	48.84	48.58	-0.26	49.00	48.77	-0.21	49.29	49.15	-0.13
55+15.57	Buffalo Speedway @ Lafayette	48.84	48.59	-0.34	49.01	48.79	-0.22	49.29	49.16	-0.14
52+64.69	Buffalo Speedway @ Georgetown E	48.82	48.54	-0.28	48.99	48.71	-0.28	49.27	49.08	-0.19
52+49.41	Buffalo Speedway @ Georgetown W	48.82	48.50	-0.31	48.98	48.71	-0.28	49.27	49.07	-0.19
49+99.73	Buffalo Speedway @ Rice E	48.69	48.27	-0.43	48.80	48.50	-0.30	49.09	48.87	-0.22
48+90.26	Buffalo Speedway @ Rice W	48.60	-	-	48.72	48.42	-0.30	48.92	48.75	-0.17
47+34.48	Buffalo Speedway @ Jarrard	48.40	48.10	-0.30	48.61	48.28	-0.33	48.86	48.65	-0.20
45+31.07	Buffalo Speedway @ Amherst W	48.31	-	-	48.44	-	-	48.69	48.46	-0.25
44+74.75	Buffalo Speedway @ Amherst E	-	-	-	-	-	-	48.68	48.46	-0.22
41+49.95	Buffalo Speedway @ University	48.09	47.85	-0.57	48.23	47.97	-0.27	48.47	48.17	-0.33
33+53.65	Buffalo Speedway @ Duke	47.78	47.40	-0.47	47.94	47.45	-0.49	48.24	47.54	-0.70
27+05.07	Buffalo Speedway @ Pittsburgh	47.43	46.55	-0.99	47.64	46.70	-0.93	48.02	46.95	-1.08
20+54.66	Buffalo Speedway @ Carnegie	47.29	-	-	47.45	-	-	47.83	-	-
14+04.91	Buffalo Speedway @ Cason	46.41	45.89	-0.51	46.85	46.02	-0.82	47.37	46.21	-0.99
9+20.49	Buffalo Speedway @ Holcombe	46.08	45.81	-0.27	46.55	45.91	-0.64	47.13	46.13	-1.00

5.5 Hydraulic Grade Line (HGL) Calculations:

The impact analysis performed using the XP-SWMM model created for Buffalo Speedway overestimates the Hydraulic Grade Line (HGL) by aggregating the peak flows assigned to each node. The reason for this is that City of Houston time of concentration calculations do not account for travel time within the system. As a result, the HGL is based on combined peak flows that are not representative of real-world conditions.

A Microsoft Excel spreadsheet was created for the design (2-Year) HGL analysis by calculating a running time of concentration (Tc) for the system, and computing peak flows at each junction / pipe size change. For the drainage area (COH N) at the upstream end of the system, the area was set to effective drainage area of 25 acres to simulate the maximum flow capacity of the existing 66-inch RCP. The Head losses were calculated in the pipes (friction losses) as well as junctions. A table of calculations for the design analysis is presented in **Appendix A**.

Exhibit 10 shows the plots of the 2-year HGL created using both design and impact analysis methods. The 100-year HGL from the impact analysis is also included.

6 Pre-Design Activities

Limited pre-design activities have been completed as needed to develop the recommended drainage improvement plan. Those activities include the following.

- Limited field survey was completed by West Belt Surveying, Inc. Information collected was limited to top of manhole and invert elevations of existing storm sewers, and digital work products were provided to HDR. **Appendix G** includes work products prepared by West Belt Surveying, Inc.
- Limited geotechnical testing was completed by Aviles Engineering Corporation. Work was limited to three (3) borings located at approximately intervals along Buffalo Speedway within the project segment. **Appendix H** includes a geotechnical investigations report prepared by Aviles Engineering Corporation. **Exhibit 11** illustrates the locations of three (3) borings completed along Buffalo Speedway. The geotechnical investigations revealed a number of concerns, including water at depths of approximately 6 feet 24 hours after drilling, as well as fat clays with Plasticity Index (PI) values as high as 56.
- An estimate of the costs associated with construction of the proposed storm drainage system was prepared by HDR Engineering, Inc. The estimated total construction cost is $17.85 million. **Appendix I** includes a copy of the cost estimate with additional calculations and details. As noted previously in this report, the estimated cost covers the installation of full-sized, dual box culvert replacements of the existing dual 66-inch storm sewer pipes from Holcombe Boulevard to Poor Farm Ditch. Depending upon the outcome of negotiations between the City of West University and the Church, it is possible that a lower-cost alternative may be implemented, but for purposes of preparing the cost estimate, the full cost for the full-capacity replacement option was included.
- Plans from prior roadway rehabilitation and infrastructure repair/upgrade projects were located and assemble for possible future consultation in the design phase. These plans are available for use by the City and its design consultants on the Buffalo Speedway project for purposes of locating utilities, identifying past construction, and evaluating new designs for space requirements and constructability. Following is a partial list of available construction documents.
    - West U Storm Sewer System (Garrett Engineering - 1942)
    - Priority Area 10 Drawings (Claunch & Miller, Inc. - 2001)
    - Priority Area 11 Drawings (Claunch & Miller, Inc. - 2001)
    - Poor Farm Ditch Outfall Rehabilitation (HDR Engineering, Inc. - 2013)
- Other information is available via GIS data. The type of GIS-based information available may be seen on **Exhibit 12**, which illustrates water line locations and sizes along Buffalo Speedway from Bissonnet Street southward to Holcombe Boulevard.

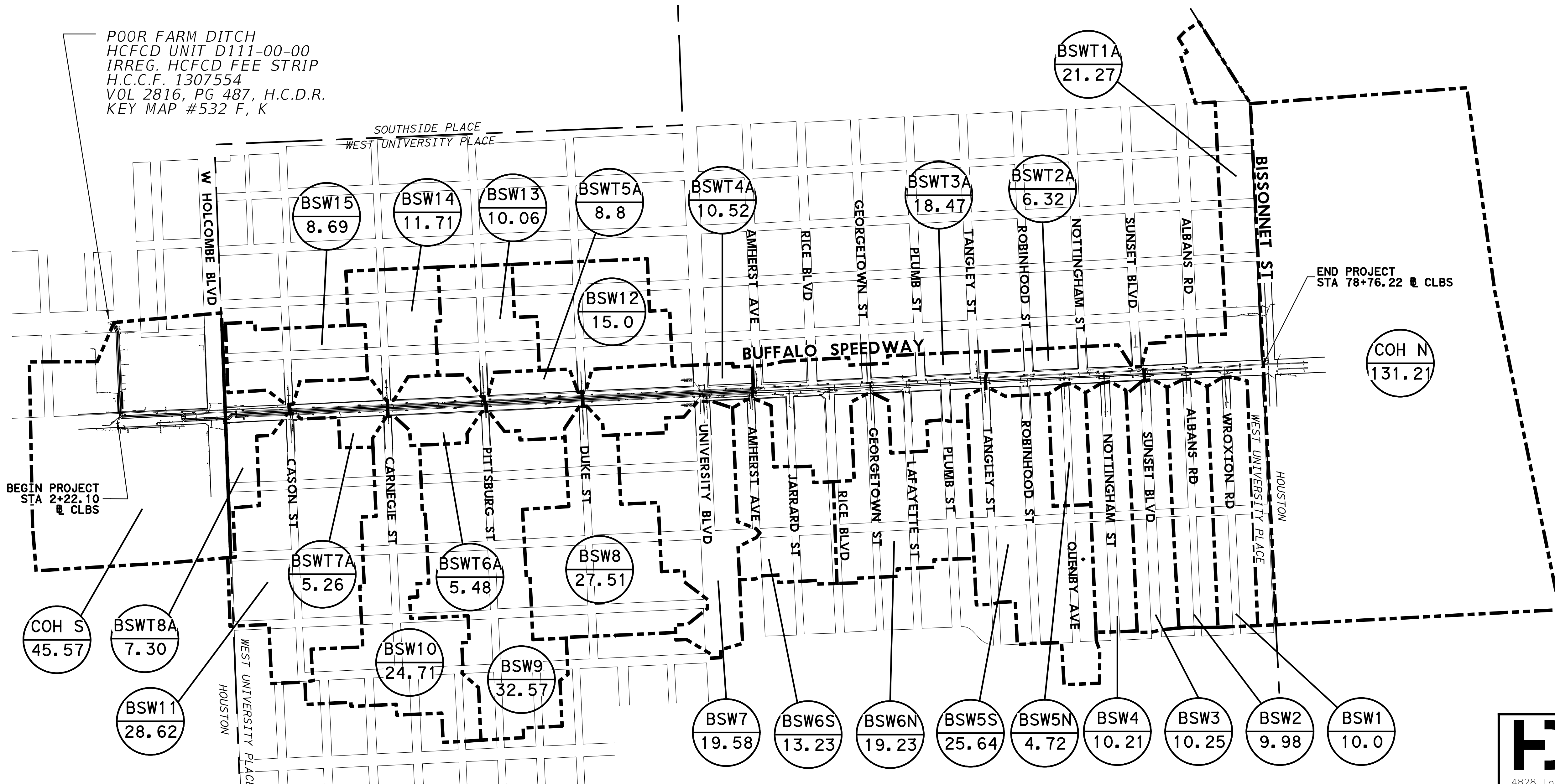
7 Conclusion

Based on the results of this analysis, the proposed improvements will not cause any adverse impacts on downstream peak flow rates along Poor Farm Ditch. The following recommendations are included as a part of the drainage plan associated with the improvements to Buffalo Speedway.

- Construct storm sewers along Buffalo Speedway between Wroxton Road to the existing outfall to Poor Farm Ditch ranging in size from one 6' x 5' RCB to dual 8' x 8' RCBs.
- Replace outfall structure.
- Construct the new storm sewers within the "inner" lanes along Buffalo Speedway in order to minimize impact to existing utilities and to allow the development of traffic control plans that provide access to driveways along both sides of the road.
- Install five (5) flow control devices along the proposed storm sewer to maintain existing conditions velocities within the storm sewer. The flow control devices should allow for a cross-sectional flow area equivalent to a 48-inch RCP.
- Design flow control devices using masonry walls that are properly designed to allow the flow controls to be adjusted or removed in the future without undue effort. Flow controls may be removed as downstream channel capacity improves or detention is provided.
- Do not construct the proposed single 66-inch RCP between Bissonnet Street and Wroxton Road in the interim, but include that pipe in the design plans so that it may be constructed in the future should the need to restrict flows from the north be eliminated.
- Removal and replacement of the existing 66" pipe to dual 8' x 8' box culverts from Holcombe Boulevard to the outfall at Poor Farm Ditch to provide future capacity.
- Coordinate with the church with regard to desired changes in the pipe alignment, and make sure there is a well-defined easement across the church property.
- In the design phase, account for possible shallow groundwater and the presence of fat clays. Provide for adequate trench safety and traffic safety at all times, in accordance with all applicable regulatory guidelines.

Based on the results of this analysis, the proposed improvements to Buffalo Speedway presented in this report will not cause any adverse impacts on downstream peak flow rates or upstream flood levels for storm events up to and including the 1% annual chance (100-year) storm event.

Exhibit 1. Drainage Area Maps



0 400' 800' 1200 1600
SCALE IN FEET

LEGEND

ID NO. / AC	DRAINAGE AREA LABEL
— — —	DRAINAGE AREA BOUNDARY

NOTE:
FOR DRAINAGE ANALYSIS, REFER TO DRAINAGE STUDY REPORT "BUFFALO SPEEDWAY IMPROVEMENTS DRAINAGE PRELIMINARY ENGINEERING REPORT" PREPARED BY HDR ENGINEERING, INC

APPROVED ON______________________.

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Construction in Harris County Flood Control District Right-of-Way requires:

Site plans must be approved prior to obtaining the required HCFCD Right-of-Way Notification. Be advised that the HCFCD Right-of-Way Notification is separate from the site development permit package

1.) HCFCD Right-of-Way Notification (permit)
2.) HCFCD 48-hr Pre-Construction Notice

Both are required prior to entering or working within Harris County Flood Control District right-of-way. The HCFCD Right-of-Way Notification and 48-hour notice must be provided to HCFCD at dcid@hcfcd.org. To apply for the HCFCD Right-of-Way Notification please go to http://apps.harriscountytx.gov/EPermits and apply for the HCFCD ROW under ROW Notification.

Failure to provide both items could result in project delay.

Area ID	Area (acres)	Intensity (in.hr)			Runoff Coefficient (C)	Peak Discharge (cfs)		
		$I_{2\text{-}YR}$	$I_{10\text{-}YR}$	$I_{100\text{-}YR}$		2-Year	10-Year	100-Year
COH N	131.21	2.69	4.06	5.79	0.80	282	426	608
BSWT 1A	21.27	2.98	4.45	6.30	0.55	35	52	74
BSW 01	10.00	3.10	4.60	6.49	0.55	17	25	36
BSW 02	9.98	3.10	4.60	6.50	0.55	17	25	36
BSW 03	10.25	3.09	4.60	6.49	0.55	17	26	37
BSWT 2A	6.32	3.16	4.69	6.61	0.55	11	16	23
BSW 04	10.21	3.09	4.60	6.49	0.55	17	26	36
BSW 05 N	4.72	3.20	4.74	6.67	0.55	8	12	17
BSW 05 S	25.64	2.95	4.42	6.25	0.55	42	62	88
BSWT 3A	18.47	3.00	4.48	6.34	0.55	31	46	64
BSW 06 N	19.23	3.00	4.47	6.33	0.55	32	47	67
BSW 06 S	13.23	3.06	4.55	6.42	0.55	22	33	47
BSW 12	15.00	3.04	4.52	6.39	0.55	25	37	53
BSWT 4A	10.52	3.09	4.59	6.48	0.55	18	27	37
BSW 07	19.58	3.00	4.47	6.32	0.55	32	48	68
BSW 13	10.06	3.10	4.60	6.49	0.55	17	25	36
BSWT 5A	8.80	3.12	4.63	6.53	0.55	15	22	32
BSW 08	27.51	2.94	4.40	6.23	0.55	45	67	94
BSW 14	11.71	3.07	4.57	6.46	0.55	20	29	42
BSWT 6A	5.48	3.18	4.72	6.64	0.55	10	14	20
BSW 09	32.57	2.92	4.37	6.19	0.55	52	78	111
BSW 15	8.69	3.12	4.63	6.53	0.55	15	22	31
BSWT 7A	5.26	3.19	4.72	6.65	0.55	9	14	19
BSW 10	24.71	2.96	4.42	6.26	0.55	40	60	85
BSWT 8A	7.30	3.14	4.66	6.57	0.55	13	19	26
BSW 11	28.62	2.94	4.39	6.22	0.55	46	69	98
COH S	45.57	2.86	4.29	6.09	0.69	90	135	191

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BUFFALO SPEEDWAY RECONSTRUCTION
(HOLCOMBE BLVD. TO BISSONNET)

OVERALL DRAINAGE AREA MAP

1" = 800'

SHEET 1 OF 1

Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6	(SEE THE TITLE SHEET)		314
STATE	DIST.	COUNTY	
TEXAS	12	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.
0912	72	360	CS

Area ID	Area (acres)	Time of Concentration (hours)	Storage Coefficient (hours)	Runoff Coefiicient (C)	Peak Discharge (cfs)		
					2-Year	10-Year	100-Year
COH N	131.21	0.64	0.40	0.80	281	462	704
BSWT 1A	21.27	0.54	0.85	0.55	32	55	87
BSW 01	10.00	0.50	0.80	0.55	16	27	42
BSW 02	9.98	0.50	0.80	0.55	16	27	42
BSW 03	10.25	0.50	0.80	0.55	16	27	43
BSWT 2A	6.32	0.48	0.78	0.55	10	17	27
BSW 04	10.21	0.50	0.80	0.55	16	27	43
BSW 05N	4.72	0.47	0.77	0.55	8	13	21
BSW 05 S	25.64	0.55	0.86	0.55	38	66	104
BSWT 3A	18.47	0.53	0.84	0.55	28	48	76
BSW 06 N	19.23	0.53	0.84	0.55	29	50	79
BSW06 S	13.23	0.51	0.82	0.55	20	35	55
BSW 12	15.00	0.52	0.82	0.55	23	39	62
BSWT 4A	10.52	0.50	0.80	0.55	16	28	44
BSW 07	19.58	0.53	0.84	0.55	30	51	81
BSW13	10.06	0.50	0.80	0.55	16	27	43
BSWT 5A	8.80	0.49	0.79	0.55	14	24	37
BSW 08	27.51	0.55	0.86	0.55	41	70	112
BSW 14	11.71	0.51	0.81	0.55	18	31	49
BSWT 6A	5.48	0.48	0.77	0.55	9	15	24
BSW 09	32.57	0.56	0.87	0.55	48	83	131
BSW 15	8.69	0.49	0.79	0.55	14	23	37
BSWT 7A	5.26	0.47	0.77	0.55	8	14	23
BSW 10	24.71	0.54	0.86	0.55	37	63	101
BSWT 8A	7.30	0.49	0.78	0.55	12	20	31
BSW 11	28.62	0.55	0.87	0.55	43	73	116
COH S	45.57	0.58	0.55	0.69	87	144	223

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

DRAINAGE AREA MAP

EXHIBIT 1B

PATH: Q:\BUFFALO_MODEL\BUFFALO SPEEDWAY REPORT\POST TXDOT REVISIONS\GIS\WORKMAP.MXD - USER: HAHMED - DATE: 9/18/2019

Exhibit 2. Storm Sewer Sizing Layout

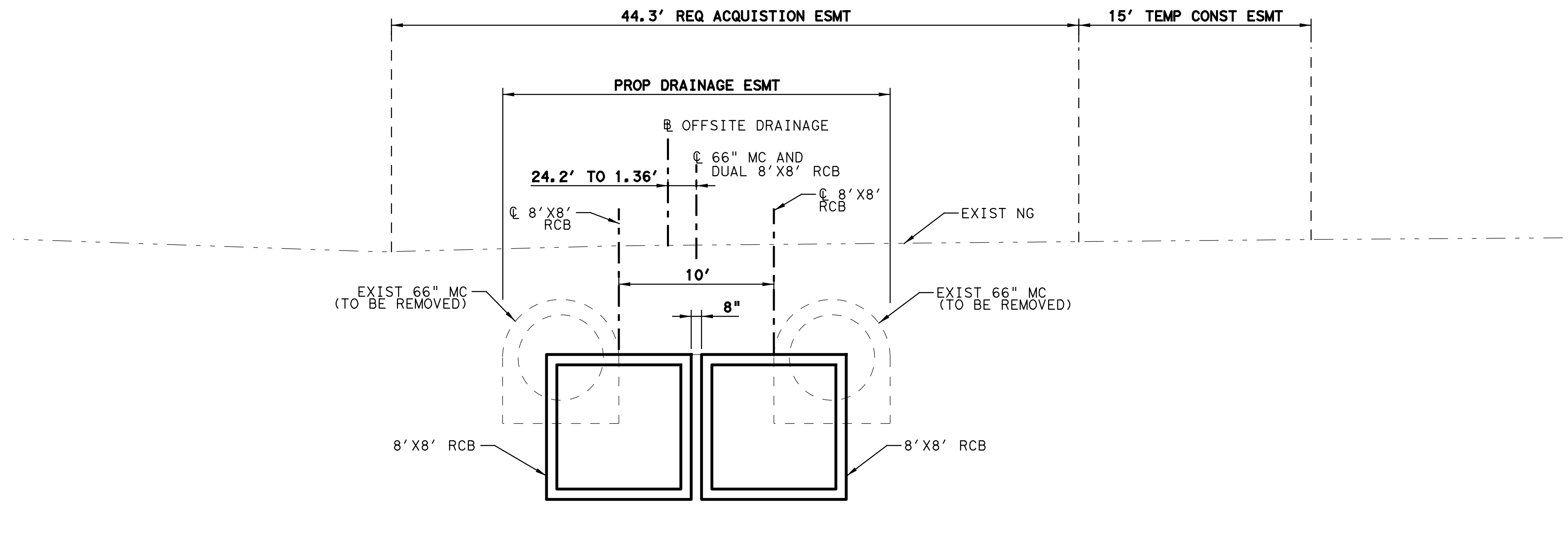
BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED DRAINAGE SYSTEM LAYOUT

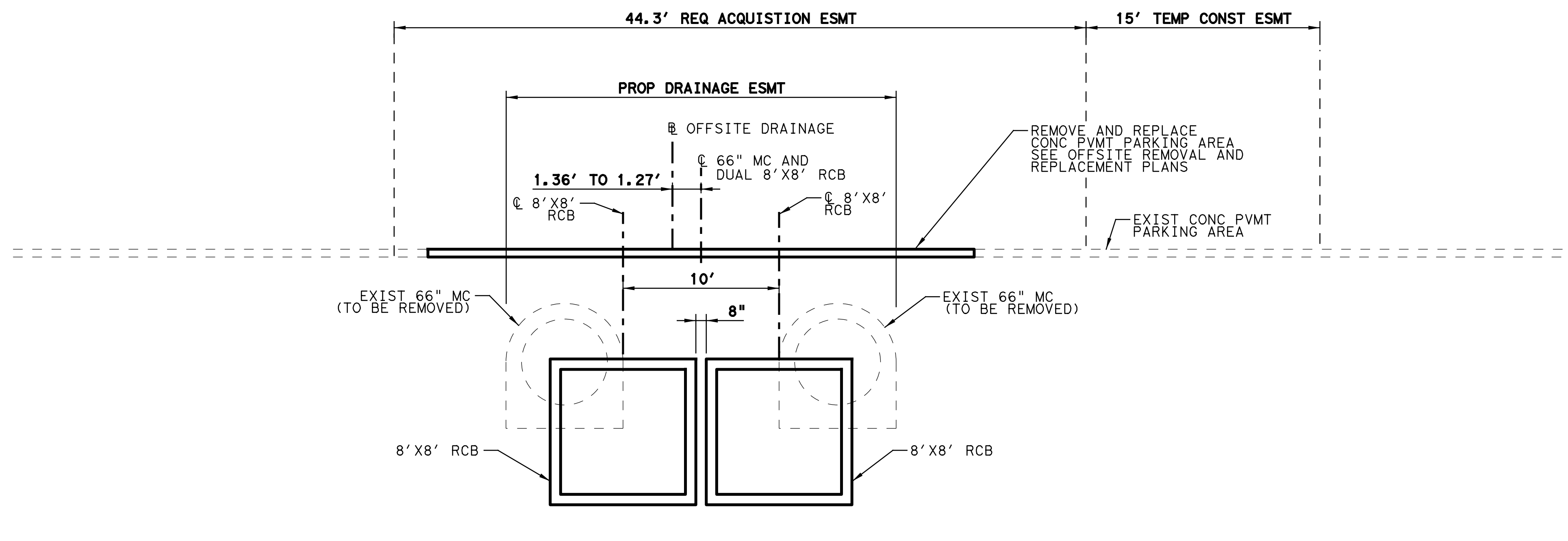
EXHIBIT 2

PATH: Q:\BUFFALO_MODEL\XPSWMM\REVISED\RESULTS\UPDATE\GIS\LAYOUT.MXD - USER: HAHMED - DATE: 9/12/2019

Exhibit 3. Existing and Proposed Typical Sections



PROPOSED TYPICAL SECTION
OFFSITE DRAINAGE
BEGIN TO STA 6+14



PROPOSED TYPICAL SECTION
OFFSITE DRAINAGE
APPROX. STA 6+14 TO STA 6+71

NOTE:

1. FOR TYPICAL SECTION STATIONING, SEE DRAINAGE PLAN AND PROFILE SHEETS.

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Texas Registered Engineering Firm 754

City of West University Place

BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD. TO BISSONNET)

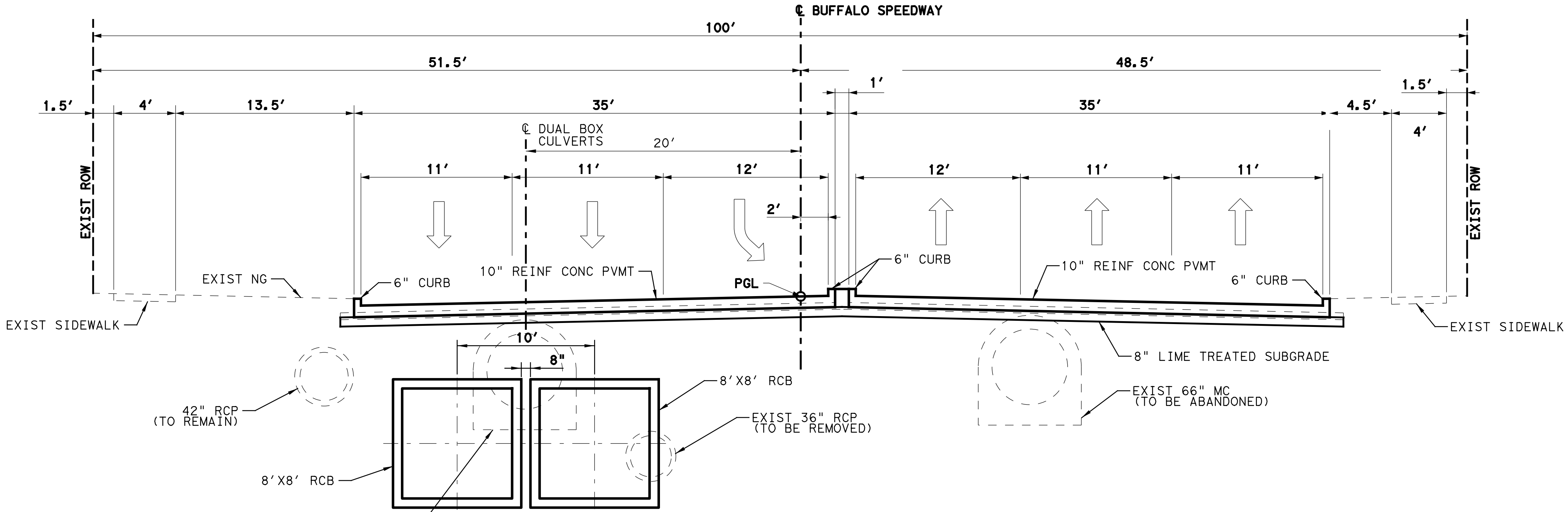
PROPOSED TYPICAL DRAINAGE SECTIONS

SCALE : NTS

SHEET 1 OF 3

Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.			SHEET NO.
6	(SEE THE TITLE SHEET)			21
STATE	DIST.	COUNTY		
TEXAS	12	HARRIS		
CONT.	SECT.	JOB	HIGHWAY NO.	
0912	72	360	CS	

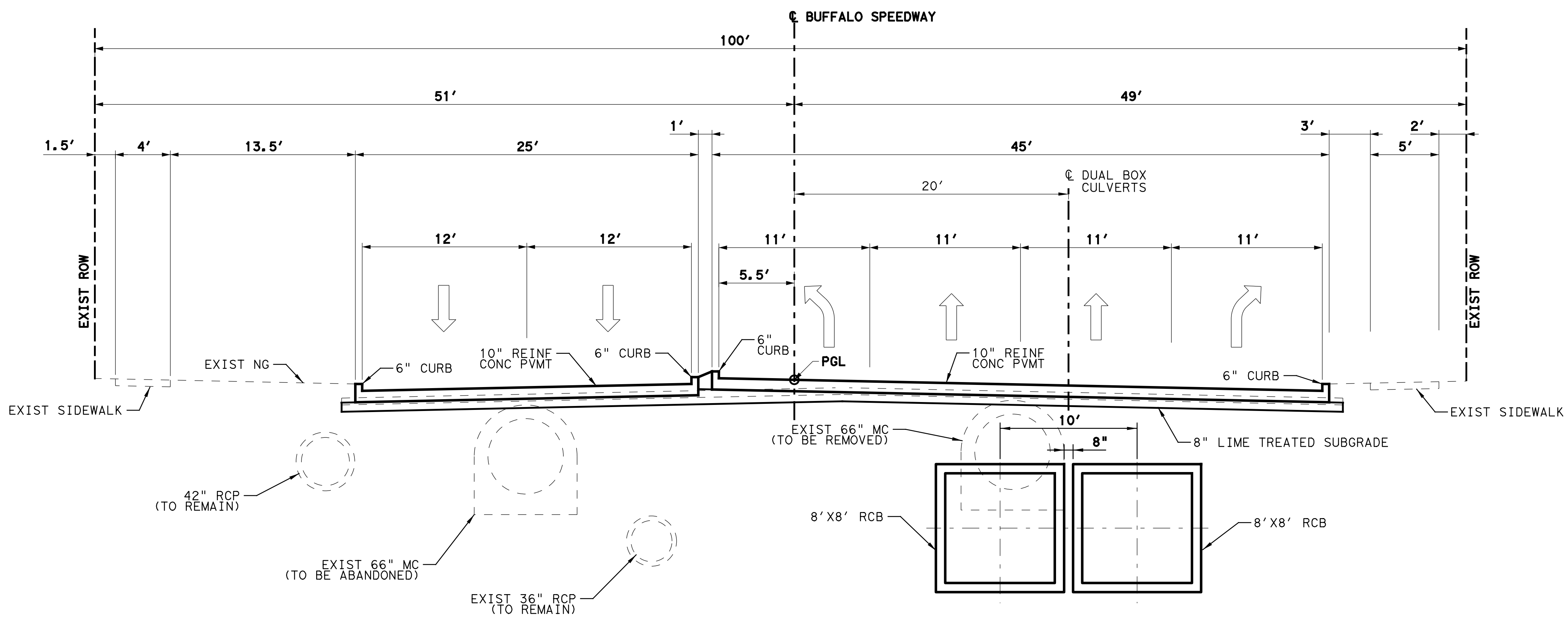


BUFFALO SPEEDWAY DRAINAGE TYPICAL SECTION

DUAL BOX CULVERTS
APPROX. STA 2+83.97 TO STA 7+00.00

NOTES:

1. FOR TYPICAL SECTION STATIONING, SEE DRAINAGE PLAN AND PROFILE SHEETS.
2. SEE ROADWAY TYPICAL SECTIONS FOR DETAILS ON THE ROADWAY RECONSTRUCTION.



BUFFALO SPEEDWAY DRAINAGE TYPICAL SECTION

DUAL BOX CULVERTS
APPROX. STA 7+00.00 TO STA 10+10.00

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BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD. TO BISSONNET)

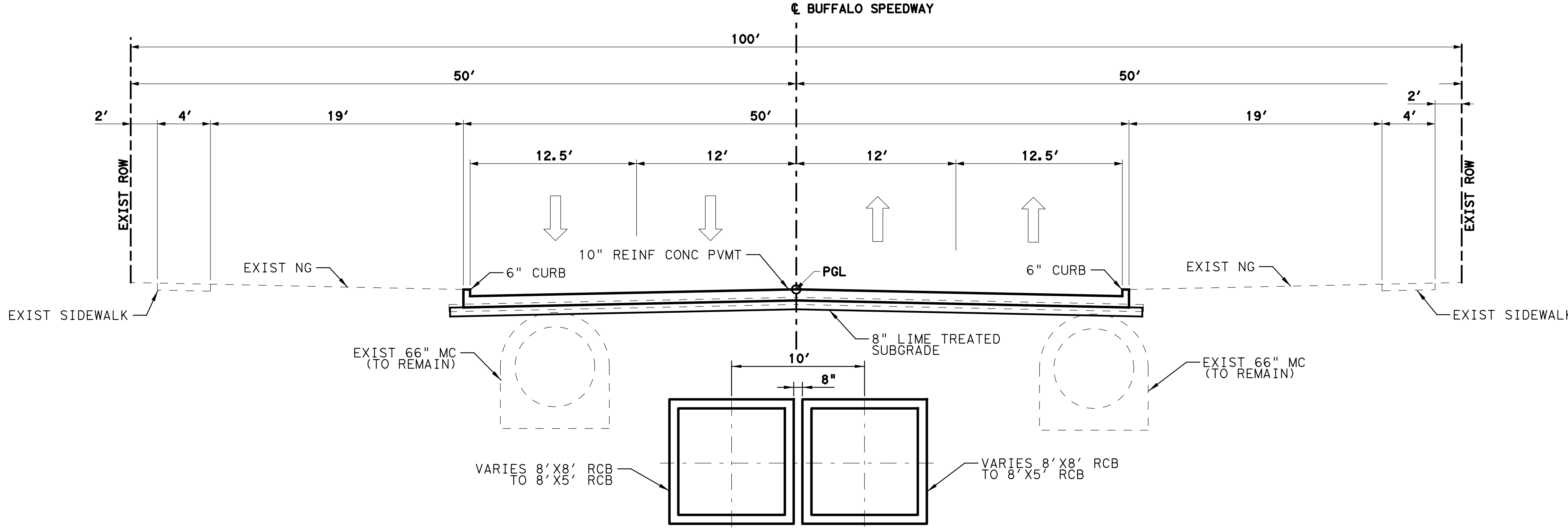
PROPOSED TYPICAL DRAINAGE SECTIONS

SCALE : NTS

SHEET 2 OF 3

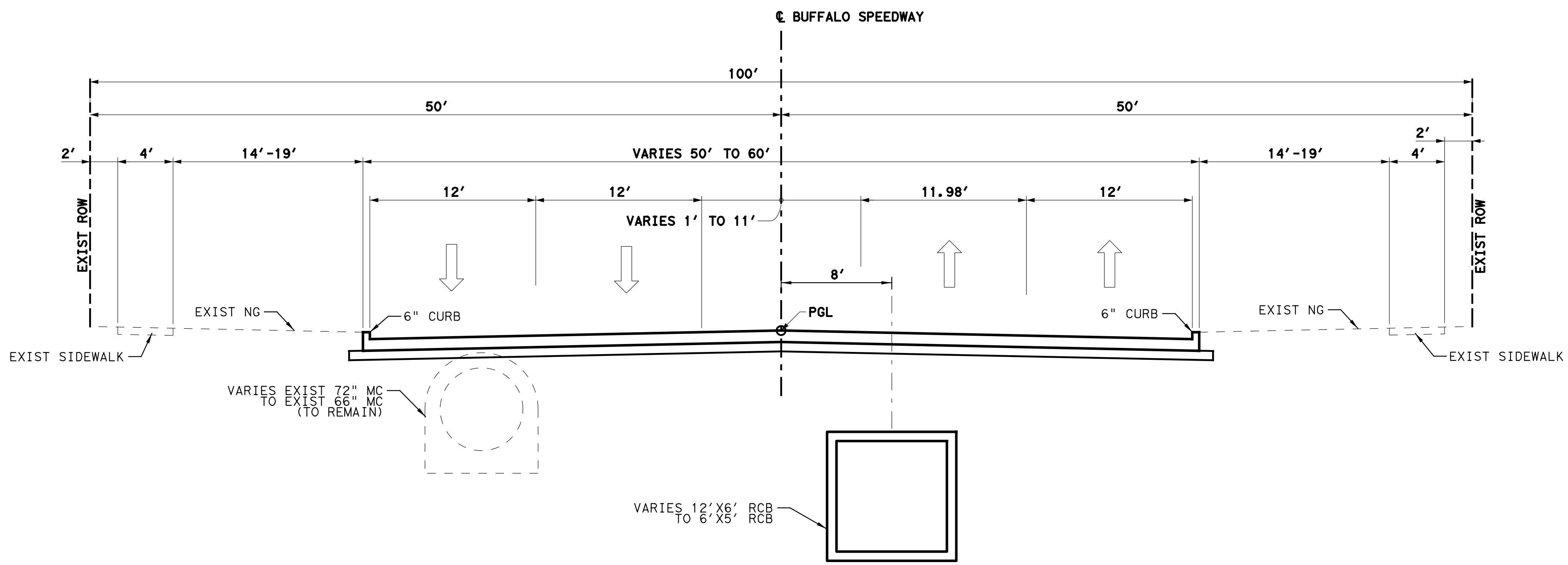
Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6	(SEE THE TITLE SHEET)		22
STATE	DIST.	COUNTY	
TEXAS	12	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.
0912	72	360	CS



BUFFALO SPEEDWAY DRAINAGE TYPICAL SECTION

DUAL BOX CULVERTS
NORTH OF HOLCOMBE BLVD TO AMHERST STREET
APPROX. STA 10+10.00 TO STA 45+10.61



BUFFALO SPEEDWAY DRAINAGE TYPICAL SECTION

SINGLE BOX CULVERTS, AND RCP
NORTH OF HOLCOMBE FROM AMHERST STREET TO BISSONNET STREET
STA 45+10.61 TO STA 78+10.00

NOTES:

1. FOR TYPICAL SECTION STATIONING, SEE DRAINAGE PLAN AND PROFILE SHEETS.
2. SEE ROADWAY TYPICAL SECTIONS FOR DETAILS ON THE ROADWAY RECONSTRUCTION.

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BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD. TO BISSONNET)

PROPOSED TYPICAL DRAINAGE SECTIONS

SCALE : NTS

SHEET 3 OF 3

Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.			SHEET NO.
6	(SEE THE TITLE SHEET)			23
STATE	DIST.		COUNTY	
TEXAS	12		HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0912	72	360	CS	

Exhibit 4. Flooding Map, Existing Conditions, 2-Year Storm Event

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

EXISTING PONDING MAP - 2-YEAR

EXHIBIT 4

PATH: Q:\BUFFALO_MODEL\GIS\04-26-2020\WORKMAP\MAPS.MXD - USER: HAHMED - DATE: 4/26/2020

Exhibit 5. Flooding Map, Existing Conditions, 10-Year Storm Event

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

EXISTING PONDING MAP - 10-YEAR

EXHIBIT 5

PATH: Q:\BUFFALO_MODEL\GIS\04-26-2020\WORKMAP\MAPS.MXD - USER: HAHMED - DATE: 4/26/2020

Exhibit 6. Flooding Map, Existing Conditions, 100-Year Storm Event

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

EXISTING PONDING MAP - 100-YEAR

EXHIBIT 6

PATH: Q:\BUFFALO_MODEL\GIS\04-26-2020\WORKMAP\MAPS.MXD - USER: HAHMED - DATE: 4/26/2020

Exhibit 7. Flooding Map, Proposed Conditions, 2-Year Storm Event

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED PONDING MAP - 2-YEAR

EXHIBIT 7

PATH: Q:\BUFFALO_MODEL\GIS\04-26-2020\WORKMAP\MAPS.MXD - USER: HAHMED - DATE: 4/26/2020

Exhibit 8. Flooding Map, Proposed Conditions, 10-Year Storm Event

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED PONDING MAP - 10-YEAR

EXHIBIT 8

PATH: Q:\BUFFALO_MODEL\GIS\04-26-2020\WORKMAP\MAPS.MXD - USER: HAHMED - DATE: 4/26/2020

Exhibit 9. Flooding Map, Proposed Conditions, 100-Year Storm Event

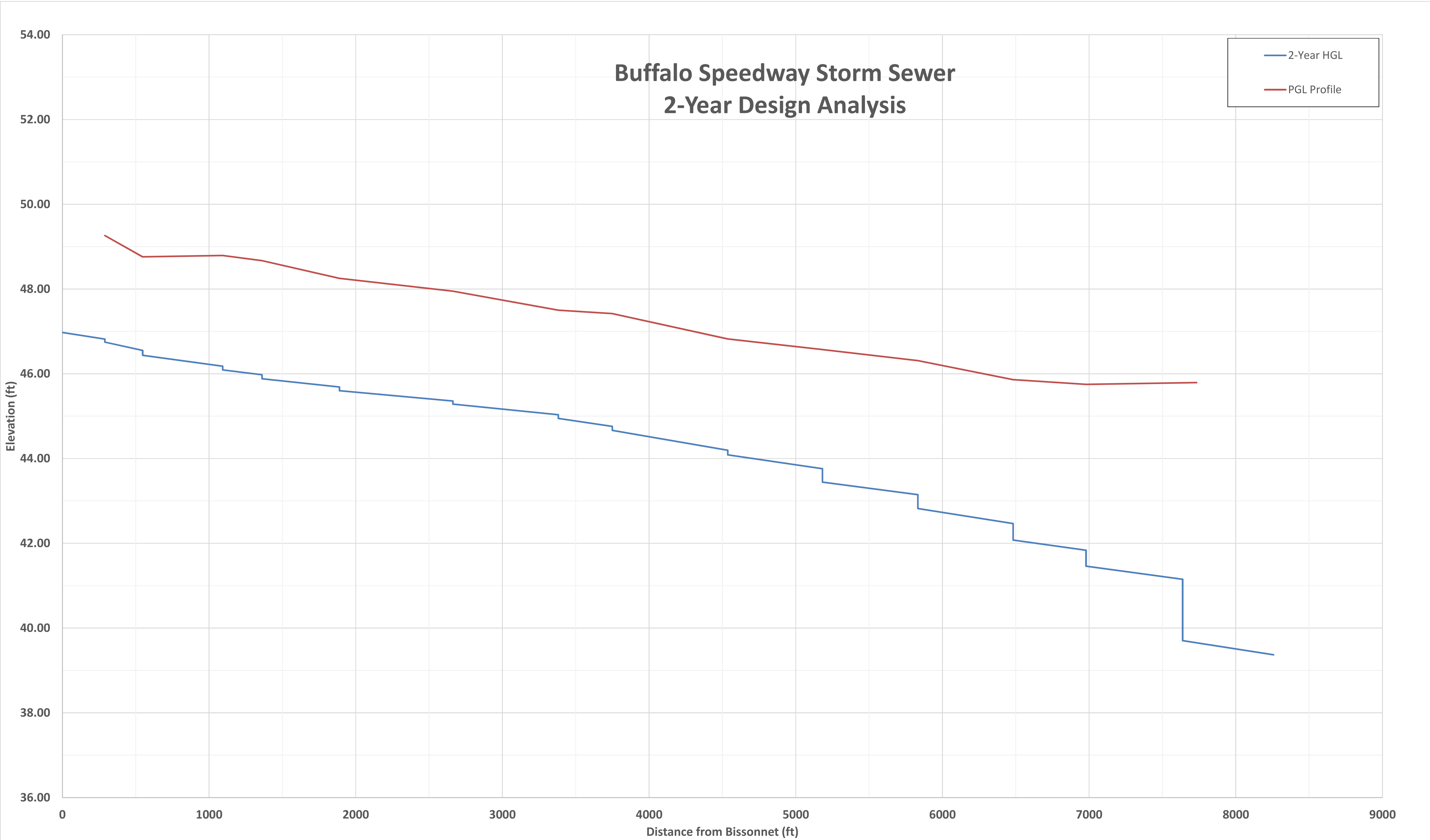
BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED PONDING MAP - 100-YEAR

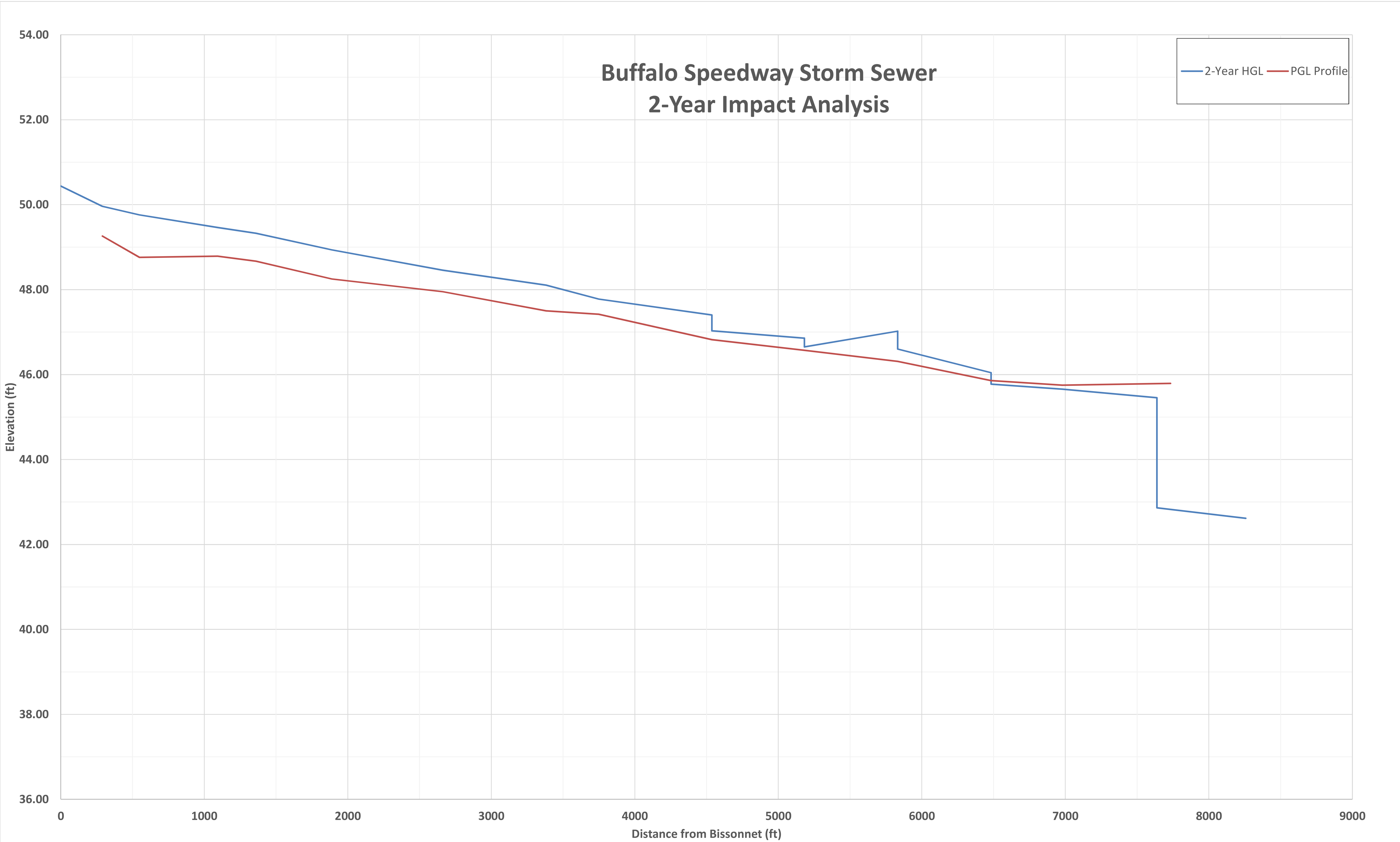
EXHIBIT 9

PATH: Q:\BUFFALO_MODEL\GIS\04-26-2020\WORKMAP\MAPS.MXD - USER: HAHMED - DATE: 4/26/2020

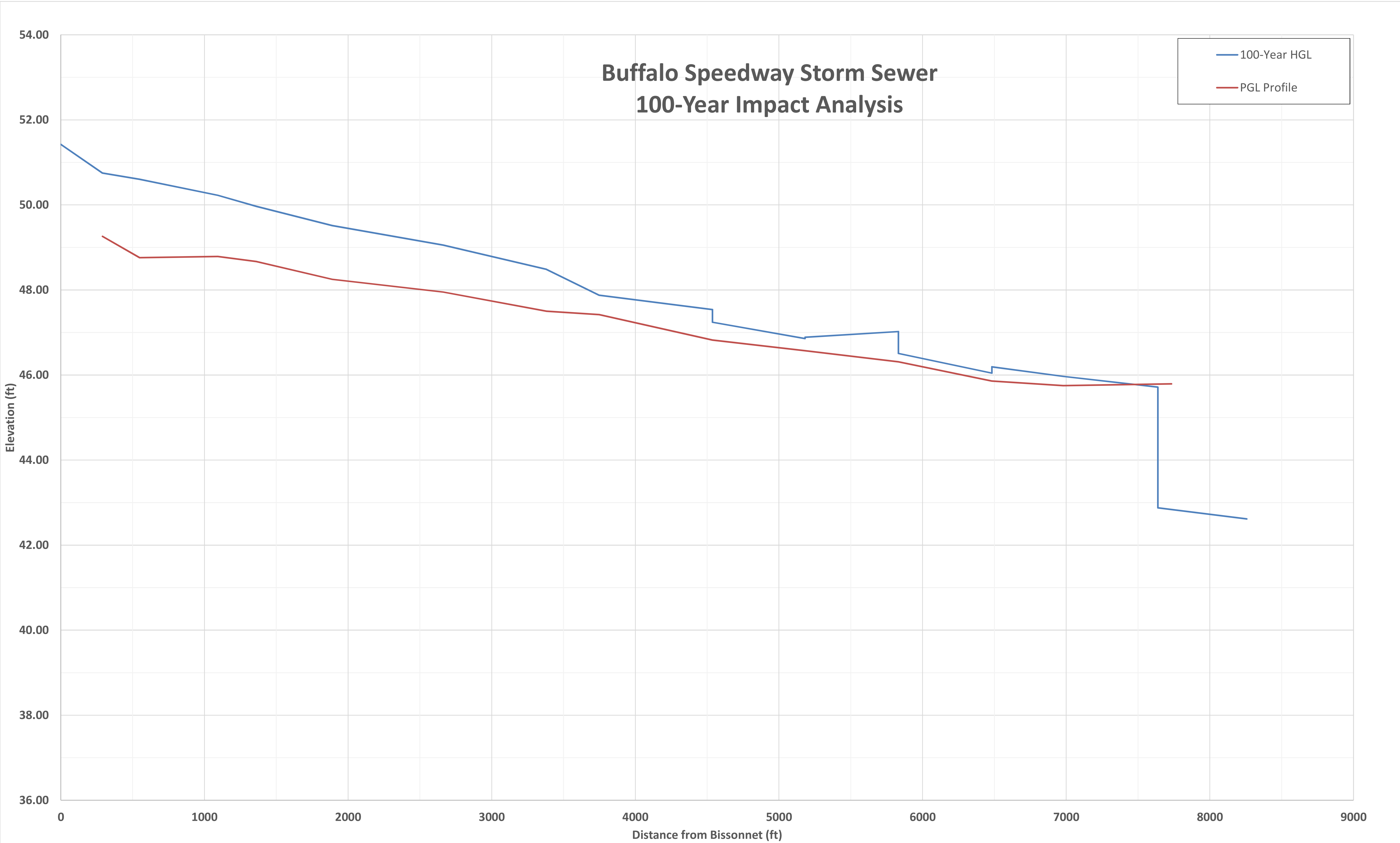
Exhibit 10. HGL Plots, Proposed System, 2-Year and 100-Year Storm Events



Buffalo Speedway Storm Sewer
2-Year Design Analysis
2-Year HGL
PGL Profile
Elevation (ft)
Distance from Bissonnet (ft)
54.00
52.00
50.00
48.00
46.00
44.00
42.00
40.00
38.00
36.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000

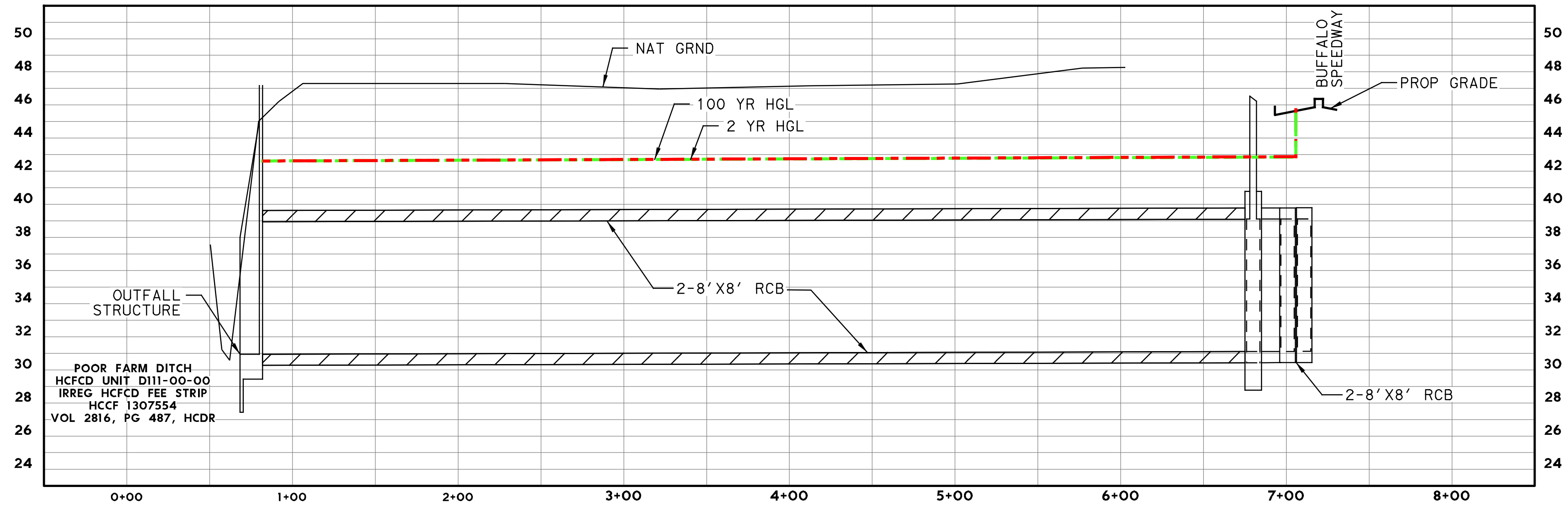


Buffalo Speedway Storm Sewer
2-Year Impact Analysis
2-Year HGL
PGL Profile
Elevation (ft)
54.00
52.00
50.00
48.00
46.00
44.00
42.00
40.00
38.00
36.00
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Distance from Bissonnet (ft)

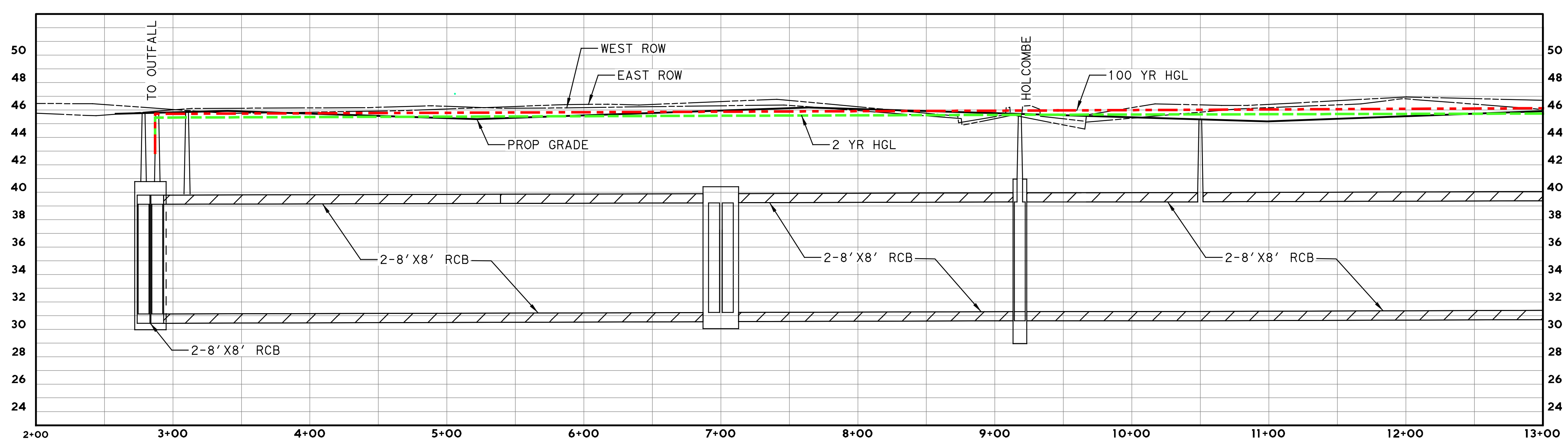

Buffalo Speedway Storm Sewer
100-Year Impact Analysis
100-Year HGL
PGL Profile
54.00
52.00
50.00
48.00
46.00
44.00
42.00
40.00
38.00
36.00
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Distance from Bissonnet (ft)

LEGEND

- 2 YR HGL
- 100 YR HGL
- PROP GRADE
- EAST ROW
- WEST ROW



OUTFALL TO BUFFALO SPEEDWAY



BUFFALO SPEEDWAY

0 50 100 150 200
HORIZ. SCALE IN FEET

0 5 10 15 20
VERT. SCALE IN FEET

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BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD TO BISSONNET)

DRAINAGE STUDY

SCALE: 1"=100'-H
1"=10'-V

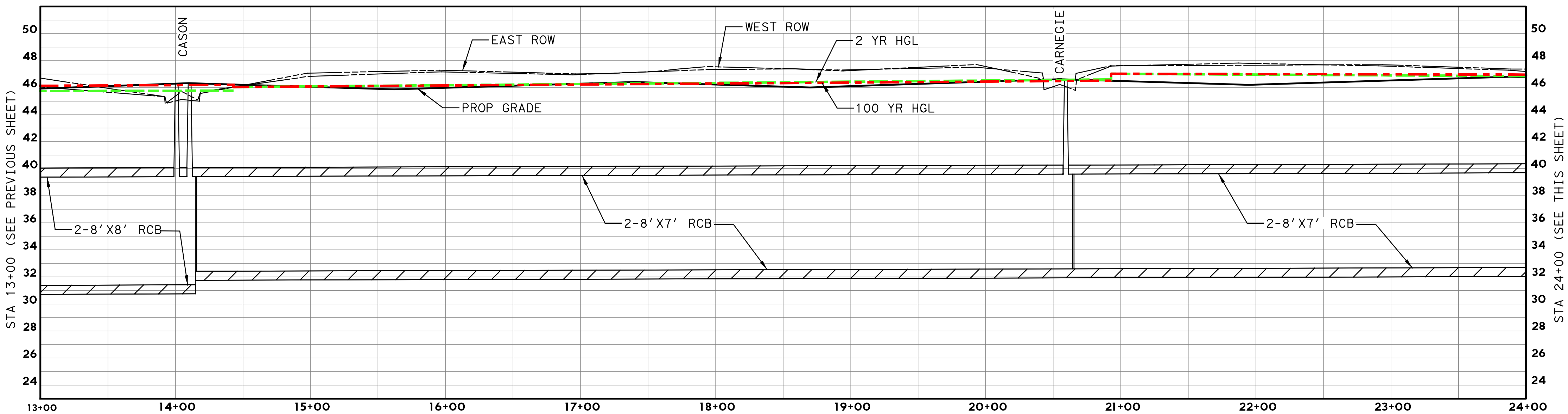
SHEET 1 OF 4

Texas Department of Transportation

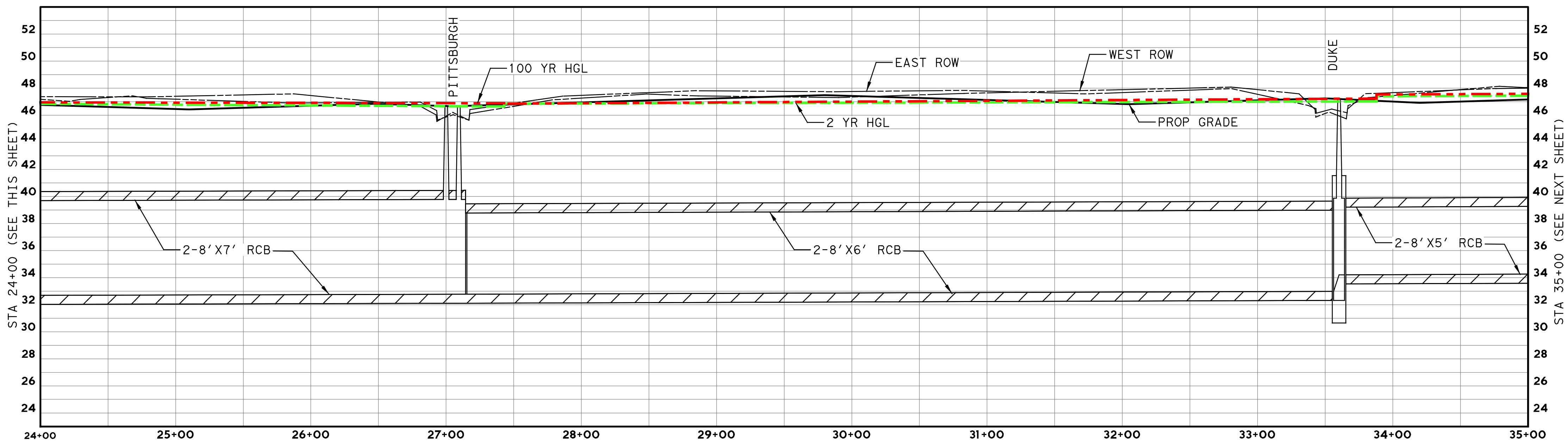
FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6	STP 1702 (818) MM		
STATE	DIST.	COUNTY	
TEXAS	12	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.
0912	72	360	CS

LEGEND

- 2 YR HGL
- 100 YR HGL
- PROP GRADE
- EAST ROW
- WEST ROW



BUFFALO SPEEDWAY



BUFFALO SPEEDWAY

0 50 100 150 200
HORIZ. SCALE IN FEET

0 5 10 15 20
VERT. SCALE IN FEET

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BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD TO BISSONNET)

DRAINAGE STUDY

SCALE: 1"=100'-H
1"=10'-V

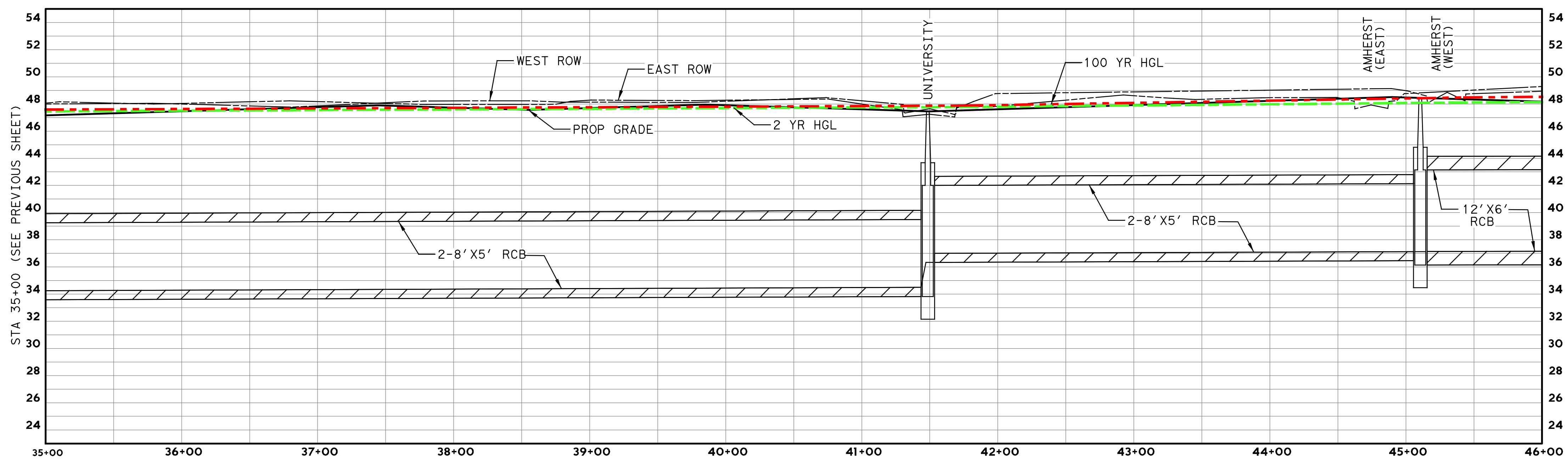
SHEET 2 OF 4

Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6	STP 1702 (818) MM		
STATE	DIST.	COUNTY	
TEXAS	12	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.
0912	72	360	CS

LEGEND

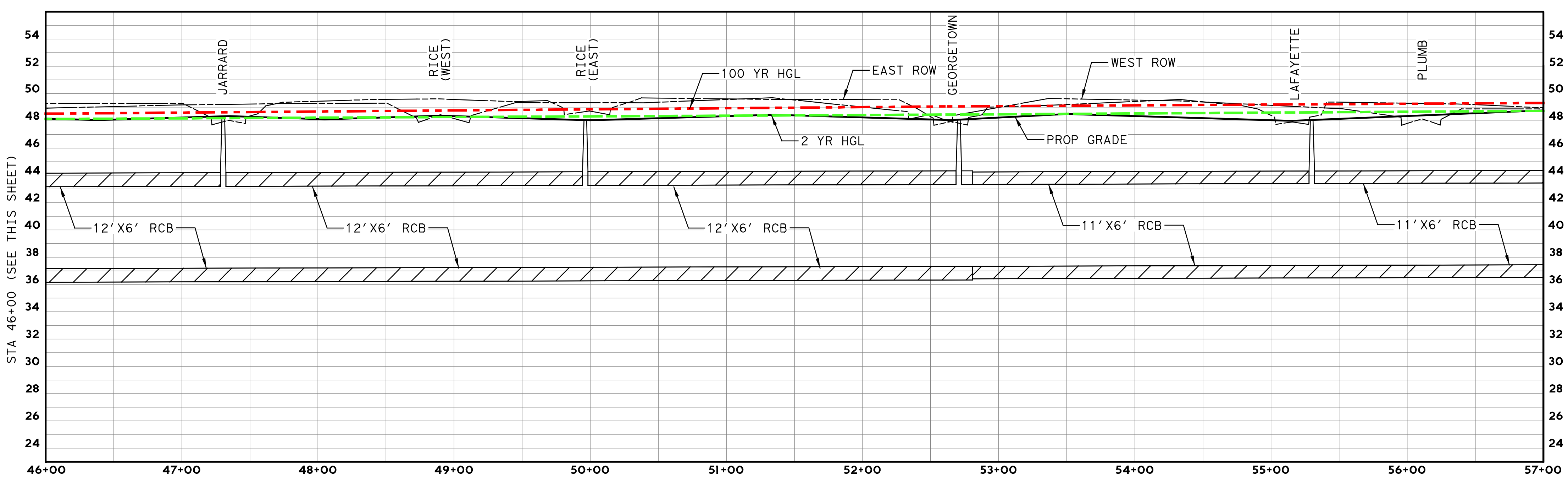
- 2 YR HGL
- 100 YR HGL
- PROP GRADE
- EAST ROW
- WEST ROW



BUFFALO SPEEDWAY

0 50 100 150 200
HORIZ. SCALE IN FEET

0 5 10 15 20
VERT. SCALE IN FEET



BUFFALO SPEEDWAY

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BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD TO BISSONNET)

DRAINAGE STUDY

SCALE: 1"=100'-H
1"=10'-V

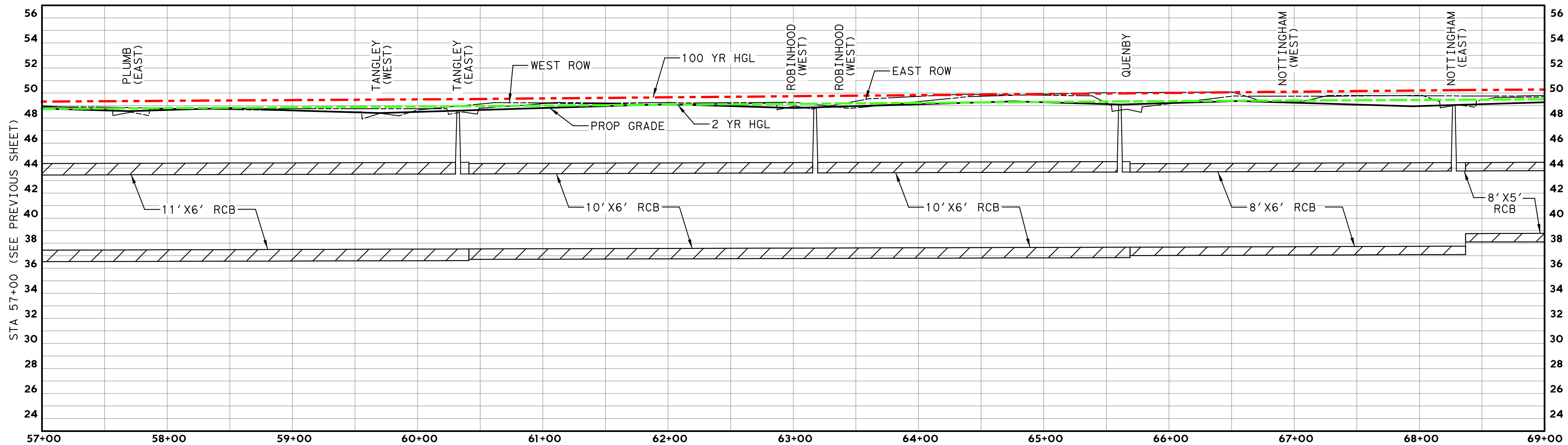
SHEET 3 OF 4

Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.			SHEET NO.
6	STP 1702 (818) MM			
STATE	DIST.		COUNTY	
TEXAS	12		HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.	
0912	72	360	CS	

LEGEND

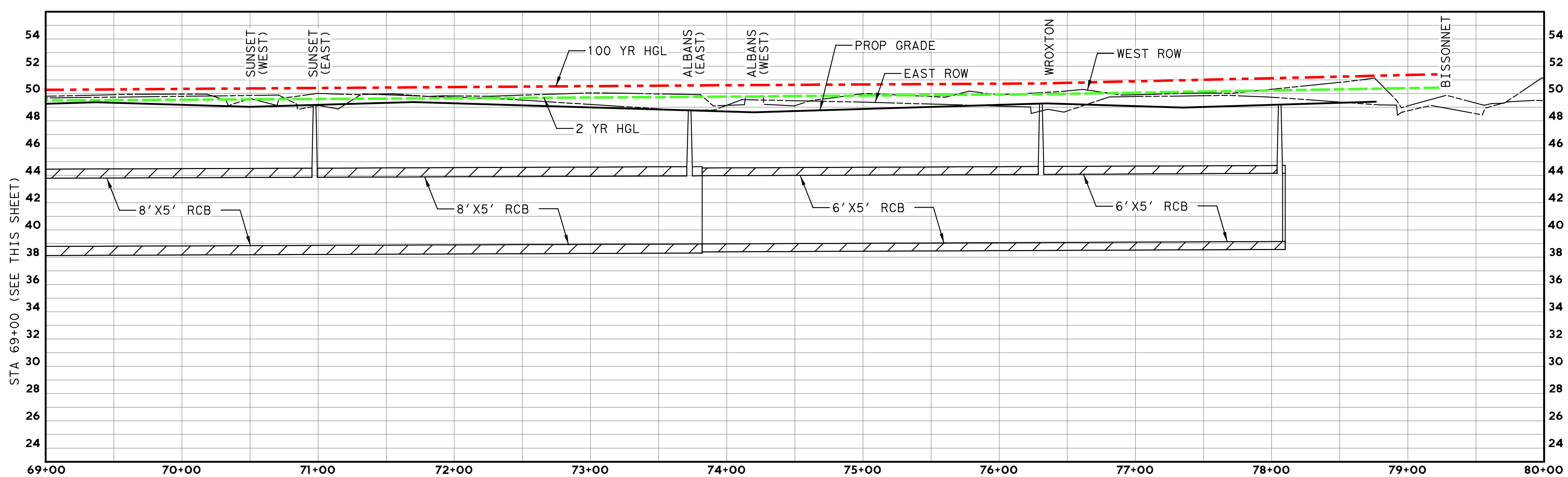
- 2 YR HGL
- 100 YR HGL
- PROP GRADE
- EAST ROW
- WEST ROW



BUFFALO SPEEDWAY

0 50 100 150 200
HORIZ. SCALE IN FEET

0 5 10 15 20
VERT. SCALE IN FEET



BUFFALO SPEEDWAY

NOT FOR CONSTRUCTION

THIS DOCUMENT IS RELEASED FOR THE PURPOSE OF INTERIM REVIEW UNDER THE AUTHORITY OF JEREMY R BLEVINS, P.E. TEXAS NO: 109719 ON DATE: MAY 1, 2020 IT IS NOT TO BE USED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

HDR
4828 Loop Central Dr, Suite 800
Houston, Texas 77081
713-622-9264
HDR Engineering, Inc.
Texas Registered Engineering Firm 754

BUFFALO SPEEDWAY RECONSTRUCTION (HOLCOMBE BLVD TO BISSONNET)

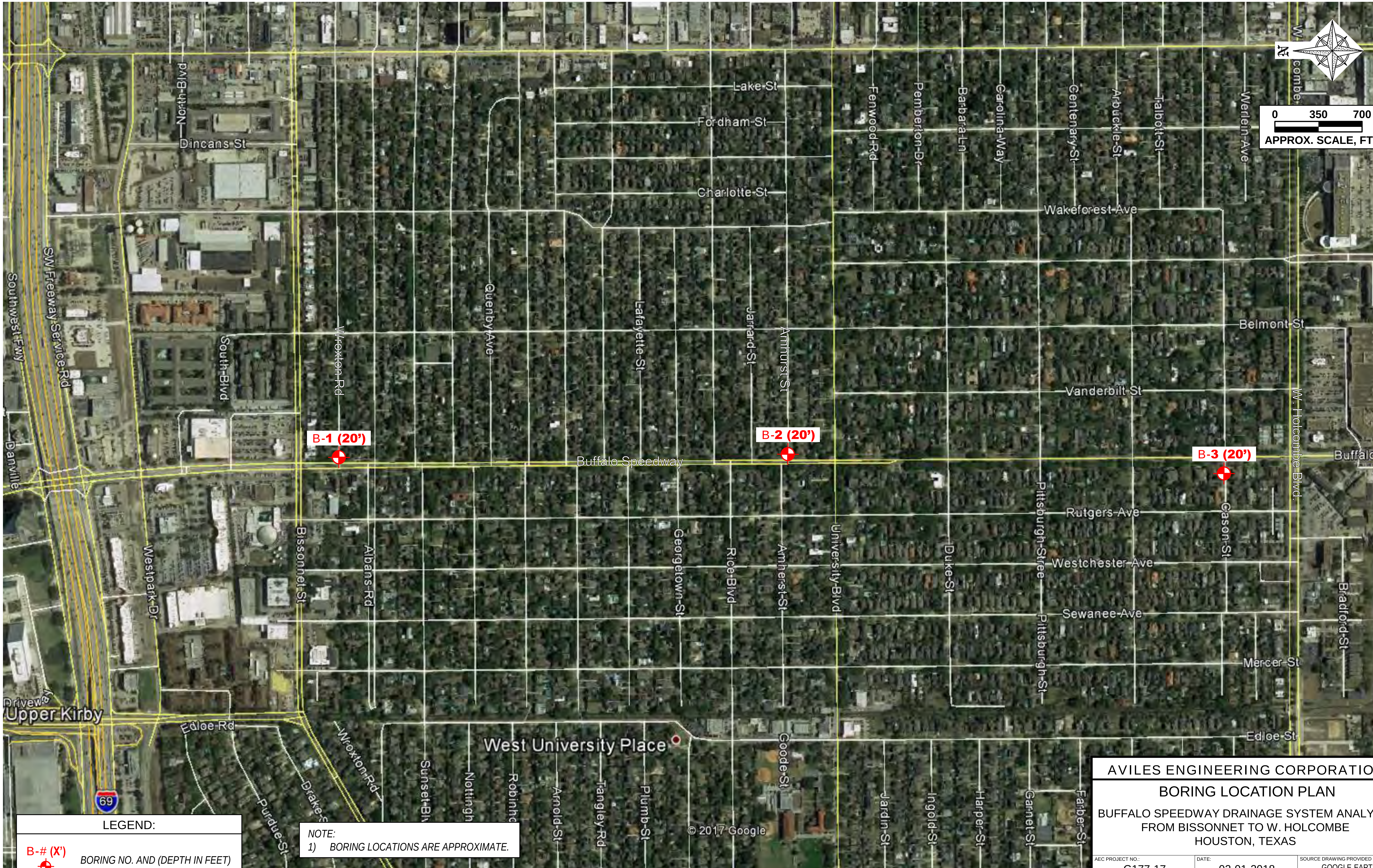
DRAINAGE STUDY

SCALE: 1"=100'-H
1"=10'-V

Texas Department of Transportation

FED.RD. DIV.NO.	PROJECT NO.		SHEET NO.
6	STP 1702 (818) MM		
STATE	DIST.	COUNTY	
TEXAS	12	HARRIS	
CONT.	SECT.	JOB	HIGHWAY NO.
0912	72	360	CS

Exhibit 11. Geotechnical Boring Plan



LEGEND:

B-# (X') BORING NO. AND (DEPTH IN FEET)

NOTE:
1) BORING LOCATIONS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

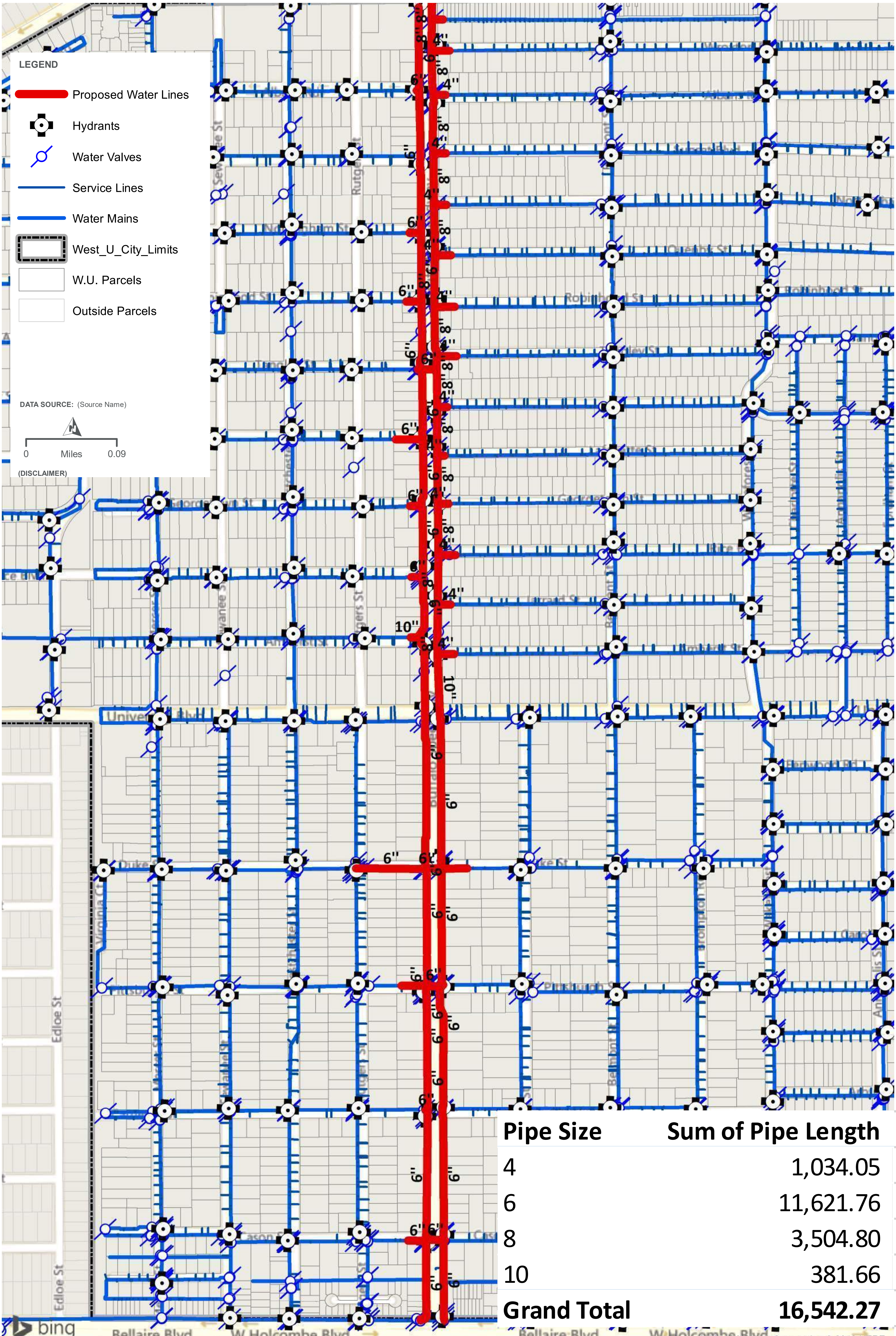
BORING LOCATION PLAN

BUFFALO SPEEDWAY DRAINAGE SYSTEM ANALYSIS
FROM BISSONNET TO W. HOLCOMBE
HOUSTON, TEXAS

AEC PROJECT NO.:	DATE:	SOURCE DRAWING PROVIDED BY:
G177-17	02-01-2018	GOOGLE EARTH
APPROX. SCALE:	DRAFTED BY:	PLATE NO.:
1" = 700'	WLW/JG	PLATE 1

EXHIBIT 11

Exhibit 12. Buffalo Speedway Water Line Layout from Recent Infrastructure Upgrades



Pipe Size	Sum of Pipe Length
4	1,034.05
6	11,621.76
8	3,504.80
10	381.66
Grand Total	**16,542.27**

PROPOSED WATER LINE REPLACEMENT ALONG BUFFALO SPEEDWAY

BISSONNET TO AMHERST

EXHIBIT 12

NTS\ANGLETON\MASTER PLAN\WATER MODEL\WEST UNIVERSITY PLACE BUFFALO SPEEDWAY WATER LINES ALL.MXD - USER: LTEFFT - DATE: 8/16/2018

Appendix A. Hydraulic Grade Line (HGL) Design Analysis Calculations

Pipe Head Loss Calculations
HDR Engineering, Inc.

This program computes head losses through composite pipes under pressure flow conditions. Use for detention basin outlets.

Note that the 6' x 4' RCB shown between Bissonnet and Wroxton simulates the existing single 66" pipe to be left in place in that segment.

Standard* Manning Roughness Coefficient = 0.013
Standard* Entrance Loss Coefficient = 0.50
Standard* Junction Loss Coefficient = 0.50
Standard* Restrictor Loss Coefficient = 1.50

** Standard values may be overridden by entering a value in the appropriate cell.*

From	To	Type of Loss	Span (feet)	Rise (feet)	No. of Barrels	X-Sec. Area	Total Q (cfs)	V_1 (ft/sec)	V_2 (ft/sec)	K / C	Manning n	Length (feet)	R (feet)	H_L (feet)	HGL (feet)	Station (feet)
Bissonnet	-----	Entrance	6	4	1	24	72.46	3.02	-----	0.50	-----	-----	-----	0.07	47.05	0
Bissonnet	Wroxton	Friction	6	4	1	24	72.46	3.02	-----	-----	0.013	290	1.200	0.16	46.97	0
Wroxton	-----	Junction	6	4	1	24	72.46	3.02	-----	0.50	-----	-----	-----	0.07	46.82	290
Wroxton	Albans	Friction	6	5	1	30	116.01	3.87	-----	-----	0.013	258	1.364	0.19	46.75	290
Albans	-----	Junction	6	5	1	30	116.01	3.87	-----	0.50	-----	-----	-----	0.12	46.55	548
Albans	Nottingham	Friction	8	5	1	40	132.71	3.32	-----	-----	0.013	545	1.538	0.26	46.44	548
Nottingham	-----	Junction	8	5	1	40	132.71	3.32	-----	0.50	-----	-----	-----	0.09	46.18	1093
Nottingham	Quenby	Friction	8	6	1	48	166.18	3.46	-----	-----	0.013	268	1.714	0.12	46.09	1093
Quenby	-----	Junction	8	6	1	48	166.18	3.46	-----	0.50	-----	-----	-----	0.09	45.97	1361
Quenby	Tangley	Friction	10	6	1	60	201.18	3.35	-----	-----	0.013	528	1.875	0.20	45.88	1361
Tangley	-----	Junction	10	6	1	60	201.18	3.35		0.50	-----	-----	-----	0.09	45.69	1889
Tangley	Georgetown	Friction	11	6	1	66	207.41	3.14	-----	-----	0.013	773	1.941	0.24	45.60	1889
Georgetown	-----	Junction	11	6	1	66	207.41	3.14	-----	0.50	-----	-----	-----	0.08	45.36	2662
Georgetown	Amherst	Friction	12	6	1	72	243.67	3.38	-----	-----	0.013	720	2.000	0.25	45.28	2662
Amherst	-----	Junction	12	6	1	72	243.67	3.38	-----	0.50	-----	-----	-----	0.09	45.03	3382
Amherst	University	Friction	8	5	2	80	274.76	3.43	-----	-----	0.013	367	1.538	0.19	44.94	3382
University	-----	Junction	8	5	2	80	274.76	3.43	-----	0.50	-----	-----	-----	0.09	44.76	3749
University	Duke	Friction	8	5	2	80	298.73	3.73	-----	-----	0.013	788	1.538	0.47	44.67	3749
Duke	-----	Junction	8	5	2	80	298.73	3.73	-----	0.50	-----	-----	-----	0.11	44.20	4537
Duke	Pittsburgh	Friction	8	6	2	96	354.31	3.69	-----	-----	0.013	645	1.714	0.33	44.09	4537
Pittsburgh	-----	Restrictor	8	6	2	96	354.31	3.69	-----	1.50	-----	-----	-----	0.32	43.76	5182
Pittsburgh	Carnegie	Friction	8	7	2	112	417.13	3.72	-----	-----	0.013	650	1.867	0.30	43.44	5182
Carnegie	-----	Restrictor	8	7	2	112	417.13	3.72	-----	1.50	-----	-----	-----	0.32	43.15	5832
Carnegie	Cason	Friction	8	7	2	112	456.35	4.07	-----	-----	0.013	650	1.867	0.36	42.82	5832
Cason	-----	Restrictor	8	7	2	112	456.35	4.07	-----	1.50	-----	-----	-----	0.39	42.46	6482
Cason	Bellaire	Friction	8	8	2	128	514.27	4.02	-----	-----	0.013	497	2.000	0.24	42.08	6482
Bellaire	-----	Restrictor	8	8	2	128	514.27	4.02	-----	1.50	-----	-----	-----	0.38	41.84	6979
Bellaire	Turn	Friction	8	8	2	128	504.53	3.94	-----	-----	0.013	659	2.000	0.31	41.46	6979
Turn	-----	90° Bends	8	8	2	128	504.53	3.94	-----	**6.00**	-----	-----	-----	1.45	41.15	7638
Turn	Outfall	Friction	8	8	2	128	542.04	4.23	-----	-----	0.013	619	2.000	0.34	39.70	7638
Outfall	-----	Exit	8	8	2	128	542.04	4.23	0.00	1.50	-----	-----	-----	0.42	39.37	8257
TOTAL HEAD LOSS (FEET)															**8.10**	
TAILWATER ELEVATION (FEET)															**38.95**	
HEADWATER ELEVATION (FEET)															**47.05**	

Three 90-degree bends @ 1.5 each plus one restrictor @ 1.5 =

Top of Pipe Elevation @ Outfall = 38.95
Maximum 2-Year WSEL @ Outfall (ft) = 42.50

Equations for Minor Losses

Avg. Junction HL (ft) = 0.09
Avg. Restrictor HL (ft) = 0.35

Entrance / Exit $H_E = K_E \times (V^2/2g)$ Ke = 0.5 - 1.0, depending on pipe material & type of entrance.

Junction / Restrictor $H_J = K_J \times (V^2/2g)$ K_J values established to reflect SWMM results.

Orifice $H_R = Q^2/(2gC^2A^2)$ K_O = 0.6 to 0.8, depending on type and shape of opening.

Appendix B. HEC-HMS Results to XP-SWMM Nodes Hydrograph Input

EXISTING CONDITIONS

XP-SWMM Input Node	HEC-HMS Output Node
Nd01	COH N
Nd02	Junction-1
Nd03	BSW 02
Nd04	BSW 03
Nd05	Junction-2
Nd06	BSW 05N
Nd07	BSW 05S
Nd08	BSWT 3A
Nd09	BSW 06N
Nd24	BSW 06S
Nd21	BSWT 4A
Nd19	BSW 07
Nd16	BSW 08
Nd17	Junction-3
Nd10	BSW 09
Nd11	Junction-6
Nd13	BSW 10
Nd12	Junction-4
Nd14	BSW 11
Nd15	Junction-5
Nd28	COH S

PROPOSED CONDITIONS

XP-SWMM Input Node	HEC-HMS Output Node
Nd01	COH N
NdP13	Junction-1
NdP11	BSW 02
NdP10	BSW 03
NdP09	Junction-2
NdP08	BSW 05N
NdP07	BSW 05S
Nd08	BSWT 3A
NdP04	BSW 06N
Nd24	BSW 06S
Nd21	BSWT 4A
Nd19	BSW 07
Nd16	BSW 08
Nd17	Junction-3
Nd10	BSW 09
Nd11	Junction-6
Nd13	BSW 10
Nd12	Junction-4
Nd14	BSW 11
Nd15	Junction-5
Nd28	COH S

Appendix C. “Virtual Tour” Photos for the Buffalo Speedway Project

Buffalo Speedway Improvements

Virtual Tour of Project Area

ALL SLIDES FACING SOUTH

City of West University Place, TX

August 10, 2018

Buffalo Speedway at Bissonnet

Buffalo Speedway at Wroxton

Buffalo Speedway at Albans

Buffalo Speedway at Sunset

Buffalo Speedway at Nottingham

Buffalo Speedway at Quenby

Buffalo Speedway at Robin Hood

Buffalo Speedway at Tangley

Buffalo Speedway at Plumb

Buffalo Speedway at Lafayette

Buffalo Speedway at Georgetown

Buffalo Speedway at Rice

Buffalo Speedway at Jarrard

Buffalo Speedway at Amherst

Buffalo Speedway at University

Buffalo Speedway at Duke

Buffalo Speedway at Pittsburgh

Buffalo Speedway at Carnegie

Buffalo Speedway at Cason

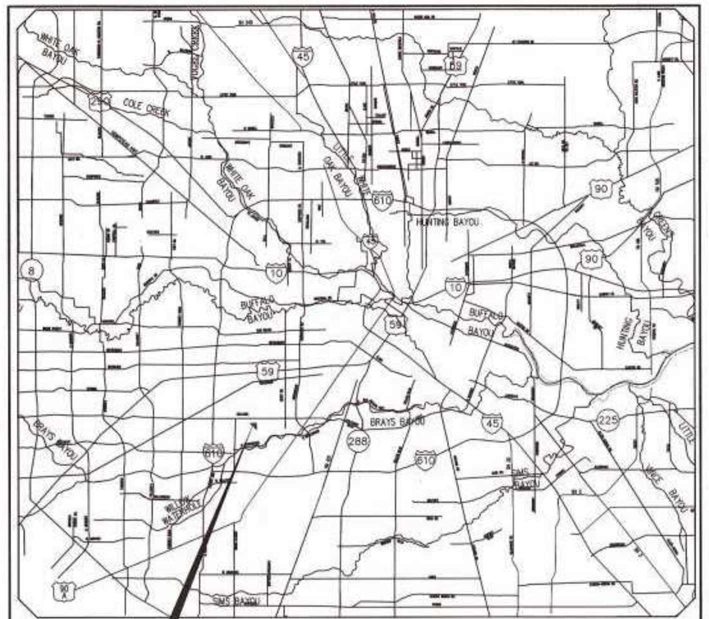
Buffalo Speedway at Bellaire Blvd.

Outfall to Poor Farm Ditch (From Bellefontaine)

Appendix D. Construction Plans for Rehabilitation of Buffalo Speedway Outfall to Poor Farm Ditch

City of West University Place, Texas

Repair of St. Vincent's Storm Sewer Outfall
at
Poor Farm Ditch Stilling Basin
April, 2014



LOCATION MAP

VICINITY MAP

NOT TO SCALE
KEY MAP NO. - 532 L
GIMS MAP NO. - 5255D
ZIP CODE - 77025

THE CITY OF WEST UNIVERSITY PLACE TEXAS

MAYOR

Bob Fry

COUNCIL

Susan Sample (Mayor Pro-Tem)
Ed Heathcoat
Joan Johnson
Dick Yehle

CITY MANAGER

Michael G. Ross

Assistant City Manager/Public Works Director

Chris Peifer

SHEET NO.	SHEET TITLE
1.	Cover Sheet/Location Map
2.	Access and Storm Water Pollution Prevention Plan
3.	Structural Repair Details
4.	H.C.F.C.D. Notes & Reinforcing Details
5.	H.C.F.C.D. Concrete Channel Lining Details
6.	H.C.F.C.D. Stormwater Pollution Prevention Details

THIS PROJECT INCLUDES WORK TO BE PERFORMED IN THE CITY OF HOUSTON'S RIGHT OF WAY AND EASEMENTS. DRAWINGS MUST BE APPROVED AND PERMITTED PRIOR TO BEGIN CONSTRUCTION

CONTACT REQUIRED SECTIONS BELOW AS INDICATED

DRAWINGS APPROVAL
- ☐ 1002 Washington (2nd Floor) 832-394-9146

PERMITS 1002 Washington (2nd Floor)
- ☐ PAVING 832-394-8851
- ☒ STORM 832-394-8851
- ☐ ALLEY 832-394-8851
- ☐ STREET CUT 832-394-9101
- ☐ EXCAVATION 832-394-9101

PERMITS 1002 Washington (3rd Floor)
- ☐ SANITARY 832-394-8971
- ☐ WATER 832-394-8971

Log No. 14-0374
ILMS No. 14027779

FOR PLAN REVIEW WALL THRU ONLY
APPROVED FLOODPLAIN GROUP
Date: 4/3/14 By: Vmo

ONE-CALL NOTIFICATION SYSTEM
CALL BEFORE YOU DIG!!!
(713) 223-4567 (in Houston)
(New Statewide Number Outside Houston)
1-800-545-6005

* NO PROPOSED WASTEWATER WORK IS SHOWN ON THIS PLAN SET NOR INCLUDED IN THIS WORK SCOPE.

Contractor shall notify the City of Houston, Department of Public Works and Engineering, Office of the City Engineer, 48 hours before starting work on this project. Telephone No. 832-394-9098.

ACCORDING TO MAP (NO. 48201C0860L) OF THE FEDERAL EMERGENCY MANAGEMENT AGENCY'S FLOOD INSURANCE RATE MAPS FOR HARRIS COUNTY AND INCORPORATED AREAS, DATED JUNE 18, 2007, THE SUBJECT TRACT IS SITUATED WITHIN: (ZONE AE).

4635 SW Fwy., Suite 1000
Houston, TX. 77027
(713) 622-9264

STATE OF TEXAS
STEPHEN RATCLIFFE
85731
LICENSED PROFESSIONAL ENGINEER
4/2/14

SURVEYED BY:
FB NO.:

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

WATER 4-3-14	STREET & BRIDGE 4-3-14
WASTEWATER * 4/3/14	TRAFFIC AND TRANSPORTATION
STORM 4-3-14	STORM WATER QUALITY 4-3-14
FACILITIES	
CITY ENGINEER 4-3-14	FOR CITY OF HOUSTON USE ONLY
DIRECTOR OF PUBLIC WORKS AND ENGINEERING 4/3/14	CITY DWG. NO. 51973
SHEET No: 1 OF 6	

SUBMITTED BY: ______________ DATE: ______________
Stephen Ratcliffe, P.E.
HDR Engineering, Inc.

HDR
HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

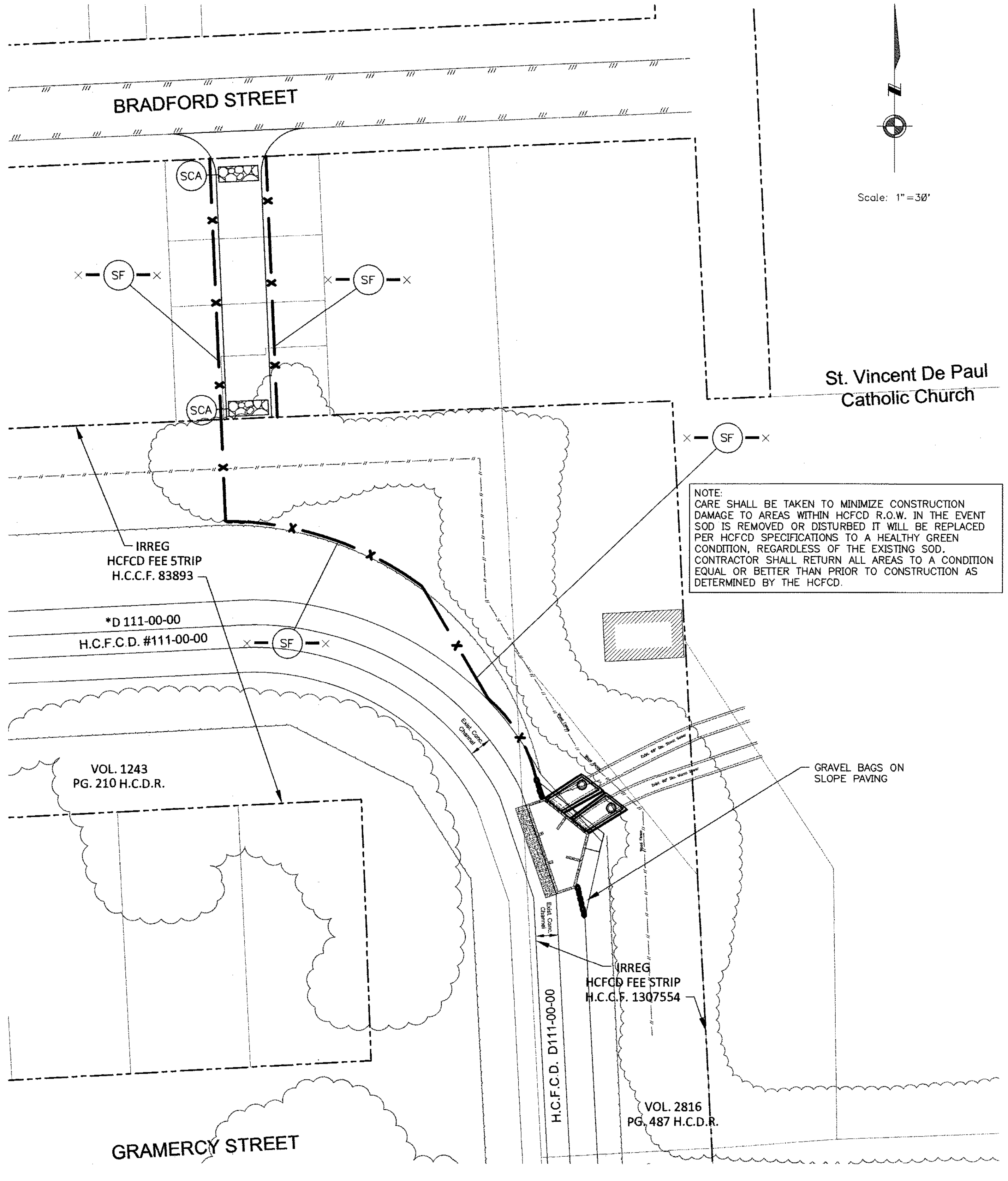
HDR JOB NO. 13-053

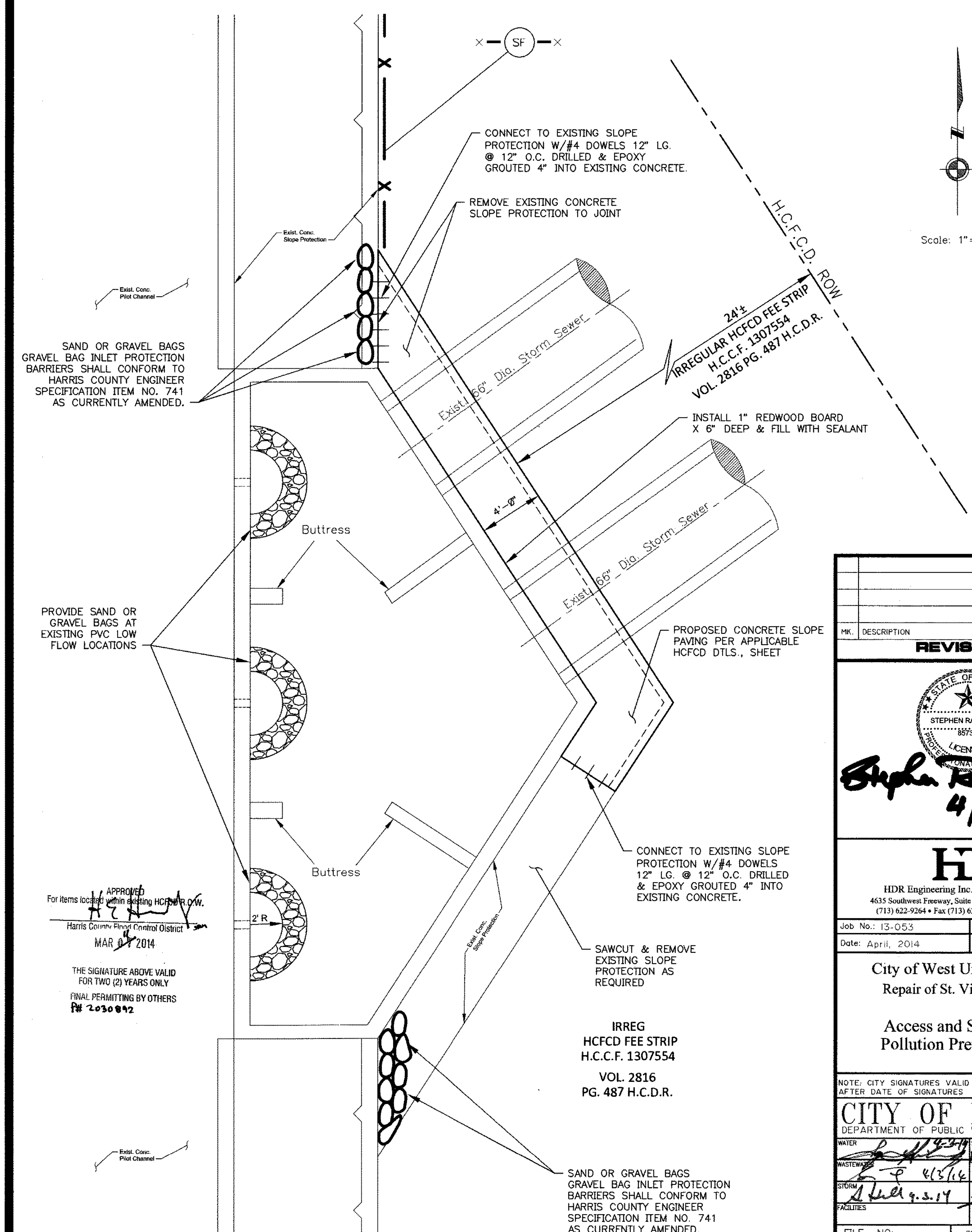
×—(SF)—× SILT FENCE

(SCA)— STABILIZED CONSTRUCTION ACCESS

SWPPP CONSTRUCTION NOTES

1. Contractor shall implement inlet protection devices and Reinforced Filter Fabric barrier along road side ditches at locations shown on the typical Storm Water Pollution Prevention (SWPP) plans to keep silt and or excavation materials from entering into the storm water inlets and ditches eventually polluting the receiving storm.
2. During the excavation phase of the project, Contractor shall schedule the work in short segments so that excavation material can be quickly hauled away from the site and to prevent it from staying uncollected on the existing pavement. Any loose excavated material which falls on pavement or driveways shall be swept back into the excavated area.
3. Contractor shall clean up the existing street intersections and driveways daily, as necessary, to remove any excess mud, silt or rock tracked from the excavated area.
4. Contractor shall follow good housekepping practices during the construction of the project, always cleaning up dirt and loose material as construction progresses.
5. Contractor to inspect and maintain the areas listed below at least once every fourteen(14) calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater.
   - Disturbed areas of the construction site that have not been finally stabilized.
   - Areas used for storage of materials that are exposed to preciptation.
   - Structural control measures.
   - Location where vehicles enter or exit the site.
6. Contractor to be responsible to maintain existing ditches and or culverts for unobstructed drainage at all times. Where sodding is distrubed by excavation on backfilling operations, such areas shall be replaced by seeding or sodding. Slopes 4:1 or steeper shall be replaced by block sodding.





NOTES:

1. ALL FUTURE WORK REQUIRES HCFCD REVIEW AND APPROVAL.
2. ALL WORK PER HCFCD SPECS. WITHIN HCFCD ROW.

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — STEPHEN RATCLIFFE — 85791 — LICENSED PROFESSIONAL ENGINEER

4/2/14

HDR

HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

Job No.: 13-053	Dwn By: G.S. Fuller
Date: April, 2014	Chkd By: D. Jorgensen

City of West University Place
Repair of St. Vincent's Outfall

Access and Storm Water Pollution Prevention Plan

NOTE: CITY SIGNATURES VALID FOR ONE YEAR ONLY AFTER DATE OF SIGNATURES

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

WATER 4-3-14	STREET & BRIDGE 4-3-14
WASTEWATER 4/3/14	TRAFFIC
STORM 4.3.14	STORM WATER QUALITY
FACILITIES	

FILE NO:

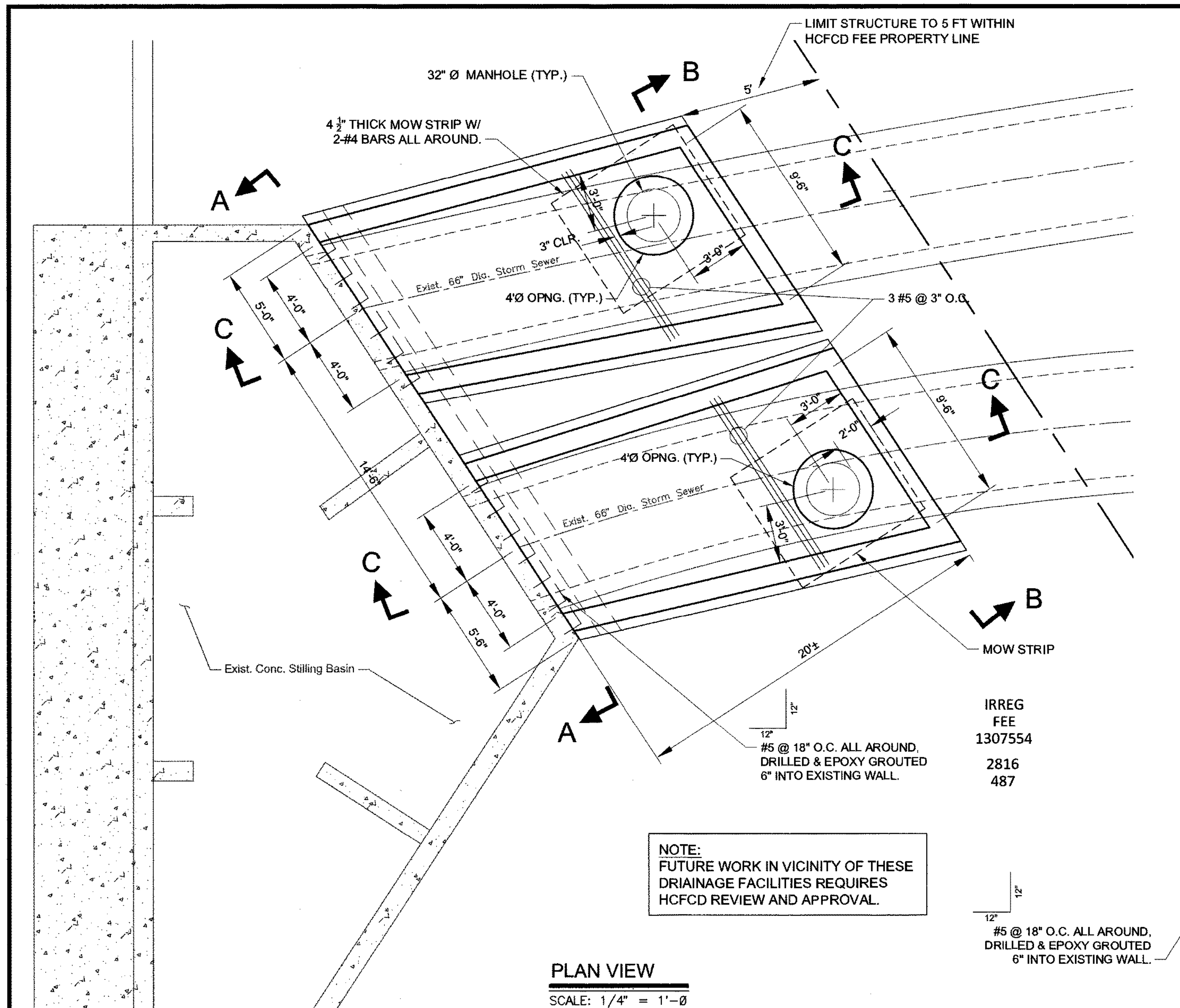
FOR CITY OF HOUSTON USE ONLY

51973

DRAWING SCALE

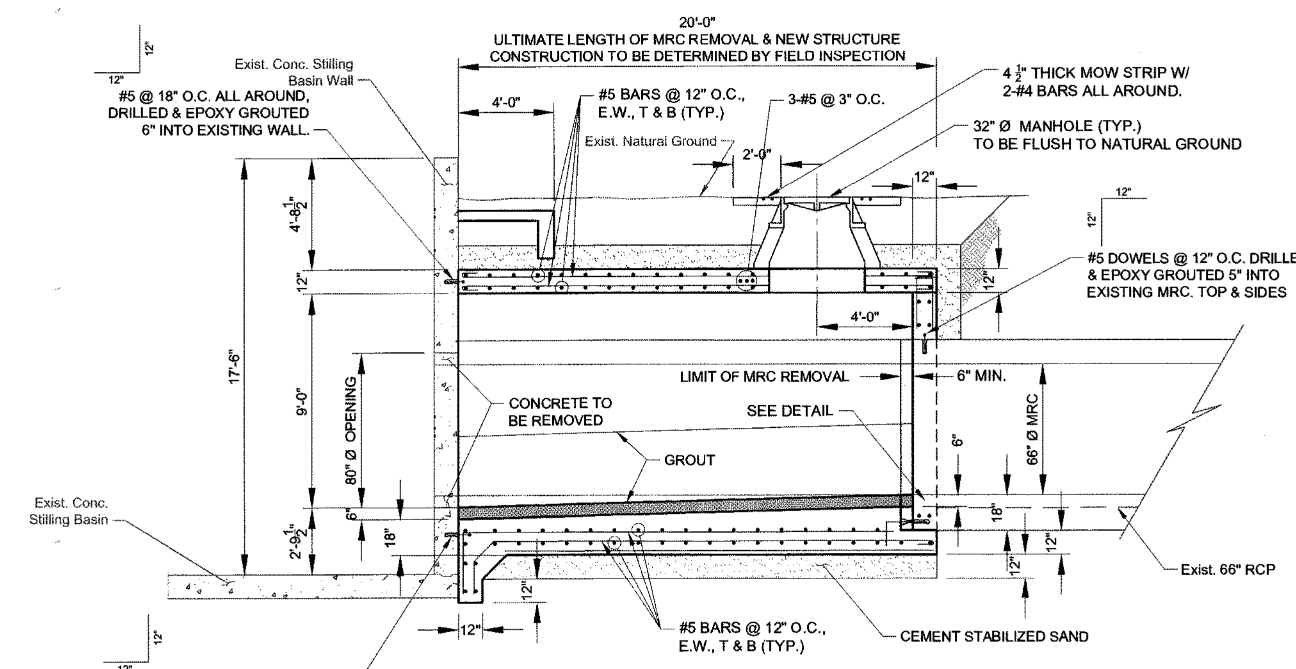
HORZ :
VERT :

SHEET No: 2 OF 6



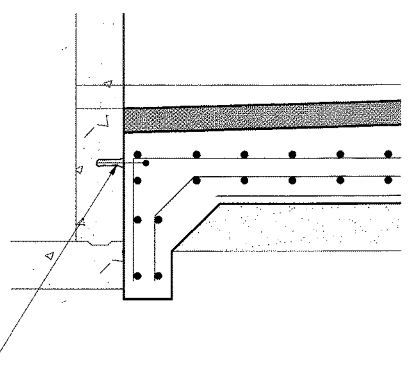
PLAN VIEW

SCALE: 1/4" = 1'-0



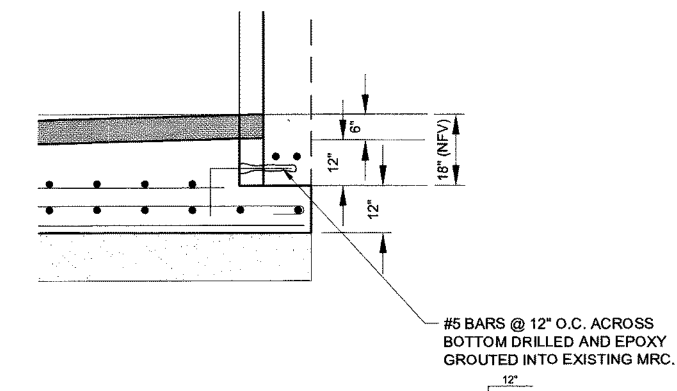
SECTION C-C (TYP.)

SCALE: 1/4' = 1'-0"



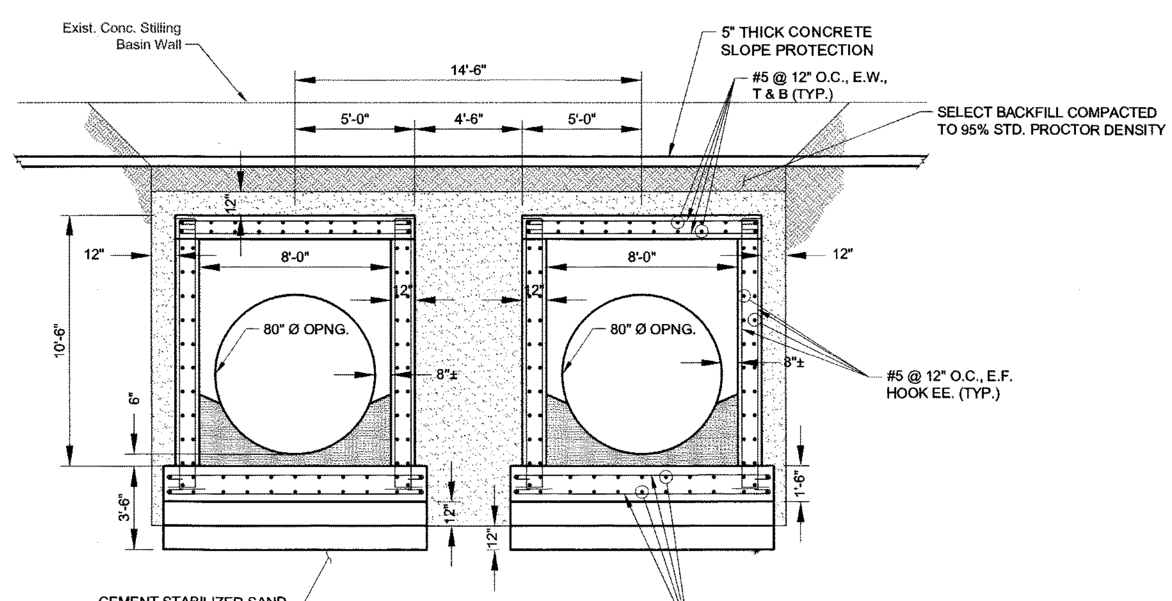
DETAIL 2

SCALE: 1/2' = 1'-0"



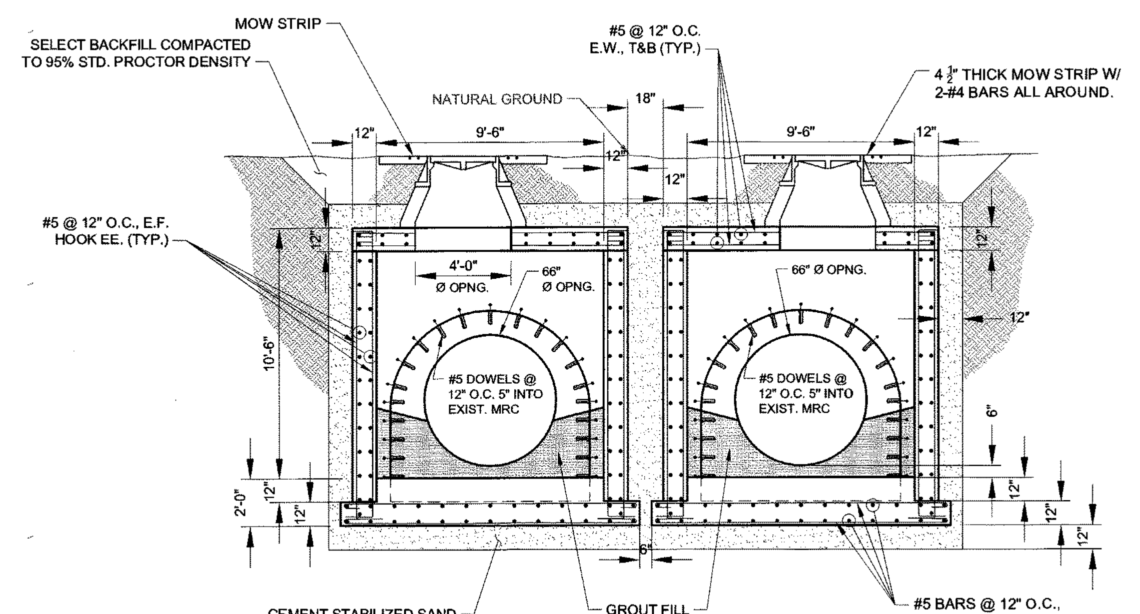
DETAIL 1

SCALE: 1/2' = 1'-0"



SECTION A-A

SCALE: 1/4' = 1'-0"



SECTION B-B

SCALE: 1/4' = 1'-0"

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — STEPHEN RATCLIFFE — 86731 — LICENSED PROFESSIONAL ENGINEER

Stephen Ratcliffe 4/2/14

HDR

HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

Job No.: 13.053	Dwn By: G.S. Fuller
Date: April, 2014	Chkd By: D. Jorgensen

City of West University Place
Repair of St. Vincent's Outfall

Structural Repair
Details

NOTE: CITY SIGNATURES VALID FOR ONE YEAR ONLY AFTER DATE OF SIGNATURES

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

WATER / STREET & BRIDGE / WASTEWATER / TRAFFIC / STORM / STORM WATER QUALITY / FACILITIES

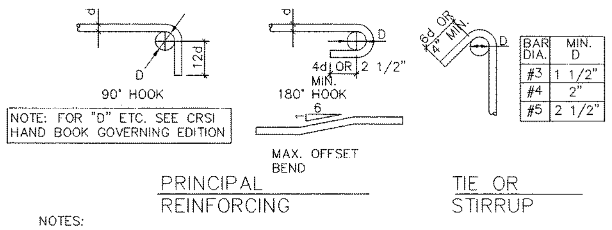
FILE NO:

FOR CITY OF HOUSTON USE ONLY

DRAWING SCALE
HORZ :
VERT :

51973

SHEET No: 3 OF 6



NOTES:
1. ALL BENDS SHALL BE MADE COLD.
2. #14 AND #18 BARS SHALL BE BEND-TESTED AND APPROVED PRIOR TO BENDING.

(1) Bar Bending Details
SCALE: N.T.S.

CONCRETE:

MATERIAL:
1. CONCRETE SHALL BE NORMAL WEIGHT CONCRETE WITH MINIMUM f'c AS INDICATED BELOW.

   A. PIERS, FOOTINGS .... f'c=3000 PSI AT 28 DAYS.

2. REINFORCING STEEL SHALL CONFORM TO FOLLOWING GRADE.
   REINFORCING BARS ASTM A-615 GRADE 60 EXCEPT NOTED
   WELDED WIRE FABRIC ASTM A-185
   REINFORCING BARS WELDED TO STEEL SHALL BE WELDABLE GRADE 40

3. DETAILING OF REINFORCING BARS AND ACCESSORIES SHALL BE IN ACCORDANCE WITH ACI PUBLICATION 315, LATEST EDITION.

4. ALL MIXING TRANSPORTING, PLACING, CURING OF CONCRETE SHALL BE ACCORDANCE WITH RECOMMENDATION OF AMERICAN CONCRETE INSTITUTE.

5. ALL MIX DESIGN SHALL BE SUBJECT TO ENGINEER'S APPROVAL.

6. ALL REINFORCING BARS SHALL HAVE CLASS B LAP SPLICE PER ACI-318-02 SECTION 12.15 UNO ON DRAWINGS.

7. ALL REINFORCING SHALL BE SUPPORTED IN PLACE BY STANDARD CHAIRS. PROVIDE 3"x6"x 20 GAGE SHEET METAL BAR CHAIR AT 4'-0" O.C. EACH WAY FOR ALL TOP REINFORCING FOR SLAB ON GRADE.

8. ALL CONSTRUCTION JOINTS SHALL BE SUBJECT TO ENGINEERS APPROVAL.

9. FORMS SHALL NOT BE REMOVED UNTIL FOLLOWING STRENGTH IS REACHED. THE STRENGTH SHOWN BELOW IS THE PERCENTAGE OF 28 DAY COMPRESSIVE STRENGTH f'c.

   WALL, COLUMN, BEAM SIDE 40 PERCENT

10. ALL POURED IN PLACE CONCRETE MEMBERS SHALL HAVE FOLLOWING CLEAR COVER TO REINFORCING.

FOOTING AND PIERS	3 INCH
GRADE BEAMS BOTTOM	3 INCH
SIDE POURED AGAINST SOIL	3 INCH
SIDE FORMED	2 INCH
TOP	1 1/2 INCH WALLS
SIDE EXPOSED TO EARTH	2 INCH
ALL OTHER	3/4 INCH
SLAB ON GRADE	1 INCH(TOP)

11. PROVIDE GRANULAR FILL BEHIND WALLS AS REQUIRED BY WEEP HOLE DETAILS ON SHEET 115.

LAP & DEVELOPMENT LENGTH INCH
NORMAL WEIGHT CONCRETE-REFER NOTES BELOW

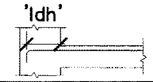
BAR SIZE	LAP CLASS	f'c=3000 psi TOP	f'c=3000 psi OTHER	f'c=4000 psi TOP	f'c=4000 psi OTHER	f'c=5000 psi TOP	f'c=5000 psi OTHER
#3	A	22	17	19	15	17	13
	B	28	22	24	19	22	17
#4	A	29	22	25	19	22	17
	B	37	29	32	25	29	22
#5	A	36	28	31	24	28	22
	B	47	36	40	31	36	28
#6	A	43	33	37	29	33	26
	B	56	43	48	37	43	33
#7	A	63	48	54	42	49	37
	B	81	63	70	54	63	49
#8	A	72	55	62	48	55	43
	B	93	72	80	62	72	55
#9	A	81	62	70	54	63	48
	B	105	81	91	70	81	63
#10	A	91	70	79	61	70	54
	B	118	91	102	79	91	70
#11	A	101	78	87	67	78	60
	B	131	101	113	87	101	78

1. DEVELOPMENT LENGTH 'ld' OF A BARS IS EQUAL TO LENGTH OF CLASS A LAP LENGTH.

(2) Reinforcing Development And Lap Lengths
SCALE: N.T.S.

MINIMUM TENSION EMBEDMENT LENGTHS 'ldh' FOR STANDARD HOOKS - GRADE 60(FY-60,000PSI) REINFORCING BARS

'ldh'



BAR SIZE	NORMAL WEIGHT CONCRETE f'c=3000 psi	f'c=4000 psi	f'c=5000 psi
#3	6	8	6
#4	8	7	6
#5	10	9	8
#6	12	10	9
#7	14	12	11
#8	16	14	12
#9	18	15	14
#10	20	17	15
#11	22	19	17

(3) Reinforcing 'ldh' Lengths
SCALE: N.T.S.

STORM SEWER CONSTRUCTION NOTES

1. STORM SEWERS SHALL BE REINFORCED CONCRETE PIPE (C-76, CLASS III), AND SHALL BE INSTALLED, BEDDED, AND BACKFILLED IN ACCORDANCE WITH THE CITY OF HOUSTON DRAWING NOS. 02317-02, 02317-03, 02317-06, AND 02317-07 (OCT. 2002) AS APPLICABLE UNLESS OTHERWISE SHOWN ON THE DRAWINGS.
2. ALL STORM SEWER CONSTRUCTED IN SIDE LOT EASEMENT SHALL BE R.C.P. (C-76, CLASS III) AND SHALL BE BEDDED IN ACCORDANCE WITH THE CITY DRAWING NOS. 02317-02, 02317-03, 02317-05, 02317-06, AND 02317-07 AS APPLICABLE.
3. ALL SEWER UNDER PROPOSED OR FUTURE PAVEMENT AND TO A POINT ONE (1) FOOT BACK OF ALL PROPOSED OR FUTURE CURBS SHALL BE BACKFILLED WITH 1-1/2 SACK CEMENT/C.Y. STABILIZED SAND TO WITH IN ONE (1) FOOT OF SUBGRADE. THE REMAINING DEPTH OF TRENCH SHALL BE BACKFILLED WITH SUITABLE EARTH MATERIAL.
4. ALL TRENCH BACKFILLS SHALL BE IN 8" LIFTS, WITH TESTS TAKEN AT 100 FOOT INTERVALS ON EACH LIFT, AND MECHANICALLY COMPACTED TO A DENSITY OF NOT LESS THAN 95% OF THE MAXIMUM DRY DENSITY AS DETERMINED BY THE STANDARD PROCTOR COMPACTION TEST (ASTM D-698/AASHTO T99).
5. CIRCULAR AND ELLIPTICAL REINFORCED CONCRETE PIPE SHALL BE INSTALLED USING RUBBER GASKET JOINTS CONFORMING TO ASTM ASTM C443 AND C877 RESPECTIVELY.
6. ALL STORM SEWER PIPES AND INLET LEADS SHALL BE 24-INCH AND LARGER R.C.P. (C-76, CLASS III).
7. ALL PROPOSED PIPE STUB-OUTS EROM MANHOLES AND INLETS ARE TO BE PLUGGED WITH 8" BRICK WALLS UNLESS OTHERWISE NOTED.
8. CONTRACTOR SHALL PROVIDE 12" MINIMUM CLEARANCE AT STORM SEWER AND WATER LINE CROSSINGS.
9. ADJUST MANHOLE COVERS TO GRADE CONFORMING TO REQUIREMENTS OF SECTION 02086-ADJUSTING MANHOLES, INLETS AND VALVE BOXES TO GRADE.
10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING, MAINTAINING, AND RESTORING ANY BACK SLOPE DRAINAGE SYSTEM DISTURBED AS A RESULT OF HIS WORK.
11. ALL DITCHES SHALL BE REGRADED TO PROPOSED ELEVATIONS TO INSURE PROPER DRAINAGE. ALL OUTFALLS SHALL BE PROPERLY BACKFILLED AND COMPACTED. ALL DISTURBED AREA SHALL BE GRADED, SEEDED, AND FERTILIZED.
12. ALL DRIVEWAYS WILL BE LOCATED TO AVOID EXISTING CURB INLET STRUCTURES.

12/21/10 Update

STANDARD HCFCD NOTES FOR CONSTRUCTION DRAWINGS

1. Obtain and comply with all applicable City, County, State, and Federal permits and approvals, with assistance from Engineer, if necessary. Obtain permit (certification) from Harris County Engineer to enter Harris County Flood Control District right-of-way.
2. Notify the Harris County Flood Control District's Property Management Department in writing at least 48 hours prior to construction. Submit the HCFCD 48 Hour Pre-Construction Notification form, a copy of the approved construction drawings, and a copy of the Corps of Engineers individual Section 404 permit, if applicable, to HCFCD, 9900 Northwest Freeway, Houston, Texas 77092, Attn: Property Management Dept. by hand delivery, or fax to 713-684-4129 (fax number).
3. Engineer shall submit certification letter and record drawings to the Harris County Flood Control District's Property Management Department requesting inspection of items constructed in Harris County Flood Control District right-of-way. Prior to requesting inspection, the drainage right-of-way and/or easements shall be staked and flagged.
4. Protect, maintain, and restore existing backslope drainage systems.
5. Backslope swale and interceptor structure elevations and locations shown on plans are approximate. Final elevations and locations shall be field verified by the Engineer prior to installation.
6. Establish turf grass on all disturbed areas within the channel or detention right-of-way, except the channel bottom and where structural erosion measures are used. Minimum acceptance criteria are 75% coverage of live Bermuda grass and no erosion or rills deeper than 4".
7. Backfill in accordance with the Harris County Flood Control District Standard Specification, Section 02315 - Excavating and Backfilling, or equivalent.
8. Excavate channel flowline to design elevation as shown on plans and downstream, as necessary, to ensure no water remains in the facility (storm sewer, lateral channel, or dry bottom detention basin) during normal water surface conditions in the channel, so the facility will function as intended. For wet bottom detention basins, ensure no water is above the design level in the wet bottom during normal water surface conditions in the channel.
9. Maintain flow in channel during construction and restore channel to original condition.
10. Remove all excavated material from the Harris County Flood Control District or drainage right-of-way. No fill is to be placed within a designated flood plain area without first obtaining a fill permit from the appropriate jurisdictional authority.

NOTE:
CONTRACTOR TO OBTAIN HCFCD PERMIT.

NOTE:
THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTING, MAINTAINING, AND RESTORING ANY BACK SLOPE DRAINAGE SYSTEM DISTURBED AS A RESULT OF HIS WORK.

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS
STEPHEN RATCLIFFE
85731
LICENSED PROFESSIONAL ENGINEER
4/2/14

HDR
HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

Job No.: 13-053	Dwn By: G.S. Fuller
Date: April, 2014	Chkd By: D. Jorgensen

City of West University Place
Repair of St. Vincent's Outfall

H.C.F.C.D. Notes & Reinforcing Details

NOTE: CITY SIGNATURES VALID FOR ONE YEAR ONLY AFTER DATE OF SIGNATURES

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

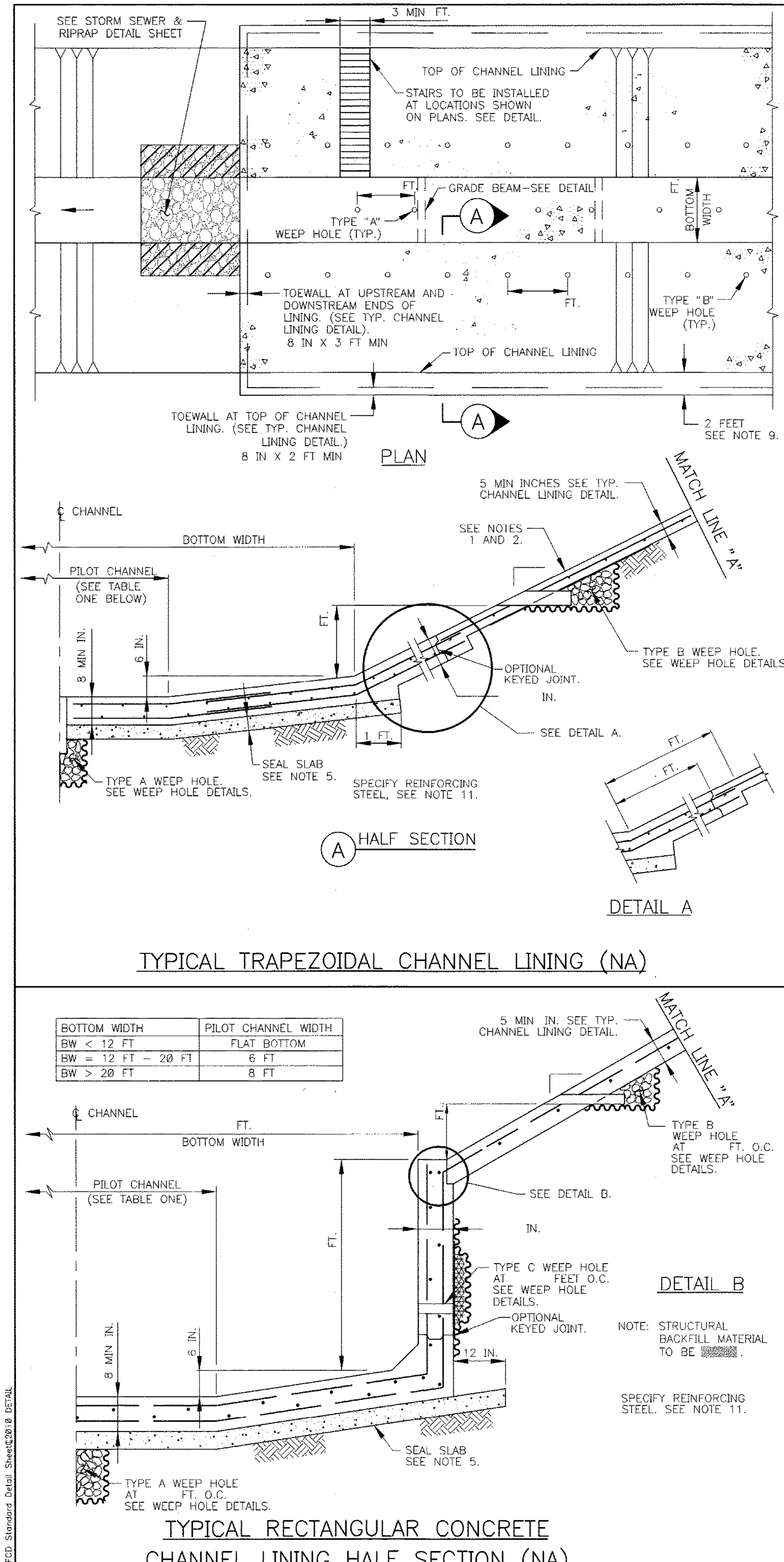
WATER 4-3-14	STREET & BRIDGE 4-3-14
WASTEWATER 4/3/14	TRAFFIC 4-3-14
STORM 4.3.14	STORM WATER QUALITY
FACILITIES	

FILE NO:

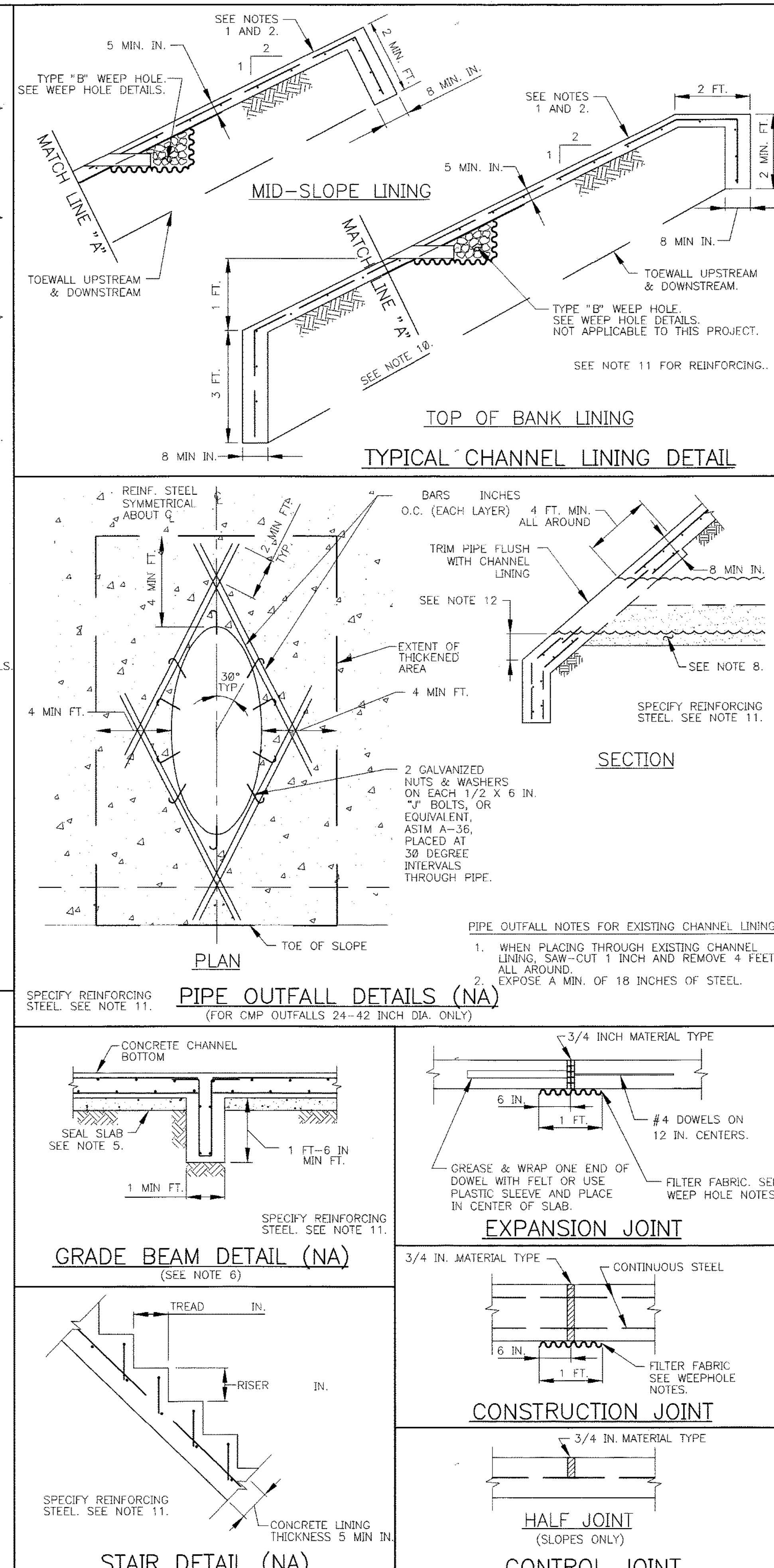
FOR CITY OF HOUSTON USE ONLY
51973

DRAWING SCALE
HORZ :
VERT :

SHEET No: 4 OF 6

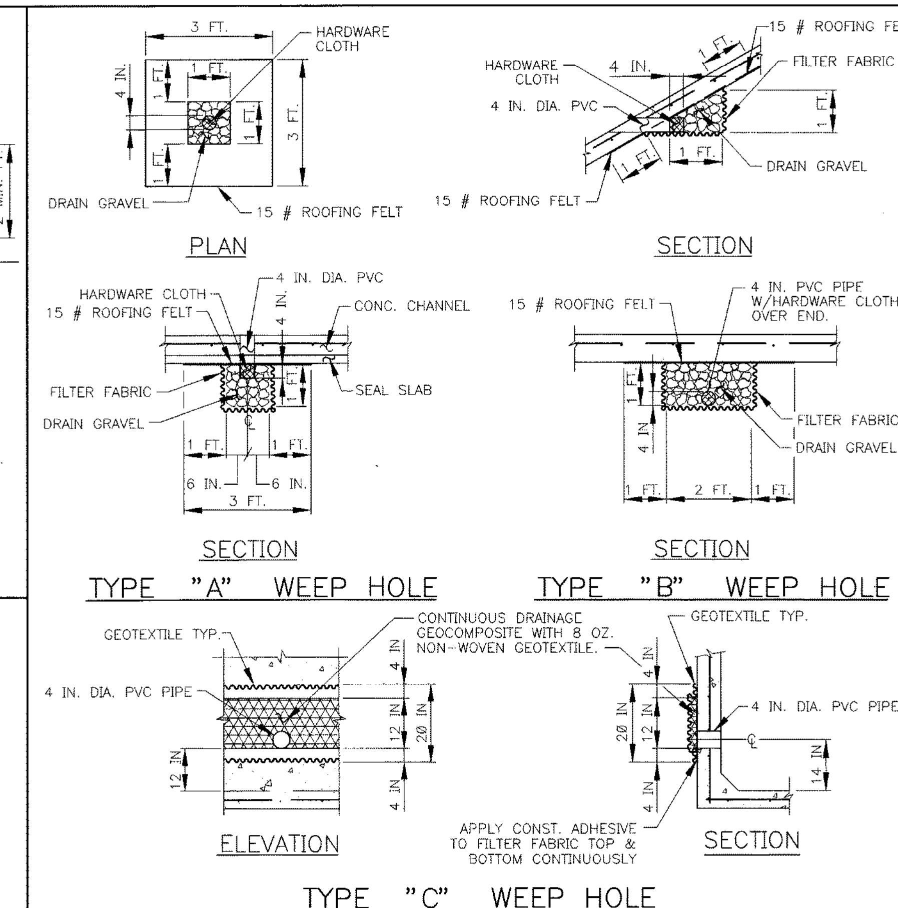


BOTTOM WIDTH	PILOT CHANNEL WIDTH
BW < 12 FT	FLAT BOTTOM
BW = 12 FT - 20 FT	6 FT
BW > 20 FT	8 FT



PIPE OUTFALL NOTES FOR EXISTING CHANNEL LINING

1. WHEN PLACING THROUGH EXISTING CHANNEL LINING, SAW-CUT 1 INCH AND REMOVE 4 FEET ALL AROUND.
2. EXPOSE A MIN. OF 18 INCHES OF STEEL.



WEEP HOLE NOTES:

1. MATERIALS:
   a. PIPE: 4 INCH DIA. SCH. 40 PVC
   b. DRAIN GRAVEL:

SIEVE SIZE	% FINER
1 IN	100
3/4 IN	70 - 100
3/8 IN	20 - 90
NO. 4	0 - 60
NO. 8	0

   c. HARDWARE CLOTH: MIN. OPEN 1/8 IN, MAX. OPEN 1/4 IN
   d. FILTER FABRIC: NON-WOVEN GEOTEXTILE

MIN. AOS	SIEVE NO.	100 MIN
MAX. AOS	SIEVE NO.	70 MAX
WEIGHT	OZ/SY	6 OZ. MIN

2. CUT WEEP HOLE PIPE FLUSH WITH CONCRETE SURFACE.
3. TYPE "A" AND "C" WEEP HOLES FOR TYPICAL RECTANGULAR CONCRETE CHANNEL LINING. TO BE STAGGERED.

WEEP HOLE DETAILS (NA)

CONCRETE CHANNEL LINING DETAILS NOTES:

1. STRUCTURAL CONCRETE FOR CONCRETE CHANNEL LINING AND NONSTRUCTURAL CONCRETE FOR SEAL SLAB SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 03310-CONCRETE.
2. REINFORCING STEEL SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 03310-CONCRETE.
3. EXCAVATION AND BACKFILL FOR CONCRETE CHANNEL LINING SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02316-STRUCTURAL EXCAVATING AND BACKFILLING.
4. RIPRAP SHALL BE IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02378-RIPRAP AND GRANULAR FILL.
5. A NON-REINFORCED 4 INCH MINIMUM NONSTRUCTURAL CONCRETE SEAL SLAB WILL BE REQUIRED BENEATH THE BOTTOM OF CONCRETE CHANNELS.
6. STRUCTURAL CONCRETE GRADE BEAMS SHALL BE INSTALLED TRANSVERSLEY AT 20 FOOT MAX. CENTERS ON CONCRETE LINED CHANNELS WITH BOTTOM WIDTHS EQUAL TO OR GREATER THAN 20 FEET.
7. JOINTS:
   A. PLACE CONSTRUCTION AND/OR EXPANSION JOINT IN CONCRETE LOW-FLOW AND TRAPEZOIDAL BOTTOM SECTIONS AT 20 FOOT MIN., 60 FOOT MAX. SPACING CONTINUOUSLY THROUGH CHANNEL LINING.
   B. PLACE CONTROL JOINT ON SLOPES AT 20 FOOT SPACING.
8. CEMENT STABILIZED SAND SHALL BE PROVIDED AND PLACED IN ACCORDANCE WITH SPECIFICATION SECTION NO. 02321-CEMENT STABILIZED SAND.
9. DELETE 2 FT FLAT EDGE WHEN LINING IS BELOW TOP OF BANK. SEE MID-SLOPE LINING DETAIL.
10. UPSTREAM AND DOWNSTREAM TOE WALL 3 FOOT MIN. DEPTH AT BOTTOM OF SLOPE AND 8 INCHES THIICK.
11. #4 AT 12 INCH O.C. MINIMUM OR EQUIVALENT WELDED WIRE FABRIC.
12. VARIES BASED ON SIDE SLOPE. MINIMUM 1 FOOT VERTICAL AT TOE OF SLOPE.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE §137.33 (b) AND (c) OF THE TEXAS STATE BOARD OF REGISTRATION FOR PROFESSIONAL ENGINEERS.

STATE OF TEXAS
STEPHEN RATCLIFFE
85731
LICENSED PROFESSIONAL ENGINEER

4/2/14

P.E. SEAL AND SIGNATUARE

51973

REV	DESCRIPTION	DATE	APPR

PROJECT ID#

REPAIR OF ST. VINCENT'S STORM SEWER OUTFALL

CONCRETE CHANNEL LINING DETAILS

PREPARED: CHECKED: APPROVED:

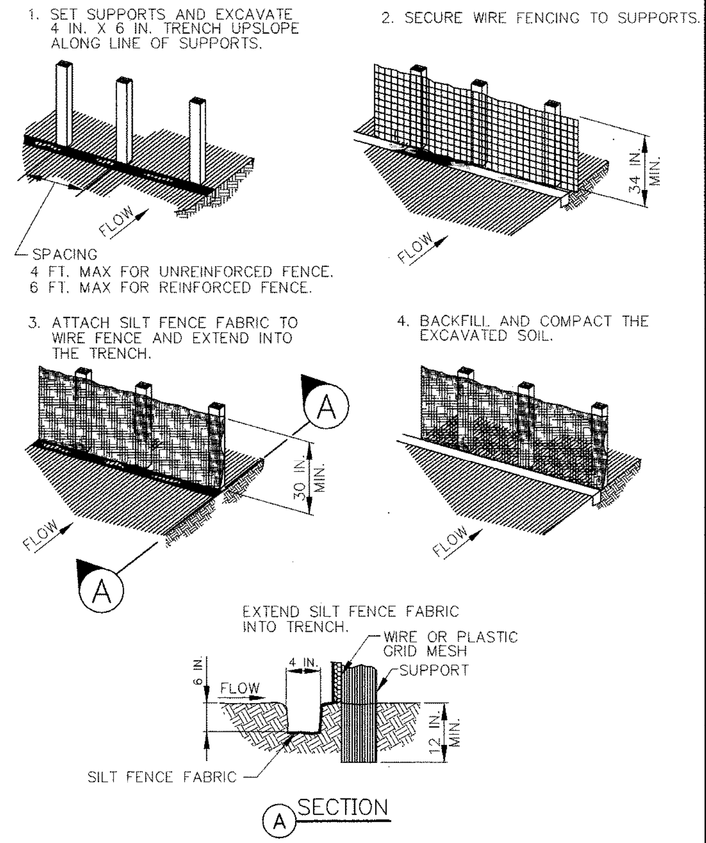
HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

Harris County Flood Control District
9900 Northwest Freeway
Houston, Texas 77092

DATE: 12-21-2010
SCALE: NTS

SHEET NUMBER
5 OF 6

HCFCD Standard Detail Sheet\2010 DETAIL
STD\CONCRETE CHANNEL LINING DETAIL



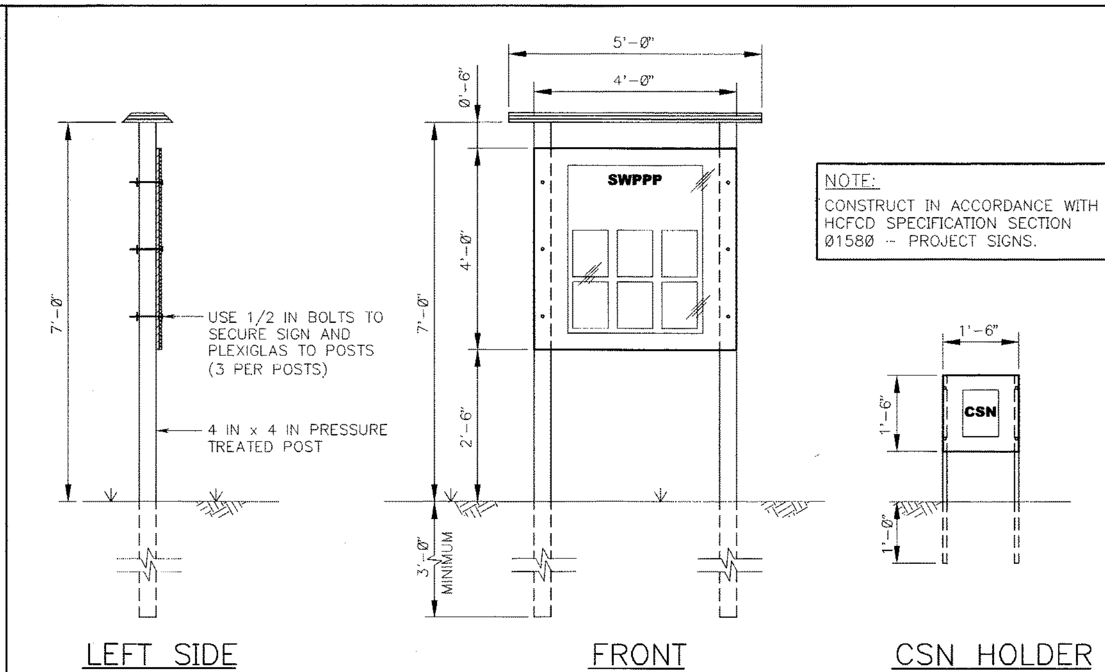
CONSTRUCTION NOTES:

1. SEE SPECIFICATION SECTION NO. 02361-SILT FENCES.

×—(RSF)—× — — REINFORCED SILT FENCE
SYMBOL

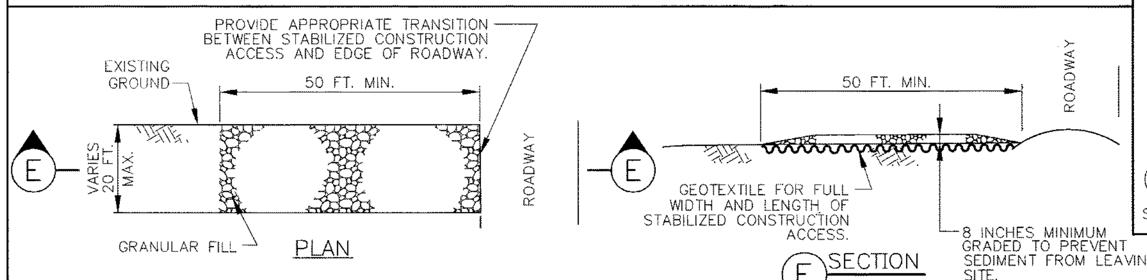
×—(SF)—× — — SILT FENCE
SYMBOL

SILT FENCE



NOTE:
CONSTRUCT IN ACCORDANCE WITH HCFCD SPECIFICATION SECTION 01580 – PROJECT SIGNS.

SWPPP / BMP SIGN AND CONSTRUCTION SITE NOTICE HOLDER DETAILS

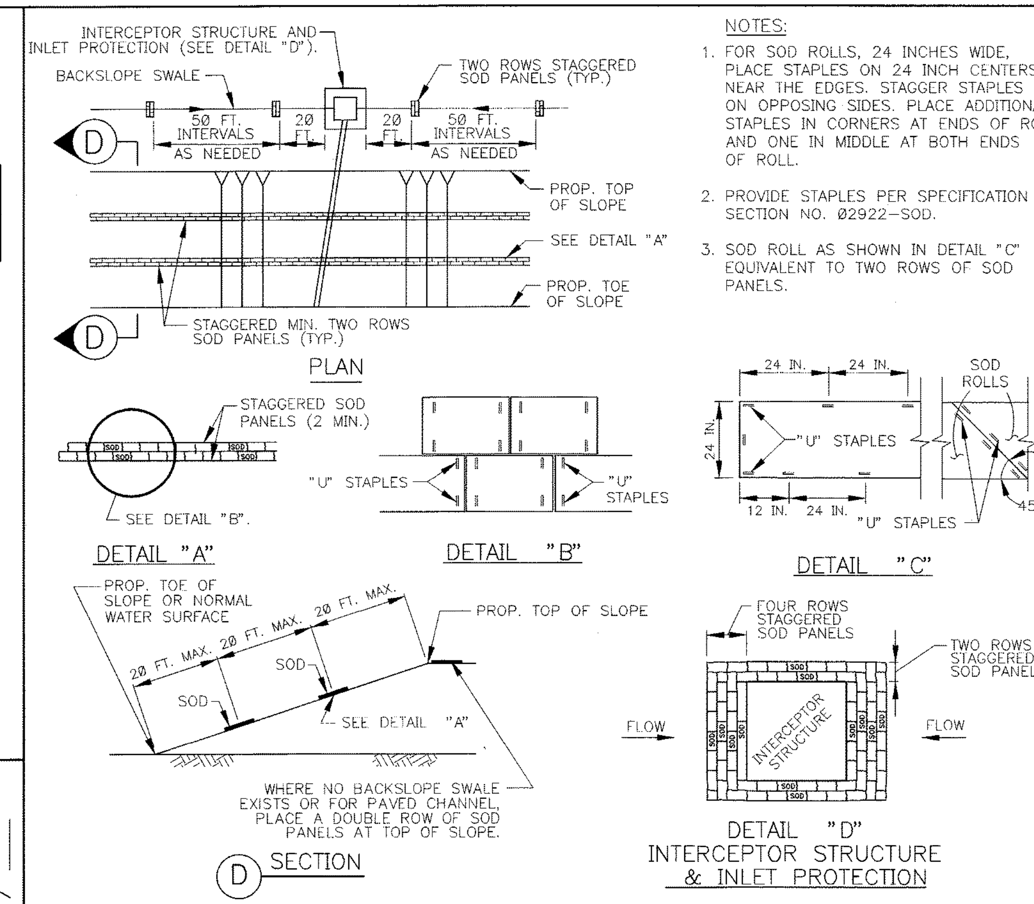


CONSTRUCTION NOTES:

1. SEE SPECIFICATION SECTION NO. 02365-STABILIZED CONSTRUCTION ACCESS.

(SCA)— SYMBOL

STABILIZED CONSTRUCTION ACCESS

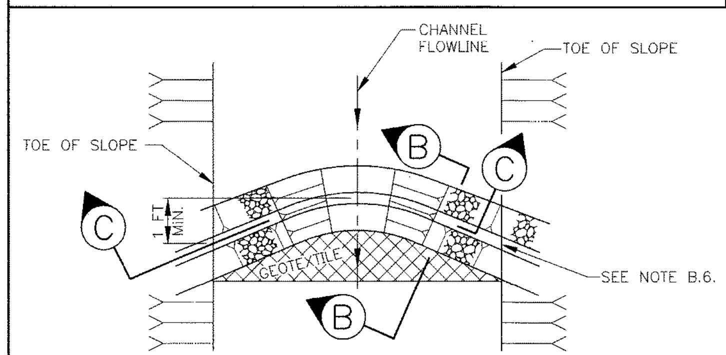


NOTES:

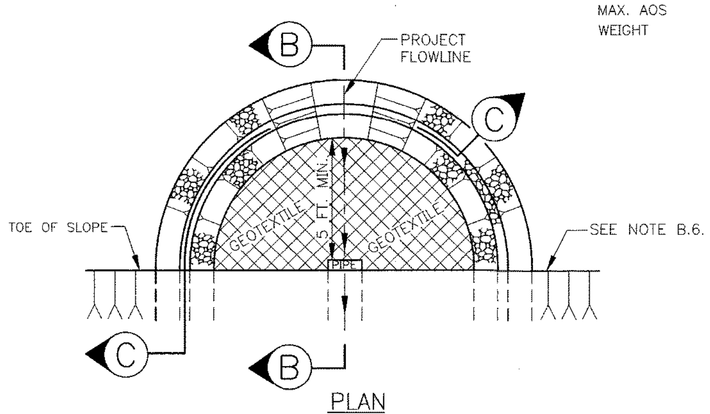
1. FOR SOD ROLLS, 24 INCHES WIDE, PLACE STAPLES ON 24 INCH CENTERS NEAR THE EDGES. STAGGER STAPLES ON OPPOSING SIDES. PLACE ADDITIONAL STAPLES IN CORNERS AT ENDS OF ROLL AND ONE IN MIDDLE AT BOTH ENDS OF ROLL.
2. PROVIDE STAPLES PER SPECIFICATION SECTION NO. 02922-SOD.
3. SOD ROLL AS SHOWN IN DETAIL "C" EQUIVALENT TO TWO ROWS OF SOD PANELS.

(SOD) SYMBOL (IP) SYMBOL

SODDING



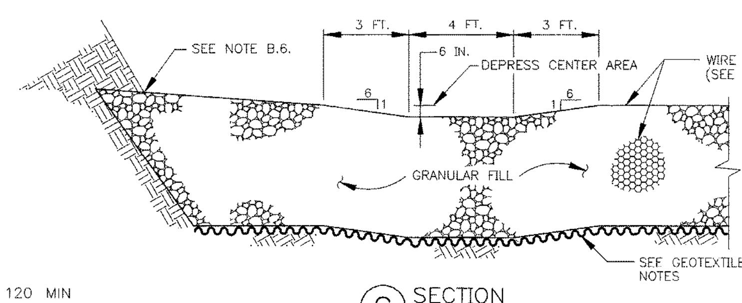
IN-CHANNEL FILTER DAM

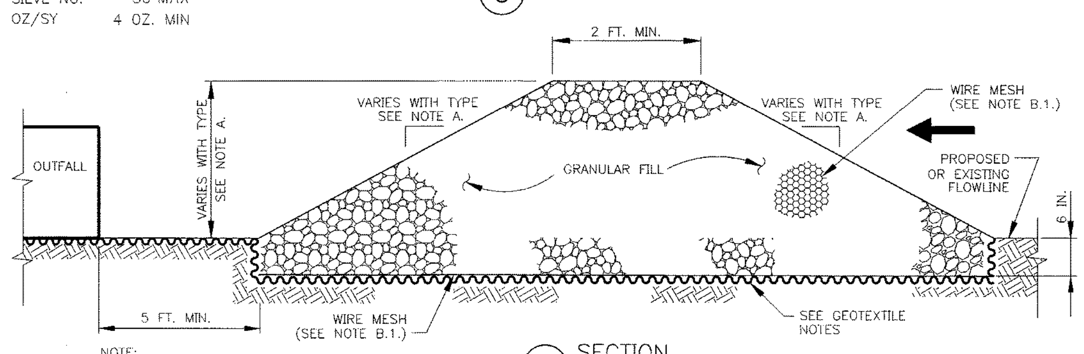


FILTER DAM AT DETENTION BASIN OUTFALL PIPE

GEOTEXTILE NOTES:

MIN. AOS	SIEVE NO.	120	MIN
MAX. AOS	SIEVE NO.	50	MAX
WEIGHT	OZ/SY	4 OZ.	MIN





NOTE:
ONLY APPLIES FOR DETENTION BASIN OUTFALL PIPE PROTECTION.

FILTER DAM

—(FD-TYPE)— SYMBOL

FILTER DAM NOTES:

A. TYPES OF FILTER DAMS
   1. TYPE 1 (NON-REINFORCED)
      a. HEIGHT – 18-24 INCHES. MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
      b. TOP WIDTH – 2 FEET (MINIMUM)
      c. SLOPES – 2:1 (MAXIMUM).
   2. TYPE 2 (REINFORCED)
      a. HEIGHT – 18-36 INCHES. MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
      b. TOP WIDTH – 2 FEET (MINIMUM).
      c. SLOPES – 2:1 (MAXIMUM).
   3. TYPE 3 (REINFORCED)
      a. HEIGHT – 36-48 INCHES. MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
      b. TOP WIDTH – 2 FEET (MINIMUM).
      c. SLOPES – 3:1 (MAXIMUM).
   4. TYPE 4 (GABION)
      a. HEIGHT – 30 INCHES (MINIMUM). MEASURE VERTICALLY FROM EXISTING GROUND TO TOP OF FILTER DAM.
      b. TOP WIDTH – 2 FEET (MINIMUM).
   5. TYPE 5. AS SHOWN ON THE PLANS.
B. CONSTRUCT FILTER DAMS ACCORDING TO THE FOLLOWING CRITERIA UNLESS SHOWN OTHERWISE ON THE PLANS.
   1. TYPE 2 AND 3 FILTER DAMS: SECURE WITH 20 GAUGE GALVANIZED WOVEN WIRE MESH WITH 1 INCH DIAMETER HEXAGONAL OPENINGS.
   2. GRANULAR FILL:
      a. PLACE ON MESH TO HEIGHT AND SLOPES SHOWN ON PLANS OR AS SPECIFIED BY THE ENGINEER.
      b. 3-5 INCHES FOR ROCK FILTER DAM TYPES 1,2, AND 4 AND 4-8 INCHES FOR ROCK FILTER DAM TYPE 3. REFER TO GRANULAR FILL IN SPECIFICATION SECTION NO. 02378-RIPRAP AND GRANULAR FILL.
   3. WIRE MESH: FOLD AT UPSTREAM SIDE OVER GRANULAR FILL AND TIGHTLY SECURE TO ITSELF ON THE DOWNSTREAM SIDE USING WIRE TIES OR HOG RINGS.
   4. IN STREAMS: SECURE OR STAKE MESH TO STREAM BED PRIOR TO AGGREGATE PLACEMENT.
   5. SEE SPECIFICATION SECTION NO. 02364-FILTER DAMS.
   6. EMBED ONE FOOT MINIMUM INTO SLOPE AND AT SLOPE RAISE ONE FOOT HIGHER THAN CENTER OF DEPRESSED AREA.

THIS DETAIL SHEET HAS BEEN PREPARED FOR USE ON HCFCD PROJECTS OR PROJECTS TO BE MAINTAINED BY THE HCFCD WHEN COMPLETED BY OTHERS. AN ENGINEER WHO INCORPORATES THE DETAILS ON THIS SHEET BECOMES RESPONSIBLE FOR ITS USE IN THE END PRODUCT IN ACCORDANCE WITH RULE §137.33 (b) AND (c) OF THE TEXAS STATE BOARD OF REGISTRATION FOR PROFESSIONAL ENGINEERS.

STATE OF TEXAS
STEPHEN RATCLIFFE
85731
LICENSED PROFESSIONAL ENGINEER

4/8/14

51973

P.E. SEAL AND SIGNATURE

REV	DESCRIPTION	DATE	APPR

PROJECT ID#

REPAIR OF ST. VINCENT'S STORM SEWER OUTFALL

STORMWATER POLLUTION PREVENTION DETAILS

PREPARED:
CHECKED:
APPROVED:

HDR
HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

Harris County Flood Control District
9900 Northwest Freeway
Houston, Texas 77092

DATE: 08-31-05
SCALE: NTS

SHEET NUMBER
6 OF 6

STD_SWPPP02.DWG

Appendix E. Construction Plans for Original West University Place Storm Sewer System

STORM SEWER SYSTEM

FOR

CITY OF WEST UNIVERSITY PLACE

MAYOR
F.M.MAINOUS

CITY SECRETARY
R.B.ALLEN

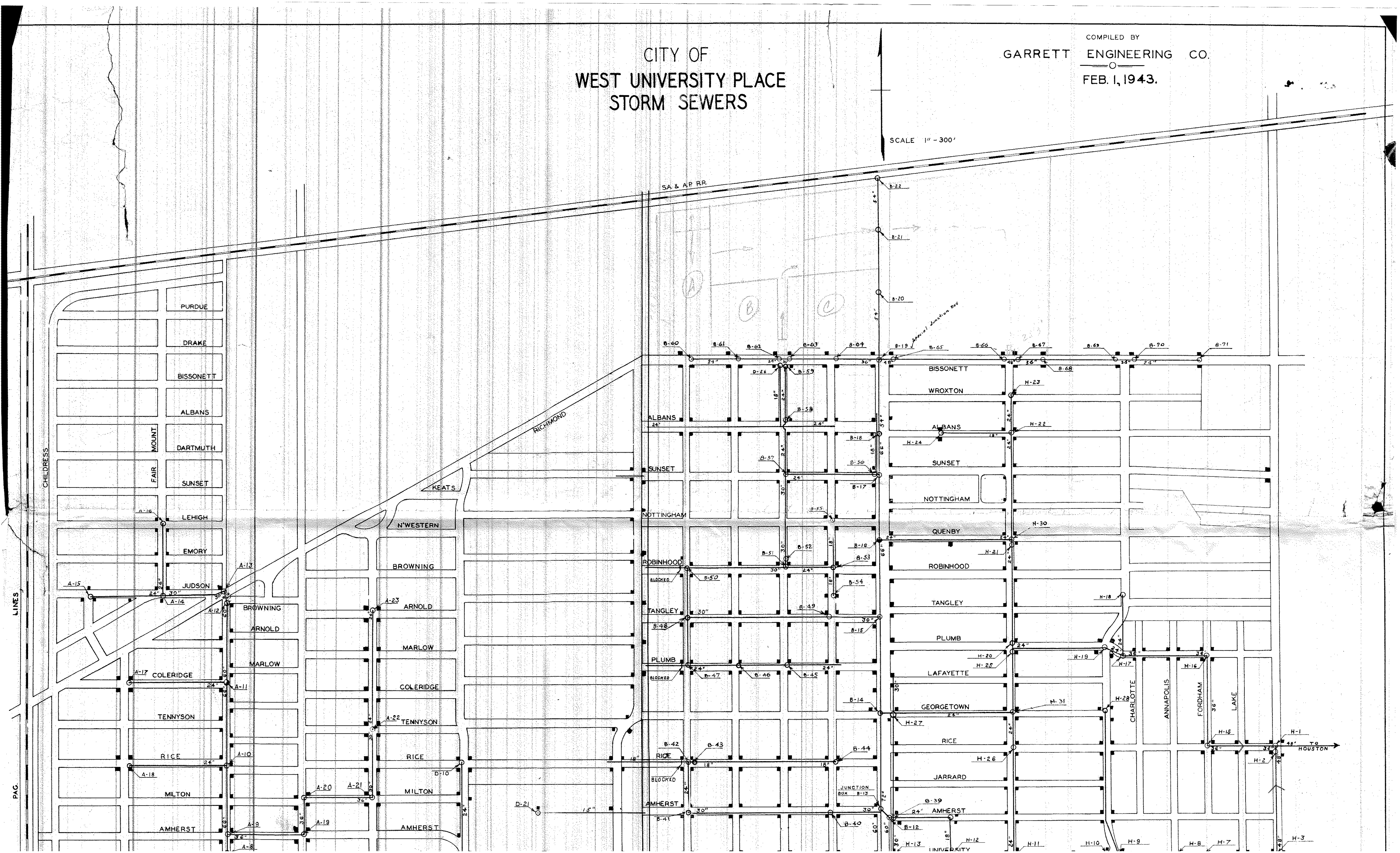
COMMISSIONERS
DR. A.L.KERBOW
DR. J.A.HERSCHEL
T.WESLEY WOODARD
J.M.DUNNINGTON

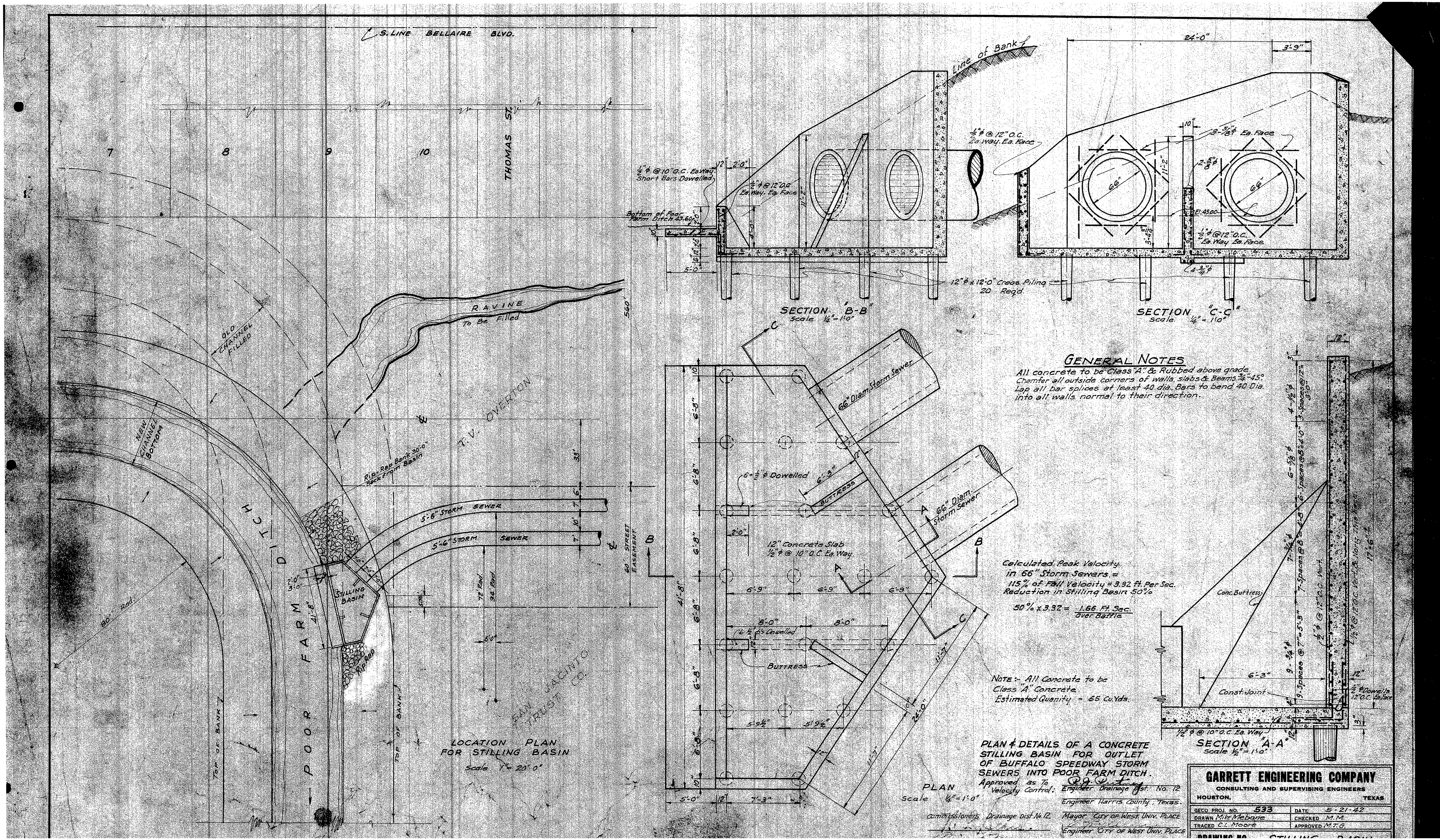
BY

GARRETT ENGINEERING CO.

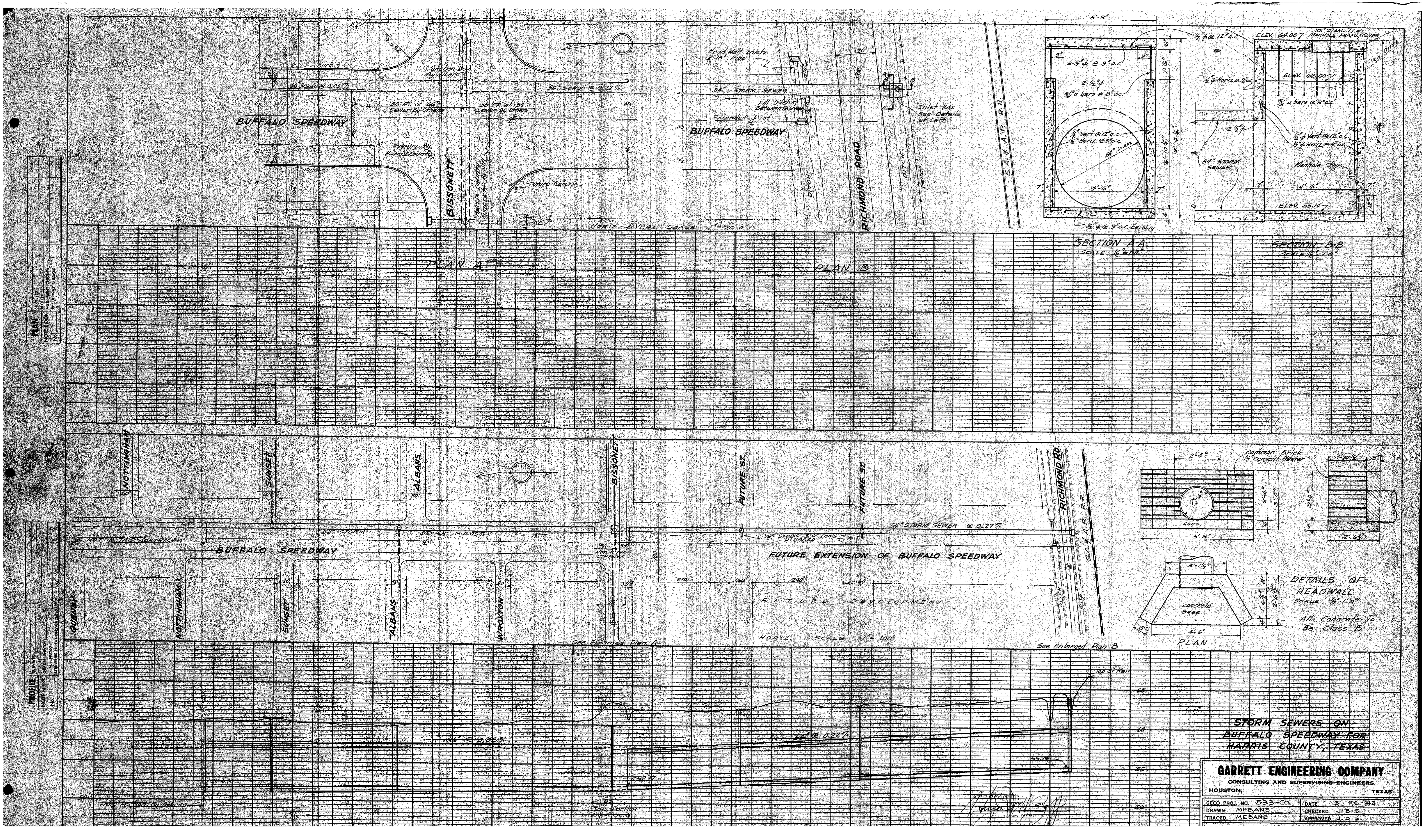
HOUSTON, TEXAS

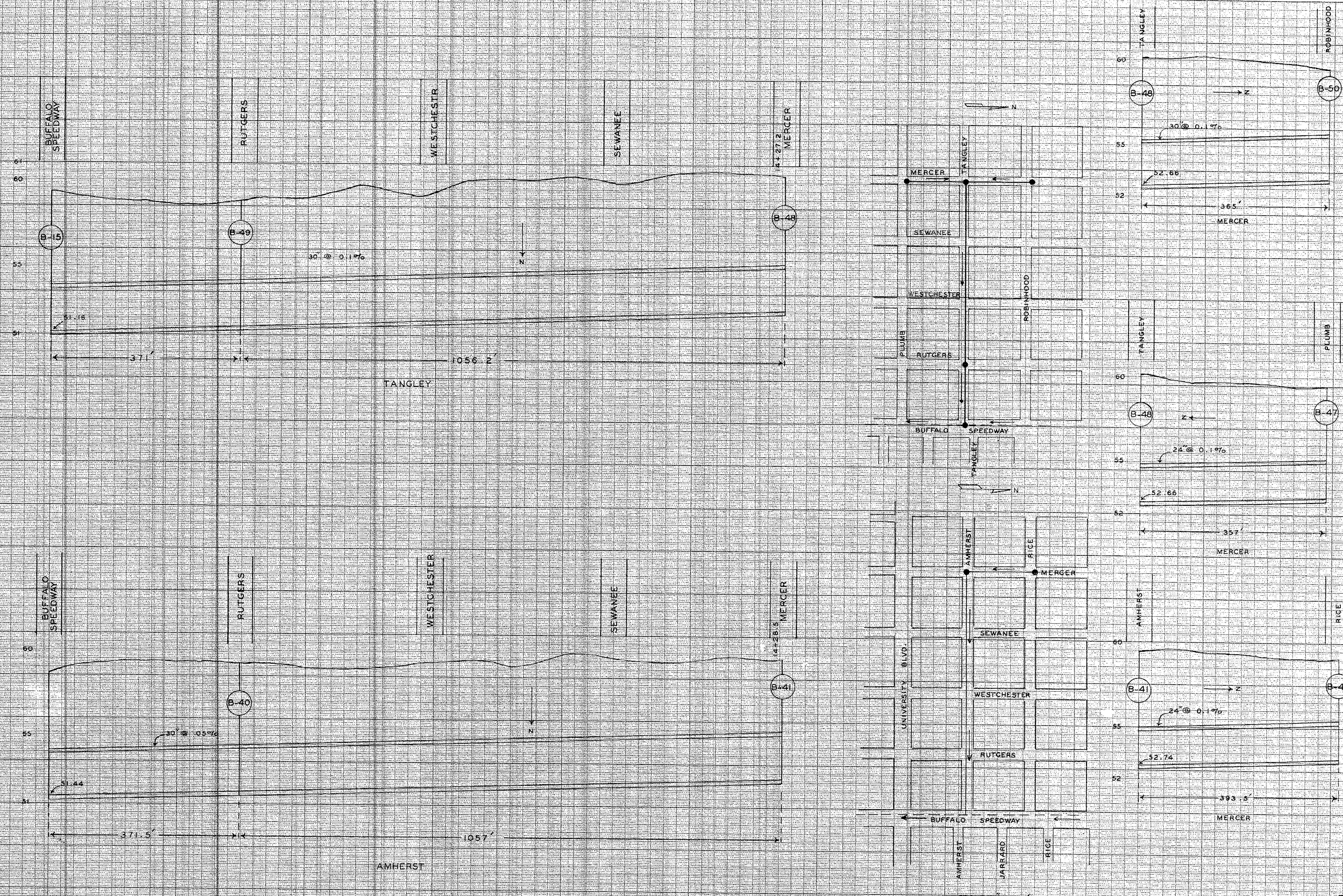
GECO.PROJ.NO. 533


CITY OF
WEST UNIVERSITY PLACE
STORM SEWERS
COMPILED BY
GARRETT ENGINEERING CO.
FEB. 1, 1943.
SCALE 1" - 300'
SA. & A.P. RR.
PURDUE
DRAKE
BISSONETT
ALBANS
DARTMUTH
SUNSET
LEHIGH
EMORY
JUDSON
MOUNT
FAIR
CHILDRESS
LINES
PAG.
BROWNING
ARNOLD
MARLOW
COLERIDGE
TENNYSON
RICE
MILTON
AMHERST
RICHMOND
KEATS
N'WESTERN
WROXTON
NOTTINGHAM
QUENBY
ROBINHOOD
TANGLEY
PLUMB
LAFAYETTE
GEORGETOWN
JARRARD
UNIVERSITY
CHARLOTTE
ANNAPOLIS
FORDHAM
LAKE
TO HOUSTON
BLOCKED
JUNCTION BOX B-13
Special Junction Box



S. LINE BELLAIRE BLVD.
THOMAS ST.
RAVINE To Be Filled
OLD CHANNEL FILLED
NEW CHANNEL BOTTOM
T.V. OVERTON
Rip-Rap Bank 30'-0" back from Basin
5'-6" STORM SEWER
5'-6" STORM SEWER
60' STREET EASEMENT
STILLING BASIN
Rip-Rap
SAN JACINTO TRUST CO.
POOR FARM DITCH
TOP OF BANK
LOCATION PLAN FOR STILLING BASIN
Scale 1" = 20'-0"
Line of Bank
½"ϕ @ 10" O.C. Ea.Way Short Bars Dowelled
½"ϕ @ 12" O.C. Ea.Way. Ea.Face
Bottom of Poor Farm Ditch 45.60
½"ϕ @ 12" O.C. Ea.Way. Ea.Face
12"ϕ x 12'-0" Creos. Piling 20 Req'd.
SECTION "B-B"
Scale ¼" = 1'-0"
24'-0"
3'-9"
3-5/8"ϕ Ea.Face
2-5/8"ϕ
El. 45.00
½"ϕ @ 12" O.C. Ea.Way Ea.Face
SECTION "C-C"
Scale ¼" = 1'-0"
66" Diam Storm Sewer
66" Diam. Storm Sewer
6-⅝"ϕ Dowelled
BUTTRESS
12" Concrete Slab ½"ϕ @ 10" O.C. Ea.Way
6-½"ϕ's Dowelled
BUTTRESS
PLAN
Scale ¼" = 1'-0"
GENERAL NOTES
All concrete to be Class "A" & Rubbed above grade.
Chamfer all outside corners of walls, slabs & Beams ¾"-45°
Lap all bar splices at least 40 dia. Bars to bend 40 Dia. into all walls normal to their direction.
Calculated Peak Velocity in 66" Storm Sewers = 115% of Fall Velocity = 3.32 Ft. Per Sec.
Reduction in Stilling Basin 50%
50% x 3.32 = 1.66 Ft. Sec. Over Baffle
Note:- All Concrete to be Class "A" Concrete. Estimated Quanity = 65 Cu.Yds.
Conc. Buttress
Const. Joint
½"ϕ Dowells 12" O.C. Ea.Face
½"ϕ @ 10" O.C. Ea.Way
SECTION "A-A"
Scale ½" = 1'-0"
PLAN & DETAILS OF A CONCRETE STILLING BASIN FOR OUTLET OF BUFFALO SPEEDWAY STORM SEWERS INTO POOR FARM DITCH.
Approved as To Velocity Control:
Engineer Drainage Dist. No. 12
Engineer Harris County, Texas.
Commissioners Drainage Dist No. 12
Mayor City of West Univ. Place
Engineer City of West Univ. Place
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS
GECO PROJ. NO. 533
DATE 5-21-42
DRAWN Mike Mebane
CHECKED M.M.
TRACED C.L. Moore
APPROVED M.T.G.


BUFFALO SPEEDWAY
BISSONETT
RICHMOND ROAD
S.A. & A.P. R.R.
Junction Box By Others
66" Sewer @ 0.05%
54" Sewer @ 0.27%
50 Ft. of 66" Sewer By Others
35 Ft. of 54" Sewer By Others
Topping By Harris County
Harris County Concrete Paving
Future Return
Head Wall Inlets & 18" Pipe
54" STORM SEWER
Fill Ditch Between Headwalls
Inlet Box See Details at Left
Ditch
Fence
HORIZ. & VERT. SCALE 1" = 20'-0"
PLAN A
PLAN B
SECTION A-A
SECTION B-B
54" DIAM.
Manhole Steps
ELEV. 55.14
ELEV. 62.00
ELEV. 64.007
NOTTINGHAM
SUNSET
ALBANS
WROXTON
QUENBY
FUTURE ST.
NOT IN THE CONTRACT
66" STORM SEWER @ 0.05%
54" STORM SEWER @ 0.27%
18" STUBS 3'-0" LONG PLUGGED
FUTURE EXTENSION OF BUFFALO SPEEDWAY
FUTURE DEVELOPMENT
HORIZ. SCALE 1" = 100'
See Enlarged Plan A
See Enlarged Plan B
Common Brick ½" Cement Plaster
concrete Base
PLAN
DETAILS OF HEADWALL
SCALE ½" = 1'-0"
All Concrete To Be Class B
Top of Rail
66" @ 0.05%
54" @ 0.27%
This Portion By Others
PLAN
PROFILE
NOTE BOOK
STORM SEWERS ON BUFFALO SPEEDWAY FOR HARRIS COUNTY, TEXAS
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS
GECO PROJ. NO. 533-CO.
DATE 3-26-42
DRAWN MEBANE
CHECKED J.B.S.
TRACED MEBANE
APPROVED J.B.S.



MERCER
Tangley
AMHERST

GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

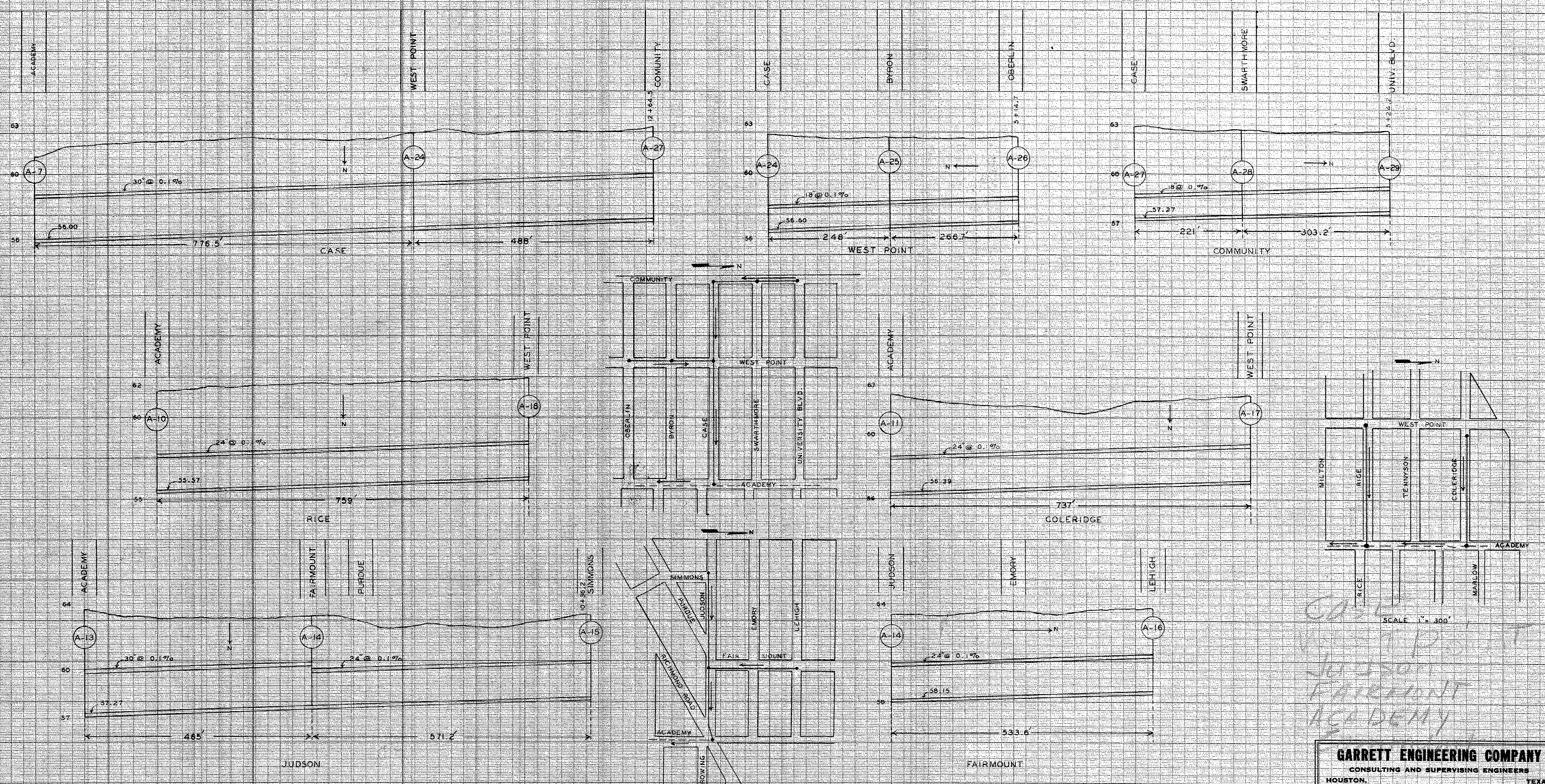
GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

NO.	DATE	BY	REMARKS

REVISIONS

DRAWING NO.

SHEET NO. 5 **OF** 13 **SHEETS**



NO.	DATE	BY	REMARKS

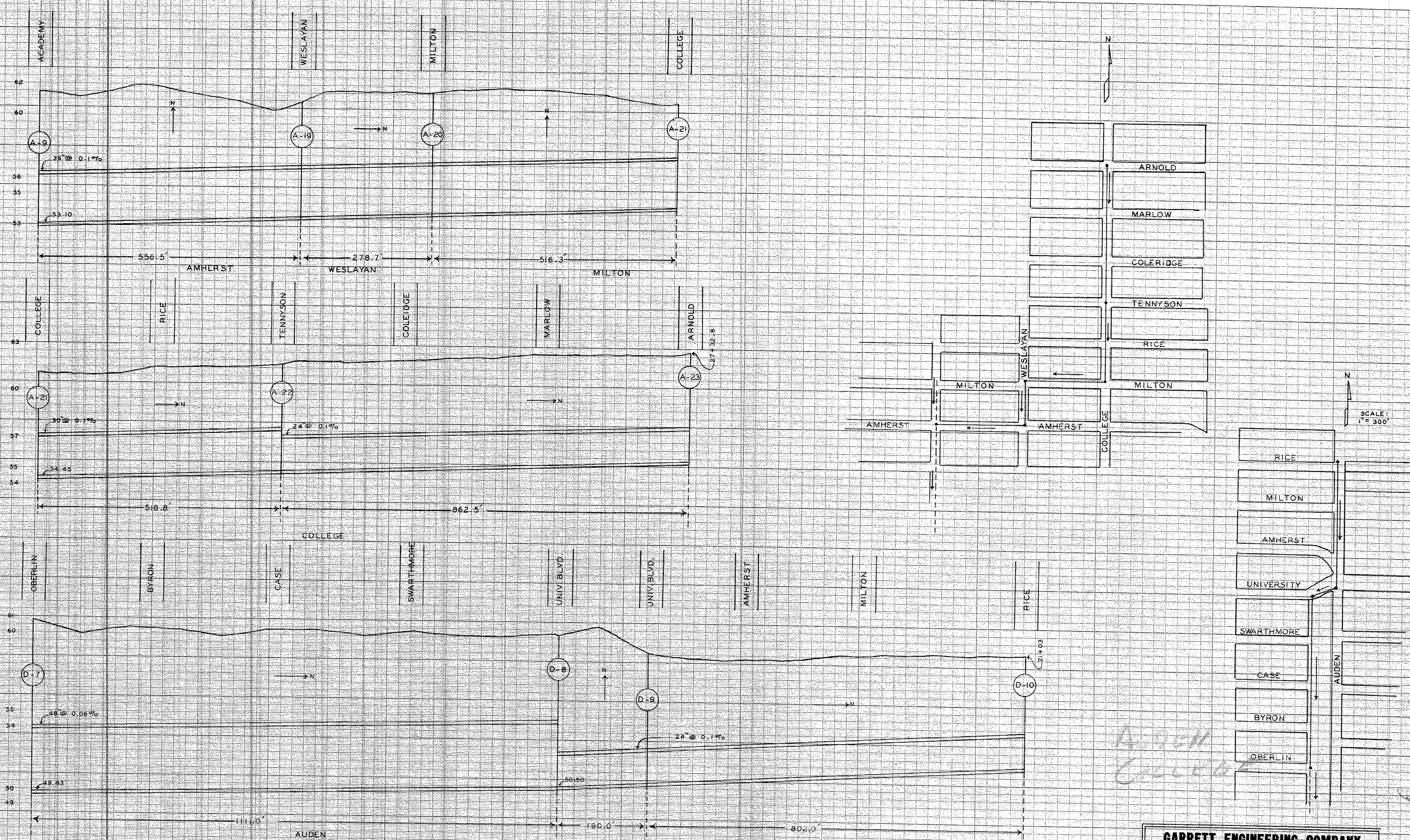
REVISIONS

GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

DRAWING NO.

SHEET NO. 6 **OF** 13 **SHEETS**

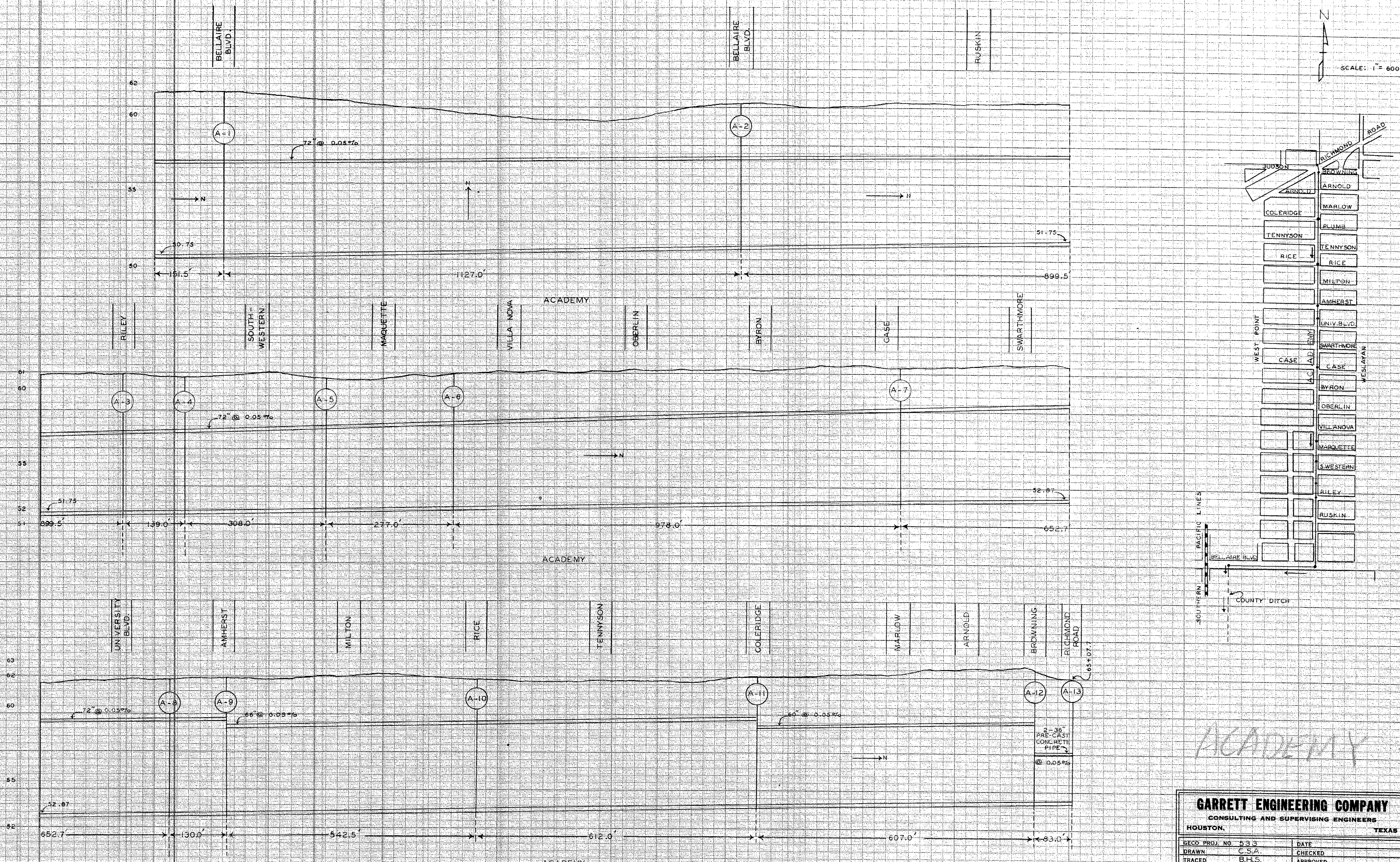


NO.	DATE	BY	REMARKS

GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

DRAWING NO.
SHEET NO. ____ OF ____ SHEETS



NO.	DATE	BY	REMARKS

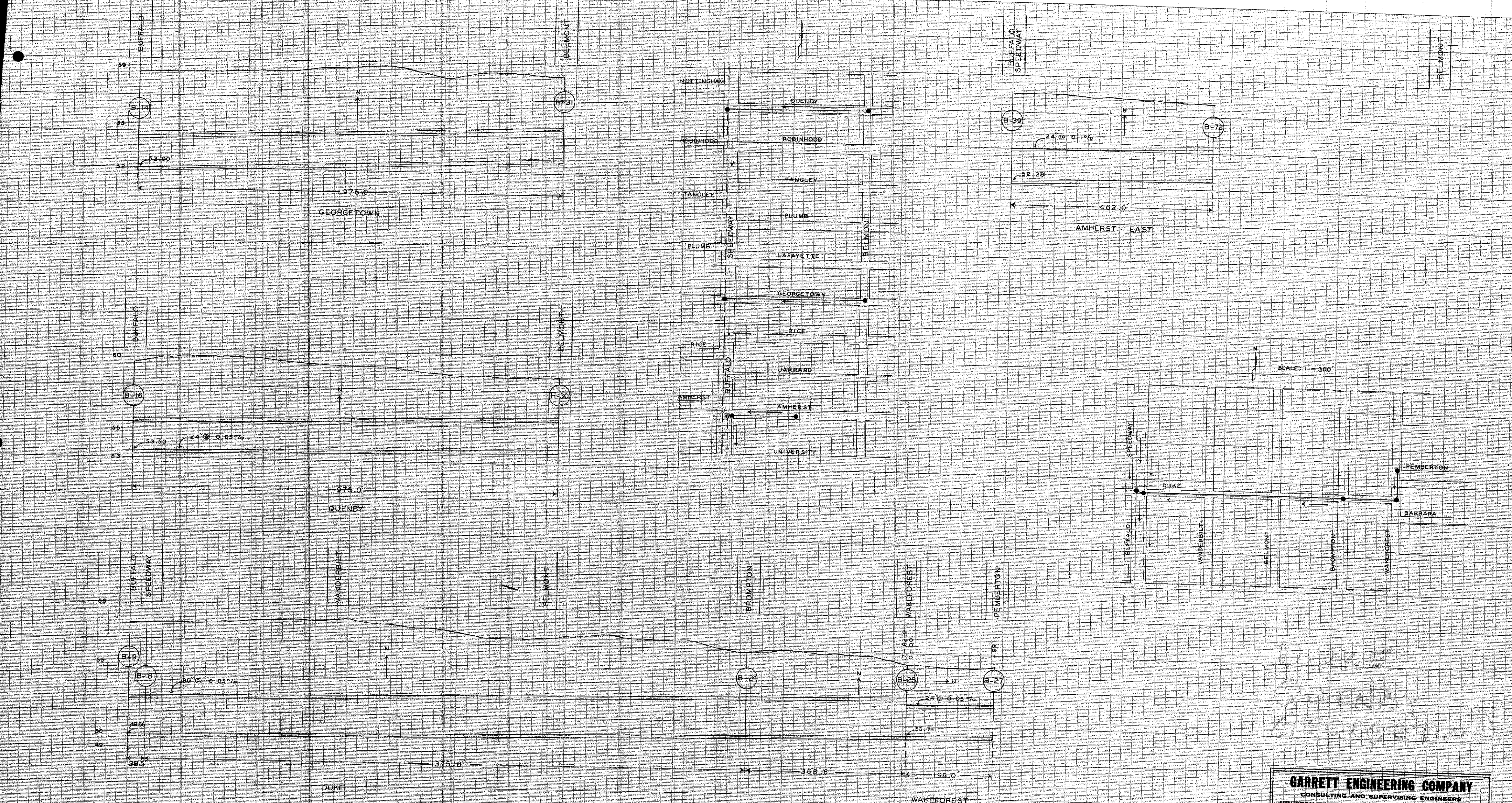
REVISIONS

GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

GECO PROJ. NO. 533	DATE
DRAWN C.S.A.	CHECKED
TRACED B.H.S.	APPROVED

DRAWING NO.

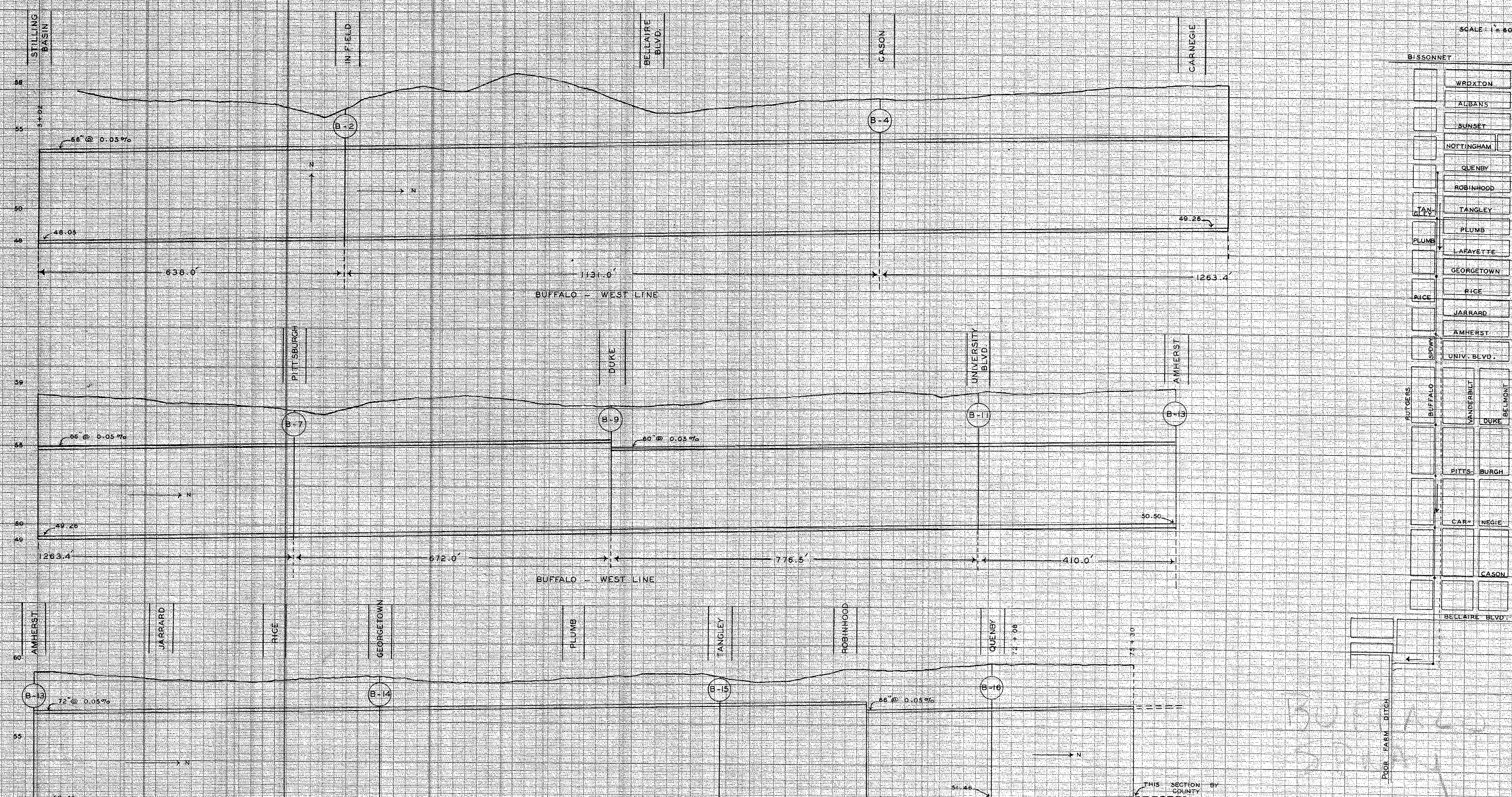
SHEET NO. 8 **OF** 13 **SHEETS**



GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

DRAWING NO.



NO.	DATE	BY	REMARKS

REVISIONS

GARRETT ENGINEERING COMPANY

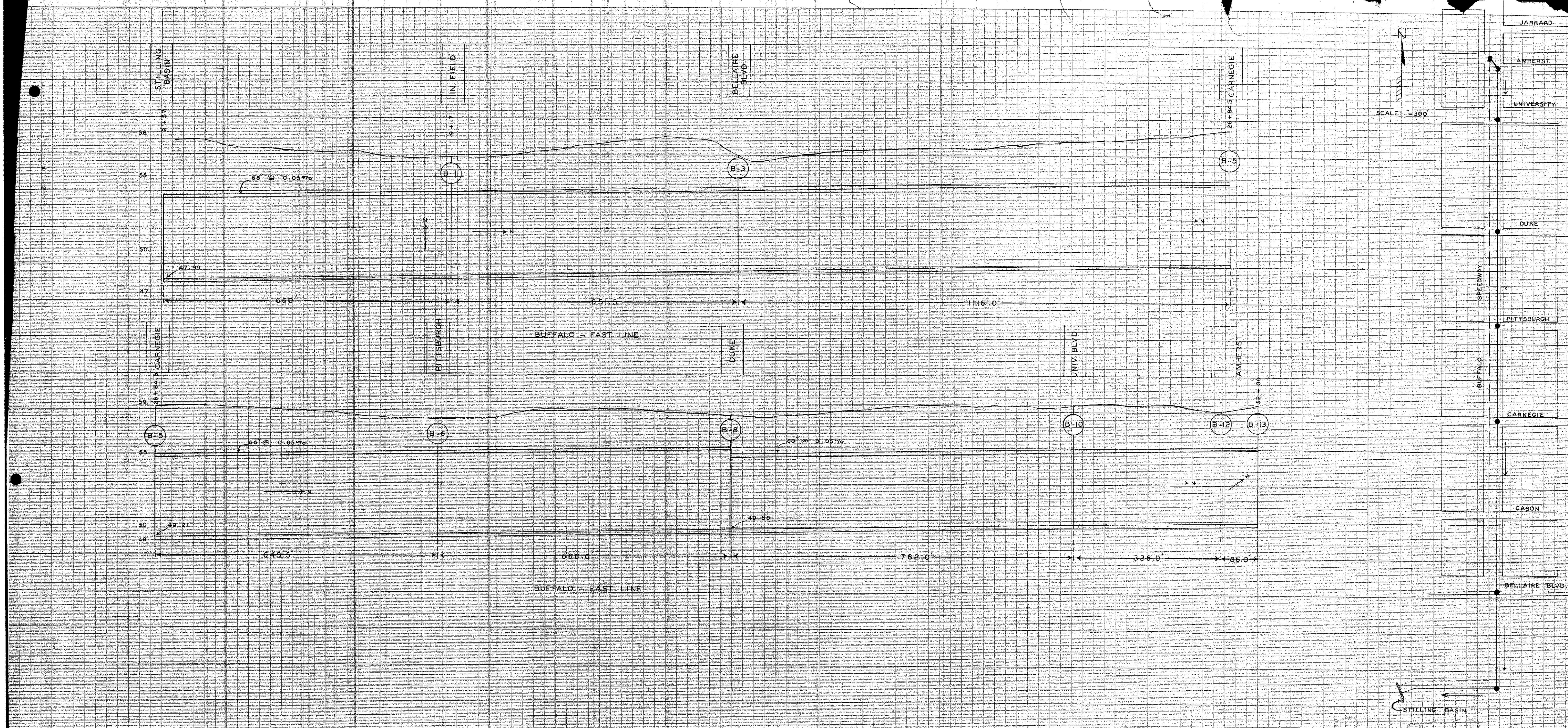
CONSULTING AND SUPERVISING ENGINEERS

HOUSTON, TEXAS

GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

DRAWING NO.

SHEET NO. [illegible] **OF** 73 **SHEETS**



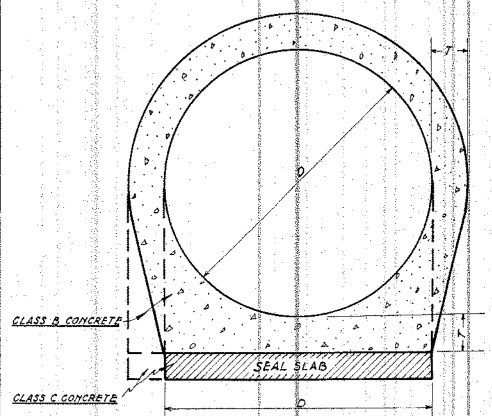
NO.	DATE	BY	REMARKS

GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

DRAWING NO.

TYPICAL PLAIN CONCRETE SEWER



SECTION

DIMENSIONS OF PLAIN CONCRETE SEWERS

INSIDE DIAMETER D = INCHES	MIN. THICKNESS T = INCHES
30	5
36	5½
42	6
48	6½
54	7
60	7½
66	8
72	8½

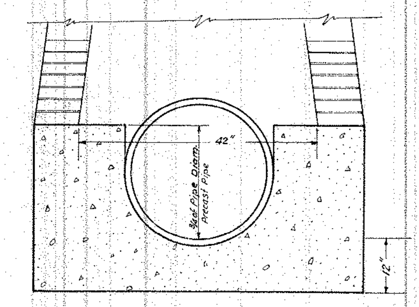
NOTE

1. Seal slab to be constructed only upon written order of the Engineer.
2. Seal slab concrete shall set 24 hours before setting forms.
3. Excavation for Seal Slab will be paid for at the Unit Price bid for Hand excavation.
4. When contractor uses a sheeting method requiring vertical sides below centerline of Sewer extra concrete used shall be placed at contractors expense.
5. When Soil conditions require vertical sides below centerline of sewer the Engineer shall order extra concrete to be placed and the contractor shall be paid for the extra concrete used at Unit price bid for concrete in place.
6. Forms shall be securely held in place with precast concrete blocks and timber shoring.

TYPICAL MANHOLE TYPE "A"

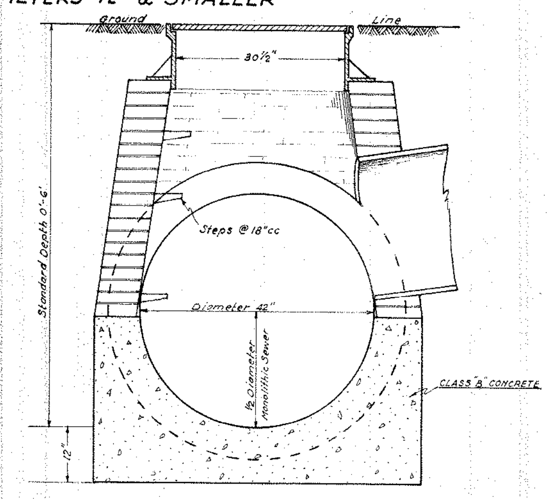
for

SEWERS WITH DIAMETERS 42" & SMALLER



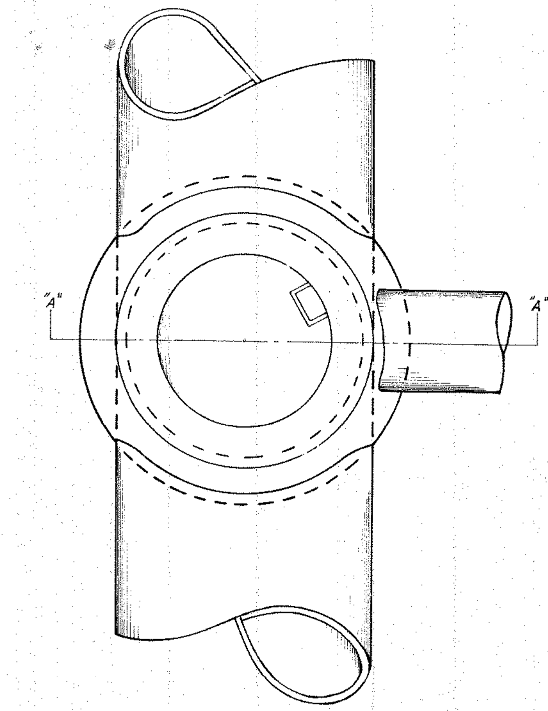
SECTION "A-A"

Diameter of Sewer Less than 42"



SECTION "A-A"

Diameter of Sewer 42"

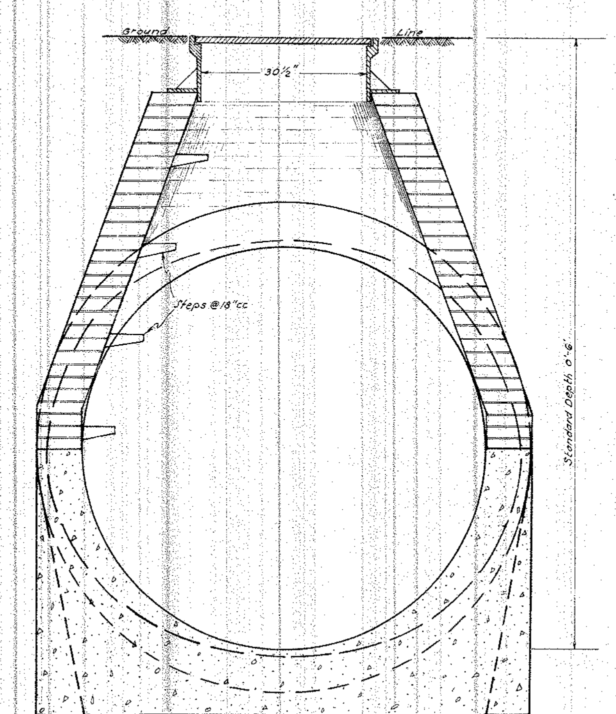


PLAN

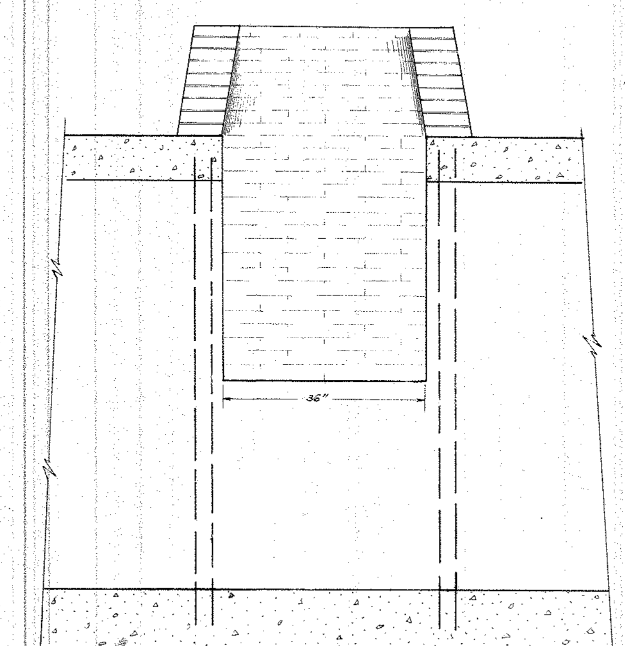
TYPICAL MANHOLE TYPE "B"

for

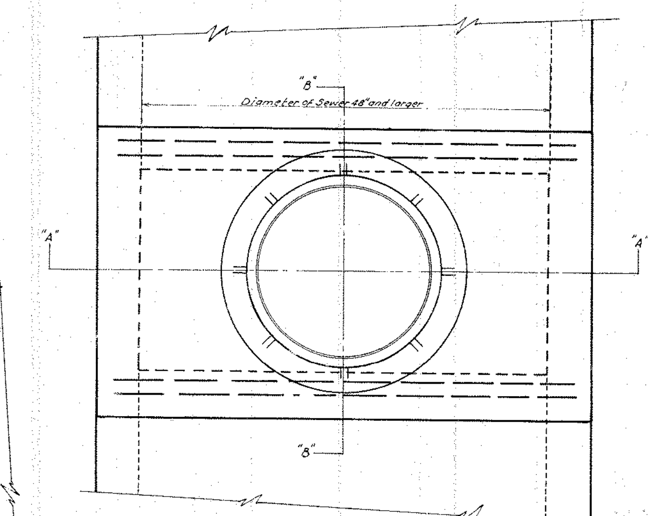
SEWERS WITH DIAMETERS 48" & LARGER



SECTION "A-A"



SECTION "B-B"



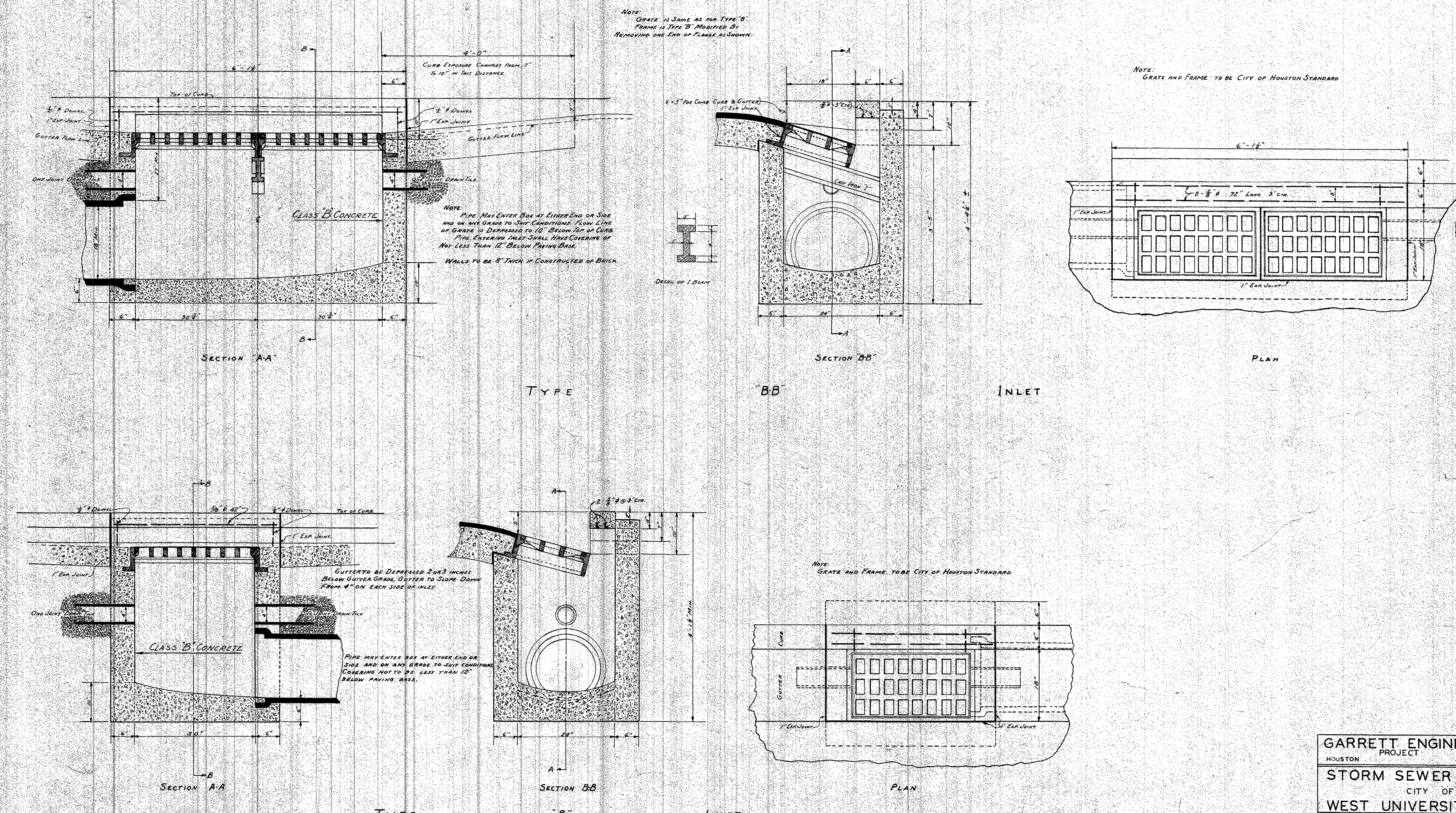
PLAN

STORM SEWERS ON BUFFALO SPEEDWAY FOR HARRIS COUNTY, TEXAS

GARRETT ENGINEERING CO.
PROJECT NO. 533
HOUSTON TEXAS

CIRCULAR STORM SEWER AND MANHOLES

REVISED	DATE	DRAWN BY	H.L.G.
J.B.S.	11-5-41	CHECKED	J.B.S.



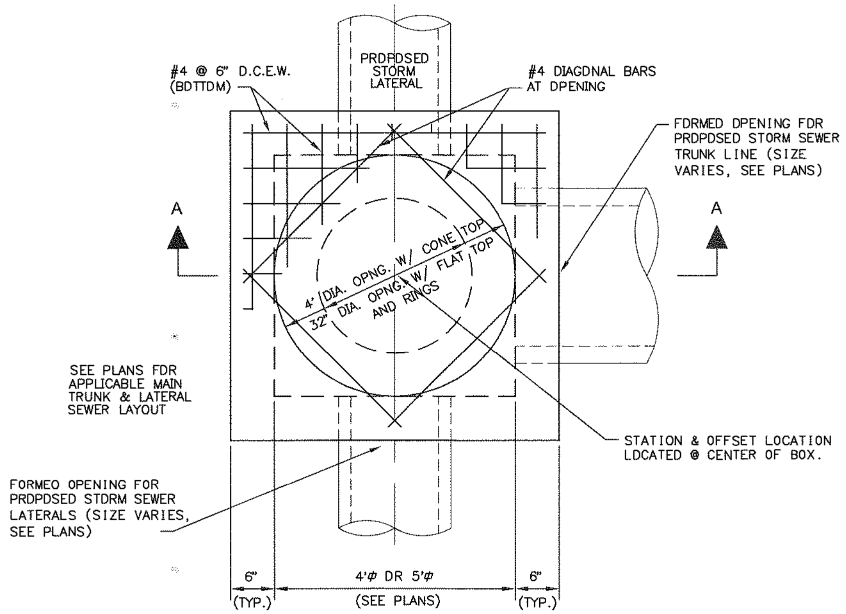
GARRETT ENGINEERING CO.
PROJECT NO. 533
HOUSTON TEXAS

STORM SEWER INLETS
CITY OF
WEST UNIVERSITY PLACE

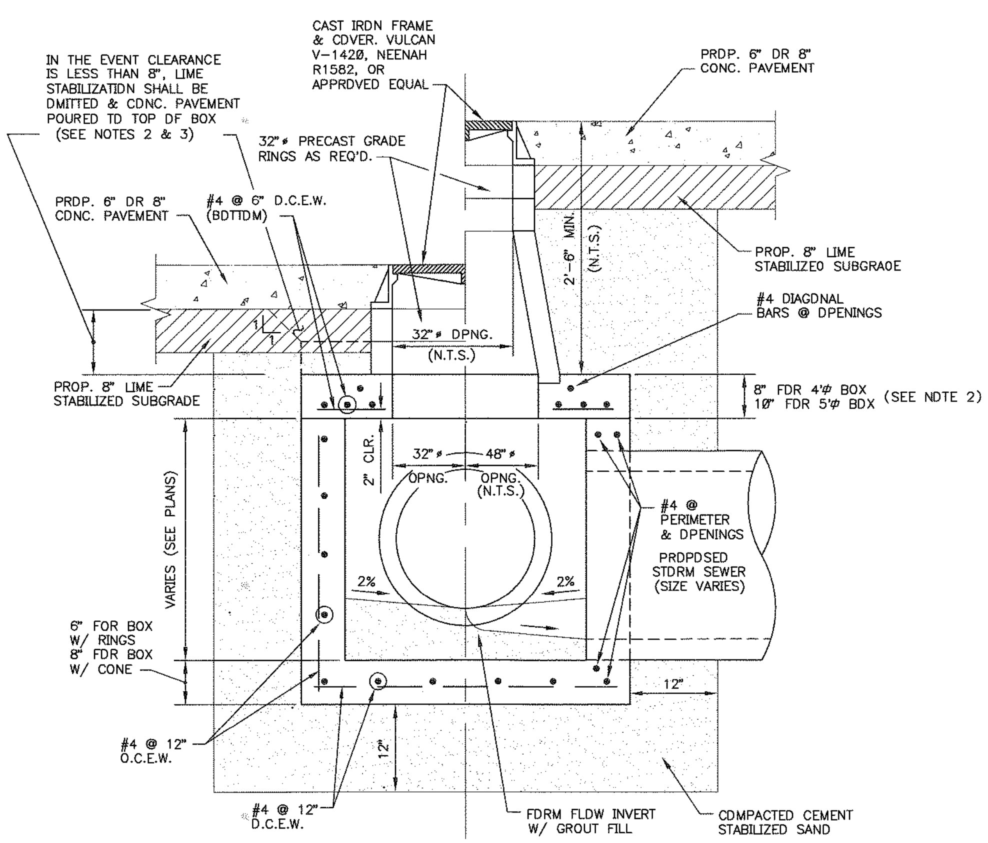
REVISED	DATE		
		DRAWN BY	H.L.G.
		CHECKED	J.B.S.
		TRACED	D.A.
		APPROVED	M.T.G.
		SHEET NO. 13 OF 13	

13-1

Appendix F. Construction Details for Connections to Existing Buffalo Speedway Monolithic Concrete Pipe



PLAN

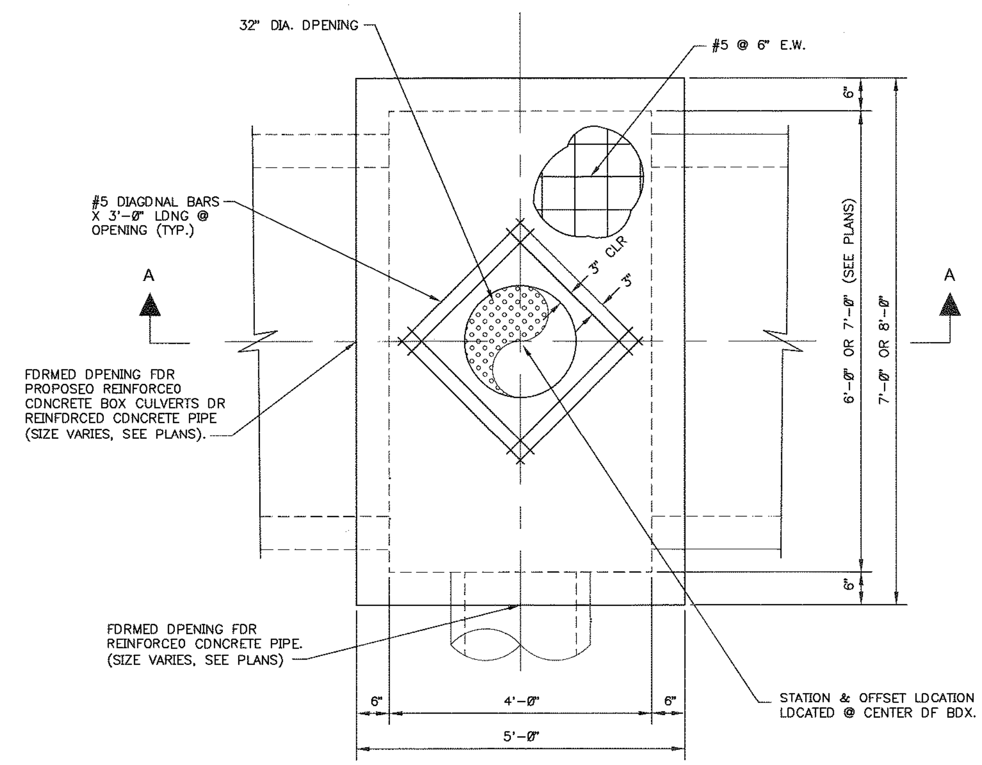


SECTION A-A

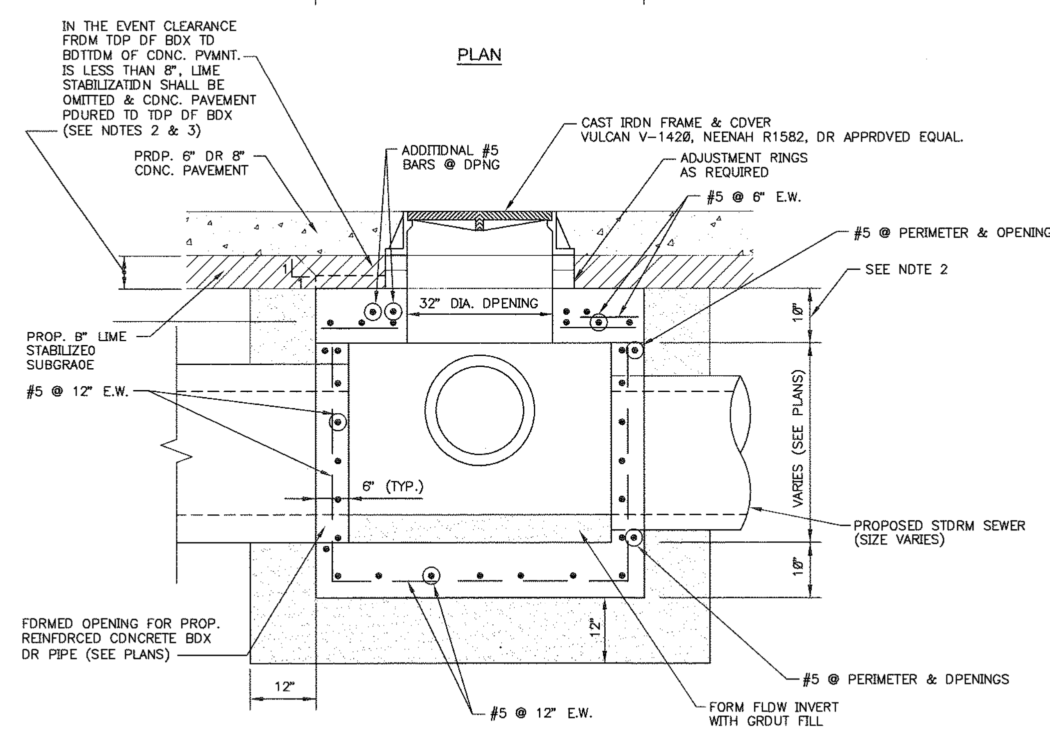
PRECAST STORM BOX MANHOLE DETAIL (SQUARE)

SCALE: NTS

BOX MANHOLES: 5-14, 18-30, 34-45, 48-63, 66, 67, & 69-85.



PLAN



SECTION A-A

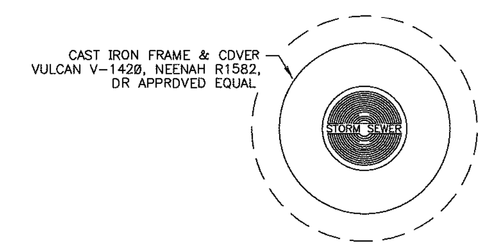
PRECAST STORM BOX MANHOLE DETAIL (RECTANGULAR)

SCALE: NTS

BOX MANHOLES: 3, 4, & 17

PRECAST STORM BOX MANHOLE NOTES:

1. ALL PRECAST STORM BOX MANHOLES SHALL BE CONSTRUCTED OF 4000 PSI CONCRETE, REINFORED 60000 PSI HS 20 LOADING PER MOOR-TEX CONCRETE PRODUCTS, INC. OR APPROVED EQUAL. THE DETAILS ON THIS SHEET REFLECT DESIGN REQUIRMENTS PROVIDED BY MOOR-TEX ENGINEERS. ANY VARIATION TO THESE DESIGNS OTHER THAN THOSE SHOWN IN THE DETAILS SHALL REQUIRE THE CONTRACTOR TO SUBMIT FOR APPROVAL SAID REVISIONS SIGNED & SEALED BY AN ENGINEER LICENSED IN THE STATE OF TEXAS.
2. CMI REVIEW INDICATES NO PRECAST STORM BOX MANHOLE TOP SLABS SHOULD ENCROACH INTO PROPOSED PAVEMENT; HOWEVER, IF ACTUAL CONSTRUCTION RESULTS IN THIS BEING UNAVOIDABLE, THE TOP SLAB THICKNESS SHALL BE MADE 14" AND REINFORCED PER TOP SLAB DETAILS FOR THE TYPE 2 STORM JUNCTION BOX ON SHEET 83.
3. CMI REVIEW DOES INDICATE THAT SOME PRECAST STORM BOX MANHOLE TOP SLABS MAY ENCROACH INTO PROPOSED PAVEMENT SUBGRADE. IN THESE CASES, THE SUBGRADE OVER THE BOX SHALL BE ELIMINATED AND THE PROPOSED CONCRETE PAVEMENT SHALL BE POURED TO THE TOP OF THE BOX AS DETAILED ON THIS SHEET.



STORM SEWER MANHOLE COVER

NOT TO SCALE

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — C. DIETER UFER — 23617 — REGISTERED PROFESSIONAL ENGINEER

C. Dieter Ufer 9/16/02

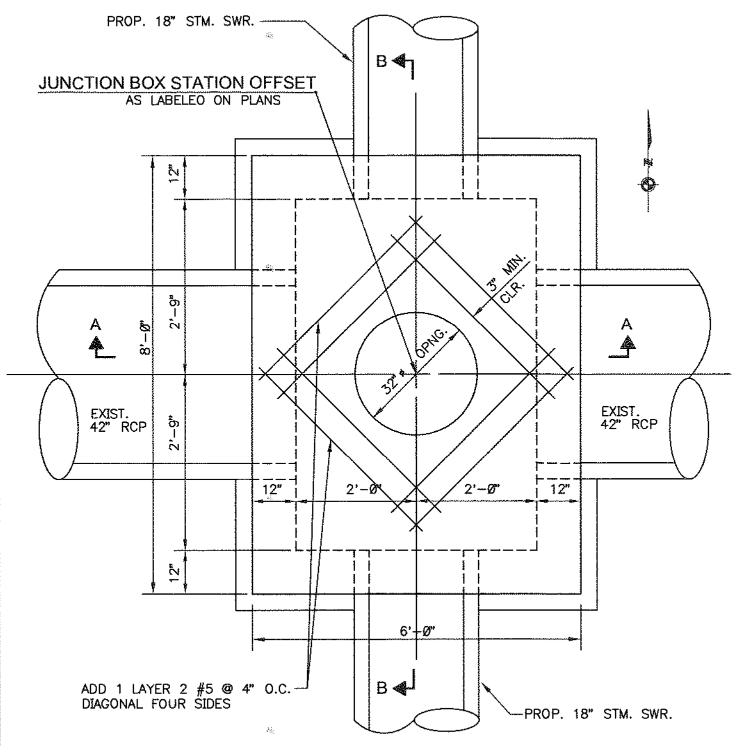
CLAUNCH & MILLER, INC.
Engineering Consultants
3701 Kirby Drive, Suite 860 • Houston, Texas 77098-3969
(713) 524-7113 • Fax (713) 524-7710 • www.claunchmiller.com

City of West University Place

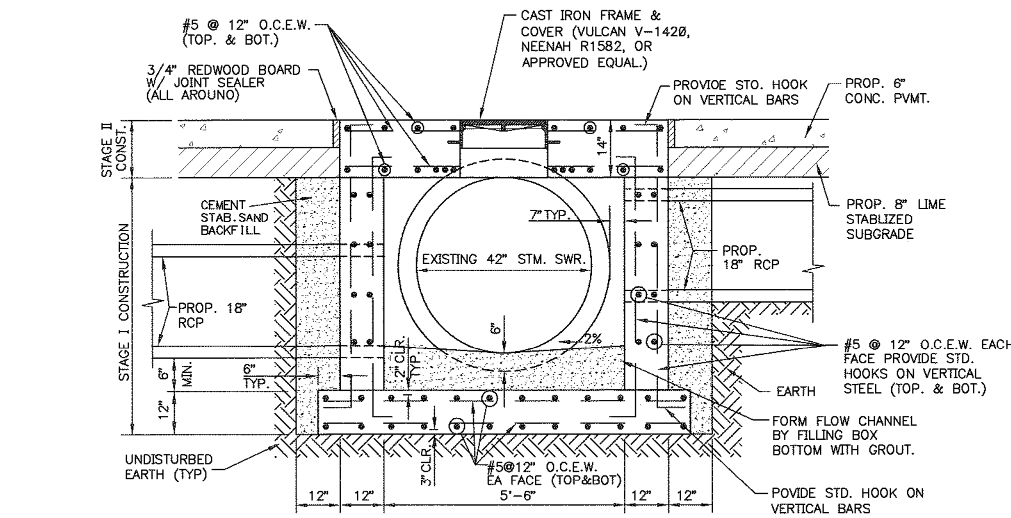
Priority Area 11B

Storm Sewer Construction Details

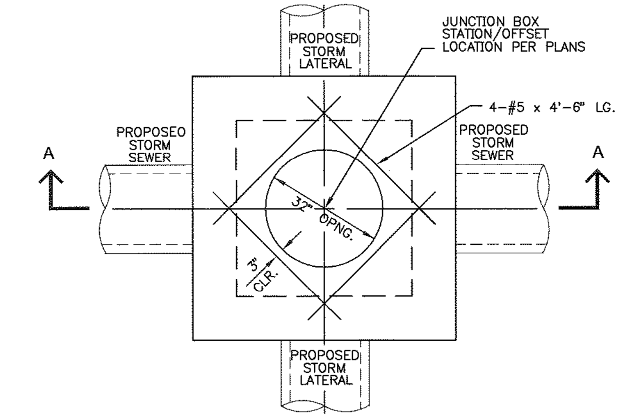
JOB No.: 01-041	SCALE: HORZ : NTS VERT : NTS	SHEET 81 OF 92
DATE: July, 2002		
DWN BY: P.B. Harsh		
CHKD BY: C.D. Ufer		



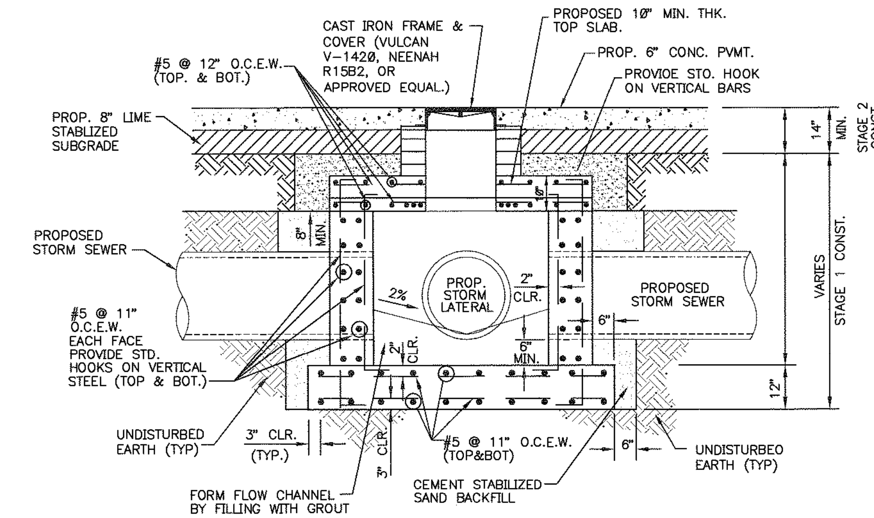
PLAN 1



SECTION B-B



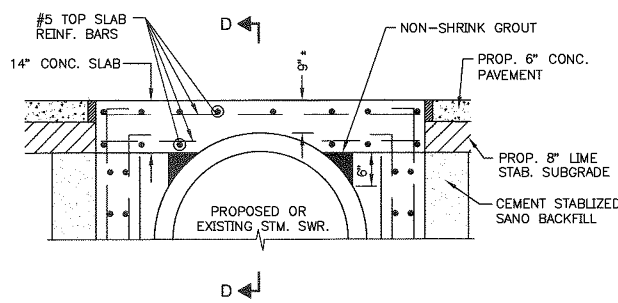
PLAN



SECTION A-A

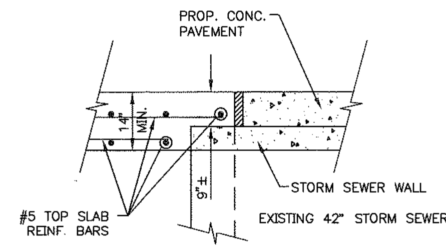
STORM SEWER JUNCTION BOX DETAIL
(FOR 30"Ø OR LESS PIPE, MANHOLE No.'s 64 & 65)

SCALE: 1/2" = 1'-0"



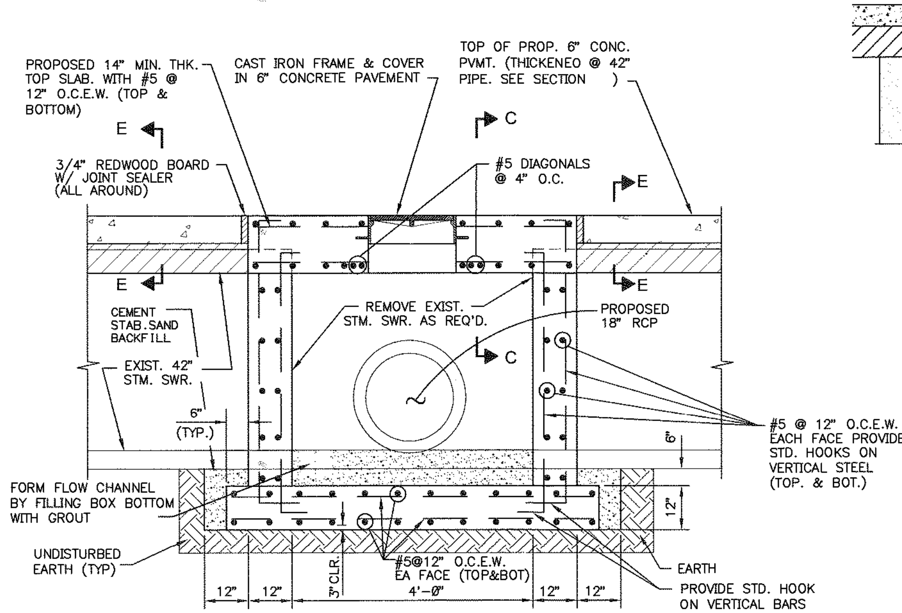
SECTION C-C

SCALE: 1/2" = 1'-0"



SECTION D-D

SCALE: 1/2" = 1'-0"



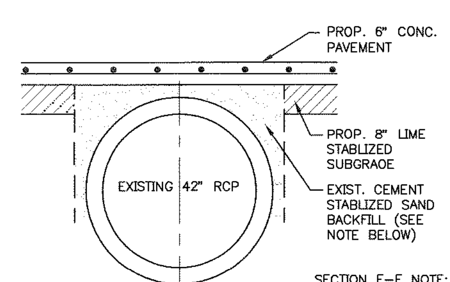
SECTION A-A

1.) ALL CONCRETE SHALL HAVE SAND AND GRAVEL AGGREGATE TYPE I PORTLAND CEMENT WITH 28 DAY COMPRESSIVE STRENGTH (f'c) OF 3000 PSI.

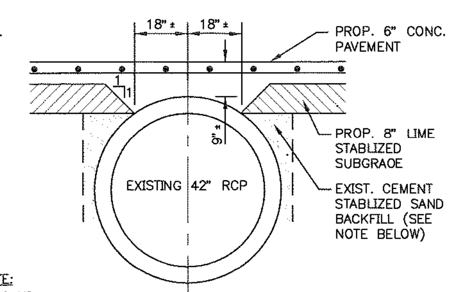
2.) ALL REINFORCING BARS SHALL CONFORM TO ASTM A615-GRADE 60.

TYPE 1 STORM SEWER JUNCTION BOX DETAIL

SCALE: 1/2" = 1'-0"
JUNCTION BOX NO. 6B

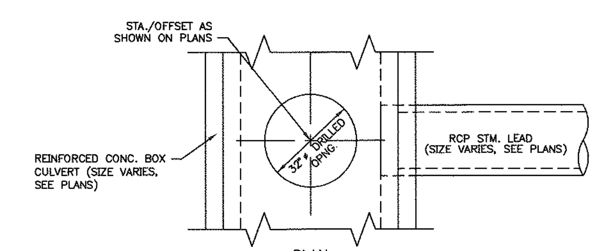


SECTION E-E
ALTERNATE 1

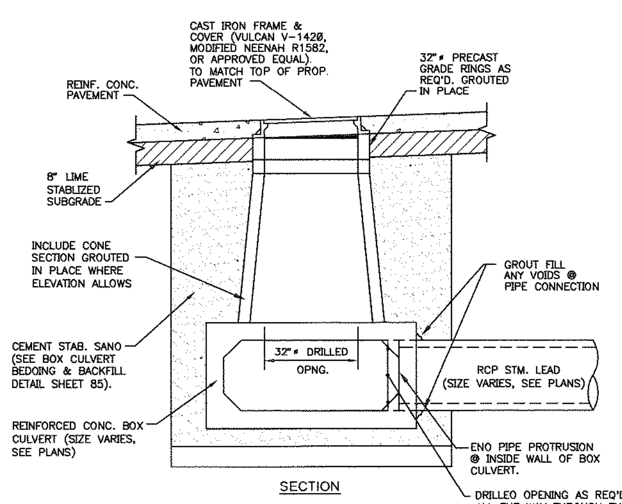


SECTION E-E
ALTERNATE 2

SECTION E-E NOTE:
IF CEMENT STAB. SAND BACKFILL EXISTS WITHIN LIMITS OF PROPOSED 8" SUBGRADE, GRIND C. SAND TO ELEVATION OF BOTTOM OF PROPOSED CONC. & CONSTRUCT AS SHOWN IN ALTERNATE 1. IF CEMENT STAB. SAND BACKFILL DOES NOT EXIST OR IS DAMAGED WITH EXCAVATION ACTIVITIES, CONSTRUCT PAVEMENT OVER 42" RCP AS SHOWN ALTERNATE 2.



PLAN



SECTION

MANWAY DETAIL

SCALE: 1/2" = 1'-0"

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — C. DIETER UFER — 23617 — REGISTERED PROFESSIONAL ENGINEER
C. Dieter Ufer 9/16/02

C&M CLAUNCH & MILLER, INC.
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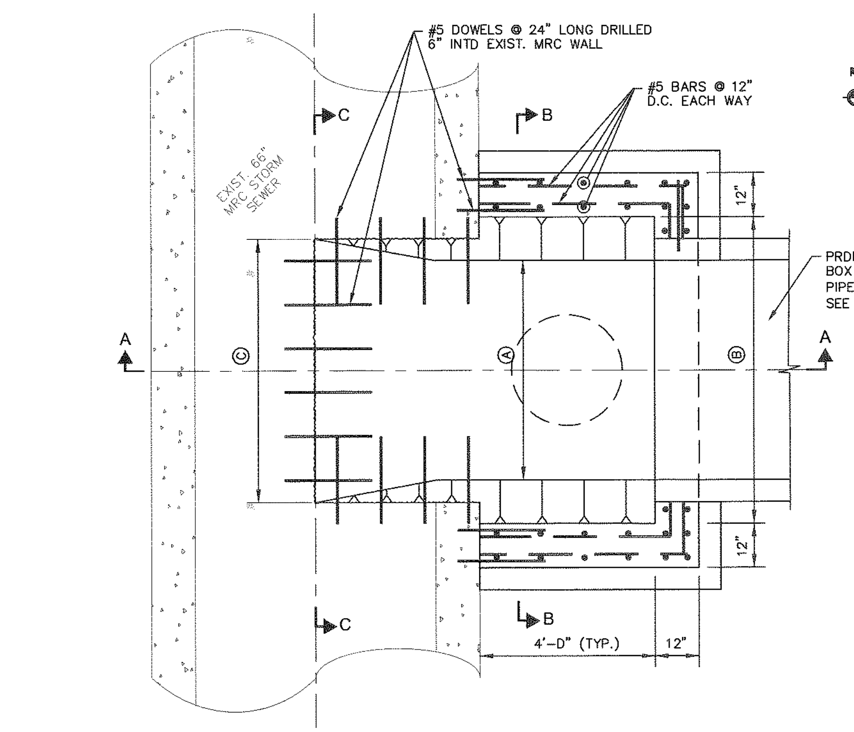
City of West University Place

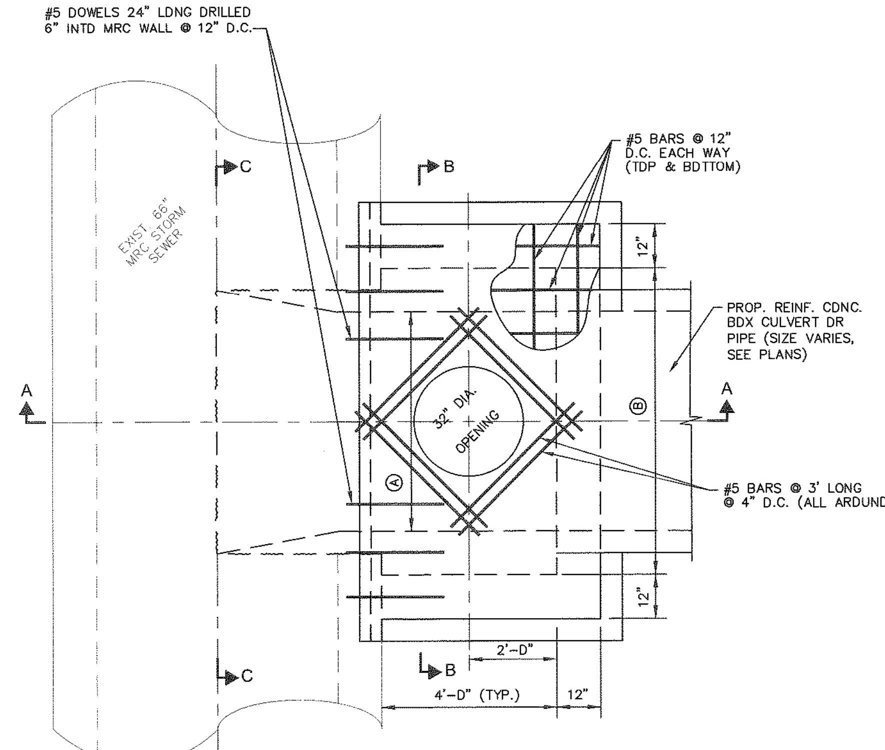
Priority Area 11B

Storm Sewer
Construction Details

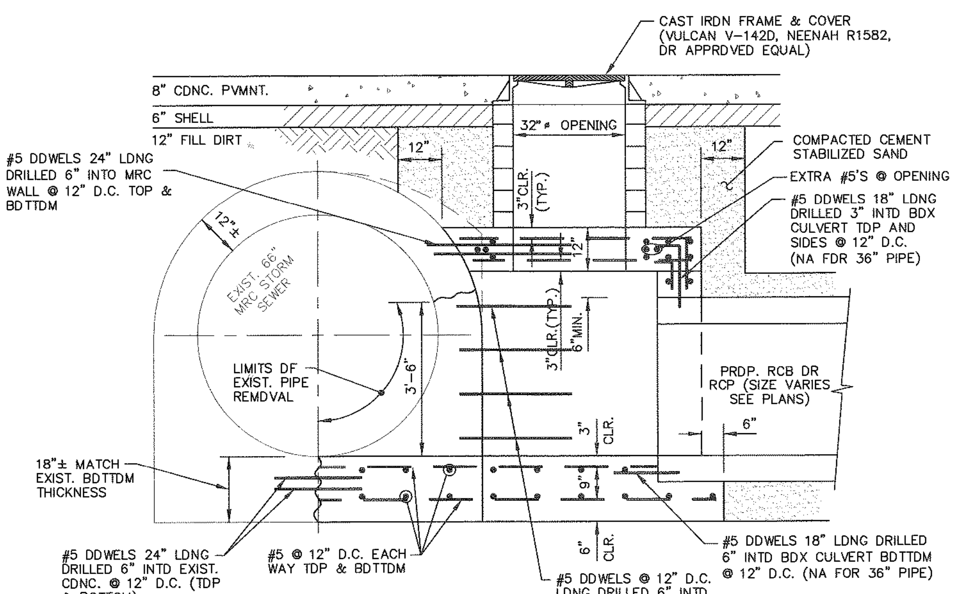
JOB NO.: 01-041	SCALE:		SHEET
DATE: July, 2002	HORZ: NTS	VERT: NTS	82
DWN BY: P.B. Harsh			
CHKD BY: C.D. Ufer			OF 92



BOTTOM PLAN



TOP PLAN

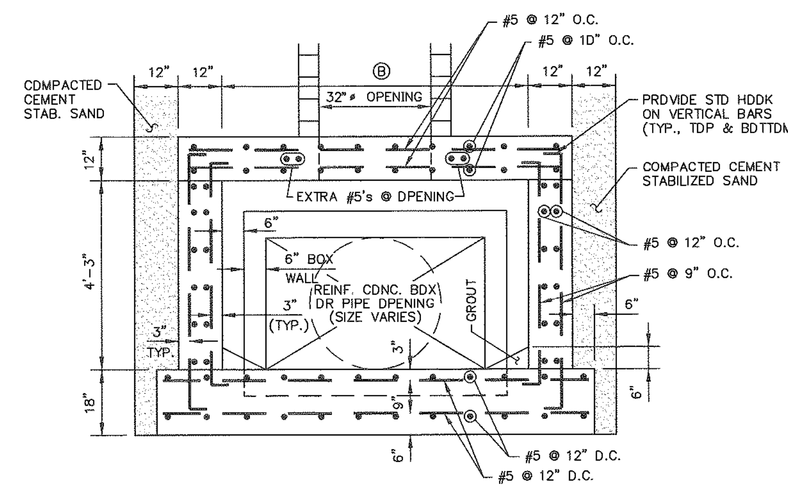


SECTION A-A

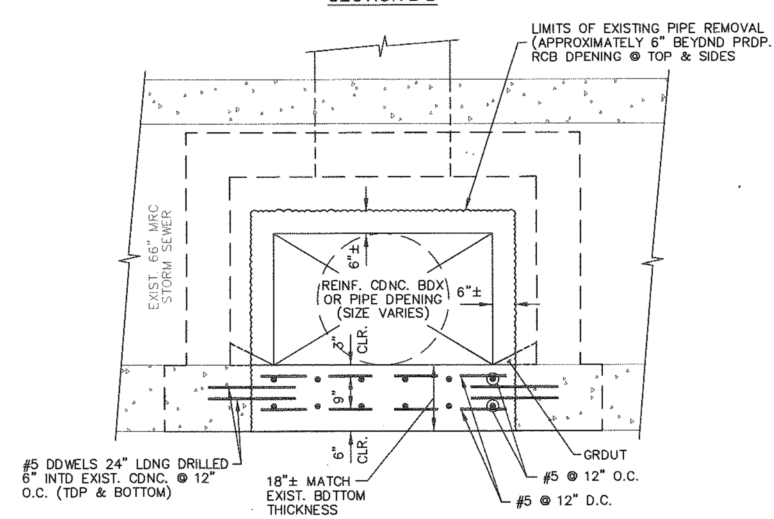
TYPE 2 STORM SEWER JUNCTION BOX TABLE			
No.	(A)	(B)	(C)
1 (4' x 2' RCB)	4'-0"	6'-0"	5'-0"
15 (4' x 2' RCB)	4'-0"	6'-0"	5'-0"
31 (4' x 2' RCB)	4'-0"	6'-0"	5'-0"
47 (36" RCP)	3'-0"	5'-0"	4'-0"

1.) ALL CONCRETE SHALL HAVE SAND AND GRAVEL AGGREGATE TYPE I PORTLAND CEMENT WITH 28 DAY COMPRESSIVE STRENGTH (f'c) OF 3000 PSI.

2.) ALL REINFORCING BARS SHALL CONFORM TO ASTM A615-GRADE 60.



SECTION B-B



SECTION C-C

TYPE 2 STORM SEWER JUNCTION

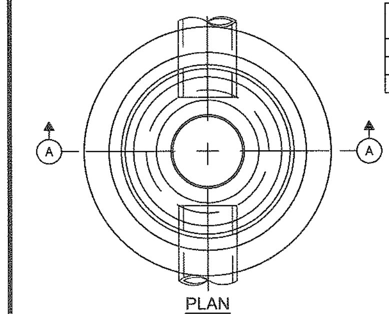
BOXES AT 66" STORM SEWER

SCALE: 1/2"= 1'-0"

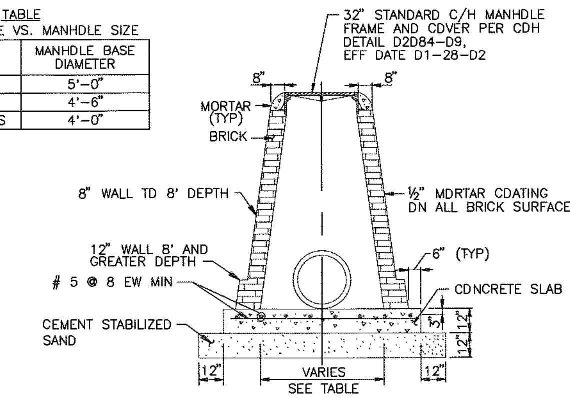
TABLE

SEWER SIZE VS. MANHOLE SIZE

SEWER SIZE	MANHOLE BASE DIAMETER
42"	5'-0"
36"	4'-6"
30" AND LESS	4'-0"



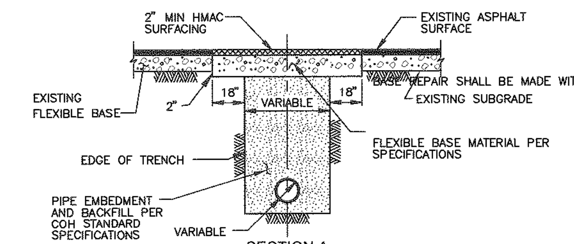
PLAN
(COVER NOT SHOWN)



SECTION A

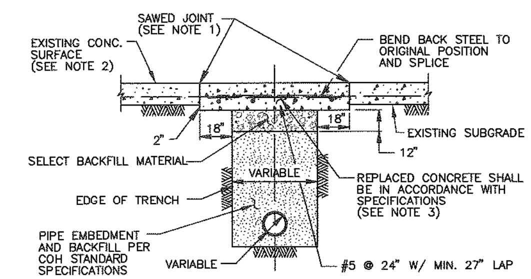
STANDARD CITY OF HOUSTON TYPE "C" STORM MANHOLE

NOT TO SCALE DTL. NO. 02081-03 EFF. DATE: JUL-01-97



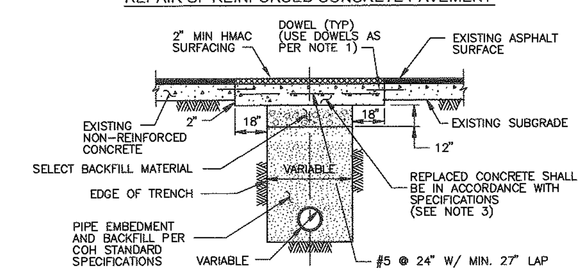
SECTION A

REPAIR OF FLEXIBLE BASE PAVEMENT



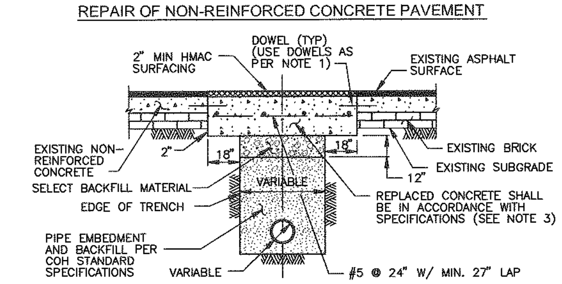
SECTION B

REPAIR OF REINFORCED CONCRETE PAVEMENT



SECTION C

REPAIR OF NON-REINFORCED CONCRETE PAVEMENT



SECTION D

REPAIR OF NON-REINFORCED CONCRETE PAVEMENT WITH BRICK

NOTE:

1. EXPOSE 15" OF REINFORCING STEEL AT PROPOSED SAWED JOINT. IF NO REINFORCING STEEL EXISTS, USE HORIZONTAL DOWELS. HORIZONTAL DOWELS SHALL BE # 6 BARS, 24" LONG, 24" C-C, DRILLED AND EMBEDDED 8" INTO THE CENTER OF THE EXISTING SLAB. WITH "PO ROC" OR EQUAL.
2. IF REINFORCED CONCRETE IS OVERLAYED WITH ASPHALT, REPLACE WITH 2" MIN HMAC SURFACING.
3. CENTER REINFORCING IN SLAB THICKNESS.

PAVEMENT REPAIR DETAILS

(FOR PAVEMENT REPAIR WITHIN CITY OF HOUSTON RIGHT-OF-WAYS ONLY)
NOT TO SCALE DTL. NO. 02902-01 EFF. DATE: JUL-01-97

CITY OF HOUSTON

DEPT. OF PUBLIC WORKS & ENGINEERING

PRIVATELY FUNDED PUBLIC WORKS | CITY FUNDED PUBLIC WORKS

WATER 9-5-02 — PROJECT MANAGER
WASTEWATER
STORM WATER 9-5-02 — CONSTRUCTION
STREET & BRIDGE 9.5.02 — CHIEF ENGINEER

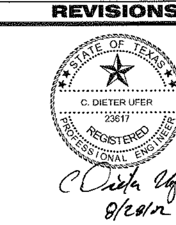
OTHER DEPARTMENTS
9-5-02
TRAFFIC AND TRANSPORTATION — SPONSOR DEPARTMENT

CITY ENGINEER — DATE

DIRECTOR OF PUBLIC WORKS AND ENGINEERING — DATE 9-5-2002

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS



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Engineering Consultants
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(713) 524-7113 • Fax (713) 524-1710 • www.claunchmiller.com

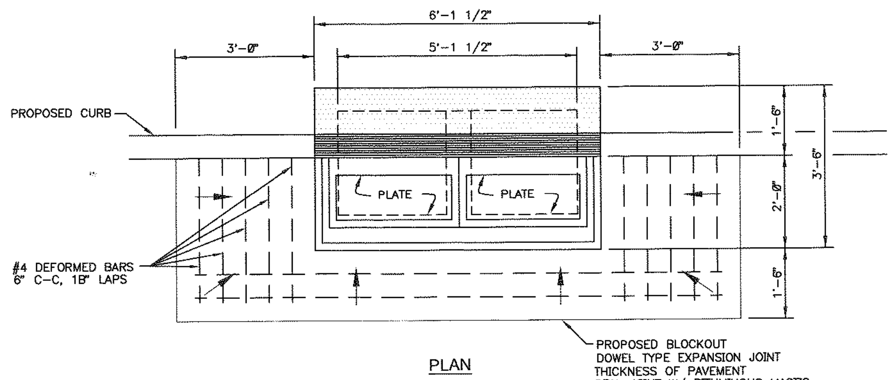
City of West University Place

Priority Area 11B

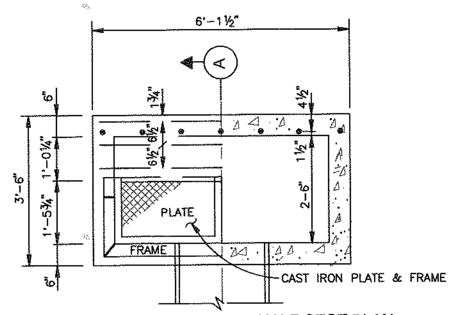
Storm Sewer
Construction Details

JOB NO. 01-041	SCALE: HORZ: NTS VERT: NTS	SHEET 83 OF 92	
DATE: July, 2002			
DWN BY: P.B. Harsh			
CHKD BY: C.D. Ufer			

X:\01-041 West University Priority Area 11B\Dwgs\Details\01-041-083 Storm Sewer Details 3.dwg, 8/28/2002 11:45:40 AM, pharsh



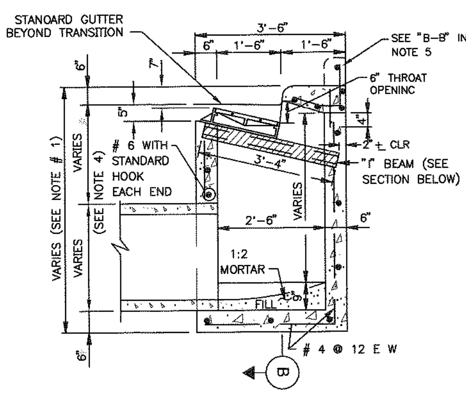
PLAN



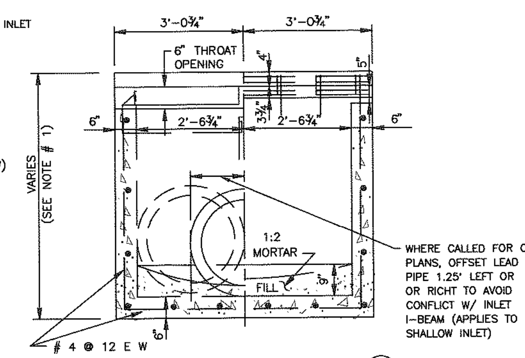
HALF PLAN HALF SECT PLAN

"B-B" INLET NOTES:

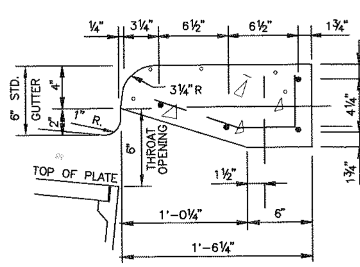
1. DIMENSION VARIES BASED ON PIPE DIAMETER AND WALL THICKNESS.
2. CENTER REINFORCINC IN SLAB AND WALLS.
3. CENTER STEEL BEAM ON INLET AND CAST INTO WALLS AS SHOWN.
4. SEE PLANS FOR TOP-OF-CURB ELEVATION, PIPE SIZE & FLOWLINE ELEVATION.
5. WHEN INLET FALLS WITHIN LIMITS OF EXACCERATED HEIGHT CURB CALLED FOR IN PLANS, DOWEL PROPOSED 6" CURB TO INLET TOP, (BACK AND SIDES) WITH #4 BARS, 9" LONC @ 12" C-C. RUN CONTINUOUS #4 BAR AS PER TYPICAL CONCRETE CURB DETAIL SHEET 86.
6. USE STD CAST IRON FRAME & PLATES. LEAD SHALL LEAVE INLET AT LOCATION AND CRADE REQUIRED.



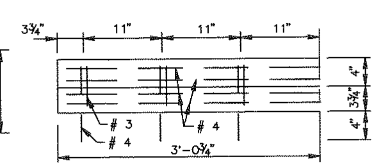
SECTION (A)



HALF FRONT ELEV HALF SECT (B)

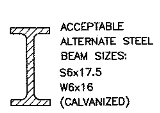


TRANS SECTION



HALF FRONT ELEV

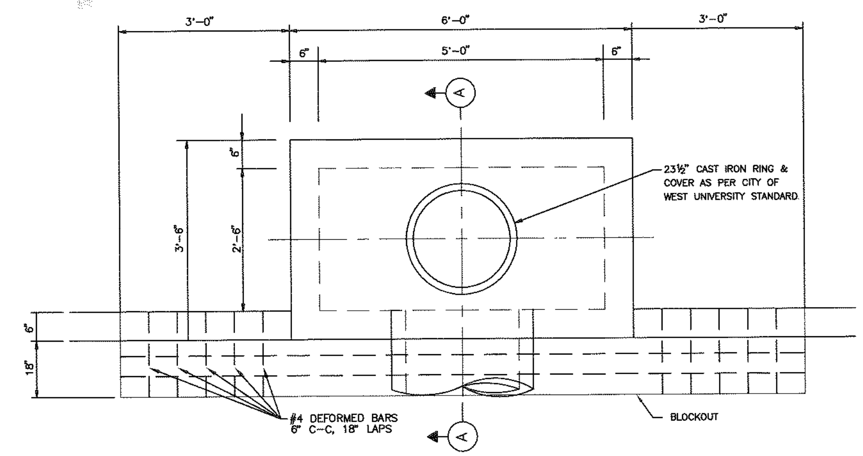
PRECAST CURB BEAM



SECTION THRU BEAM

CURB BEAM BAR LIST				
NO	SIZE	LENCTH	SHAPE	LOC
4	# 4	5'-10"	ST	HOR
7	# 4	0'-10"	ST	VERT
7	# 3	1'-6"	BT	

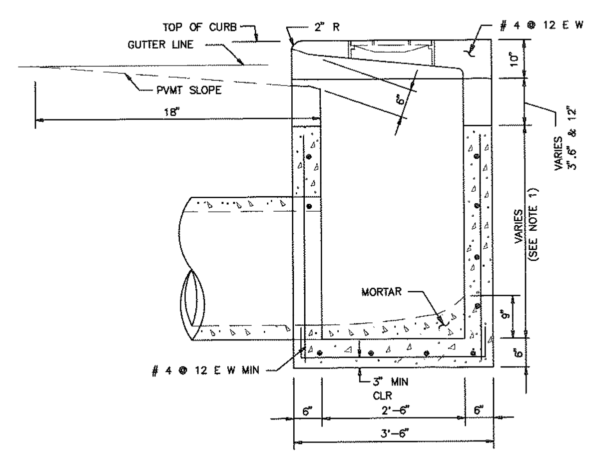
TYPE "BB" INLET DETAIL
NOT TO SCALE



PLAN

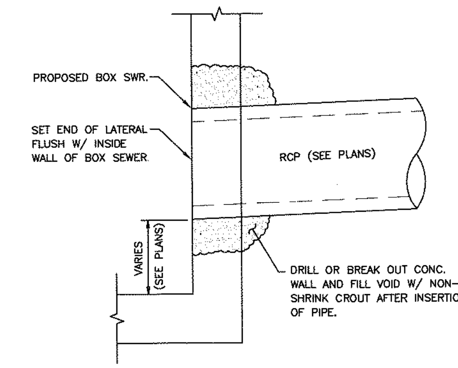
"H-2" INLET NOTES:

1. DIMENSION VARIES BASED ON PIPE DIAMETER AND WALL THICKNESS.
2. CENTER REINFORCINC IN SLAB AND WALLS.
3. SEE PLANS FOR TOP-OF-CURB ELEVATION, PIPE SIZE, & FLOWLINE ELEVATION.
4. WHEN INLET FALLS WITHIN LIMITS OF EXACERATED HEIGHT CURB (WHERE CALLED FOR ON PLANS) DOWEL PROPOSED 6" CURB TO TOP, BACK & SIDES OF INLET TOP WITH # 4 BARS, 9" LONC @ 12" OC. RUN CONTINUOUS #4 BAR AS PER TYPICAL CONCRETE CURB DETAIL, SHEET B6.

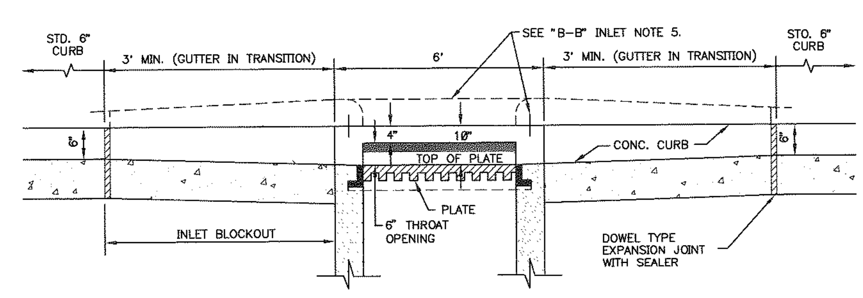


SECTION (A)

TYPE "H-2" PRECAST INLET DETAIL
NOT TO SCALE



PIPE-TO-BOX CONNECTION DETAIL
NOT TO SCALE



GUTTER DEPRESSIONS FOR TYPE "BB" & "H-2" INLET

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS
C. DIETER UFER
29617
REGISTERED PROFESSIONAL ENGINEER
C Dieter Ufer
9/16/02

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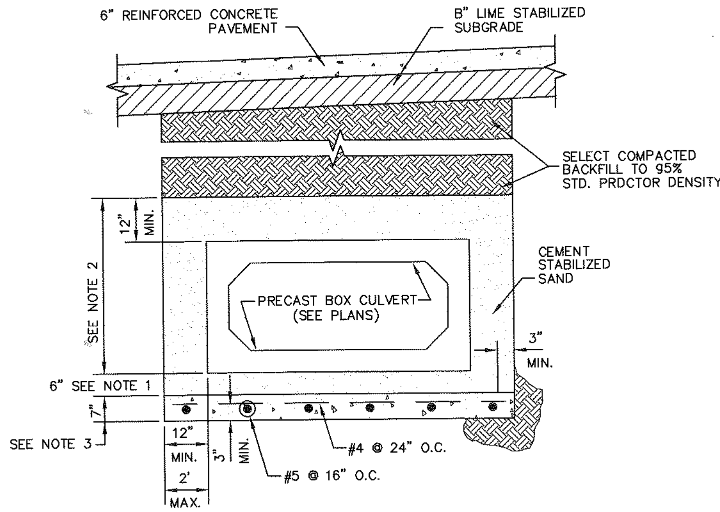
City of West University Place

Priority Area 11B

Storm Sewer Construction Details

JOB No.: 01-041	SCALE: HORZ : NTS VERT : NTS	SHEET 84 OF 92
DATE: July, 2002		
DWN BY: P.B. Harsh		
CHKD BY: C.D. Ufer		



BOX CULVERT BEDDING & BACKFILL DETAIL

SCALE: 1/2" = 1'-0"

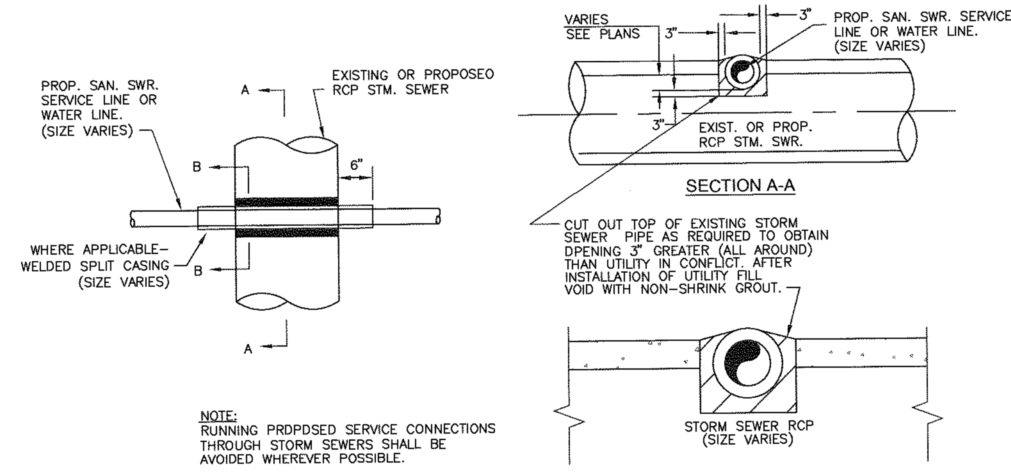
NOTES:

1. CEMENT STABILIZED SAND TO BE LAID PRIOR TO BOX PLACEMENT.
2. CEMENT STABILIZED SAND TO BE LAID AFTER BOX PLACEMENT.
3. IN DRY TRENCH CONDITION, THE 7" REINFORCED CONCRETE SLAB SHALL BE OMITTED. (NOTE: 12" THICK CRUSHED ROCK MAY BE INSTALLED IN PLACE OF 7" REINF. CONC. SLAB, ADD DEPTH AS NEEDED FOR SEEPAGE DRAINAGE.)

DRY TRENCH CONDITIONS ARE DEFINED AS FOLLOWS:

A. STRATA FROM THE SPRINGLINE (CENTER) TO 3' BELOW THE FLOWLINE OF THE BOX CONSIST OF NON-WATERBEARING COHESIVE SOILS HAVING A SHEAR STRENGTH OF 1000 PSF OR GREATER.

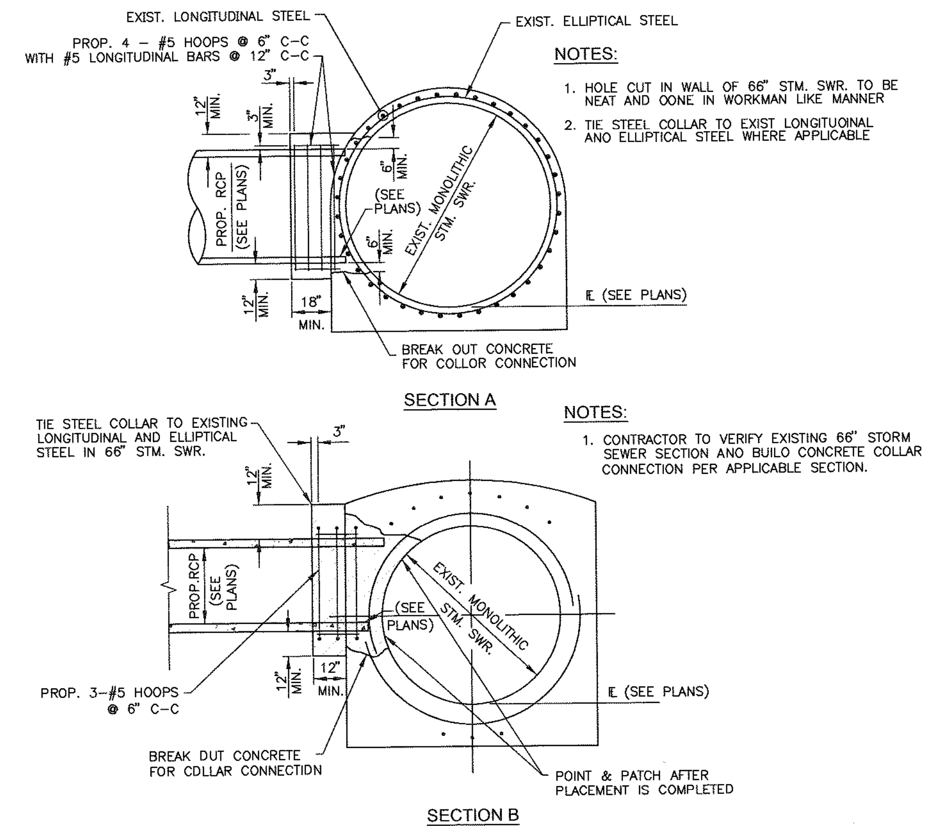
B. NO WET SAND STRATA EXIST IN THE AREA FROM 1' ABOVE THE TOP OF THE BOX TO 3' BELOW THE FLOWLINE.



NOTE:
RUNNING PROPOSED SERVICE CONNECTIONS THROUGH STORM SEWERS SHALL BE AVOIDED WHEREVER POSSIBLE.

STORM SEWER/UTILITY CONFLICT DETAIL

NOTE:
SEE SHEET 79 FOR SPLIT CASING DETAIL.



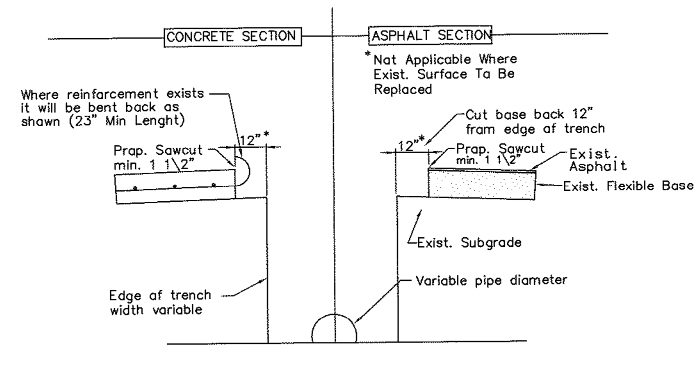
NOTES:

1. HOLE CUT IN WALL OF 66" STM. SWR. TO BE NEAT AND DONE IN WORKMAN LIKE MANNER
2. TIE STEEL COLLAR TO EXIST LONGITUDINAL AND ELLIPTICAL STEEL WHERE APPLICABLE

NOTES:

1. CONTRACTOR TO VERIFY EXISTING 66" STORM SEWER SECTION AND BUILD CONCRETE COLLAR CONNECTION PER APPLICABLE SECTION.

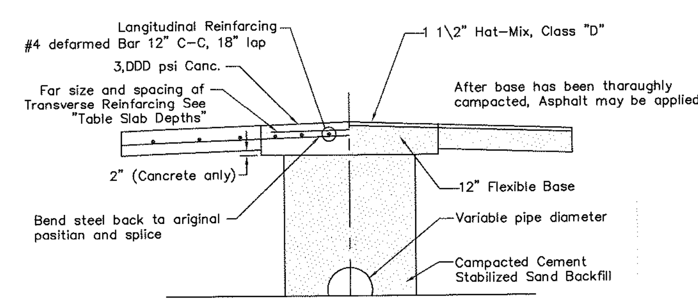
CONCRETE COLLAR CONNECTION DETAIL



SECTION SHOWING METHOD OF CUTTING

Table of Slab Depths & Reinf.

Min. Depth of Slab	Width of Trench	Size of Bar	Spacing	Length of Bar
8"	18"	4	9"	40"
8"	24"	4	8"	46"
8"	30"	4	7"	52"
8"	36"	4	6"	58"
10"	42"	4	8½"	64"
10"	48"	4	7½"	70"
10"	54"	4	7"	76"
10"	60"	4	6½"	82"
10"	66"	5	9"	88"
10"	72"	6	8½"	94"
10"	78"	6	8"	100"
10"	84"	6	7½"	106"

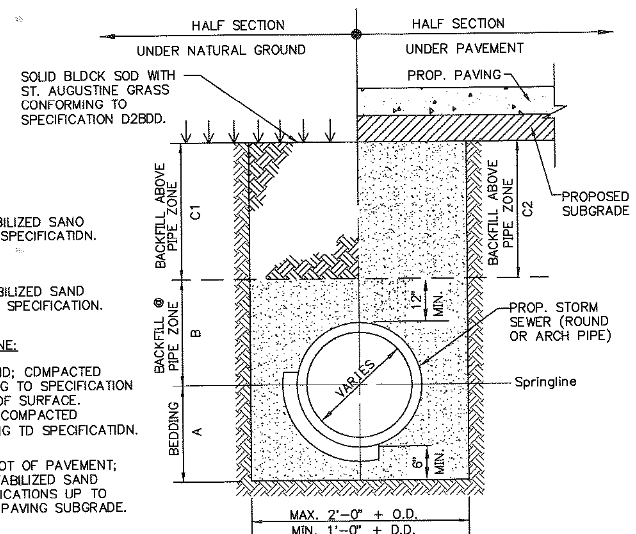


SECTION SHOWING METHOD OF REPAIR

SEE DETAILS, SHEET 83 FOR PAVEMENT REPAIR REQUIREMENTS WITHIN CITY OF HOUSTON RIGHT-OF-WAY.

CUTTING AND REPAIRING CONCRETE AND ASPHALT PAVEMENT DETAIL

NOTE: THIS DETAIL SHALL ONLY BE USED IN THE PROJECT WHERE THE EXISTING STREET PAVEMENT IS NOT TO BE REPLACED. TYPICAL FOR ALL PROPOSED UTILITY CONSTRUCTION.



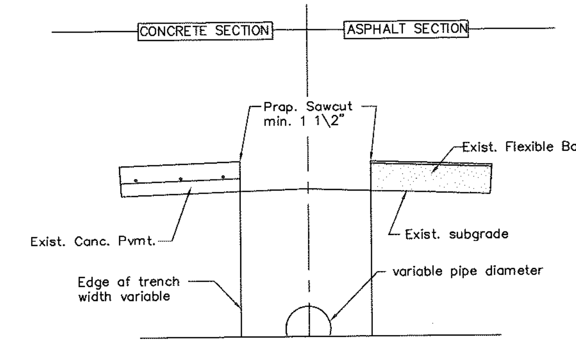
A. BEDDING:
COMPACTED CEMENT-STABILIZED SAND BEDDING CONFORMING TO SPECIFICATION.

B. BACKFILL @ PIPE ZONE:
COMPACTED CEMENT-STABILIZED SAND BACKFILL CONFORMING TO SPECIFICATION.

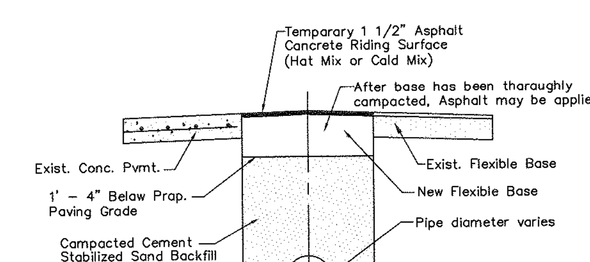
C. BACKFILL ABOVE PIPE ZONE:
1. UNDER NATURAL GROUND; COMPACTED BANK SAND CONFORMING TO SPECIFICATION UP TO WITHIN 1 FOOT OF SURFACE. TOP 1 FOOT SHALL BE COMPACTED SELECT FILL CONFORMING TO SPECIFICATION.
2. UNDER OR WITHIN 1 FOOT OF PAVEMENT; COMPACTED CEMENT STABILIZED SAND CONFORMING TO SPECIFICATIONS UP TO BOTTOM OF PROPOSED PAVING SUBGRADE.

STORM SEWER BEDDING & BACKFILL DETAILS

NOT TO SCALE



SECTION SHOWING METHOD OF CUTTING



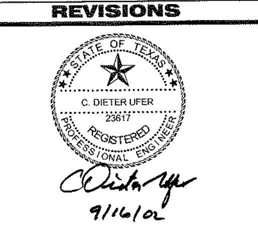
SECTION SHOWING METHOD OF REPAIR

CUTTING AND REPAIRING CONCRETE AND ASPHALT PAVEMENT DETAIL

NOTE: THIS DETAIL SHALL ONLY BE USED IN THE PROJECT WHERE THE EXISTING STREET PAVEMENT IS TO BE REPLACED. TYPICAL FOR ALL PROPOSED UTILITY CONSTRUCTION.

MK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS



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City of West University Place

Priority Area 11B

Storm Sewer Construction Details

JOB NO.: 01-041	SCALE: HORZ: NTS VERT: NTS	SHEET 85 OF 92
DATE: July, 2002		
DWN BY: P.B. Harsh		
CHKD BY: C.D. Ufer		

Appendix G. Field Survey Data and Field Notes from West Belt Surveying, Inc.

Node Data

Name	Ground Elevation	Invert Elevation
	ft	ft
Nd01	49.545	40.840
Nd02	48.977	41.390
Nd03	48.841	40.770
Nd04	49.347	40.980
Nd05	49.367	40.650
Nd06	48.713	40.530
Nd07	48.038	40.560
Nd08	48.298	40.220
Nd09	48.196	40.520
Nd10	46.790	38.370
Nd11	46.628	38.340
Nd12	46.823	38.050
Nd13	47.043	37.850
Nd14	46.019	37.630
Nd15	45.833	37.500
Nd16	47.161	38.960
Nd17	46.865	39.020
Nd18	46.623	38.830
Nd19	47.950	39.460
Nd20	48.000	39.380
Nd21	47.354	39.450
Nd22	48.234	40.520
Nd23	47.561	40.090
Nd24	48.482	39.680
Nd25	48.499	40.020
Nd26	48.001	39.830
Nd27	47.305	40.510
Nd28	45.077	37.500
Nd29	44.643	37.490
Nd30	45.632	37.450
Nd31	44.941	37.480
Nd32	45.880	37.590
Nd33	45.126	37.020

Appendix H. Geotechnical Investigations Report from Aviles Engineering Corporation

AVILES
ENGINEERING CORP.

GEOTECHNICAL INVESTIGATION

BUFFALO SPEEDWAY DRAINAGE SYSTEM EVALUATION
FROM BISSONNET TO HOLCOMBE
WEST UNIVERSITY PLACE, TEXAS

Prepared for:
HDR Engineering, Inc.
Houston, Texas

by

Aviles Engineering Corporation
5790 Windfern Road
Houston, Texas 77041
713-895-7645

REPORT NO. G177-17

December 2018

ENGINEERING CORP.

5790 Windfern Road
Houston, Texas 77041
Tel: (713)-895-7645
Fax: (713)-895-7943

December 12, 2018

Mr. Jeremy Blevins, P.E.
HDR Engineering, Inc.
4828 Loop Central Drive, Suite 800
Houston, Texas 77081

Reference: Geotechnical Investigation
Buffalo Speedway Drainage System Evaluation from Bissonnet to Holcombe
West University Place, Texas
AEC Report No. G177-17

Dear Mr. Blevins,

Aviles Engineering Corporation (AEC) is pleased to present this report of the results of our geotechnical investigation for the above referenced project. Project terms and conditions were in accordance with the Geotech Subconsultant Agreement between HDR Engineering, Inc. (HDR) and AEC, dated December 20, 2017. The project scope of services was performed in general accordance with AEC Proposal G2017-07-04, dated July 10, 2017.

AEC appreciates the opportunity to be of service to you. Please call us if you have any questions or comments concerning this report or when we can be of further assistance.

Respectfully submitted,
Aviles Engineering Corporation
(TBPE Firm Registration No. F-42)

STATE OF TEXAS
WILBER L. WANG
99226
LICENSED
PROFESSIONAL ENGINEER

Wilber L. Wang, P.E. — 12/12/18 — Jacob Garza, E.I.T.
Senior Engineer — Staff Engineer

Reports Submitted: 2 HDR Engineering, Inc.
1 File (electronic)

Z:\ENGINEERING\REPORTS\2017\177-17 BUFFALO SPEEDWAY DRAINAGE PER - HDR (WILBER)\G177-17 FINAL.DOCX

AVILES ENGINEERING CORP.

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ENGINEERING CORP.

GEOTECHNICAL INVESTIGATION

BUFFALO SPEEDWAY DRAINAGE SYSTEM EVALUATION
FROM BISSONNET TO HOLCOMBE
WEST UNIVERSITY PLACE, TEXAS

1.0 INTRODUCTION

1.1 General

Aviles Engineering Corporation (AEC) performed a geotechnical investigation for the proposed evaluation of existing 66 inch diameter storm sewers along Buffalo Speedway from Bissonnet Street to Holcombe Boulevard, in West University Place, Texas (Harris County Key Map No. 532B and F). A vicinity map of the project alignment is presented on Plate A-1, in Appendix A.

1.2 Project Description and Scope of Work

AEC understands that this project is part of the Preliminary Engineering Report (PER) to evaluate the condition of the existing 66 inch diameter storm sewer located along Buffalo Speedway, at the intersections of Bissonnet Street, University Boulevard, and W. Holcombe Boulevard. As-built drawings for the intersection of Buffalo Speedway and Wroxton Road, Amherst Street, and Cason Street were provided to AEC prior to drilling. The as-built drawings indicate that the existing 66 inch storm sewer is approximately 8 to 10 feet deep at these intersections.

To avoid disrupting traffic on Buffalo Speedway during drilling, AEC performed Borings B-1 through B-3 on residential cross streets that were in the vicinity of the project intersections, approximately 280 to 460 feet away. However, at the time of AEC's field investigation, Boring B-3 was moved to a distance of approximately 550 feet from the intersection of Buffalo Speedway and W. Holcombe Boulevard because of potential utility conflicts and trees along Cason Street. AEC recommends that the soil and groundwater conditions encountered in the borings be used for general PER evaluation purposes only. AEC notes that changed soil or groundwater conditions could potentially be encountered at the specific project intersections because the soil borings are located on adjacent residential cross streets. AEC recommends that additional borings be performed at or near the project intersections if the PER recommends that the existing storm sewer be replaced in the future.

As directed by HDR, the purpose of this geotechnical investigation is to determine the soil and groundwater conditions encountered in the borings and provide geotechnical engineering recommendations as if new storm sewers will be installed by open cut method. The scope of this geotechnical investigation is summarized below:

1. Drilling and sampling three geotechnical borings to 20 feet below existing grade;
2. Soil laboratory testing on selected soil samples;
3. Engineering analyses and recommendations for the installation of storm sewers by open cut method, including loadings on pipes, trench excavation, shoring, bedding and backfill;
4. Construction recommendations for the storm sewer.

2.0 SUBSURFACE INVESTIGATION PROGRAM

The subsurface exploration consisted of drilling and sampling a total of three borings each to 20 feet below existing grade. The boring locations are shown on the Boring Location Plan on Plate A-2, in Appendix A. The total drilling footage is 60 feet. Boring locations were marked in the field by AEC personnel. Boring survey data was not available at the time this report was prepared.

Prior to drilling, existing pavement was first cut with a core barrel. Borings were performed with a truck-mounted drill rig and advanced using dry auger method. Undisturbed samples of cohesive soils were obtained from the borings by pushing 3-inch diameter thin-wall, seamless steel Shelby tube samplers in general accordance with ASTM D-1587. Granular soils were sampled with a 2-inch split-barrel sampler in accordance with ASTM D-1586. Standard Penetration Test resistance (N) values were recorded for the granular soils as "Blows per Foot" and are shown on the boring logs. Strength of the cohesive soils was estimated in the field using a hand penetrometer. The undisturbed samples of cohesive soils were extruded mechanically from the core barrels in the field and wrapped in aluminum foil; all samples were sealed in plastic bags to reduce moisture loss. Reasonable care was taken to minimize disturbance to the samples during transport to AEC's laboratory. After completion of drilling, the borings were left open so that 24 hour groundwater readings could be obtained. After the final water readings were obtained, the borings were backfilled using bentonite chips. Existing pavement was then patched using non-shrink grout.

AVILES ENGINEERING CORP.

3.0 LABORATORY TESTING PROGRAM

Samples from the borings were examined and classified in the laboratory by a geotechnical technician under supervision of a geotechnical engineer. Laboratory tests were performed on selected soil samples to evaluate the engineering properties of the foundation soils in accordance with applicable ASTM/TxDOT Standards. Soil classification and index property tests included Atterberg limits, moisture content, percent passing No. 200 sieve, sieve analysis, and dry unit weight. Torvane (TV), unconfined compression (UC), and unconsolidated-unconfined (UU) triaxial tests were performed on selected undisturbed samples to estimate the shear strength of cohesive soils. The laboratory test results are summarized on their respective boring logs. The key to symbols, classification of soils for engineering purposes, terms used on boring logs, and ASTM/TxDOT designation for soil laboratory testing are presented on Plates A-6 through A-9, respectively, in Appendix A. The sieve analysis result is presented on Plate A-10, in Appendix A.

4.0 SITE CONDITIONS

A summary of existing pavement encountered the borings is presented in Table 1.

Table 1. Pavement Cores

Boring No.	Street	Pavement Section
B-1	Wroxton Road	7.25" concrete, 5.125" cement stabilized crushed shell
B-2	Amherst Street	6.25" concrete, 7" cement stabilized crushed stone
B-3	Cason Street	6.625" concrete, 7.375" cement stabilized crushed shell

4.1 Subsurface Conditions

Details of the soils encountered during drilling are presented in the boring logs. Soil strata encountered in our borings are summarized below.

Boring	Depth (ft)	Description of Stratum
B-1	0 - 1	Pavement and Base: see Table 1 in Section 4.0 of this report
	1 - 8	Firm to very stiff, Lean Clay with Sand (CL)
	8 - 16	Stiff to very stiff, Sandy Lean Clay (CL)
	16 - 20	Medium dense, Silty Sand (SM), with clayey sand pockets

Boring	Depth (ft)	Description of Stratum
B-2	0 - 1.1	Pavement and Base: see Table 1 in Section 4.0 of this report
	1.1 - 2	Fill: stiff, Sandy Lean Clay (CL), with gravel and silty sand seams
	2 - 12	Stiff to very stiff, Sandy Fat Clay (CH), with ferrous nodules and sandy lean clay pockets
	12 - 17	Medium dense, Poorly Graded Sand (SP)
	17 - 20	Very stiff, Fat Clay (CH), with chalk pockets and siltstones
B-3	0 - 1.2	Pavement and Base: see Table 1 in Section 4.0 of this report
	1.2 - 17	Stiff to very stiff, Fat Clay (CH), with slickensides
	17 - 20	Very stiff, Sandy Lean Clay (CL), with vertical silt partings, ferrous nodules, and calcareous nodules

Details of the soils encountered during drilling are presented on the boring logs. The cohesive soils encountered in our borings have Liquid Limits (LL) ranging from 37 to 74 and Plasticity Indices (PI) ranging from 21 to 56. In general, the cohesive soils encountered in the borings have high to very high expansive potential. The cohesive soils encountered at the site are classified as "CL" and "CH" type soils and granular soils are classified as "SM" and "SP" type soils in accordance with ASTM D 2487. "CH" soils can undergo significant volume changes due to seasonal changes in moisture contents. "CL" soils with lower LL (less than 40) and PI (less than 20) generally do not undergo significant volume changes with changes in moisture content. However, "CL" soils with LL approaching 50 and PI greater than 20 essentially behave as "CH" soils and could undergo significant volume changes.

Groundwater Conditions: Groundwater levels and boring cave-in depths encountered during drilling are presented in Table 2. Based on Table 2, groundwater along the project alignment is likely to be pressurized.

Table 2. Water Levels in Borings

Boring/PZ No.	Date Drilled	Boring Depth (ft)	Groundwater Depth (ft)	Boring Cave in Depth (ft)
B-1	02/08/18	20	16 (Drilling) 9 (Completion) 5 (02/09/18)	5.6 (02/09/18)
B-2	02/08/18	20	12 (Drilling) 10 (Completion) 6 (02/09/18)	6.4 (02/09/18)
B-3	02/08/18	20	17 (Drilling) 15 (Completion) 6.5 (02/09/18)	8.5 (02/09/18)

The information in this report summarizes conditions found on the dates the borings were drilled. It should be noted that our groundwater observations are short-term; groundwater depths and subsurface soil moisture contents will vary with environmental variations such as frequency and magnitude of rainfall, the time of year when construction is in progress, and the water level in nearby bodies of water such as channels or ponds.

4.2 Subsurface Variations

The information contained in this report summarizes the conditions encountered on the dates the borings were drilled. The ground water depths and subsurface soil moisture contents will vary with seasonal and environmental variations, frequency, and magnitude of rainfall and the time of year when construction is in progress.

Clay soils in the Greater Houston area typically have secondary features such as slickensides and contain sand/silt seams/lenses/layers/pockets. It should be noted that the information in the boring logs is based on 3-inch diameter soil samples which were generally continuously obtained at intervals of 2 feet in the top 10 feet of the borings and then at intervals of 5 feet thereafter to the boring termination depths. A detailed description of the soil secondary features may not have been obtained due to the small sample size and sampling interval between the samples. Therefore, while some of AEC's logs show the soil secondary features, it should not be assumed that the features are absent where not indicated on the logs. Fill soils could also vary considerably in regards to soil/material type, thickness, depth, and consistency.

5.0 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

5.1 Storm Sewer

Storm sewers installed by open-cut methods should be designed and installed in accordance with Item 430 of the 2017 Harris County Engineering Department (HCED) Standard Engineering Design Specifications for Construction and Maintenance of Roads and Bridges (SEDS), or equivalent local standard.

5.1.1 Geotechnical Parameters for Storm Sewers

Geotechnical Parameters: Recommended geotechnical parameters for the subsurface soils along the alignment to be used for design of the storm sewers are presented on Plate B-1, in Appendix B. The design values are based on the results of field and laboratory test data on individual boring logs as well as our experience. It should be noted that because of the variable nature of soil stratigraphy, soil types and properties along the alignment or at locations away from a particular boring may vary substantially.

5.1.2 Loadings on Pipes

Underground conduits support the weight of the soil and water above the crown, as well as roadway traffic and any structures that exist above the conduits.

Earth Loads: For underground conduits to be installed using the trench method, the vertical soil load W_e can be calculated as the larger of the two values from Equations (1) and (3):

$$W_e = C_d \gamma B_d^2 \qquad \text{...........Equation (1)}$$

$$C_d = [1 - e^{-2K\mu'(H/B_d)}]/(2K\mu') \qquad \text{...........Equation (2)}$$

$$W_e = \gamma B_c H \qquad \text{...........Equation (3)}$$

where:
W_e = trench fill load, in pounds per linear foot (lb/ft);
C_d = trench load coefficient, see Plate B-2, in Appendix B;
γ = effective unit weight of soil over the conduit, in pounds per cubic foot (pcf);
B_d = trench width at top of the conduit < 1.5 B_c (ft);
B_c = outside diameter of the conduit (ft);
H = variable height of fill (ft);
when the height of fill above the top of the conduit H_c >2 B_d, $H = H_h$ (height of fill above the middle of the conduit). When H_c < 2 B_d, H varies over the height of the conduit; and
$K\mu'$ = 0.1650 maximum for sand and gravel,
0.1500 maximum for saturated top soil,
0.1300 maximum for ordinary clay,
0.1100 maximum for saturated clay.

When underground conduits are located below ground water, the total vertical dead loads should include the weight of the projected volume of water above the conduits.

Traffic Loads: The vertical stress p_L (psf) resulting from traffic loads (from a HS-20 truck) can be obtained from Plate B-3, in Appendix B. The live load on the top of the underground conduit can be calculated from Equation (4):

$$W_L = p_L B_c \qquad \text{...........Equation (4)}$$

where: W_L = live load on the top of the conduit (lb/ft);
p_L = vertical stress (on the top of the conduit) resulting from traffic loads (psf);
B_c = outside diameter of the conduit, (ft);

Lateral Loads: The lateral soil pressure p_l can be calculated from Equation (5); hydrostatic pressure should be added, if applicable.

$$p_l = 0.5\,(\gamma H_h + p_s) \qquad \text{...........Equation (5)}$$

where: H_h = height of fill above the center of the conduit (ft);
γ = effective unit weight of soil over the conduit (pcf);
p_s = vertical pressure on conduit resulting from traffic and/or construction equipment (psf).

5.1.3 Trench Stability

Cohesive soils in the Greater Houston area contain many secondary features which affect trench stability, including sand seams, slickensides, and siltstones. Slickensides are shiny weak failure planes which are commonly present in fat clays; such clays often fail along these weak planes when they are not laterally supported, such as in an open excavation. The Contractor should not assume that slickensides and sand seams/layers/pockets are absent where not indicated on the logs.

The Contractor should be responsible for designing, constructing and maintaining safe excavations. The excavations should not cause any distress to existing structures.

Trenches 20 feet and Deeper: The Occupational Safety and Health Administration (OSHA) requires that shoring or bracing for trenches 20 feet and deeper be specifically designed by a licensed professional engineer.

Trenches Less than 20 Feet Deep: Trench excavations that are less than 20 feet deep may be shored, sheeted and braced, or laid back to a stable slope for the safety of workers, the general public, and adjacent structures, except for excavations which are less than 5 feet deep and verified by a competent person to have no cave-in potential. The excavation and trenching should be in accordance with OSHA Safety and Health Regulations, 29 CFR, Part 1926. Recommended OSHA Soil Types for trench design for existing soils can be found on Plate B-1, in Appendix B. Granular soils and fill soils should be considered OSHA Class “C” soils.

Submerged soils should also be considered OSHA Class "C" soils, unless dewatering is conducted to lower the ground water level below the excavation.

Critical Height is defined as the height a slope will stand unsupported for a short time; in cohesive soils, it is used to estimate the maximum depth of open-cuts at given side slopes. Critical Height may be calculated based on the soil cohesion. Values for various slopes and cohesion are shown on Plate C-1, in Appendix C. Cautions listed below should be exercised in use of Critical Height applications:

1. No more than 50 percent of the Critical Height computed should be used for vertical slopes. Unsupported vertical slopes are not recommended where granular soils or soils that will slough when not laterally supported are encountered within the excavation depth.

2. If the soil at the surface is dry to the point where tension cracks occur, any water in the crack will increase the lateral pressure considerably. In addition, if tension cracks occur, no cohesion should be assumed for the soils within the depth of the crack. The depth of the first waler should not exceed the depth of the potential tension crack. Struts should be installed before lateral displacement occurs.

3. Shoring should be provided for excavations where limited space precludes adequate side slopes, e.g., where granular soils will not stand on stable slopes and/or for deep open cuts.

4. All excavation, trenching and shoring should be designed and constructed by qualified professionals in accordance with OSHA requirements.

Plate C-2, in Appendix C presents the maximum (steepest) allowable slopes for OSHA Soil Types for excavations less than 20 feet.

If limited space is available for the required open trench side slopes, the space required for the slope can be reduced by using a combination of bracing and open cut as illustrated on Plate C-3, in Appendix C. Guidelines for bracing and calculating bracing stress are presented below.

Stockpile and Equipment Surcharge: To avoid surcharging the excavation walls, stockpile of excavated materials immediately adjacent to the excavation face should be prohibited. We recommend stockpiled materials be placed at least 6 feet away from the edge of an excavation face, and no higher than 3 feet. Construction equipment working near the trench may also induce excessive surcharge loads; AEC recommends appropriate shoring or shield system be provided considering these impacts in addition to the lateral earth and hydrostatic pressures.

Computation of Bracing Pressures: The following method can be used for calculating earth pressure against bracing for open cuts. Lateral pressure resulting from construction equipment, traffic loads, or other surcharge should be taken into account by adding the equivalent uniformly distributed surcharge to the design lateral pressure. Hydrostatic pressure, if any, should also be considered. The active earth pressure at depth z can be determined by Equation (6), the design soil parameters are presented on Plate B-1, in Appendix B.

$$p_a = (q_s + \gamma h_1 + \gamma' h_2)K_a - 2c\sqrt{K_a} + \gamma_w h_2 \qquad \text{...........Equation (6)}$$

where:
- p_a = active earth pressure (psf);
- q_s = uniform surcharge pressure (psf);
- γ, γ' = wet unit weight and buoyant unit weight of soil (pcf);
- h_1 = depth from ground surface to ground water table (ft);
- h_2 = $z-h_1$, depth from ground water table to the point under consideration (ft);
- z = depth below ground surface for the point under consideration (ft);
- K_a = coefficient of active earth pressure;
- c = cohesion of clayey soils (psf);
- γ_w = unit weight of water, 62.4 pcf.

Pressure distribution for the practical design of struts in open cuts for clays and sands are illustrated on Plates C-4 through C-6, in Appendix C.

Bottom Stability: In open-cuts, it is necessary to consider the possibility of the bottom failing by heaving, due to the removal of the weight of excavated soil. Heaving typically occurs in soft plastic clays when the excavation depth is sufficiently deep enough to cause the surrounding soil to displace vertically due to bearing capacity failure of the soil beneath the excavation bottom, with a corresponding upward movement of the soils in the bottom of the excavation. In fat and lean clays, heave normally does not occur unless the ratio of Critical Height to Depth of Cut approaches one. In very sandy and silty lean clays and granular soils, heave can occur if an artificially large head of water is created due to installation of impervious sheeting while bracing the cut. This can be mitigated if ground water is lowered below the excavation by dewatering the area. Guidelines for evaluating bottom stability in clay soils are presented on Plate C-7, in Appendix C.

If the excavation extends below ground water, and the soils at or near the bottom of the excavation are mainly sands or silts, the bottom can fail by blow-out (boiling) when a sufficient hydraulic head exists. The potential for boiling or in-flow of granular soils increases where the ground water is pressurized. To reduce the potential for boiling of excavations terminating in granular soils below pressurized ground water, the ground water table should be lowered at least 3 feet below the excavation.

Calcareous nodules and silt partings were encountered within the cohesive soil strata in the borings. These secondary structures may become sources of localized instability when they are exposed during excavation, especially when they become saturated. Such soils have a tendency to slough or cave in when not laterally confined, such as in trench excavations. The Contractor should be aware of the potential for cave-in of the soils. Low plasticity soils (silts and clayey silts) will lose strength and may behave like granular soils when saturated.

5.1.4 Bedding and Backfill

Trench excavation, bedding, and backfill for storm sewers should be in accordance with Item 430 of the 2017 HCED SEDS, or equivalent local standard.

6.0 CONSTRUCTION CONSIDERATIONS

6.1 Site Preparation and Grading

To mitigate site problems that may develop following prolonged periods of rainfall, it is essential to have adequate drainage to maintain a relatively dry and firm surface prior to starting any work at the site. Adequate drainage should be maintained throughout the construction period. Methods for controlling surface runoff and ponding include proper site grading, berm construction around exposed areas, and installation of sump pits with pumps.

6.2 Dewatering

The need for groundwater control will depend on the depth of excavation relative to the groundwater depth at the time of construction. In the event that there is heavy rain prior to or during construction, the groundwater table may be higher than indicated in this report; higher seepage is also likely and may require a more extensive groundwater control program. In addition, groundwater may be pressurized in certain areas of the alignment, requiring further evaluation and consideration of the excess hydrostatic pressures. Groundwater control should be in general accordance with Item 436 of the 2017 HCED SEDS, or equivalent local standard.

The Contractor should be responsible for selecting, designing, constructing, maintaining, and monitoring a groundwater control system and adapt his operations to ensure the stability of the excavations. Groundwater information presented in Section 4.1 and elsewhere in this report, along with consideration for potential environmental and site variation between the time of our field exploration and construction, should be incorporated in evaluating groundwater depths. The following recommendations are intended to guide the Contractor during design and construction of the dewatering system.

In cohesive soils seepage rates are lower than in granular soils and groundwater is usually collected in sumps and channeled by gravity flow to storm sewers. If cohesive soils contain significant secondary features, seepage rates will be higher. This may require larger sumps and drainage channels, or if significant granular layers are interbedded within the cohesive soils, methods used for granular soils may be required. Where it is present, pressurized groundwater will also yield higher seepage rates.

Groundwater for excavations within saturated sands can be controlled by the installation of wellpoints. The practical maximum dewatering depth for well points is about 15 feet. When groundwater control is required in sands or silts below 15 feet, possible ground water control measures include: (i) deep wells with turbine or submersible pumps (for sands); (ii) multi-staged well points (for sands); (iii) eductor or ejector type systems (for silts); or (iv) water-tight sheet pile cut-off walls. Generally, the groundwater depth should be lowered at least 3 feet below the excavation bottom to be able to work on a firm surface when water-bearing granular soils are encountered.

Extended and/or excessive dewatering can result in settlement of existing structures in the vicinity of the dewatering; the Contractor should take the necessary precautions to minimize the effect on existing structures in the vicinity of the dewatering operation. We recommend that the Contractor verify the groundwater depths and seepage rates prior to and during construction and retain the services of a dewatering expert (if necessary) to assist him in identifying, implementing, and monitoring the most suitable and cost-effective method of controlling groundwater.

For open cut construction in cohesive soils, the possibility of bottom heave must be considered due to the removal of the weight of excavated soil. In lean and fat clays, heave normally does not occur unless the ratio of Critical Height to Depth of Cut approaches one. In silty clays, heave does not typically occur unless an artificially large head of water is created through the use of impervious sheeting in bracing the cut. Guidelines for evaluating bottom stability are presented in Section 5.1.3 of this report.

6.3 Construction Monitoring

Site preparation (including clearing and proof rolling), earthwork operations, soil stabilization, and foundation construction should be monitored by qualified geotechnical professionals to check for compliance with project documents and changed conditions, if encountered. AEC should be allowed to review the design and construction plans and specifications prior to release to check that the geotechnical recommendations and design criteria presented herein are properly interpreted.

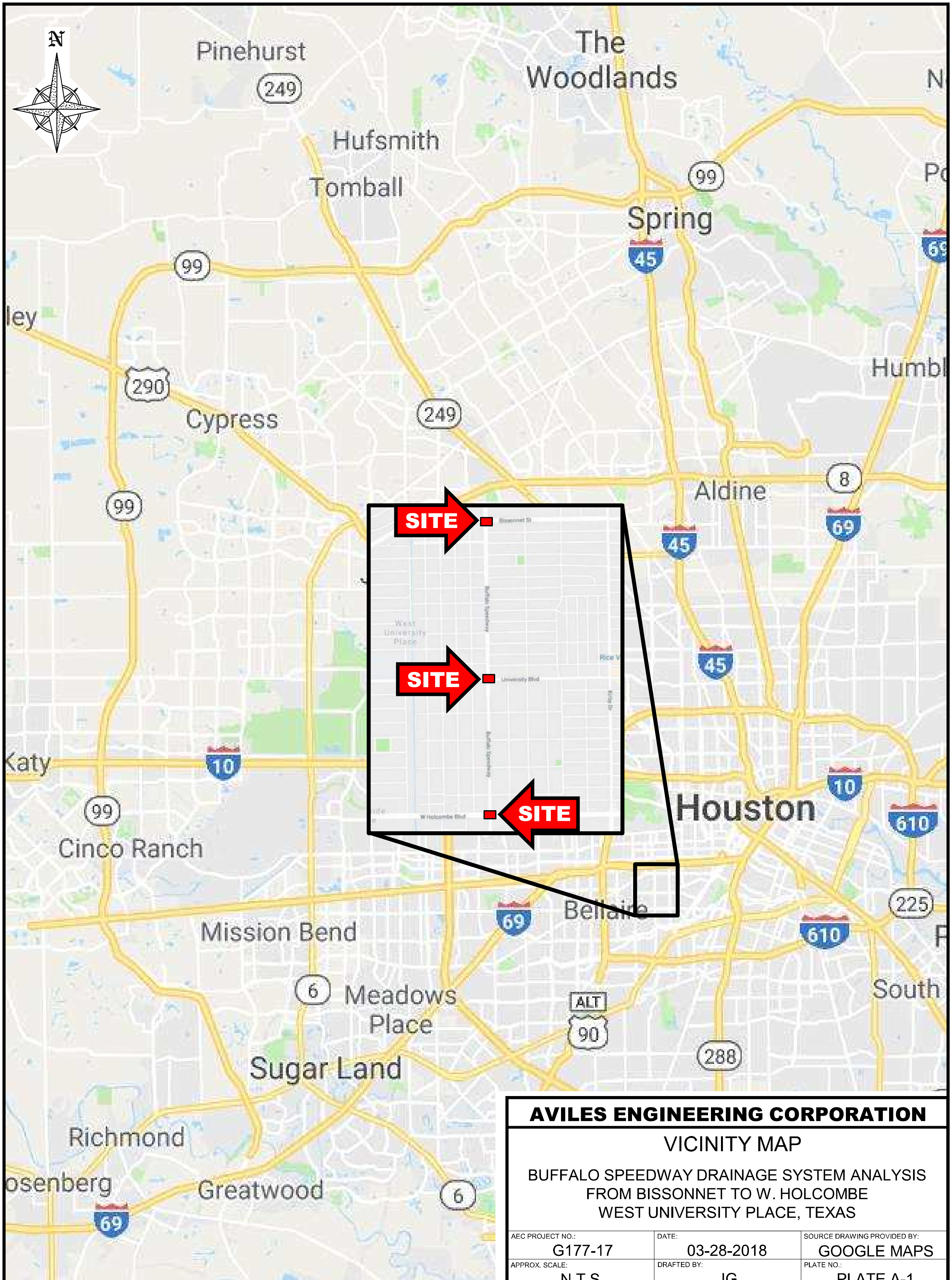
7.0 LIMITATIONS

The information contained in this report summarizes conditions found on the dates the borings were drilled. The attached boring logs are true representations of the soils encountered at the specific boring locations on the date of drilling. Reasonable variations from the subsurface information presented in this report should be anticipated. AEC should be notified immediately if conditions encountered during construction are significantly different from those presented in this report.

This investigation was performed using the standard level of care and diligence normally practiced by recognized geotechnical engineering firms in this area, presently performing similar services under similar circumstances. This report is intended to be used in its entirety. The report has been prepared exclusively for the project and location described in this report. If pertinent project details change or otherwise differ from those described herein, AEC should be notified immediately and retained to evaluate the effect of the changes on the recommendations presented in this report, and revise the recommendations if necessary. The recommendations presented in this report should not be used for other structures located along these alignments or similar structures located elsewhere, without additional evaluation and/or investigation.

APPENDIX A

Plate A-1	Vicinity Map
Plate A-2	Boring Location Plan
Plates A-3 to A-5	Boring Logs
Plate A-6	Boring Log Key to Symbols
Plate A-7	Classification of Soils for Engineering Purposes
Plate A-8	Terms Used on Boring Logs
Plate A-9	ASTM & TXDOT Designation for Soil Laboratory Tests
Plate A-10	Sieve Test Result

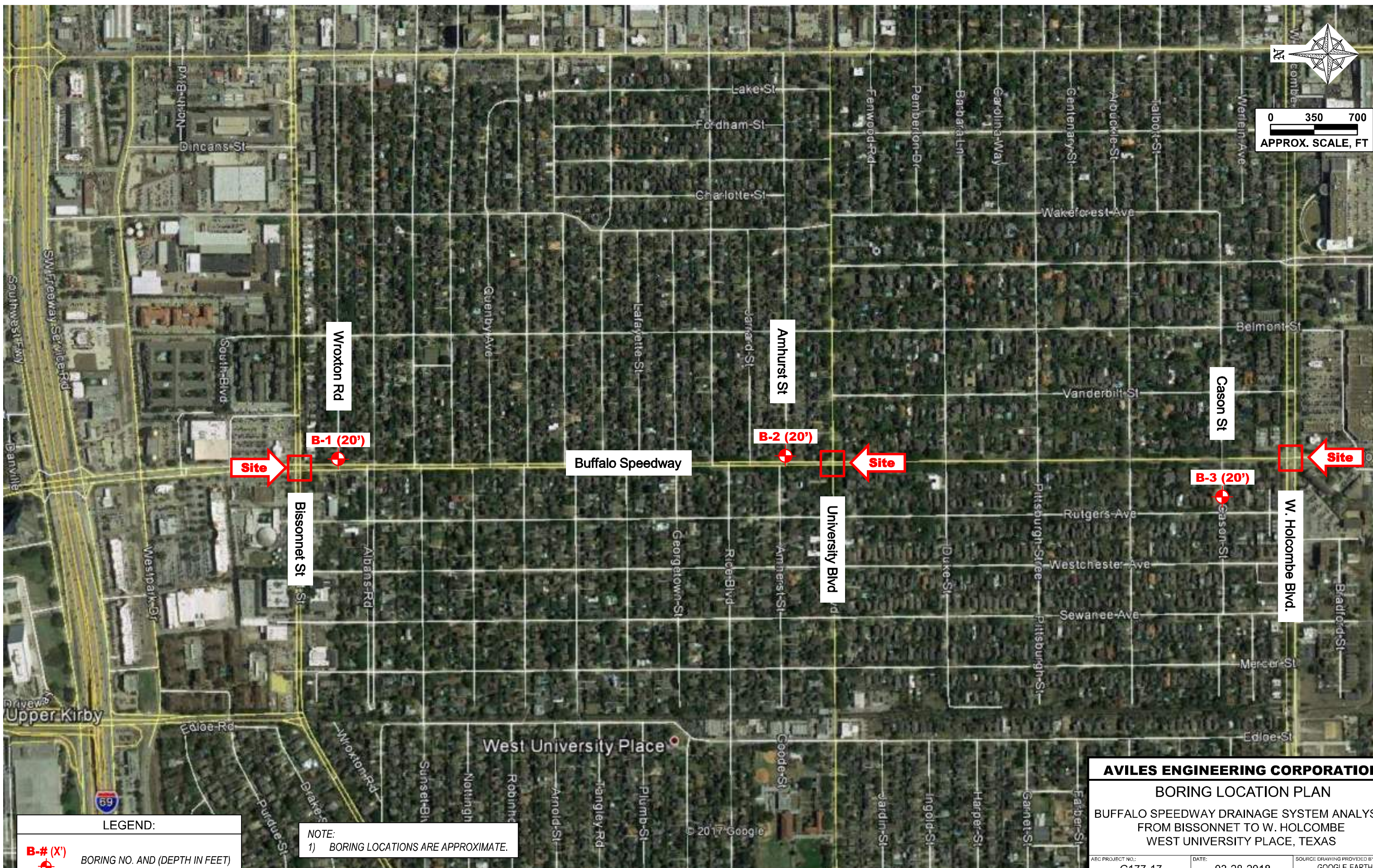


AVILES ENGINEERING CORPORATION

VICINITY MAP

BUFFALO SPEEDWAY DRAINAGE SYSTEM ANALYSIS
FROM BISSONNET TO W. HOLCOMBE
WEST UNIVERSITY PLACE, TEXAS

AEC PROJECT NO.:	DATE:	SOURCE DRAWING PROVIDED BY:
G177-17	03-28-2018	GOOGLE MAPS
APPROX. SCALE:	DRAFTED BY:	PLATE NO.:
N.T.S.	JG	PLATE A-1



LEGEND:

B-# (X') BORING NO. AND (DEPTH IN FEET)

NOTE:
1) BORING LOCATIONS ARE APPROXIMATE.

AVILES ENGINEERING CORPORATION

BORING LOCATION PLAN

BUFFALO SPEEDWAY DRAINAGE SYSTEM ANALYSIS
FROM BISSONNET TO W. HOLCOMBE
WEST UNIVERSITY PLACE, TEXAS

AEC PROJECT NO.:	DATE:	SOURCE DRAWING PROVIDED BY:
G177-17	03-28-2018	GOOGLE EARTH
APPROX. SCALE:	DRAFTED BY:	PLATE NO.:
1" = 700'	WLW/JG	PLATE A-2

PROJECT: **Buffalo Speedway Drainage System PER**

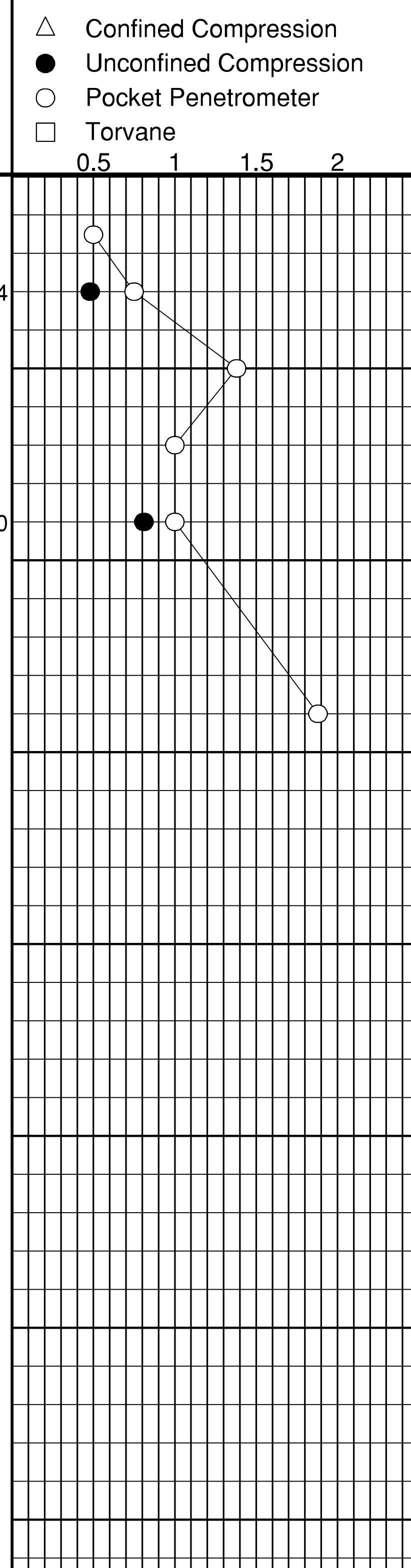
AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

BORING **B-1**

DATE **02/08/18** TYPE **4" Auger** LOCATION **See Boring Location Plan**

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 7.25" concrete							
	Base: 5.125" cement stabilized crushed shell		24					
	Firm to very stiff, gray and tan Lean Clay with Sand (CL)		20	106.4				
	-with fat clay 1'-2' and ferrous nodules 1'-8'							
5	-with silty clay partings 2'-4' and calcareous nodules 2'-8'		17		70	48	15	33
	-boring cave-in at 5.6' on 02/09/18							
	-with fat clay pockets and seams 6'-8'		22					
	Stiff to very stiff, gray and tan Sandy Lean Clay (CL)		21	109.0				
10	-groundwater measured at 9' after completion of drilling							
	-light gray and tan 13'-15'		16			37	16	21
15								
	Medium dense, light gray Silty Sand (SM), with clayey sand pockets							
		17	27		18			
20	Termination Depth = 20 feet							
25								
30								
35								

SHEAR STRENGTH, TSF



BORING DRILLED TO **20** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **16** FEET WHILE DRILLING

WATER LEVEL AT **5** FEET AFTER **02/09/18**

DRILLED BY **JH** DRAFTED BY **JG** LOGGED BY **JH**

PROJECT NO. **G177-17**

PLATE **A-3**

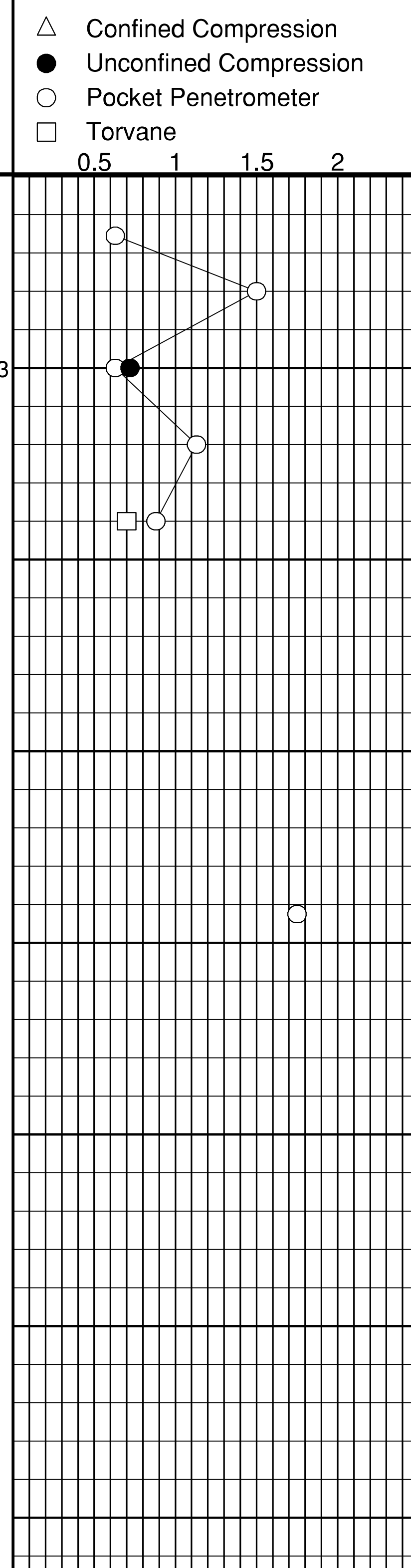
AVILES ENGINEERING CORP.
GEOTECHNICAL ENGINEERS

PROJECT: **Buffalo Speedway Drainage System PER** BORING **B-2**

DATE **02/08/18** TYPE **4" Auger** LOCATION **See Boring Location Plan**

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 6.25" concrete							
	Base: 7" cement stabilized crushed stone		25					
	Fill: stiff, gray and dark gray Sandy Lean Clay (CL), with gravel and silty sand seams		19		63	50	16	34
5	Stiff to very stiff, gray and tan Sandy Fat Clay (CH), with ferrous nodules and sandy lean clay pockets -with calcareous nodules 2'-6' -boring cave-in at 6.4' on 02/09/18		19	110.3				
			21					
			20					
10	-groundwater measured at 10' after completion of drilling							
	Medium dense, tan Poorly Graded Sand (SP)	16	22		4			
15								
	Very stiff, tan and light gray Fat Clay (CH), with chalk pockets and siltstones	31	17		93			
20	Termination Depth = 20 feet							
25								
30								
35								

SHEAR STRENGTH, TSF



BORING DRILLED TO **20** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **12** FEET WHILE DRILLING

WATER LEVEL AT **6** FEET AFTER **02/09/18**

DRILLED BY **JH** DRAFTED BY **JG** LOGGED BY **JH**

PROJECT NO. G177-17 **PLATE A-4**

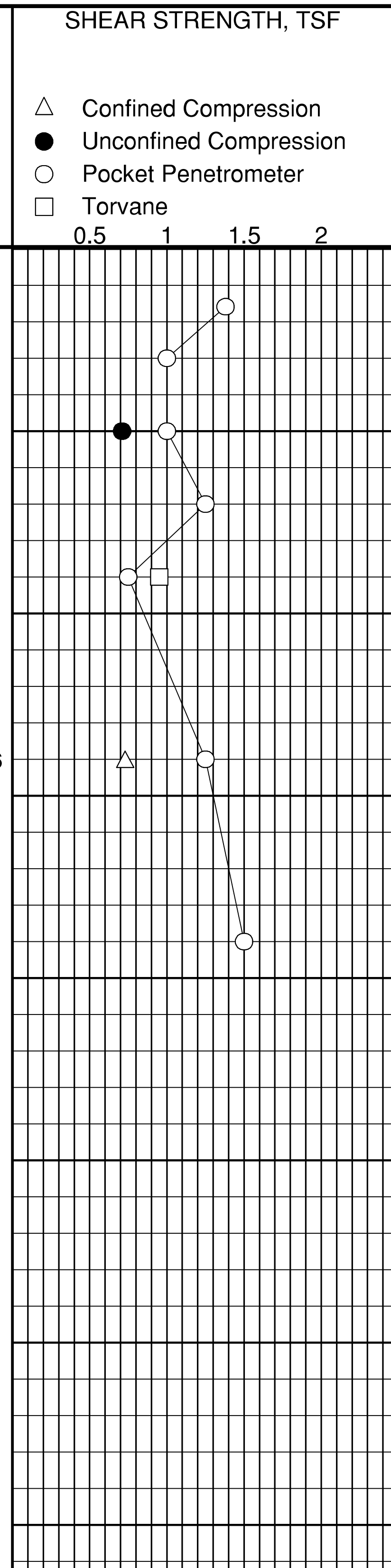
PROJECT: **Buffalo Speedway Drainage System PER**

AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

BORING **B-3**

DATE **02/08/18** TYPE **4" Auger** LOCATION **See Boring Location Plan**

DEPTH IN FEET	DESCRIPTION	S.P.T. BLOWS / FT.	MOISTURE CONTENT, %	DRY DENSITY, PCF	-200 MESH	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
0	Pavement: 6.625" concrete							
	Base: 7.375" cement stabilized crushed shell		25					
	Stiff to very stiff, dark gray and olive gray Fat Clay (CH), with slickensides					74	18	56
	-with lean clay pockets 1'-2' and ferrous nodules 1'-6'		25					
5	-dark gray and tan 2'-4'		26	99.1				
	-gray and tan, with calcareous nodules 4'-10'							
	-with lean clay pockets 6'-8'		28					
	-boring cave-in at 8.5' on 02/09/18		29		86	68	19	49
10								
	-reddish tan and light gray 13'-15'		30	94.6				
15	-groundwater measured at 15' after completion of drilling							
	Very stiff, tan and gray Sandy Lean Clay (CL), with vertical silt partings, ferrous nodules, and calcareous nodules		16					
20	Termination Depth = 20 feet							
25								
30								
35								



BORING DRILLED TO **20** FEET WITHOUT DRILLING FLUID

WATER ENCOUNTERED AT **17** FEET WHILE DRILLING

WATER LEVEL AT **6.5** FEET AFTER **02/09/18**

DRILLED BY **JH** DRAFTED BY **JG** LOGGED BY **JH**

PROJECT NO. G177-17

KEY TO SYMBOLS

Symbol Description

<u>Strata symbols</u>

Paving

Low plasticity clay

Silty sand

Fill

High plasticity clay

<u>Misc. Symbols</u>

Water table depth during drilling

Subsequent water table depth

Pocket Penetrometer

Unconfined Compression

Torvane

Confined Compression

<u>Soil Samplers</u>

Rock core

Undisturbed thin wall Shelby tube

Standard penetration test

AYLES ENGINEERING CORP.

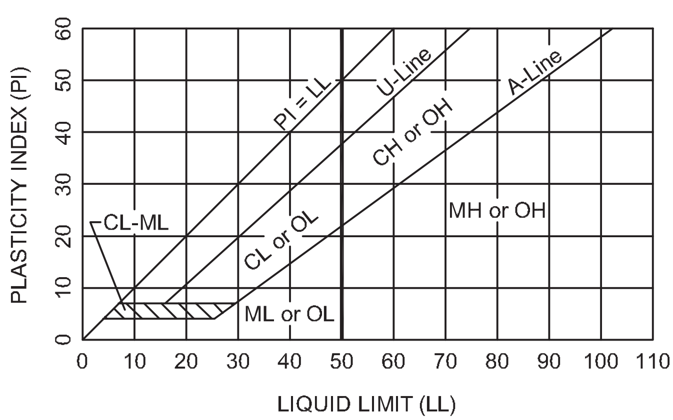
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation D-2487

MAJOR DIVISIONS				GROUP SYMBOL	TYPICAL NAMES
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (Less than 50% of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)		GW	Well-graded gravel, well-graded gravel with sand
				GP	Poorly-graded gravel, poorly-graded gravel with sand
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	GM	Silty gravel, silty gravel with sand
			Limits plot above "A" line & hatched zone on plasticity chart	GC	Clayey gravel, clayey gravel with sand
	SANDS (50% or more of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)		SW	Well-graded sand, well-graded sand with gravel
				SP	Poorly-graded sand, poorly-graded sand with gravel
		SANDS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart	SM	Silty sand, silty sand with gravel
			Limits plot above "A" line & hatched zone on plasticity chart	SC	Clayey sand, clayey sand with gravel
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)		SILTS AND CLAYS (Liquid Limit Less Than 50%)		ML	Silt, silt with sand, silt with gravel, sandy silt, gravelly silt
				CL	Lean clay, lean clay with sand, lean clay with gravel, sandy lean clay, gravelly lean clay
				OL	Organic clay, organic clay with sand, sandy organic clay, organic silt, sandy organic silt
		SILTS AND CLAYS (Liquid Limit 50% or More)		MH	Elastic silt, elastic silt with sand, sandy elastic silt, gravelly elastic silt
				CH	Fat clay, fat clay with sand, fat clay with gravel, sandy fat clay, gravelly fat clay
				OH	Organic clay, organic clay with sand, sandy organic clay, organic silt, sandy organic silt

NOTE: Coarse soils between 5% and 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone of the plasticity chart are to have dual symbols.

PLASTICITY CHART



Equation of A-Line: Horizontal at PI=4 to LL=25.5, then PI=0.73(LL-20)

Equation of U-Line: Vertical at LL=16 to PI=7, then PI=0.9(LL-8)

DEGREE OF PLASTICITY OF COHESIVE SOILS

Degree of Plasticity	Plasticity Index
None	0 - 4
Slight	5 - 10
Medium	11 - 20
High	21 - 40
Very High	>40

SOIL SYMBOLS

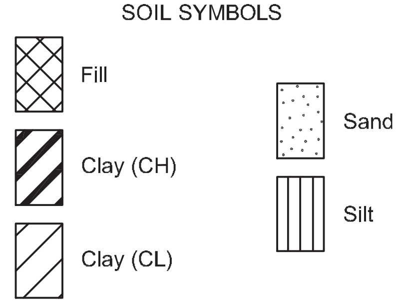


PLATE A-7

AVILES ENGINEERING CORP.

TERMS USED ON BORING LOGS

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

6"		3"		3/4"		#4		#10		#40		#200		

BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

152 | 76.2 | 19.1 | 4.76 | 2.00 | 0.420 | 0.074 | 0.002

SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

Consistency	Undrained Shear Strength, Kips per Sq. ft.	SPT Blowcount
Very Soft	less than 0.25	< 2 bpf
Soft	0.25 to 0.50	2-4 bpf
Firm	0.50 to 1.00	4-8 bpf
Stiff	1.00 to 2.00	8-16 bpf
Very Stiff	2.00 to 4.00	16-32 bpf
Hard	greater than 4.00	>32 bpf

RELATIVE DENSITY OF COHESIONLESS SOILS FROM STANDARD PENETRATION TEST

Very Loose .... <4 bpf
Loose .... 5-10 bpf
Medium Dense .... 11-30 bpf
Dense .... 31-50 bpf
Very Dense .... >50 bpf

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows per Foot	Description
25	25 blows driving sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows driving sampler 7 inches, after initial 6 inches of seating.
Ref/3"	50 blows driving sampler 3 inches, during initial 6-inches seating interval.

NOTE: To avoid change to sampling tools, driving is limited to 50 blows during or after seating interval.

DRY STRENGTH ASTM D2488

None	Dry specimen crumbles into powder with mere pressure of handling
Low	Dry specimen crumbles into powder with some finger pressure
Medium	Dry specimen breaks into pieces or crumbles with considerable pressure
High	Dry specimen cannot be broken with finger pressure, it can be broken between thumb and hard surface
Very High	Dry specimen cannot be broken between thumb and hard surface

MOISTURE CONDITION ASTM D2488

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the easiness of breaking along these planes.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick extending through the sample.
Seam	Inclusion 1/8 inch to 3 inches thick extending through the sample.
Layer	Inclusion greater than 3 inches thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil types.
Interlayered	Soil sample composed of alternating layers of different soil types.
Intermixed	Soil sample composed of pockets of different soil types and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of calcium material.

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ASTM & TXDOT DESIGNATION FOR SOIL LABORATORY TESTS

SOIL TEST	ASTM TEST DESIGNATION	TXDOT TEST DESIGNATION
Unified Soil Classification System	D 2487	Tex-142-E
Moisture Content	D 2216	Tex-103-E
Specific Gravity	D 854	Tex-108-E
Sieve Analysis	D 6913	Tex-110-E (Part 1)
Hydrometer Analysis	D 7928	Tex-110-E (Part 2)
Minus No. 200 Sieve	D 1140	Tex-111-E
Liquid Limit	D 4318	Tex-104-E
Plastic Limit	D 4318	Tex-105-E
Standard Proctor Compaction	D 698	Tex-114-E
Modified Proctor Compaction	D 1557	Tex-113-E
California Bearing Ratio	D 1883	-
Swell	D 4546	-
Consolidation	D 2435	-
Unconfined Compression	D 2166	-
Unconsolidated-Undrained Triaxial	D 2850	Tex-118-E
Consolidated-Undrained Triaxial	D 4767	Tex-131-E
Permeability (constant head)	D 5084	-
Pinhole	D 4647	-
Crumb	D 6572	-
Double Hydrometer	D 4221	-
pH of Soil	D 4972	Tex-128-E
Soil Suction	D 5298	-
Soil Sulfate	C 1580	Tex-145-E
Organics	D 2974	Tex-148-E

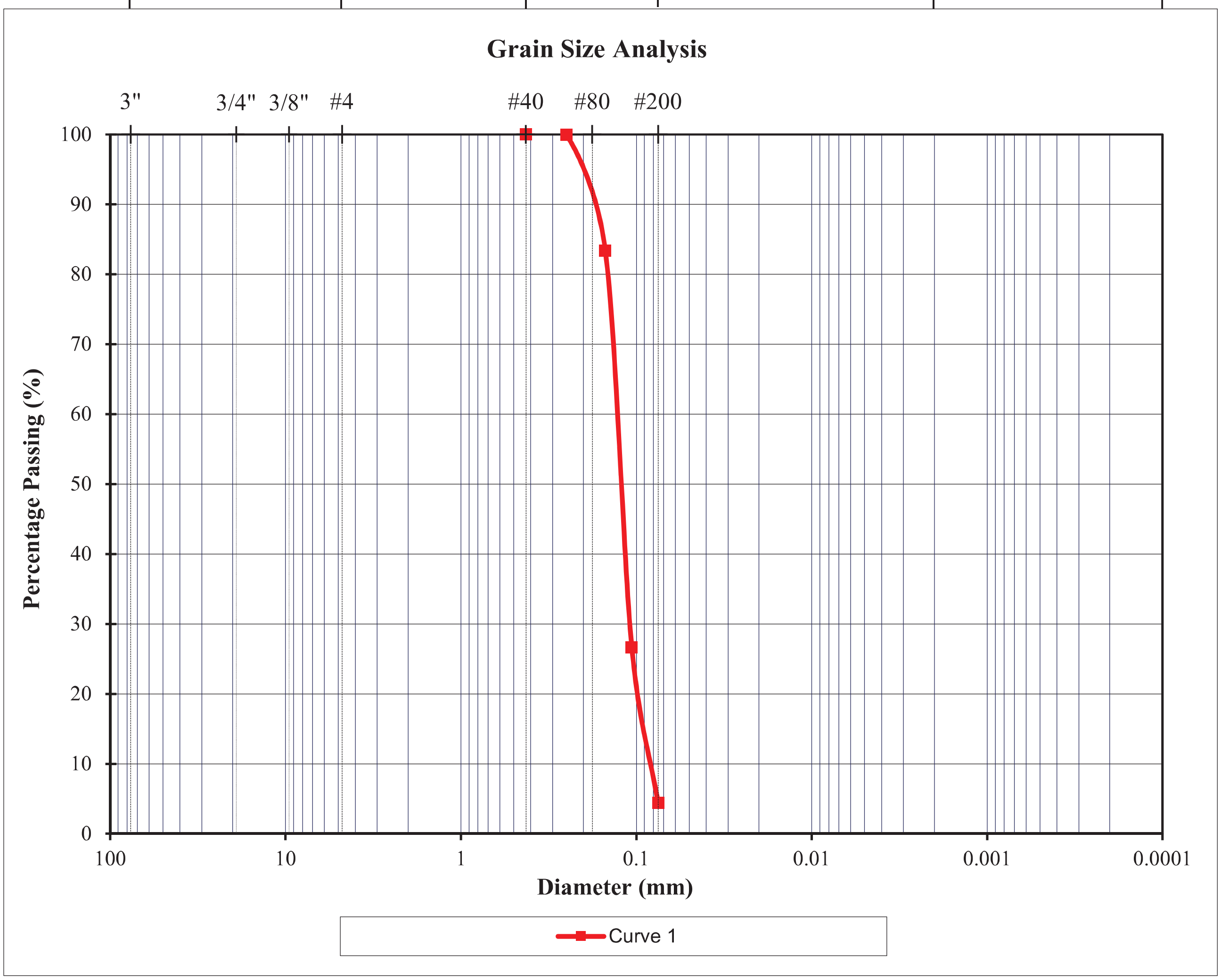
AVILES ENGINEERING CORPORATION

Consulting Engineers - Geotechnical, Construction Materials Testing, Environmental

GRAIN SIZE ANALYSIS - SIEVE

Project : Buffalo Speedway Drainage System PER **Job No.:** G177-17
Location of Project: West University Place, Texas **Date of Testing:** 2/19/2018

	Gravel	Sand: Coarse to Medium	Sand: Fine	Silt	Clay



Curve	Boring	Depth (ft)	Soil Description	Cu	Cc
1	B-2	13-15	Poorly Graded Sand (SP)	1.59	1.10

APPENDIX B

Plate B-1	Recommended Geotechnical Design Parameters for Underground Utilities
Plate B-2	Load Coefficients for Pipe Loading
Plate B-3	Live Loads on Pipe Crossing Under Roadway

G177-17 BUFFALO SPEEDWAY DRAINAGE SYSTEM PER, WEST UNIVERSITY PLACE, TEXAS
SOIL PARAMETERS FOR UNDERGROUND UTILITIES

Boring	Depth (ft)	Soil Type	γ (pcf)	γ' (pcf)	OSHA Type	Short-Term					Long-Term				
						C (psf)	φ (deg)	K_a	K_0	K_p	C' (psf)	φ' (deg)	K_a	K_0	K_p
B-1	0-4	Firm to very stiff CL	128	66	C	900	0	1.00	1.00	1.00	75	18	0.53	0.69	1.89
	4-16	Stiff to very stiff CL	132	70	C*	1600	0	1.00	1.00	1.00	150	18	0.53	0.69	1.89
	16-20	Medium dense SM	120	58	C	0	30	0.33	0.50	3.00	0	30	0.33	0.50	3.00
B-2	0-2	Fill: stiff CL	120	58	C	800	0	1.00	1.00	1.00	75	18	0.53	0.69	1.89
	2-12	Stiff to very stiff CH	131	69	B (C*, 6-12)	1400	0	1.00	1.00	1.00	125	16	0.57	0.72	1.76
	12-17	Medium dense SP	120	58	C	0	30	0.33	0.50	3.00	0	30	0.33	0.50	3.00
	17-20	Very stiff CH	120	58	C*	2500	0	1.00	1.00	1.00	250	16	0.57	0.72	1.76
B-3	0-20	Stiff to very stiff CH/CL	123	61	B (C*, 6.5-20)	1450	0	1.00	1.00	1.00	125	16	0.57	0.72	1.76

(1) γ = Unit weight for soil above water level, γ' = Buoyant unit weight for soil below water level;

(2) C = Soil ultimate cohesion for short term (upper limit of 3,000 psf for design purposes), φ = Soil friction angle for short term;

(3) C' = Soil ultimate cohesion for long term (upper limit of 300 psf for design purposes), φ' = Soil friction angle for long term;

(4) K_a = Coefficient of active earth pressure, K_0 = Coefficient of at-rest earth pressure, K_p = Coefficient of passive earth pressure;

(5) CL = Lean Clay, CH = Fat Clay, SM = Silty Sand, SP = Poorly Graded Sand;

(6) OSHA Soil Types for soils in the top 20 feet below grade:

A: cohesive soils with qu = 1.5 tsf or greater (qu = Unconfined Compressive Strength of the Soil)

B: cohesive soils with qu = 0.5 tsf or greater

C: cohesive soils with qu = less than 0.5 tsf, fill materials, or granular soil

C*: submerged cohesive soils; dewatered cohesive soils can be considered OSHA Type B.

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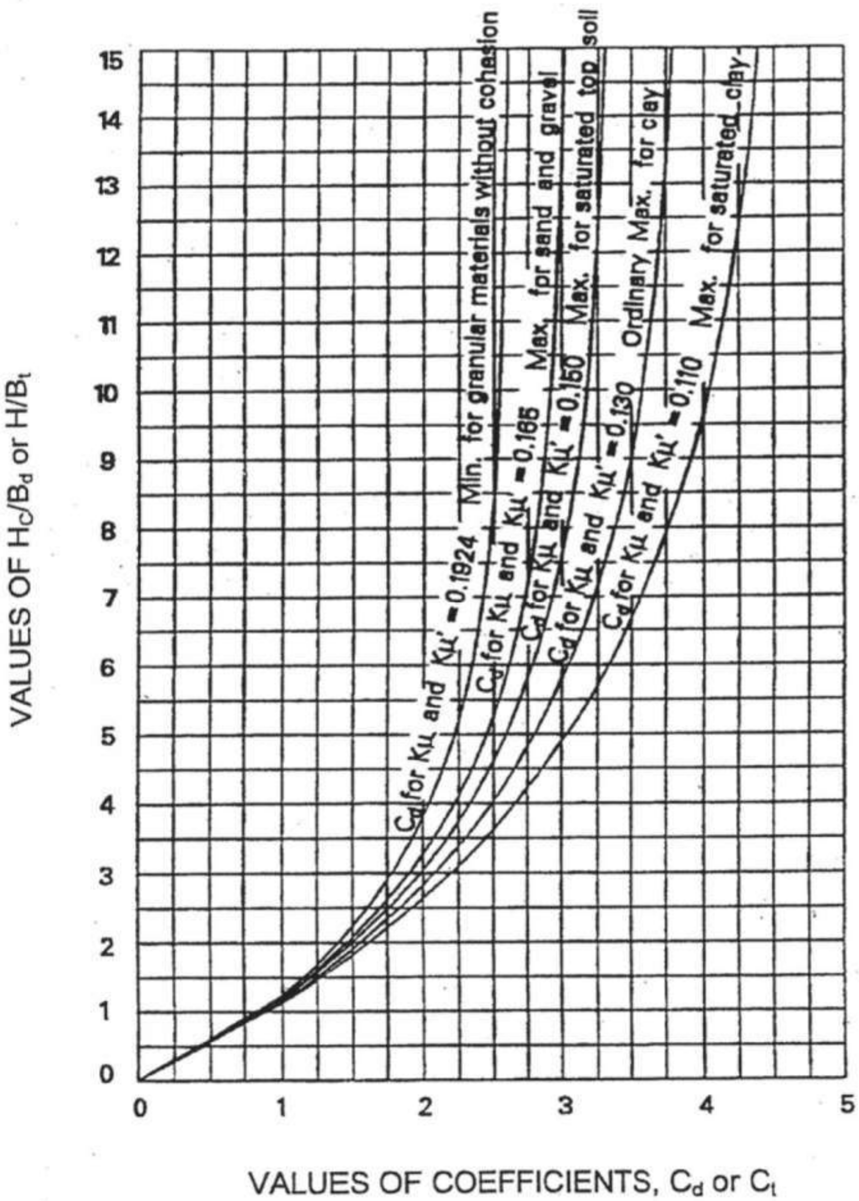
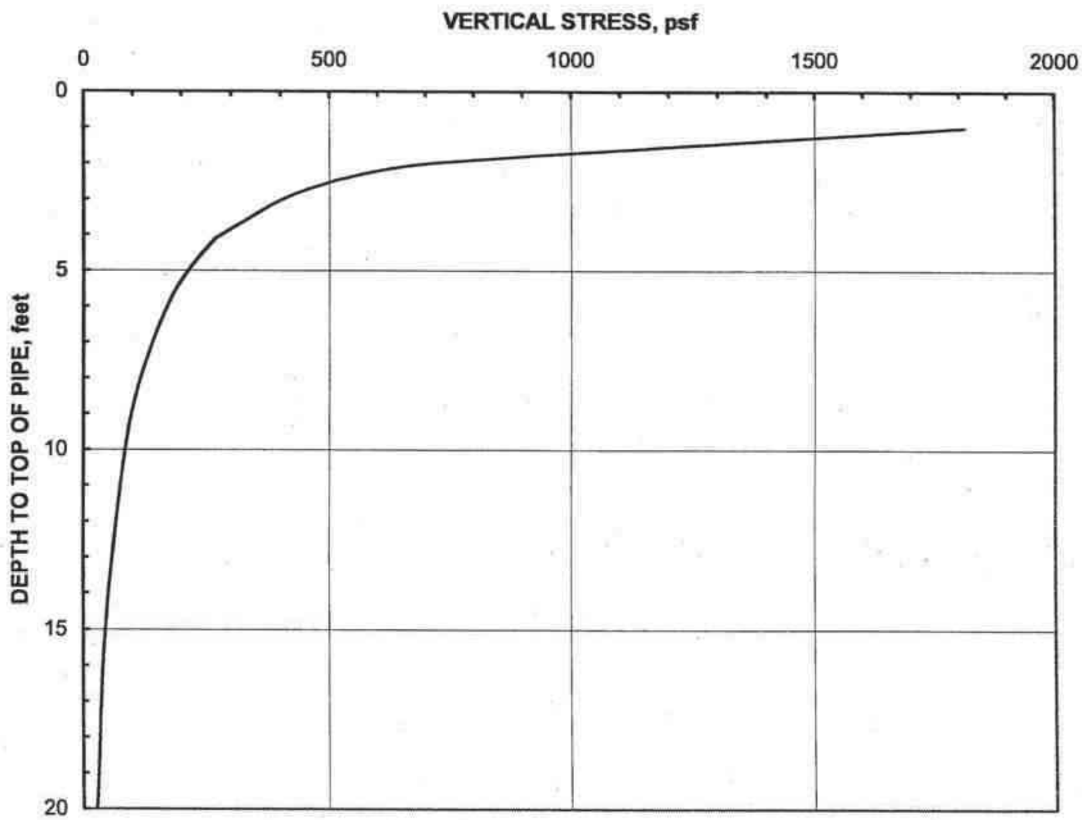
TRENCH LOAD COEFFICIENTS



Reference: US Army Corps of Engineers Engineering Manual, EM 1110-2-2902, Oct. 31, 1997, Figure 2-5.

AVILES ENGINEERING CORP.



LIVE LOADS ON PIPE CROSSING UNDER ROADWAY

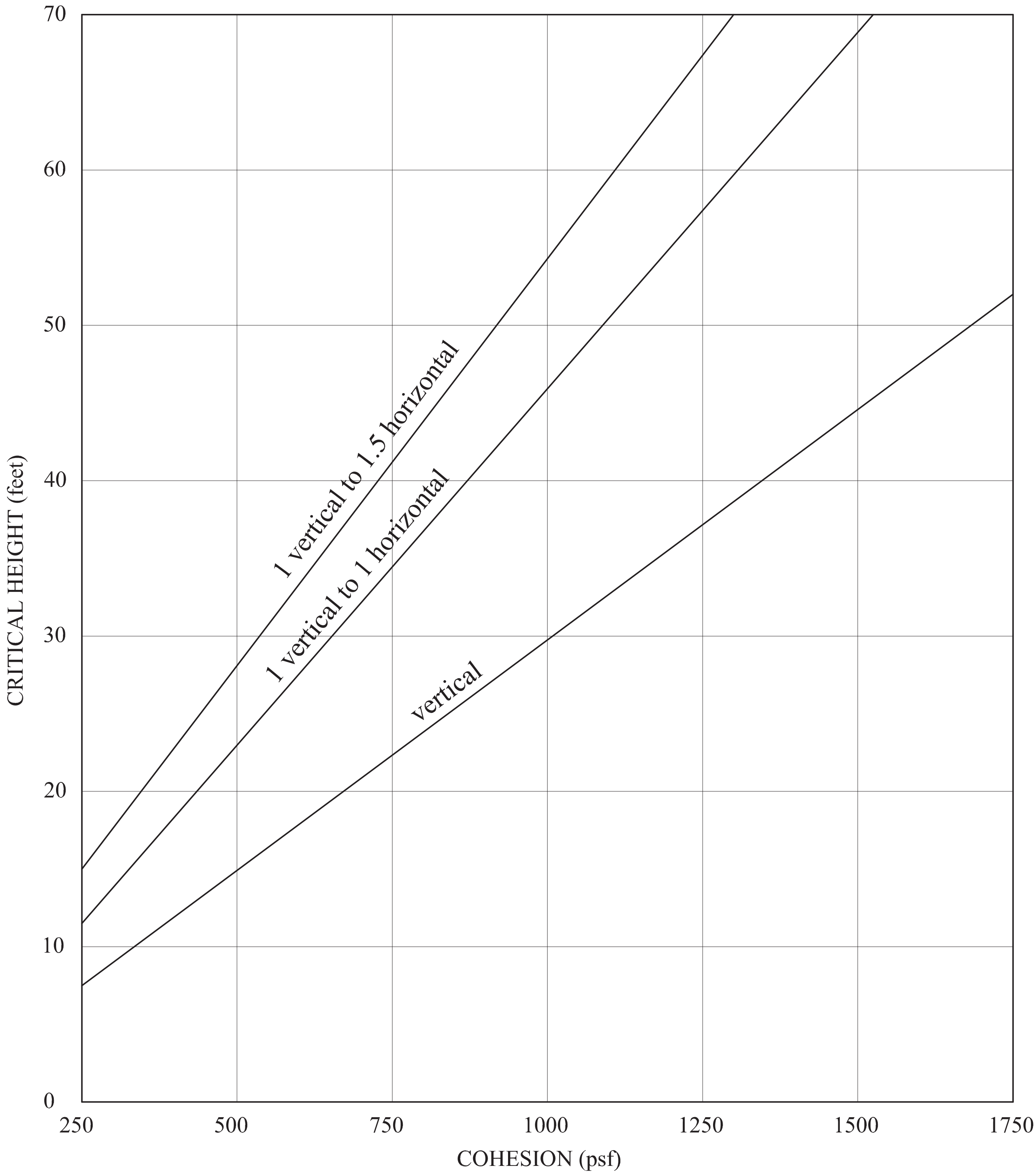
Note: 1. The vertical stress was estimated using AASHTO HS20 truck axle loadings on paved surfaces (Reference: ASCE 15-98, "Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standandard Installations").

2. Single truck passing.

APPENDIX C

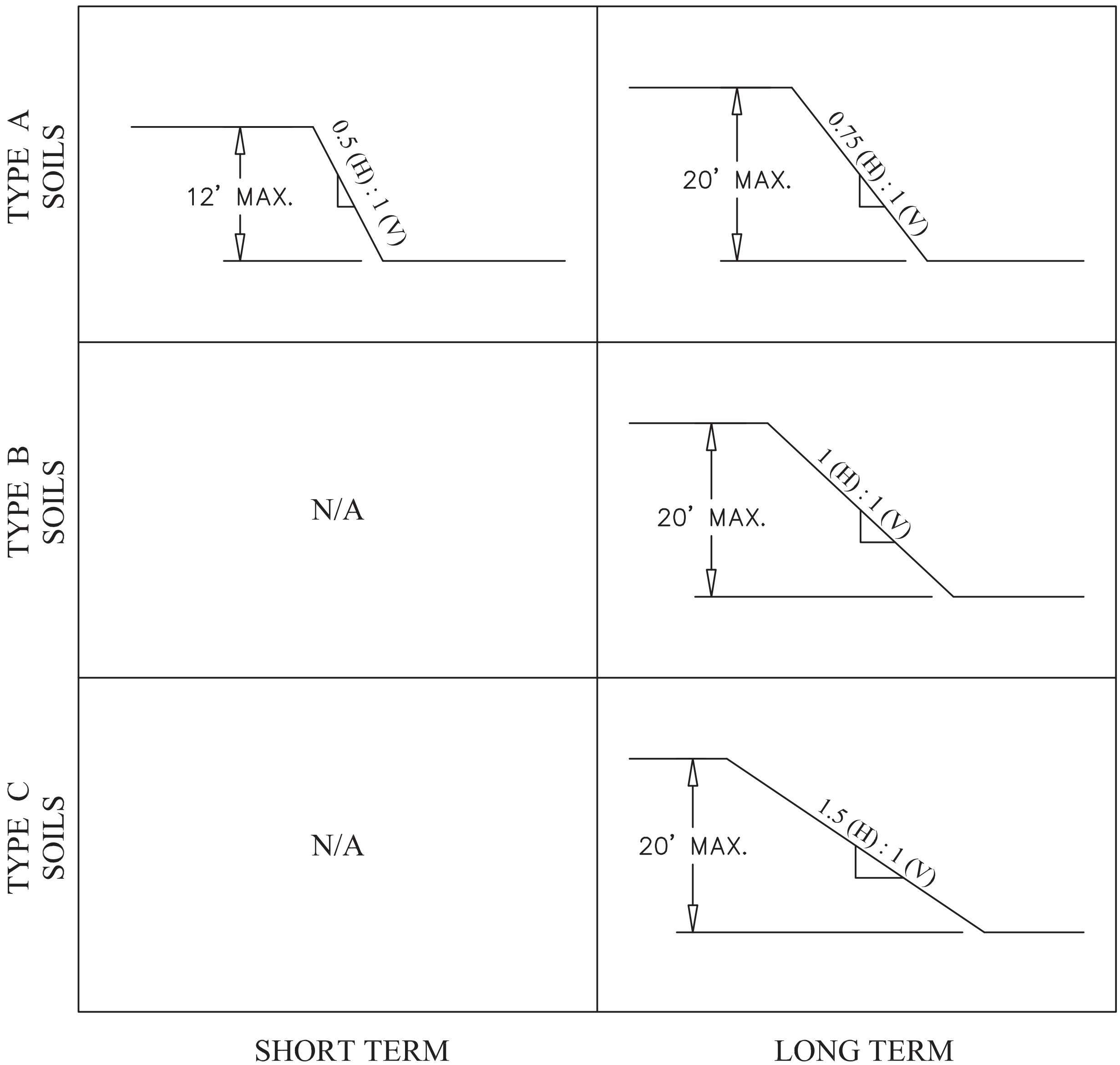
Plate C-1	Critical Heights of Cut Slopes in Nonfissured Clays
Plate C-2	Maximum Allowable Slopes
Plate C-3	A Combination of Bracing and Open Cuts
Plate C-4	Lateral Pressure Diagrams for Open Cuts in Cohesive Soil-Long Term Conditions
Plate C-5	Lateral Pressure Diagrams for Open Cuts in Cohesive Soil-Short Term Conditions
Plate C-6	Lateral Pressure Diagrams for Open Cuts in Sand
Plate C-7	Bottom Stability for Braced Excavation in Clay

Critical Heights of Cut Slopes in Nonfissured Clays



Note: The charts are calculated based on NAVFAC DM7.1, Page 7.1-319, assuming the critical circles are toe circles, and wet unit weight of soils = 125pcf.

MAXIMUM ALLOWABLE SLOPES



NOTES:

(1) For Type A soils, a short term maximum allowable slope of 0.5 (H) : 1 (V) is allowed in excavations that are 12 feet or less in depth; short term (24 hours or less) maximum allowable slopes for excavations greater than 12 feet in depth shall be 0.75 (H) : 1 (V).

(2) Maximum depth for above slopes is 20 feet. For slopes deeper than 20 feet, trench protection should be designed by the Contractor's professional engineer.

Reference: OSHA, Safety and Health Regulations for Construction, 1926 Subpart P.

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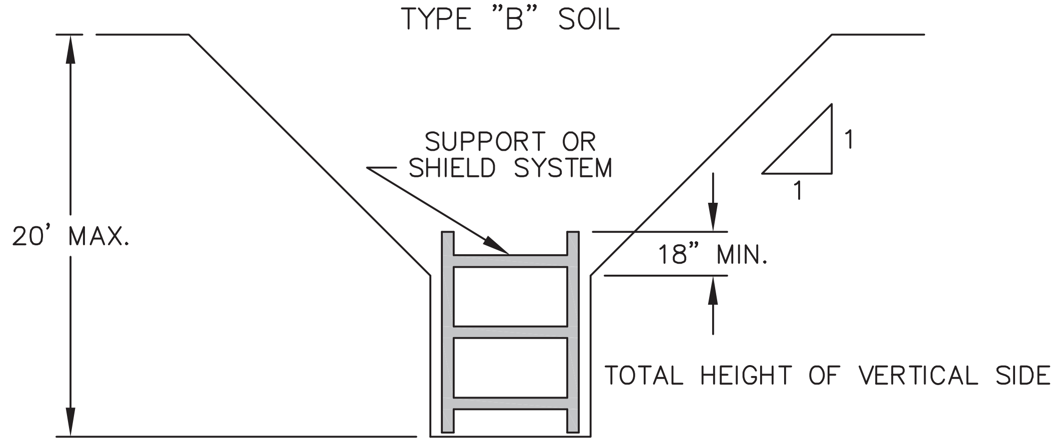
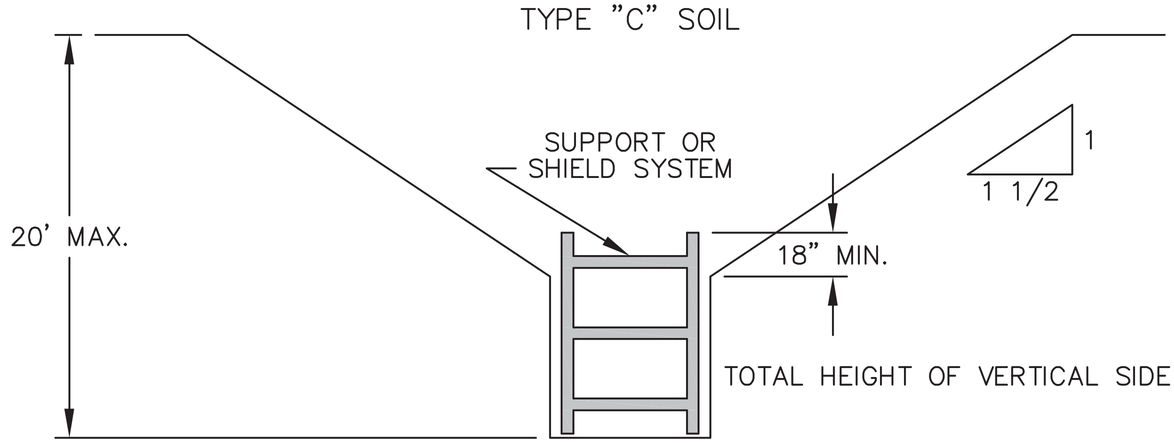
A COMBINATION OF BRACING AND OPEN CUTS

TYPE "B" SOIL



TYPE "C" SOIL

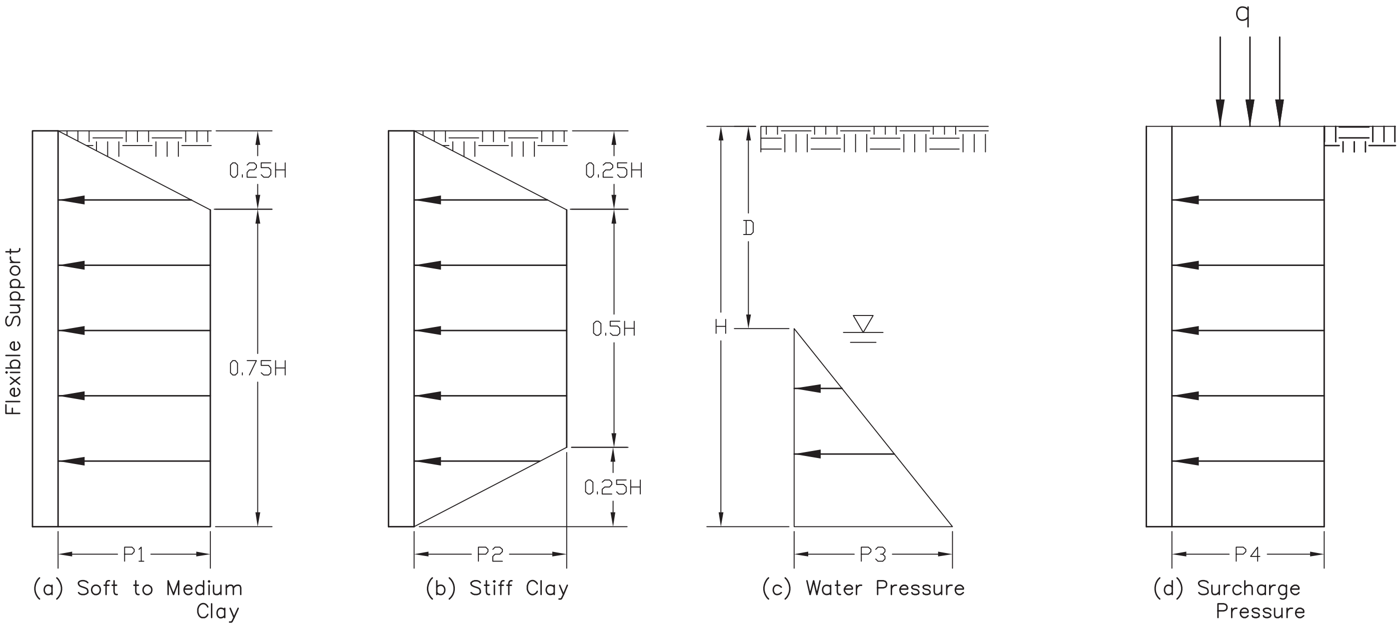


Reference: OSHA, Safety and Health Regulations for Construction, 1926 Subpart P.

ENGINEERING CORP.

LATERAL PRESSURE DIAGRAMS

FOR OPEN CUTS IN COHESIVE SOIL - LONG TERM CONDITIONS



Empirical Pressure Distributions

Where:

H = Total excavation depth, feet

D = Depth to water table, feet

P1 = Lateral earth pressure = γH-4C, psf

P2 = Lateral earth pressure = 0.4γH, psf

P3 = Water pressure = γ_w (H-D), psf

P4 = Lateral earth pressure caused by surcharge = qK_a, psf

γ = Effective unit weight of soil, pcf

γ_w = Unit weight of water, pcf

C = Drained shear strength or cohesion, psf

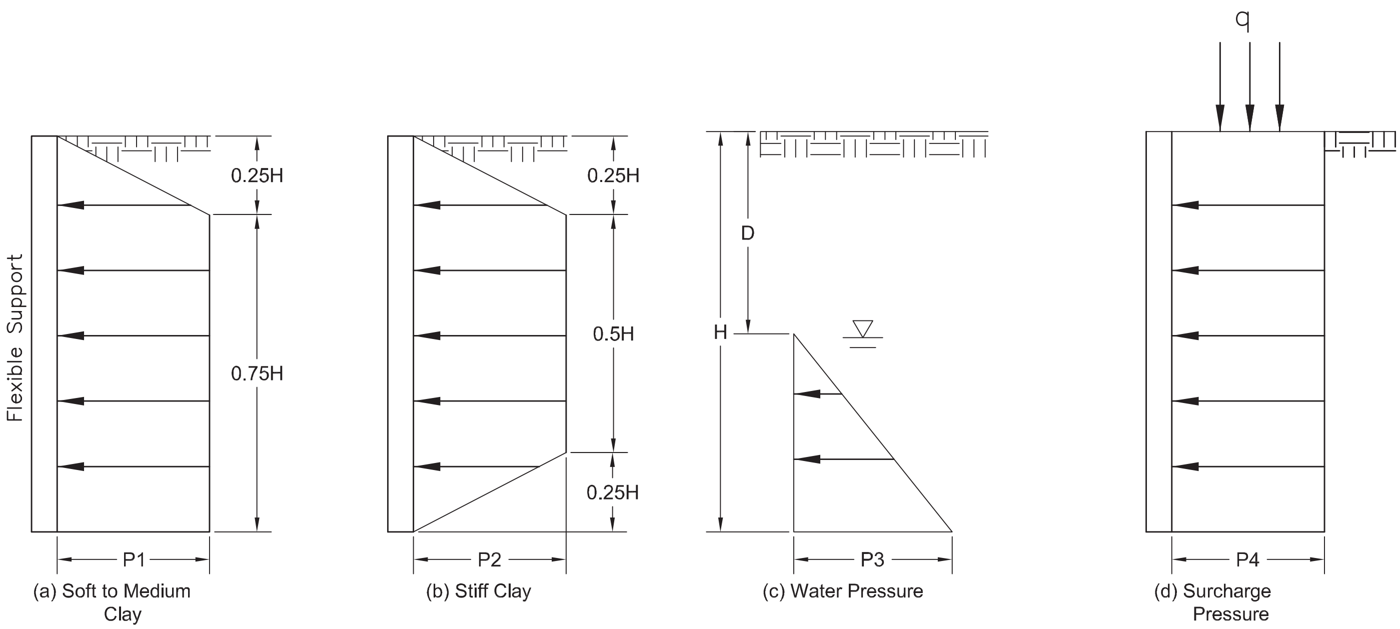
K_a = Coefficient of active earth pressure

Notes:

1. All pressures are additive.
2. No safety factors are included.
3. For use only during long term construction.
4. If γH/C < 4, use section (b),
   If 4 < γH/C < 6, use larger of section (a) or (b),
   If γH/C > 6, use section (a).

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.

LATERAL PRESSURE DIAGRAMS
FOR OPEN CUTS IN COHESIVE SOIL - SHORT TERM CONDITIONS



Empirical Pressure Distributions

Where:
H = Total excavation depth, feet
D = Depth to water table, feet
P1 = Lateral earth pressure = $\gamma H-4S_u$, psf
P2 = Lateral earth pressure = $0.2\gamma H$, psf
P3 = Water pressure = γ_w (H-D), psf
P4 = Lateral earth pressure caused by surcharge = qK_a, psf
γ = Effective unit weight of soil, pcf
γ_w = Unit weight of water, pcf
S_u = Undrained shear strength = $q_u/2$, psf
q_u = Unconfined compressive strength, psf
K_a = Coefficient of active earth pressure

Notes:
1. All pressures are additive.
2. No safety factors are included.
3. For use only during short term construction.
4. If $\gamma H/S_u < 4$, use section (b),
If $4 < \gamma H/S_u < 6$, use larger of section (a) or (b),
If $\gamma H/S_u > 6$, use section (a).

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.

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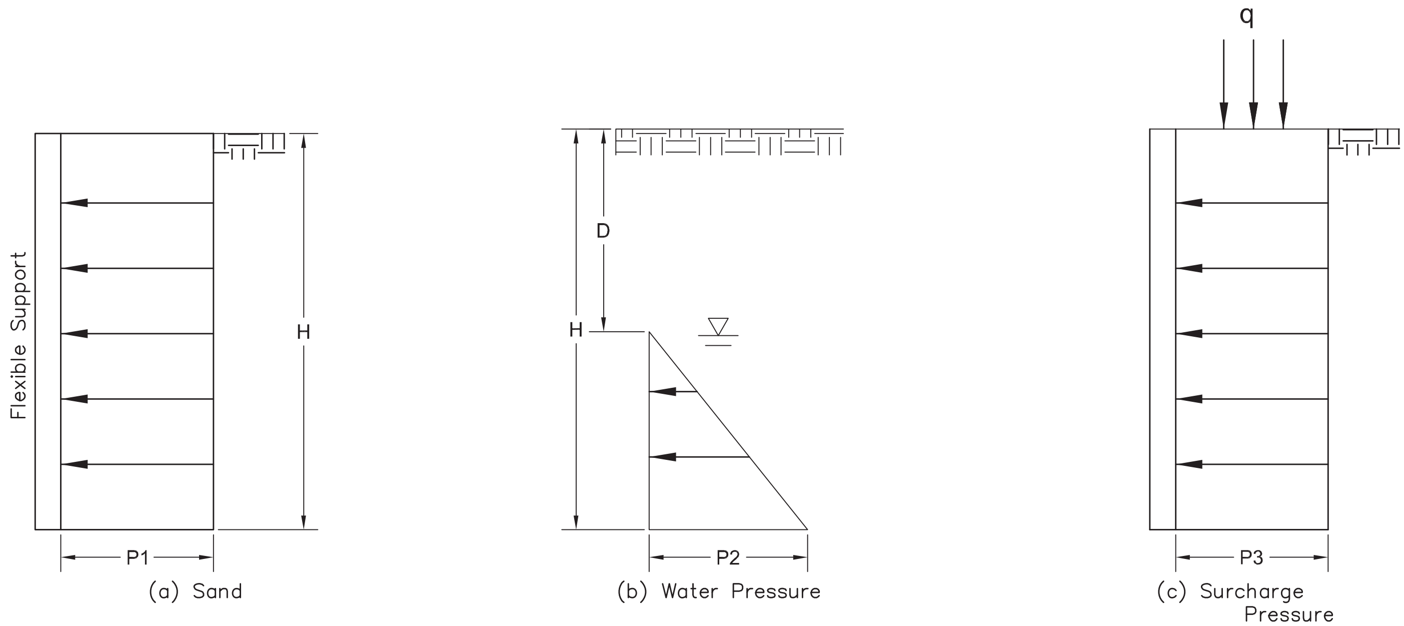
LATERAL PRESSURE DIAGRAMS
FOR OPEN CUTS IN SAND



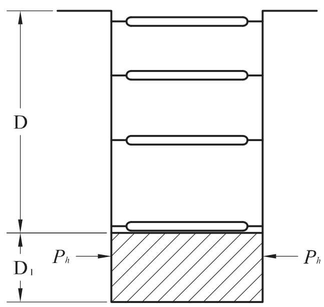
Empirical Pressure Distributions

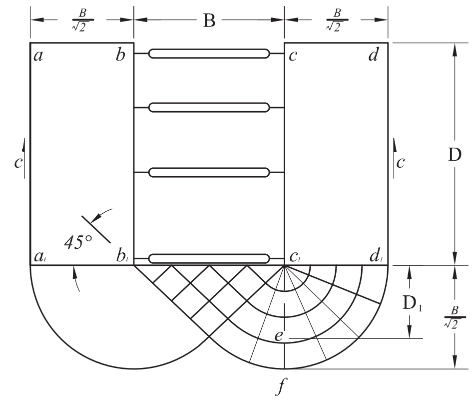
Where:
H = Total excavation depth, feet
D = Depth to water table, feet
P1 = Lateral earth pressure = $0.65^*\gamma HK_a$, psf
P2 = Water pressure = γ_w (H-D), psf
P3 = Lateral earth pressure caused by surcharge = qK_a, psf
γ = Effective unit weight of soil, pcf
γ_w = Unit weight of water, pcf
K_a = Coefficient of active earth pressure = $(1-\sin\varphi)/(1+\sin\varphi)$
φ = Drained friction angle

Notes:
1. All pressures are additive.
2. No safety factors are included.

Reference: Peck, R.B. (1969), "Deep Excavation and Tunneling in soft Ground", 7th ICSMFE, State of art volume, pp. 225-290.

BOTTOM STABILITY FOR BRACED EXCAVATION IN CLAY





Factor of Safety against bottom of heave,

$$F.S = \frac{NcC}{(\gamma D+q)}$$

where, Nc = Coefficient depending on the dimension of the excavation (see Figure at the bottom)
C = Undrained shear strength of soil in zone immediately around the bottom of the excavation,
γ = Unit weight of soil,
D = Depth of excavation,
q = Surface surcharge.

If F.S < 1.5, sheeting should be extended further down to achieve stability

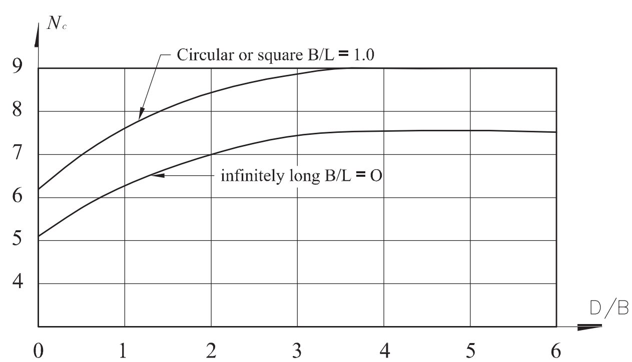
$$\text{Depth of Buried Length, } (D_1) = \frac{1.5(\gamma D+q)-NcC}{(C/B)-0.5\gamma} \; ; D_1 \geq 5 \text{ ft.}$$

Pressure on buried length, P_h:

For $D_1 < 0.47B$; $P_h = 1.5\, D_1(\gamma D - 1.4\, CD/B - 3.14C)$

For $D_1 > 0.47B$; $P_h = 0.7\, (\gamma DB - 1.4\, CD - 3.14CB)$

where; B = width of excavation



N_c rectangular = $(0.84 + 0.16B/L)N_c$ square

Reference: Bjerrum, L. and Eide, O., Stability of Strutted Excavations in Clay, Geotechnique, 6, 32-47 (1956).

Appendix I. Preliminary Construction Quantity Take-off and Cost Estimate from HDR Engineering, Inc.

DRAINAGE IMPROVEMENTS

BID CODE	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL COST
100 6002	PREPARING ROW	STA	7.25	$ 4,000.00	$ 29,000.00
104 6009	REMOVING CONC (RIPRAP)	SY	870	$ 5.00	$ 4,350.00
110 6002	EXCAVATION (CHANNEL)	CY	654	$ 15.00	$ 9,810.00
400 6005	CEM STABIL BKFL	CY	15715	$ 50.00	$ 785,736.77
400 6009	CEMENT STAB BACKFILL (INLET OR MH)	CY	59	$ 50.00	$ 2,950.00
401 6001	FLOWABLE BACKFILL	CY	693	$ 180.00	$ 124,740.00
402 6001	TRENCH EXCAVATION PROTECTION	LF	8650	$ 3.00	$ 25,950.00
420 6010	CL A CONC (PLUG)	EA	18	$ 800.00	$ 14,400.00
420 6071	CL C CONC (COLLAR)	EA	1	$ 2,000.00	$ 2,000.00
420 6074	CL C CONC (MISC)	CY	17	$ 3,000.00	$ 51,000.00
420 6133	CL A CONC (CHANNEL LINING)	CY	11	$ 550.00	$ 6,050.00
432 6005	RIPRAP (CONC) (CL A)	CY	8	$ 500.00	$ 4,000.00
462 6007	CONC BOX CULV (5 FT X 3 FT)	LF	6	$ 420.00	$ 2,520.00
462 6012	CONC BOX CULV (6 FT X 5 FT)	LF	420	$ 630.00	$ 264,600.00
462 6020	CONC BOX CULV (8 FT X 5 FT)	LF	2855	$ 690.00	$ 1,969,950.00
462 6021	CONC BOX CULV (8 FT X 6 FT)	LF	1544	$ 745.00	$ 1,150,280.00
462 6022	CONC BOX CULV (8 FT X 7 FT)	LF	2600	$ 760.00	$ 1,976,000.00
462 6023	CONC BOX CULV (8 FT X 8 FT)	LF	3553	$ 780.00	$ 2,771,340.00
462 6030	CONC BOX CULV (10 FT X 6 FT)	LF	528	$ 1,115.00	$ 588,720.00
462 6036	CONC BOX CULV (11 FT X 6 FT)	LF	760	$ 1,260.00	$ 957,600.00
462 6041	CONC BOX CULV (12 FT X 6 FT)	LF	777	$ 1,455.00	$ 1,130,535.00
462 xxxx	FLOW REGULATOR	SF	466	$ 50.00	$ 23,300.00
464 6005	RC PIPE (CL III)(24 IN)	LF	257	$ 115.00	$ 29,555.00
464 6007	RC PIPE (CL III)(30 IN)	LF	40	$ 145.00	$ 5,800.00
464 6008	RC PIPE (CL III)(36 IN)	LF	24	$ 180.00	$ 4,320.00
464 6009	RC PIPE (CL III)(42 IN)	LF	8	$ 200.00	$ 1,600.00
464 6010	RC PIPE (CL III)(48 IN)	LF	79	$ 225.00	$ 17,775.00
464 6011	RC PIPE (CL III)(54 IN)	LF	18	$ 260.00	$ 4,680.00
464 6013	RC PIPE (CL III)(66 IN)	LF	14	$ 325.00	$ 4,550.00
465 6006	JCTBOX(COMPL)(PJB)(4FTX4FT)	EA	3	$ 5,500.00	$ 16,500.00
465 6009	JCTBOX(COMPL)(PJB)(5FTX5FT)	EA	2	$ 6,500.00	$ 13,000.00
465 xxxx	TYPE A JCT BOX(COMPL)(CIP)(21FTX8FT)	EA	5	$ 71,500.00	$ 357,500.00
465 xxxx	TYPE B JCT BOX(COMPL)(CIP)(9FTX8FT)	EA	15	$ 36,500.00	$ 547,500.00
465 xxxx	TYPE C JCT BOX(COMPL)(CIP)(24FTX12.42FT)	EA	1	$ 61,500.00	$ 61,500.00
465 xxxx	TYPE D JCT BOX(COMPL)(CIP)(9FTX9FT)	EA	2	$ 41,000.00	$ 82,000.00
465 xxxx	TYPE E JCT BOX(COMPL)(CIP)(9FTX11FT)	EA	2	$ 50,100.00	$ 100,200.00
465 xxxx	MANH (COMPL)(TY C)	EA	7	$ 7,500.00	$ 52,500.00
465 xxxx	MANWAY ON BOX CULVERT	EA	20	$ 2,000.00	$ 40,000.00
466 6232	WINGWALL (SPL)	EA	1	$ 95,000.00	$ 95,000.00
481 6013	PIPE (PVC) (SCH 40) (6 IN)	LF	10	$ 60.00	$ 600.00
481 6016	PIPE (PVC) (SCH 40) (12 IN)	LF	34	$ 90.00	$ 3,060.00
496 6003	REMOV STR (MANHOLE)	EA	29	$ 500.00	$ 14,500.00
496 6005	REMOV STR (WINGWALL)	EA	1	$ 20,000.00	$ 20,000.00
496 6007	REMOV STR (PIPE)	LF	3783	$ 25.00	$ 94,575.00
496 6023	REMOVE STR (JUNCTION BOX)	EA	12	$ 2,500.00	$ 30,000.00
500 6001	MOBILIZATION	LS	1	$ 1,450,874.68	$ 1,450,874.68
502 6001	BARRICADES, SIGNS AND TRAFFIC HANDLING	MO	5	$ 10,000.00	$ 50,000.00
7033 6024	SWR(CLEANOUT)(6")	EA	2	$ 500.00	$ 1,000.00
xxx xxxx	POINT REPAIR OF OF 66-72 INCH CONC PIPE	LF	186	$ 1,700.00	$ 316,200.00
	RECONSTRUCTION ACROSS S OF HOLCOMBE FOR STM SWR	LS	1	$ 650,000.00	$ 650,000.00

CHURCH ITEMS

BID CODE	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL COST
104 6001	REMOVING CONC (PAV)	SY	227	$ 12.00	$ 2,724.00
104 6021	REMOVING CONC (CURB)	LF	60	$ 2.00	$ 120.00
104 6036	REMOVING CONC (SIDEWALK OR RAMP)	SY	67	$ 30.00	$ 2,010.00
162 xxxx	BLOCK SODDING (TIFWAY TIFTON 419 BERMUDA)	SY	2850	$ 8.00	$ 22,800.00
170 6001	IRRIGATION SYSTEM	LS	1	$ 5,000.00	$ 5,000.00
275 6010	CEMENT TREAT (SUBGRADE) (8")	SY	197	$ 25.00	$ 4,925.00
360 6028	CONC PAV (JOINT REINF) (6")	SY	39	$ 80.00	$ 3,120.00
360 6029	CONC PAV (JOINT REINF) (7")	SY	188	$ 90.00	$ 16,920.00
496 6041	REMOV STR (LARGE)	EA	2	$ 1,750.00	$ 3,500.00
496 6042	REMOV STR (SMALL)	EA	1	$ 1,000.00	$ 1,000.00
496 6052	REMOV STR (TABLE)	EA	4	$ 100.00	$ 400.00
496 6053	REMOV STR (WOOD STR)	EA	5	$ 100.00	$ 500.00
500 6001	MOBILIZATION	LS	1	$ 10,657.90	$ 10,657.90
528 6006	REMOVE AND RELAY PAVERS	SY	28	$ 75.00	$ 2,100.00
529 6002	CONC CURB (TY II)	LF	60	$ 10.00	$ 600.00

531 6003	CONC SIDEWALKS (6")	SY	66	$ 75.00	$ 4,950.00
550 6001	CHAIN LINK FENCE (INSTALL) (6')	LF	65	$ 30.00	$ 1,950.00
550 6003	CHAIN LINK FENCE (REMOVE)	LF	65	$ 12.00	$ 780.00
550 6015	REMOVE AND INSTALL EXISTING GATE	EA	1	$ 3,500.00	$ 3,500.00
610 6004	RELOCATE RD IL ASM (TRANS-BASE)	EA	1	$ 2,500.00	$ 2,500.00
1002 6004	LANDSCAPE AMENITY (TY 3)	EA	1	$ 15,000.00	$ 15,000.00
1002 6005	LANDSCAPE AMENITY (TY 4)	EA	1	$ 8,750.00	$ 8,750.00
1002 6028	LANDSCAPE AMENITY (ENTRY GATE)	EA	1	$ 1,750.00	$ 1,750.00
5008 6001	WHEEL STOPS	EA	6	$ 250.00	$ 1,500.00
6038 6001	MULTIPOLYMER PAV MRK (W)(4")(SLD)	LF	180	$ 1.00	$ 180.00

CITY UTILITY ITEMS

BID CODE	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL COST
104 6036	REMOVING CONC (SIDEWALK OR RAMP)	SY	382	$ 30.00	$ 11,460.00
500 6001	MOBILIZATION	LS	1	$ 94,233.50	$ 94,233.50
530 6005	DRIVEWAYS (ACP)	SY	100	$ 65.00	$ 6,500.00
531 6001	CONC SIDEWALKS (4")	SY	382	$ 60.00	$ 22,920.00
7016 6028	REMOVE EXIST WATER PIPE (6")	LF	264	$ 20.00	$ 5,280.00
7016 6030	REMOVE EXIST WATER PIPE (10")	LF	178	$ 20.00	$ 3,560.00
7016 6032	REMOVE EXIST WATER PIPE (16")	LF	80	$ 20.00	$ 1,600.00
7016 6080	REMOVE EXIST SAN SEWER PIPE (12")	LF	130	$ 20.00	$ 2,600.00
7017 6007	SANITARY SEWER (12IN) (PVC) (C900)	LF	130	$ 100.00	$ 13,000.00
7017 6079	ABANDON SANITARY SEWER (12IN)	EA	2	$ 1,100.00	$ 2,200.00
7017 6091	FM CONNECTION (FORCE MAIN)	EA	2	$ 5,000.00	$ 10,000.00
7032 6011	WTR(GATE VALVE & BOX)COMPL(10")	EA	2	$ 2,100.00	$ 4,200.00
7032 6012	WTR(GATE VALVE & BOX)COMPL(8")	EA	14	$ 1,800.00	$ 25,200.00
7032 6013	WTR(GATE VALVE & BOX)COMPL(6")	EA	28	$ 1,500.00	$ 42,000.00
7032 6091	WTR(GATE VALVE & BOX)COMPL(12")	EA	2	$ 2,400.00	$ 4,800.00
7049 6010	WATER MAIN PIPE (PVC) (4IN) (C-900)	LF	347	$ 65.00	$ 22,555.00
7049 6011	WATER MAIN PIPE (PVC) (6IN) (C-900)	LF	460	$ 80.00	$ 36,800.00
7049 6012	WATER MAIN PIPE (PVC) (8IN) (C-900)	LF	3317	$ 95.00	$ 315,115.00
7049 6013	WATER MAIN PIPE (PVC) (10IN) (C-900)	LF	350	$ 110.00	$ 38,500.00
7049 6014	WATER MAIN PIPE (PVC) (12IN) (C-900)	LF	62	$ 125.00	$ 7,750.00
7049 6037	WATER MAIN PIPE (DI) (16IN) LF	LF	156	$ 175.00	$ 27,300.00
7049 6043	CASING STEEL (14IN)	LF	344	$ 160.00	$ 55,040.00
7049 6045	CASING STEEL (18IN)	LF	195	$ 185.00	$ 36,075.00
7049 6046	CASING STEEL (20IN)	LF	54	$ 240.00	$ 12,960.00
7049 6048	CASING STEEL (24IN)	LF	90	$ 300.00	$ 27,000.00
7049 6052	FIRE HYDRANT BRANCH (LEAD) (6IN)	LF	148	$ 65.00	$ 9,620.00
7049 6053	SPLIT STEEL CASING (20IN)	LF	30	$ 275.00	$ 8,250.00
7049 6076	SERVICE LINE (SHORT SIDE) (1-1/2"TO 2")	EA	13	$ 2,000.00	$ 26,000.00
7049 6080	TAPPING VALVE AND VALVE (6IN X 6IN)	EA	4	$ 5,500.00	$ 22,000.00
7049 6104	FIRE HYDRANT ASSEMBLY	EA	13	$ 5,000.00	$ 65,000.00
7049 6119	REMOVING AND SALVAGING FIRE HYDRANT	EA	11	$ 600.00	$ 6,600.00
7049 6125	CUT AND PLUG WATER MAIN (4IN)	EA	13	$ 600.00	$ 7,800.00
7049 6126	CUT AND PLUG WATER MAIN (6IN)	EA	5	$ 750.00	$ 3,750.00
7049 6127	CUT AND PLUG WATER MAIN (8IN)	EA	2	$ 850.00	$ 1,700.00
7049 6128	CUT AND PLUG WATER MAIN (10IN)	EA	5	$ 1,000.00	$ 5,000.00
7049 6131	CUT AND PLUG WATER MAIN (16IN)	EA	2	$ 1,400.00	$ 2,800.00
7049 6138	WET CONNECTION (4IN)	EA	13	$ 1,200.00	$ 15,600.00
7049 6139	WET CONNECTION (6IN)	EA	5	$ 1,400.00	$ 7,000.00
7049 6140	WET CONNECTION (8IN)	EA	1	$ 2,000.00	$ 2,000.00
7049 6141	WET CONNECTION (10IN)	EA	4	$ 2,400.00	$ 9,600.00
7049 6142	WET CONNECTION (12IN)	EA	2	$ 2,500.00	$ 5,000.00
7049 6144	WET CONNECTION (16IN)	EA	2	$ 2,700.00	$ 5,400.00
7155 6013	ABANDON EXISTING GATE VALVE & BOX	EA	16	$ 300.00	$ 4,800.00

SUBTOTAL DRAINAGE IMPROVEMENTS	**$**	**15,959,621.45**
5% CONTINGENCIES	**$**	**797,981.07**
TOTAL DRAINAGE IMPROVEMENTS	**$**	**16,757,602.52**
SUBTOTAL CHURCH ITEMS	**$**	**117,236.90**
5% CONTINGENCIES	**$**	**5,861.85**
TOTAL CHURCH ITEMS	**$**	**123,098.75**
SUBTOTAL CITY UTILITY ITEMS	**$**	**1,036,568.50**
5% CONTINGENCIES	**$**	**51,828.43**
TOTAL CITY UTILITY ITEMS	**$**	**1,088,396.93**
TOTAL	**$**	**17,845,999.44**

Appendix J. Project Flood Insurance Rate Map (FIRM)

To obtain more detailed information in areas where **Base Flood Elevation** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevation (BFEs) shown on this map apply only landward of 0.0' North American Vertical Datum (NAVD). Users of this FIRM should be aware that coastal flood elevations may also be provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this community. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map is Universal Tranverse Mercator (UTM) zone 15. The **horizontal datum** is NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of the FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

Spatial Reference System Division
National Geodetic Survey, NOAA
Silver Spring Metro Center
1315 East-West Highway
Silver Spring, Maryland 20910
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242,** or visit their website at www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by the Harris Galveston Area Council and was revised and enhanced by Harris County.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

An accompanying Flood Insurance Study report, Letters of Map Revision or Letters of Map Amendment revising portions of this panel, and digital versions of this PANEL may be available. Contact the **FEMA Map Service Center** at the following phone numbers and Internet address for infomation on all related products available from FEMA;

Phone: 800-358-9616
FAX: 800-358-9620
www.fema.gov/msc

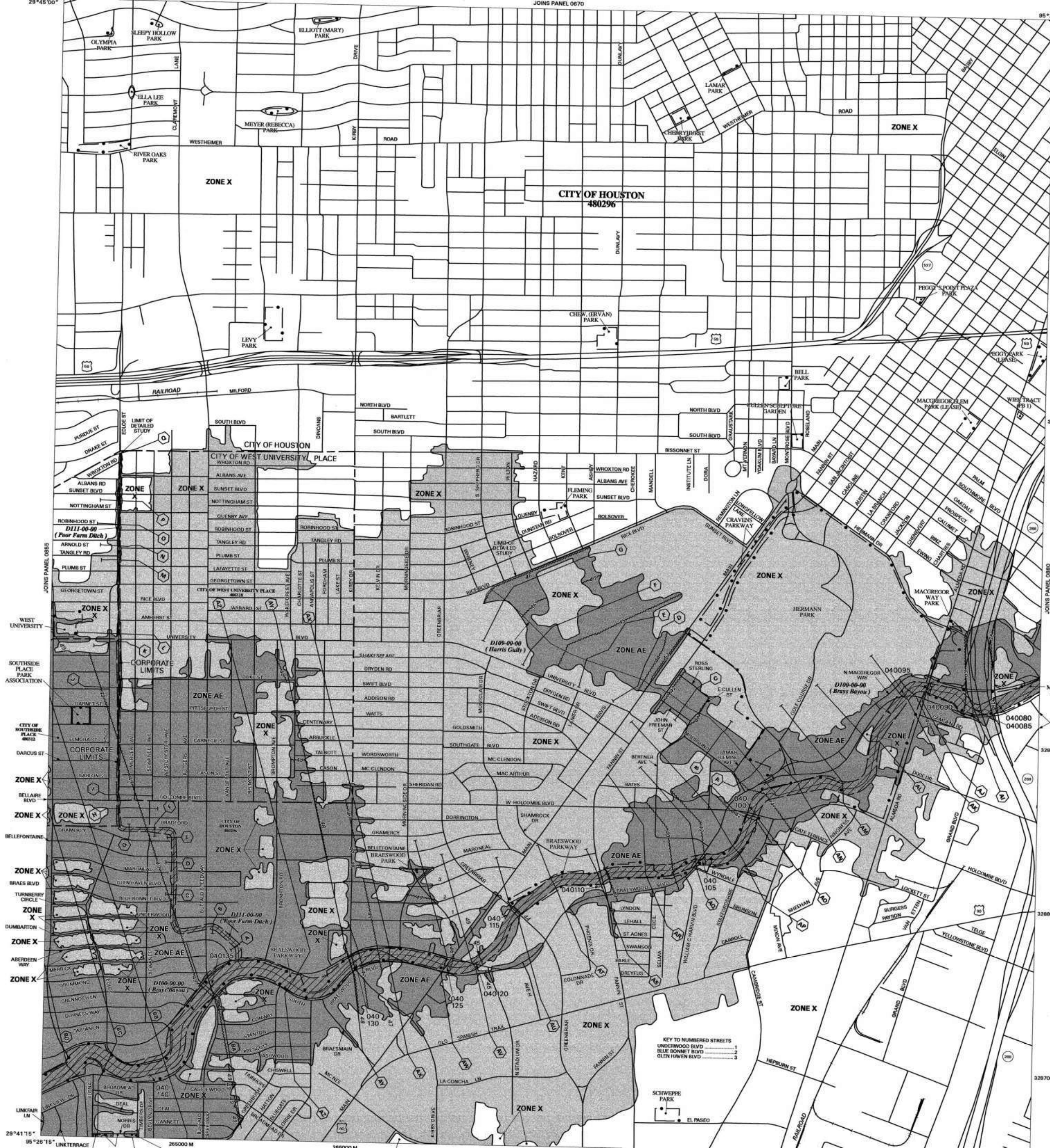
If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at www.fema.gov.

This map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report may reflect stream channel distances that differ from what is shown on this map.

Vertical Datum Adjustment due to subsidence is the 2001 adjustment.

Benchmarks shown on this map were provided by either Harris County or the National Geodetic Survey. To obtain elevation, description, and location information for benchmarks provided by Harris County, please contact the Permits Office of the Public Infrastructure Departement at (713) 956-3000 or visit their website at http://www.eng.hctx.net/permits. For information regarding the benchmarks provided by the National Geodetic Survey, please see note above.

Some bridges and other structures shown on the detailed studied streams are not labeled. See corresponding flood profile for appropriate name.



Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood.

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Area of special flood hazard formerly protected from the 1% annual chance flood event by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood event.
ZONE A99	Area to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no base flood elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); base flood elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or velocities.
~~513~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

(A)——(A)	Cross Section Line
(23)- - - -(23)	Transect Line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4276000M	1000-meter Universal Transverse Mercator grid values, zone 15
600000 FT	5000-foot grid ticks
DX5510×	Bench mark (see explanation in Notes to Users section of this FIRM panel).
• M1.5	River Mile

MAP REPOSITORY
Refer to Repository Listing on Index Map

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
SEPTEMBER 28, 1990

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

SEPTEMBER 30, 1992
NOVEMBER 6, 1996
APRIL 20, 2000
JUNE 18, 2007: to change base flood elevations, to add special flood hazard areas, to change special flood hazard areas, to change zone designations, to reflect updated topographic information, and to change floodway.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at (800) 638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0860L

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

PANEL 860 OF 1150
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
HOUSTON, CITY OF	480296	0860	L
WEST UNIVERSITY PLACE, CITY OF	480318	0860	L
SOUTHSIDE PLACE, CITY OF	480312	0860	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
48201C0860L

MAP REVISED: