Appendix

A

Buffalo Speedway Drainage Preliminary Engineering Report

Draft – October 19, 2018

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2nd DRAFT REPORT

Buffalo Speedway Improvements

Drainage Preliminary Engineering Report

City of West University Place, TX

October 19, 2018

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1 Project Introduction

This preliminary engineering report describes the drainage system upgrades associated with proposed roadway improvements to Buffalo Speedway within the City of West University Place, Texas. 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.

Buffalo Speedway is a four-lane, curb-and-gutter roadway with storm sewer drainage. It passes through the east-central portion of West University Place 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. Storm sewers along Buffalo Speedway drain storm runoff from a total drainage area of approximately 541 acres, including approximately 131 acres north of West U and 46 acres to the south. The Buffalo Speedway drainage system empties into Poor Farm Ditch a short distance south of Bellaire Boulevard. **Exhibit 1** is a drainage area map for the Buffalo Speedway storm sewer system.

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

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 existing storm sewer passes through the St. Vincent De Paul Catholic Church property prior to reaching the Poor Farm Ditch outfall. The alignments and extents of the existing trunk line storm sewers are illustrated on **Exhibit 1**.

Various lateral pipes empty into the Buffalo Speedway system from the east and west, and connectors are provided between the dual 66-inch RCPs to allow water to flow from one pipe to the other. The existing system does not have sufficient capacity to convey the 2-year storm 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 University Place proposes to complete improvements to Buffalo Speedway from Bissonnet Street southward Bellaire Boulevard and has secured Transportation Improvement Program (TIP) funding for re-paving the roadway within the proposed project limits. In addition to paving improvements, West U proposes to upgrade the existing storm sewer drainage system, with improvements extending all the way to the Poor Farm Ditch outfall. The following figure illustrates the general extents of the Buffalo Speedway project and the size

of the proposed new storm sewer pipes and culverts along the roadway. 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 66-inch RCP at Bissonnet Street to dual 8' x 8' RCB culverts at the point where the Buffalo Speedway storm sewer exits the road right-of-way to cross the St. Vincent de Paul campus and outfall to 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.

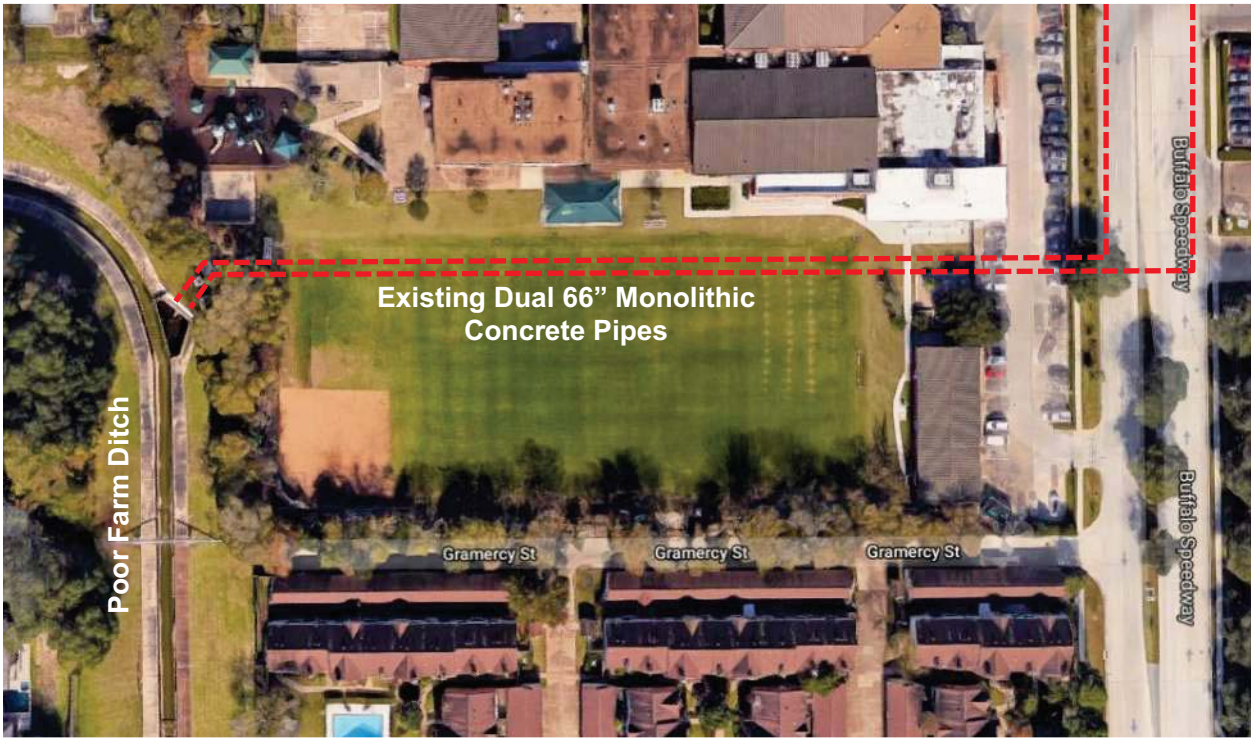


Figure 2: Route of Existing Dual 66" Storm Sewer Across the St. Vincent de Paul Campus

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. The existing dual 66-inch storm sewer pipes between Buffalo Speedway and Poor Farm Ditch (i.e., the pipes that pass through the St. Vincent de Paul campus) are assumed to be replaced with either dual 8' x 8' box culverts plus flow regulators or replaced in kind (i.e., as new dual 66-inch pipes) to regulate flows to the outfall. Regulating structures are provided at intervals along the Buffalo Speedway system to make full use of system storage. No increases in downstream are proposed for storm events ranging from the 10-year (10% annual chance) event to the 100-year (1% annual chance) storm event. Flow rates are increased somewhat 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.

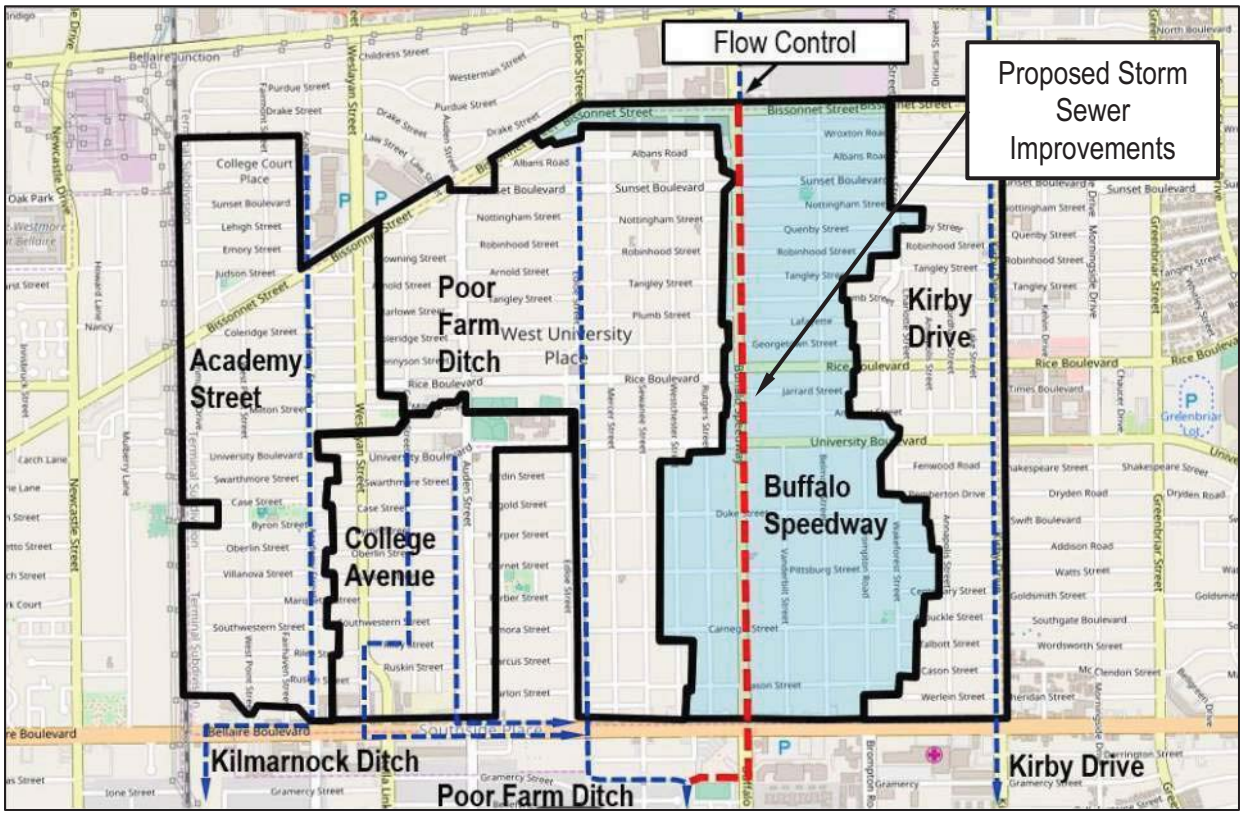


Figure 3: General Extents of Buffalo Speedway Drainage Improvements

A set of images provided in Appendix A 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 Bellaire 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.

2 Hydrologic Methodology

Peak discharge rates for the areas draining toward Buffalo Speedway were computed using the Rational Method. The time of concentration was computed using the method described in the TXDOT Hydraulic Design Manual using the equation shown below. This equation is based on an average storm sewer flow velocity of 3 feet per second, which is very standard for the Houston area.

$$T_c = 10\ minutes + \frac{Length\ of\ Flow\ Path}{3\ {}^{ft}/_{s} \times 60\ \frac{s}{min}}$$

The rainfall intensity for each drainage area was computed using the equation shown below.

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

The e, d and b values required to compute rainfall intensities were taken from the latest version of the TXDOT "*EBD Look-Up Table*." The peak discharge rates were computed for the 2-year (50% annual chance) and 100-year (1% annual chance) storm events using the Rational Method and the equation below:

$$Q = CiA$$

Where Q = peak discharge rate in cubic feet per second, i = rainfall intensity in inches per hour, C = runoff coefficient based on land use, and A = drainage area of the sub-watershed.

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

Table 1 below provides a summary of the drainage areas, their times of concentration, and the peak discharge rates computed with HEC-HMS for the 2-year, 10-year, and 100-year storm events. **Exhibit 1** provides a drainage area map of the Buffalo Speedway drainage system. The boundaries of each of the drainage area listed in **Table 1** are illustrated on the exhibit. The figure at right illustrates a sample computed hydrographs for the 100-year storm event.

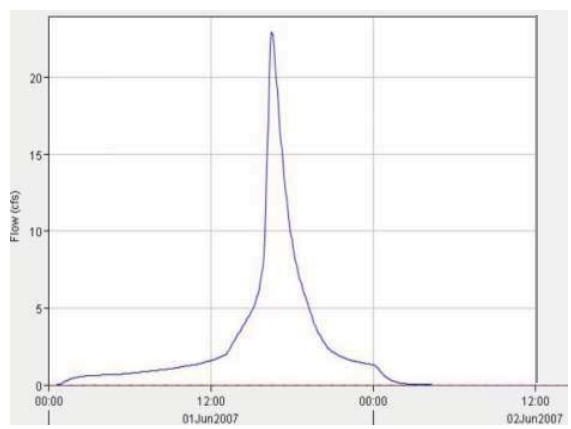


Figure 4: Sample 100-Year Hydrograph

Table 1 - Summary of Peak Discharge Rates

Area ID	Area (acres)	Time of Concentration (hours)	Storage Coefficient (hours)	Peak Discharge (cfs)		
				2-Year	10-Year	100-Year
COH N	131.21	0.64	0.40	251	411	608
COH S	45.57	0.58	0.55	77	128	191
BSW 09	32.57	0.56	0.87	42	72	111
BSWT 1A	21.27	0.54	0.85	28	48	74
BSW 01	10.00	0.50	0.80	14	23	36
BSW 11	28.62	0.55	0.87	37	64	98
BSW 08	27.51	0.55	0.86	36	62	94
BSW 05 S	25.64	0.55	0.86	34	58	88
BSW 10	24.71	0.54	0.86	32	56	85
BSW 12	15.00	0.52	0.82	20	35	53
BSWT 5A	8.80	0.49	0.79	12	21	32
BSW 07	19.58	0.53	0.84	26	45	68
BSW 06 N	19.23	0.53	0.84	26	44	67
BSWT 3A	18.47	0.53	0.84	25	42	64
BSW 14	11.71	0.51	0.81	16	27	42
BSWT 7A	5.26	0.47	0.77	7	13	19
BSW 04	10.21	0.50	0.80	14	24	36
BSWT 2A	6.32	0.48	0.78	9	15	23
BSW 15	8.69	0.49	0.79	12	21	31
BSWT 8A	7.30	0.49	0.78	10	17	26
BSW13	10.06	0.50	0.80	14	24	36
BSWT 6A	5.48	0.48	0.77	8	13	20
BSW06 S	13.23	0.51	0.82	18	31	47
BSWT 4A	10.52	0.50	0.80	14	25	38
BSW 03	10.25	0.50	0.80	14	24	37
BSW 02	9.98	0.50	0.80	14	23	36
BSW 05N	4.72	0.47	0.77	7	11	17

Computed hydrographs are inserted into hydraulic models (described in Section 4 of this report) at nodes where tributary storm sewer systems tie into the Buffalo Speedway system, typically from the east or west.

3 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. A Microsoft Excel® spreadsheet was used to establish preliminary storm sewer sizes based on a nominal full flow velocity of 3 feet per second, a value which initial assessments would minimize the potential for downstream impacts on peak flow rates. Detailed modeling of the existing and proposed storm sewers is described in the next section of this report.

3.1 Proposed Storm Sewer Sizing & Layout

The proposed storm sewer ranges in size from a single 66-inch RCP at Bissonnet Street (increasing to a 72-inch RCP just downstream of Bissonnet) to dual 8'x8' box culverts near the outfall. The outfall pipes which cross the St. Vincent De Paul Catholic Church property are proposed to remain as 66-inch RCPs in order to maintain the same existing drainage easement through that property. Connectors between existing and proposed storm sewers will be provided in order to allow storm water to transfer between 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 restrictors 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 steel plates or other means that allow restrictors to be adjusted or removed as downstream channel capacity is increased or detention becomes available. The existing pipes along Buffalo Speedway are proposed to be left in place and connected to the proposed storm sewer to provide storage within the drainage system. **Table 2** provides a summary of the existing storm sewer and the proposed storm sewer improvements.

Table 2 – Summary of Proposed Storm Sewer Improvements

Cross-Street	Existing Storm Sewer		Proposed Storm Sewer		
	Number	Diameter (inches)	Number	Span/Dia (ft)	Rise (ft)
Bissonnet	1	66	1	6	-
Albans	1	66	1	8	5
Nottingham	1	66	1	8	6
Tangley	1	66	1	8	8
Georgetown	1	72	1	9	8
Amherst	2	66	2	8	5
University	2	66	2	8	5
Duke	2	66	2	8	6
Pittsburgh	2	66	2	8	7
Carnegie	2	66	2	8	7
Cason	2	66	2	8	8
Bellaire	2	66	2	8	8
Outfall	2	66	2	5.5	-

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.

The following figures illustrates 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 Bissonnet southward to Amherst, the new storm sewer is proposed to be constructed on the east side of the road as indicated on **Figure 5**.

Figure 5: Proposed Storm Sewer Arrangement North of Amherst

South of Amherst, an existing 66-inch storm sewer pipe lies along each side of the road, so it is recommended that the proposed storm sewers be constructed “inside” of the existing pipes, as indicated on **Figure 6**.

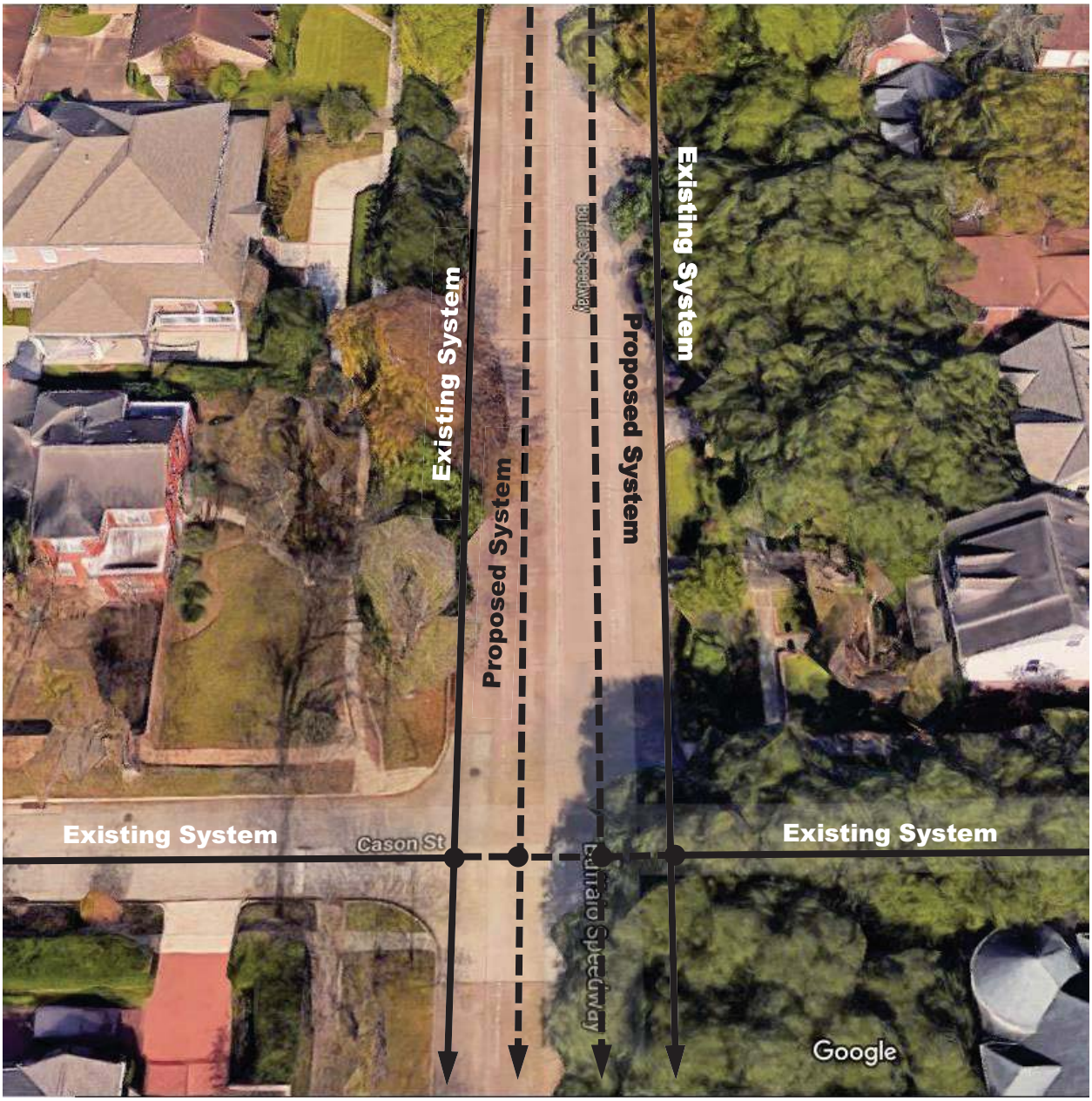


Figure 6: Proposed Storm Sewer Arrangement South of Amherst

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. The following figure illustrates this approach to traffic control, which has been successfully utilized by HDR on recent construction projects.

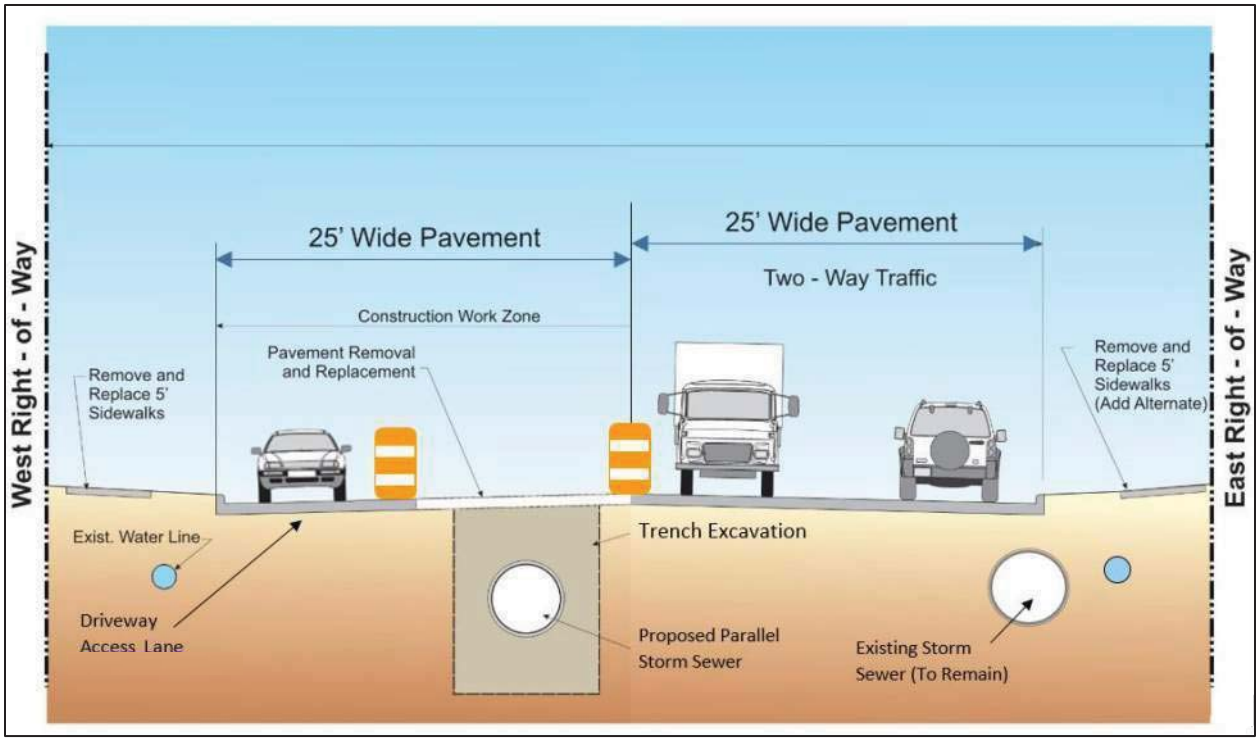


Figure 7: Possible Traffic Control Approach for Buffalo Speedway

3.2 Crossing the St. Vincent de Paul Church Property

Hydraulic modeling results indicate that the existing dual 66-inch storm sewer crossing the St. Vincent de Paul Catholic Church campus could, in terms of capacity, be left in place to regulate flows to Poor Farm Ditch. However, information provided by the City of West University Place indicates that the existing pipes are in less than satisfactory condition and must be replaced. The replacement storm sewer may take the form of dual 8' x 8' box culvert storm sewers per the design summary presented on **Exhibit 2**. Alternatively, the existing dual 66-inch storm sewers may be replaced in kind, with the new dual 66-inch pipes regulating flow to Poor Farm Ditch. The latter approach would likely result in significant cost savings, but should conditions change sufficiently in the future to allow the flow regulators in the proposed system to be removed, replacing the dual 66-inch storm sewers in kind would not provide full capacity for the non-regulated condition. Additionally, entering the church property a second time in the future to re-construct or add to the dual 66-inch storm sewers may prove to be problematic. Following is a list of possible design issues and approaches that must be considered for these two options.

Option #1: Construct New Dual 8' x 8' Box Culvert Storm Sewer

- Accounted for in the project cost estimate.
- Provides capacity for possible future condition where detention is provided downstream.
- Must negotiate an alignment and easement with the church.
- Can remove the existing dual 66-inch pipes or grout fill in place.
- Easement will be wider if existing 66-inch pipes are left in place.
- If existing 66-inch pipes are left in place, will have to construct a new outfall at Poor Farm Ditch.

- If existing 66-inch pipes are left in place, the new storm sewer will intersect the existing.
- Leaving existing 66-inch pipes in place will reduce disturbance related to required pipe demo.
- If 66-inch pipes are removed, can replace with 2 – 8' x 8' and preserve the existing outfall.
- The cost estimate developed for the project does not account for a new outfall.

Option #2: Construct Dual 66-inch Storm Sewer

- Cost would be reduced, as 2 – 8' x 8' are accounted for in the project cost estimate.
- Would lack capacity for possible future condition where detention is provided downstream.
- Permutation would involve new dual 66" & cure-in-place of existing 66" for future capacity.
- Must negotiate an alignment and easement with the church.
- Can remove the existing dual 66-inch pipes or grout fill in place.
- Easement will be wider if existing 66-inch pipes are left in place.
- If existing 66-inch pipes are left in place, will have to construct a new outfall at Poor Farm Ditch.
- Leaving existing 66-inch pipes in place will reduce disturbance related to required pipe demo.
- If existing 66-inch pipes are cured in place, can use the existing outfall for those existing pipes.
- If 66-inch pipes are removed, can replace with dual 66-inch and preserve the existing outfall.
- The cost estimate developed for the project does not account for a new outfall.

The following figure illustrates some of the possible combinations described above.

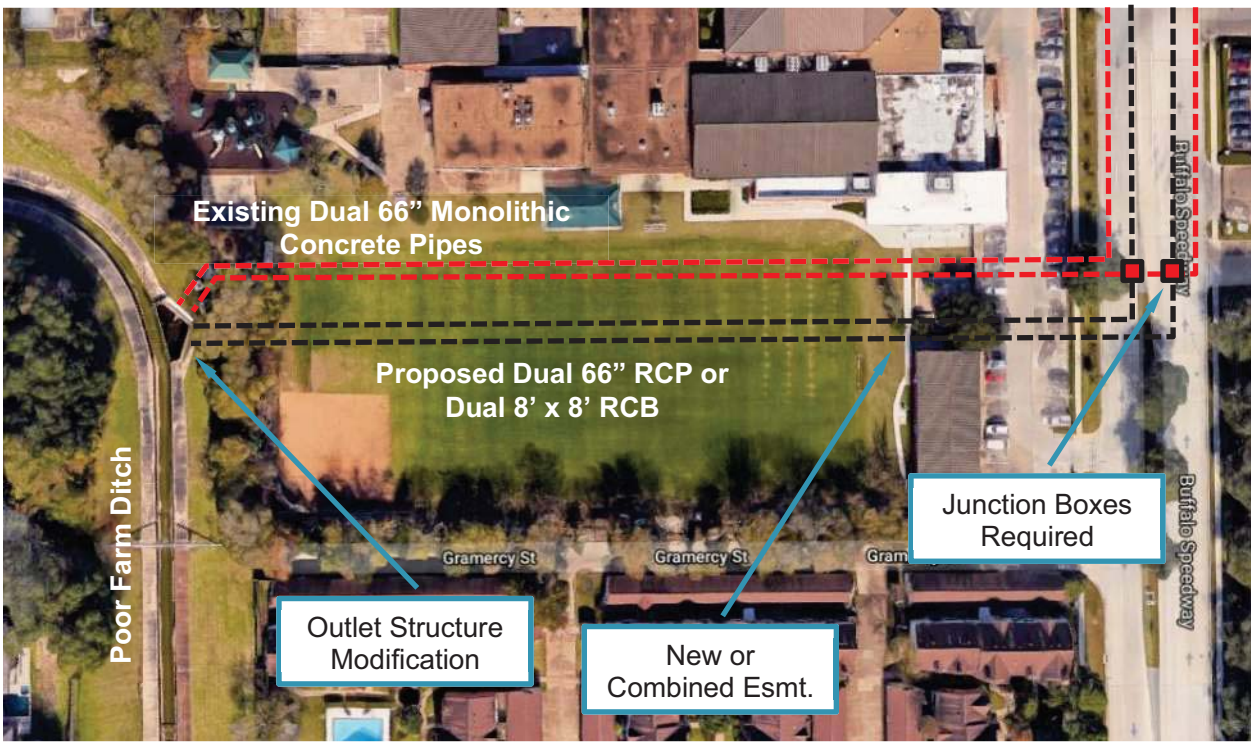


Figure 8: Possible Pipe Combinations Across the St. Vincent de Paul Campus

As indicated, leaving the existing monolithic pipes in place creates the need for an added easement or a wider easement, and may require that the existing outfall structure be replaced or significantly

modified. That structure was repaired in 2014. Construction documents prepared for that project by HDR Engineering, Inc. in 2014 are attached to this report as **Appendix B**.

3.3 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. The figure 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 C**. 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.

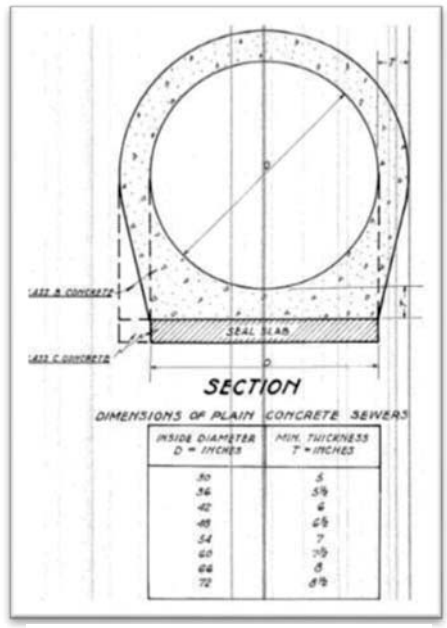


Figure 9: Typical Section, Monolithic Concrete Storm Sewer

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. The figure 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.

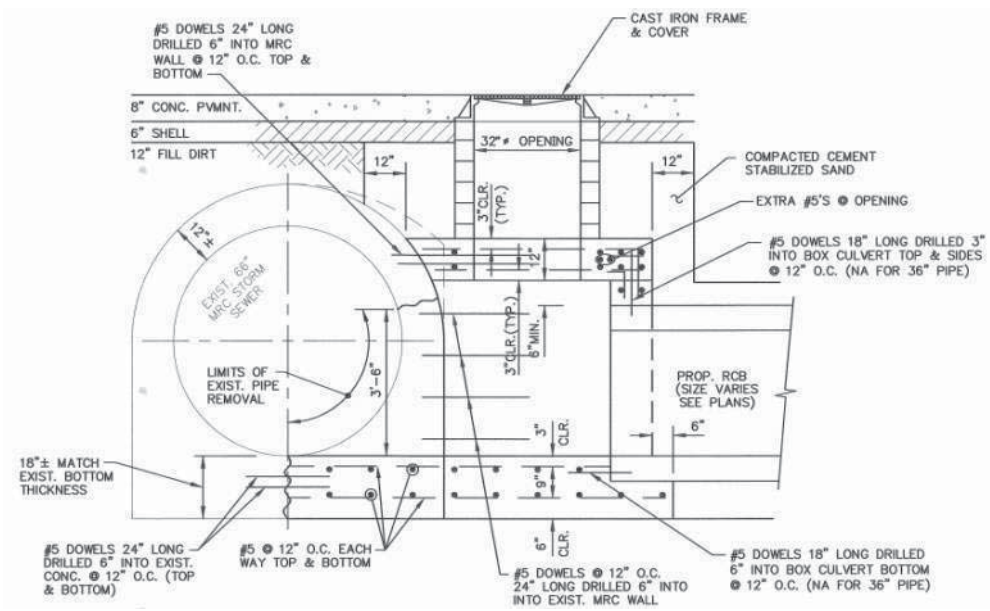


Figure 10: Detail for Connecting to Monolithic Concrete Storm Sewers

Appendix D contains excerpts from construction plans developed by Claunch & Miller, Inc. in 2002 for Priority Area 10 improvements, which involved side streets south of University Boulevard, and for Priority Area 11B, which involved side streets north of University Boulevard.

3.4 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 Bissonnet Street right-of-way be left in place to serve as a flow regulator. The following figure provides a basic approach to the manner in which this is proposed to be accomplished.

Figure 11: Flow Regulation at Bissonnet Street

As indicated in the figure, 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 may 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.

3.5 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 to provide in-line detention storage. Proposed new box culvert storm sewers are designed to accommodate the existing conditions 2-year flow from the area north of Bissonnet Street (set equal for design purposes to the capacity of the existing 66-inch storm sewer that enters West University Place from the north) 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 Bellaire 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 from the proposed storm sewer system, the proposed storm sewers are proposed 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 some downstream location.

In the proposed conditions XPSWMM models of the Buffalo Speedway drainage system, a total of six (6) flow regulators are represented at intervals along the new storm sewer. These regulators are modeled as 48-inch pipes, but the actual physical configuration of the regulators may take a number of forms. Possible alternatives for constructing the required regulators include the following.

- Construct masonry walls in manholes or junction boxes to limit flow openings at regulator locations to roughly to the equivalent of a 48-inch pipe.
- Install steel plates at manholes or junction boxes to limit flow openings at regulator locations to roughly to the equivalent of a 48-inch pipe.
- Concrete or grout short segments of 48-inch pipe into the proposed box culverts at the prescribed locations.
- Use a stop-log system at each of the prescribed locations to limit flow openings at regulator locations to roughly to the equivalent of a 48-inch pipe.

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. The following matrix is used to evaluate the various regulation alternatives for overall suitability.

Table 3: Evaluation of Potential Flow Regulation Methods

Approach/ Method	Simple	Cost-Effective	Long Lasting	Easily Maintained	Easily Modified
Masonry Walls	✓	✓	✓	✓	
Steel Plates	✓	✓			✓
Pipe Segments	✓		✓	✓	
Stop-Logs	✓		✓		✓

As indicated in the table, none of the evaluated approaches satisfies all of the criteria, but a simple masonry wall satisfies most of the criteria, failing only the ease of modification criterion. The

following figure 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.

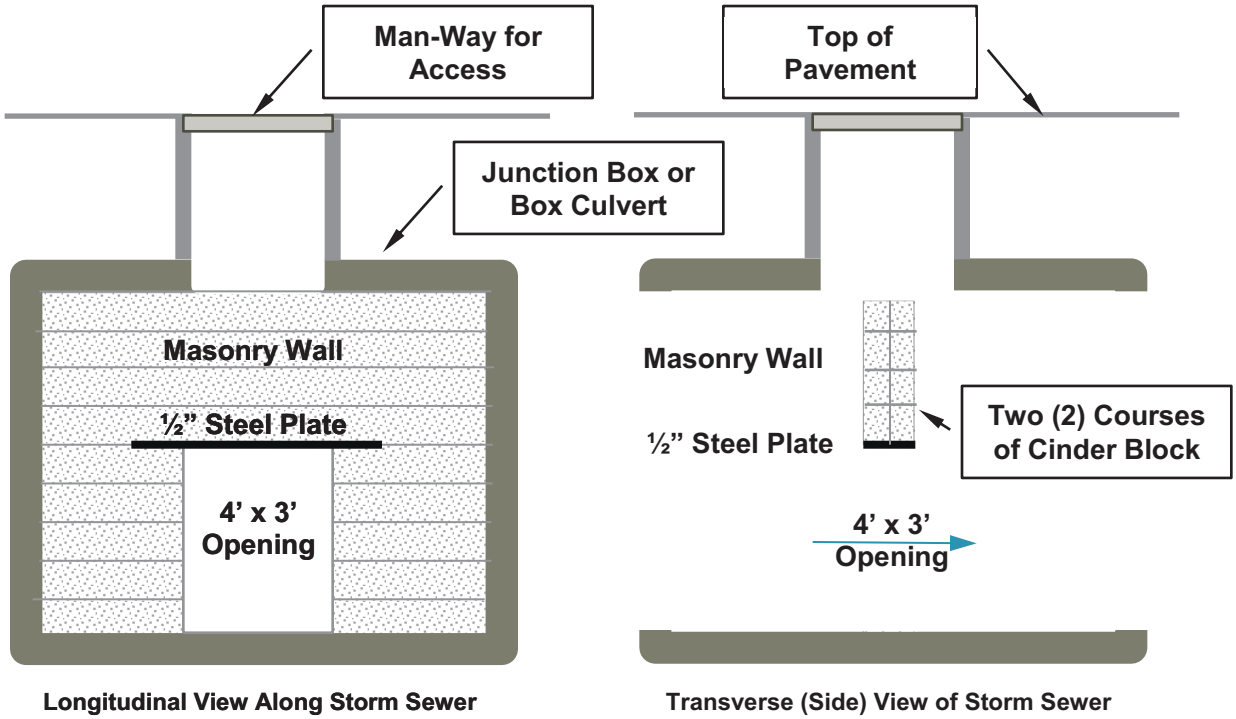


Figure 12: General Form of Masonry Flow Regulator

3.6 Utility Concerns

In constructing the proposed new storm sewers, care must be exercised to avoid existing utilities along Buffalo Speedway. The figure at right is representative of the water line layout for the entire length of the proposed roadway and drainage improvement 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 13: Typical Water Line Arrangement along Buffalo Speedway

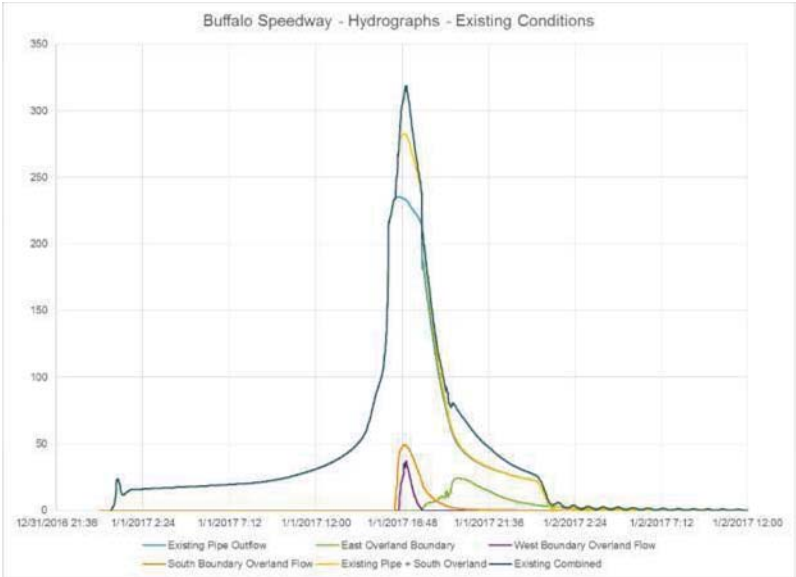
4 Hydraulic Analysis

4.1 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 E** contains a map of the Buffalo Speedway project area with tabulated field survey data for the existing storm sewer system between Bissonnet Street and Poor Farm Ditch. 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 at the top of the outfall pipe at Poor Farm Ditch.

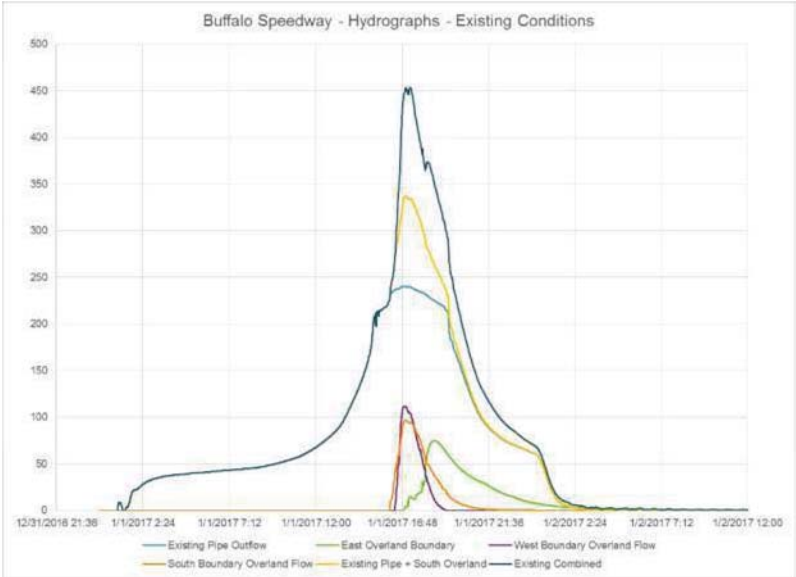
The results of the existing conditions hydraulic analysis indicate that the storm sewer trunk line does not have sufficient capacity to convey the 2-year peak discharge. Storm water ponding is expected along the entire corridor of Buffalo Speedway, and storm water flows eastward toward Belmont Street 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 14**. 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 325 cfs. The combined peak discharge at the outlet to Poor Farm Ditch is approximately 280 cfs.

Figure 14 - Existing Conditions 2-Year Runoff Hydrographs



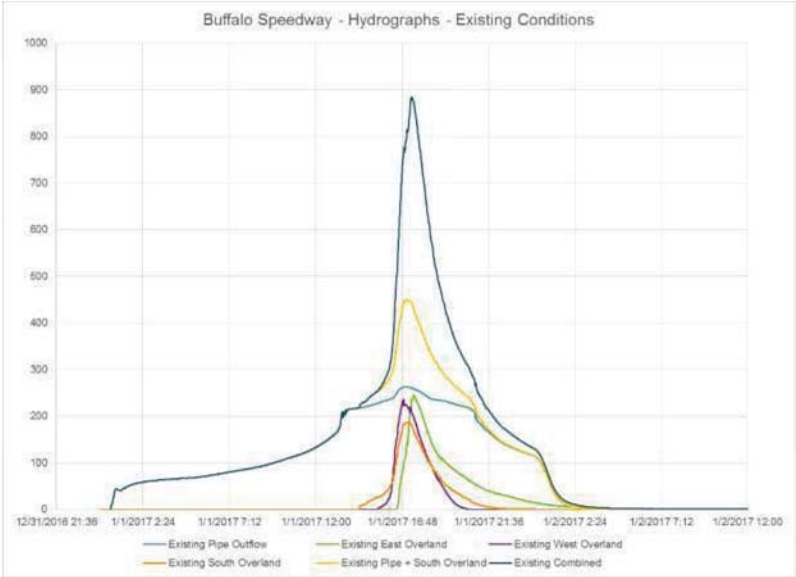
The 10-year runoff hydrographs for the existing conditions are shown below in **Figure 15**. As shown, the combined peak discharge from the system (via all routes) is approximately 450 cfs. The 10-year peak discharge at the storm sewer outfall to Poor Farm Ditch is approximately 340 cfs.

Figure 15 - Existing Conditions 10-year Runoff Hydrographs



The 100-year runoff hydrographs for the existing conditions are provided below in **Figure 16**. As shown, the combined peak discharge (via all routes) is approximately 880 cfs. The 100-year peak discharge at the Poor Farm Ditch outfall is approximately 450 cfs.

Figure 16 - Existing Conditions 100-Year Runoff Hydrographs



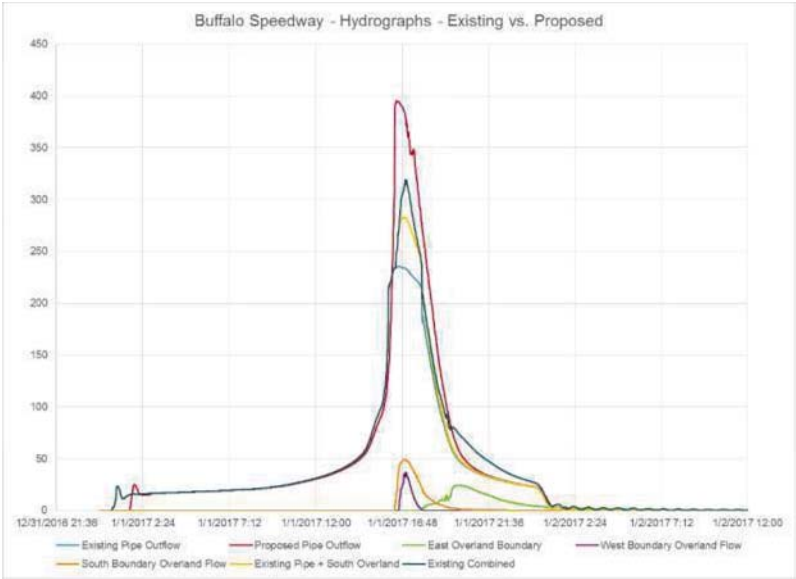
Flooding depth grids of the 2-year, 10-year, and 100-year storm events are provided in **Exhibits 3, 4, and 5**, respectively. Hydraulic grade line plots of the 2-year and 100-year storm events (generated directly from XPSWMM) are provided in **Exhibits 6 and 7**, respectively.

4.2 Proposed Conditions

The existing conditions hydraulic model was modified to include the proposed storm sewer. The proposed storm sewer sizes range from a single 66-inch RCP at Bissonnet Street 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 17**. As shown, the proposed combined peak discharge from the system is approximately 390 cfs, which is an increase of approximately 110 cfs above the existing peak discharge rate at Poor Farm Ditch outfall. Based on that increase and evaluation of existing and proposed conditions 2-year discharge hydrographs, approximately 9 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.

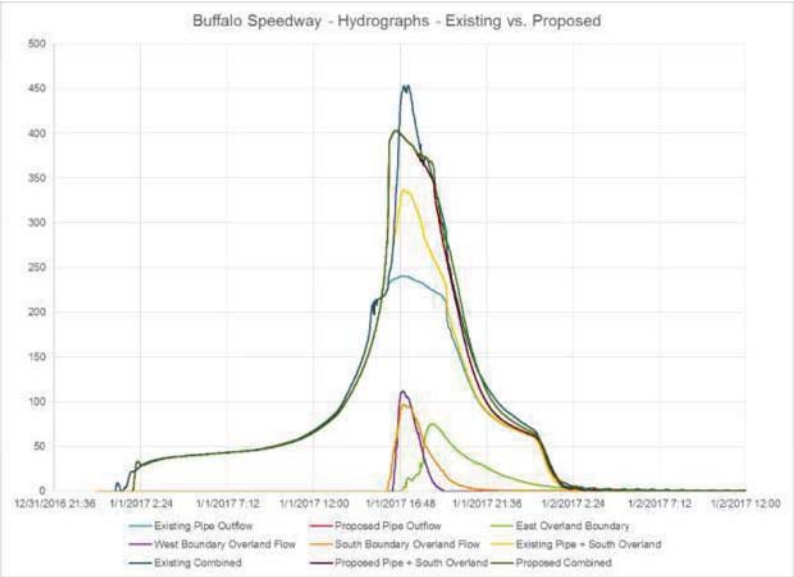
Figure 17 –Existing Conditions vs. Proposed Conditions 2-Year Runoff Hydrographs



The 10-year runoff hydrographs for the existing conditions are provided below in **Figure 18**. As shown, the combined peak discharge is approximately 400 cfs, which is less than the combined existing conditions peak discharge 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. Storage within the streets and the storm sewer system, including storage provided in the existing sewer pipes left in place, meters flow out of the system to broaden the hydrograph to reduce the combined peak discharge rate to Poor Farm Ditch to a value less than the existing conditions combined value for all discharge routes. Thus, while the 10-year peak discharge to Poor Farm Ditch increases

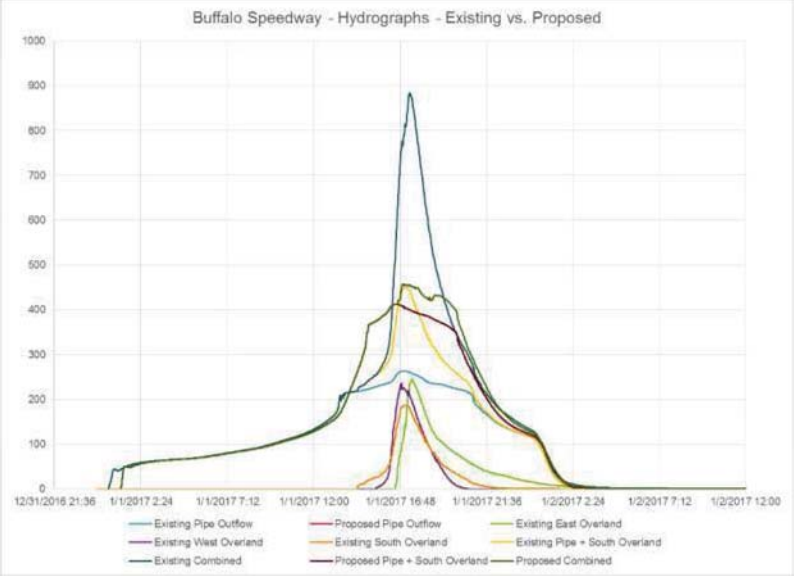
from approximately 340 cfs to approximately 400 cfs, the combined peak discharge to Brays Bayou via all routes is reduced from 450 cfs to 400 cfs, and the HCFCD has indicated that the channel of Poor Farm Ditch downstream of Bellaire Boulevard has 100-year flow capacity.

Figure 18 - Existing Conditions vs. Proposed Conditions 10-Year Runoff Hydrographs



The 100-year runoff hydrographs for the existing conditions are provided below in **Figure 19**. As shown, the combined peak discharge is approximately 450 cfs, which is very comparable to the existing conditions combined peak discharge 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. Storage within the streets and storm sewer system meters flow out the system to broaden the hydrograph to reduce the peak discharge rates to Poor Farm Ditch.

Figure 19 – Existing Conditions vs. Proposed Conditions 100-Year Runoff Hydrographs



These results demonstrate no increase in peak discharge to Poor Farm Ditch, although the volume of water flowing to the channel is increased due to the elimination of overland flow to Brays Bayou via alternate routes. Flooding depth grids of the 2-year, 10-year, and 100-year storm events are provided on **Exhibits 8, 9, and 10**, respectively. Hydraulic grade line plots of the 2-year and 100-year storm events are provided on **Exhibits 11 and 12**, respectively.

4.3 Comparison of Ponding Depths along Buffalo Speedway

Table 3 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 Rice Blvd. and Bissonnet St. and between University Blvd. and Bellaire Blvd. During a 10-year and 100-year storm event, street flooding is expected along the entire stretch of Buffalo Speedway between Bissonnet St. and Bellaire 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 4 - Comparison of Ponding Depths along Buffalo Speedway

Location	2-Year			10-Year			100-Year		
	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
Buffalo Speedway @ Bissonet	1.5	1.4	-0.1	1.7	1.7	0.0	2.0	2.0	0.0
Buffalo Speedway @ Wroxton	1.3	1.0	-0.3	1.7	1.7	0.0	2.2	2.1	-0.1
Buffalo Speedway @ Albans	1.6	1.2	-0.4	2.0	1.9	0.0	2.5	2.4	-0.1
Buffalo Speedway @ Sunset	1.1	0.6	-0.5	1.2	1.2	0.0	1.8	1.7	-0.1
Buffalo Speedway @ Nottingham	0.5	0.2	-0.3	0.8	0.6	-0.2	1.1	1.0	-0.1
Buffalo Speedway @ Quenby	0.2	0.2	0.0	1.1	0.7	-0.4	1.4	1.2	-0.2
Buffalo Speedway @ Robinhood	0.3	0.0	-0.3	0.5	0.4	-0.1	0.7	0.6	-0.1
Buffalo Speedway @ Tangley	0.8	0.5	-0.3	0.9	0.8	-0.1	1.0	0.8	-0.2
Buffalo Speedway @ Plumb	1.0	0.4	-0.5	1.0	0.9	-0.1	1.2	1.2	0.0
Buffalo Speedway @ Lafayette	1.2	1.0	-0.2	1.2	1.1	-0.1	1.4	1.3	-0.1
Buffalo Speedway @ Georgetown	1.3	0.7	-0.6	1.4	0.9	-0.5	1.4	1.3	-0.1
Buffalo Speedway @ Rice	0.5	0.1	-0.4	0.7	0.4	-0.3	0.9	0.8	-0.1
Buffalo Speedway @ Jarrard	0.0	0.0	0.0	0.6	0.4	-0.2	0.8	0.5	-0.3
Buffalo Speedway @ Amherst	0.0	0.0	0.0	0.0	0.3	0.3	0.6	0.6	-0.1
Buffalo Speedway @ University	0.9	0.8	-0.1	1.0	0.9	-0.2	1.2	0.6	-0.5
Buffalo Speedway @ Duke	1.8	0.9	-0.9	1.8	1.2	-0.7	2.0	1.2	-0.8
Buffalo Speedway @ Pittsburgh	1.6	0.0	-1.6	1.9	0.6	-1.3	2.2	0.6	-1.6
Buffalo Speedway @ Carnegie	0.8	0.0	-0.8	1.1	0.0	-1.1	1.3	0.0	-1.3
Buffalo Speedway @ Cason	1.3	0.2	-1.1	1.7	0.2	-1.5	2.1	0.6	-1.5
Buffalo Speedway @ Bellaire	1.5	0.5	-1.1	1.8	0.6	-1.2	2.0	0.5	-1.5

5 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 E** includes work products prepared by West Belt Surveying, Inc.
- Limited geotechnical testing was completed by Aviles Engineering Corporation was completed. Work was limited to three (3) borings located at approximately intervals along Buffalo Speedway within the project segment. **Appendix F** includes a geotechnical investigations report prepared by Aviles Engineering Corporation. **Exhibit 13** 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 $15.2 million. **Appendix G** 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 that cross the St. Vincent de Paul Catholic Church campus. 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. Similarly, the cost estimate includes a proposed 66-inch storm sewer between Bissonnet Street and Wroxton Road that, as noted previously, will likely not be constructed in the near-term so that flows entering West University Place from the north are regulated to existing conditions levels. Again, for purposes of preparing the cost estimate, the full cost for the proposed Buffalo Speedway drainage infrastructure 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 14**, which illustrates water line locations and sizes along Buffalo Speedway from Bissonnet Street southward to Bellaire Boulevard.

6 Conclusion

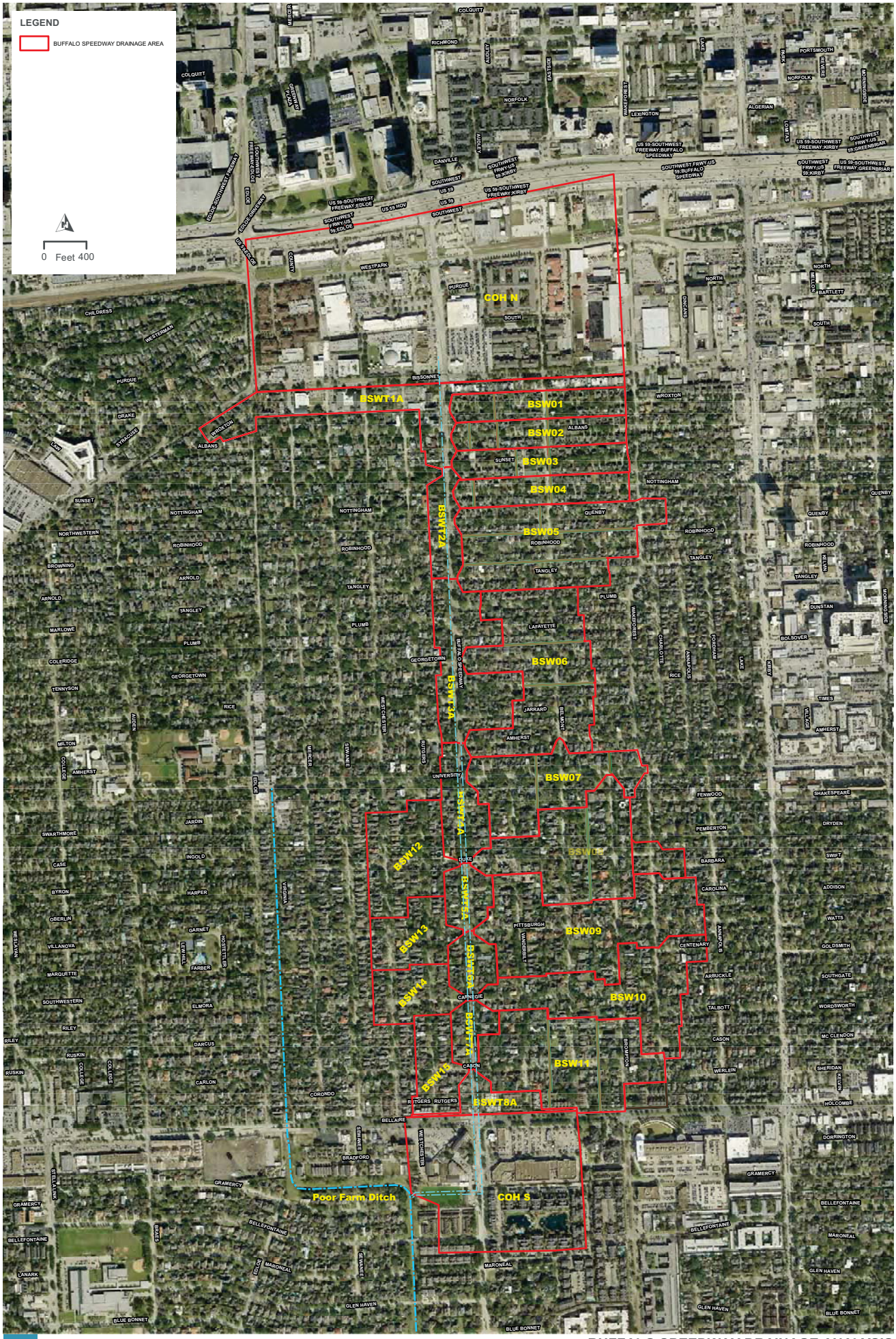
Based on the results of this analysis, the proposed improvements will not cause any adverse impacts on downstream peak flow rates along Poor Farm Ditch. The following recommendations are included as a part of the drainage plan associated with the improvements to Buffalo Speedway.

- Construct storm sewers along Buffalo Speedway between Bissonnet Street to the existing outfall to Poor Farm Ditch ranging in size from one 66-inch RCP to dual 8' x 8' RCBs.
- 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 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 or other means that are properly design 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.
- Consider alternatives for leaving the existing dual 66" storm sewers in place across the St. Vincent De Paul Catholic Church property, replacing the existing 66" storm sewers in kind, or upsizing to dual 8' x 8' box culverts to provide future capacity. Coordinate with the church with regard to any 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.

CHESTER
MERCER
SEWANEE
RUTGERS
UNIVERSITY
DUKE
PITTSBURGH
CARNEGIE
CASON
CORONDO
RUTGERS
RUTGERS
BELLAIRE
AMHERST
BELMONT
VANDERBILT
BROMPTON

EXHIBITS



BUFFALO SPEEDWAY DRAINAGE ANALYSIS

DRAINAGE AREA MAP

EXHIBIT 1

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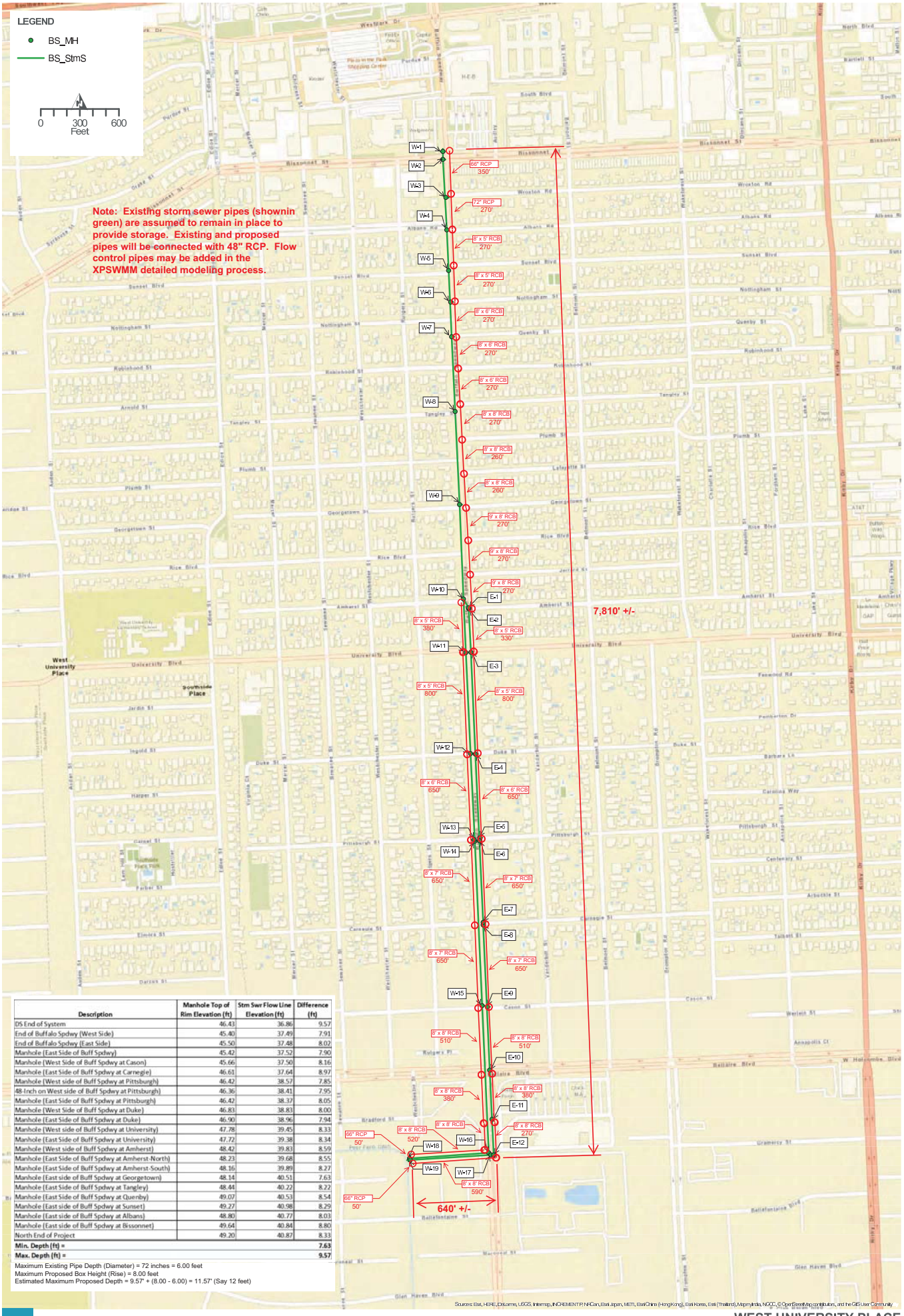

Description	Manhole Top of Rim Elevation (ft)	Stm Swr Flow Line Elevation (ft)	Difference (ft)
DS End of System	46.43	36.86	9.57
End of Buffalo Spdwy (West Side)	45.40	37.49	7.91
End of Buffalo Spdwy (East Side)	45.50	37.48	8.02
Manhole (East Side of Buff Spdwy)	45.42	37.52	7.90
Manhole (West Side of Buff Spdwy at Cason)	45.66	37.50	8.16
Manhole (East Side of Buff Spdwy at Carnegie)	46.61	37.64	8.97
Manhole (West side of Buff Spdwy at Pittsburgh)	46.42	38.57	7.85
48-Inch on West side of Buff Spdwy at Pittsburgh)	46.36	38.41	7.95
Manhole (East Side of Buff Spdwy at Pittsburgh)	46.42	38.37	8.05
Manhole (West Side of Buff Spdwy at Duke)	46.83	38.83	8.00
Manhole (East Side of Buff Spdwy at Duke)	46.90	38.96	7.94
Manhole (West side of Buff Spdwy at University)	47.78	39.45	8.33
Manhole (East Side of Buff Spdwy at University)	47.72	39.38	8.34
Manhole (West side of Buff Spdwy at Amherst)	48.42	39.83	8.59
Manhole (East Side of Buff Spdwy at Amherst-North)	48.23	39.68	8.55
Manhole (East Side of Buff Spdwy at Amherst-South)	48.16	39.89	8.27
Manhole (East side of Buff Spdwy at Georgetown)	48.14	40.51	7.63
Manhole (East Side of Buff Spdwy at Tangley)	48.44	40.22	8.22
Manhole (East Side of Buff Spdwy at Quenby)	49.07	40.53	8.54
Manhole (East side of Buff Spdwy at Sunset)	49.27	40.98	8.29
Manhole (East side of Buff Spdwy at Albans)	48.80	40.77	8.03
Manhole (East side of Buff Spdwy at Bissonnet)	49.64	40.84	8.80
North End of Project	49.20	40.87	8.33
Min. Depth (ft) =			**7.63**
Max. Depth (ft) =			**9.57**

Maximum Existing Pipe Depth (Diameter) = 72 inches = 6.00 feet
Maximum Proposed Box Height (Rise) = 8.00 feet
Estimated Maximum Proposed Depth = 9.57' + (8.00 - 6.00) = 11.57' (Say 12 feet)

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

Note: Proposed storm sewer pipes are shown in red. This exhibit illustrates a preliminary design based on 2-year flow rates and gravity flow pipe capacity calculations.

HDR

WEST UNIVERSITY PLACE

BUFFALO SPEEDWAY

EXISTING DRAINAGE LAYOUT

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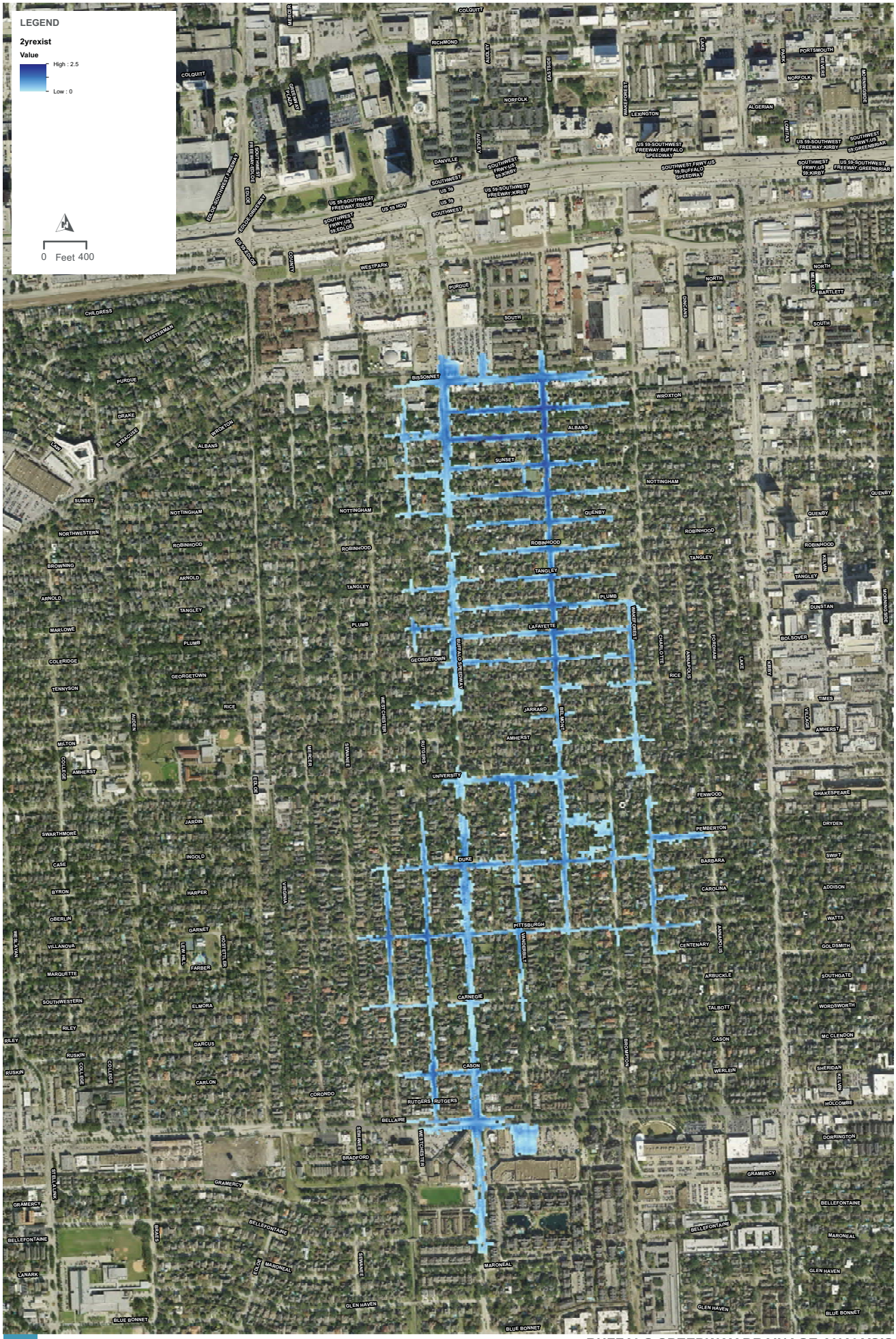
WEST U BUFFALO SPEEDWAY PER

EXHIBIT 2



BUFFALO SPEEDWAY DRAINAGE ANALYSIS

EXISTING PONDING MAP - 2-YEAR

EXHIBIT 3

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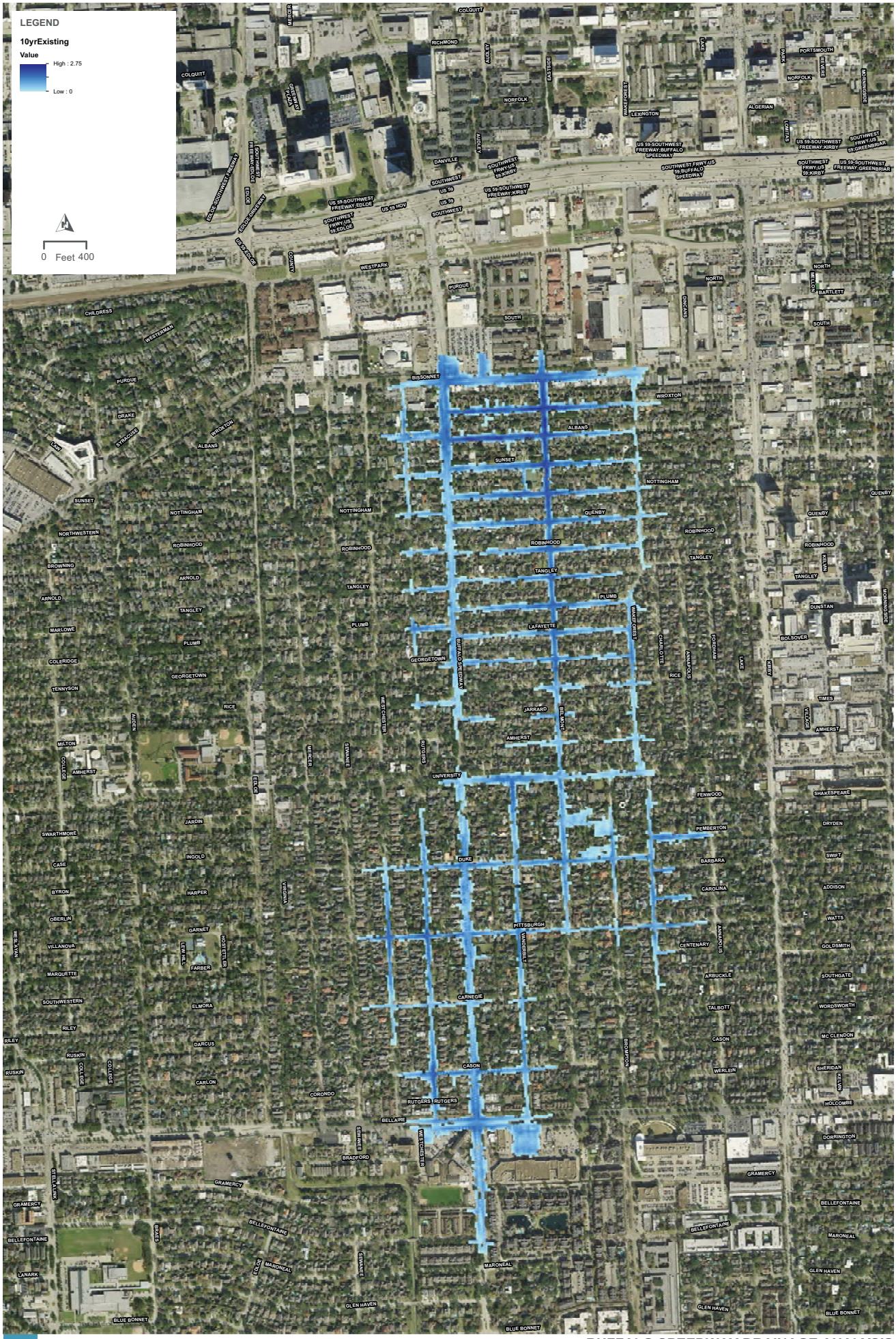

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

EXISTING PONDING MAP - 10-YEAR

EXHIBIT 4

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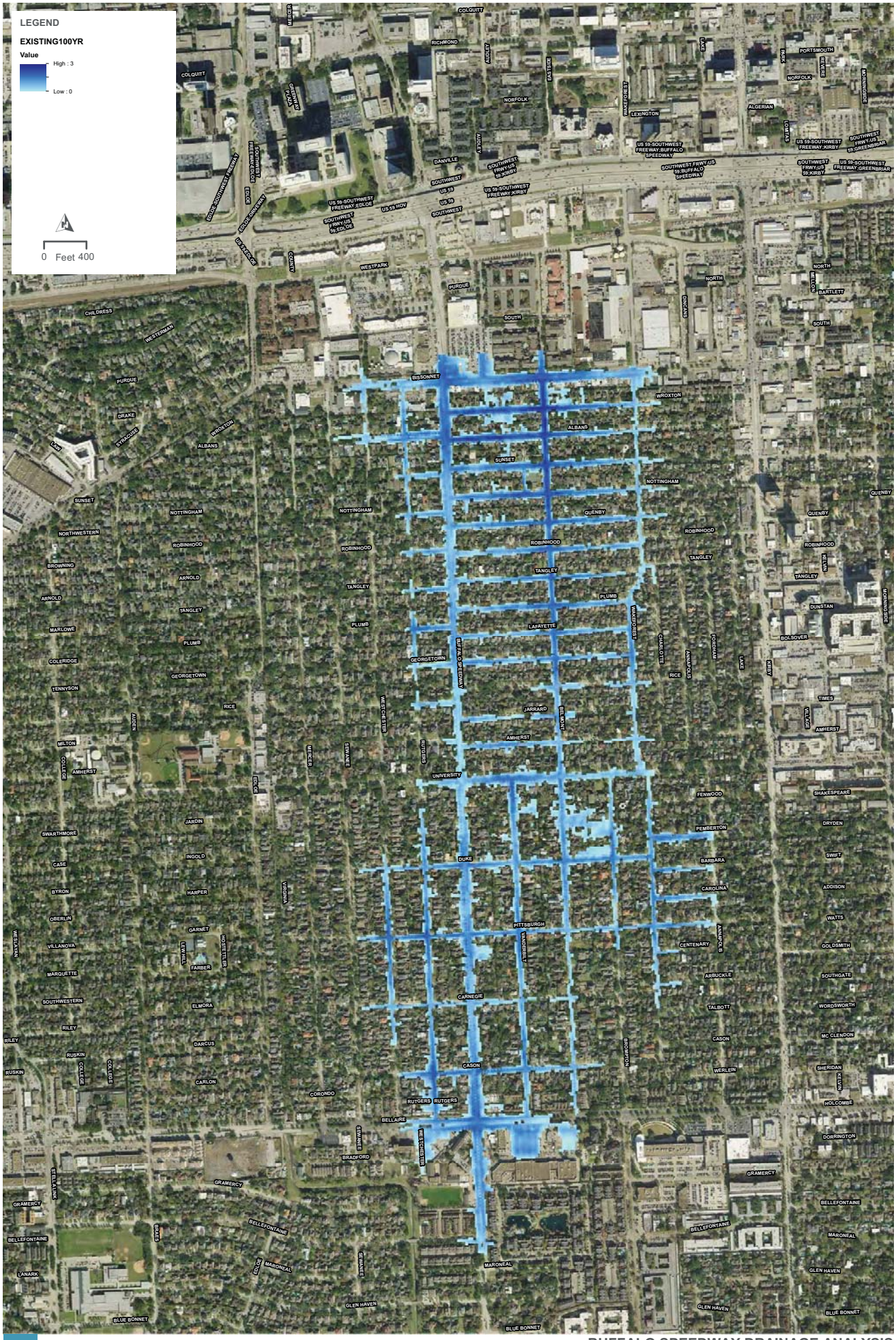

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

EXISTING PONDING MAP - 100-YEAR

EXHIBIT 5

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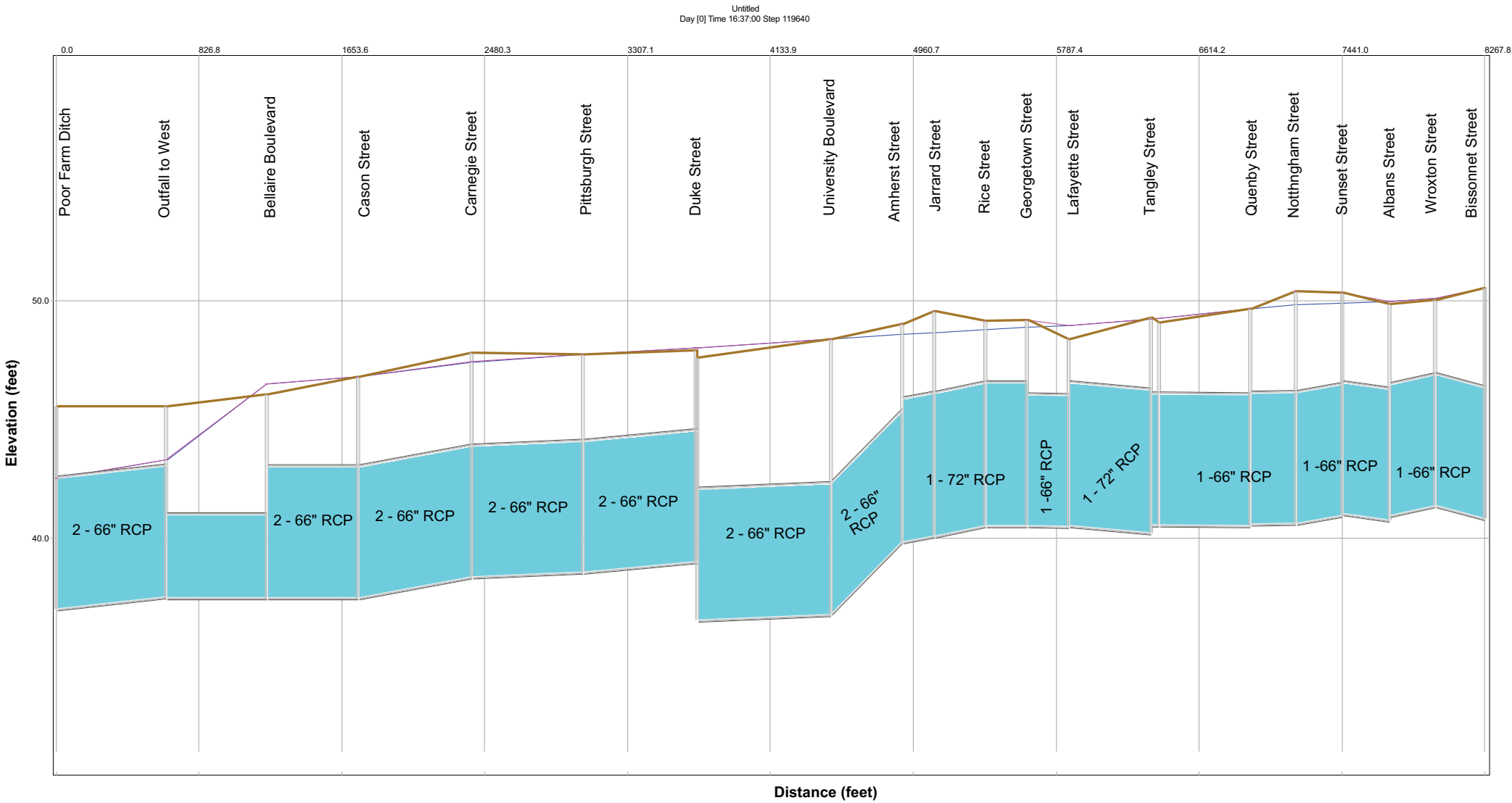
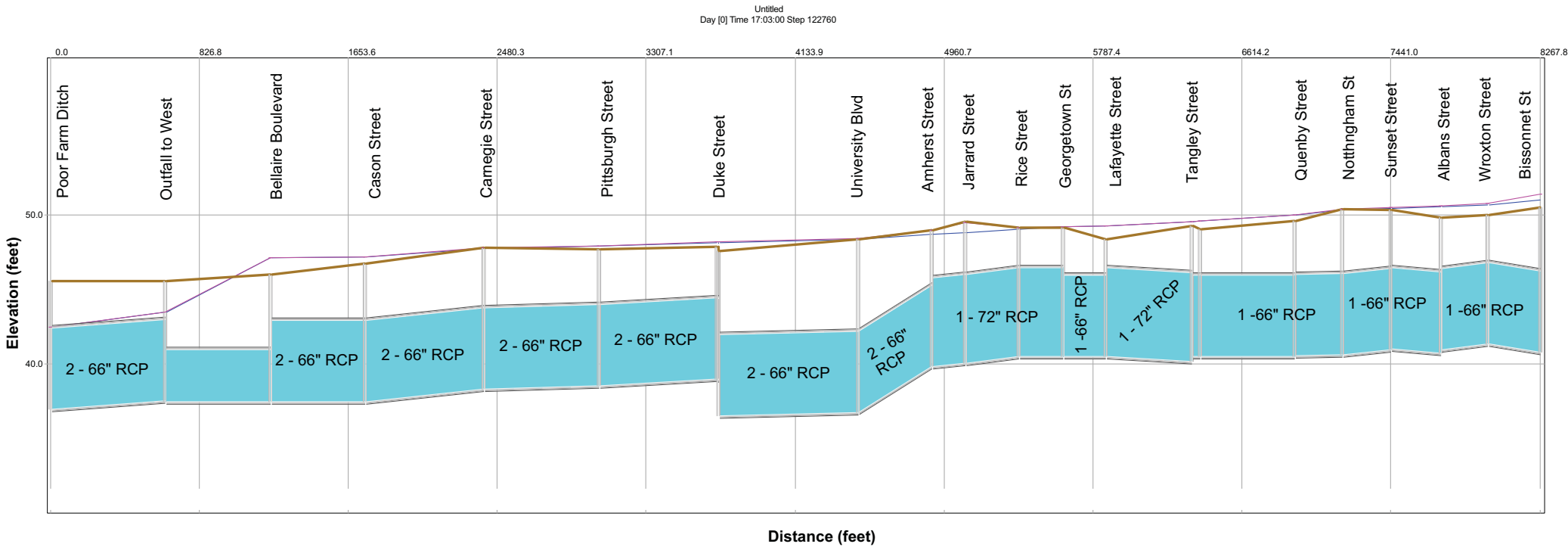
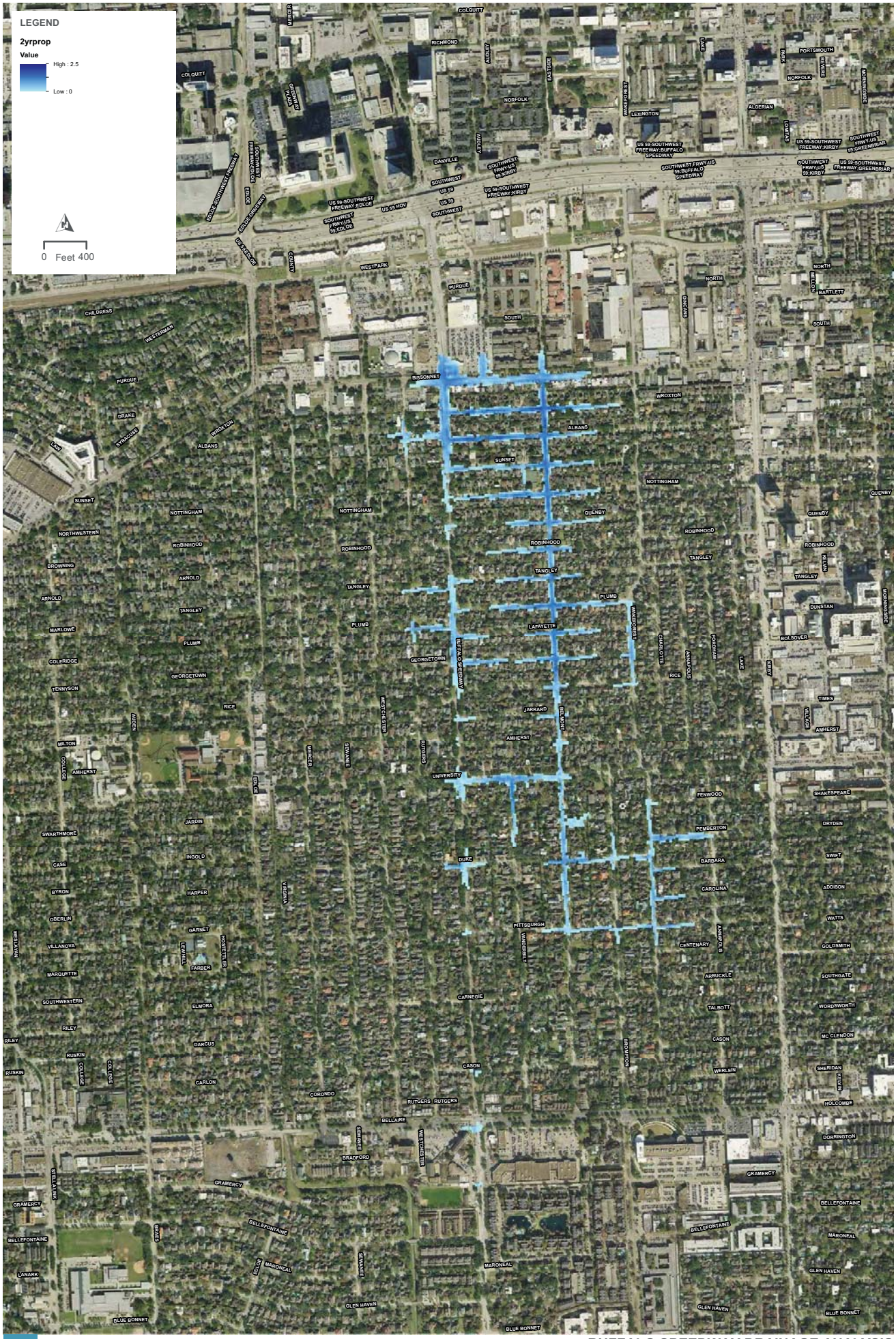


BUFFALO SPEEDWAY DRAINAGE PRELIMINARY ENGINEERING REPORT

EXHIBIT 6 - 2-YEAR HGL PLOT - EXISTING CONDITIONS



BUFFALO SPEEDWAY DRAINAGE PRELIMINARY ENGINEERING REPORT
EXHIBIT 7 - 100-YEAR HGL PLOT - EXISTING CONDITIONS



BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED PONDING MAP - 2-YEAR

EXHIBIT 8

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BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED PONDING MAP - 10-YEAR

EXHIBIT 9

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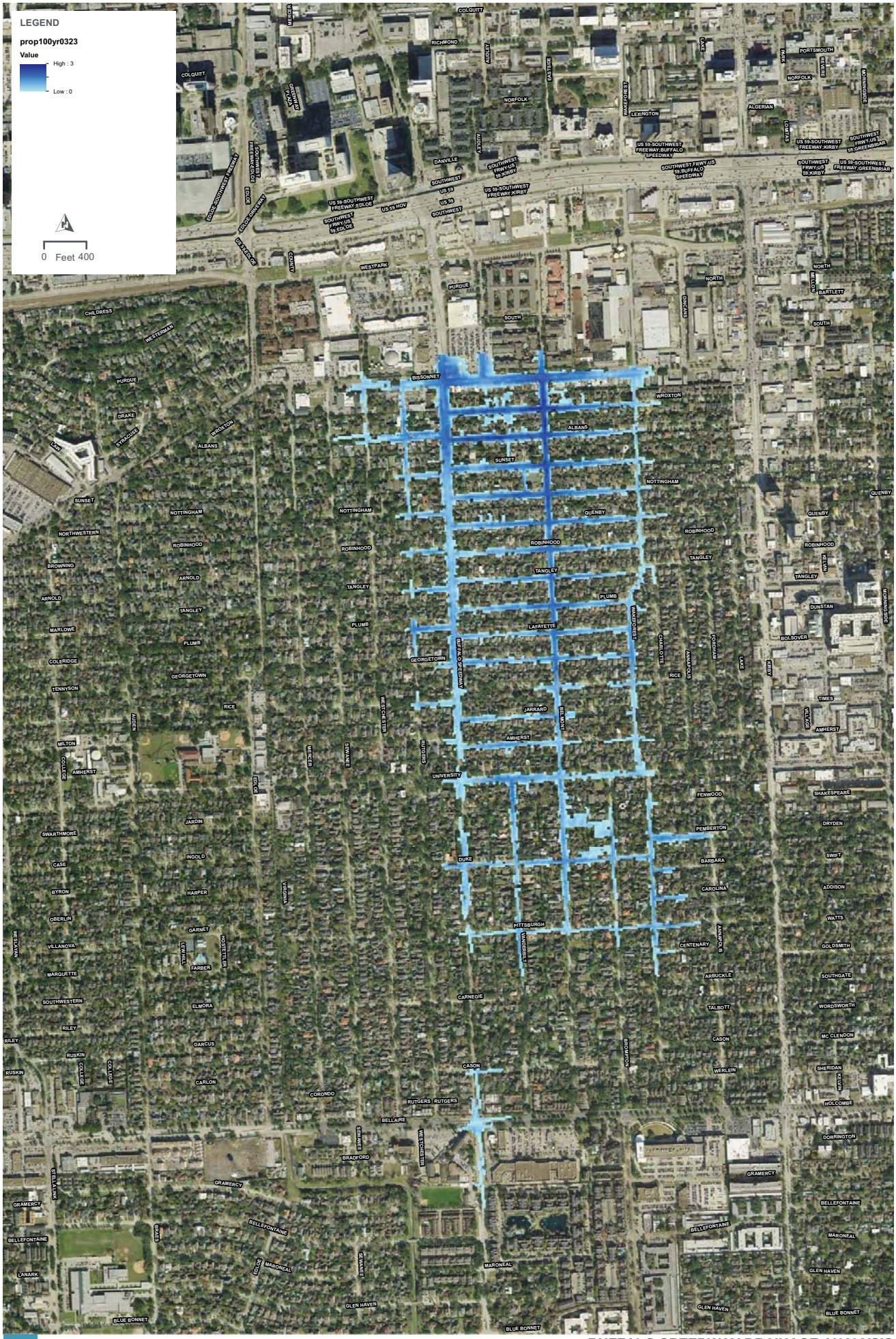

BUFFALO SPEEDWAY DRAINAGE ANALYSIS

PROPOSED PONDING MAP - 100-YEAR

EXHIBIT 10

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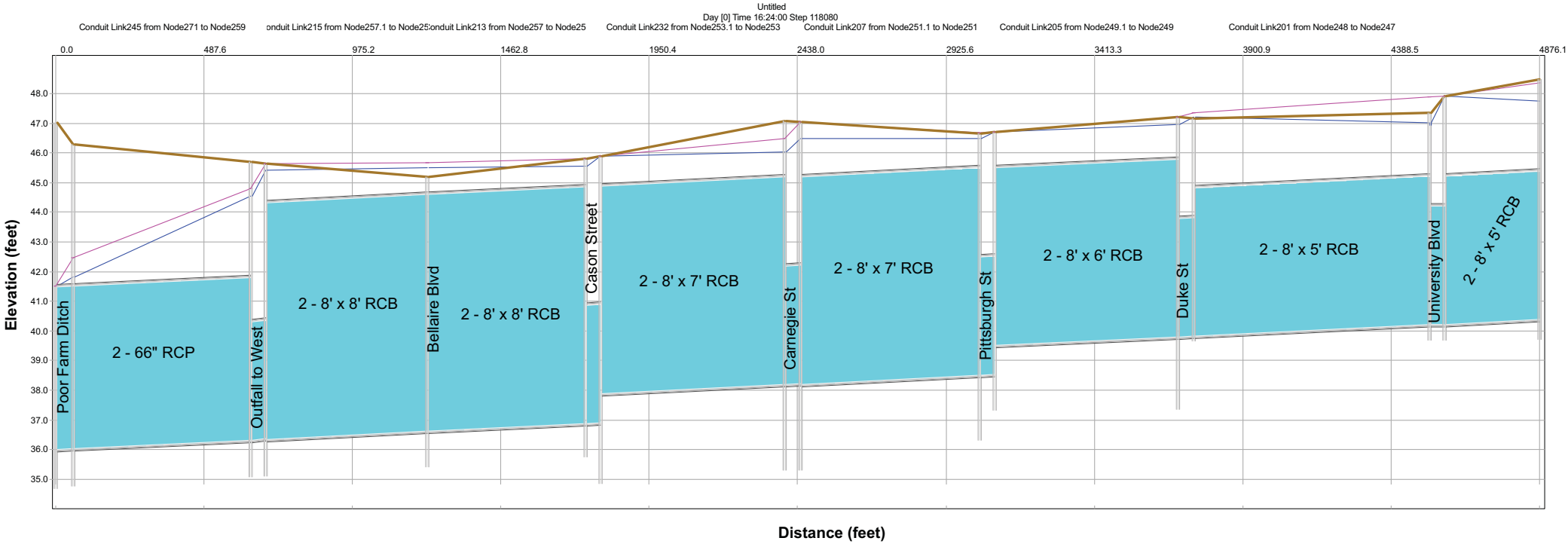
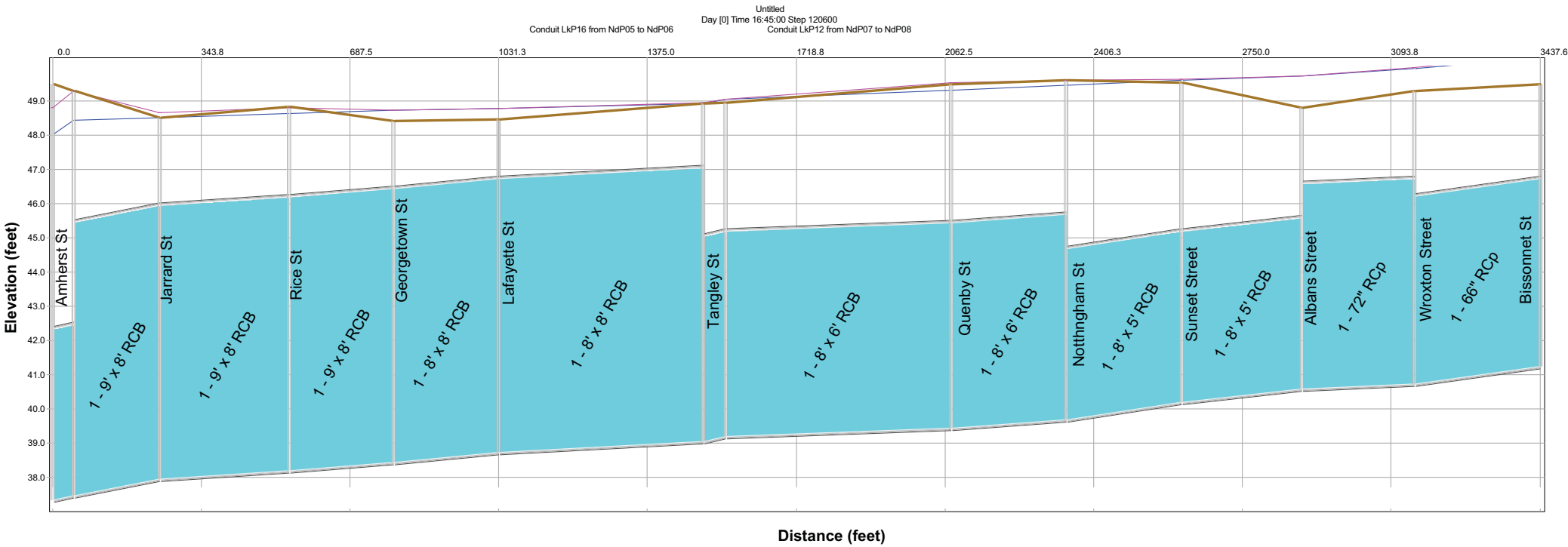
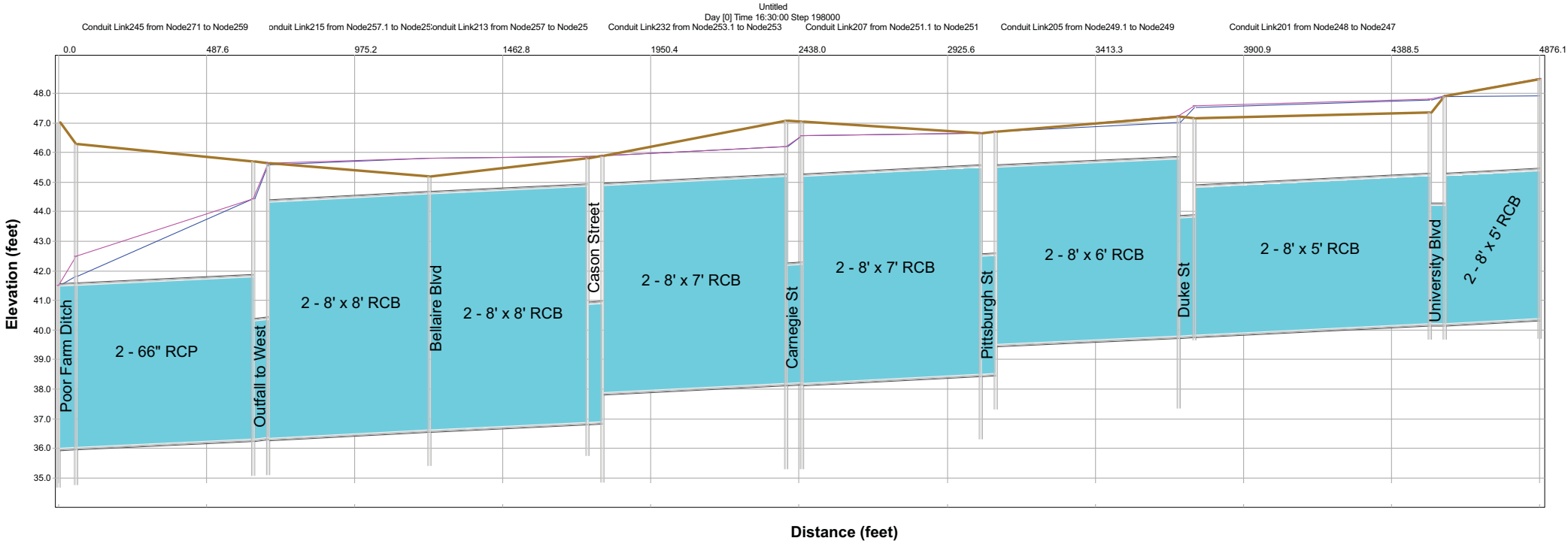


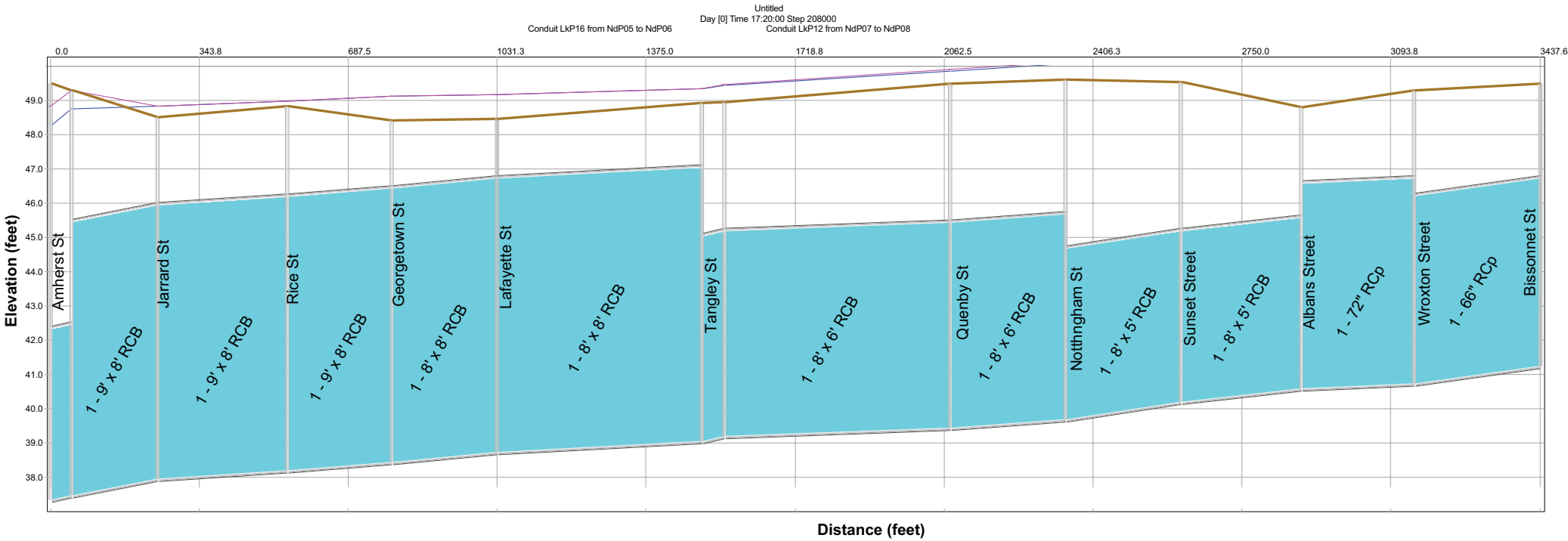
BUFFALO SPEEDWAY DRAINAGE PRELIMINARY ENGINEERING REPORT
EXHIBIT 11A - 2-YEAR HGL PLOT - PROPOSED CONDITIONS
DOWNSTREAM END OF SYSTEM



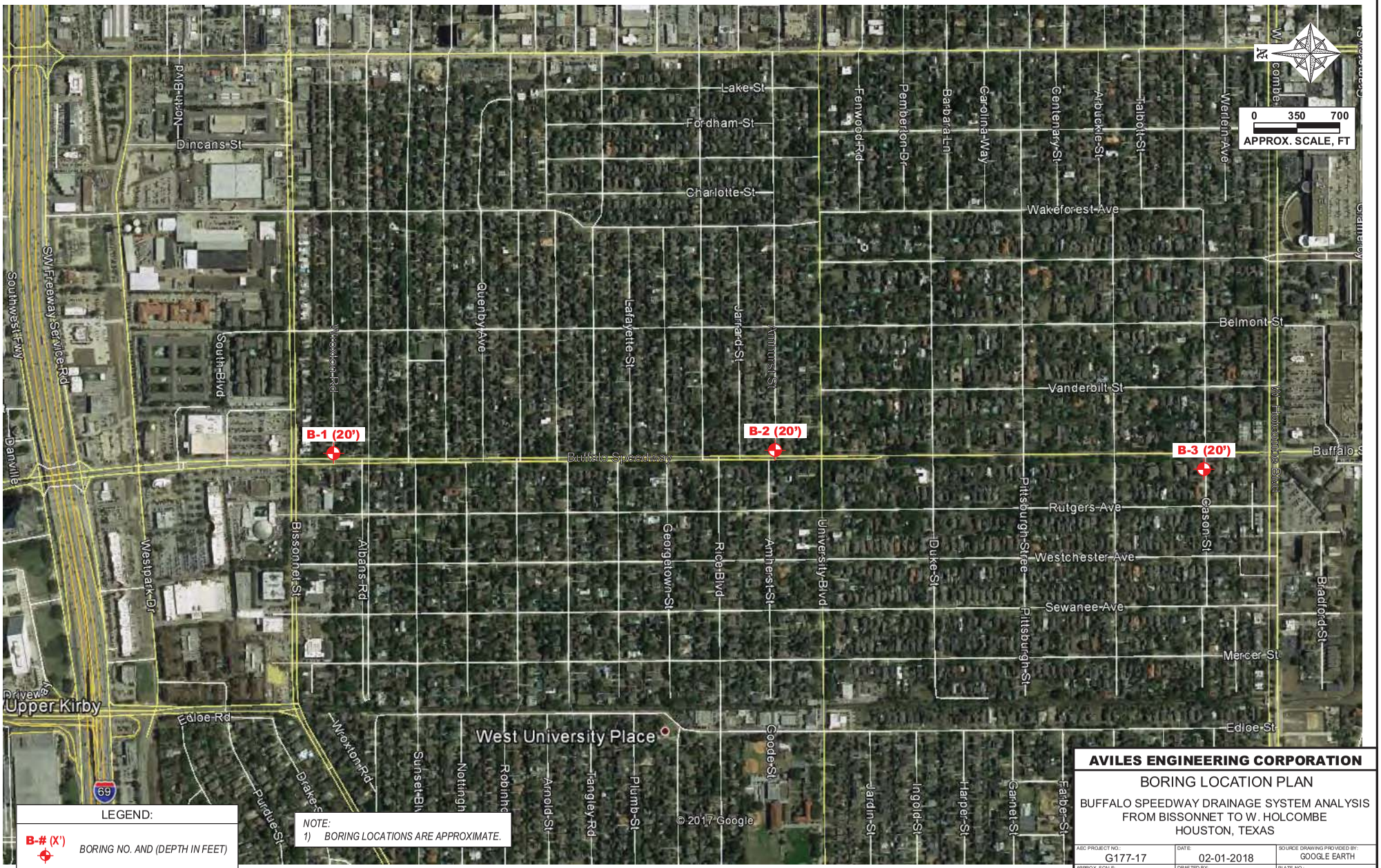
BUFFALO SPEEDWAY DRAINAGE PRELIMINARY ENGINEERING REPORT
EXHIBIT 11B - 2-YEAR HGL PLOT - PROPOSED CONDITIONS
UPSTREAM END OF SYSTEM



BUFFALO SPEEDWAY DRAINAGE PRELIMINARY ENGINEERING REPORT
EXHIBIT 12A - 100-YEAR HGL PLOT - PROPOSED CONDITIONS
DOWNSTREAM END OF SYSTEM



BUFFALO SPEEDWAY DRAINAGE PRELIMINARY ENGINEERING REPORT
EXHIBIT 12B - 100-YEAR HGL PLOT - PROPOSED CONDITIONS
UPSTREAM END OF SYSTEM



LEGEND:

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

NOTE:
1) BORING LOCATIONS ARE APPROXIMATE.

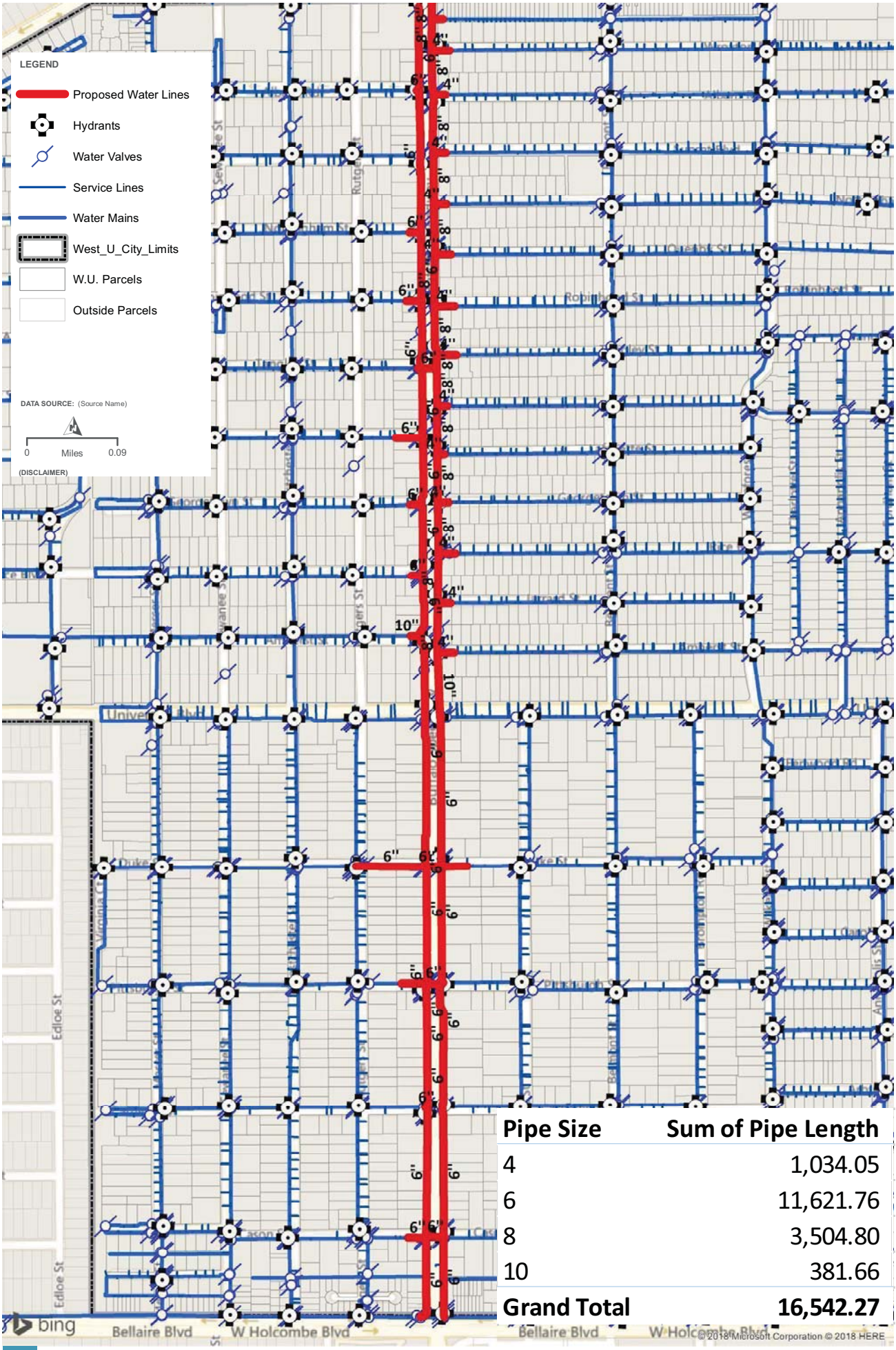
AVILES ENGINEERING CORPORATION

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: 1" = 700'	DRAFTED BY: WLW/JG	PLATE NO.: PLATE 1

EXHIBIT 13



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

(FIGURE #)

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

EXHIBIT 14

APPENDIX A

"Virtual Tour" Photographs

Buffalo Speedway Improvements

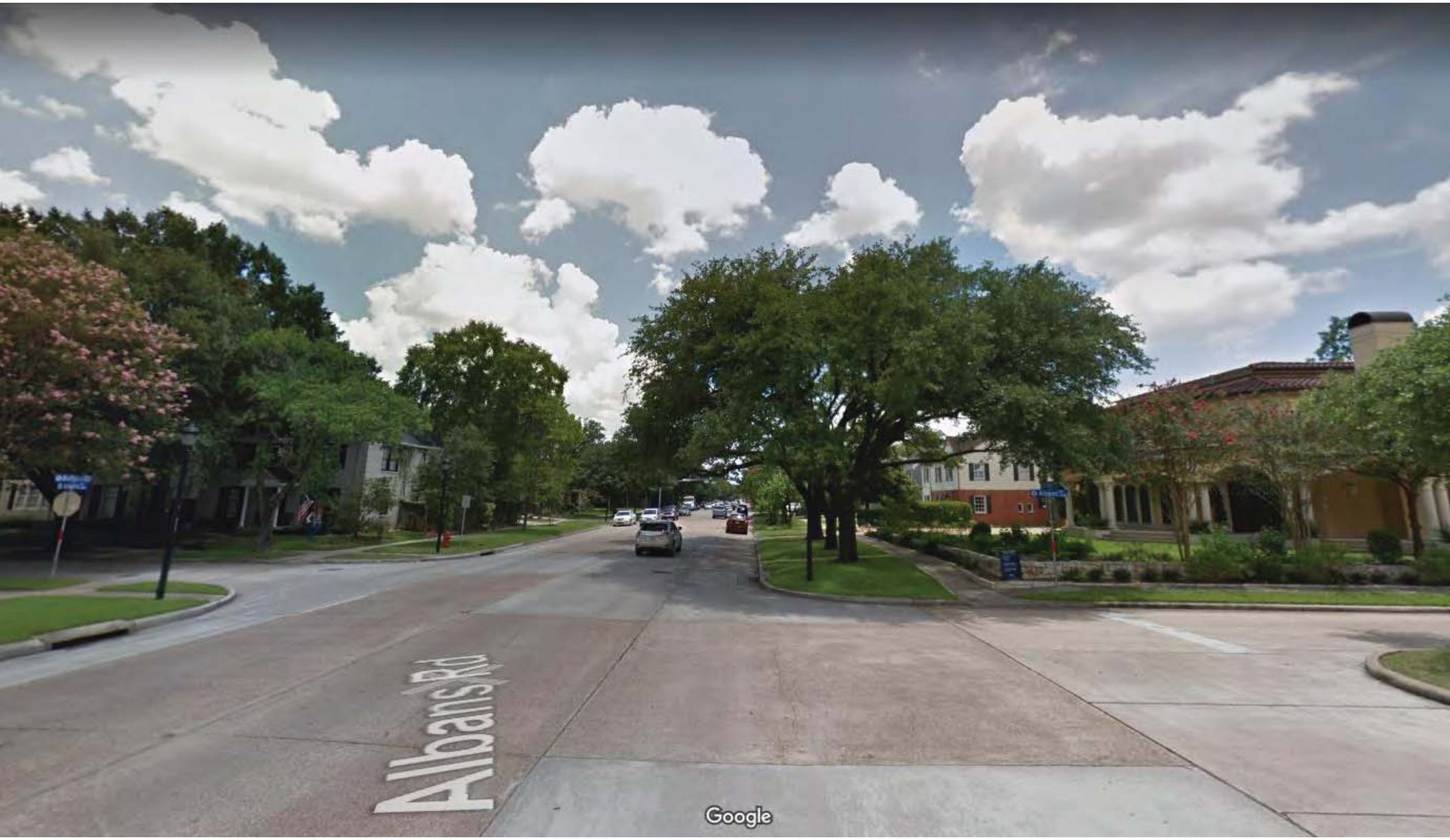
Virtual Tour of Project Area

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)

Existing Storm Sewer Outfall Route

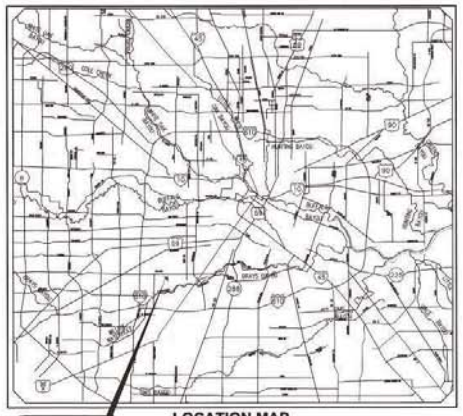
APPENDIX B

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

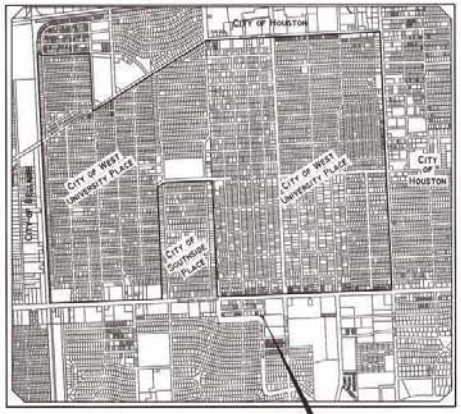
City of West University Place, Texas

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

SUBMITTED BY: _____ DATE: _____

Stephen Ratcliffe, P.E.
HDR Engineering, Inc.

MAYOR

Bob Fry

COUNCIL

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

CITY MANAGER

Michael G. Ross

Assistant City Manager/Public Works Director

Chris Peifer

HDR
HDR Engineering Inc. Texas Reg. No. 754
4635 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 •Fax (713) 623-9265 • www.hdrinc.com

HDR JOB NO. 13-053

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 (2nd Floor)
☐ SANITARY 832-394-8971
☐ WATER 832-394-8971

Log No. 14-0274
ILMS No. 14027779

FOR PLAN REVIEW WALK THRU ONLY
APPROVED
FLOODPLAIN GROUP
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
66251
4/2/14

SURVEYED BY:
FB NO.:

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

WATER
WASTEWATER *
STORM
FACILITIES
WATER AND WASTEWATER QUALITY
STORM WATER QUALITY

CITY ENGINEER
DIRECTOR OF PUBLIC WORKS AND ENGINEERING

FOR CITY OF HOUSTON USE ONLY
51973

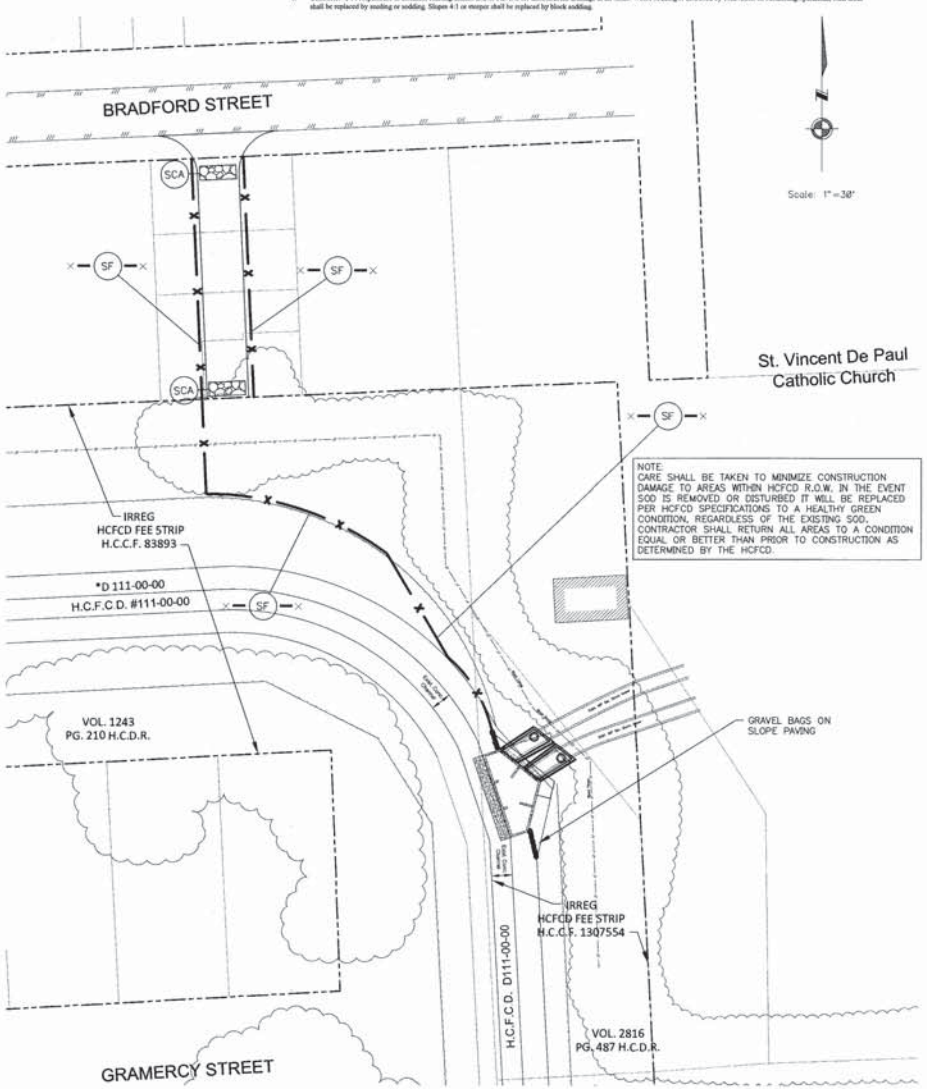
SHEET No: 1 OF 6

SWPP CONSTRUCTION NOTES

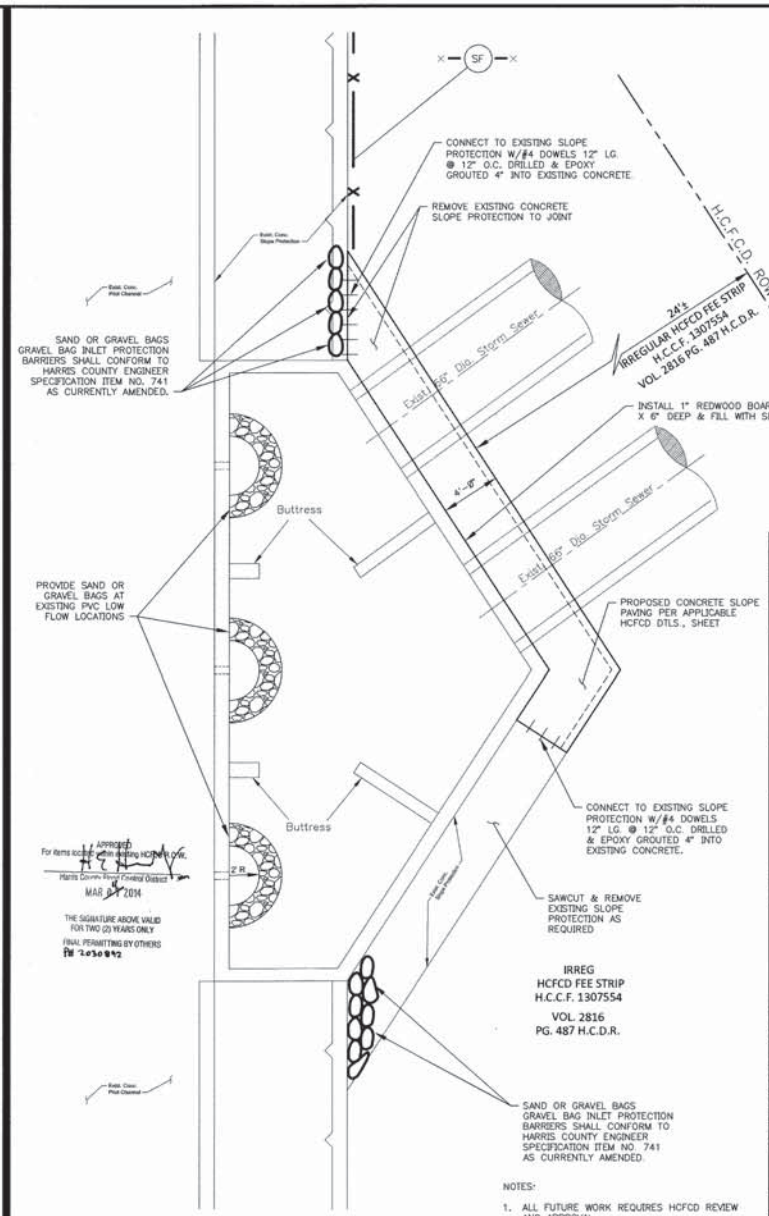
× — (SF) — × SILT FENCE

(SCA) STABILIZED CONSTRUCTION ACCESS

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 streets.
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 housekeeping 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 precipitation.
   - 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 disrupted by excavation on backfilling operations, such areas shall be replaced by sodding or sodding. Slopes 4:1 or steeper shall be replaced by block sodding.



NOTE:
CARE SHALL BE TAKEN TO MINIMIZE CONSTRUCTION DAMAGE TO AREAS WITHIN HCFCD R.O.W. IN THE EVENT SOD IS REMOVED OR DISTURBED IT WILL BE REPLACED PER HCFCD SPECIFICATIONS TO A HEALTHY GREEN CONDITION, REGARDLESS OF THE EXISTING SOD. CONTRACTOR SHALL RETURN ALL AREAS TO A CONDITION EQUAL OR BETTER THAN PRIOR TO CONSTRUCTION AS DETERMINED BY THE HCFCD.



APPROVED
For items located within existing HCFCD ROW.
Harris County Flood Control District
MAR 27 2014
THE SIGNATURE ABOVE VALID FOR TWO (2) YEARS ONLY
FINAL PERMITTING BY OTHERS
PM 2030892

NOTES:

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

No.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS
STEPHEN RATCLIFFE
LICENSED
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.: 13-0153 | 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

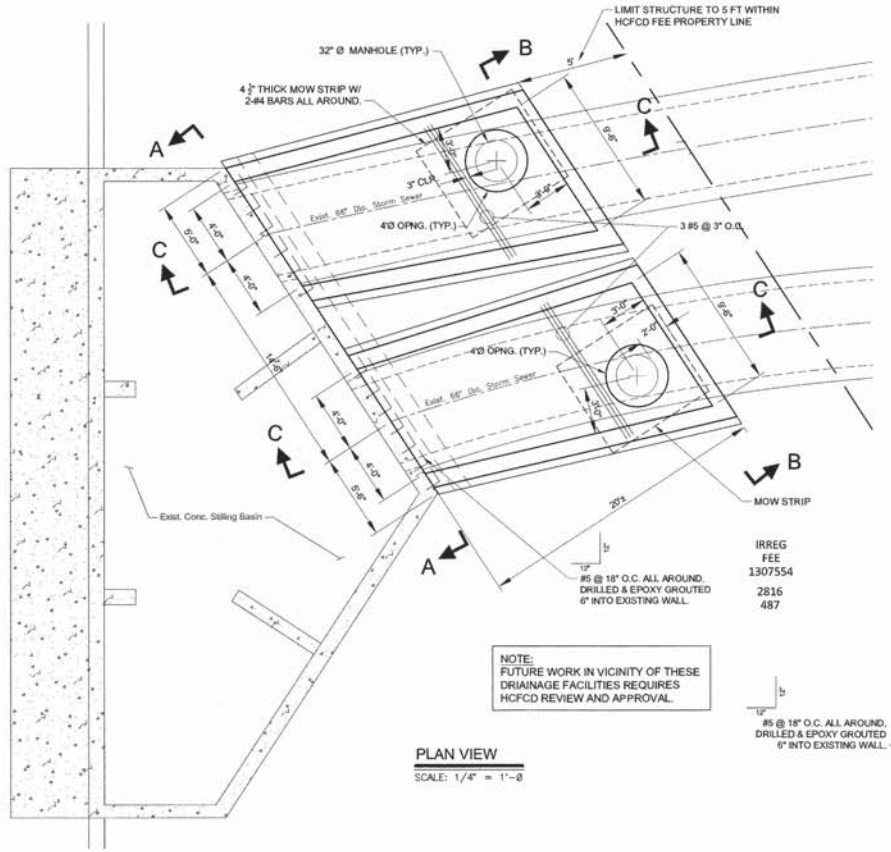
NOTE: CITY SIGNATURES VALID FOR ONE YEAR ONLY AFTER DATE OF SIGNATURES

CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
WATER
WASTEWATER
DRAINAGE
PAVING
DATE
FOR CITY OF HOUSTON USE ONLY

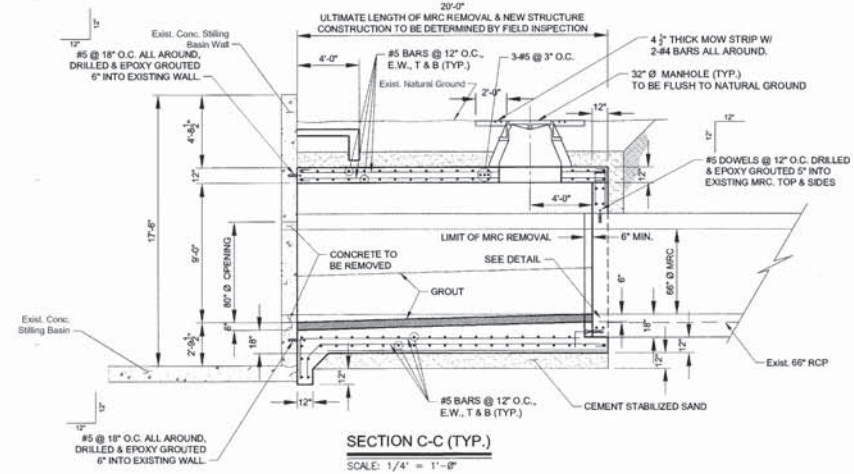
FILE NO:
DRAWING SCALE
HORZ :
VERT :

51973

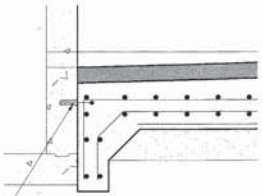
SHEET No. 2 OF 6



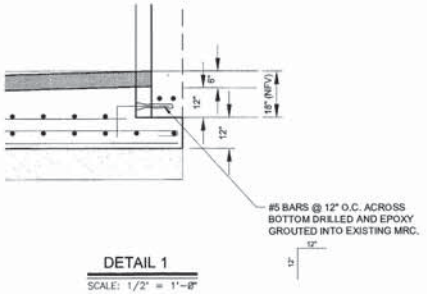
PLAN VIEW
SCALE: 1/4" = 1'-0



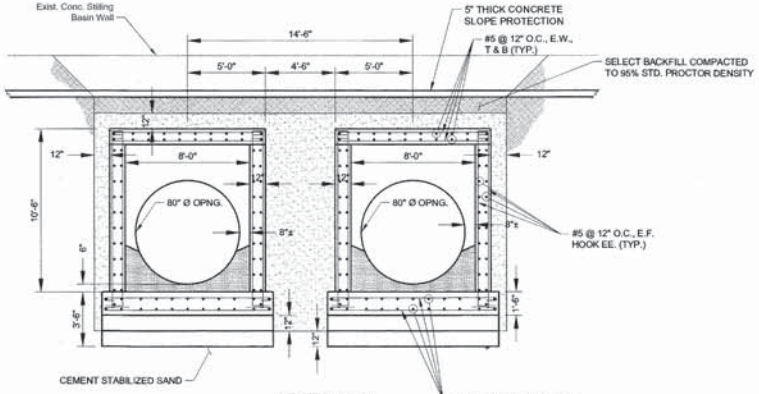
SECTION C-C (TYP.)
SCALE: 1/4" = 1'-0"



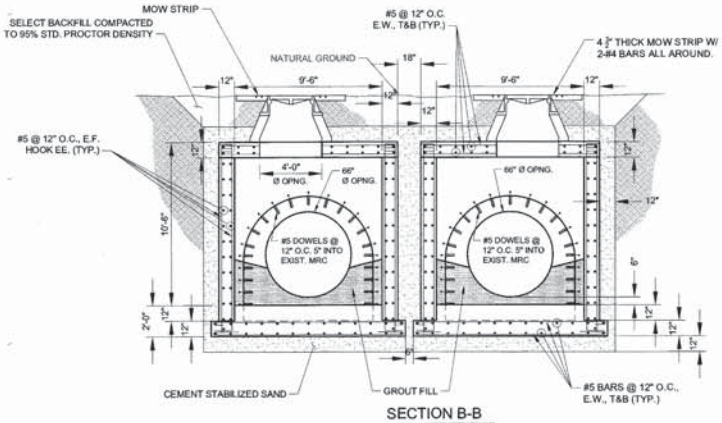
DETAIL 2
SCALE: 1/2" = 1'-0"



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



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



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

PK.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — STEPHEN RATCLIFFE — LICENSED — PROFESSIONAL ENGINEER

4/2/14

HDR

HDR Engineering Inc. Texas Reg. No. 754
4615 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: G. 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

MAYOR 4-3-14
CITY ENGINEER 4/3/14
DIRECTOR 4.3.14
PROJECT MANAGER 4/3/14

FILE NO:

DRAWING SCALE
HORZ :
VERT :

SHEET No: 3 OF 6

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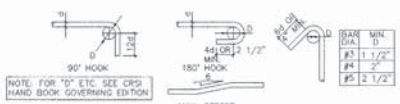


PRINCIPAL REINFORCING

TIE OR STIRRUP

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
51973
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.: 15 053 | 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

MAYOR
DIRECTOR 4/3/14
CITY ENGINEER 4.3.14
DEPUTY DIRECTOR
FACILITIES

FILE NO:

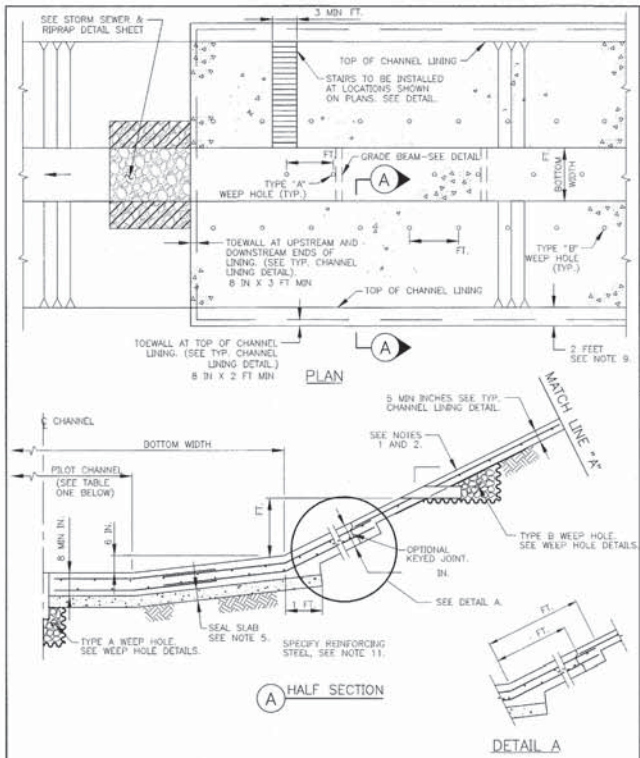
FOR CITY OF HOUSTON USE ONLY

DRAWING SCALE

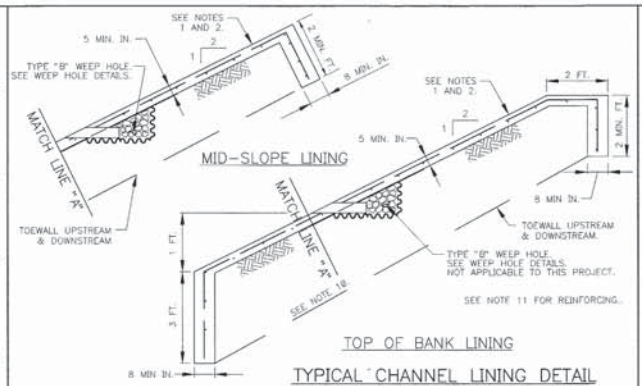
HORZ :
VERT :

STATE OF TEXAS
51973
LICENSED PROFESSIONAL ENGINEER

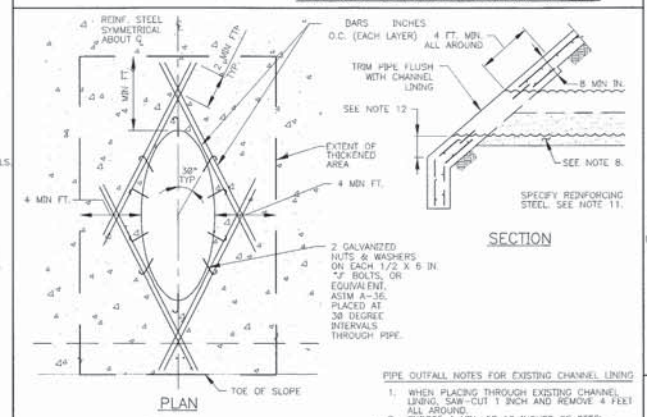
SHEET No: 4 OF 6



TYPICAL TRAPEZOIDAL CHANNEL LINING (NA)



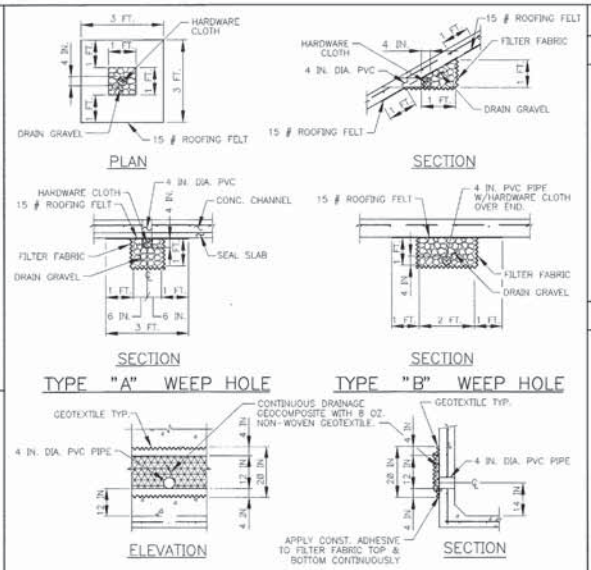
TYPICAL CHANNEL LINING DETAIL



PIPE OUTFALL DETAILS (NA)
(FOR CMP OUTFALLS 24-42 INCH DIA. ONLY)

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

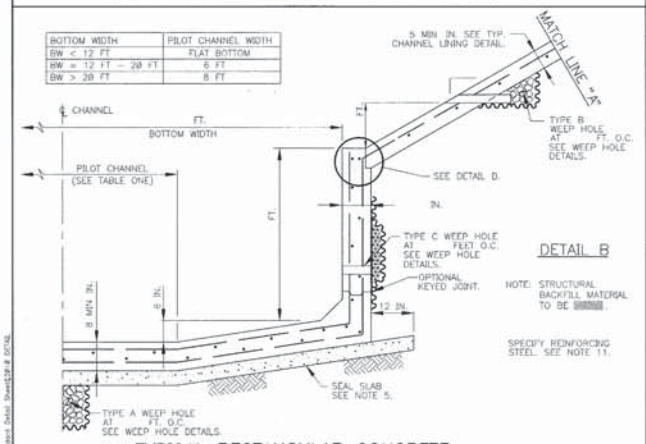
   c. HARDWARE CLOTH: MIN. OPEN 1/8 IN, MAX. OPEN 1/4 IN
   d. FILTER FABRIC: NON-WOVEN GEOTEXTILE

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

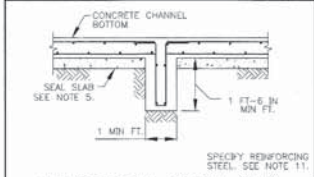
2. CUT WEEP HOLE PIPE FLUSH WITH CONCRETE SURFACE.
3. TYPE "A" AND "C" WEEP HOLES FOR TYPICAL RECTANGULAR CONCRETE CHANNEL LINING, TO BE STAGGERED.

WEEP HOLE DETAILS (NA)

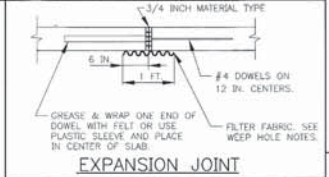
BOTTOM WIDTH	PILOT CHANNEL WIDTH
BW < 12 FT	FLAT BOTTOM
BW = 12 FT – 20 FT	6 FT
BW > 20 FT	8 FT



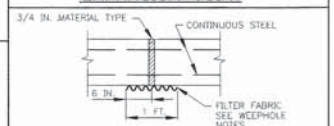
TYPICAL RECTANGULAR CONCRETE CHANNEL LINING HALF SECTION (NA)



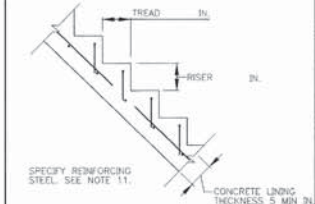
GRADE BEAM DETAIL (NA)
(SEE NOTE 6)



EXPANSION JOINT



CONSTRUCTION JOINT



STAIR DETAIL (NA)

HALF JOINT
(SLOPES ONLY)

CONTROL JOINT

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. 02310-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 THICK.
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
51973
LICENSED
4/2/14

P.E. SEAL AND SIGNATURE

51973

REV	DESCRIPTION	DATE	APPR

PROJECT ID#

REPAIR OF ST. VINCENT'S STORM SEWER OUTFALL

CONCRETE CHANNEL LINING DETAILS

PREPARED: CHECKED: APPROVED:

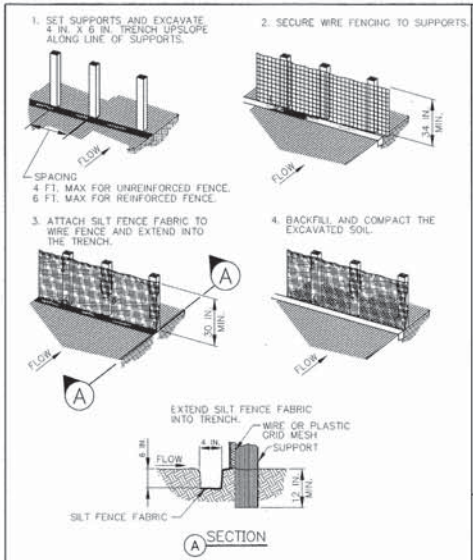
HDR
HDR Engineering, Inc. Texas Reg. No. 754
4615 Southwest Freeway, Suite 1000 • Houston, Texas 77027
(713) 622-9264 • Fax (713) 622-9265 • www.hdrinc.com

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

DATE: 12-21-2010
SCALE: NTS

SHEET NUMBER
5 OF 6

STD\CONCRETE CHANNEL LINING DETAIL



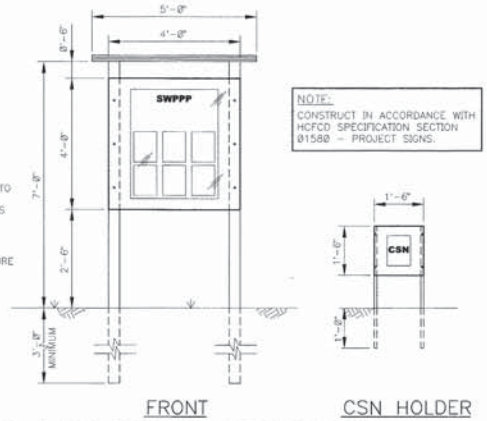
CONSTRUCTION NOTES:

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

RSF — REINFORCED SILT FENCE
SYMBOL

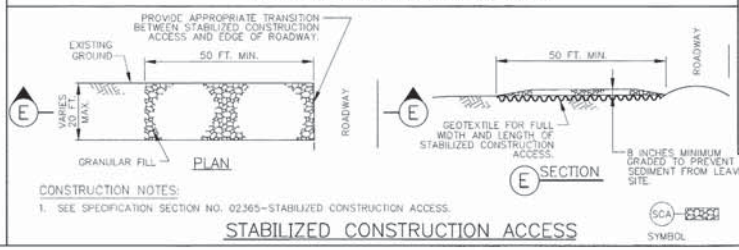
SF — SILT FENCE
SYMBOL

SILT FENCE



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

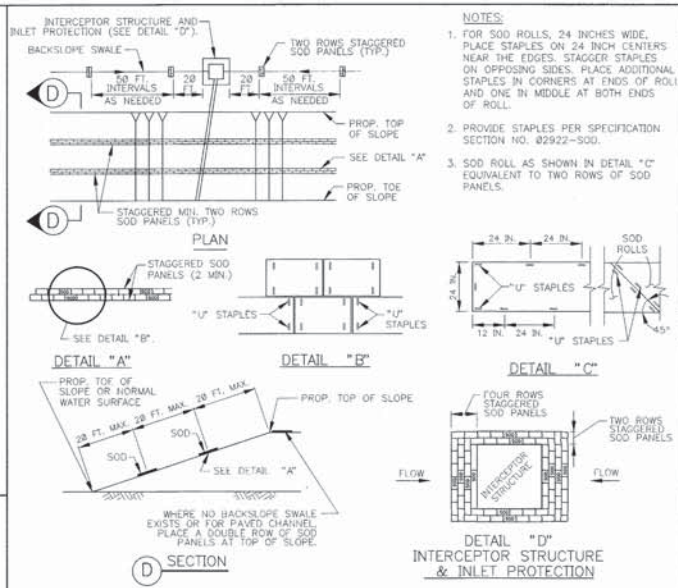
SWPPP / BMP SIGN AND CONSTRUCTION SITE NOTICE HOLDER DETAILS



CONSTRUCTION NOTES:

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

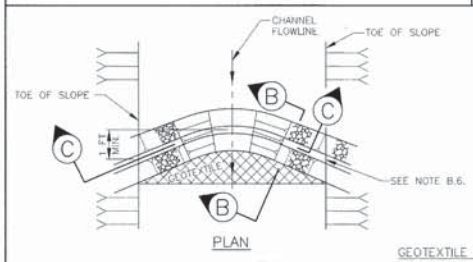
STABILIZED CONSTRUCTION ACCESS



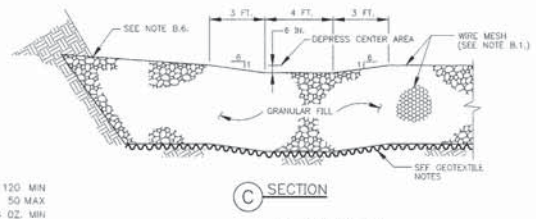
NOTES:

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.

SODDING

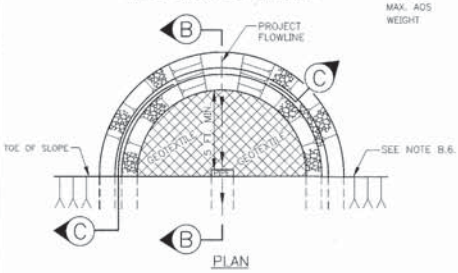


IN-CHANNEL FILTER DAM

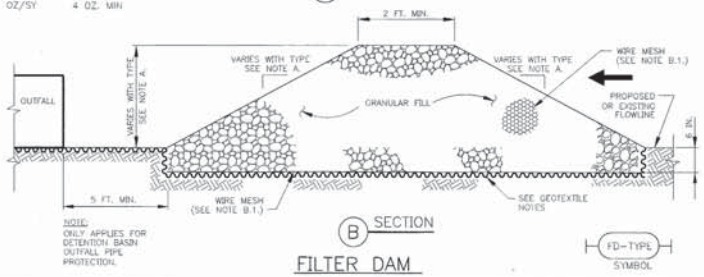


GEOTEXTILE NOTES:

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



FILTER DAM AT DETENTION BASIN OUTFALL PIPE



NOTE:
ONLY APPLIES FOR DETENTION BASIN OUTFALL PIPE PROTECTION.

FILTER DAM

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.

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
4835 Southwest Freeway, Suite 1200, Houston, Texas 77027
(713) 62-2000 • FAX (713) 962-3201 • 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 C

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

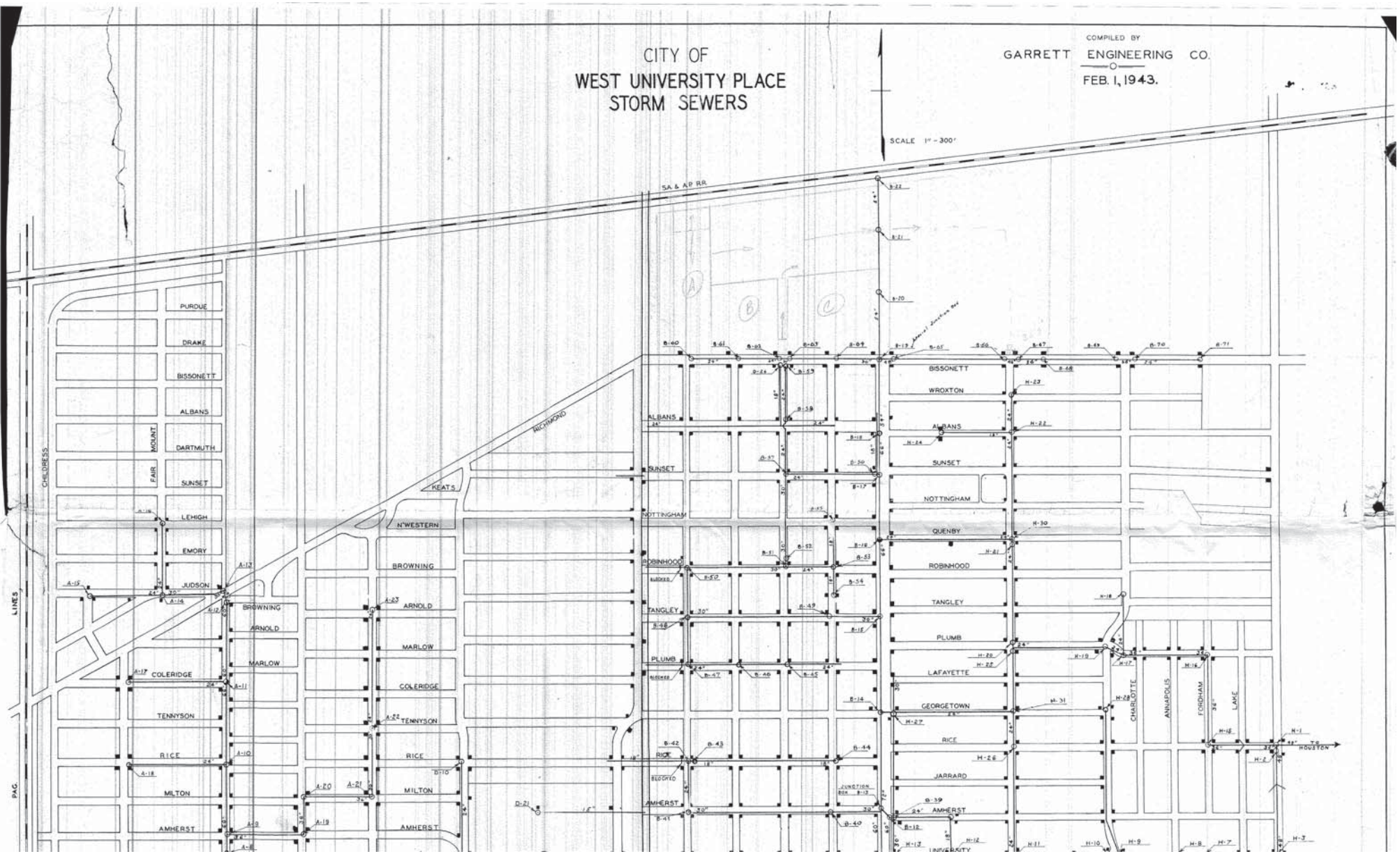
COMMISSIONERS
DR. A.L.KERBOW
DR. J.A.HERSCHEL
T.WESLEY WOODARD
J.M.DUNNINGTON

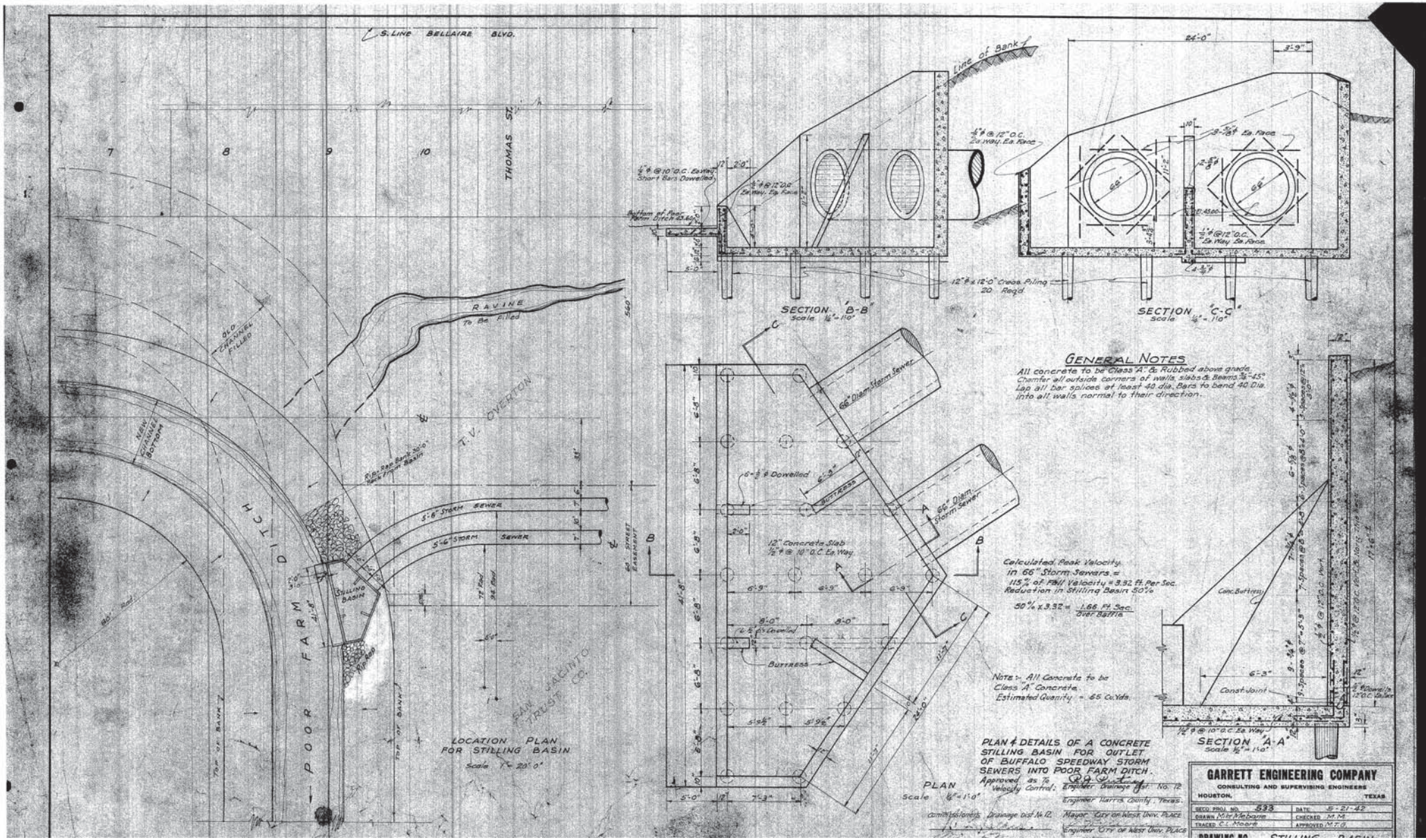
BY

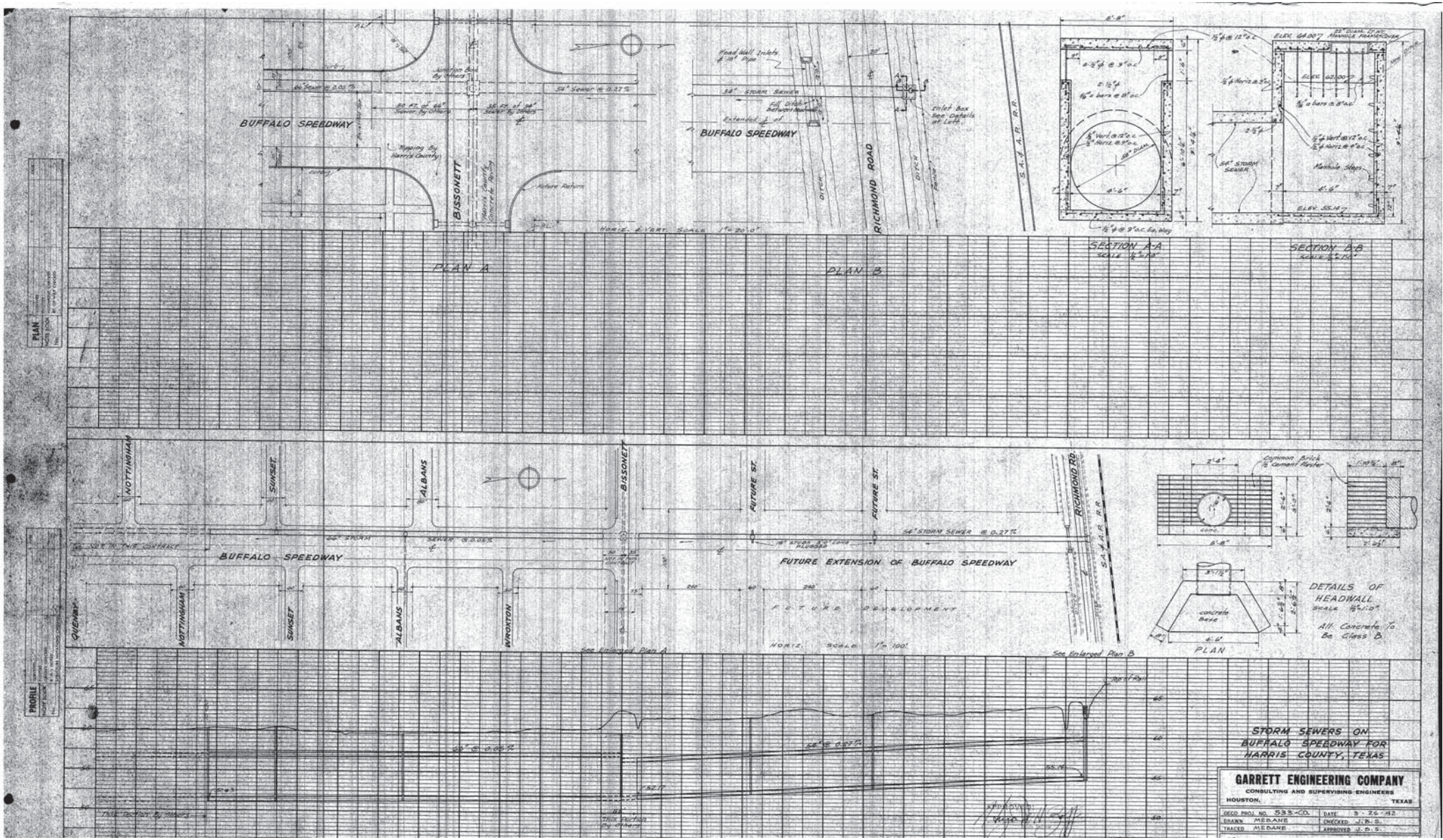
GARRETT ENGINEERING CO.

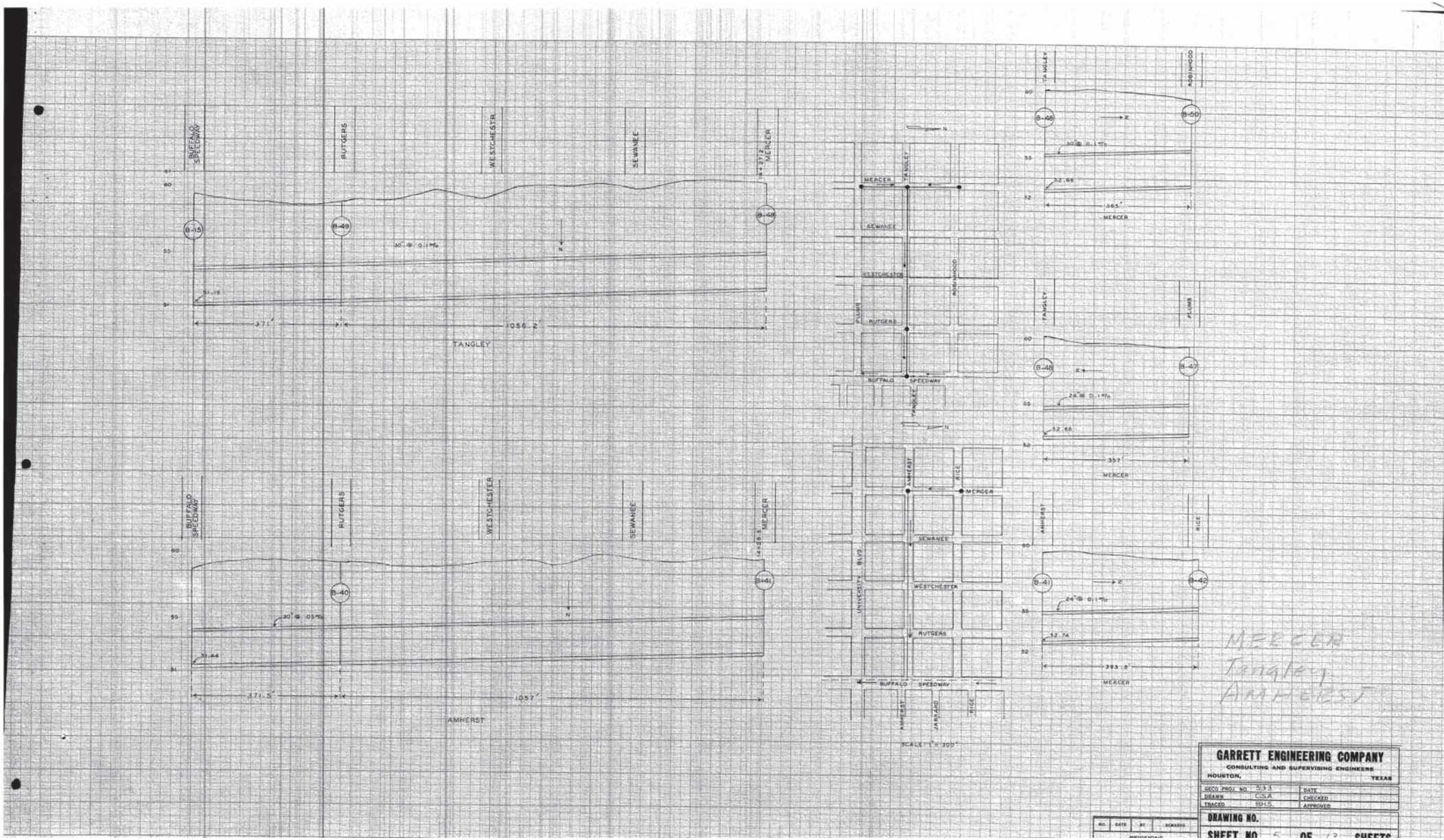
HOUSTON, TEXAS

GECO.PROJ.NO. 533


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


S. LINE BELLAIRE BLVD.
THOMAS ST.
7
8
9
10
RAVINE
To Be Filled
OLD CHANNEL FILLED
NEW CHANNEL BOTTOM
T.V. OVERTON
POOR FARM DITCH
STILLING BASIN
RIP RAP
5'-6" STORM SEWER
5'-6" STORM SEWER
80' STREET EASEMENT
TOP OF BANK
SAN JACINTO TRUST CO.
LOCATION PLAN
FOR STILLING BASIN
Scale 1" = 20'-0"
Line of Bank
24'-0"
3'-9"
SECTION "B-B"
Scale 1/4" = 1'-0"
SECTION "C-C"
Scale 1/4" = 1'-0"
12" x 12'-0" Creos. Piling
20 Reqd.
66" Diam. Storm Sewer
12" Concrete Slab
1/2" ϕ @ 10" O.C. Ea. Way
Buttress
PLAN
Scale 1/8" = 1'-0"
GENERAL NOTES
All concrete to be Class "A" & Rubbed above grade.
Chamfer all outside corners of walls, slabs & Beams 3/4" - 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 Full 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 Quantity = 65 Cu. Yds.
Conc. Buttress
Const. Joint
SECTION "A-A"
Scale 1/2" = 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: R. A. Dunlap 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
RECD. PROJ. NO. 533
DATE 5-21-42
DRAWN Mike Mebane
CHECKED M.M.
TRACED C.L. Moore
APPROVED M.T.G.
DRAWING NO.
STILLING BASIN


BUFFALO SPEEDWAY
BISSONETT
Junction Box By Others
66" Sewer @ 0.05%
54" Sewer @ 0.27%
80 Ft. of 66" Sewer By Others
35 Ft. of 54" Sewer By Others
Mapping By Harris County
Future Return
Harris County Curve Marking
Head Wall Inlets & 18" Pipe
54" STORM SEWER
Fill Ditch Between Headwalls
Extended ℄ of
Inlet Box See Details at Left
DITCH
RICHMOND ROAD
S.A. & A.P. R.R.
HORIZ. & VERT. SCALE 1"=20'-0"
PLAN A
PLAN B
SECTION A-A
SCALE 1/4"=1'0"
SECTION B-B
SCALE 1/4"=1'0"
ELEV. 64.00
ELEV. 62.00
ELEV. 55.14
Manhole Steps
NOTTINGHAM
SUNSET
ALBANS
FUTURE ST.
RICHMOND RD.
66" STORM SEWER @ 0.05%
54" STORM SEWER @ 0.27%
18" STORM SEWER PROPOSED
SEE IN THE CONTRACT
FUTURE EXTENSION OF BUFFALO SPEEDWAY
QUEWAY
WROXTON
FUTURE DEVELOPMENT
HORIZ. SCALE 1"=100'
See Enlarged Plan A
See Enlarged Plan B
Common Brick
½ Cement Mortar
concrete Base
PLAN
DETAILS OF HEADWALL
SCALE 1/4"=1'0"
All Concrete To Be Class B
Top of Pavt.
66" @ 0.05%
54" @ 0.27%
55.16
52.17
THIS SECTION BY OTHERS
THIS SECTION By Others
PROFILE
PLAN
STORM SEWERS ON BUFFALO SPEEDWAY FOR HARRIS COUNTY, TEXAS
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS
GECO PROJ. NO. 535-CO.
DATE 3-26-42
DRAWN MEDANE
CHECKED J.B.S.
TRACED MEDANE
APPROVED J.B.S.



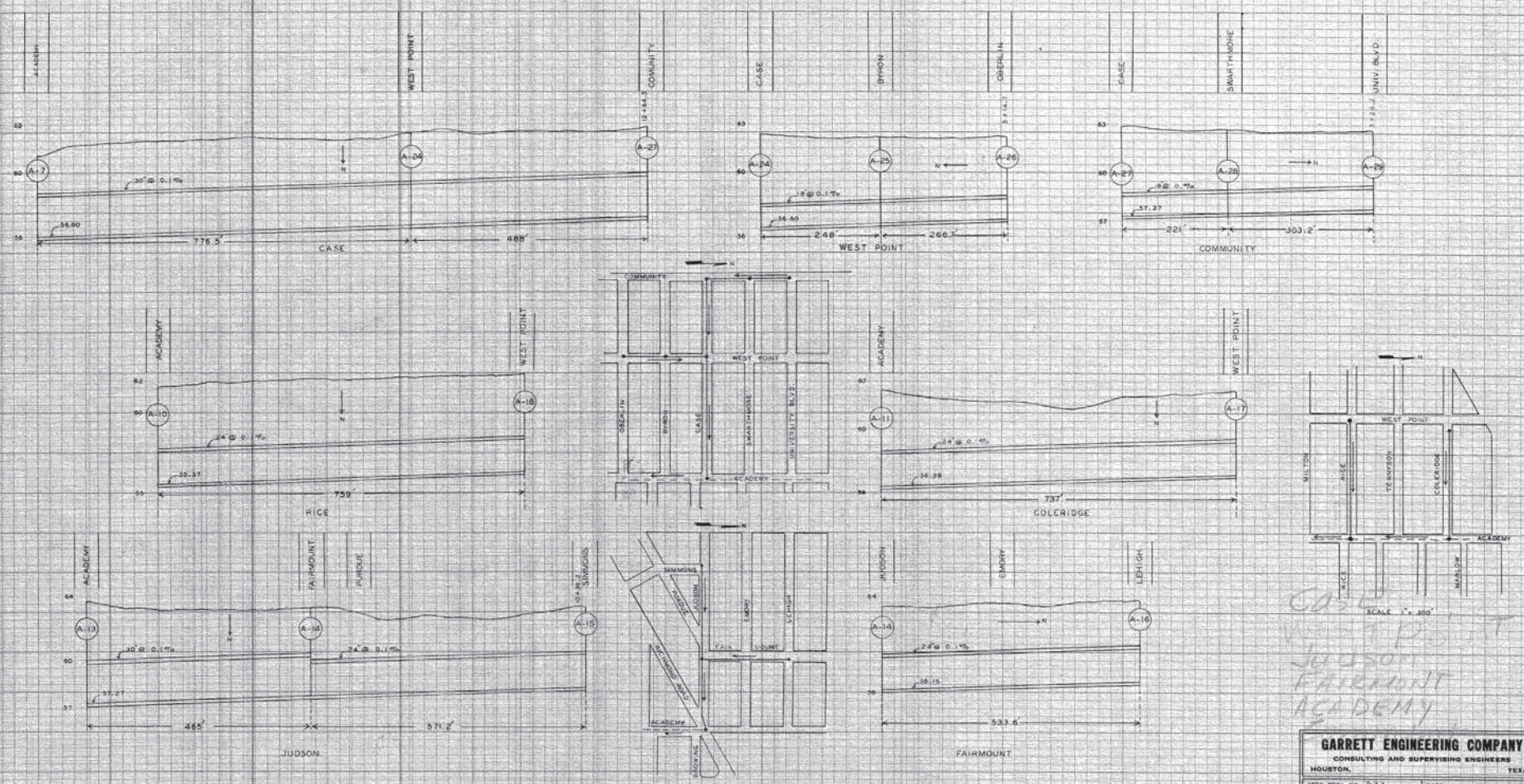
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

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

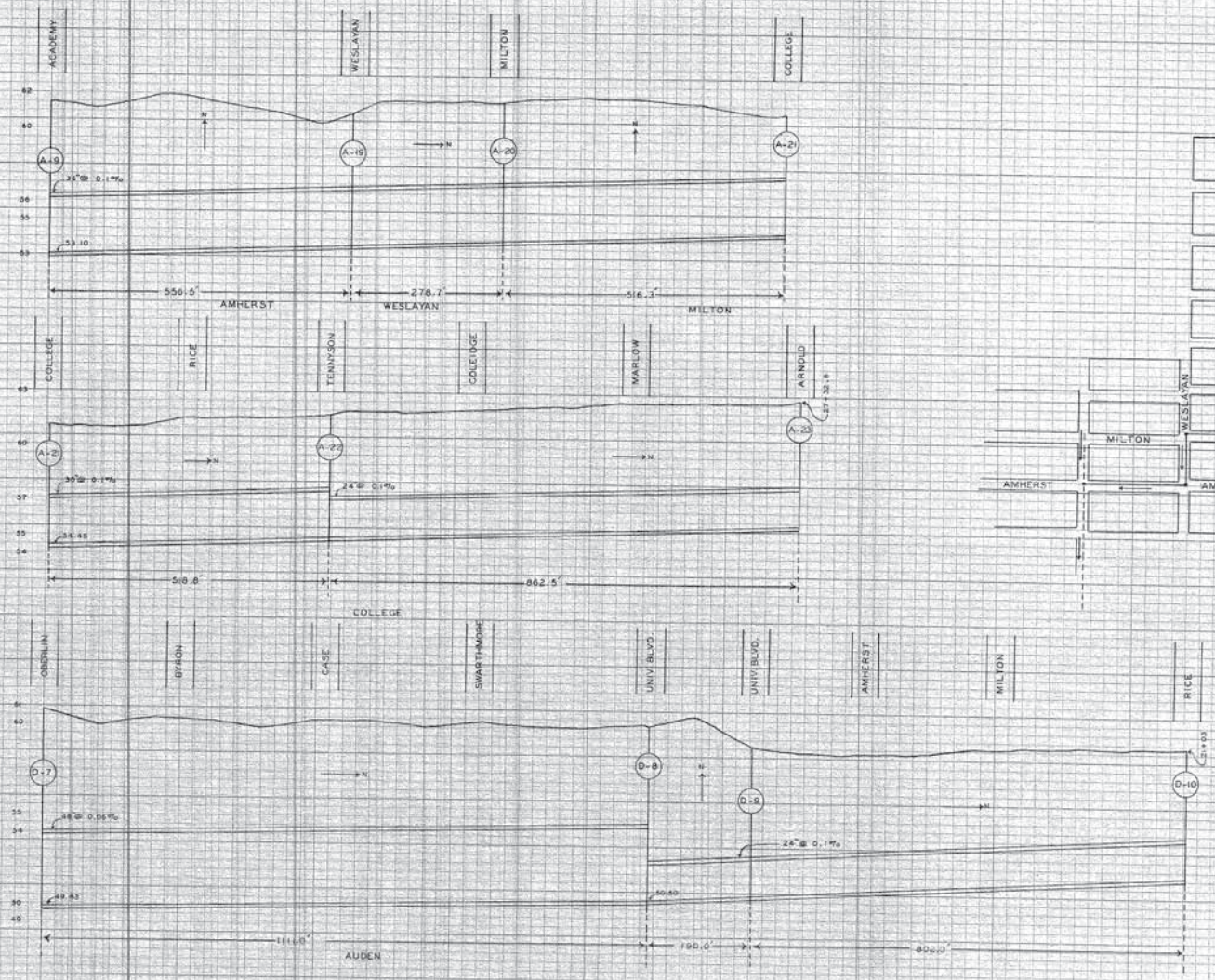
DRAWING NO.

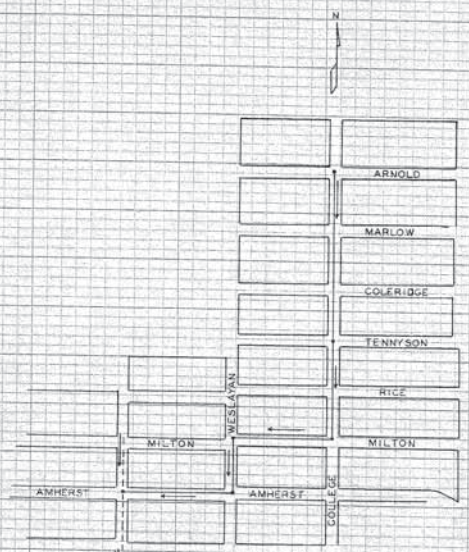
SHEET NO. 5 OF 13 SHEETS

NO.	DATE	BY	REMARKS
			REVISIONS



Jefferson
Fairmont
Academy





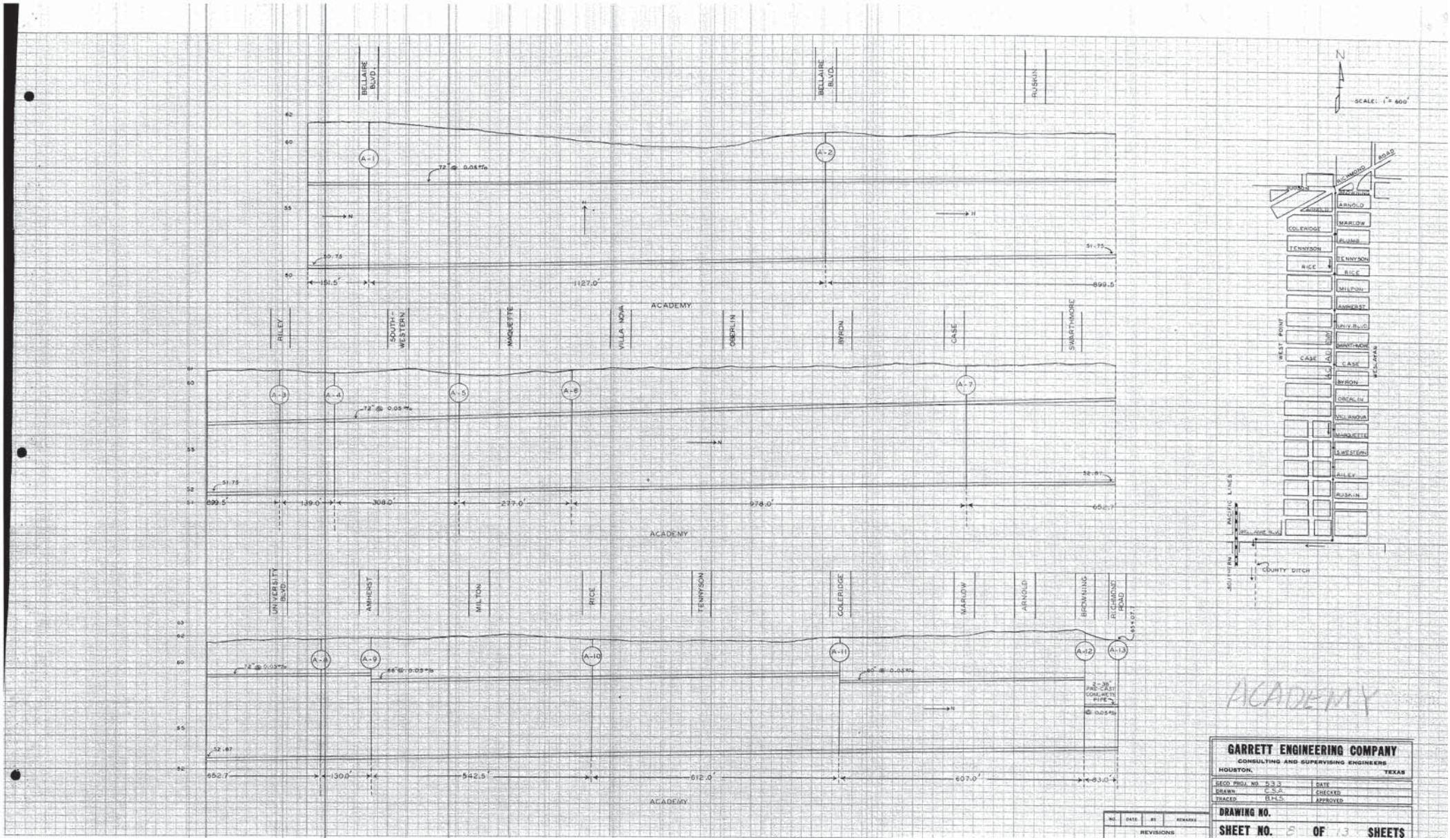
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

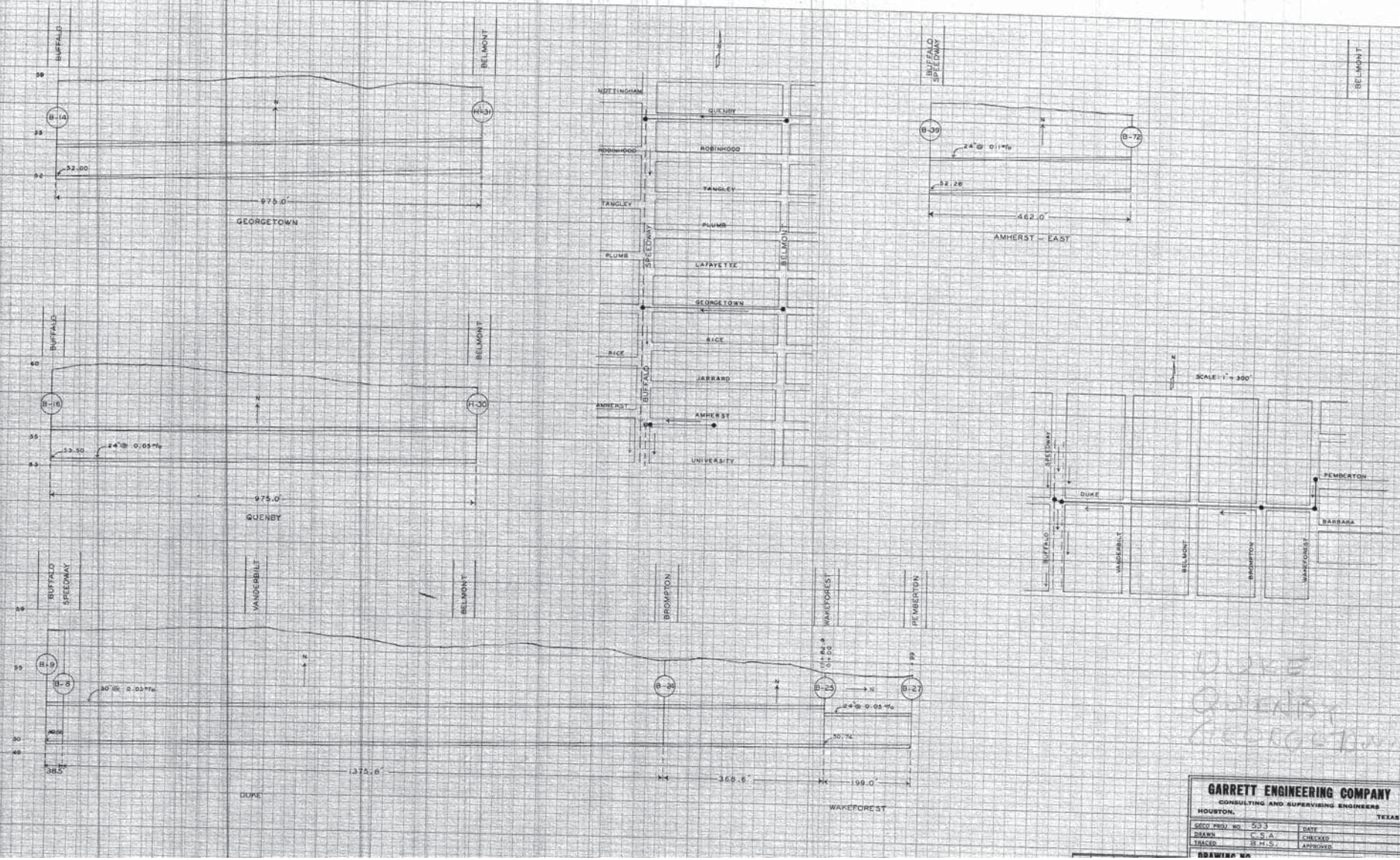
GECO PROJ. NO.	533	DATE	
DRAWN	C.S.A.	CHECKED	
TRACED	B.H.S.	APPROVED	

DRAWING NO.

NO.	DATE	BY	REMARKS

SHEET NO. OF SHEETS


BELLAIRE BLVD.
RUSKIN
A-1
A-2
72" @ 0.05%
50.75
51.75
151.5'
1127.0'
899.5'
ACADEMY
RILEY
SOUTH-WESTERN
MARQUETTE
VILLA NOVA
OBERLIN
BYRON
CASE
SMARTHMORE
A-3
A-4
A-5
A-6
A-7
52.87
139.0'
308.0'
277.0'
978.0'
652.7'
UNIVERSITY BLVD.
AMHERST
MILTON
RICE
TENNYSON
COLERIDGE
MARLOW
ARNOLD
BROWNING
RICHMOND ROAD
A-8
A-9
A-10
A-11
A-12
A-13
66" @ 0.05%
80" @ 0.05%
2-36" PRE-CAST CONCRETE PIPE @ 0.05%
130.0'
542.5'
612.0'
607.0'
83.0'
N
SCALE: 1" = 600'
RICHMOND ROAD
RUSKIN
ARNOLD
MARLOW
BROWNING
COLERIDGE
TENNYSON
RICE
MILTON
AMHERST
UNIV. BLVD.
SMARTMORE
CASE
BYRON
OBERLIN
VILLANOVA
MARQUETTE
S. WESTERN
RILEY
RUSKIN
WEST POINT
BELLAIRE
SOUTHERN PACIFIC LINES
COUNTY DITCH
ACADEMY
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS
GECO PROJ. NO. 533
DRAWN: G.S.A.
TRACED: B.H.S.
DATE
CHECKED
APPROVED
DRAWING NO.
SHEET NO. 8 OF 13 SHEETS
NO. DATE BY REMARKS
REVISIONS

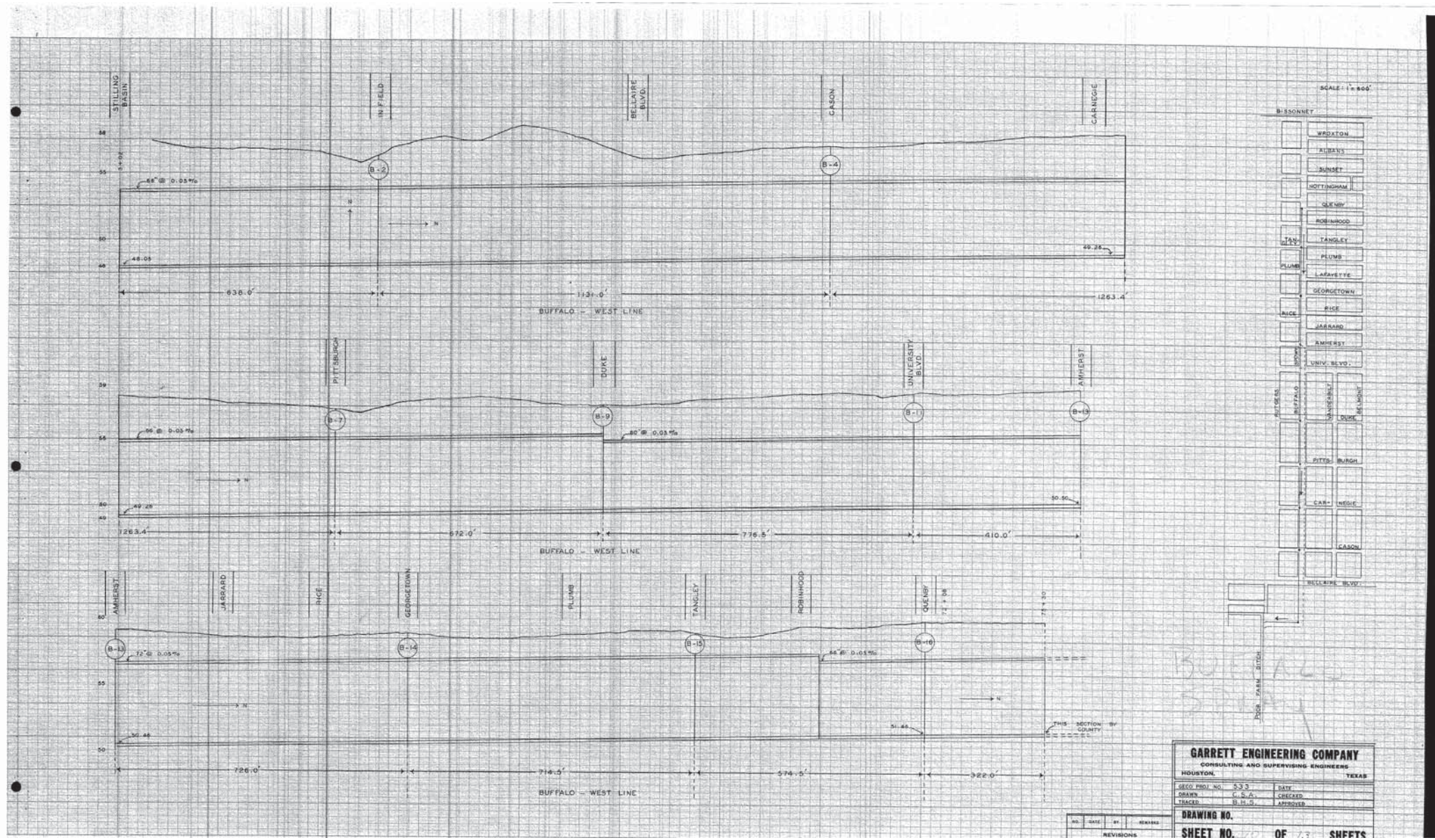


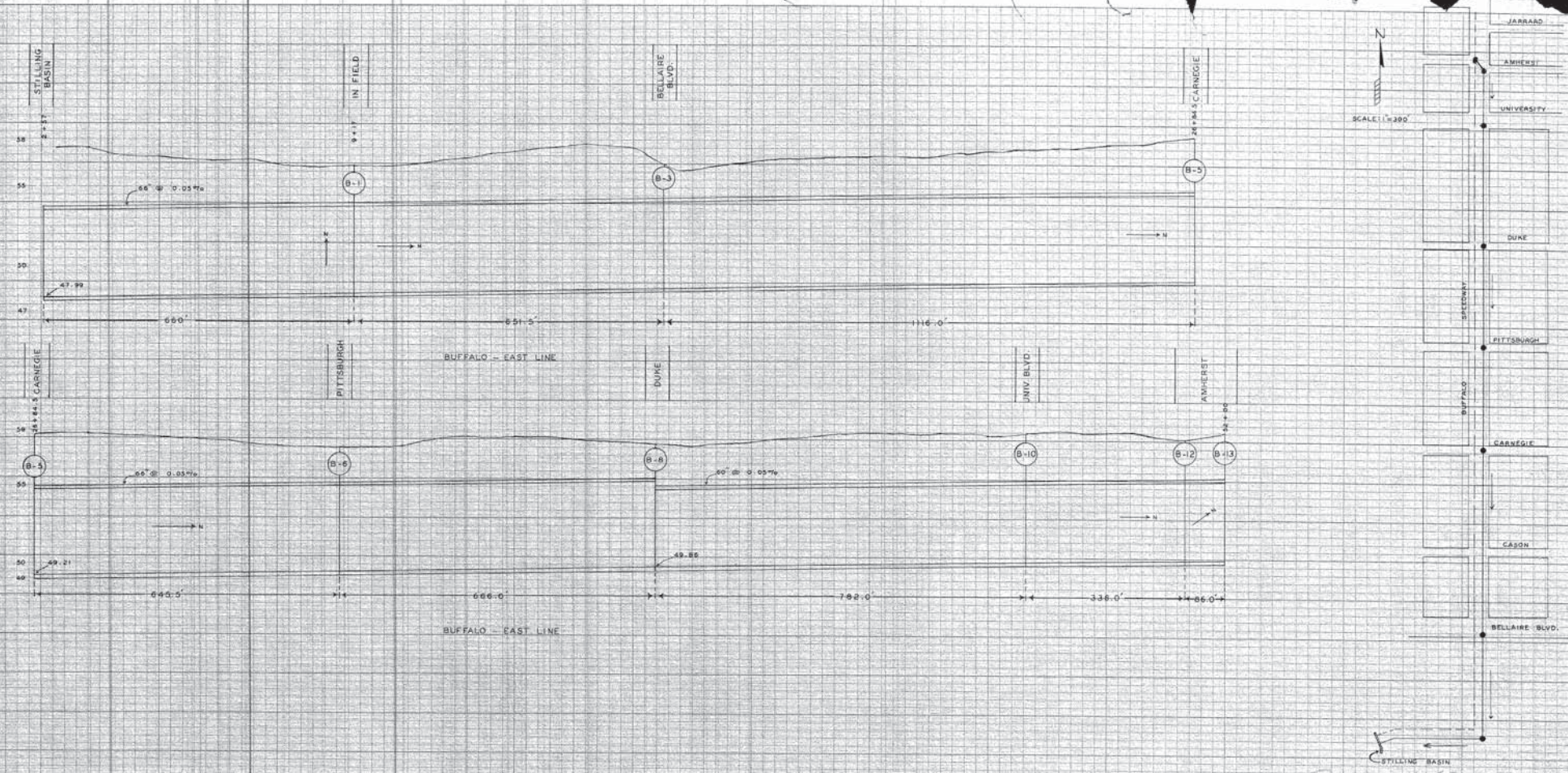
DUKE
BARBARA
PEMBERTON

GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

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

DRAWING NO.


STILLING BASIN
INFIELD
BELLAIRE BLVD.
CASON
CARNEGIE
B-2
B-4
68' @ 0.05%
46.05
49.28
638.0'
1131.0'
1263.4'
BUFFALO - WEST LINE
PITTSBURGH
DUKE
UNIVERSITY BLVD.
AMHERST
B-7
B-9
B-11
B-13
66' @ 0.05%
80' @ 0.05%
49.28
50.50
1263.4'
672.0'
776.5'
410.0'
BUFFALO - WEST LINE
AMHERST
JARRARD
RICE
GEORGETOWN
PLUMB
TANGLEY
ROBINHOOD
QUENBY
B-13
B-14
B-15
B-16
72' @ 0.05%
66' @ 0.05%
50.46
51.46
THIS SECTION BY COUNTY
726.0'
714.5'
574.5'
322.0'
BUFFALO - WEST LINE
SCALE: 1" = 800'
BISSONNET
WROXTON
ALBANS
SUNSET
NOTTINGHAM
QUENBY
ROBINHOOD
TANGLEY
PLUMB
LAFAYETTE
GEORGETOWN
RICE
JARRARD
AMHERST
UNIV. BLVD.
BUFFALO
VANDERBILT
BELMONT
DUKE
PITTS-BURGH
CARNEGIE
CASON
BELLAIRE BLVD.
POOR FARM DITCH
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS
GECO PROJ. NO. 533
DRAWN C.S.A.
TRACED B.H.S.
DATE
CHECKED
APPROVED
DRAWING NO.
SHEET NO. OF SHEETS
NO. DATE BY REMARKS
REVISIONS



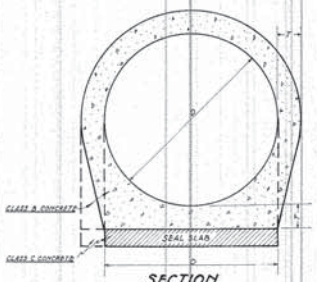
GARRETT ENGINEERING COMPANY
CONSULTING AND SUPERVISING ENGINEERS
HOUSTON, TEXAS

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

DRAWING NO.

NO.	DATE	BY	REMARKS

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

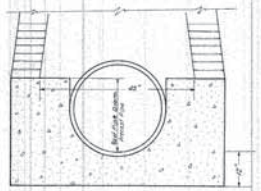
NOTE

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 center line of sewer, extra concrete used shall be placed at contractor's expense.
5. When soil conditions require vertical sides below center line 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"

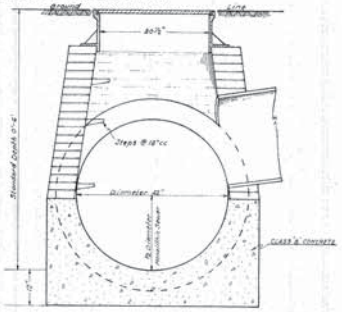
for

SEWERS WITH DIAMETERS 42" & SMALLER



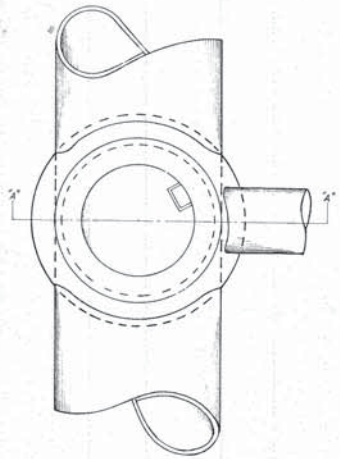
SECTION "A-A"

Diameter of Sewer Less than 42"



SECTION "A-A"

Diameter of Sewer 42"

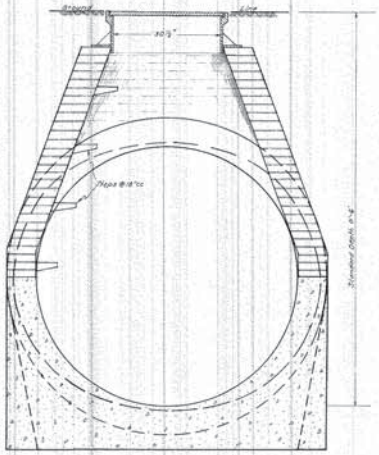


PLAN

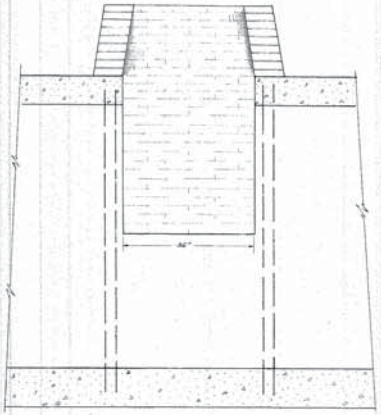
TYPICAL MANHOLE TYPE "B"

for

SEWERS WITH DIAMETERS 48" & LARGER



SECTION "A-A"



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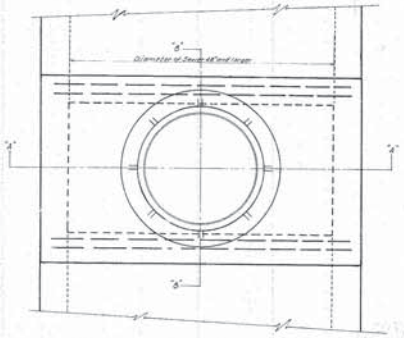


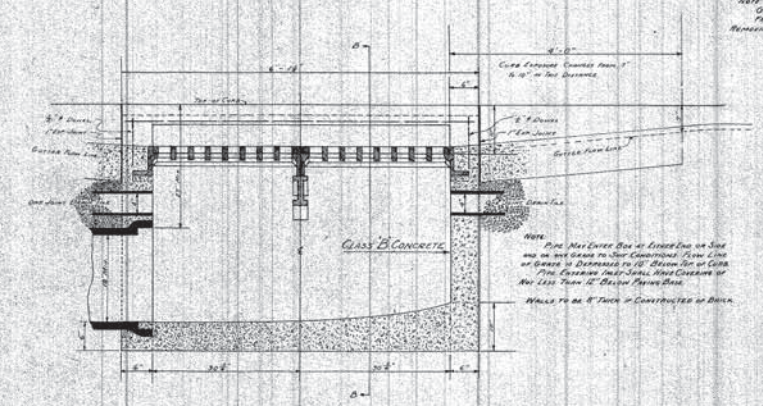
PLAN

STORM SEWERS ON BUFFALO SPEEDWAY FOR HARRIS COUNTY, TEXAS

GARRETT ENGINEERING CO.
HOUSTON PROJECT NO. 533 TEXAS

CIRCULAR STORM SEWER AND MANHOLES

REVISED	DATE	DRAWN BY	M.L.G.
J.P.C.	11-5-41	CHECKED	J.A.S.



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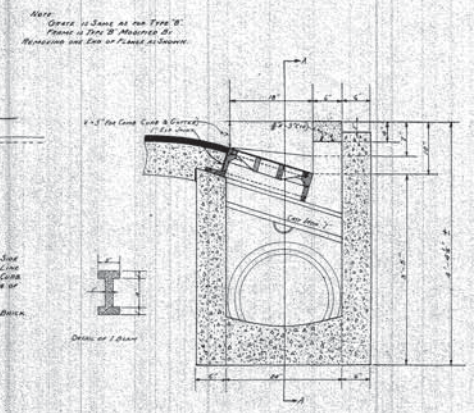
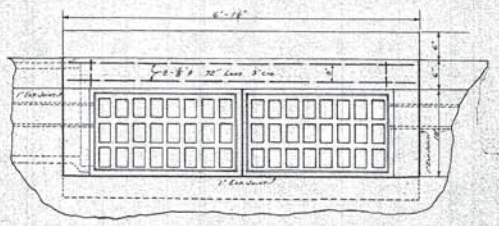
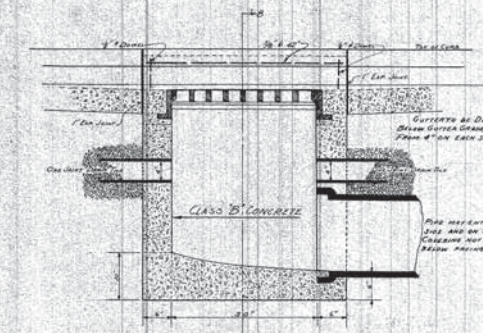


Section "B-B"

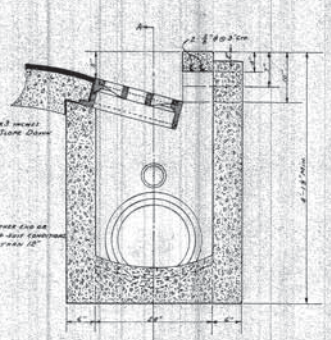


Plan

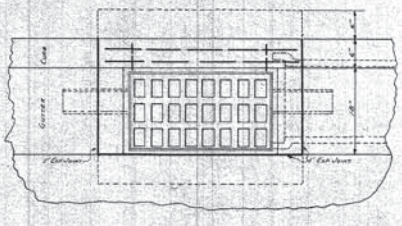
Type "B-B" Inlet



Section A-A



Section B-B



Plan

Type "B" Inlet

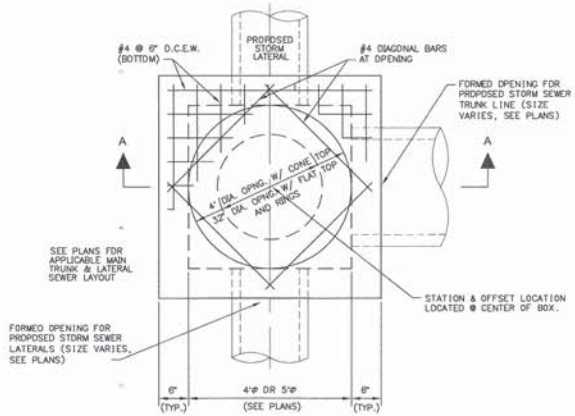
GARRETT ENGINEERING CO.
HOUSTON PROJECT NO. 533 TEXAS

STORM SEWER INLETS
CITY OF
WEST UNIVERSITY PLACE

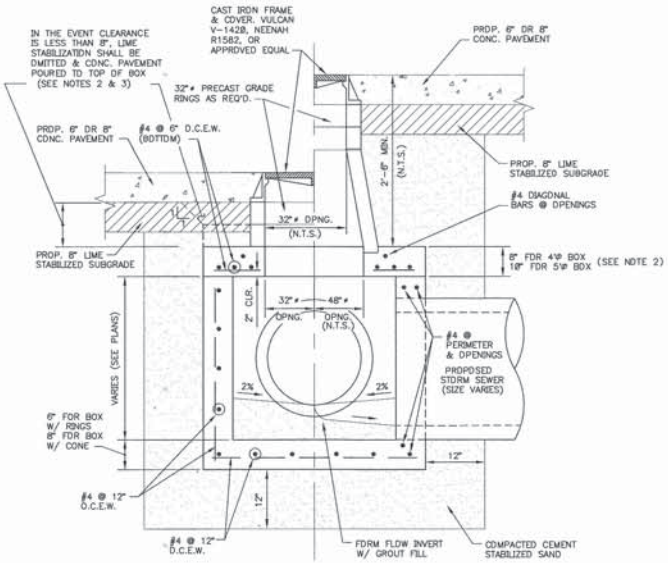
REVISED	DATE		
		DRAWN BY	H.L.G.
		CHECKED	J.B.S.
		TRACED	D.A.
		APPROVED	M.T.G.
		SHEET NO.	13 OF 13

APPENDIX D

Construction Details for Connections to Existing Monolithic Concrete Pipe



PLAN

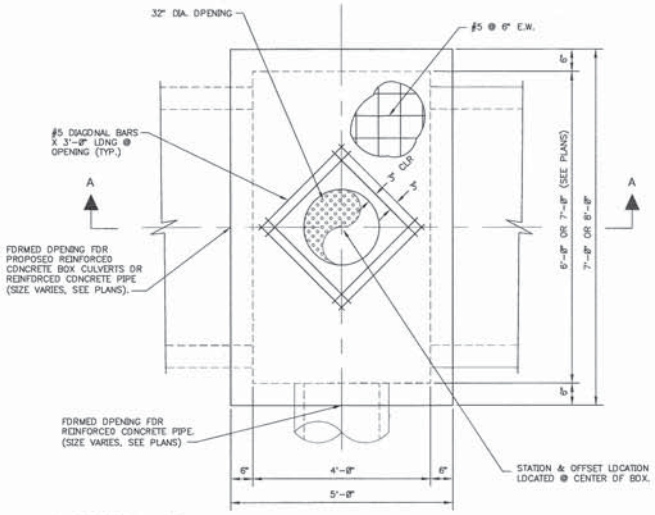


SECTION A-A

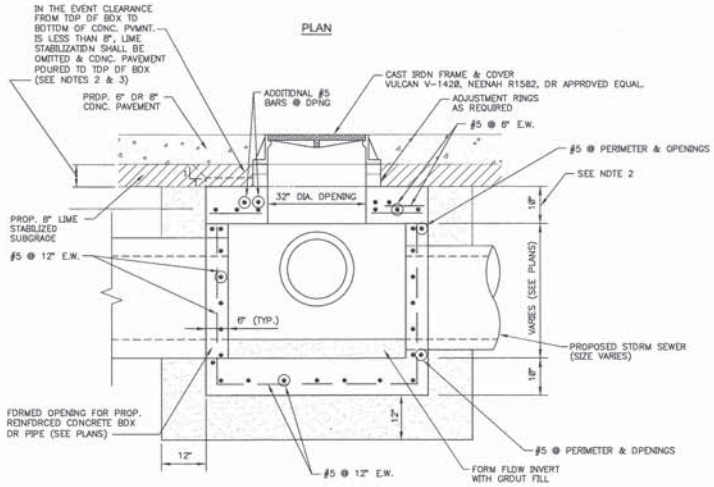
PRECAST STORM BOX MANHOLE DETAIL (SQUARE)

SCALE: NTS

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



PLAN



SECTION A-A

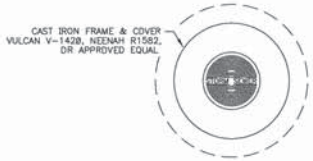
PRECAST STORM BOX MANHOLE DETAIL (RECTANGULAR)

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, REINFORCED 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. CWI 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. CWI 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

NO.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS
C. DIETER UFER
53617
REGISTERED PROFESSIONAL ENGINEER

C Dieter Ufer
9/16/02

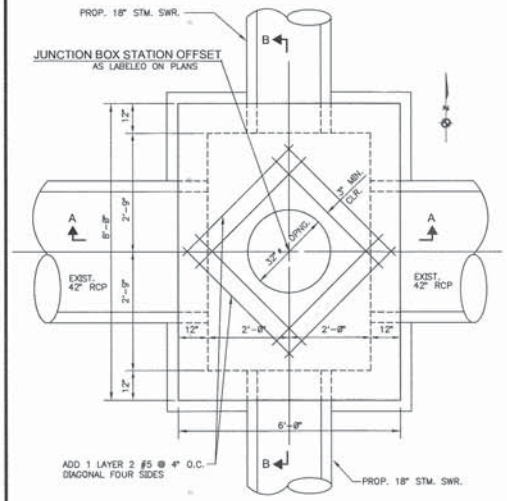
CLAUNCH & MILLER, INC.
Engineering Consultants
1701 Kirby Drive, Suite 1604 • Houston, Texas 77098-3969
(713) 524-7133 • Fax (713) 524-7770 • www.claunchmiller.com

City of West University Place

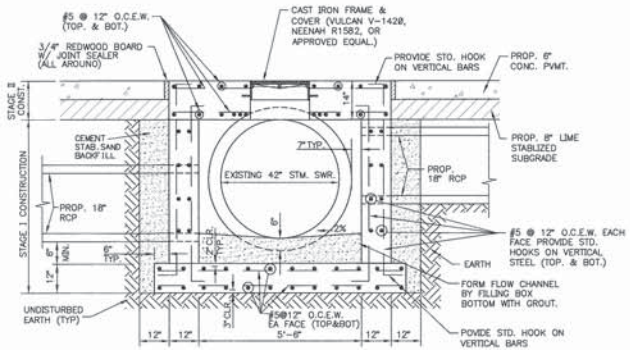
Priority Area 11B

Storm Sewer
Construction Details

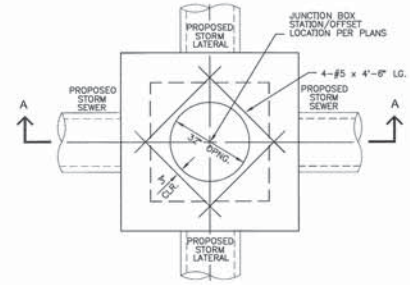
Job No.: 01-041	SCALE: HORZ: NTS VERT: NTS	SHEET 81 OF 92
Date: July, 2002		
Dwn By: P.B. Hopsh		
Chkd By: C.D. Ufer		



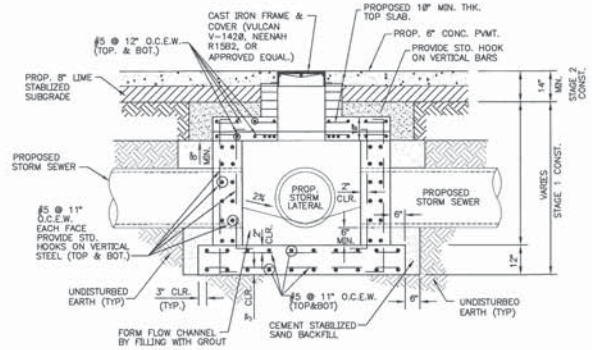
PLAN 1



SECTION B-B



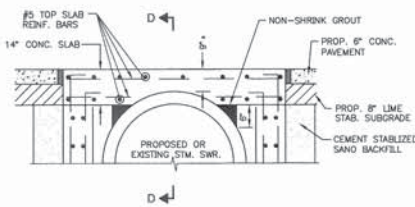
PLAN



SECTION A-A

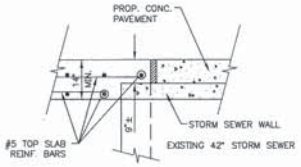
STORM SEWER JUNCTION BOX DETAIL
(FOR 30"Ø OR LESS PIPE, MANHOLE No.'s 64 & 65)

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



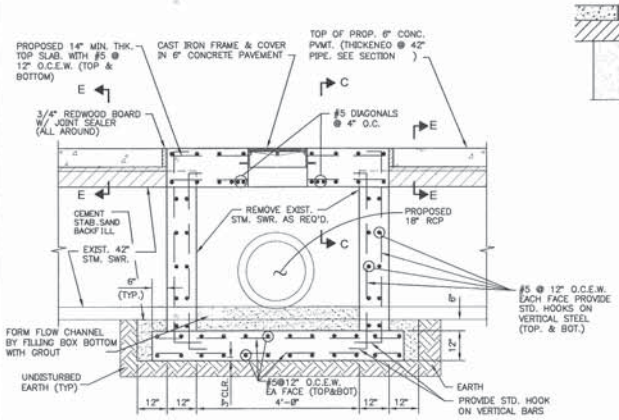
SECTION C-C

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

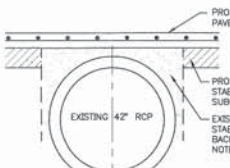


SECTION D-D

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

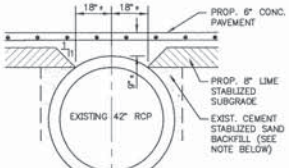


SECTION A-A

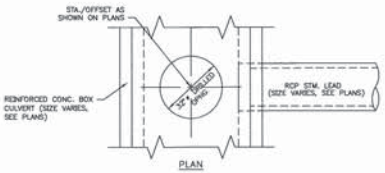


SECTION E-E
ALTERNATE 1

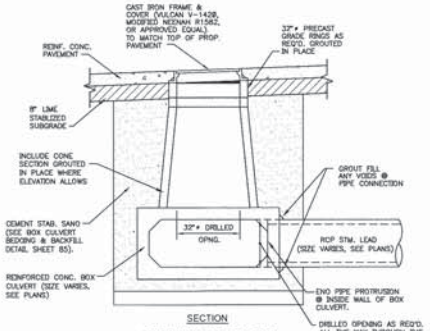
SECTION E-E NOTE:
IF CEMENT STAB. SAND BACKFILL EXISTS WITHIN LIMITS OF PROPOSED 8" SUBGRADE, GRIND C. SAND TO ELEVATION OF BOTTOM OF PROPOSED CONC. & CONSTRUCT AS SHOWN IN ALTERNATE 1. IF CEMENT STAB. SAND BACKFILL DOES NOT EXIST OR IS DAMAGED WITH EXCAVATION ACTIVITIES, CONSTRUCT PAVEMENT OVER 42"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



SECTION E-E
ALTERNATE 2



PLAN



SECTION

MANWAY DETAIL

SCALE: 1/2" = 1'-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.

TYPE 1 STORM SEWER JUNCTION BOX DETAIL

SCALE: 1/2" = 1'-0"
JUNCTION BOX NO. 68

NO.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — C. DIETER UFER — 65617 — REGISTERED PROFESSIONAL ENGINEER

9/14/02

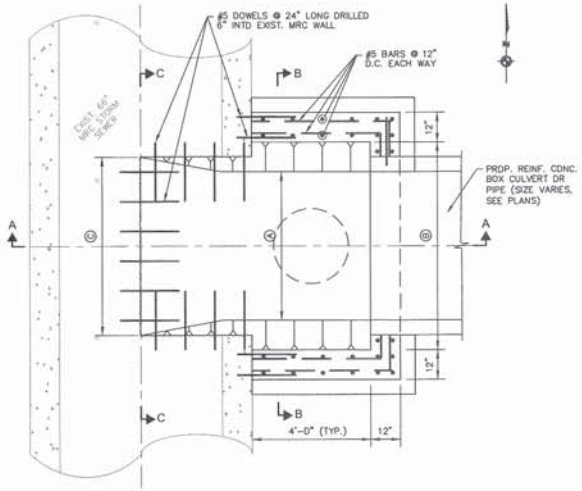
CLAUNCH & MILLER, INC.
Engineering Consultants
3701 Kirby Drive, Suite 860a Houston, Texas 77098-3969
(713) 524-7113 • Fax (713) 524-1716 • www.claunchmiller.com

City of West University Place

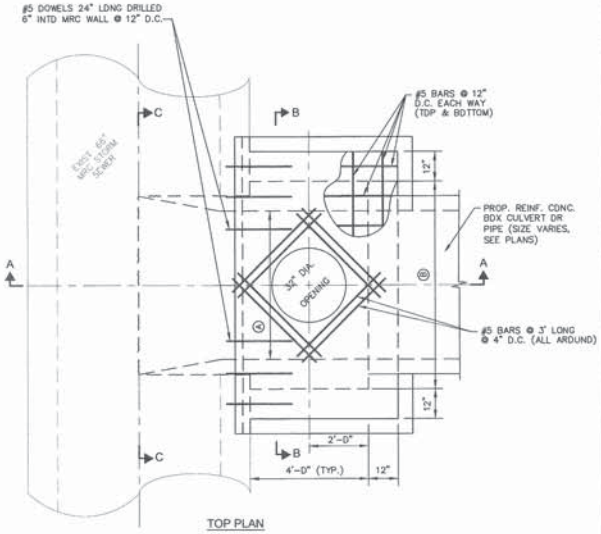
Priority Area 11B

Storm Sewer
Construction Details

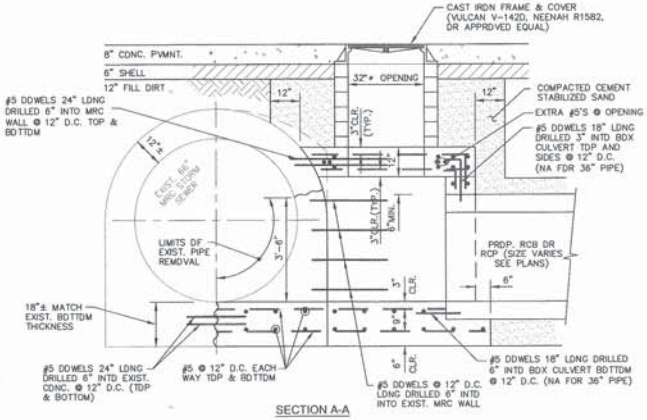
Job No.: 00-041	Scale: HORZ - NTS VERT - NTS	SHEET 82 OF 92
Date: July, 2002		
Dwn By: P.B. Horsh		
Chkd By: C.D. Ufer		



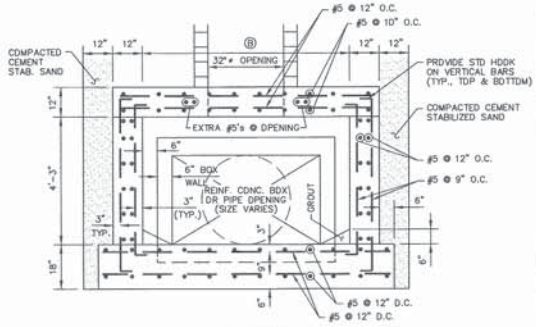
BOTTOM PLAN



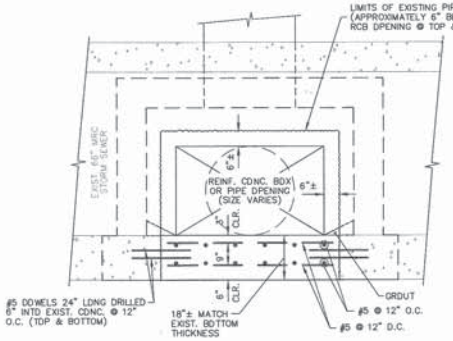
TOP PLAN



SECTION A-A



SECTION B-B



SECTION C-C

TYPE 2 STORM SEWER JUNCTION BOX TABLE			
No.	Ⓐ	Ⓑ	Ⓒ
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.

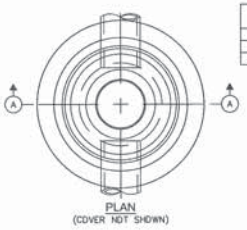
2.) ALL REINFORCING BARS SHALL CONFORM TO ASTM A615-GRADE 60.

TYPE 2 STORM SEWER JUNCTION BOXES AT 66" STORM SEWER

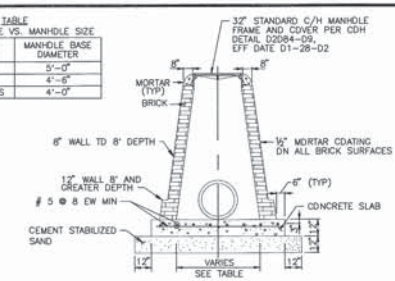
SCALE: 1/2" = 1'-0"

TABLE
SEWER SIZE VS. MANHOLE SIZE

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



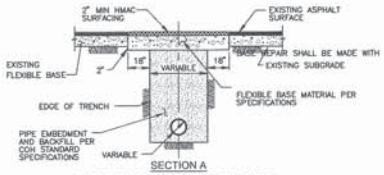
PLAN
(COVER NOT SHOWN)



SECTION A

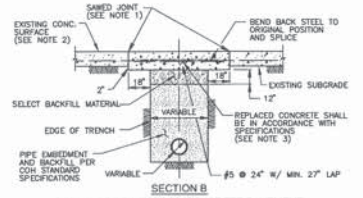
STANDARD CITY OF HOUSTON TYPE "C" STORM MANHOLE

NOT TO SCALE DTL. NO. D2081-D3 EFF. DATE: JUL-01-97



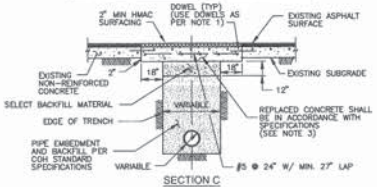
SECTION A

REPAIR OF FLEXIBLE BASE PAVEMENT



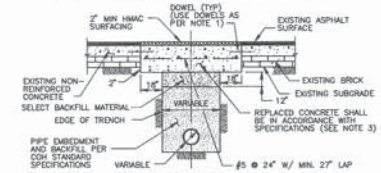
SECTION B

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
WASTEWATER — PROJECT MANAGER
STORM WATER — 9.5.02 — CONSTRUCTION
STREET & BRIDGE — 9.5.02 — CHIEF ENGINEER
OTHER DEPARTMENTS
TRAFFIC AND TRANSPORTATION — 9-5-02 — SPONSOR DEPARTMENT
CITY ENGINEER — DATE
DIRECTOR OF PUBLIC WORKS AND ENGINEERING — DATE 9-5-2002

NO.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — C. DIETER UFER — 39001 — REGISTERED PROFESSIONAL ENGINEER
8/20/02

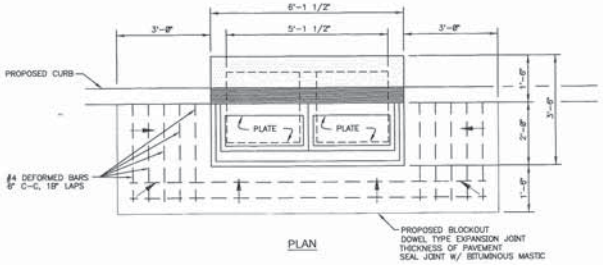
CLAUNCH & MILLER, INC.
Engineering Consultants
3701 Kirby Drive, Suite 860 • Houston, Texas 77098-3969
(713) 524-7113 • Fax (713) 524-1718 • www.claunchmiller.com

City of West University Place

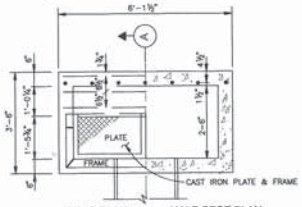
Priority Area 11B

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		
CHK BY: C.D. Ufer		



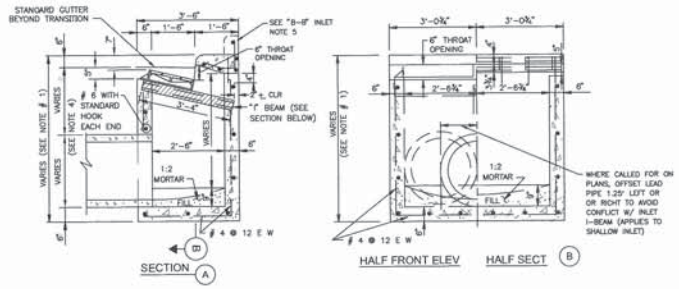
PLAN



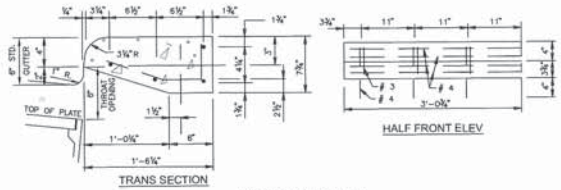
HALF PLAN HALF SECT PLAN

"B-B" INLET NOTES:

1. DIMENSION VARIES BASED ON PIPE DIAMETER AND WALL THICKNESS.
2. CENTER REINFORCING 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" LONG @ 12" C-C. RUN CONTINUOUS #4 BAR AS PER TYPICAL CONCRETE CURB DETAIL SHEET B6.
6. USE STD CAST IRON FRAME & PLATES. LEAD SHALL LEAVE INLET AT LOCATION AND GRADE REQUIRED.



SECTION (A) HALF FRONT ELEV HALF SECT (B)



TRANS SECTION HALF FRONT ELEV

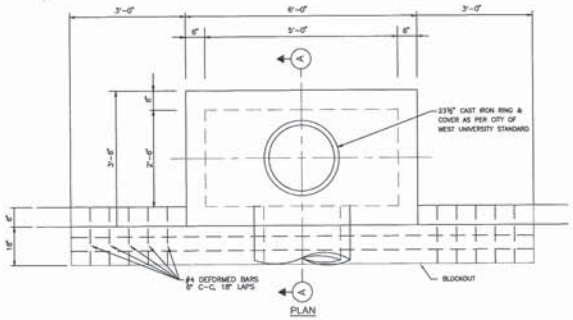
PRECAST CURB BEAM

ACCEPTABLE ALTERNATE STEEL BEAM SIZES: S8x17.5 W8x16 (GALVANIZED)

SECTION THRU BEAM

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

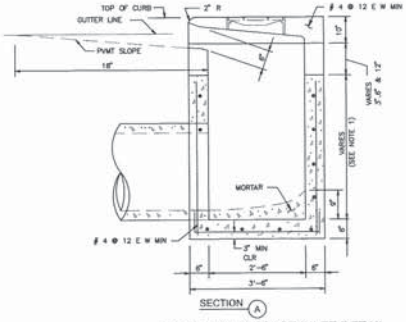
TYPE "BB" INLET DETAIL
NOT TO SCALE



PLAN

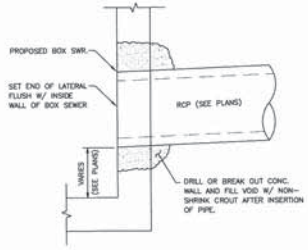
"H-2" INLET NOTES:

1. DIMENSION VARIES BASED ON PIPE DIAMETER AND WALL THICKNESS.
2. CENTER REINFORCING 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" LONG @ 12" OC. RUN CONTINUOUS #4 BAR AS PER TYPICAL CONCRETE CURB DETAIL, SHEET B6.

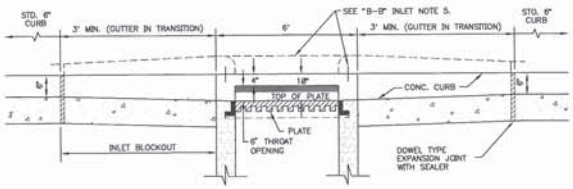


SECTION (A)

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

NO.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

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

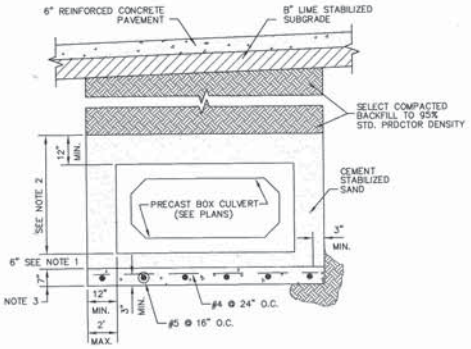
CLAUNCH & MILLER, INC.
Engineering Consultants
3701 Kirby Drive, Suite 860• Houston, Texas 77098-3969
(713) 524-7115 • Fax (713) 524-1719• www.clauncheller.com

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"

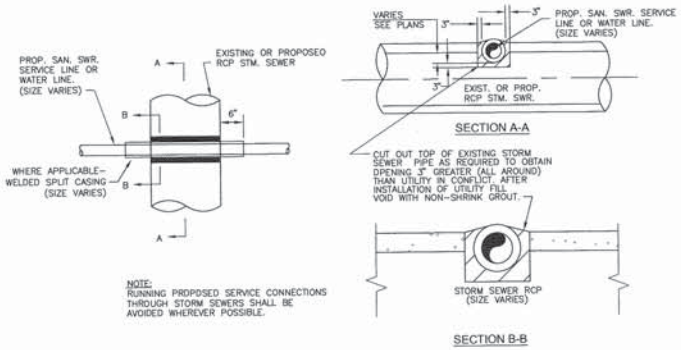
NOTES:

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.

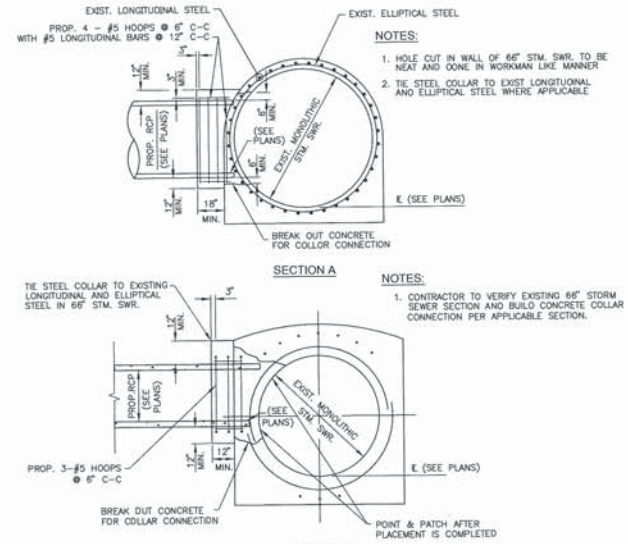
B. NO WET SAND STRATA EXIST IN THE AREA FROM 1' ABOVE THE TOP OF THE BOX TO 3' BELOW THE FLOWLINE.



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.



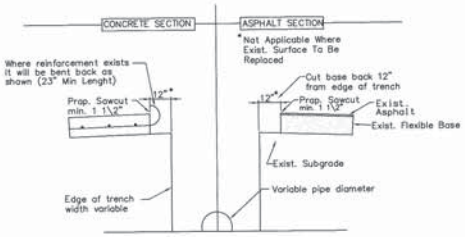
NOTES:

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.

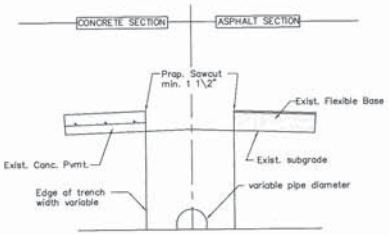
CONCRETE COLLAR CONNECTION DETAIL



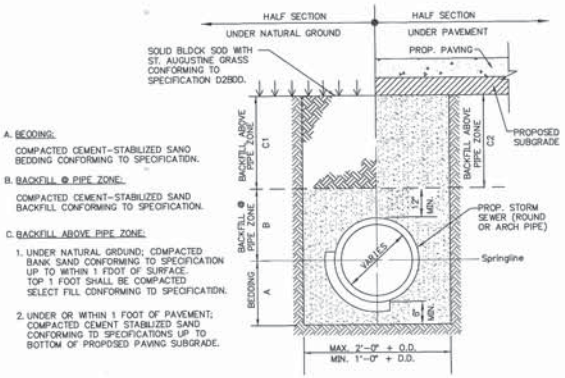
SECTION SHOWING METHOD OF CUTTING

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"	48"
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 CUTTING



A. BEDDING:

COMPACTED CEMENT-STABILIZED SAND BEDDING CONFORMING TO SPECIFICATION.

B. BACKFILL @ PIPE ZONE:

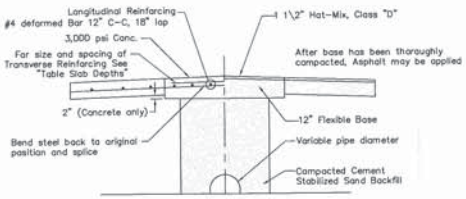
COMPACTED CEMENT-STABILIZED SAND BACKFILL CONFORMING TO SPECIFICATION.

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

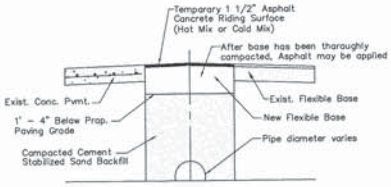


SECTION SHOWING METHOD OF REPAIR

CUTTING AND REPAIRING CONCRETE AND ASPHALT PAVEMENT DETAIL

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

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



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.

No.	DESCRIPTION	DATE	DWN.	CHK.

REVISIONS

STATE OF TEXAS — C. DIETER UFER — 23017 — REGISTERED PROFESSIONAL ENGINEER

9/16/02

CLAUNCH & MILLER, INC.
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3701 Kirby Drive, Suite 1086 Houston, Texas 77098-3969
(713) 524-1111 • Fax (713) 524-2710 • www.claunchmiller.com

City of West University Place

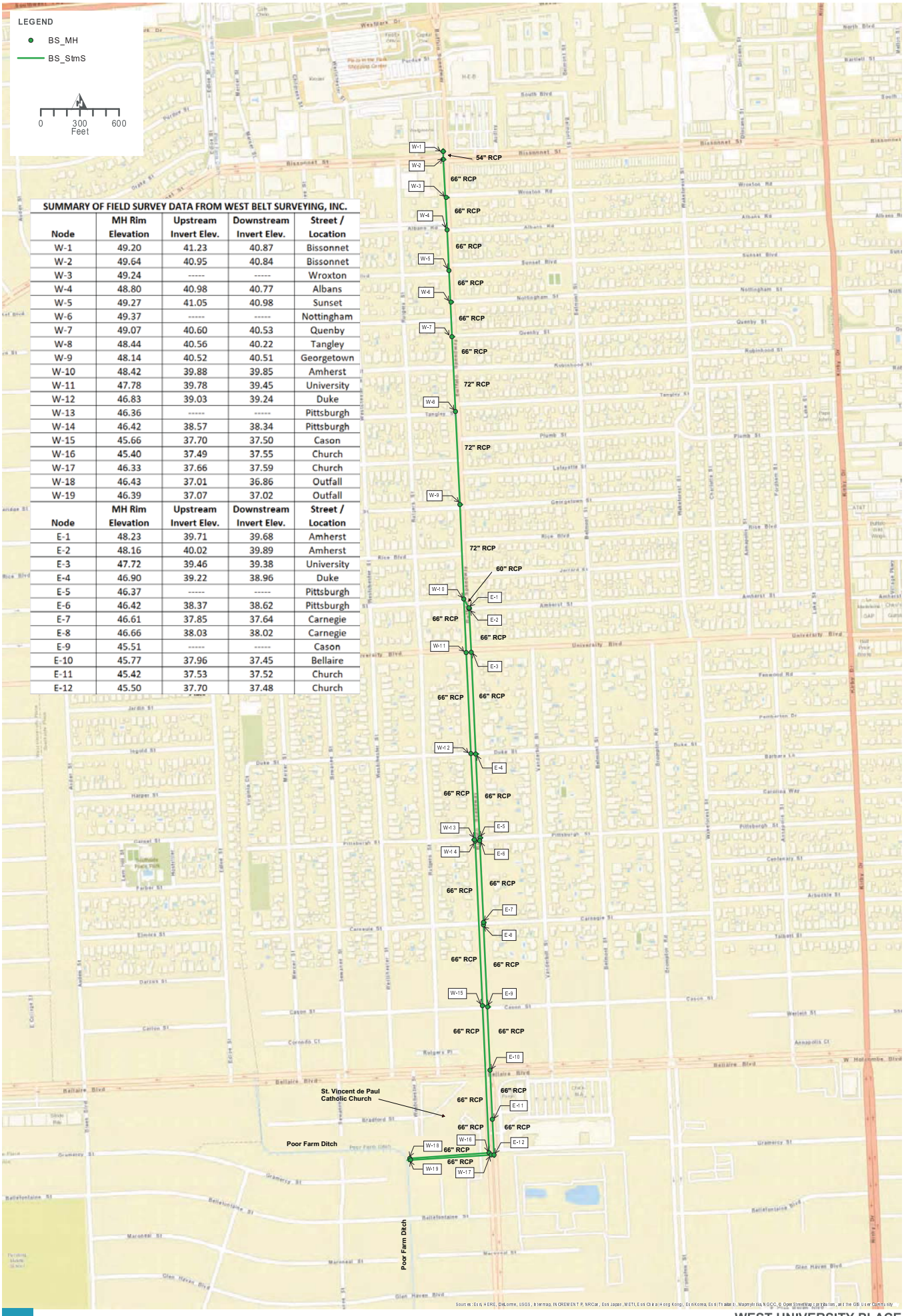
Priority Area 11B

Storm Sewer Construction Details

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

APPENDIX E

Field Notes and Survey Data



SUMMARY OF FIELD SURVEY DATA FROM WEST BELT SURVEYING, INC.				
Node	MH Rim Elevation	Upstream Invert Elev.	Downstream Invert Elev.	Street / Location
W-1	49.20	41.23	40.87	Bissonnet
W-2	49.64	40.95	40.84	Bissonnet
W-3	49.24	-----	-----	Wroxton
W-4	48.80	40.98	40.77	Albans
W-5	49.27	41.05	40.98	Sunset
W-6	49.37	-----	-----	Nottingham
W-7	49.07	40.60	40.53	Quenby
W-8	48.44	40.56	40.22	Tangley
W-9	48.14	40.52	40.51	Georgetown
W-10	48.42	39.88	39.85	Amherst
W-11	47.78	39.78	39.45	University
W-12	46.83	39.03	39.24	Duke
W-13	46.36	-----	-----	Pittsburgh
W-14	46.42	38.57	38.34	Pittsburgh
W-15	45.66	37.70	37.50	Cason
W-16	45.40	37.49	37.55	Church
W-17	46.33	37.66	37.59	Church
W-18	46.43	37.01	36.86	Outfall
W-19	46.39	37.07	37.02	Outfall
Node	MH Rim Elevation	Upstream Invert Elev.	Downstream Invert Elev.	Street / Location
E-1	48.23	39.71	39.68	Amherst
E-2	48.16	40.02	39.89	Amherst
E-3	47.72	39.46	39.38	University
E-4	46.90	39.22	38.96	Duke
E-5	46.37	-----	-----	Pittsburgh
E-6	46.42	38.37	38.62	Pittsburgh
E-7	46.61	37.85	37.64	Carnegie
E-8	46.66	38.03	38.02	Carnegie
E-9	45.51	-----	-----	Cason
E-10	45.77	37.96	37.45	Bellaire
E-11	45.42	37.53	37.52	Church
E-12	45.50	37.70	37.48	Church

HDR

WEST UNIVERSITY PLACE

BUFFALO SPEEDWAY

EXISTING DRAINAGE LAYOUT

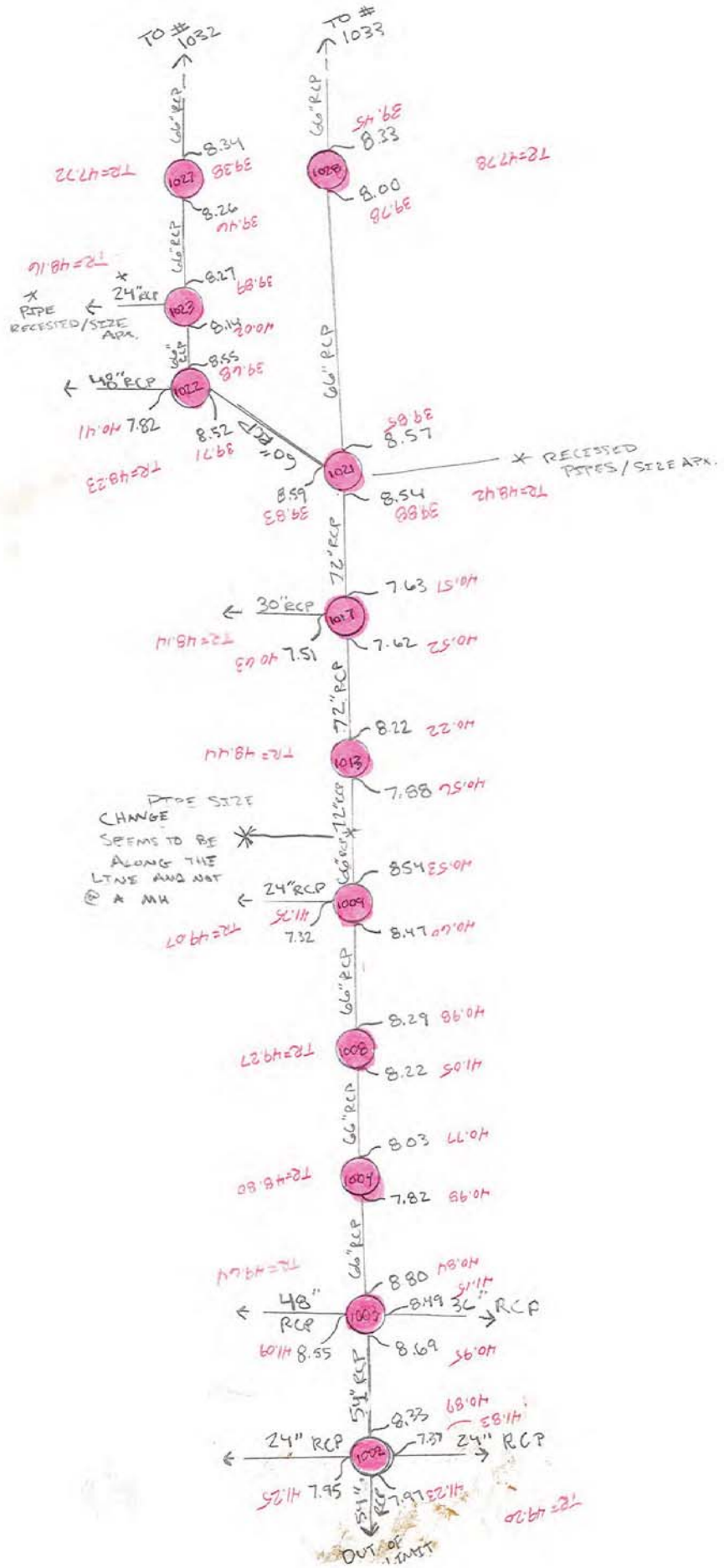
PATH: C:\USERS\ROBIBAJO\DOCUMENTS\ARCGIS\WEST_U_BSBUFFALO_SPDWY.MXD - USER: ROBIBAJO - DATE: 2/6/2018

WEST U BUFFALO SPEEDWAY PER

AM 12 15 17

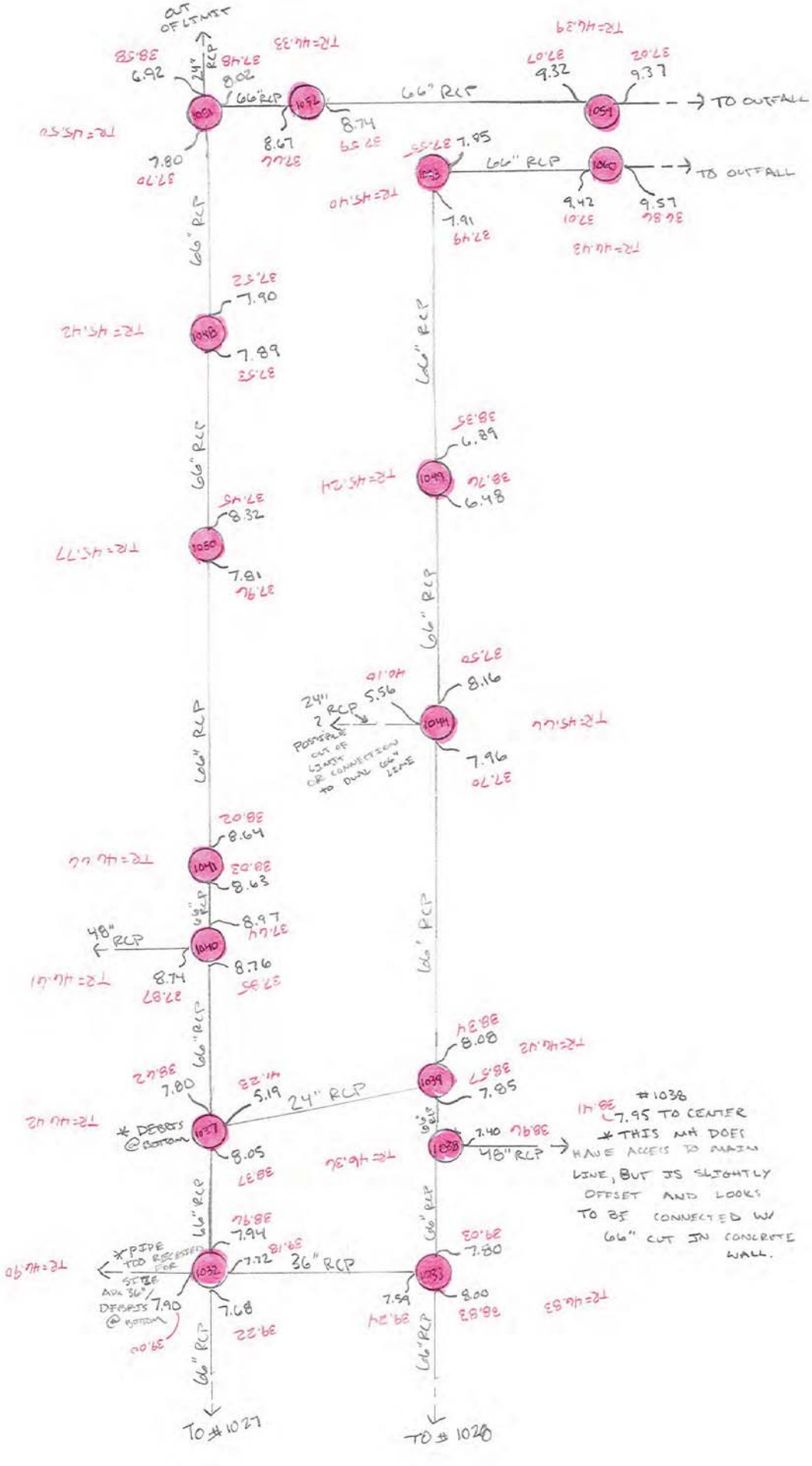
BUFFALO SPEEDWAY
STORM

N



AM 12.15.17

BUFFALO SPEEDWAY STORM



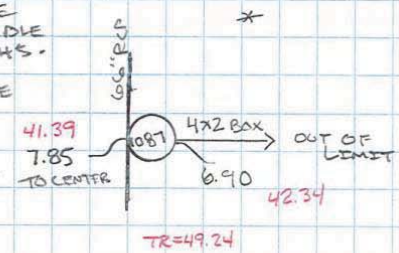
1N

BUFFALO SPEEDWAY STORM

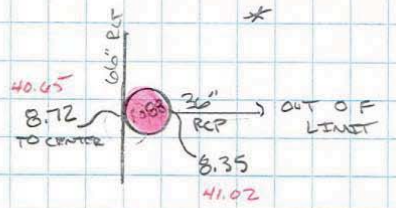
* MAIN LINE NOT VISIBLE ON THESE MH'S.

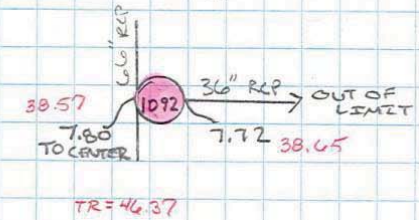
· MH'S DO HAVE ACCESS TO MAIN LINE BUT SEEM OFFSET FROM THE LINE

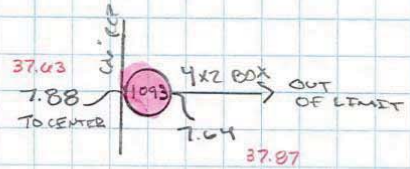
#1049 IS NOT PART OF MAIN SYSTEM



* ALL PIPES RECESSED / SIZES ARE APX.







APPENDIX F

Geotechnical Investigations Report

This document is released for the purpose of interim review under the authority of Wilber L. Wang, P.E. 99226 on March 30, 2018. It is not to be used for bidding or construction purposes.

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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
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REPORT NO. G177-17

MARCH 2018

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March 30, 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)

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Wilber L. Wang, P.E.
Senior Engineer

Jacob Garza, E.I.T.
Staff Engineer

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

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AVILES ENGINEERING CORP.

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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 the Preliminary Engineering Report (PER) is 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.

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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 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.

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

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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
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

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Boring	Depth (ft)	Description of Stratum
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.

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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.

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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 2016 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):

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

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

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

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):

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

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);

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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.

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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

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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.

<u>Bottom Stability:</u> 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.

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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 2016 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 2016 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

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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.

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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.

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APPENDIX A

APPENDIX A

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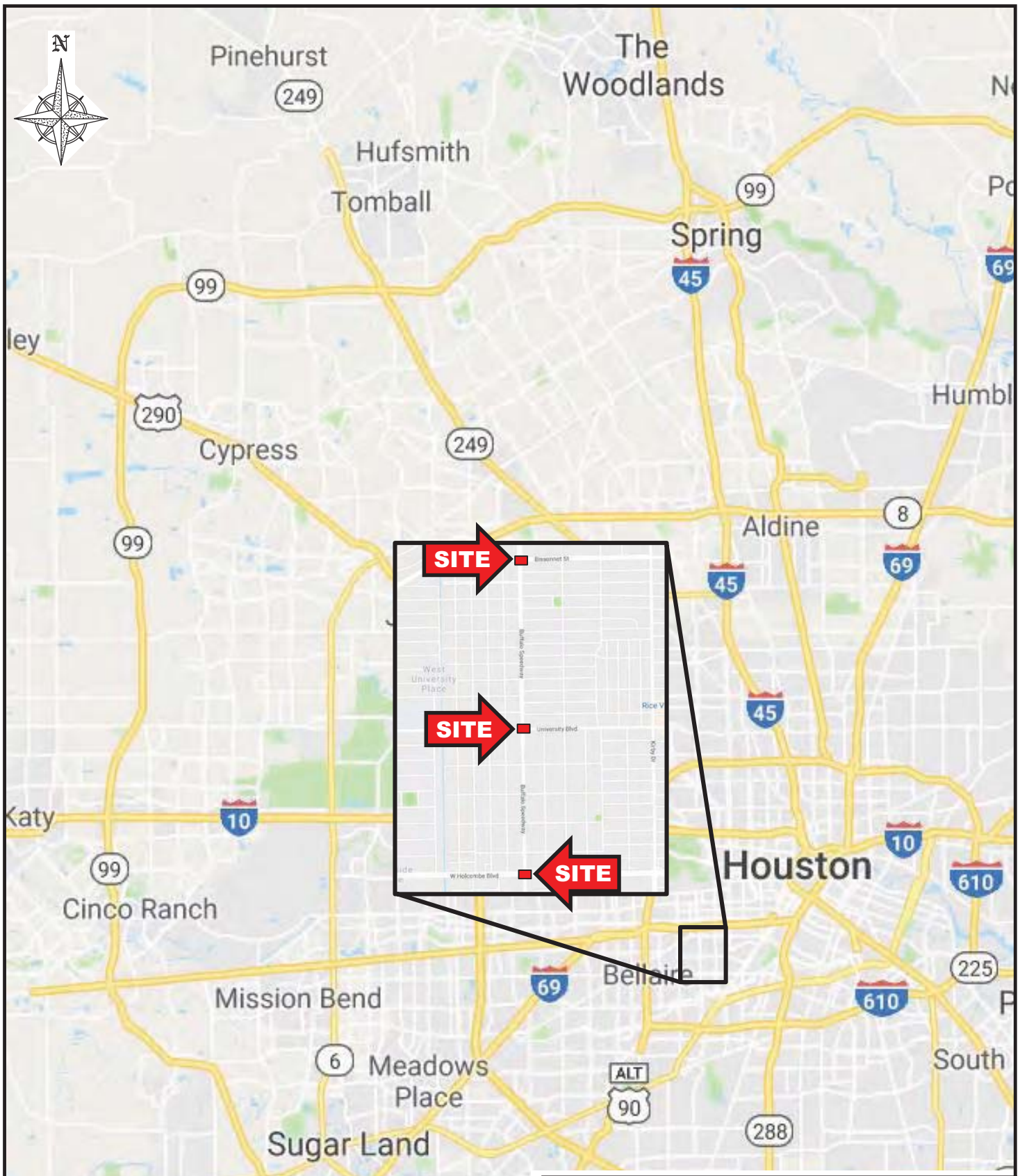

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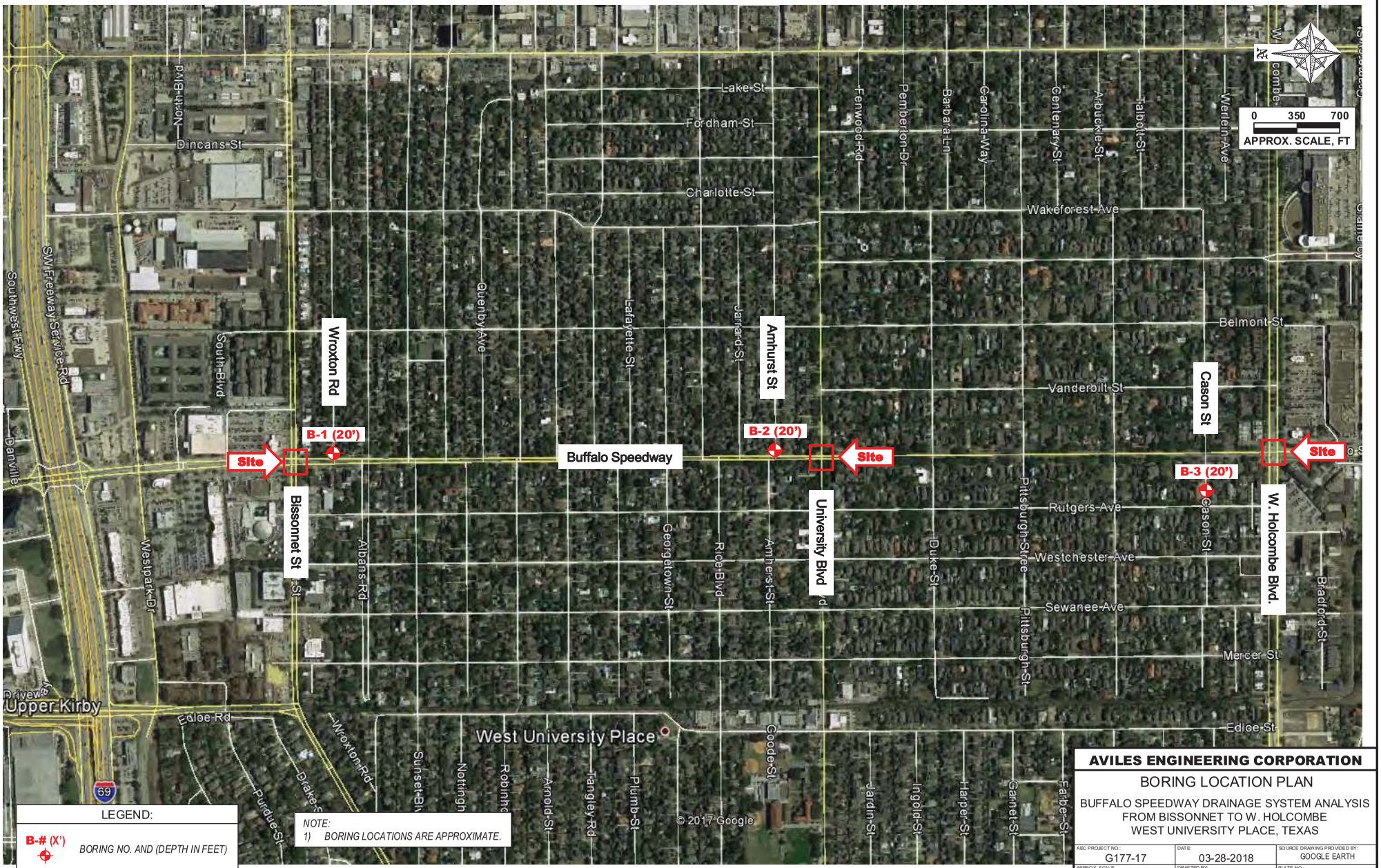
VICINITY MAP

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: 1" = 700'	DRAFTED BY: WLW/JG	PLATE NO.: PLATE A-2

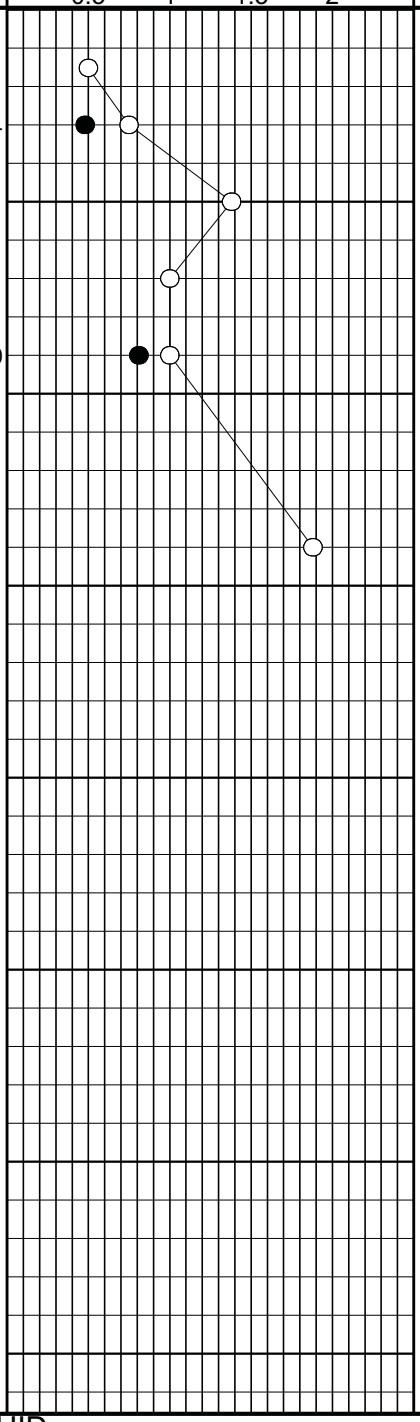
AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

PROJECT: **Buffalo Speedway Drainage System PER** BORING **B-1**

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

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	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



△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane

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**

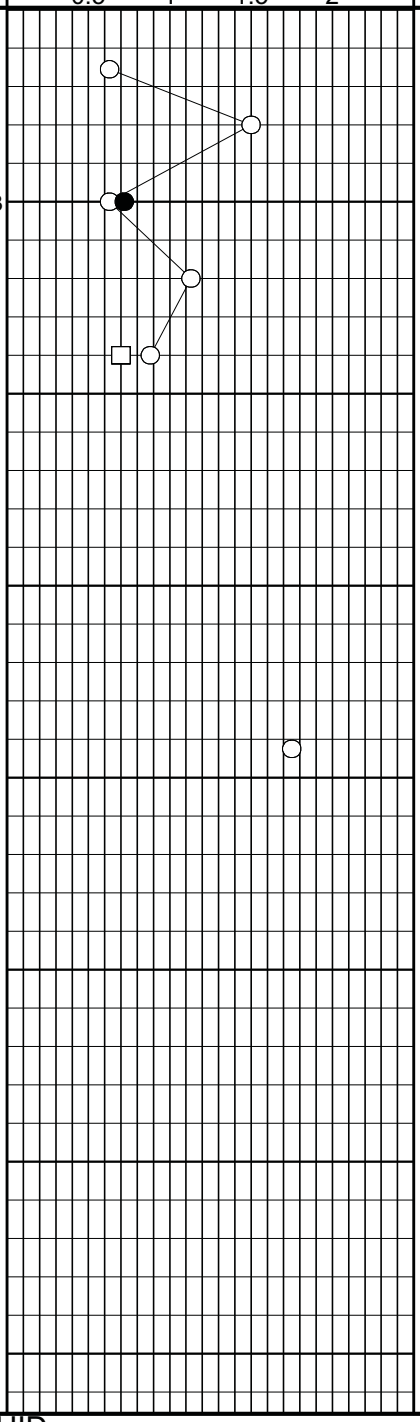
AVILES ENGINEERING CORP. GEOTECHNICAL ENGINEERS

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

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

DEPTH IN FEET	SYMBOL	SAMPLE INTERVAL	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
			Stiff to very stiff, gray and tan Sandy Fat Clay (CH), with ferrous nodules and sandy lean clay pockets							
5			-with calcareous nodules 2'-6'		19	110.3				
			-boring cave-in at 6.4' on 02/09/18		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**

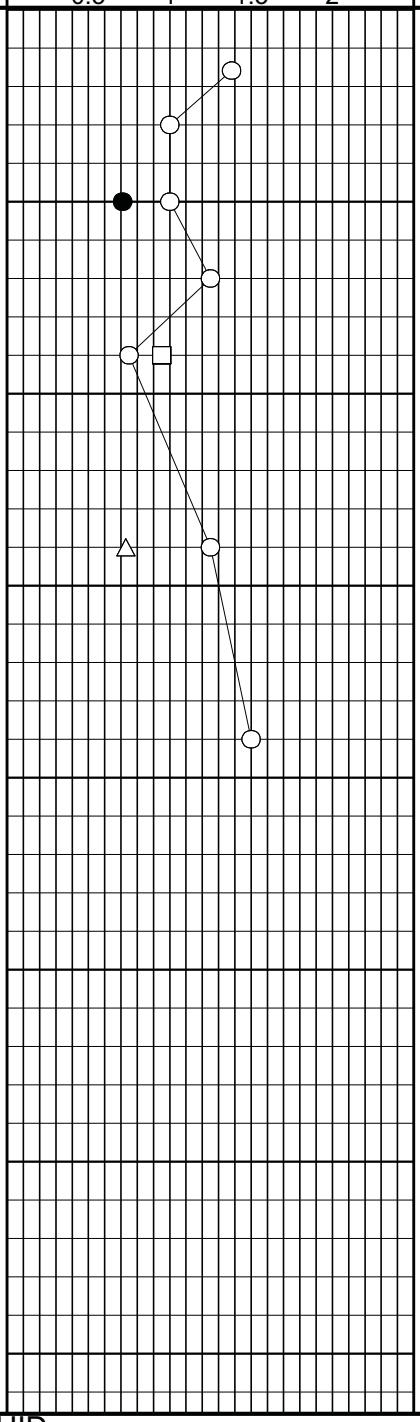
PROJECT: **Buffalo Speedway Drainage System PER** BORING **B-3**

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

DEPTH IN FEET	DESCRIPTION	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						
	Stiff to very stiff, dark gray and olive gray Fat Clay (CH), with slickensides	25					
	-with lean clay pockets 1'-2' and ferrous nodules 1'-6'	25			74	18	56
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							

SHEAR STRENGTH, TSF

△ Confined Compression
● Unconfined Compression
○ Pocket Penetrometer
□ Torvane



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**

KEY TO SYMBOLS

Symbol	Description
Strata symbols	
	Paving
	Low plasticity clay
	Silty sand
	Fill
	High plasticity clay
Misc. Symbols	
	Water table depth during drilling
	Subsequent water table depth
○	Pocket Penetrometer
●	Unconfined Compression
□	Torvane
△	Confined Compression
Soil Samplers	
	Rock core
	Undisturbed thin wall Shelby tube
	Standard penetration test

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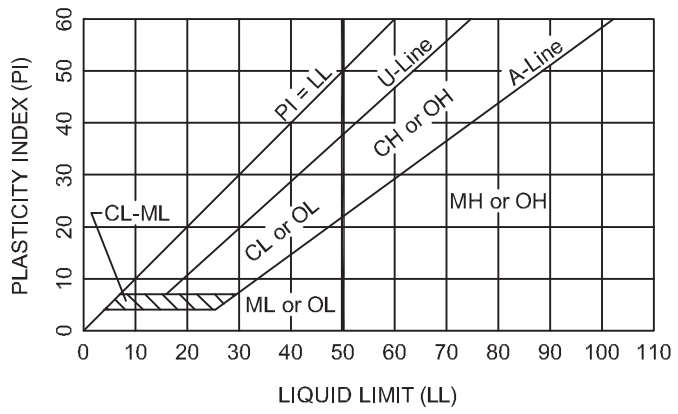
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

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



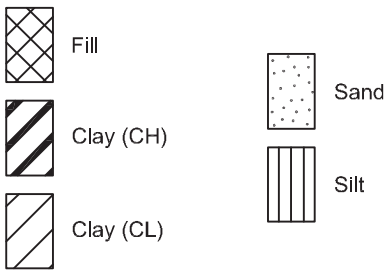
Equation of A-Line: Horizontal at PI=4 to LL=25.5, then PI=0.73(LL-20)

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



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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

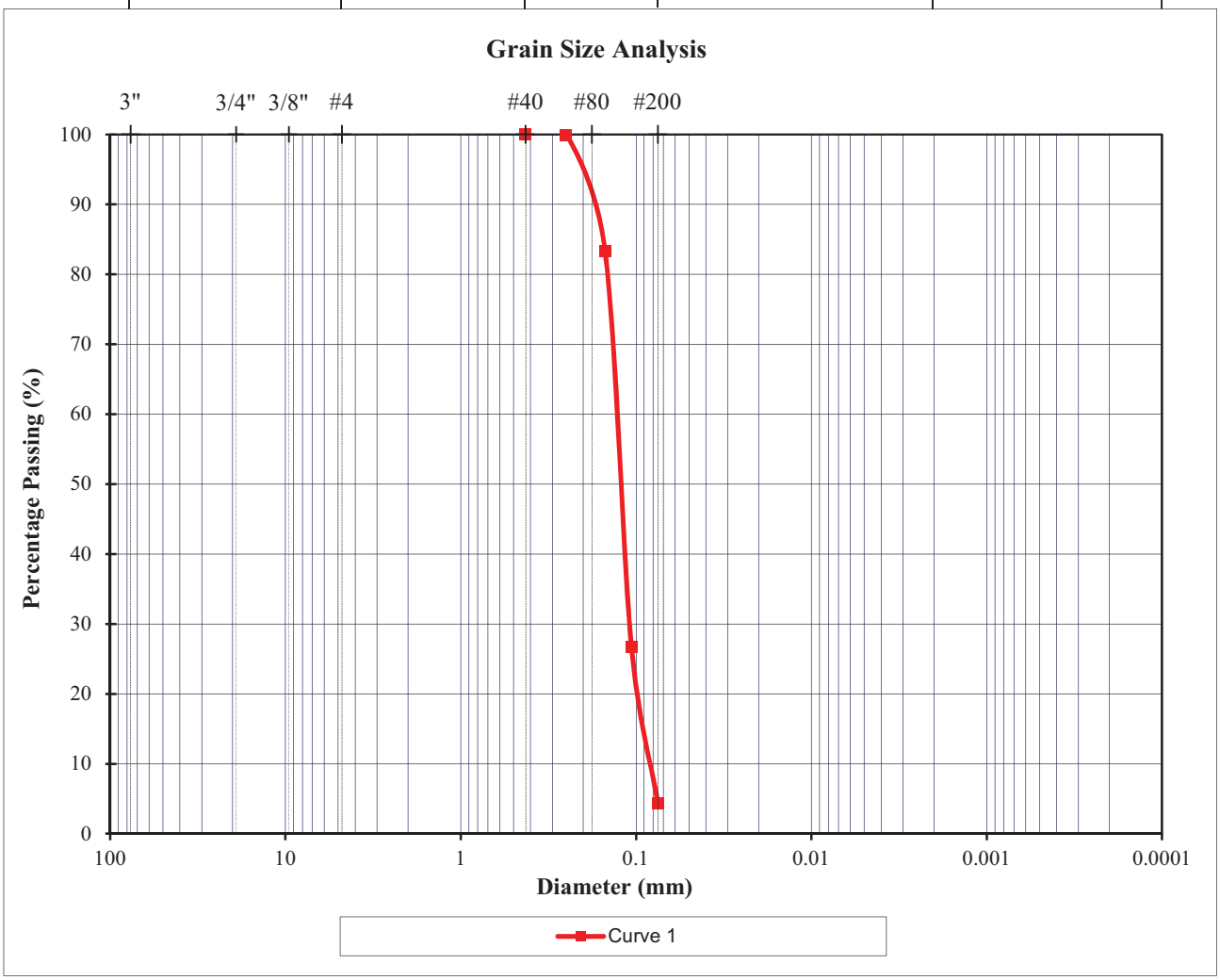
AVILES ENGINEERING CORPORATION

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		Silt	Clay
	Coarse to Medium	Fine		



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

APPENDIX B

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:

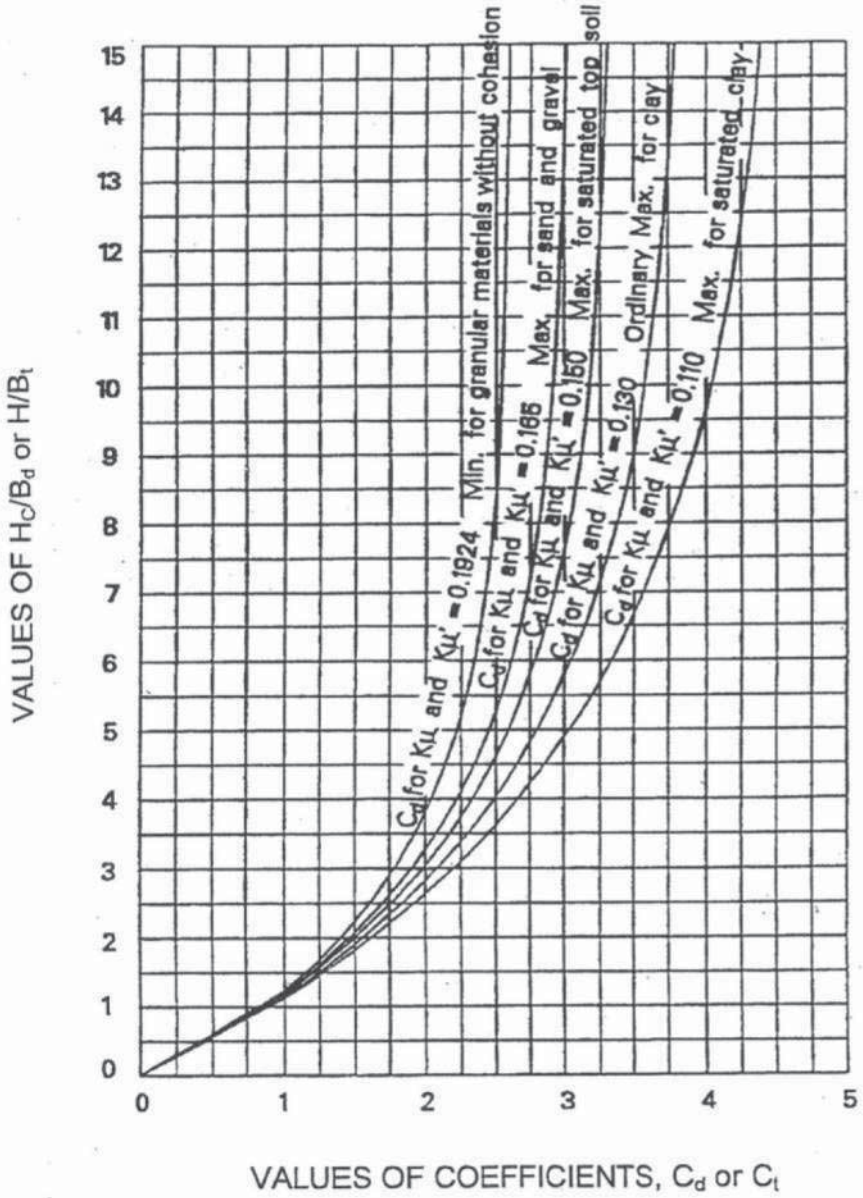
A: cohesive soils with qu = 1.5 tsf or greater (qu = Unconfined Compressive Strength of the Soil)

B: cohesive soils with qu = 0.5 tsf or greater

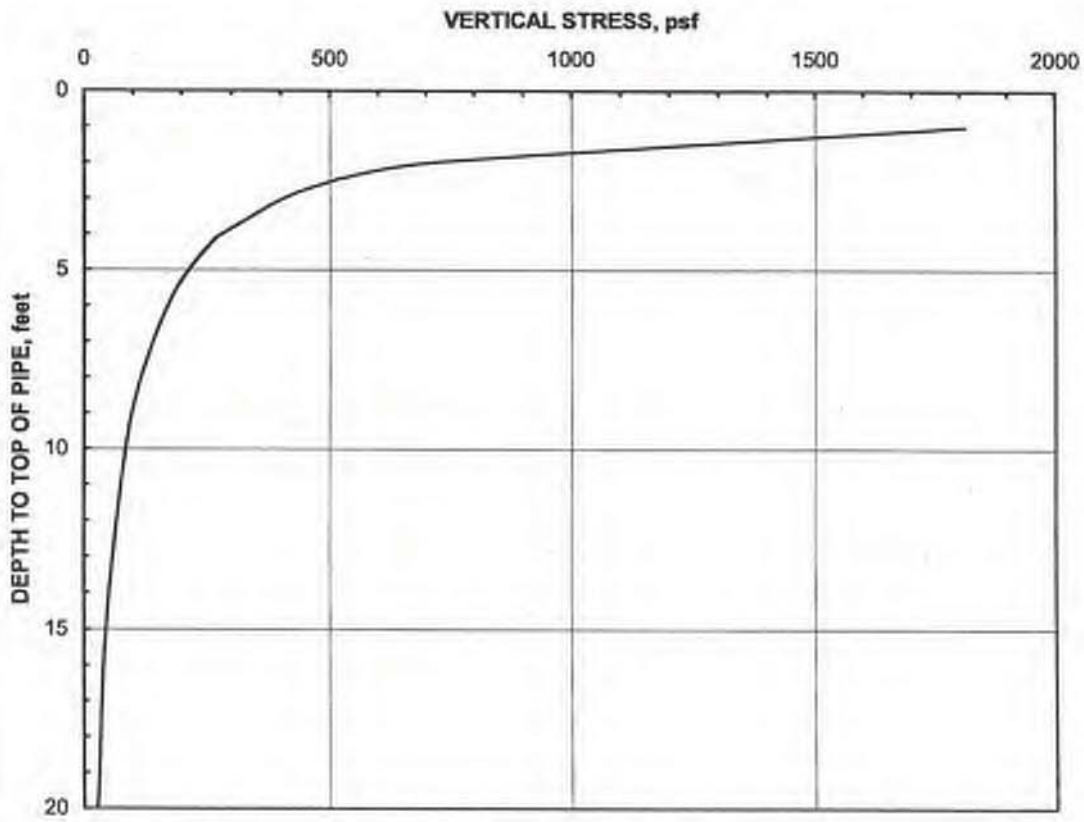
C: cohesive soils with qu = less than 0.5 tsf, fill materials, or granular soil

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

TRENCH LOAD COEFFICIENTS



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



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

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

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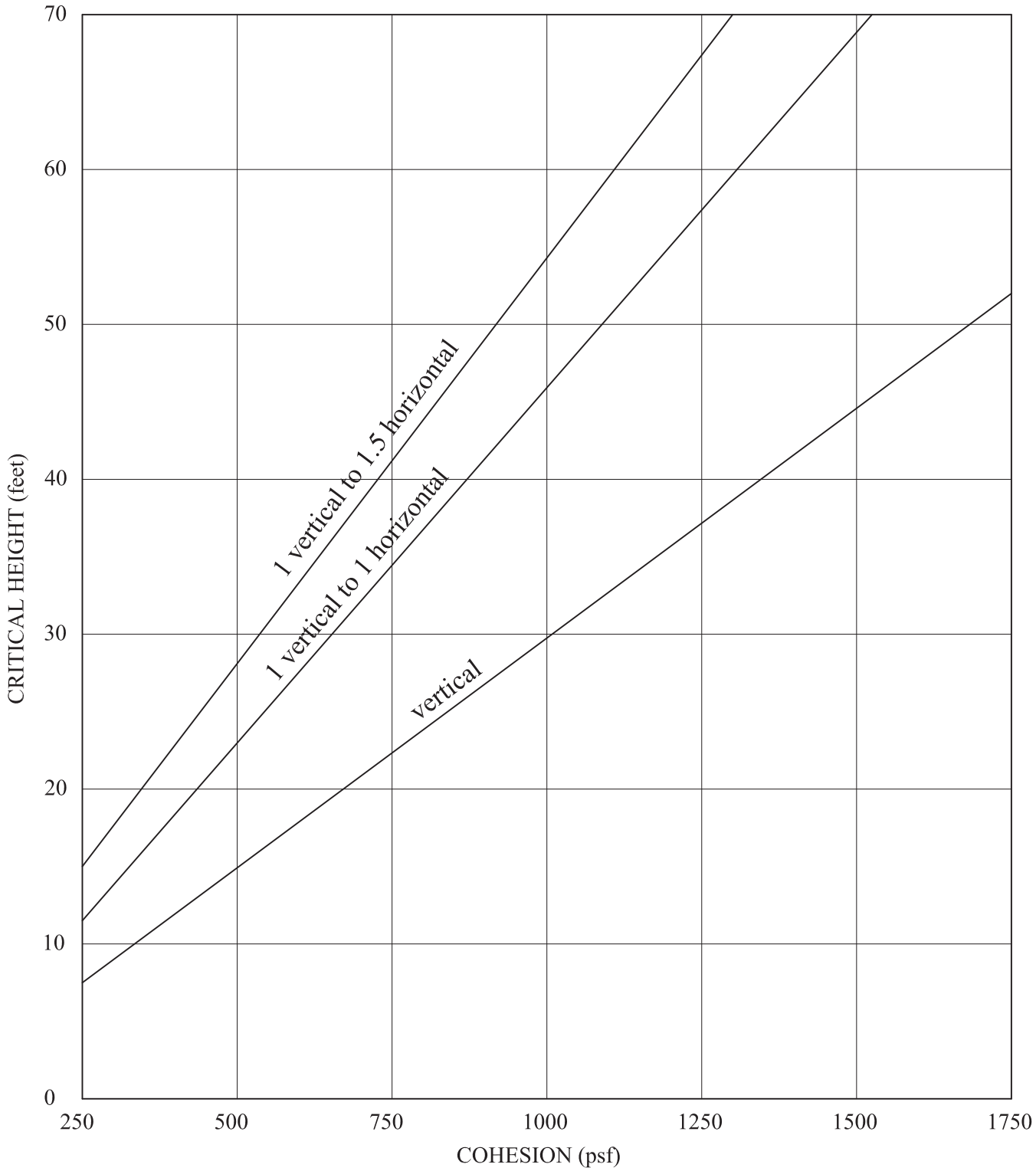
Critical Heights of Cut Slopes in Nonfissured Clays



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.

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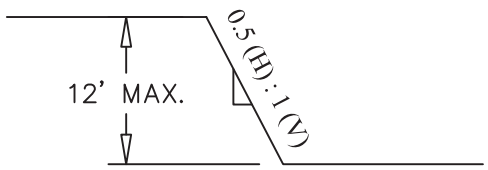
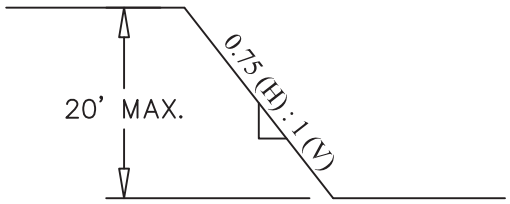
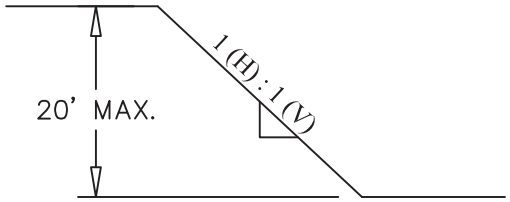
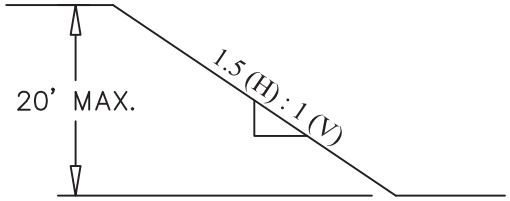
MAXIMUM ALLOWABLE SLOPES

	SHORT TERM	LONG TERM
TYPE A SOILS		
TYPE B SOILS	N/A	
TYPE C SOILS	N/A	

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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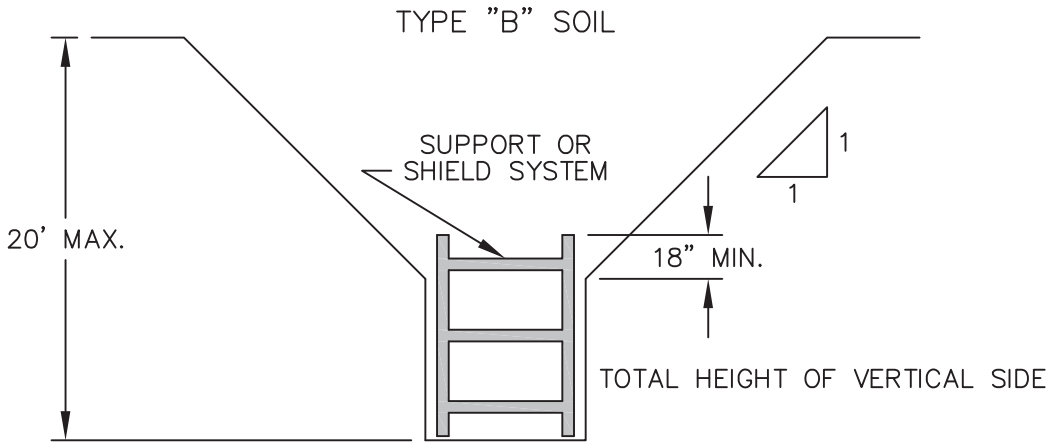
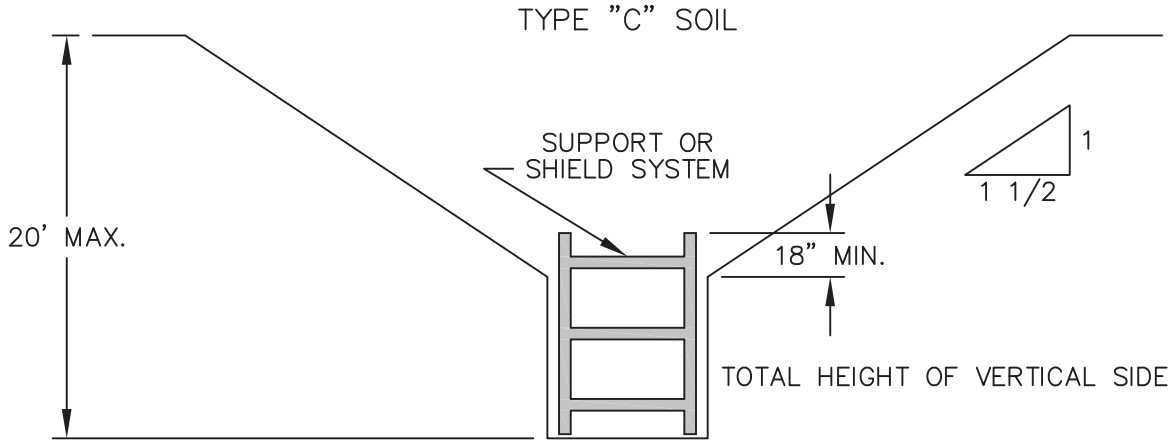
A COMBINATION OF BRACING AND OPEN CUTS





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

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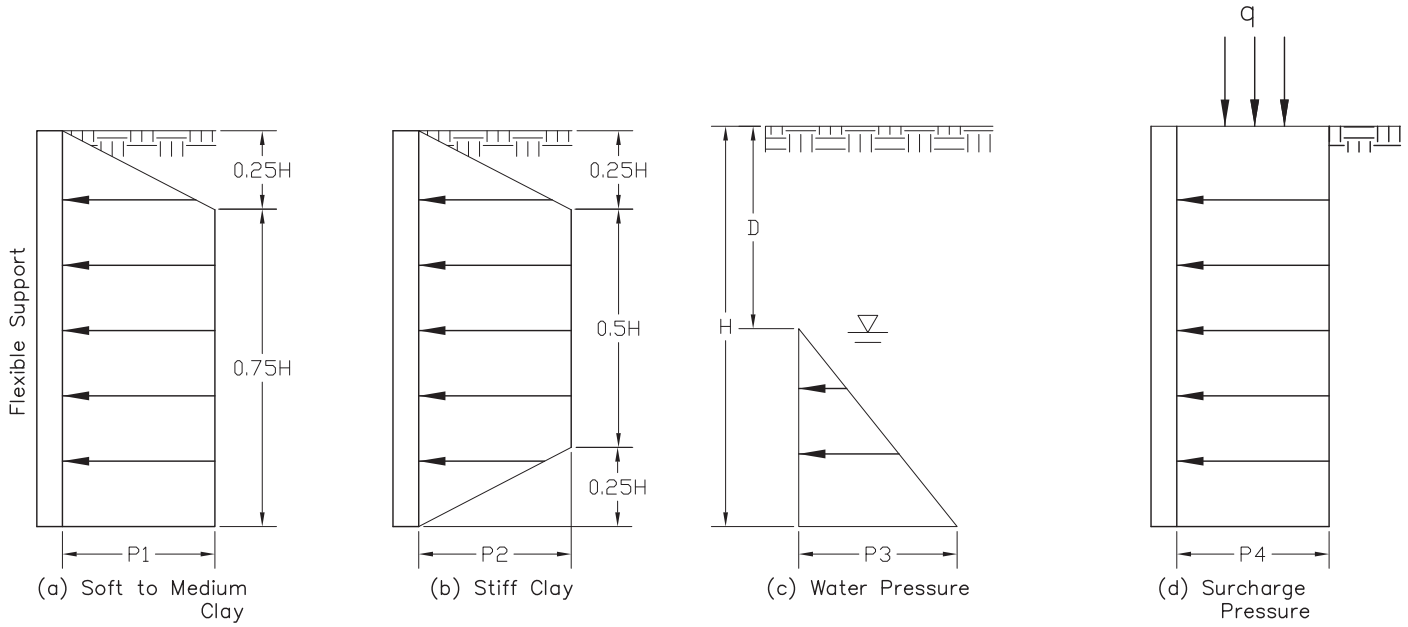
LATERAL PRESSURE DIAGRAMS
FOR OPEN CUTS IN COHESIVE SOIL - LONG TERM CONDITIONS



Empirical Pressure Distributions

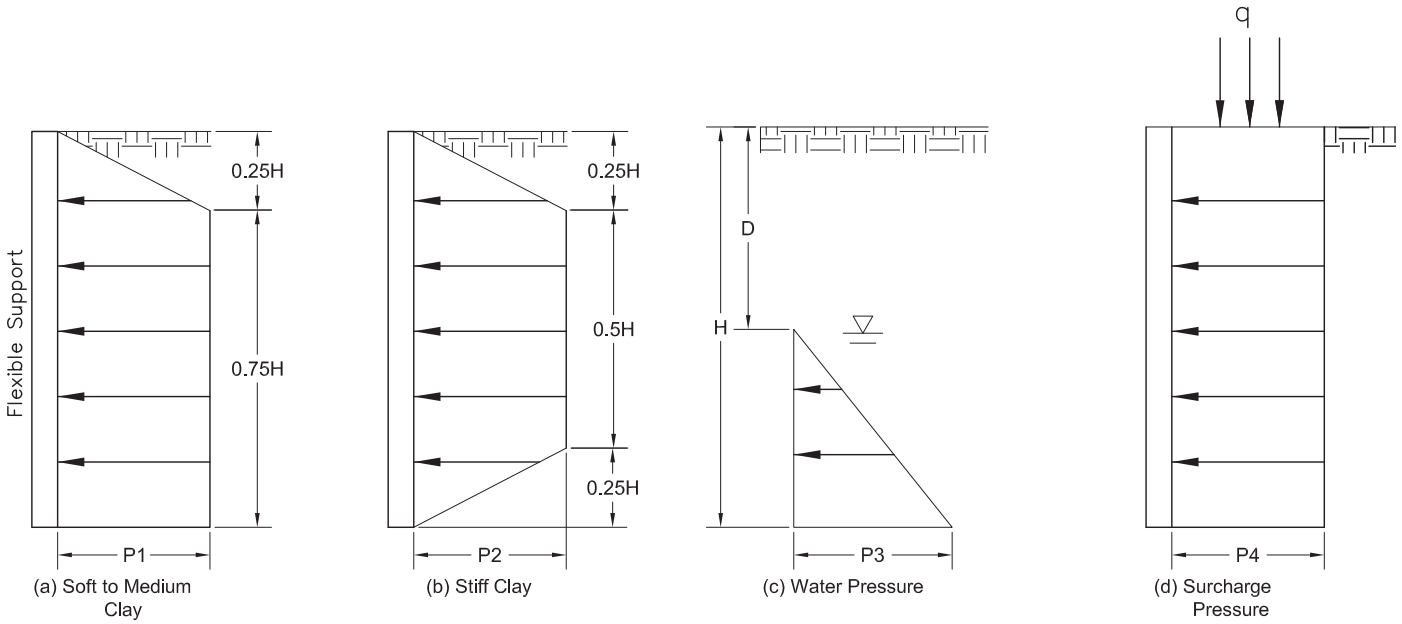
Where:
H = Total excavation depth, feet
D = Depth to water table, feet
P1 = Lateral earth pressure = γH-4C, psf
P2 = Lateral earth pressure = 0.4γH, psf
P3 = Water pressure = γ_w (H-D), psf
P4 = Lateral earth pressure caused by surcharge = qK_a, psf
γ = Effective unit weight of soil, pcf
γ_w = Unit weight 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.

AYLES ENGINEERING CORP.

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



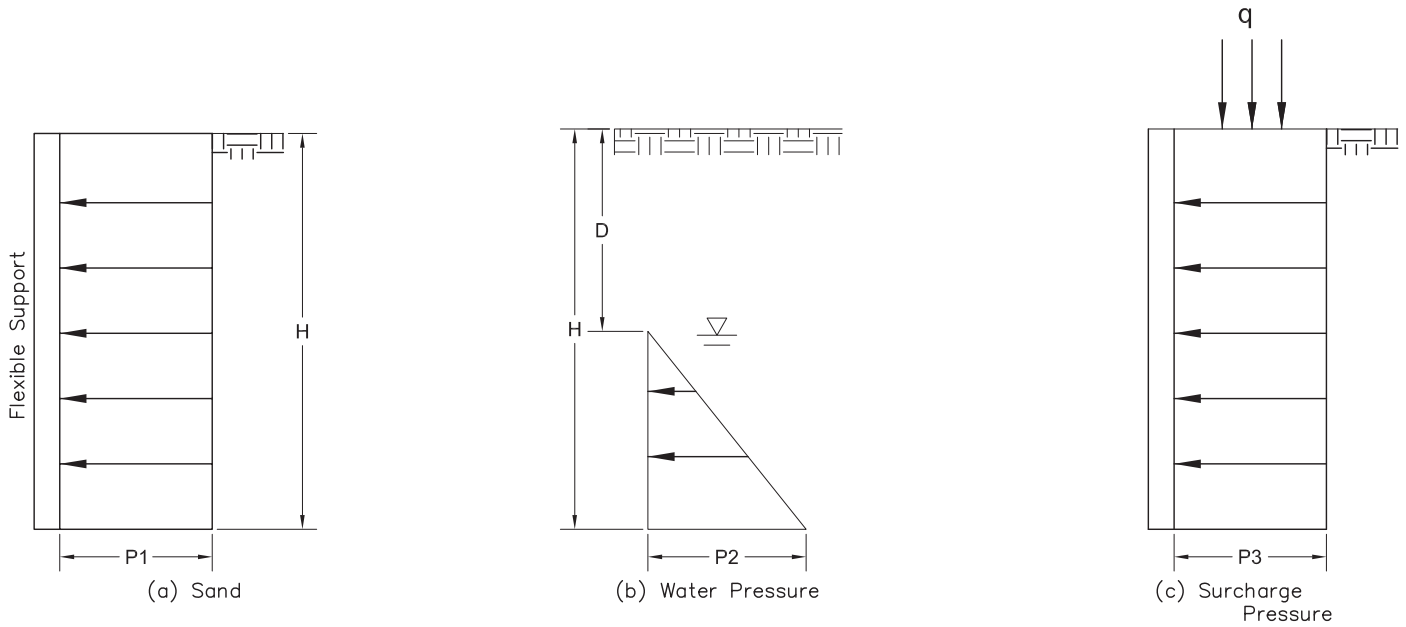
Empirical Pressure Distributions

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.

LATERAL PRESSURE DIAGRAMS
FOR OPEN CUTS IN SAND



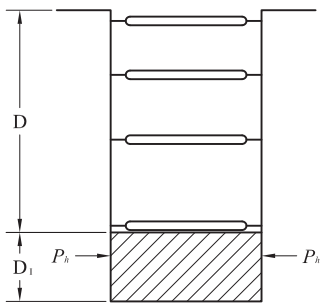
Empirical Pressure Distributions

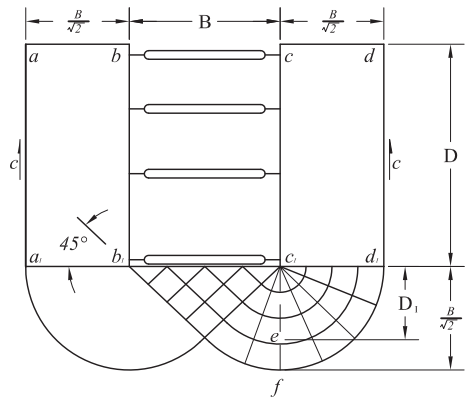
Where:
H = Total excavation depth, feet
D = Depth to water table, feet
P1 = Lateral earth pressure = $0.65*\gamma HK_a$, psf
P2 = Water pressure = γ_w (H-D), psf
P3 = Lateral earth pressure caused by surcharge = qK_a, psf
γ = Effective unit weight of soil, pcf
γ_w = Unit weight of water, pcf
K_a = Coefficient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

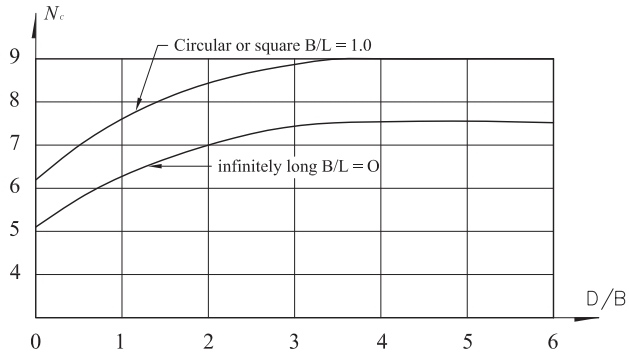
$$\textit{Depth of Buried Length, } (D_1) = \frac{1.5(\gamma D+q)-NcC}{(C/B)-0.5\gamma} \; ; D_1 \geq 5\ ft.$$

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 G

Preliminary Quantity Take-Off and Cost Estimate

Buffalo Speedway Preliminary Drainage Capacity Check
HDR Engineering, Inc.
8/9/2018

Note: The City of Houston drainage area upstream of Bissonnet covers an area of about 130 acres, but is represented in this spreadsheet as covering an area of only 47.35 acres, a value which yields a 2-year peak flow rate consistent with the capacity of the existing single 66-inch pipe that enters West U from the north. This simulates the flow restriction created by the 66-inch pipe, which lacks full 2-year capcity.

	Drainage Area & 2-Year Peak Flow Rate								Existing Storm Sewer						Proposed Storm Sewer						
Location	DDA	∑DA	Length	∑Length	Tc	I_2	C	Q_2	Number	Diameter	Area/Pipe	Total Area	Capacity	Diff.	Number	Span/Dia	Span	Area/Pipe	Total Area	Capacity	Diff.
Bissonnet	47.35	47.35	2720	2720	37.09	2.74	0.55	71.25	1	66	23.76	23.76	71.27	0.03	1	6	-	28.26	28.26	84.78	13.53
Albans	39.70	87.05	720	3440	41.09	2.56	0.55	122.69	1	66	23.76	23.76	71.27	-51.42	1	8	5	40.00	40.00	120.00	-2.69
Nottingham	23.31	110.36	730	4170	45.15	2.41	0.55	146.30	1	66	23.76	23.76	71.27	-75.03	1	8	6	48.00	48.00	144.00	-2.30
Tangley	35.44	145.80	710	4880	49.09	2.28	0.55	182.88	1	66	23.76	23.76	71.27	-111.60	1	8	8	64.00	64.00	192.00	9.12
Georgetown	24.69	170.49	750	5630	53.26	2.16	0.55	202.49	1	72	28.27	28.27	84.82	-117.67	1	9	8	72.00	72.00	216.00	13.51
Amherst	25.47	195.96	330	5960	55.09	2.11	0.55	227.48	2	66	23.76	47.52	142.55	-84.93	2	8	5	40.00	80.00	240.00	12.52
University	21.82	217.78	810	6770	59.59	2.00	0.55	239.65	2	66	23.76	47.52	142.55	-97.10	2	8	5	40.00	80.00	240.00	0.35
Duke	48.95	266.73	660	7430	63.26	1.92	0.55	281.70	2	66	23.76	47.52	142.55	-139.15	2	8	6	48.00	96.00	288.00	6.30
Pittsburgh	47.07	313.80	640	8070	66.81	1.85	0.55	319.09	2	66	23.76	47.52	142.55	-176.54	2	8	7	56.00	112.00	336.00	16.91
Carnegie	40.57	354.37	660	8730	70.48	1.78	0.55	347.16	2	66	23.76	47.52	142.55	-204.61	2	8	7	56.00	112.00	336.00	-11.16
Cason	41.80	396.17	520	9250	73.37	1.73	0.55	377.33	2	66	23.76	47.52	142.55	-234.78	2	8	8	64.00	128.00	384.00	6.67
Bellaire	4.99	401.16	390	9640	75.53	1.70	0.55	374.33	2	66	23.76	47.52	142.55	-231.78	2	8	8	64.00	128.00	384.00	9.67
Outfall	28.89	**430.05**	650	10290	79.15	1.64	0.55	**388.25**	2	66	23.76	47.52	142.55	-245.70	2	8	8	64.00	128.00	384.00	-4.25

NOTES

Preliminary Cost Estimate for Buffalo Speedway Storm Sewer Infrastructure

Number	Span/Dia	Span	Map Length	Total Length	Unit Price	Cost	West U Cost
1	6	-	520	520	$485	$252,200	$252,200
1	8	5	720	720	$660	$475,200	$475,200
1	8	6	730	730	$770	$562,100	$562,100
1	8	8	710	710	$920	$653,200	$653,200
1	9	8	750	750	$940	$705,000	$705,000
2	8	5	330	660	$660	$435,600	$435,600
2	8	5	810	1,620	$660	$1,069,200	$1,069,200
2	8	6	660	1,320	$770	$1,016,400	$1,016,400
2	8	7	640	1,280	$840	$1,075,200	$1,075,200
2	8	7	660	1,320	$840	$1,108,800	$1,108,800
2	8	8	520	1,040	$920	$956,800	$956,800
2	8	8	540	1,080	$920	$993,600	$993,600
2	8	8	650	1,300	$920	$1,196,000	$1,196,000
City of Houston Paving							$710,000
Sub-Total for Box Culverts			8240.00			**$10,499,300**	**$11,209,300**
Contingency for Inlets & Manholes					**7.00%**	**$734,951**	**$784,651**
Sub-Total						**$11,234,251**	**$11,993,951**
Contingency for Quantity					**10.00%**	**$1,123,425**	**$1,199,395**
Sub-Total						**$12,357,676**	**$13,193,346**
Engineering					**15.00%**	**$1,853,651**	**$1,979,002**
Estimated Total Cost						**$14,211,328**	**$15,172,348**

City of Houston 2018 Box Culvert Prices

263138	8x5 RCB	LF	$660
263139	8x6 RCB	LF	$770
263140	8X7 RCB	LF	$840
263141	8x8 RCB	LF	$920
263142	9X5 RCB	LF	$710
263143	9x6 RCB	LF	$780
263144	9X7 RCB	LF	$850
263145	9X8 RCB	LF	
263146	9X9 RCB	LF	$960
263147	10X5 RCB	LF	$850
263148	10X6 RCB	LF	$880
263149	10X7 RCB	LF	
263150	10X8 RCB	LF	$960
263151	10X9 RCB	LF	$1,130
263152	10X10 RCB	LF	$1,300
263153	11X4 RCB	LF	
263154	11X6 RCB	LF	
263155	11X8 RCB	LF	
263109	72-inch RCP	LF	$485

TxDOT Intensity Equation

$$I = \frac{b}{(t_c + d)^e}$$

COH Tc = 15 + 10($A^{0.1761}$)

Tc values are based on time of travel with Tc values are based on time of travel with storm sewer velocity of 3 feet per second. The Tc at the most upstream inlet at the upper end of the system is computed using the City of Houston eqn for 90 acres. Intensities are computed using the 2-year eqn from the TxDOT Hydraulic Manual.

The drainage area is set equal to the value that produces a 2-year flow rate equal to the capacity of the existing 66" RCP at the upstm end of the system with V = 3 ft/sec.

Preliminary Opinion of Probable Constuction Cost for West University Place: Buffalo Speedway

STREET NAME	**Buffalo Speedway**			
LENGTH (FT)	8240		1	*= 2 if Boulevard Street*
WIDTH (FT)	25		4	*= No. of Driveways*

ITEM NO.	ITEM DESCRIPTION	UNIT	QUAN.	UNIT PRICE	TOTAL AMOUNT	
GENERAL ITEMS						
1	Traffic Control and Regulation, including signs, barrels, barricades, and flagmen	L.S.	1	$ 50,000.00	$ 50,000.00	
2	Temporary Sediment Control including Inlet protection barrier, Stage I and II inlets and existing inlets, including filter fabric fence, gravel bags, repair and replacement, maintenance and removal of sediments, complete in place the sum of:	L.S.	1	$ 25,000.00	$ 25,000.00	
				SUB-TOTAL GENERAL ITEMS:	**$ 75,000.00**	
PAVING ITEMS (CITY OF HOUSTON SOUTH OF BELLAIRE BOULEVARD)						
3	Existing concrete pavement removal, complete in place the sum of:	S.Y.	6,000	$ 13.00	$ 78,000.00	
4	6" thick reinforced concrete pavement, including reinforcement, joints and grading, complete in place the sum of:	S.Y.	6,000	$ 70.00	$ 420,000.00	
5	8" lime stabilized subgrade, including grading, mixing, compacting and curing, complete in place the sum of:	S.Y.	6,000	$ 12.00	$ 72,000.00	
6	Lime for lime stabilized subgrade (7% minimum by dry weight), complete in place the sum of:	TON	152	$ 165.00	$ 25,080.00	
7	6" concrete curb, including reinforcement and joints, complete in place the sum of:	L.F.	3,000	$ 8.00	$ 24,000.00	
8	6" concrete driveway, including blockout, reinforcement and joints, complete in place the sum of:	S.Y.	134	$ 75.00	$ 10,050.00	
9	5' concrete sidewalk, complete in place the sum of:	S.F.	100	$ 13.00	$ 1,300.00	
10	Concrete curb ramp per ADA requirements, complete in place the sum of:	EA.	0	$ 2,000.00	$ -	# of Int., St. cont.
				SUB-TOTAL PAVING ITEMS:	**$ 630,430.00**	# of Int, St. ends
DRAINAGE ITEMS						
11	Remove existing storm sewer pipe, all sizes and all depths, complete in place the sum of:	L.F.	-	$ 20.00	$ -	
12	Remove existing storm sewer box, all sizes and all depths, complete in place the sum of:	L.F.	-	$ 40.00	$ -	
13	Remove existing storm sewer inlets, complete in place the sum of:	EA.	-	$ 370.00	$ -	
14	Remove existing storm sewer manhole, complete in place the sum of:	EA.	-	$ 390.00	$ -	
15	72" RCP, all depths, including foundation and backfill, complete in place the sum of:	L.F.	520	$ 485.00	$ 252,200.00	
16	8 x 5 RCB, all depths, including foundation and backfill, complete in place the sum of:	L.F.	3,000	$ 660.00	$ 1,980,000.00	
17	8 x 6 RCB, all depths, including foundation and backfill, complete in place the sum of:	L.F.	2,050	$ 770.00	$ 1,578,500.00	
18	8 x 8 RCB, all depths, including foundation and backfill, complete in place the sum of:	L.F.	4,130	$ 920.00	$ 3,799,600.00	
19	9 x 8 RCB, all depths, including foundation and backfill, complete in place the sum of:	L.F.	750	$ 940.00	$ 705,000.00	
20	8 x 7 RCB, all depths, including foundation and backfill, complete in place the sum of:	L.F.	2,600	$ 840.00	$ 2,184,000.00	
21	Type "BB" Inlet, all depths, including foundation and backfill, complete in place the sum of:	EA.	-	$ 4,000.00	$ -	
22	Type "D" Inlet, all depths, including foundation and backfill, complete in place the sum of:	EA.	-	$ 3,500.00	$ -	
23	Manholes, all depths, including foundation and backfill, complete in place the sum of:	EA.	20	$ 3,470.00	$ 69,400.00	
24	Reinforced precast junction box, including excavation, bedding and backfill, connection to existing system, complete in place, the sum of:	EA.	35	$ 4,500.00	$ 157,500.00	
25	Trench safety for all storm sewers 5' - 10' deep, including installation, operation and removal, complete in place the sum of:	L.F.	4120	$ 2.00	$ 8,240.00	
26	Trench safety for all storm sewers 10' - 15' deep, including installation, operation and removal, complete in place the sum of:	L.F.	4120	$ 2.50	$ 10,300.00	
				SUB-TOTAL DRAINAGE ITEMS:	**$ 10,744,740.00**	
				ESTIMATED PROBABLE COST OF CONSTRUCTION:	**$ 11,450,170.00**	
				15% CONTINGENCY:	**$ 1,717,525.50**	
				TOTAL ESTIMATED PROBABLE COST OF CONSTRUCTION:	**$ 13,167,695.50**	
	Design Engineering Services (12%)				**$ 1,580,123.46**	
	Bid Phase Services (1%)				**$ 131,676.96**	
	Construction Administration Services (1%)				**$ 131,676.96**	
	Surveying Services (1%)				**$ 131,676.96**	
	Geotechnical Services				**$ 30,000.00**	16 No. of borings
	Urban Forester				**$ 13,600.00**	
	OPCC INCLUDING PROFESSIONAL SERVICES:				**$ 15,186,449.83**	

Engineering Fee Assumptions:

[1] Geotechnical services fee is estimated based on $110/VF. The average depth of borehole is assumed as 15 VF. Borehole is assume to be placed every 500 LF.

[2] Urban Forester service fee is estimated based on $1.50/LF.