STUDY PHASE REPORT

FOR

PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS

WITHIN HARRIS COUNTY PRECINCT 4

UPIN: 19104MF16Q01

Prepared For:

Harris County Engineering Department

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Houston, Texas 77002-1819

Prepared By:

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STATE OF TEXAS
DELEA R. COOPER
104591
LICENSED
PROFESSIONAL ENGINEER
8/23/2021

August 2021

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1 EXECUTIVE SUMMARY

Bleyl Engineering has performed engineering services for the study of the Prestonwood Forest Subdivision drainage ditch system to provide recommendations to improve the conveyance, capacity, and maintenance of the ditch system. This drainage ditch system, approximately 4,000 feet long, is located in northwestern Harris County along Hargrave Road and the western boundary of the BNSF Railroad right-of-way. The ditch system currently suffers from overgrown vegetation and the lack of regular maintenance and no longer provides sufficient capacity for the conveyance of storm runoff from the surrounding developments.

Data provided by the Surveying, Environmental, Geotechnical Engineering, and Drainage consultants detailed the existing conditions of the ditch system and provided the following determinations:

- The presence of existing utilities that conflict with the proposed ditch design
- Minimum slope of the ditch to be 0.10% and maximum side slopes to be 2H:1V
- Minimum 5-inch thick concrete driveways
- The proposed design of the ditch provides no adverse impact to the receiving waterways

The proposed design for the rehabilitation of the ditch system includes:

- Clean and de-muck the ditches
- Remove existing structures (nine concrete driveways, culverts, and slope paving)
- Install 24” RCP culverts and construct new concrete driveways per current design standards
- Re-establish the ditch slope at 0.10% with maximum side slopes at 2H:1V
- Install dual 18-inch RCP and 5-inch thick concrete slope paving
- Relocate and/or replace existing mailboxes per current design standards

1.1 Introduction

On June 9, 2020, the Harris County Commissioner's Court approved a Professional Engineering Services Agreement between Bleyl Engineering (Bleyl) and Harris County Precinct Four (Precinct). This agreement authorized Bleyl to provide engineering services for the Study, Design, and Bidding of the necessary drainage improvements within the Prestonwood Forest Subdivision located within Harris County Precinct 4 (UPIN 19104MF16Q1).

1.2 Purpose and Scope

The purpose of this Study Report (SR) is to provide the Precinct with design recommendations and construction cost estimates for improvements to existing drainage ditches within and surrounding the Prestonwood Forest Subdivision. These improvements that will aid in reducing the flood risk within the subdivision. The scope of the improvements includes the clearing, grubbing, reshaping, and rehabilitation of drainage ditches along Hargrave Road and the BNSF Railroad.

Study Phase (pre-design) Services include Survey, Geotechnical, Environmental, and Drainage analyses and investigations. Findings from these investigations will be presented in this study report and used to determine the best and most economical option for rehabilitation of the drainage ditch systems.

1.3 Project Location and History

The Prestonwood Forest Subdivision project area, located in Northwest Harris County, is within Harris County Precinct No 4, east of State Highway 249 and approximately 500 feet west of the Hargrave Road and Cutten Road intersection; as shown in **Exhibit 1 – Location Map**. More specifically, the project area consists of the existing Hargrave Road north roadside drainage ditch and a connecting drainage ditch that parallels Cutten Road and is located within the BNSF Railway, Inc (BNSF) right-of-way (ROW).

The project location can be found on Key Map 370A. The Hargrave Road north roadside ditch is located within the Prestonwood Forest Municipal Utility District (MUD). The connecting drainage ditch (BNSF ditch), located just outside the MUD boundary line, extends northwest towards Cypresswood Drive. The BNSF ditch was constructed in 1990 and was allowed by BNSF to be located within the most western 30 feet of the 100-foot BNSF ROW. A drainage easement was not provided by BNSF.

1.3.1 Survey of Existing Conditions and Topographic Investigation

A topographic field survey of the project area, shown in **Exhibit 5**, was performed and prepared by Hovis Surveying Company, Inc. The survey was prepared according to Harris County and Texas Land Surveys standard Category 5, Condition 2. The public right-of-way survey information provided was prepared per Texas Land Surveys standard Category 1B, Condition 2. The topographic survey was accepted by the Precinct on October 20, 2020.

The topographic survey details the project area which is comprised of an approximate 4,000 linear-foot open-ditch drainage system. The upstream portion of the drainage system is within the Hargrave Road north roadside ditch. This ditch, approximately 900 feet long, contains several driveway and culvert locations and does not provide optimum stormwater conveyance and capacity. The lack of maintenance during the service life of the ditch has resulted in overgrown brush and roots, silted culverts, reverse grades, reduced ditch capacity and flooding of the nearby structures. Existing ditch cross-sections are found in **Exhibit 2.**

Runoff from the subdivision flows into the Hargrave Road roadside ditch system, drains east and continues, turning northward into the BNSF ditch, continuing to the downstream end of the system and ultimately to the Harris County Flood Control District (HCFCD) Unit K100-00-00 (Cypress Creek). The survey shows the BNSF ditch system to be approximately 3,100 feet long. The ditch system is contained within a 100-foot BNSF railway easement that parallels Cutten Road and is bordered by the Prestonwood Forest Subdivision to the west.

Per the topographic survey, Hargrave Road is a public road with a 60-foot right-of-way (ROW). The project scope does not require widening of the ROW. Hargrave Road contains various utilities that serve the Prestonwood Forest Subdivision; including water, gas, telecommunication, and overhead electric power transmission lines. These utilities, as depicted in the topographic survey, were provided per a Level B Subsurface Utility Engineering study.

1.3.2 Environmental Due Diligence Report

The Environmental Due Diligence report (EDD) was prepared by the Harris County Engineering Department and is provided as **Appendix A**. The EDD report was performed as a cursory screening of the site for the presence of significant environmental concerns. Several sites, such as dry cleaners and medical complexes, within a mile radius of the project site were noted in the report as possible concerns.

- The onsite investigation found no evidence of significant environmental concerns.
- The report concluded that these sites are located a significant distance from the proposed work and/or do not conduct activities likely to affect the project site.
- No further environmental investigation of the site was recommended or required.

1.3.3 Geotechnical Report

The geotechnical engineering report, shown in **Appendix B,** was prepared by Gorrondona Engineering Services, Inc. The report was approved and accepted by the Precinct on August 25, 2020. The report details the results of the evaluation of soil and groundwater conditions and provides design recommendations for the rehabilitation of the drainage ditches within the project area. The scope of study for this report was restricted to the drainage ditch along Hargrave Road, as required by the Precinct.

Subsurface conditions were defined using three 15-foot boring samples; namely B-01 thru B-03. Soil materials encountered at a depth of from below the pavement to 2 feet were sandy

silty clay (CL-ML). From depths of 2 feet to 15 feet, the soil materials were determined to be sandy lean clay (CL) with some stiff fat clay with sand (CH).

There was no groundwater encountered during the initial and 15-minute interval auger drilling. Long-term groundwater monitoring could yield different results, but is beyond the scope of this project. It is noted that groundwater level can fluctuate throughout the year with variations in precipitation. If groundwater is encountered during excavation activities, dewatering to bring the groundwater below the bottom of excavations may be required.

The report provides the following recommendations:

- The proposed drainage ditch slopes to be constructed at no steeper than 2H:1V
- Proposed concrete driveways to be minimum 5-inch thick

All excavation operations and the installation of new culverts and residential driveways should be carried out in accordance with OSHA standards and the Harris County standard specifications.

1.3.4 Drainage Impact Analysis

A drainage impact analysis (DIA) report of the existing drainage conditions for the project area is provided in **Appendix C** and was performed by Freese and Nichols, Inc. The DIA was prepared per the Harris County Flood Control District (HCFCD) Policy, Criteria, and Procedure Manual. The HCFCD provided a letter of no objection (INO Letter), as shown in **Appendix D**, to the Harris County Permits Division on March 2, 2021; upon which, the report was approved and accepted by the Precinct (HCFCD Project #2101270030). The intent of this Drainage Impact Analysis (DIA) is to demonstrate that the improvements proposed for the ditch rehabilitation project will not have an adverse impact on the receiving stream, Cypress Creek.

Both the Hargrave Road ditch and the BNSF ditch suffer from the lack of maintenance and no longer provide adequate capacity, causing several homes to flood during recent storm events. The proposed project will regrade both ditches, remove vegetation, install new culverts and underground storm sewer pipe so to improve the conveyance and capacity of the ditch system.

The DIA details the results of the hydrologic (HEC-HMS) and hydraulics (HEC-RAS) models, peak flows, and water surface elevation before and after the project improvements. Using the results of the modeling, the DIA concludes that the proposed project will cause no adverse impact to flood hazard conditions on the receiving waterways for storm events up to and including the 100-year Atlas 14 storm event.

1.3.5 Utility Conflicts

The Utility Conflict Table, shown in **Exhibit 3**, lists existing utilities that potentially conflict with the proposed project:

- CenterPoint Energy Electric – Overhead electrical power
- CenterPoint Energy Gas – 4" gas line
- Prestonwood Forest MUD - 8" water lines
- AT&T – Underground telecom cable
- Comcast – Underground telecom cable
- Crown Castle Fiber - Underground fiber optic cable

The Precinct will coordinate with the utility owners during the design and construction phases to relocate or abandon utilities that conflict with the proposed improvements.

The Precinct will also coordinate with the homeowners of the lots facing Hargrave Road to remove and/or relocate:

- Trees
- Wooden retaining walls
- mailboxes

1.4 Proposed Drainage Improvements

The proposed ditch rehabilitation project has been designed per recommendations provided in the various consultant reports. These improvements will follow Harris County standards and specifications, unless existing conditions prohibit such. The following are significant components of the proposed drainage improvements.

- The existing ROW of Hargrave Road is 60 feet. No additional ROW is proposed.
- The Hargrave Road roadside ditch will be stripped and cleaned of vegetation and overgrowth.
- The Hargrave Road northern roadside ditch will be regraded with a slope of 0.10% to 1.0%
- Existing 24-inch reinforced concrete pipe (RCP) driveway culverts within the Hargrave Road ditch will be removed and replaced with like culverts at 0.10% slope.
- 100 linear feet of dual 18-inch RCP underground storm sewer will be installed. A Type "A" inlet will be installed midpoint of one of the dual 18-inch pipes to capture overland sheet flow.
- The Hargrave Road ditch side-slopes will be regraded at a max slope of 2:1 to maximize capacity.
- The railroad ditch will be stripped and cleaned of vegetation and overgrowth
- The railroad ditch will be regraded at 0.10%.
- The railroad ditch side slopes will be cleaned and stabilized with max slopes generally at max 2:1, but will be steeper in some areas depending upon the elevation of adjacent property.

It is important to note that due to limitations of the existing conditions, the design of the Hargrave Road roadside ditch could not meet all Harris County standards. The slopes of the 24-inch driveway culverts are designed flatter than desired in order to maintain a safe ditch depth of four (4) feet or less along vehicular road. Also, the dual 18-inch underground RCP will be buried with approximately ten (10) inches of cover, which is shallower than desired, but is also required to maintain the maximum 4-foot ditch depth.

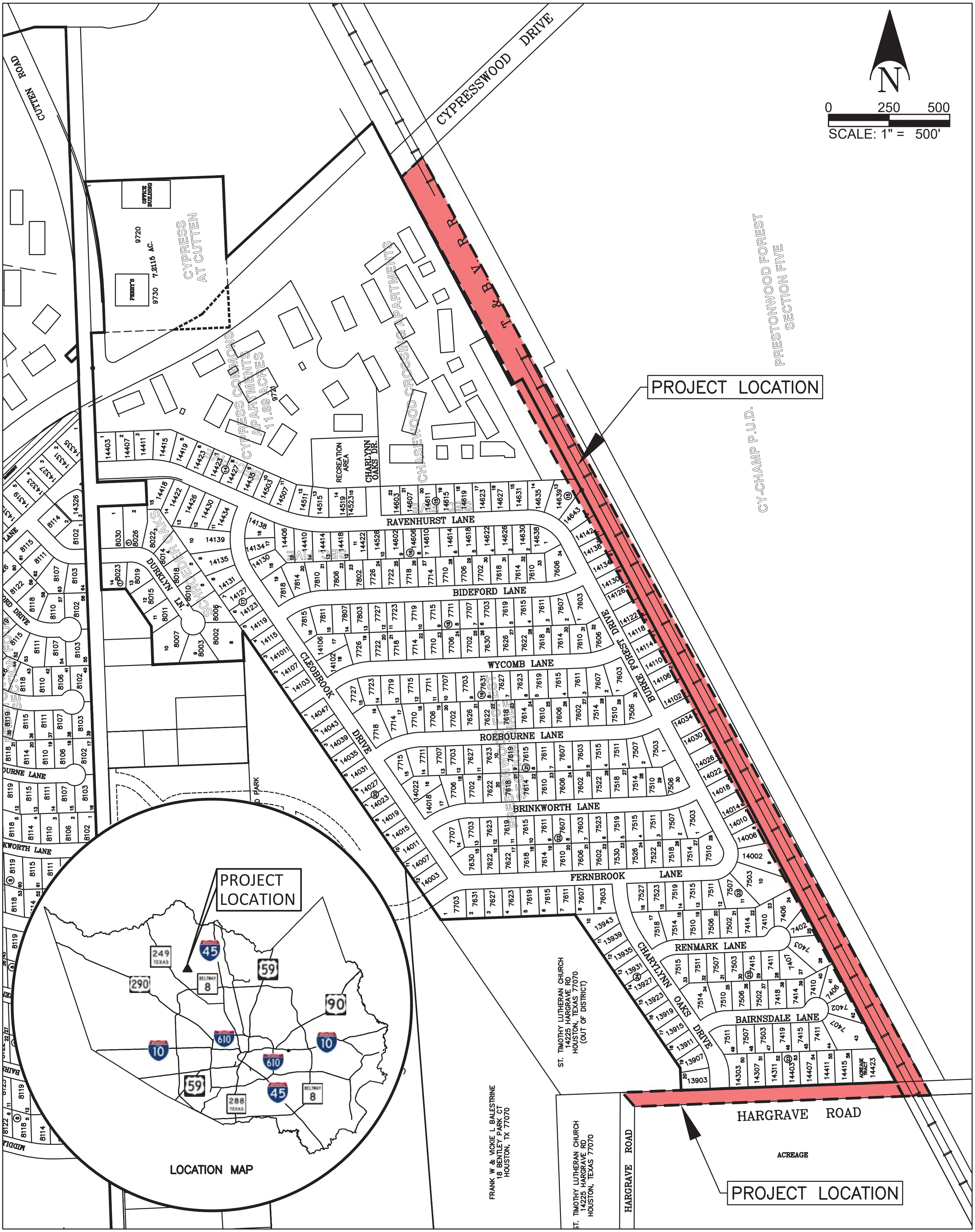
Proposed ditch cross-sections are shown in **Exhibit 2**.

1.4.1 Proposed Construction Cost Estimate

The estimate of construction costs for the proposed drainage improvements is estimated at $665,200. A breakdown of construction costs is shown in **Exhibit 4**.

Exhibit 1

Location Map

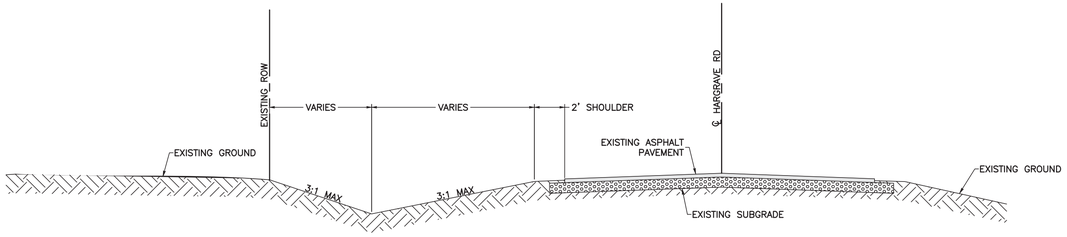


N
0 250 500
SCALE: 1" = 500'
CYPRESSWOOD DRIVE
CUTTEN ROAD
T. & B. Y. R. R.
PROJECT LOCATION
PRESTONWOOD FOREST SECTION FIVE
CY-CHAMP P.U.D.
CYPRESS AT CUTTEN
9720
9730 7.2115 AC.
OFFICE BUILDING
PERRY'S
CYPRESS COMMONS APARTMENTS 11.89 ACRES
CHASEWOOD CROSSING APARTMENTS
RECREATION AREA
CHARLYNN OAKS DR.
RAVENHURST LANE
BIDEFORD LANE
WYCOMB LANE
ROEBOURNE LANE
BRINKWORTH LANE
FERNBROOK LANE
RENMARK LANE
BAIRNSDALE LANE
CLEOBROOK DRIVE
BURKE FOREST DRIVE
CHARLYNN OAKS DRIVE
DURKLYN LN.
HARGRAVE ROAD
ACREAGE
ACREAGE TRACT
ST. TIMOTHY LUTHERAN CHURCH 14225 HARGRAVE RD HOUSTON, TEXAS 77070 (OUT OF DISTRICT)
ST. TIMOTHY LUTHERAN CHURCH 14225 HARGRAVE RD HOUSTON, TEXAS 77070
FRANK W & VICKIE L BALESTRINE 18 BENTLEY PARK CT HOUSTON, TX 77070
PROJECT LOCATION
249 TEXAS
45
59
290
BELTWAY 8
90
610
10
288 TEXAS
LOCATION MAP

Exhibit 2

Existing & Proposed Cross-Sections

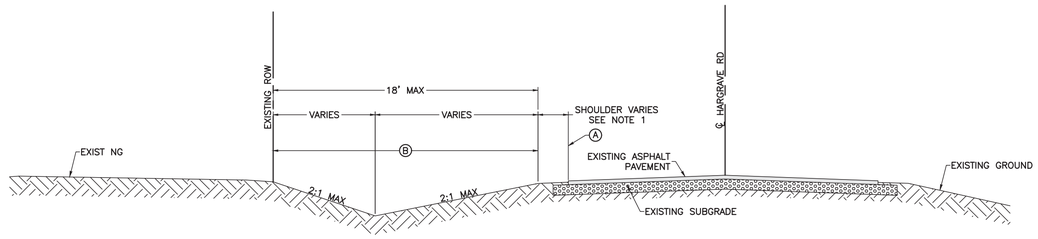
S:\2566 Harris County Engineering Department\12635 Prestonwood Forest Subdivision Drainage Improvements\04 CAD\Design Phase\9 EXISTING AND PROPOSED TYPICAL SECTIONS.dwg



EXISTING HARGRAVE ROAD DRAINAGE DITCH TYPICAL SECTION

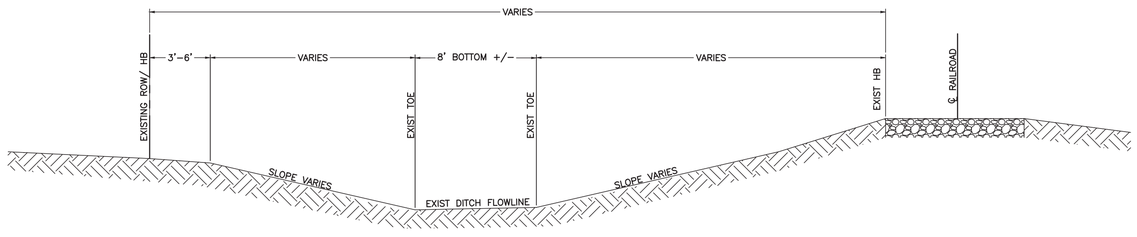
Ⓐ PROPOSED SOD– 1 STRIP (16") AT EDGE OF EXISTING ROAD

Ⓑ HYDROMULCH FROM EDGE OF SOD TO ROW

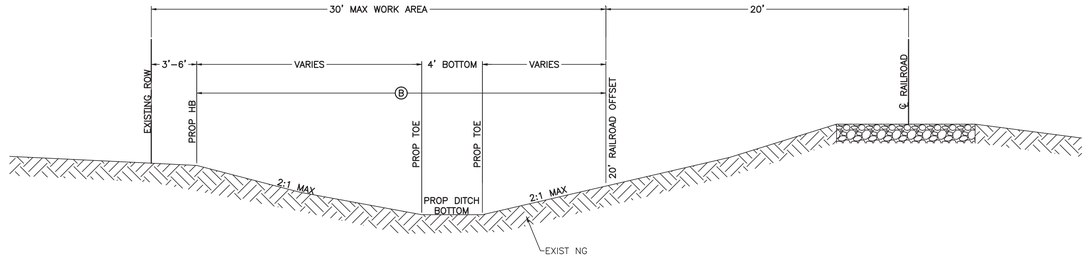


PROPOSED HARGRAVE ROAD DRAINAGE DITCH TYPICAL SECTION

NOTES:
1. SHOULDER VARIES FROM 1 FOOT AND 2 FOOT.



EXISTING BNSF DRAINAGE DITCH TYPICAL SECTION



PROPOSED BNSF DRAINAGE DITCH TYPICAL SECTION

NO.	REVISIONS	DATE	NAME
1			
2			
3			
4			
5			

HARRIS COUNTY ENGINEERING DEPARTMENT

BLEYL ENGINEERING
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AUSTIN BRYAN CONROE HOUSTON

STATE OF TEXAS · DELEA R. COOPER · 104591 · LICENSED · PROFESSIONAL ENGINEER

8/16/2021

PROJECT TITLE:	PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS–2018
SHEET DESCRIPTION:	EXISTING AND PROPOSED TYPICAL SECTIONS
DRAWN BY:	WSW
CK'D BY:	DC
SCALE:	1"=5'
DATE:	8/16/2021
SHEET NO:	9 / 40

Exhibit 3

Utility Conflict Table

Utility Contact/Conflict Table

Project Name: **Prestonwood Forest Subdivision Drainage Improvements**

Project Limits: Hargrave Road & BNSF RR Ditch

UPIN No. 19104MF16Q1

Consultant Name/Project Mgr: Bleyl Engineering - Delea Cooper, P.E.

No.	Beginning Station	Ending Station	Alignment / Street Name	Utility Type	Owner	Is facility located in an easement? Yes/No	Conflict Yes/No	Probed Yes/No	SUE (QL D, QL B, or No) Yes/No	Contact Name	Address	Phone No.	Email	Describe Conflict (if applicable)	Est. Cost	Reloc. Start Date	Reloc. Com. Date
1	2+30	13+92	Hargrave Road	Overhead Electrical	Centerpoint Energy Electrical	Yes	Yes	No	Yes	Marcus Williams	1111 Louisiana St, Houston, TX 77002	713-945-4997	marcus.williams@centerpointenergy.com	Ditch flowline regrading near power poles at 6+82, 9+43, 11+91, 13+53			
2	11+89	11+89	Hargrave Road	Overhead Electrical	Centerpoint Energy Electrical	No	No	No	Yes	Marcus Williams	1111 Louisiana St, Houston, TX 77002	713-945-4997	marcus.williams@centerpointenergy.com				
3	4+35	13+92	Hargrave Road	Underground Fiber Optic	Crown Castle Fiber	No	No	No	No	Adrian Jones		346-206-5125					
4	14+14	14+14	Hargrave Road	Underground Telecom Cable	Comcast Houston	No	No	No	No	Jeffrey Phelps	8590 West Tidwell Rd, Houston, TX 77040	281-624-3034	jeffrey_phelps@comcast.com				
5	2+30	13+55	Hargrave Road	Underground Telecom Cable	AT&T	Yes	Yes	No	Yes	Justin Rumsey	7602 Spring Cypress Rd, Spring, Texas 77379	832-728-3851	jr207H@att.com	Telecom lines could interfere with ditch flowline regrading			
6	4+85	4+85	Hargrave Road	Underground Telecom Cable	AT&T	Yes	Yes	No	Yes	Justin Rumsey	7603 Spring Cypress Rd, Spring, Texas 77379	832-728-3851	jr207H@att.com	Telecom lines could interfere with ditch flowline regrading			
7	4+88	4+88	Hargrave Road	Underground Telecom Cable	AT&T	Yes	Yes	No	Yes	Justin Rumsey	7604 Spring Cypress Rd, Spring, Texas 77379	832-728-3851	jr207H@att.com	Telecom lines could interfere with ditch flowline regrading			
9	5+08	7+53	Hargrave Road	4" Gas	Centerpoint Energy Gas	Yes	Yes	No	Yes	Russell Young	1111 Louisiana St, Houston, TX 77002	713-207-4606	russell.young@centerpointenergy.com	Possible service leads interfere with ditch flowline regrading			
10	2+30	13+52	Hargrave Road	8" Water Line	Prestonwood Forest UD	No	No	No	No	Mark Adam	400 Randal Way, Ste 300, Spring, Texas 77388	936-271-9602	mwadam@bleylengineering.com				
11	2+30	13+92	Hargrave Road	6" Sanitary Force Main	Harris County MUD No. 191	No	No	No	No	Rene Parsales	2200 Sciaca Rd, Spring, Texas 77373	281-924-7701	dispatch2@haysutility.com				
12	41+70	41+70	Drainage Ditch	Underground Telecom Cable	Comcast Houston	No	No	No	Yes	Jeffrey Phelps	8590 West Tidwell Rd, Houston, TX 77040	281-624-3034	jeffrey_phelps@comcast.com				
13	13+99	13+99	Drainage Ditch	Overhead Electrical	Centerpoint Energy Electrical	No	No	No	Yes	Marcus Williams	1111 Louisiana St, Houston, TX 77002	713-945-4997	marcus.williams@centerpointenergy.com				
14	14+12	14+12	Drainage Ditch	Overhead Fiber Optic	Crown Castle Fiber	No	No	No	No	Adrian Jones		346-206-5125					

Exhibit 4

Construction Cost Estimate

CONSTRUCTION COST ESTIMATE

Project:	**Prestonwood Forest Subdivision Drainage Improvements**
Limit From:	**Hargrave Rd**
Limit To:	**BNSF Railroad**
Proj Length:	**3800'**
Precinct:	**Four**
UPIN:	**19104MF16Q01**
Job No:	**This is the number avaiable when advertising project**
Prepared By:	**Bleyl Engineering**
Date:	**08/16/21**

Summary of Estimate		
Stage:		**1st Submittal**
Total Amount for Roadway:		**$665,200.00**
Total Amount for XXXX:		**$0.00**
Total Amount for XXXX:		**$0.00**
Total Amount for XXXX:		**$0.00**
Grant Total Amount:		**$665,200.00**
Contingencies:	**0%**	**$0.00**
Grand Total Project:		**$665,200.00**

ITEM NO.	SPEC NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
A	**SITE PREPARATION AND EARTHWORK**					
1	Drawing	Furnish, Install, and Remove Harris County Project Sign	EA	2.00	$1,000.00	$2,000.00
2	102	Clearing and Grubbing, including wood retaining wall encroachments	Sta	38.00	$3,200.00	$121,600.00
3	104	Removing Old Concrete (Pavement)	SY	250.00	$8.00	$2,000.00
4	104	Removing Old Concrete (Slope Paving)	SY	20.00	$10.00	$200.00
5	110	Hargrave Rd Ditch Excavation Including 3" Topsoil	CY	356.00	$10.00	$3,560.00
6	120	BNSF Railroad Ditch Excavation, Including 3" Topsoil	CY	1,502.00	$20.00	$30,040.00
7	465	Remove and Dispose of Existing Concrete or Metal Pipe (All Sizes)	LF	150.00	$13.00	$1,950.00
8	500	Remove & Relocate Traffic Signs, Mail Boxes and Roadway Signs	LS	1.00	$3,000.00	$3,000.00
					Subtotal of Item A	**$164,350.00**
B	**PAVING**					
9	530	Reinforced Concrete Driveways (6"), High Early Strength, including stabilized subgrade and tie-ins	SY	300.00	$75.00	$22,500.00
10	340	HMAC surface course at driveway transitions per plan, complete in place	TON	4.00	$250.00	$1,000.00
					Subtotal of Item B	**$23,500.00**
C	**STORM SEWER**					
11	429	Trench Safety System (all depths)	LF	250.00	$3.00	$750.00
12	460	Reinforced Concrete Pipe, C76, Class III, Rubber Gasket (24")	LF	150.00	$70.00	$10,500.00
13	460	Reinforced Concrete Pipe, C76, Class III, Rubber Gasket (18")	LF	200.00	$45.00	$9,000.00
14	472	Type A Inlet	EA	1.00	$2,500.00	$2,500.00
15	491	Reinforced concrete Slope Paving (5")	SY	34.00	$70.00	$2,380.00
					Subtotal of Item C	**$25,130.00**
E	**TRAFFIC CONTROL PLAN**					
16	671	Traffic Control - Barricades, Barriers, Barrels, Cones, and Signing	MO	4.00	$4,000.00	$16,000.00
17	671	Temporary Residential Driveways - Furnish-Install & Remove	EA	7.00	$500.00	$3,500.00
18	673	Temporary Pipe Under Driveway for Installing-Maintaining and Removal	LF	250.00	$50.00	$12,500.00
					Subtotal of Item E	**$32,000.00**
H	**STORM WATER POLLUTION PREVENTION PLAN**					
19	162	Sodding for Erosion Control (Various Widths)	SY	1,000.00	$5.00	$5,000.00
20	165	Hydro-Mulch Seeding	AC	2.50	$2,000.00	$5,000.00
21	713	Filter Fabric Fence (60% of unit cost for furnish and installation and 40% of unit cost for removal)	LF	3,500.00	$2.00	$7,000.00
22	719	Inlet Protection Barrier (Stage 1, With Fiber Rolls; 60% of unit cost for furnish and installation, and 40% of unit cost for removal)	EA	1.00	$70.00	$70.00
23	724	Stabilized Construction Access (Type 1-Rock; 60% of unit cost for furnish and installation, and 40% of unit cost for removal))	SY	80.00	$15.00	$1,200.00
24	730	Concrete Truck Washout Structures (60% of unit cost for furnish and installation, and 40% of unit cost for removal)	LS	1.00	$1,000.00	$1,000.00
25	750	Rock Filter Dam (Type 2; 60% of unit cost for furnish and installation, 40% of unit cost for removal)	LF	30.00	$55.00	$1,650.00
26	751	SWPPP Inspection and Maintenance (Min. Bid - $6,000.)	MO	4.00	$6,000.00	$24,000.00
27	700	TPDES general permit no TXR 150000 notice of intent (NOI) application fees	EA	2.00	$225.00	$450.00

CONSTRUCTION COST ESTIMATE

Project:	**Prestonwood Forest Subdivision Drainage Improvements**
Limit From:	**Hargrave Rd**
Limit To:	**BNSF Railroad**
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Precinct:	**Four**
UPIN:	**19104MF16Q01**
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Total Amount for XXXX:		**$0.00**
Grant Total Amount:		**$665,200.00**
Contingencies:	**0%**	**$0.00**
Grand Total Project:		**$665,200.00**

ITEM NO.	SPEC NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
					Subtotal of Item H	**$45,370.00**
I	**** EXTRA WORK ITEMS**					
28	559	Construction Safety Fence	LF	500.00	$10.00	$5,000.00
29	672	Uniformed Police Officer - As Directed by Engineer (Min. Bid $45/HR)	HR	1,000.00	$45.00	$45,000.00
30	N/A	BNSF Railroad Construction Inspector ($350 Mobilization + $1,350 daily min, 10hr/day)	Days	120.00	$1,350.00	$162,350.00
31	N/A	BNSF Railroad Construction Flagger ($1,350 daily min, 10hr/day)	Days	120.00	$1,350.00	$162,000.00
32	N/A	BNSF Safety Training Orientation (required for site access, $40/person, $10 upload fee)	LS	1.00	$500.00	$500.00

Exhibit 5

Topographical Survey

LEGEND:

A = ASPHALT
BFP = BACKFLOW PREVENTOR
B.L. = BUILDING LINE
BPM = BLUE PAINT MARK
B = BRICK
C/CONC. = CONCRETE
CLD = CENTERLINE DITCH
CLRD = CENTERLINE ROAD
CMP = CORRUGATED METAL PIPE
CW = CONCRETE WALL
DD = DIRT DRIVE
DG = DOWN GUY
EB = ELECTRIC BOX
F.C. NO. = FILM CODE NUMBER
FH = FIRE HYDRANT
FL = FLOW LINE
FOCM = FIBER OPTIC CABLE MARKER
G GUTTER
GB = GRADE BREAK
GI = GRATE INLET
GP = GATE POST
H.C.F.C.D. = HARRIS COUNTY FLOOD CONTROL DITCH
HB = HIGH-BANK
ICV = IRRIGATION CONTROL VALVE
LS = LIGHT STANDARD
LST = LANDSCAPE TIMBERS
MB = MAILBOX
MH = MANHOLE
MP = METER POLE
M.R.H.C. = MAP RECORDS OF HARRIS COUNTY
NG = NATURAL GROUND
OPM = ORANGE PAINT MARK
PP = POWER POLE
RCP = REINFORCED CONCRETE PIPE
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SP = SERVICE POLE
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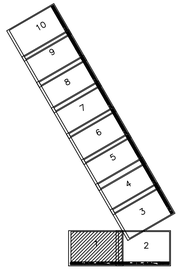
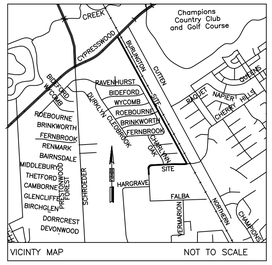
SANITARY SEWER FORCE MAIN



SHEET 1 OF 10



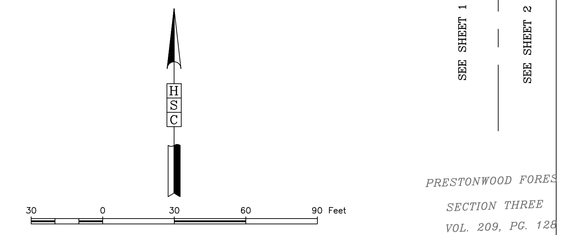
BENCHMARK:

RM 150770: FLOODPLAIN REFERENCE NUMBER 150770 IS A STAINLESS STEEL ROD IN CASING STAMPED HGCSD 11 1986 LOCATED IN THE JARED'S JEWELERS PARKING LOT AT THE NORTHEASTERLY INTERSECTION OF F.M. 1960 AND BRETON RIDGE STREET IN THE GREENS WATERSHED NEAR STREAM E150-00-00.

ELEVATION = 120.92' (NAVD 1988, 2001 ADJUSTED)

MAILBOXES

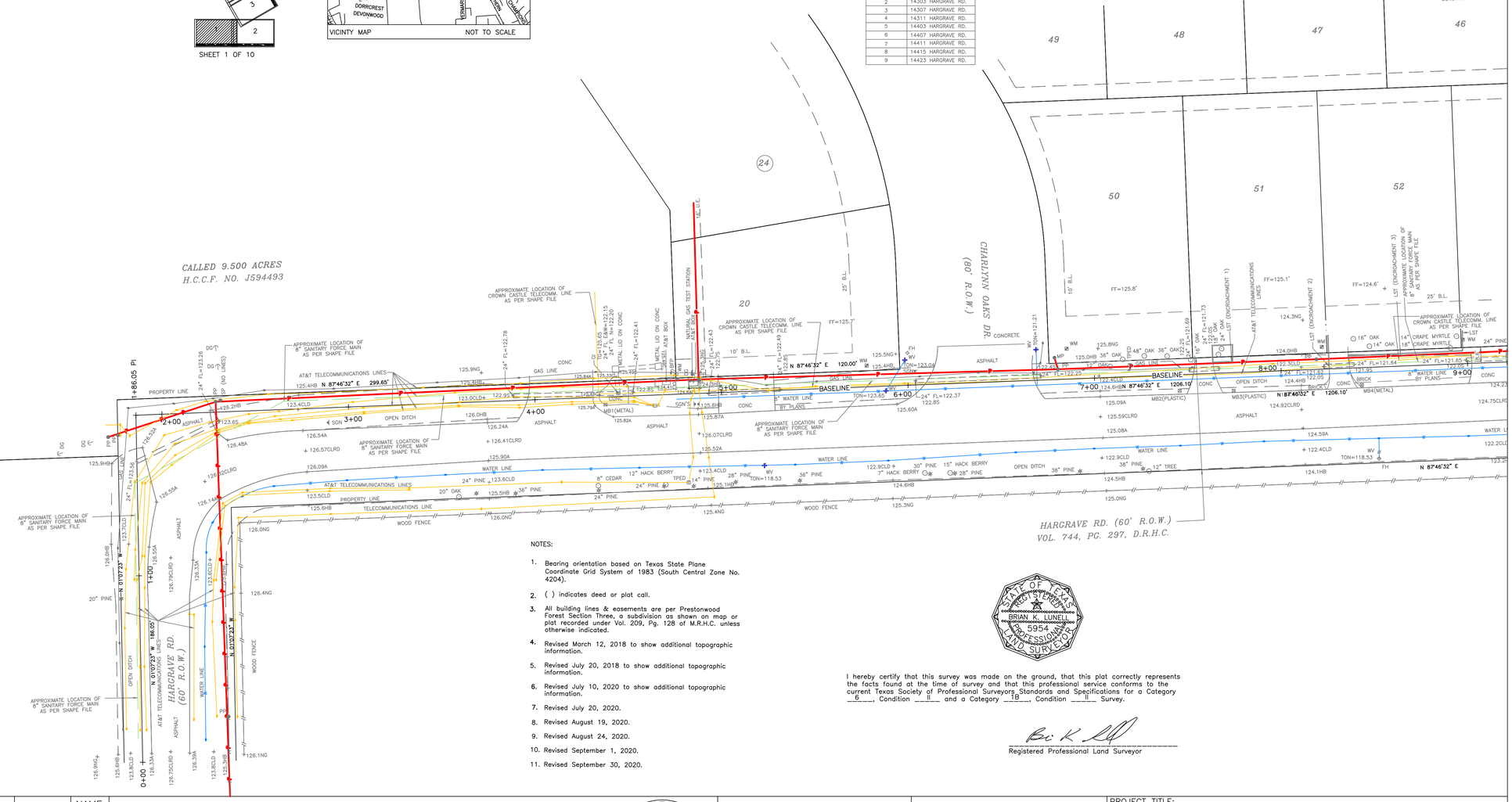
MAILBOX NO.	ADDRESS
1	14225 HARGRAVE RD.
2	14303 HARGRAVE RD.
3	14307 HARGRAVE RD.
4	14311 HARGRAVE RD.
5	14403 HARGRAVE RD.
6	14407 HARGRAVE RD.
7	14411 HARGRAVE RD.
8	14415 HARGRAVE RD.
9	14423 HARGRAVE RD.



SEE SHEET 1

SEE SHEET 2

PRESTONWOOD FOREST
SECTION THREE
VOL. 209, PG. 128
M.R.H.C.



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Brian K. Lunell
Registered Professional Land Surveyor

NO.	REVISIONS		NAME

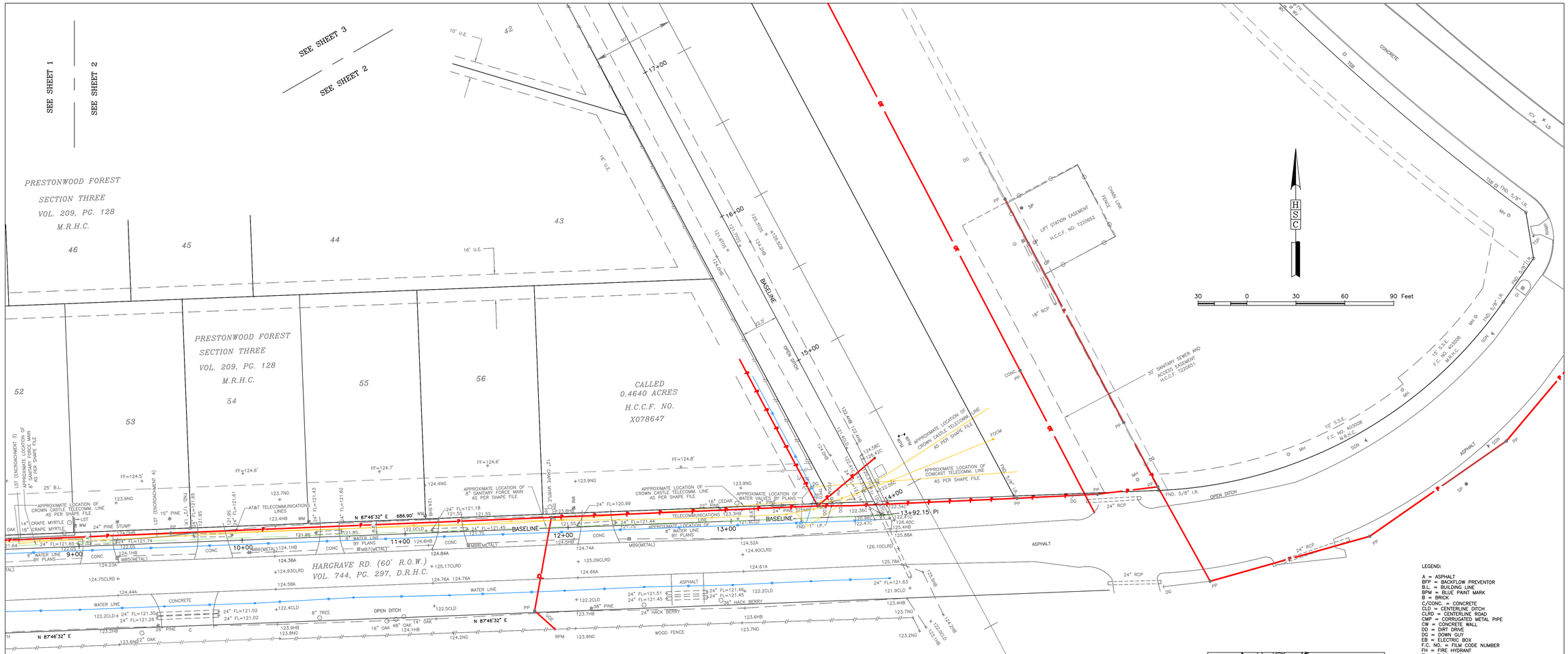
HARRIS COUNTY
ENGINEERING DEPARTMENT

HOVIS SURVEYING COMPANY
Land Surveys – Computer Mapping
5000 Cabbage – Spring, Texas 77379
(281) 320-9591
Acreage – Residential – Industrial – Commercial
Texas Firm Registration No. 10030400

PROJECT TITLE: PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS 2018, UPIN: 19104MF16Q1

SHEET DESCRIPTION: TOPOGRAPHIC SURVEY

DRAWN BY:		DATE:
BKL	1800700A.DWG	8/19/20
CK'D BY:	SCALE:	SHEET NO:
BKL	1"=30'	1 / 10



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BENCHMARK:

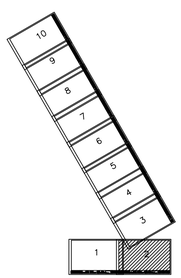
RM 150770: FLOODPLAIN REFERENCE NUMBER 150770 IS A STAINLESS STEEL ROD IN CASING STAMPED HCCSD 11 1986 LOCATED IN THE JARED'S JEWELERS PARKING LOT AT THE NORTHEASTERLY INTERSECTION OF F.M. 1960 AND BRETON RIDGE STREET IN THE GREENS WATERSHED NEAR STREAM E150-00-00.

ELEVATION = 120.92' (NAVD 1988, 2001 ADJUSTED)

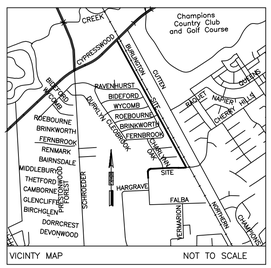
STATE OF TEXAS
BRIAN K. LUNELL
5954
REGISTERED PROFESSIONAL LAND SURVEYOR

I hereby certify that this survey was made on the ground, that this plat correctly represents the facts found at the time of survey and that this professional service conforms to the current Texas Society of Professional Surveyors Standards and Specifications for a Category __6__, Condition __II__ and a Category __1B__, Condition __II__ Survey.

Registered Professional Land Surveyor



SHEET 2 OF 10



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NO.	REVISIONS		NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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5000 Cabbage – Spring, Texas 77379
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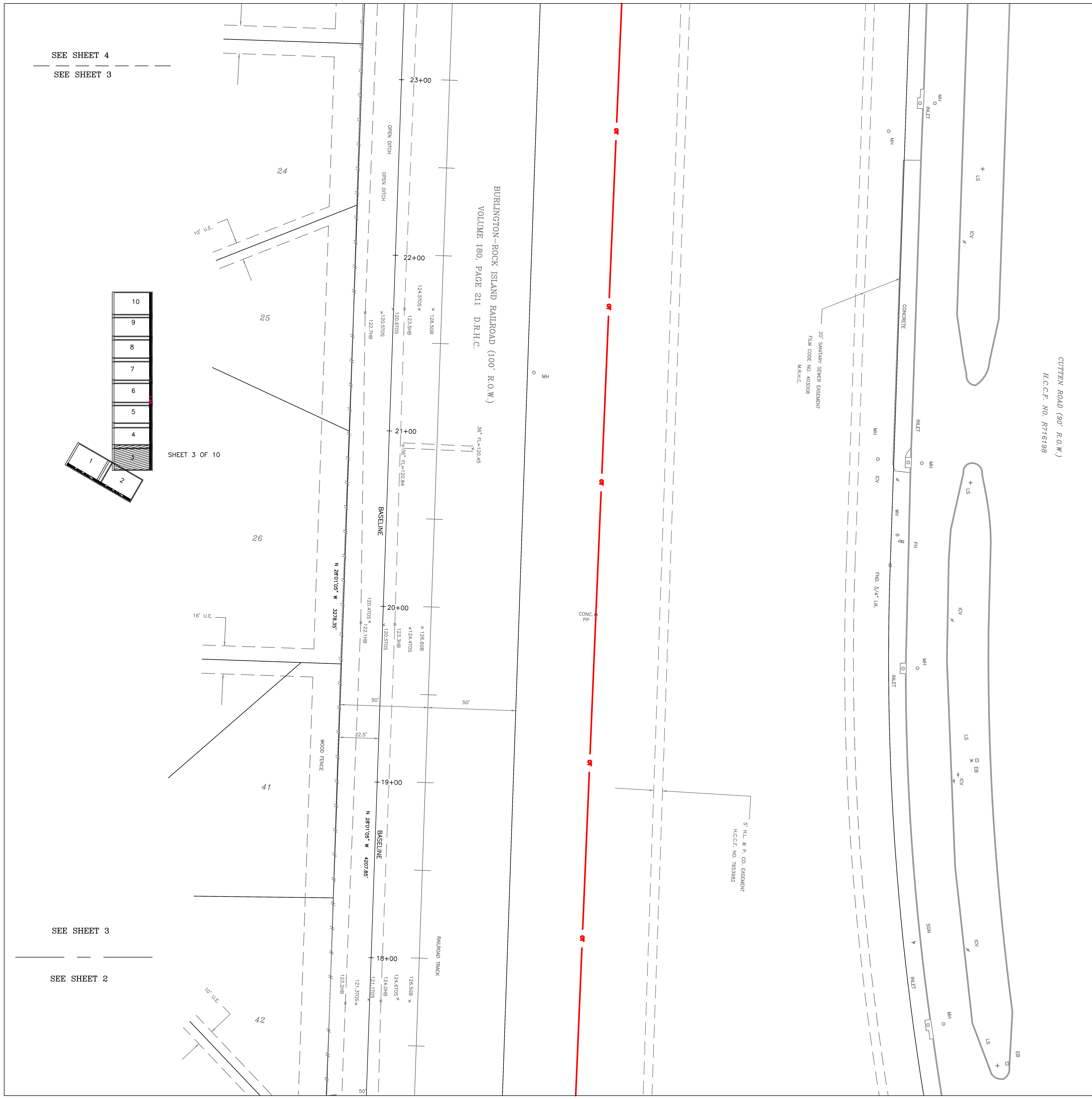
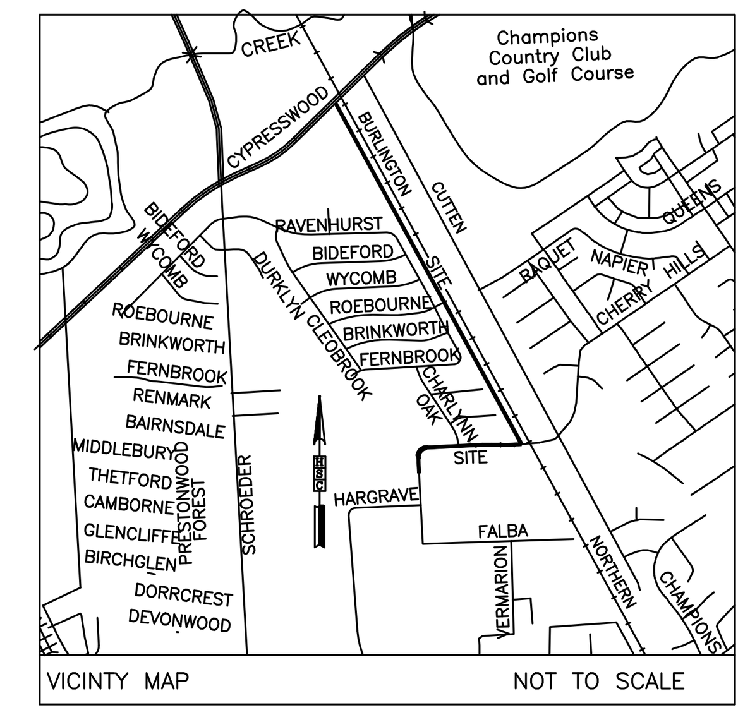
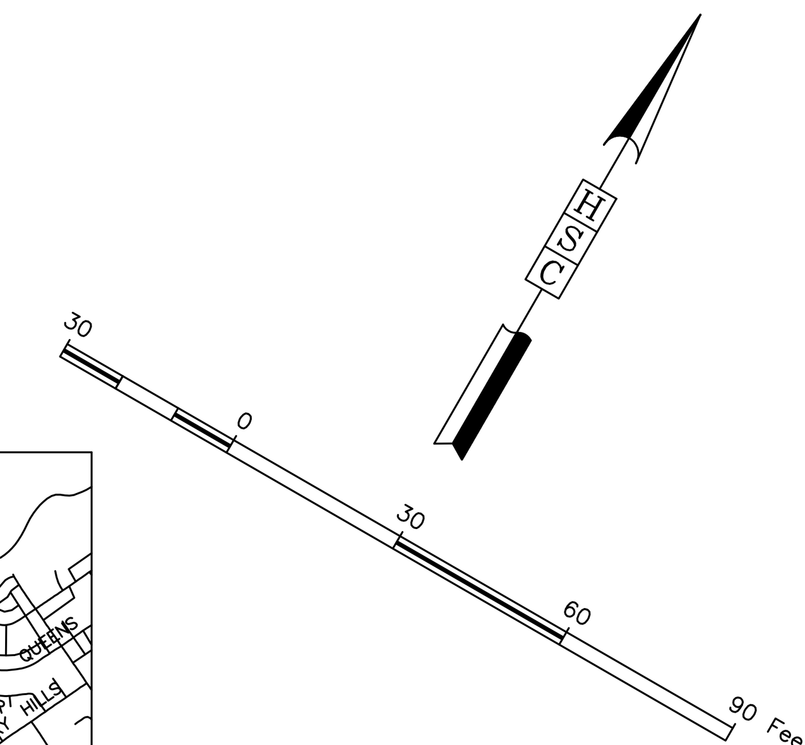
SHEET DESCRIPTION: TOPOGRAPHIC SURVEY

DRAWN BY:		DATE:
BKL	1800700A.DWG	8/19/20
CK'D BY:	SCALE:	SHEET NO:
BKL	1"=30'	2 / 10







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BENCHMARK:

RM 150770: FLOODPLAIN REFERENCE NUMBER 150770 IS A STAINLESS STEEL ROD IN CASING STAMPED HGCSD 11 1986 LOCATED IN THE JARED'S JEWELERS PARKING LOT AT THE NORTHEASTERLY INTERSECTION OF F.M. 1960 AND BRETON RIDGE STREET IN THE GREENS WATERSHED NEAR STREAM E150-00-00.

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STATE OF TEXAS REGISTERED BRIAN K. LUNELL 5954 PROFESSIONAL LAND SURVEYOR

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Registered Professional Land Surveyor

NO.	REVISIONS	DATE	NAME

PROJECT TITLE: PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS 2018, UPIN: 19104MF16Q1

SHEET DESCRIPTION: TOPOGRAPHIC SURVEY

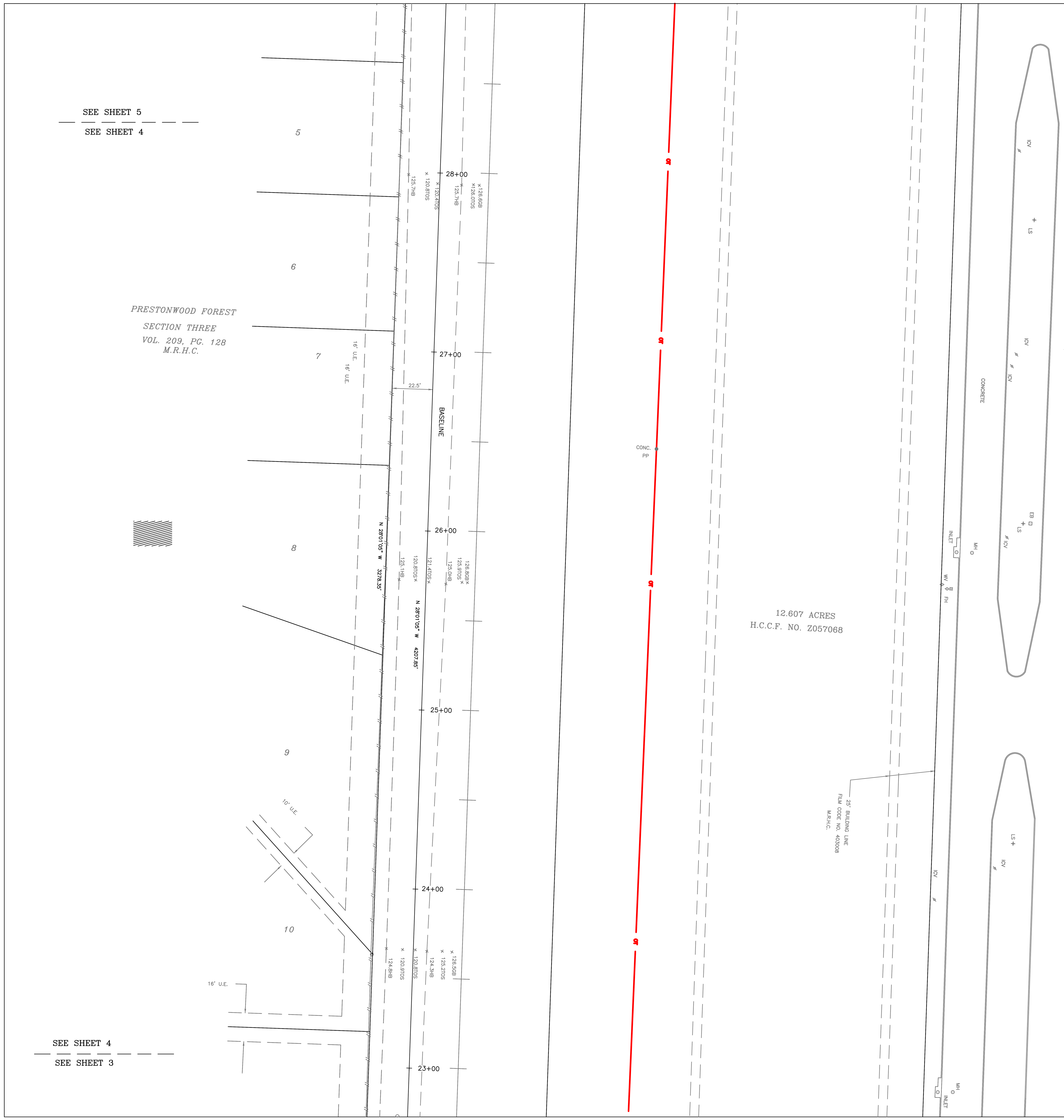
DRAWN BY: BKL	1800700A.DWG	
CK'D BY: BKL	SCALE: 1"=30'	JOB NO: 19104MF16Q1	DATE: 8/19/20

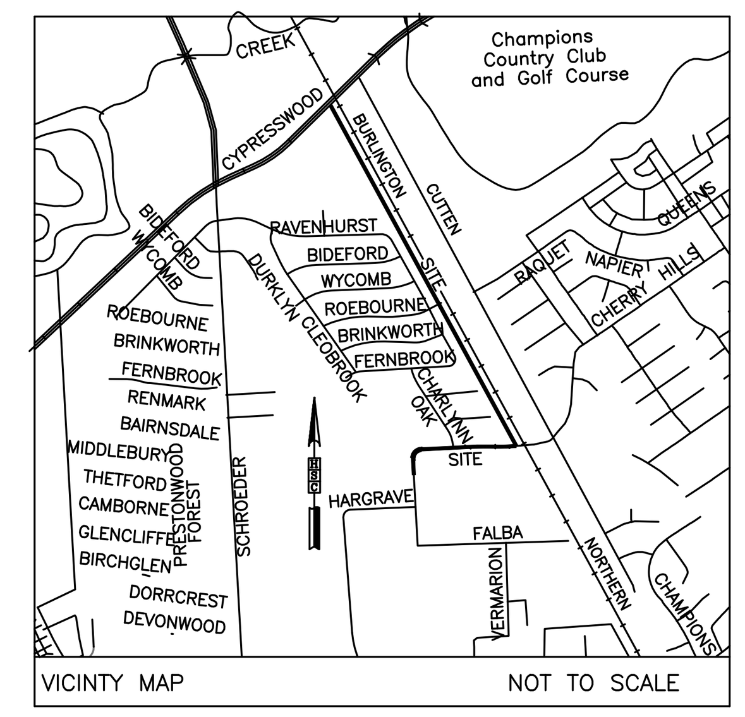
HARRIS COUNTY TEXAS 1836

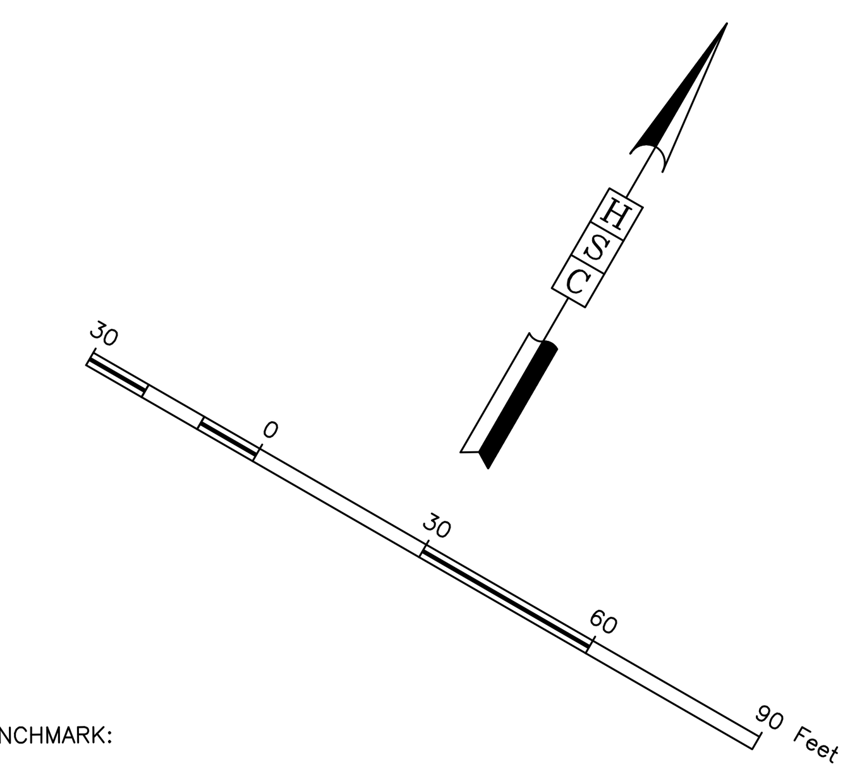
HARRIS COUNTY ENGINEERING DEPARTMENT

HOVIS SURVEYING COMPANY

SHEET NO: 3 / 10







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Registered Professional Land Surveyor

NO.	REVISIONS	DATE	NAME

PROJECT TITLE: PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS 2018, UPIN: 19104MF16Q1

SHEET DESCRIPTION: TOPOGRAPHIC SURVEY

1800700A.DWG

DRAWN BY: BKL

CK'D BY: BKL

JOB NO: 19104MF16Q1

SCALE: 1"=30'

HARRIS COUNTY 1836 TEXAS

HARRIS COUNTY
ENGINEERING
DEPARTMENT

HSC HOVIS SURVEYING COMPANY
Land Surveys - Computer Mapping
5000 Cabbage - Spring, Texas 77379
(281) 320-9591
Acreage - Residential - Industrial - Commercial
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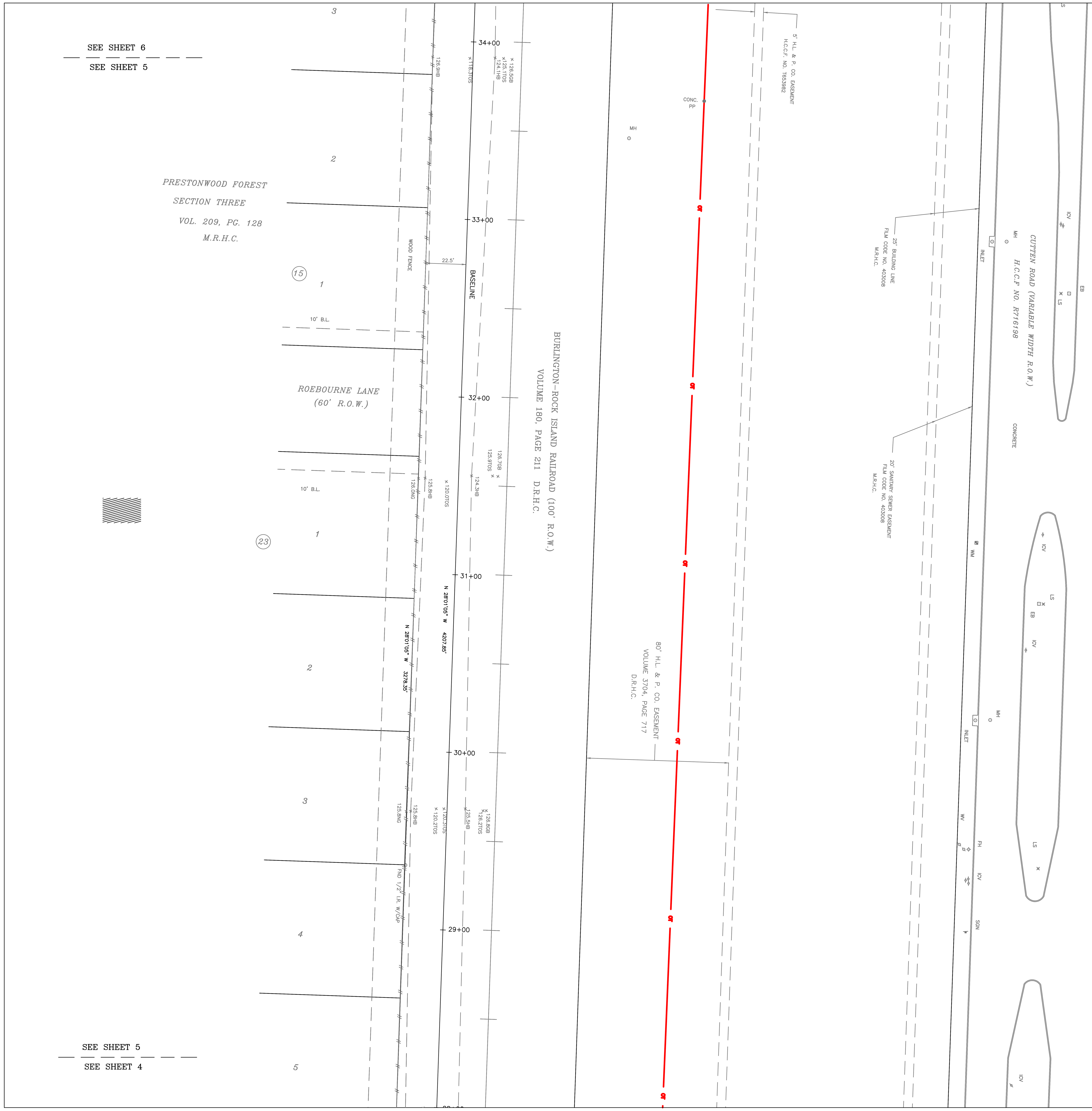
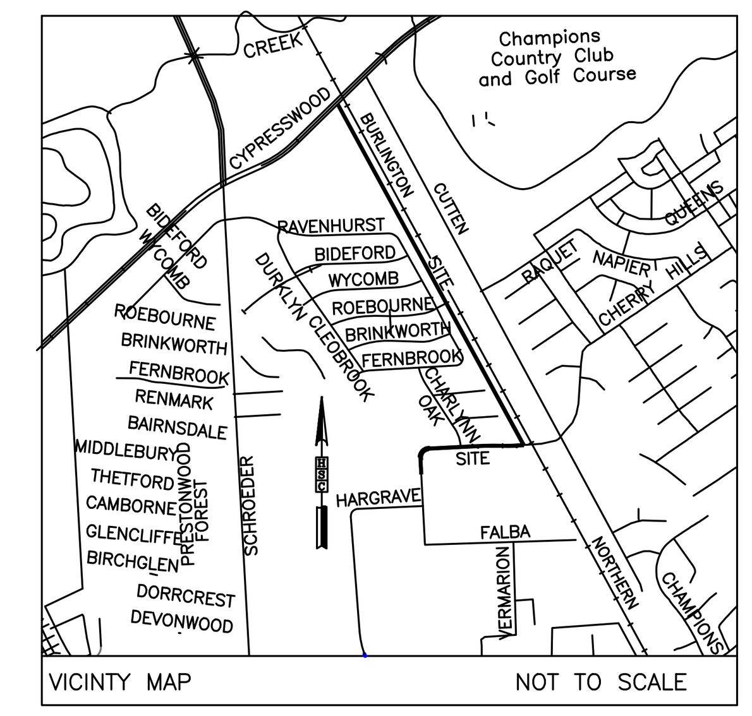
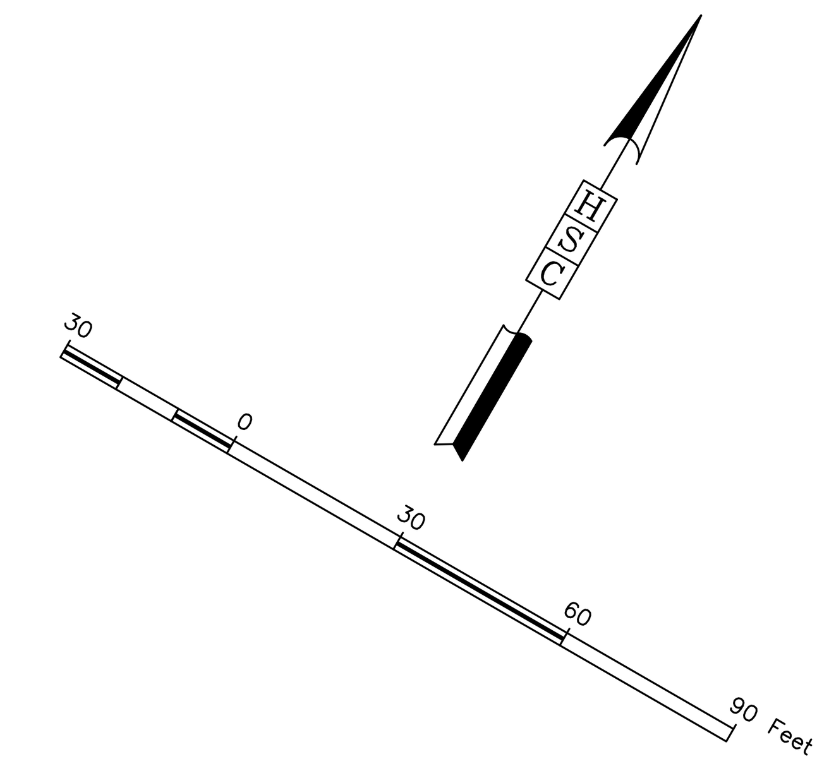
FOR INTERIM

SHEET NO: 4 / 10







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Registered Professional Land Surveyor

NO.	REVISIONS	DATE	NAME

PROJECT TITLE: PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS 2018, UPIN: 19104MF16Q1

SHEET DESCRIPTION: TOPOGRAPHIC SURVEY

DRAWN BY: BKL — 1800700A.DWG

CK'D BY: BKL — SCALE: 1"=30' — JOB NO: 19104MF16Q1 — DATE: 8/19/20

HARRIS COUNTY 1836 TEXAS

HARRIS COUNTY ENGINEERING DEPARTMENT

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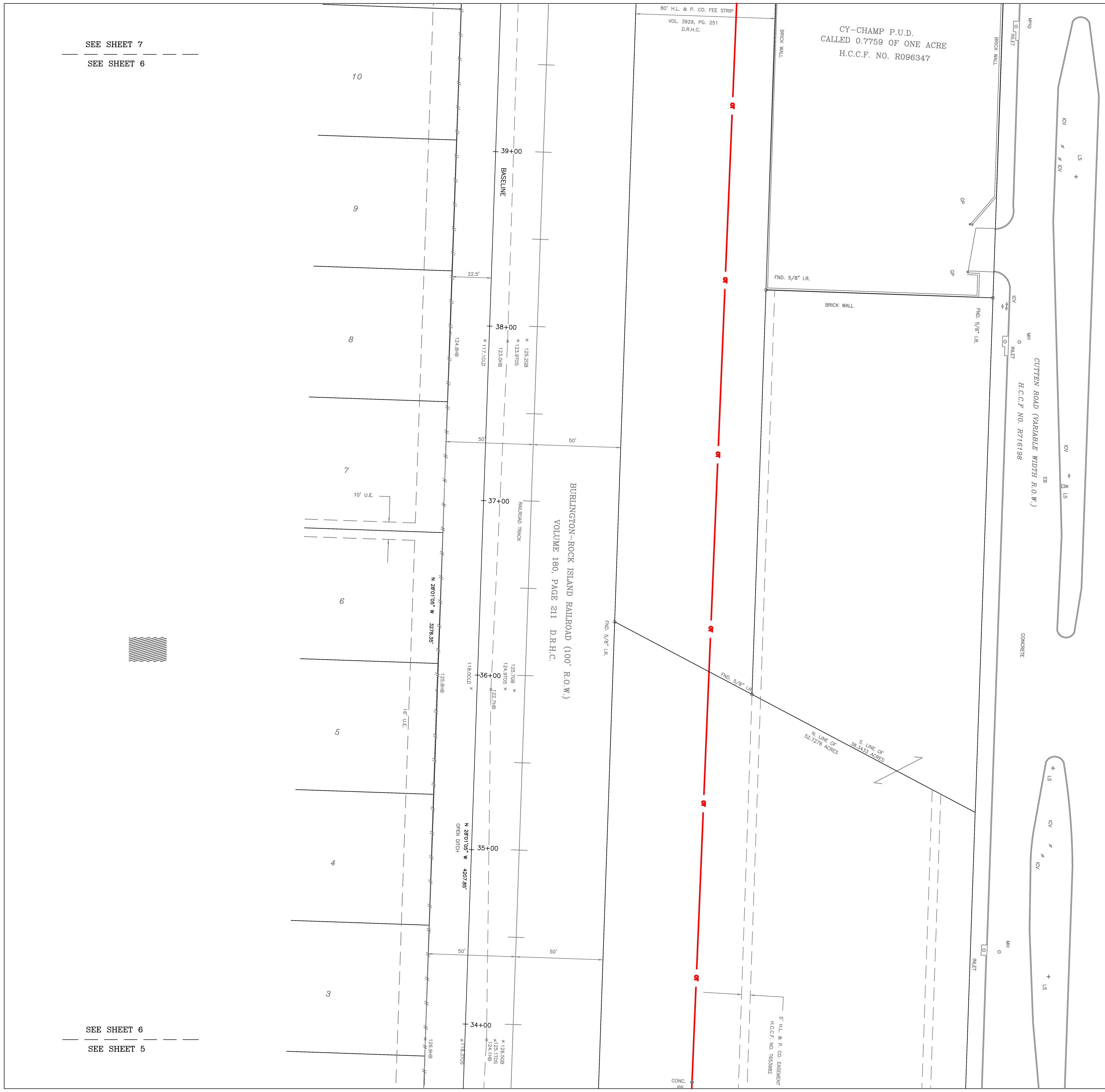
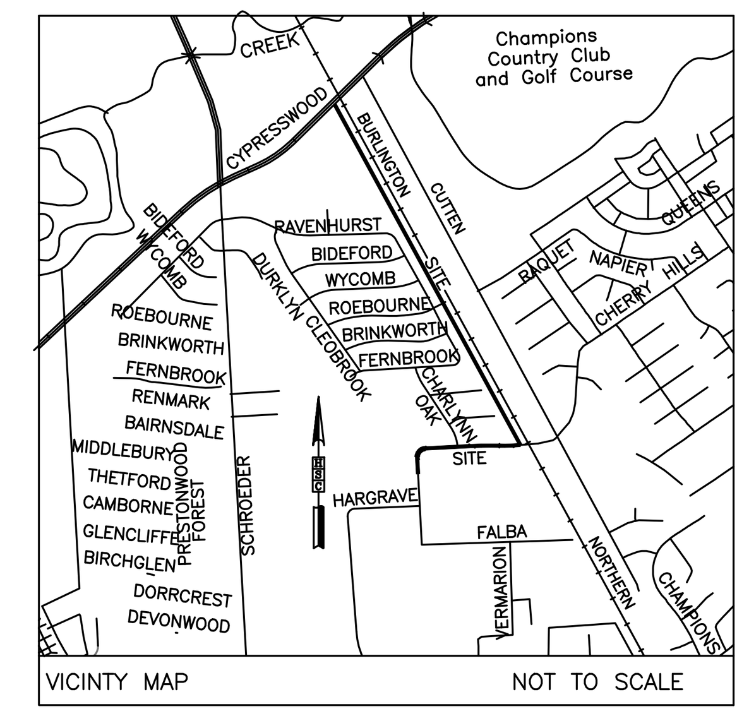
SHEET NO: 5 / 10





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BENCHMARK:

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Registered Professional Land Surveyor

NO.	REVISIONS	DATE	NAME

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SHEET DESCRIPTION: TOPOGRAPHIC SURVEY

1800700A.DWG

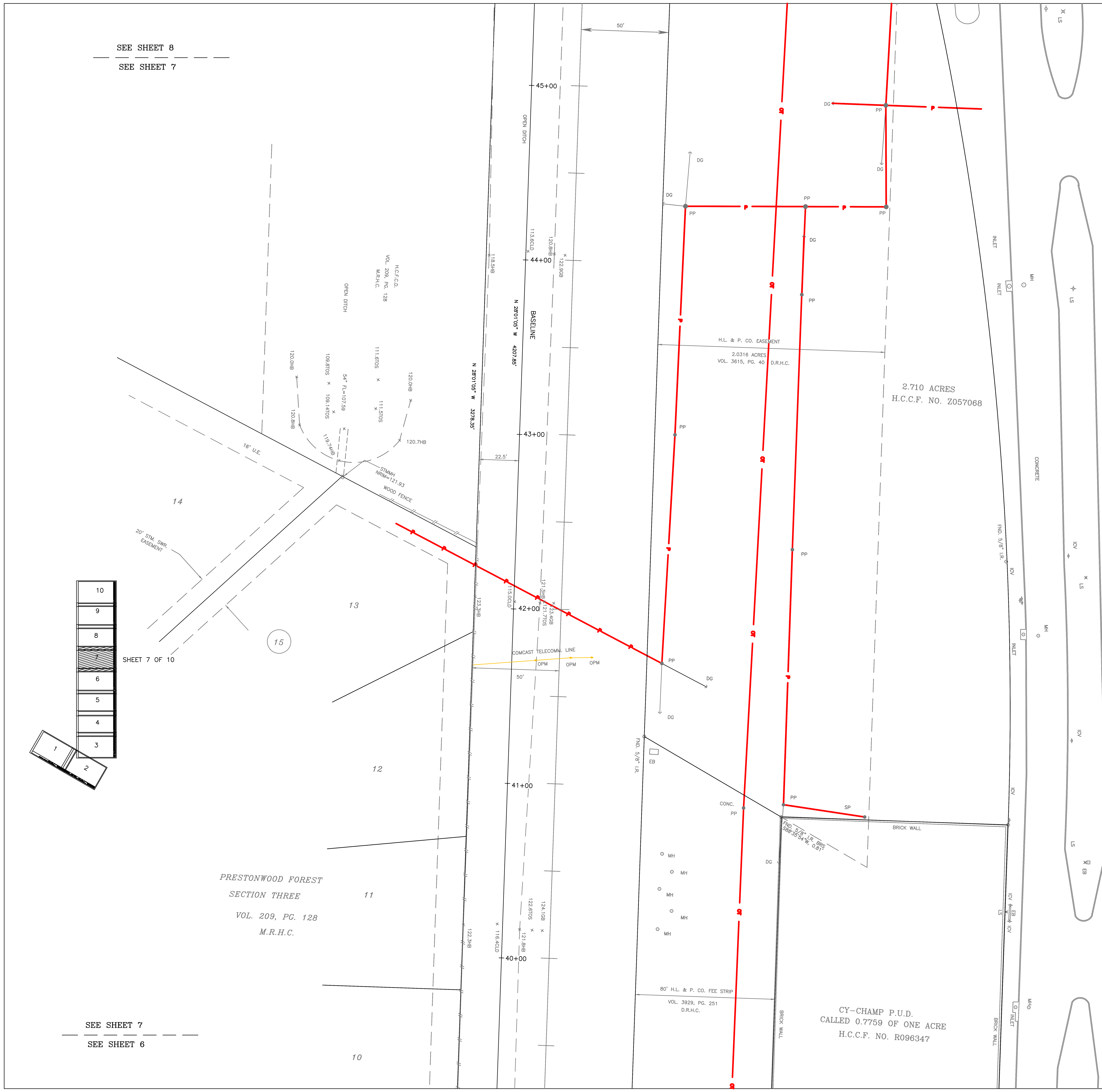
DRAWN BY: BKL
CK'D BY: BKL
SCALE: 1"=30'
JOB NO: 19104MF16Q1
DATE: 8/19/20

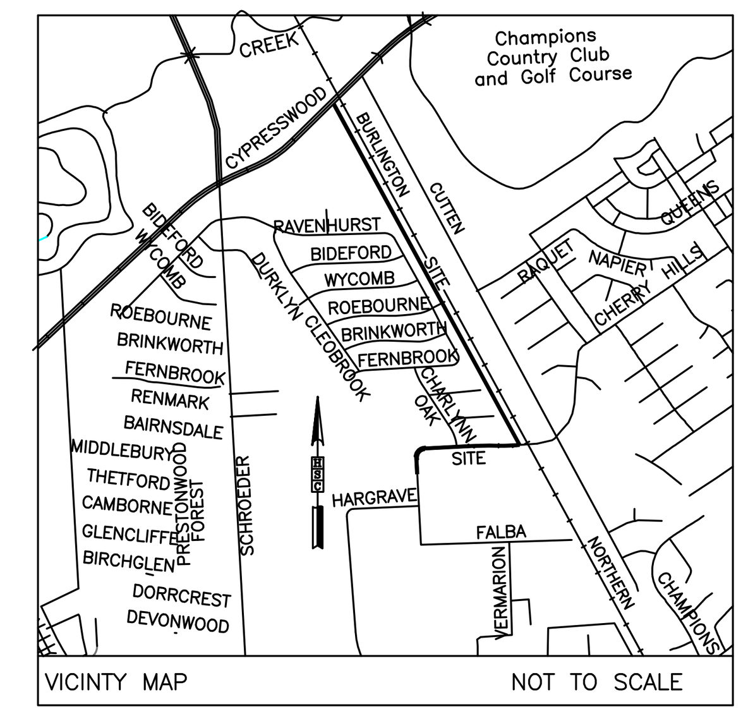
HARRIS COUNTY TEXAS 1836

HARRIS COUNTY ENGINEERING DEPARTMENT

HOVIS SURVEYING COMPANY
Land Surveys - Computer Mapping

SHEET NO: 6 / 10





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REGISTERED
BRIAN K. LUNELL
5954
PROFESSIONAL
LAND SURVEYOR

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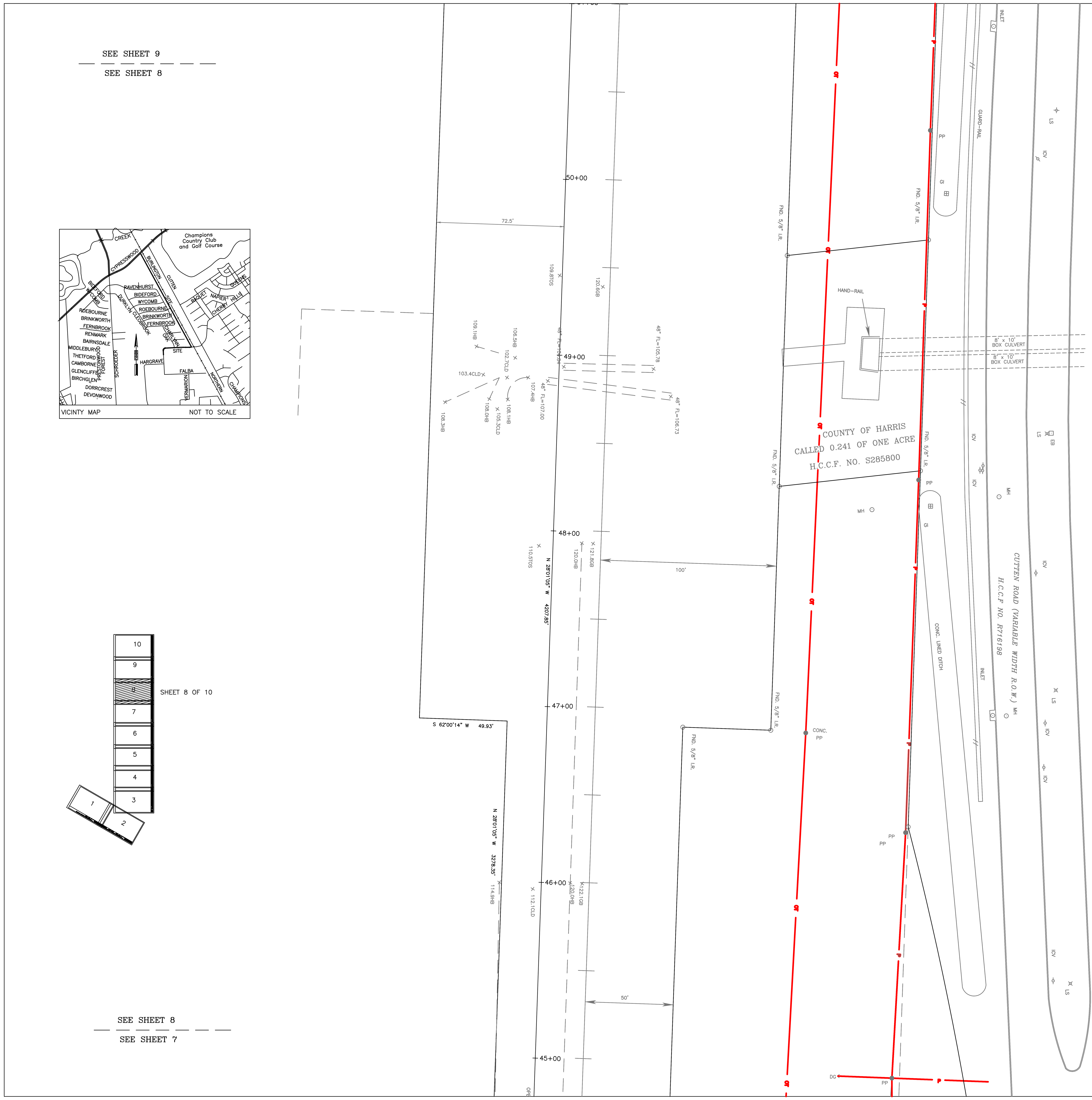
CK'D BY: BKL — SCALE: 1"=30' — JOB NO: 19104MF16Q1 — DATE: 8/19/20

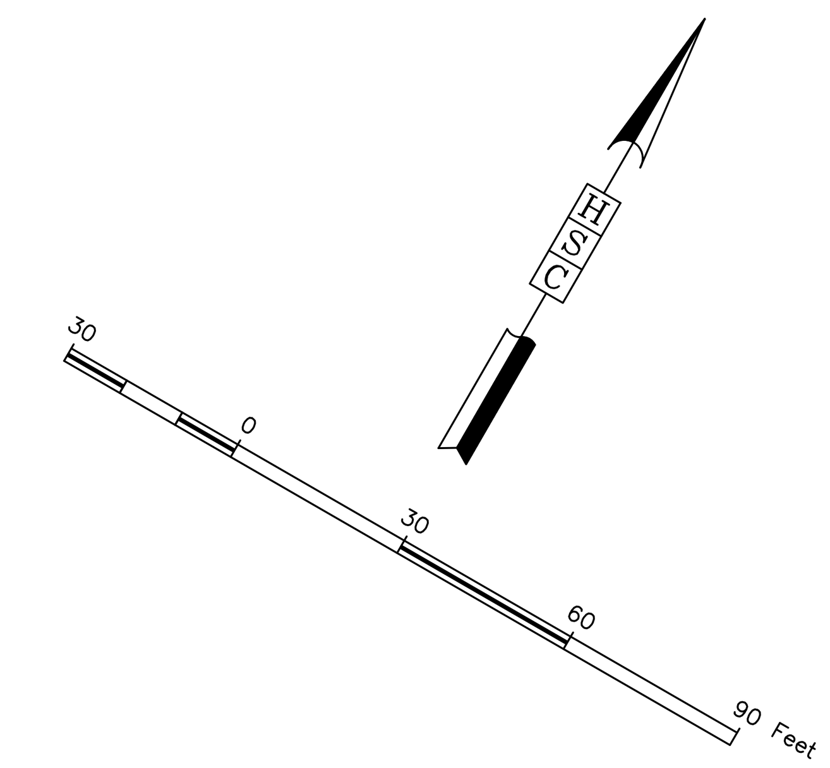
HARRIS COUNTY 1836 TEXAS

HARRIS COUNTY ENGINEERING DEPARTMENT

HOVIS SURVEYING COMPANY
Land Surveys - Computer Mapping
5000 Cabbage - Spring, Texas 77379
(281) 320-9591
Acreage - Residential - Industrial - Commercial
Texas Firm Registration No. 10030400

SHEET NO: 7 / 10





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HARRIS COUNTY TEXAS 1836

HARRIS COUNTY ENGINEERING DEPARTMENT

HOVIS SURVEYING COMPANY
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5000 Cabbage – Spring, Texas 77379
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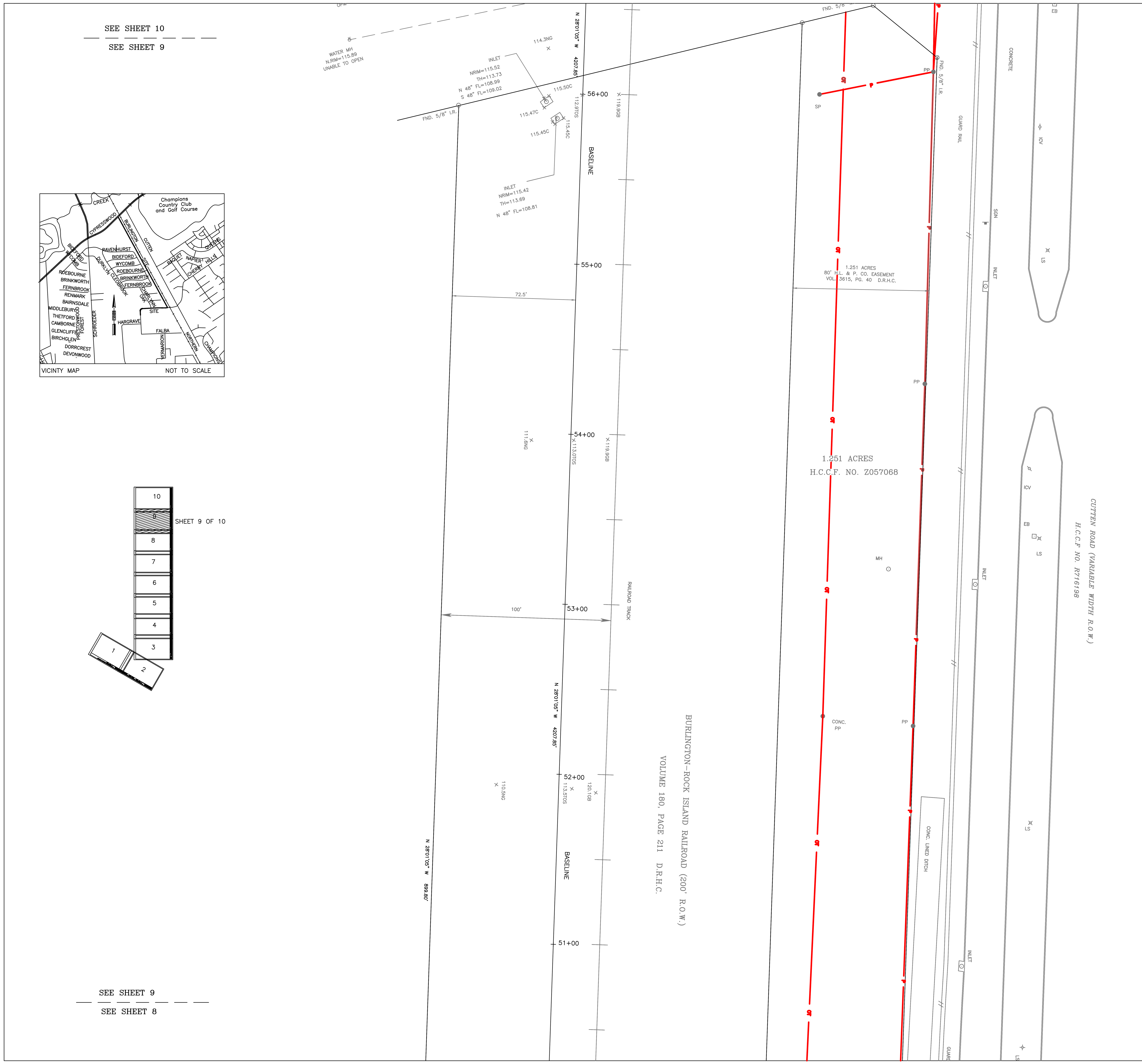
SHEET NO: 8 / 10



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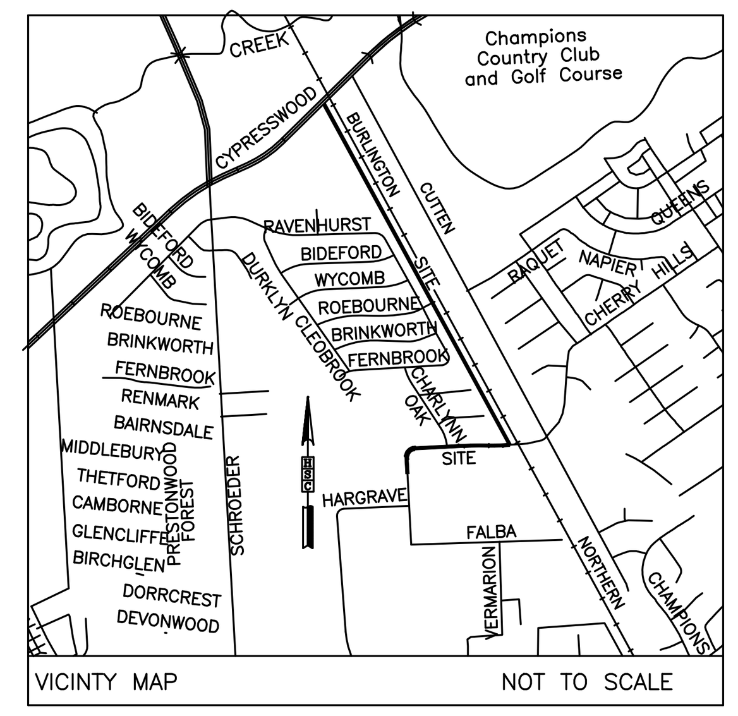

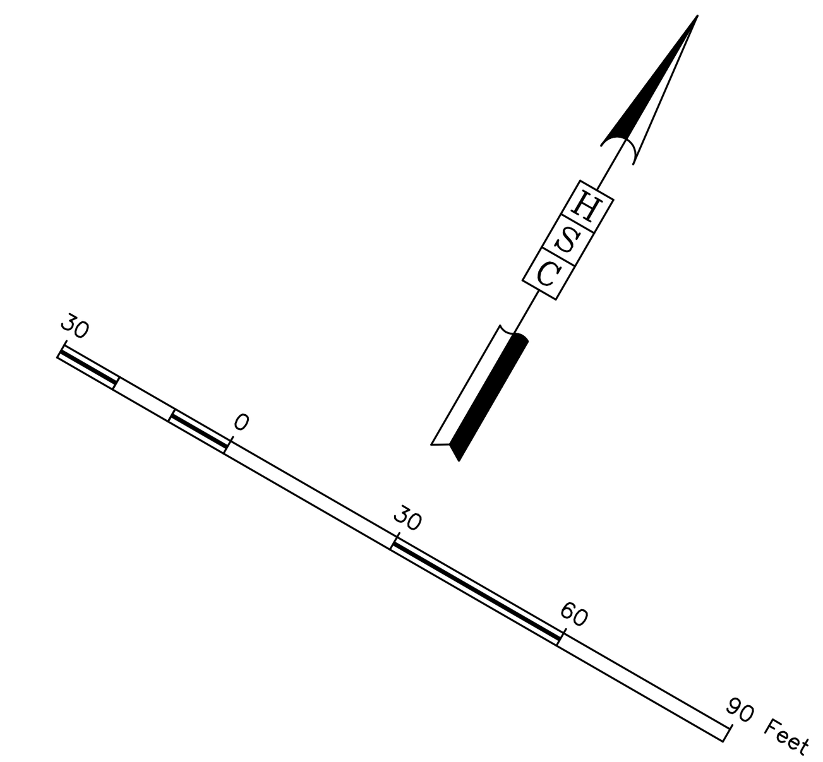

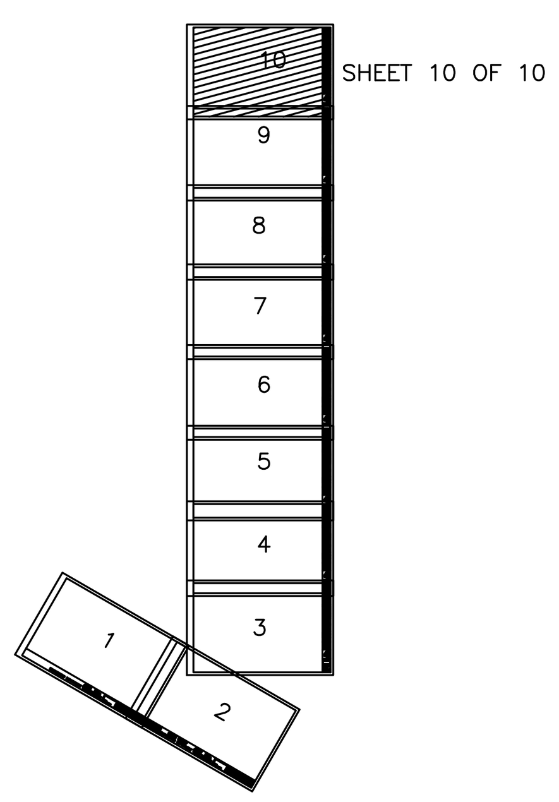

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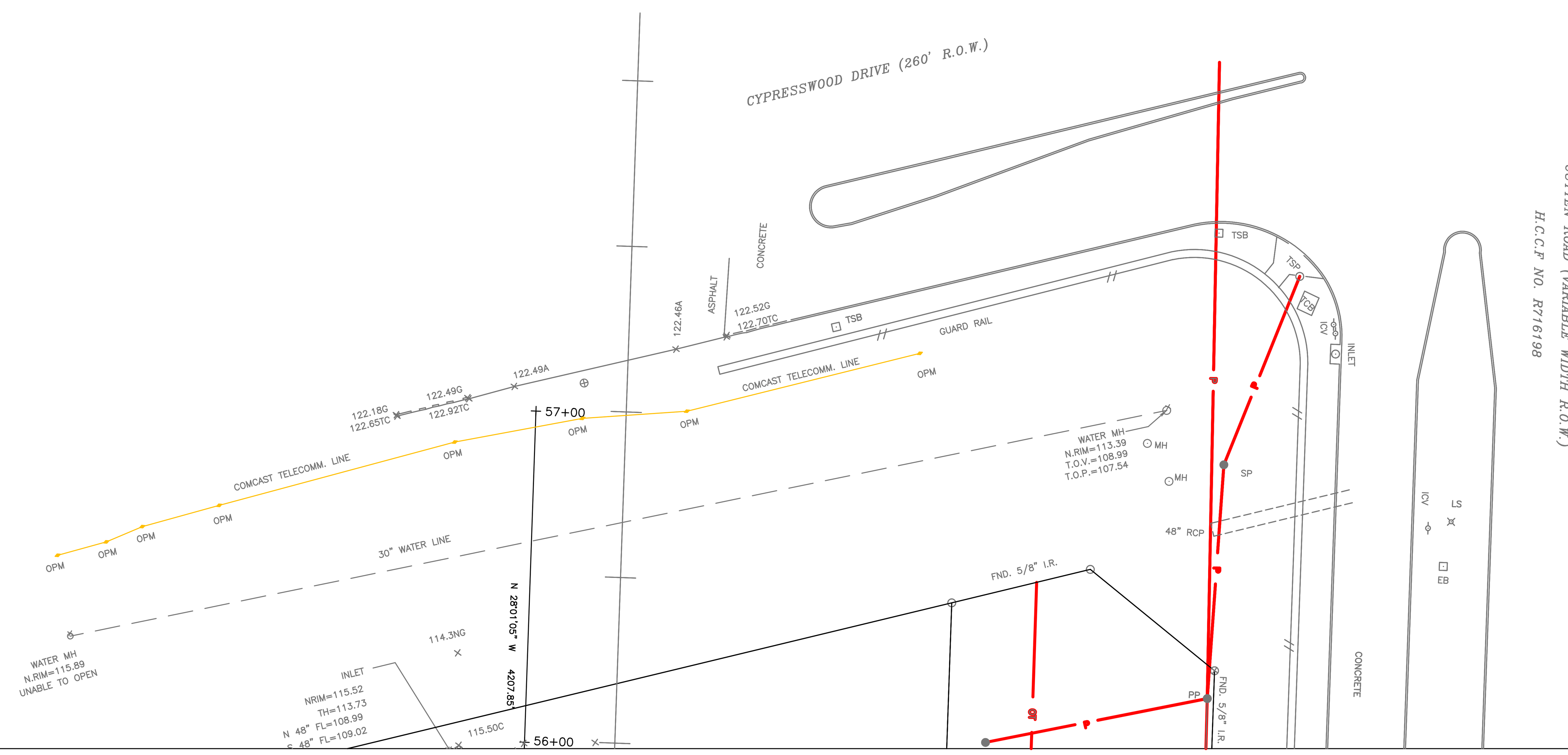

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Appendix A

Environmental Due Diligence Report

Environmental Due Diligence

Prestonwood Forest Subdivision Drainage Improvements – 2018

April 22, 2020

Project Description

Prestonwood Forest Subdivision Drainage Improvements – 2018 is a HCED-RRD project located within Harris County Precinct 4. The Project consists of regrading preexisting ditches along the north side of Hargrave Road from Charlynn Oaks Drive to roughly 680 feet east to the railroad tracks, then continuing north along the west side of the tracks for roughly 3500 feet. All work will take place in existing Harris County Right of Way or on property belonging to BNSF Railroad.

Location and Topography

Prestonwood Forest is located within Precinct 4 in northwestern Harris County. The project area is located east of SH 249, south of Cypresswood Drive, and west of Cutten Road Cypress Creek, HCFCD Unit No. K100-00-00, is north of the project area, across Cypresswood Drive. The project is located completely outside the K100-00-00 (Cypress Creek) 100-year (1% AEP) floodplain.

Findings

A Radius Report was acquired from NETR Online which used ASTM radius sizes from 29.980092, -95.546494. All distances listed are based on this point. A total of eight database findings, representing six properties of concern were identified within the search radius:

<u>US RCRA Generators</u>

Country Cleaners- 9641-A CYPRESSWOOD DR- CESQG

Implications: Dry cleaning drop off site, minimal potential for contamination.

Tip Top Cleaners- 13455 CUTTEN RD

Implications: 0.37 Miles away. Dry cleaning drop off site, minimal potential for contamination.

<u>US NPDES</u>

Houston Methodist Orthopedics & Sports Medicine- 13802 Centerfield Dr Suite 300

Implications: 0.77 miles away. Minimal potential for contamination.

Prestonwood Forest UD WWTP- 14210 Prestonwood Forest Drive

Implications: 0.84 Miles away. Minimal potential for contamination.

Champions Drive

Implications: 0.91 miles away. Minimal potential for contamination.

TX Leaking Petroleum Storage Tanks

Champions Golf Club- 13722 Champions DR

Implications: 0.96 Miles away. Clean up status inactive as of 1992. Minimal potential for impact.

TX Drycleaners

Tip Top Cleaners- 13455 CUTTEN RD

Implications: 0.37 Miles away. Dry cleaning drop off site, minimal potential for contamination.

Site Visit

Site reconnaissance was conducted March 23, 2020 by Brady Johnson of HCED-RRD. The entire length of the proposed ditch was surveyed for evidence of environmental concerns. Some evidence of illegal dumping along the fence line on the west side of the railroad track was noted. Common items observed included fence posts and empty containers.

Opinion

No evidence suggesting the presence of significant environmental concerns was found during this investigation. All sites reported in environmental databases are located a significant distance from the proposed work and/or do not conduct activities likely to effect the project site. Dumping sites discovered during site reconnaissance are composed largely of household waste or non-hazardous construction debris, and represent only a de minimus condition. No further investigation is recommended.

Debris removed from the site during construction activities should be evaluated and disposed of in accordance with relevant rules and regulations. If any evidence of chemical contamination is encountered during excavation, work in that area should immediately cease and relevant authorities should be contacted.

Note: This report is meant as a cursory screening of the project site for Harris County use. The tools and procedures used do not conform to AAI requirements and the findings of this report do not preclude the existence of onsite contamination.

X

Brady Johnson
Environmental Coordinator, HCED-RRD

Site Photographs

Image 1: Facing east from western project boundary

Image 2: Intersection of Hargrave and railroad track

Image 3: Facing south along Railroad track

Image 4: De minimus dumping of construction waste

Appendix B

Geotechnical Engineering Report

GEOTECHNICAL ENGINEERING REPORT

PRESTONWOOD FOREST SUBDIVISION DRAINAGE IMPROVEMENTS
(UPIN 19104MF16Q01)
HARRIS COUNTY, PRECINCT 4, TEXAS

GEOTECHNICAL ENGINEERING REPORT

Prestonwood Forest Subdivision Drainage Improvements
(UPIN 19104MF16Q01)
Harris County, Precinct 4, Texas

Prepared by:

Gorrondona Engineering Services, Inc.

Prepared for:

Bleyl Engineering
400 Randal Way, Suite 300
Spring, Texas 77388

Attention: Ms. Delea R. Cooper, P.E.

August 21, 2020

GES Project No. 20-0281

TEXAS ENGINEERING FIRM REGISTRATION NO. F-17076

Gorrondona Engineering Services, Inc.

Geotechnical Engineering • Construction Materials Testing & Inspection

August 21, 2020

Ms. Delea R. Cooper, P.E.
Bleyl Engineering
400 Randal Way, Suite 300
Spring, Texas 77388

Re: GEOTECHNICAL ENGINEERING REPORT
Prestonwood Forest Subdivision Drainage Improvements
(UPIN 19104MF16Q01)
Harris County, Precinct 4, Texas
GES Project No. 20-0281

Dear Ms. Cooper:

Gorrondona Engineering Services, Inc. (GES) is pleased to submit this Geotechnical Engineering Report for the referenced project. We appreciate the opportunity of working with you. Please contact us if you have any questions or require additional services.

Respectfully submitted,

Hamed Ardalan, Ph.D., P.E.
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Engineering Manager

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GEOTECHNICAL ENGINEERING REPORT

Prestonwood Forest Subdivision Drainage Improvements
(UPIN 19104MF16Q01)
Harris County, Precinct 4, Texas

1.0 EXECUTIVE SUMMARY

- A geotechnical investigation was conducted by Gorrondona Engineering Services, Inc. (GES) to provide geotechnical engineering recommendation for the improvements of approximately 1,000 LF of existing drainage ditches (up to 4-feet deep) and about nine (9) driveway culvert bridges along Hargrave Road within Prestonwood Forest Subdivision, in Harris County, Precinct 4, Texas (UPIN 19104MF16Q01).

- This study consisted of drilling and sampling three soil borings (B-01 through B-03) along proposed drainage improvements to a depth of 15 feet below the existing grade, performing laboratory tests on samples recovered from borings, performing engineering analysis and providing geotechnical recommendations for the proposed improvements.

- As revealed by the borings, the subsurface soils along the proposed drainage improvements generally consist of cohesive soils. Brown sandy silty clay was encountered to depth of about 2 feet below the existing grade. The cohesive soils encountered below 2 feet consist of soft to hard light gray, light brown lean clay with sand/sandy lean clay and stiff light gray, light brown fat clay with sand.

- Groundwater was not encountered at boring locations during the subsurface investigation.

- Based on the available information from U.S. Geological Survey (USGS) Maps and other public records relating to geologic faults, no documented fault exists in the project area. A geologic fault study was beyond the scope of this investigation.

- All excavation operations should be carried out in accordance with OSHA standards and the Harris County Specifications. Construction excavation recommendations are provided in Section 7.1.

- The project should be designed and constructed in accordance with Harris County standards and specifications.

- Recommendation for buried pipes are provided in Section 7.6.

- Recommendation for culverts are provided in Section 7.7.

- Recommendation for retaining structures are provided in Section 7.8.
- Recommendations for drainage ditches are provided in Section 7.9.
- Recommendations for residential driveway pavement are provided in Section 7.10

2.0 INTRODUCTION

Project Location. The project alignment is along the existing Hargrave road in Harris County, Precinct 4, Texas. The general location and orientation of the site are provided in Appendix A - Project Location Diagrams.

Project Description. The project consists of improvement of approximately 1,000 LF of drainage ditches and about nine driveway culvert bridges along Hargrave Road in Prestonwood Forest Subdivision (UPIN 19104MF16Q01).

Project Authorization. This geotechnical investigation was authorized by Ms. Delea R. Cooper, P.E. with Bleyl Engineering and performed in accordance with GES Proposal No. P20-0288 dated May 20, 2020.

Purpose and Methodology. The principal purposes of this investigation were to evaluate the general soil conditions at the proposed site and to develop geotechnical engineering design recommendations. To accomplish its intended purposes, the study was conducted in the following phases: (1) drill sample borings to evaluate the soil conditions at the boring locations and to obtain soil samples; (2) conduct laboratory tests on selected samples recovered from the borings to establish the pertinent engineering characteristics of the soils; and (3) perform engineering analyses, using field and laboratory data, to develop design criteria.

Cautionary Statement Regarding Use of this Report. As with any geotechnical engineering report, this report presents technical information and provides detailed technical recommendations for civil and structural engineering design and construction purposes. GES, by necessity, has assumed the user of this document possesses the technical acumen to understand and properly utilize information and recommendations provided herein. GES strives to be clear in its presentation and, like the user, does not want potentially detrimental misinterpretation or misunderstanding of this report. Therefore, we encourage any user of this report with questions regarding its content to contact GES for clarification. Clarification will be provided verbally and/or issued by GES in the form of a report addendum, as appropriate.

Report Specificity. This report was prepared to meet the specific needs of the client for the specific project identified. Recommendations contained herein should not be applied to any other project at this site by the client or anyone else without the explicit approval of GES.

3.0 PURPOSE AND SCOPE

The purposes of this study were to evaluate soil and groundwater conditions and to provide geotechnical engineering recommendations for improvement of approximately 1,000 LF of drainage ditches and about nine (9) driveway culvert bridges along Hargrave Road within Prestonwood Forest Subdivision, in Harris County, Precinct 4, Texas (UPIN 19104MF16Q01). The scope of this investigation consisted of the following:

- Drill and sample three (3) 15-foot borings along the proposed approximately 1,000 LF of drainage improvements.

- Perform appropriate laboratory tests in accordance with ASTM methods on selected samples to develop engineering properties of the soil.

- Review (desk-top study) of available fault information to evaluate the potential for known active faults that may impact the project. Perform engineering analyses in accordance with the Harris County Geotechnical Investigation Guidelines to develop geotechnical recommendations for the proposed drainage improvement.

- Prepare a geotechnical report that includes all field data, laboratory test data and geotechnical recommendations for the proposed drainage ditch improvements, culvert bridges, and residential driveways.

4.0 FIELD INVESTIGATION

Subsurface Investigation. The subsurface investigation for this project is summarized below. Boring locations are provided in Appendix B - Boring Location Diagram.

Boring Nos.	Depth, feet bgs[1]	Date Drilled	Location[2]
B-01 to B-03	15	6/18/2020	Along the alignment of proposed improvements

Notes:
1. bgs = below ground surface
2. Boring locations provided in Appendix B - Boring Location Diagram were not surveyed and should be considered approximate. Borings were located by recreational hand-held GPS unit. Horizontal accuracy of such units is typically on the order of 20-feet.

Boring Logs. Subsurface conditions were defined using the sample borings. Boring logs generated during this study are included in Appendix C - Boring Logs and Laboratory Results. Borings were advanced between sample intervals using continuous flight auger drilling procedures.

Cohesive Soil Sampling. Cohesive soil samples were generally obtained using Shelby tube samplers in general accordance with American Society for Testing and Materials (ASTM) D1587. The Shelby tube sampler consists of a thin-walled steel tube with a sharp cutting edge connected to a head equipped with a ball valve threaded for rod connection. The tube is pushed into the undisturbed soils by the hydraulic pulldown of the drilling rig. The soil specimens were extruded from the tube in the field, logged, tested for consistency using a hand penetrometer, sealed and packaged to maintain "in situ" moisture content.

Consistency of Cohesive Soils. The consistency of cohesive soil samples was evaluated in the field using a calibrated hand penetrometer. In this test a 0.25-inch diameter piston is pushed into the undisturbed sample at a constant rate to a depth of 0.25-inch. The results of these tests are tabulated at the respective sample depths on the boring logs. When the capacity of the penetrometer is exceeded, the value is tabulated as 4.5+.

Granular Soil Sampling. Granular soil samples were generally obtained using split-barrel sampling procedures in general accordance with ASTM D1586. In the split-barrel procedure, a disturbed sample is obtained in a standard 2-inch outside diameter (OD) split barrel sampling spoon driven 18-inches into the ground using a 140-pound (lb) hammer falling freely 30 inches. The number of blows for the last 12-inches of a standard 18-inch penetration is recorded as the Standard Penetration Test resistance (N-value). The N-values are recorded on the boring logs at the depth of sampling. Samples were sealed and returned to our laboratory for further examination and testing.

Groundwater Observations. Groundwater observations are shown on the boring logs.

Borehole Plugging. Upon completion of the borings, the boreholes were backfilled from the top and plugged at the surface.

5.0 LABORATORY TESTING

GES performs visual classification and any of a number of laboratory tests, as appropriate, to define pertinent engineering characteristics of the soils encountered. Tests are performed in general accordance with ASTM or other standards and the results included at the respective sample depths on the boring logs or separately tabulated, as appropriate, and included in Appendix C - Boring Logs and Laboratory Results. Laboratory tests and procedures routinely utilized, as appropriate, for geotechnical investigations are tabulated below.

Test Procedure	Description
ASTM D421	Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D1140	Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75-µm) Sieve
ASTM D2166	Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
ASTM D2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2217	Standard Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
ASTM D2487	Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D2850	Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soil
ASTM D4220	Standard Practices for Preserving and Transporting Soil Samples
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
Manufacturer's Instructions	Soil Strength Determination Using a Torvane.

6.0 SITE CONDITIONS

6.1 General

Review of Aerial Photographs. Historical aerial photographs of the site were reviewed for potential past alterations to the site which could impact geotechnical design conditions. Specifically, aerial photographs were reviewed to visually assess obvious areas of significant past fill on site. Aerial photographs reviewed for this study are identified below and are included in Appendix D - Aerial Photographs.

Aerial Photographs Reviewed	
Year	Observations Since Prior Aerial Photograph
1944	The existing roadway was noted in the site.
1978	No visible changes.
1989	No visible changes.
1995	No visible changes.
2002	No visible changes.
2006	No visible changes.
2010	No visible changes.
2013	No visible changes.
2017	No visible changes.
2019	No visible changes.

Site Fills. Our review revealed no obvious areas of significant fill on-site.

Limitations. Due to the intermittent nature and relatively low resolution of aerial photographs, as well as our lack of detailed information regarding the past land use of the site, our review should not be interpreted as eliminating the possibility of cuts and/or fills on site which could detrimentally affect future construction.

Topography. A United States Geological Survey (USGS) topographic map of the site is provided in Appendix E - USGS Topographic Map.

Site Photographs. Photographs representative of the site at the time of this investigation are provided in Appendix F - Site Photographs. Photographed conditions are consistent with the aerial photographs and topographic map.

6.2 Geology

Geologic Formation. Based on available surface geology maps and our experience, it appears this site is located in the Lissie Formation. A geologic atlas and U.S. Geological Survey (USGS) formation description are provided in Appendix G - Geologic Informatio. Soils within the Lissie Formation can generally be characterized as sand, silt, clay, and minor amount of gravel.

Geologic Faults. According to the published map "Principal faults in the Houston, Texas, metropolitan area (after Shah, S. D., & Lanning-Rush, J., 2005)", the nearest geologic fault is about 6.7-miles southeast of the project site. The noted geologic fault has no impact on the proposed drainage improvements. A geologic fault study was beyond the scope of this investigation.

6.3 Soil

Stratigraphy. Descriptions of the various strata and their approximate depths and thickness per the Unified Soil Classification System (USCS) are provided on the boring logs included in Appendix C - Boring Logs and Laboratory Results. Terms and symbols used in the USCS are presented in Appendix C - Boring Logs and Laboratory Results.. A brief summary of the stratigraphy indicated by the borings is provided below.

Generalized Subsurface Conditions at Proposed Along the Alignment of Proposed Improvements (Borings B-01 to B-03)			
Nominal Depth, feet bgs (Except as Noted)		General Description	Detailed Description of Soils/Materials Encountered
Top of Layer	Bottom of Layer		
0	9.5-inches	PAVEMENT	9.5-inch ASPHALT.
9.5-inches	2	SILTY CLAY	SANDY SILTY CLAY (CL-ML).
2	15	LEAN CLAY WITH SOME FAT CLAY	Soft to hard LEAN CLAY WITH SAND (CL) / SANDY LEAN CLAY (CL) and stiff FAT CLAY WITH SAND (CH).
Note: Boring Termination Depth = 15 feet bgs.			

Moisture Change Susceptibility of Near Surface Soils. The silty/sandy soils encountered at and near the ground surface at this site are very susceptible to changes in moisture. The presence of surface water due to precipitation or groundwater may result in a decrease in the ability to compact and work with the soil. It is common for these soils to pump when subjected to high levels of moisture. In addition, these soils located at and near the ground surface will allow surface water to infiltrate until the water becomes perched on a less permeable layer at depth. Soils of this type are especially prone to requiring the implementation of wet weather/soft subgrade recommendations provided in this report.

Swell Potential based on Atterberg Limits. Atterberg (plastic and liquid) limits were performed on 6 shallow soil samples obtained at depths between 0- and 8-feet bgs. The plasticity index of the samples was between 5 and 25 with an average of 12 indicating that the soils have a low to moderate potential for shrinking and swelling with changes in soil moisture content.

6.4 Groundwater

Groundwater Levels. The borings were advanced using auger drilling and intermittent sampling methods in order to observe groundwater seepage levels. Groundwater levels encountered in the borings during this investigation are identified in the following table.

Boring No.	Depth Groundwater Initially Encountered (feet, bgs)	Groundwater Depth after 15 Minutes (feet, bgs)
B-01 to B-03	Not Encountered	Not Encountered

Long-term Groundwater Monitoring. Long-term monitoring of groundwater conditions via piezometers was not performed during this investigation and was beyond the scope of this study. Long-term monitoring can reveal groundwater levels materially different than those encountered during measurements taken while drilling the borings.

Groundwater Fluctuations. Future construction activities may alter the surface and subsurface drainage characteristics of this site. It is difficult to accurately predict the

magnitude of subsurface water fluctuations that might occur based upon short-term observations. The groundwater level should be expected to fluctuate throughout the years with variations in precipitation.

7.0 ANALYSIS AND RECOMMENDATIONS

7.1 Construction Excavations

Applicability. Recommendations in this section apply to short-term construction-related excavations for this project. Further, drainage improvement excavation should be in accordance with Harris County standard specification Item 120.

Sloped Excavations. All sloped short-term construction excavations on-site should be designed in accordance with Occupational Safety and Health Administration (OSHA) excavation standards. Borings from this investigation indicated that the soils may be classified per OSHA regulations as Type B from the ground surface to a depth of 15-feet bgs. Short-term construction excavations may be constructed with a maximum slope of 1:1, horizontal to vertical (H:V), to a depth of 15-feet bgs. If excavations are to be deeper than 15-feet, we should be contacted to evaluate the excavation. Recommendations provided herein are not valid for any long-term or permanent slopes on-site.

Shored Excavations. As an alternative to sloped excavations, vertical short-term construction excavations may be used in conjunction with trench boxes or other shoring systems. Shoring systems should be designed using an equivalent fluid weight of 65 pounds per cubic foot (pcf) above the groundwater table and 95 pcf below the groundwater table. Surcharge pressures at the ground surface due to dead and live loads should be added to the lateral earth pressures where they may occur. Lateral surcharge pressures should be assumed to act as a uniform pressure along the upper 10-feet of the excavation based on a lateral earth coefficient of 0.5. Surcharge loads set back behind the excavation at a horizontal distance equal to or greater than the excavation depth may be ignored. We recommend that no more than 200-feet of unshored excavation should be open at any one time to prevent the possibility of failure and excessive ground movement to occur. We also recommend that unshored excavations do not remain open for a period of time longer than 24-hours.

Limitations. Recommendations provided herein assume there are no nearby structures or other improvements which might be detrimentally affected by the construction excavation. Before proceeding, we should be contacted to evaluate construction excavations with the potential to affect nearby structures or other improvements.

Excavation Monitoring. Excavations should be monitored to confirm site soil conditions consistent with those encountered in the borings drilled as part of this study. Discrepancies

in soil conditions should be brought to the attention of GES for review and revision of recommendations, as appropriate.

7.2 Groundwater Control

Groundwater was not encountered during the subsurface investigation. If groundwater is encountered during excavation, dewatering to bring the groundwater below the bottom of excavations may be required. Dewatering could consist of standard sump pits and pumping procedures, which may be adequate to control seepage on a local basis during excavation. Supplemental dewatering will be required in areas where standard sump pits and pumping is not effective. Supplemental dewatering could include submersible pumps in slotted casings, well points, or eductors. The contractor should submit a groundwater control plan, prepared by a licensed engineer experienced in that type of work.

7.3 Earthwork

7.3.1 Site Preparation

In the area of improvements, all concrete, trees, stumps, brush, debris, septic tanks, abandoned structures, roots, vegetation, rubbish and any other undesirable matter should be removed and properly disposed. All vegetation should be removed and the exposed surface should be scarified to an additional depth of at least 6 inches. It is the intent of these recommendations to provide a loose surface with no features that would tend to prevent uniform compaction by the equipment to be used.

7.3.2 Grading and Drainage

Every attempt should be made to limit the extreme wetting or drying of the subsurface soils because swelling and shrinkage of these soils will result. Standard construction practices of providing good surface water drainage should be used. A positive slope of the ground away from any foundation should be provided. Ditches or swales should be provided to carry the run-off water both during and after construction.

Root systems from trees and shrubs can draw a substantial amount of water from the clay soils at this site, causing the clays to dry and shrink. This could cause settlement beneath grade-supported slabs such as floors, walks and paving. Trees and large bushes should be located a distance equal to at least one-half their anticipated mature height away from grade slabs.

7.3.3 Wet Weather/Soft Subgrade

Soft and/or wet surface soils may be encountered during construction, especially following periods of wet weather. Wet or soft surface soils can present difficulties for compaction and other construction equipment. If specified compaction cannot be achieved due to soft or wet surface soils, one of the following corrective measures will be required:

1. Removal of the wet and/or soft soil and replacement with select fill,
2. Chemical treatment of the wet and/or soft soil to improve the subgrade stability, or
3. If allowed by the schedule, drying by natural means.

Chemical treatment is usually the most effective way to improve soft and/or wet surface soils. GES should be contacted for additional recommendations if chemical treatment is planned due to wet and/or soft soils.

7.3.4 Fill

Fill. Fill should consist of material approved by the Geotechnical Engineer with a liquid limit less than 50 and plasticity index (PI) more than 12. Fill should be placed in loose lifts not exceeding 8-inches and should be uniformly compacted in accordance with Harris County standard specification Item 132 and 205, as applicable.

Fill Restrictions. Fill should consist of those materials meeting the requirements stated. Fill should not contain material greater than 4-inches in any direction, debris, vegetation, waste material, environmentally contaminated material, or any other unsuitable material.

Unsuitable Materials. Materials considered unsuitable for use as fill include low and high plasticity silt (ML and MH), silty clay (CL-ML), organic clay and silt (OH and OL) and highly organic soils such as peat (Pt). These soils may be used for site grading and restoration in unimproved areas as approved by the Geotechnical Engineer. Soil placed in unimproved areas should be placed in loose lifts not exceeding 10-inches and should be compacted to at least 92 percent maximum dry density (per ASTM D-698) and at a moisture content within ±4 percentage points of optimum.

7.3.5 Testing

Required Testing and Inspections. Construction monitoring services should be provided for all construction activities according to Harris County Standard Specifications. The minimum level of testing will consist of at least 3 tests for each 1,000 feet per lane of roadway or 4,000 square feet of embankment, per lift. We recommend the soil compaction testing be performed per Harris County Specification.

7.4 Demolition Considerations

Applicability. Recommendations in this section apply to the removal of any existing utilities or pavement which may be present on this site.

General. Special care should be taken in the demolition and removal of existing utilities to minimize disturbance of the subgrade. Excessive disturbance of the subgrade resulting from demolition activities can have serious detrimental effects on future paving elements.

Existing Utilities. Existing utilities and bedding to be abandoned should be completely removed. Existing utilities and bedding may be abandoned in place if they do not interfere with planned development. Utilities which are abandoned in place should be properly pressure-grouted to completely fill the utility.

Backfill. Excavations resulting from the excavation of existing utilities should be backfilled in accordance with Section 7.3.4 – Fill.

Other Buried Structures. If other types of buried structures (e.g. wells, cisterns, etc.) are located on the site, GES should be contacted to address these types of structures on a case-by-case basis.

7.5 Loading on Buried Structures

Applicability. Recommendations in this section apply to buried structures associated with this project (e.g. culverts and underground storm sewer lines).

Uplift. Buried water-tight structures are subjected to uplift forces caused by differential water levels adjacent to and within the structure. Soils with any appreciable silt or sand content will likely become saturated during periods of heavy rainfall and the effective static water level will be at the ground surface. For design purposes, we recommend the groundwater level be assumed at the ground surface. Resistance to uplift pressure is provided by soil skin friction and the dead weight of the structure. Skin friction should be neglected for the upper 3 feet of soil. A skin friction of 200 pounds per square foot (psf) may be used below a depth of 3 feet.

Lateral Pressure. Lateral pressures on buried structures due to soil loading can be determined using an equivalent fluid weight of 95 pounds per cubic foot (pcf). This includes hydrostatic pressure but does not include surcharge loads. The lateral load produced by a surcharge may be computed as 50 percent of the vertical surcharge pressure applied as a constant pressure over the full depth of the buried structure. Surcharge loads located a horizontal distance equal to or greater than the buried structure depth may be ignored.

Vertical Pressure. Vertical pressures on buried structures due to soil loading can be determined using an equivalent fluid weight of 125 pcf. This does not include surcharge loads. The vertical load produced by a surcharge may be computed as 100 percent of the vertical surcharge pressure applied as a constant pressure over the full width of the buried structure.

7.6 Buried Pipe

Applicability. Recommendations in this section are applicable to the design of buried piping placed by open cut methods associated with this project.

Pressure on Buried Pipe. Design recommendations provided in the "Loading on Buried Structures" section of this report apply to buried piping.

Thrust Restraints. Resistance to lateral forces at thrust blocks will be developed by friction developed along the base of the thrust block and passive earth pressure acting on the vertical face of the block. We recommend a coefficient of base friction of 0.25 (using a Factor of Safety of 2) along the base of the thrust block. Passive resistance on the vertical face of the thrust block may be calculated using the allowable passive earth pressures presented below.

Allowable Passive Earth Pressure by Material Type	
Material	Allowable Passive Pressure (psf)
Native Clay and Clayey Sand	2,000
Compacted Clay Fill	1,500
Note: Passive resistance should be neglected for any portion of the thrust block within 3 feet of the final site grade. The allowable passive resistance for native clays and clayey sand is based on the thrust block bearing directly against vertical, undisturbed cuts in these materials.	

Bedding and Backfill. Pipe bedding and pipe-zone backfill for the storm drain piping should be in accordance with Harris County standard specification Item 430. The pipe-zone consists of all materials surrounding the pipe in the trench from six (6) inches below the pipe to 12 inches above the pipe.

Trench Backfill. Excavated site soils will be utilized to backfill the trenches above the pipe-zone. Backfilled soil should be placed in loose lifts not exceeding 8-inches and should be compacted in accordance with Harris County standard specification Item 430.

Trench Settlement. Settlement of backfill should be anticipated. Even for properly compacted backfill, fills in excess of 8 to 10 feet are still subject to settlements over time of about 1 to 2 percent of the total fill thickness. This level of settlement can be significant for fills beneath streets. Therefore, close coordination and monitoring should be performed to reduce the potential for future movement.

7.7 Culverts

Pressure on Culverts. Design recommendations provided in the "Loading on Buried Structures" section of this report apply to buried culverts associated with this project.

Bedding and Backfill. Culverts bedding and backfill should be in accordance with Harris County standard specification Item 430. Cement stabilized bedding and backfill for culverts should be in accordance with Harris County Standard Specification Item 433.

Bearing Capacity. We understand that the box culverts may be supported on a seal slab foundation. Seal slab foundation can be proportioned using a net dead load plus sustained live load bearing pressure of 1,500 psf or a net total load bearing pressure of 2,250 psf, whichever condition results in a larger bearing surface.

7.8 Retaining Structures

General. Recommendations provided in this section are applicable to retaining structures (e.g. headwalls and wingwalls). Headwall and wingwalls associated with the proposed culvert bridges should be designed and constructed based on Harris County Criteria. *It is imperative that global stability be reviewed by GES on any retaining structure in excess of 6-feet in height.*

Lateral Pressure. Lateral pressures on retaining structures due to soil loading can be determined using an equivalent fluid weight of 65 pounds per cubic foot (pcf) if fill behind the wall is free-draining and above the groundwater table and 95 pcf if fill behind the wall is not free draining or is below the groundwater table. This does not include surcharge loads. This also assumes a horizontal ground surface behind the structure. The lateral load produced by a surcharge may be computed as 50 percent of the vertical surcharge pressure applied as a constant pressure over the full depth of the buried structure. Surcharge loads set back behind the retaining structure at a horizontal distance equal to or greater than the structure height may be ignored.

Lateral Resistance. Resistance to lateral loads may be provided by the soil adjacent to the structure. We recommend using an equivalent fluid weight of 100 pcf for lateral resistance (using a Factor of Safety of 3). An allowable coefficient of sliding friction of 0.25 (using a Factor of Safety of 2) between the retaining structure concrete footings and underlying soil may be combined with the passive lateral resistance.

Bearing Capacity. Assuming a minimum embedment depth of 24-inches, an allowable bearing capacity of 1,500 psf may be used for retaining structure footings (using a Factor of Safety of 3).

7.9 Drainage Ditch

Soil Condition. As revealed by the borings, the subsurface soils along the proposed drainage ditch improvement generally consist of cohesive soils. Brown sandy silty clay was encountered to depth of about 2 feet below the existing grade. The cohesive soils encountered below 2 feet consist of soft to hard light gray, light brown lean clay with sand/sandy lean clay and stiff light gray, light brown fat clay with sand.

Recommended Geometry. Based on the provided information, we understand the maximum depth of the proposed improved drainage ditches can be up to 4-feet. Based on the subsurface condition encountered, we recommend that the proposed drainage ditch slopes be constructed at slopes no steeper than 2H:1V.

Erosion Protection. Erosion protection measures (e.g. turf grass) are recommended for drainage ditch side slopes. The erosion protection should be in accordance with Harris County standard specifications.

7.10 Residential Driveway

Applicability. Recommendations in this section are applicable to the design of private residential driveways associated with the project.

Concrete Residential Driveway. Portland cement concrete (PCC) with a minimum 28-day compressive strength of 3,500 pounds per square inch (psi) should be utilized for residential driveway pavement. Grade 60 reinforcing steel should be utilized in the transverse and longitudinal directions. The following pavement thickness and reinforcing are recommended:

Paving Use	Thickness (inches)	Longitudinal Reinforcing
Residential Driveway	5	No. 3 bars spaced on 20-inch intervals

Where not specified herein, concrete pavement should comply with Harris County Standard Specifications, Item 360, "Concrete Pavement".

Subgrade. The residential driveway pavement subgrade should be placed in loose lifts not exceeding 8-inches and should be uniformly compacted in accordance with Harris County standard specification Item 205.

8.0 GENERAL COMMENTS

Data Assumptions. By necessity, geotechnical engineering design recommendations are based on a limited amount of information about subsurface conditions. In the analysis, the geotechnical engineer must assume subsurface conditions are similar to those encountered in the borings. The analyses, conclusions and recommendations contained in this report are based on site conditions as they existed at the time of the field investigation and on the assumption that the exploratory borings are representative of the subsurface conditions throughout the site; that is, the subsurface conditions everywhere are not significantly different from those disclosed by the borings at the time they were completed.

Subsurface Anomalies. Anomalies in subsurface conditions are often revealed during construction. If during construction, different subsurface conditions from those encountered in our borings are observed, or appear to be present in excavations, we must be advised promptly so that we can review these conditions and reconsider our recommendations where necessary.

Change of Conditions. If there is a substantial lapse of time between submission of this report and the start of the work at the site, if conditions have changed due either to natural causes or to construction operations at or adjacent to the site, or if structure locations, structural loads or finish grades are changed, we should be promptly informed and retained to review our report to determine the applicability of the conclusions and recommendations, considering the changed conditions and/or time lapse.

Design Review. GES, Inc. should be retained to review those portions of the plans and specifications for this particular project that pertain to earthwork and foundations as a means to determine whether the plans and specifications are consistent with the recommendations contained in this report.

Construction Materials Testing and Inspection. GES should be retained to observe earthwork and foundation installation and perform materials evaluation and testing during the construction phase of the project. This enables GES's geotechnical engineer to stay abreast of the project and to be readily available to evaluate unanticipated conditions, to conduct additional tests if required and, when necessary, to recommend alternative solutions to unanticipated conditions. It is proposed that construction phase observation and materials testing commence by the project geotechnical engineer (GES) at the outset of the project. Experience has shown that the most suitable method for procuring these services is for the owner to contact directly with the project geotechnical engineer. This results in a clear, direct line of communication between the owner and the owner's design engineers and the geotechnical engineer.

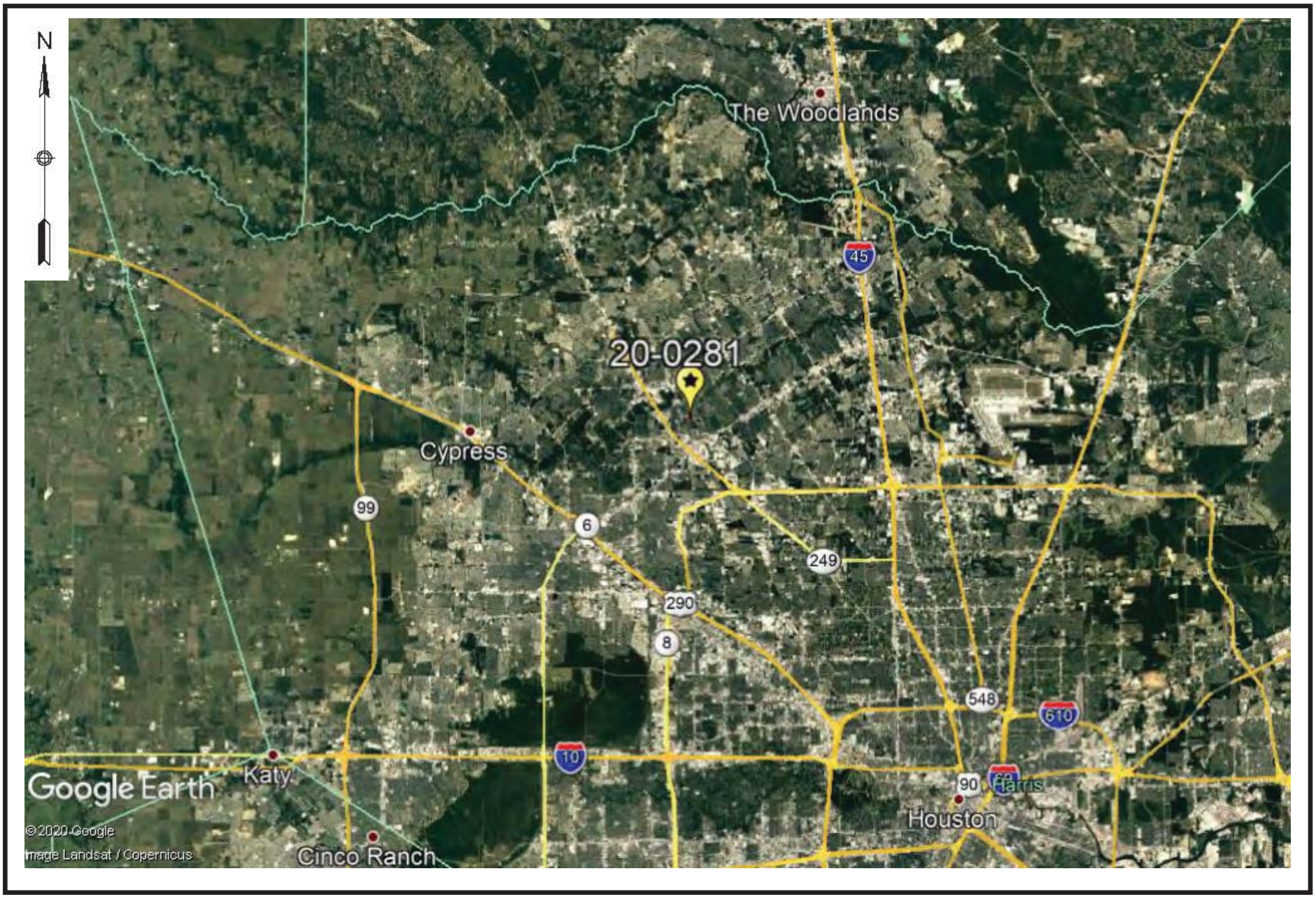
Report Recommendations are Preliminary. Until the recommended construction phase services are performed by GES, the recommendations contained in this report on such items as final foundation bearing elevations, final depth of undercut of expansive soils for non-expansive earth fill pads and other such subsurface-related recommendations should be considered as preliminary.

Liability Limitation. GES cannot assume responsibility or liability for recommendations provided in this report if construction inspection and/or testing recommended herein is performed by another party.

Warranty. This report has been prepared for the exclusive use of the Client and their designated agents for specific application to design of this project. We have used that degree of care and skill ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality. No other warranty, expressed or implied, is made or intended.

Appendix A - Project Location Diagrams

PROJECT LOCATION DIAGRAM - GENERAL



GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

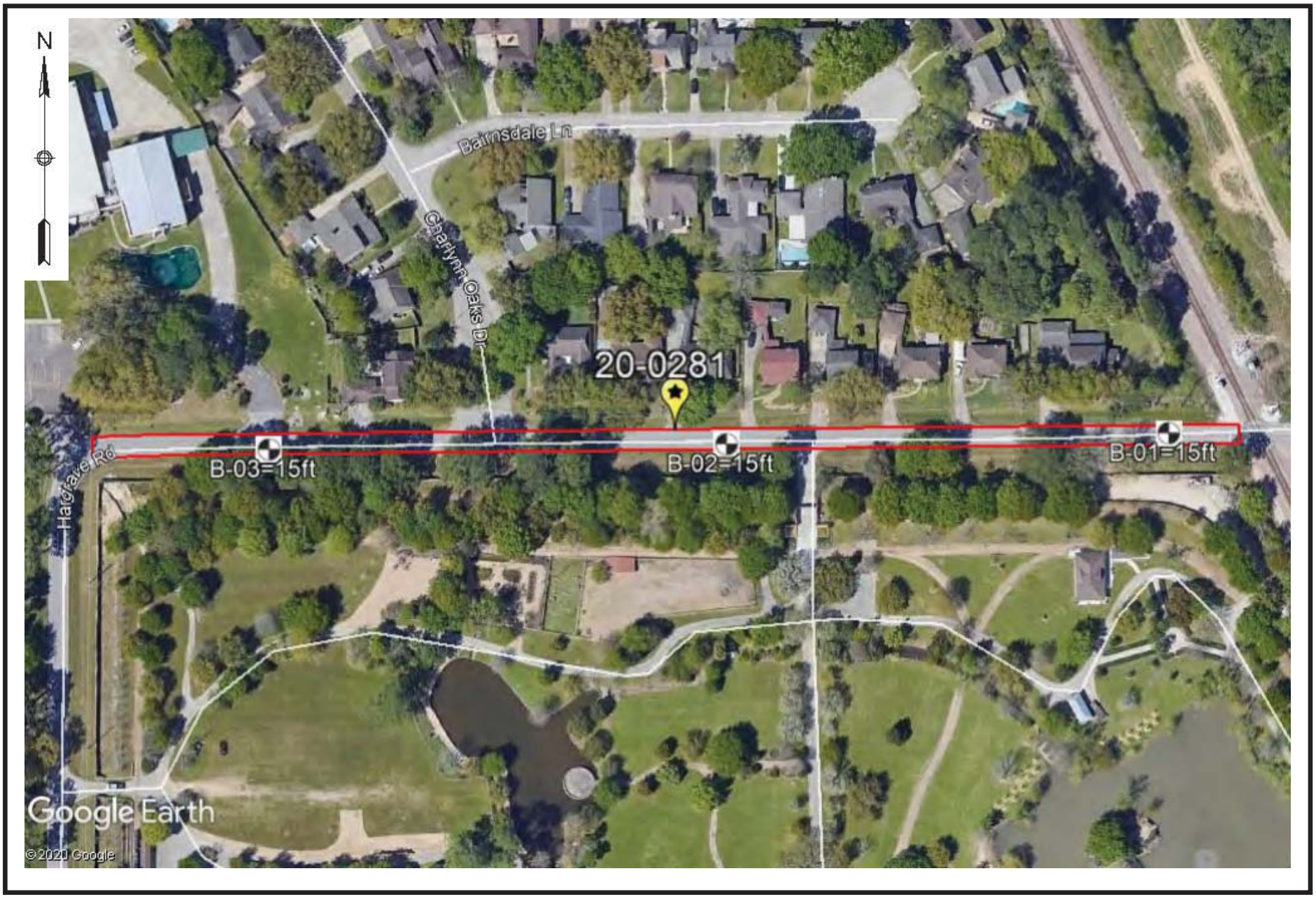
PROJECT LOCATION DIAGRAM - LOCAL

GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

Appendix B - Boring Location Diagram

BORING LOCATION DIAGRAM



GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

Appendix C - Boring Logs and Laboratory Results

Gorrondona Engineering Services
4641 Kennedy Commerce Drive, Houston, TX 77032
Telephone: 281-469-3347; Fax: 281-469.3594

BORING NUMBER B-01

CLIENT Bleyl Engineering
PROJECT NAME Prestonwood Forest Subdivision Drainage Improvements
PROJECT NUMBER 20-0281
PROJECT LOCATION Harris County, Precinct 4, Texas
DATE STARTED 6/18/20 **COMPLETED** 6/18/20
GROUND ELEVATION _____ **HOLE SIZE** _____
CONTRACTOR GES
GROUND WATER LEVELS:
METHOD Auger
INITIALLY ENCOUNTERED Not Encountered
LOGGED BY M.S. **CHECKED BY** A.A.
AFTER 15 MIN. Not Encountered
NOTES _____
AFTER ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	TORVANE (tsf)	Compressive Strength (tsf)	Confining Pressure (psi)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		PAVEMENT - 9.5-inch ASPHALT.													
		SANDY SILTY CLAY (CL-ML) - Brown.	AU								14	19	12	7	63
2.5		LEAN CLAY WITH SAND (CL) / SANDY LEAN CLAY (CL) - Stiff to very stiff, brown and light brown. with sand pockets to 6 feet.	ST			2.50	1.0								
5.0			ST			2.00	1.1				15	26	13	13	71
7.5			ST			4.00	1.3								
10.0			ST			3.00	1.0	2.2	0	121	14				
12.5		FAT CLAY WITH SAND (CH) - Stiff, light gray and light brown.													
15.0			ST			3.00	1.1	1.9	6	95	28				

Bottom of hole at 15.0 feet.

Gorrondona Engineering Services
4641 Kennedy Commerce Drive, Houston, TX 77032
Telephone: 281-469-3347; Fax: 281-469.3594

BORING NUMBER B-02

CLIENT Bleyl Engineering
PROJECT NAME Prestonwood Forest Subdivision Drainage Improvements
PROJECT NUMBER 20-0281
PROJECT LOCATION Harris County, Precinct 4, Texas
DATE STARTED 6/18/20 **COMPLETED** 6/18/20
GROUND ELEVATION _____ **HOLE SIZE** _____
CONTRACTOR GES
GROUND WATER LEVELS:
METHOD Auger
INITIALLY ENCOUNTERED Not Encountered
LOGGED BY M.S. **CHECKED BY** A.A.
AFTER 15 MIN. Not Encountered
NOTES _____
AFTER ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	TORVANE (tsf)	Compressive Strength (tsf)	Confining Pressure (psi)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		PAVEMENT - 9.5-inch ASPHALT.													
		SANDY SILTY CLAY (CL-ML) - Brown.	AU								16				
2.5		LEAN CLAY WITH SAND (CL) / SANDY LEAN CLAY (CL) - Soft to hard, light gray and light brown. with sand pockets to 6 feet.	ST			2.50	0.8				17	24	12	12	74
5.0			ST			1.00	0.6								
7.5			ST			3.50	1.5				18	38	13	25	72
10.0			ST			4.50+	1.3	3.5	0	122	13				
		With sand seams below 10 feet.													
12.5															
15.0			ST			1.00	0.8	.7	6	105	17				

Bottom of hole at 15.0 feet.

Gorrondona Engineering Services
4641 Kennedy Commerce Drive, Houston, TX 77032
Telephone: 281-469-3347; Fax: 281-469.3594

BORING NUMBER B-03

CLIENT Bleyl Engineering
PROJECT NAME Prestonwood Forest Subdivision Drainage Improvements
PROJECT NUMBER 20-0281
PROJECT LOCATION Harris County, Precinct 4, Texas
DATE STARTED 6/18/20 **COMPLETED** 6/18/20
GROUND ELEVATION _____ **HOLE SIZE** _____
CONTRACTOR GES
GROUND WATER LEVELS:
METHOD Auger
INITIALLY ENCOUNTERED Not Encountered
LOGGED BY M.S. **CHECKED BY** A.A.
AFTER 15 MIN. Not Encountered
NOTES _____
AFTER ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	TORVANE (tsf)	Compressive Strength (tsf)	Confining Pressure (psi)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		PAVEMENT - 9.5-inch ASPHALT.													
		SANDY SILTY CLAY (CL-ML) - Brown.	AU								8	17	12	5	57
2.5		LEAN CLAY WITH SAND (CL) / SANDY LEAN CLAY (CL) - Hard, light gray and light brown. with sand pockets to 8 feet.	ST			4.50+									
5.0			ST			4.50+					10	22	12	10	62
7.5			ST			4.50+	1.6								
10.0			ST			4.50+	1.5				10				
12.5															
15.0			ST			4.50+	1.8				9				

Bottom of hole at 15.0 feet.

Laboratory Testing Summary

Sample Source	Sample Number	Depth, feet bgs (Except as Noted)	MC[1] (%)	Soil Type[2]	Atterberg Limits[3]			Percent Passing No. 200 Sieve[4]	Compressive Strength[5] (tsf)	Confining Pressure[5] (psi)	Dry Unit Weight[5] (pcf)	Other
					LL	PL	PI					
B-01												
	1	9.5-inch to 2	14	CL-ML	19	12	7	63				
	2	2 to 4		CL								
	3	4 to 6	15	CL	26	13	13	71				
	4	6 to 8		CL								
	5	8 to 10	14	CL					2.2	0	121	
	6	13 to 15	28	CH					1.9	6	95	
B-02												
	1	9.5-inch to 2	16	CL-ML								
	2	2 to 4	17	CL	24	12	12	74				
	3	4 to 6		CL								
	4	6 to 8	18	CL	38	13	25	72				
	5	8 to 10	13	CL					3.5	0	122	
	6	13 to 15	17	CL					0.7	6	105	
B-03												
	1	9.5-inch to 2	8	CL-ML	17	12	5	57				
	2	2 to 4		CL								
	3	4 to 6	10	CL	22	12	10	62				
	4	6 to 8		CL								
	5	8 to 10	10	CL								
	6	13 to 15	9	CL								

Notes: 1. ASTM D 2216, 2. ASTM D 2487, 3. ASTM D 4318, 4. ASTM D 1140, 5. See test reports for test method

Definitions: MC: Moisture Content, Soil Type: USCS (Unified Soil Classification System), LL: Liquid Limit, PL: Plastic Limit, PI: Plasticity Index, CBR: California Bearing Ratio, OC: Organic Content (ASTM D 2974)

Project No. 20-0281
Project Name: Prestonwood Forest Subdivision Drainage Improvements
Date Sampled: 6/18/2020

Gorrondona Engineering Services, Inc.
4641 Kennedy Commerce Drive
Houston, Texas 77032
Phone: (281) 469-3347

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)			
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines
		SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)			
SILTS AND CLAYS Liquid limit less than 50%		ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils

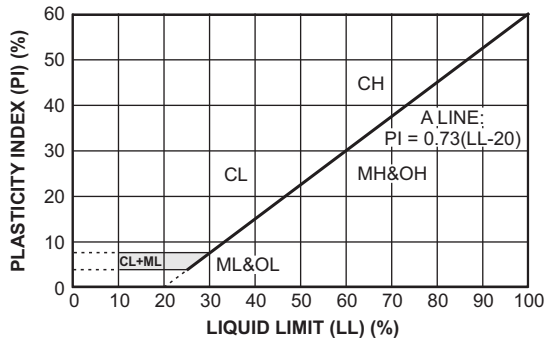
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent ..... GW, GP, SW, SP
More than 12 percent ..... GM, GC, SM, SC
5 to 12 percent ..... Borderline cases requiring dual symbols

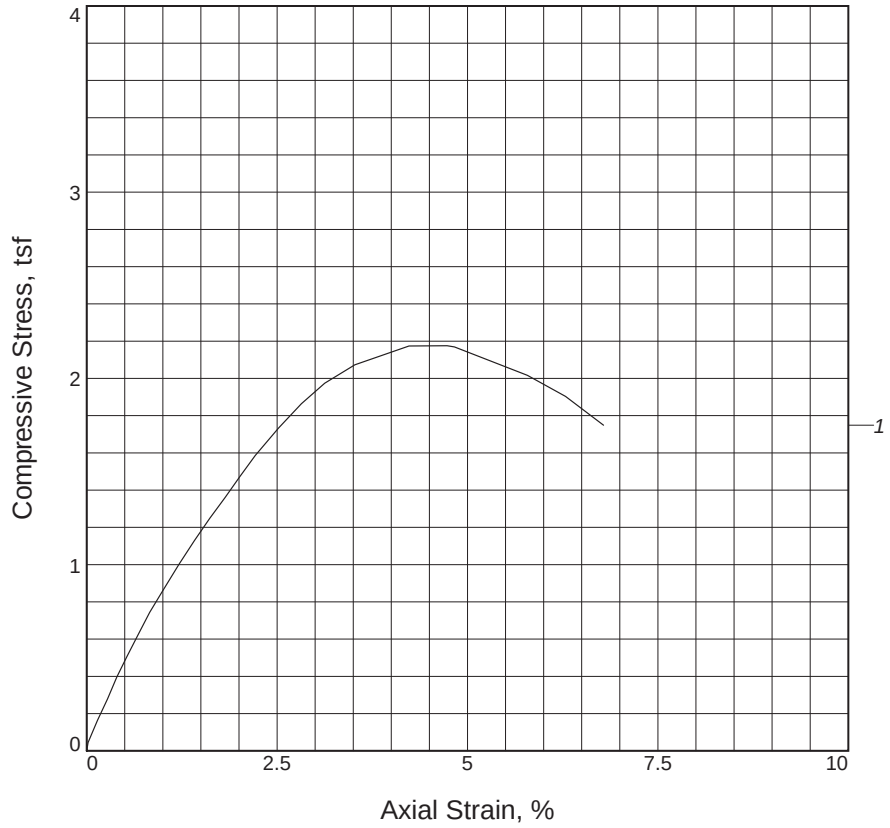
PLASTICITY CHART



TERMS DESCRIBING SOIL CONSISTENCY

Fine Grained Soils		Coarse Grained Soils		
Description	Penetrometer Reading (tsf)	Penetration Resistance (blows/ft)	Description	Relative Density
Soft	0.0 to 1.0	0 to 4	Very Loose	0 to 20%
Firm	1.0 to 1.5	4 to 10	Loose	20 to 40%
Stiff	1.5 to 3.0	10 to 30	Medium Dense	40 to 70%
Very Stiff	3.0 to 4.5	30 to 50	Dense	70 to 90%
Hard	4.5+	Over 50	Very Dense	90 to 100%

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	2.1755			
Undrained shear strength, tsf	1.0877			
Failure strain, %	4.7			
Strain rate, in./min.	1.000			
Water content, %	13.7			
Wet density, pcf	137.2			
Dry density, pcf	120.6			
Saturation, %	91.6			
Void ratio	0.4081			
Specimen diameter, in.	2.77			
Specimen height, in.	5.75			
Height/diameter ratio	2.08			

Description: Ligh Brown LEAN CLAY WITH SAND (CL)

LL =	**PL =**	**PI =**	**Assumed GS=** 2.72	**Type:** Shelby Tube

Project No.: 20-0281
Date Sampled: 6/18/2020
Remarks:

Figure _____

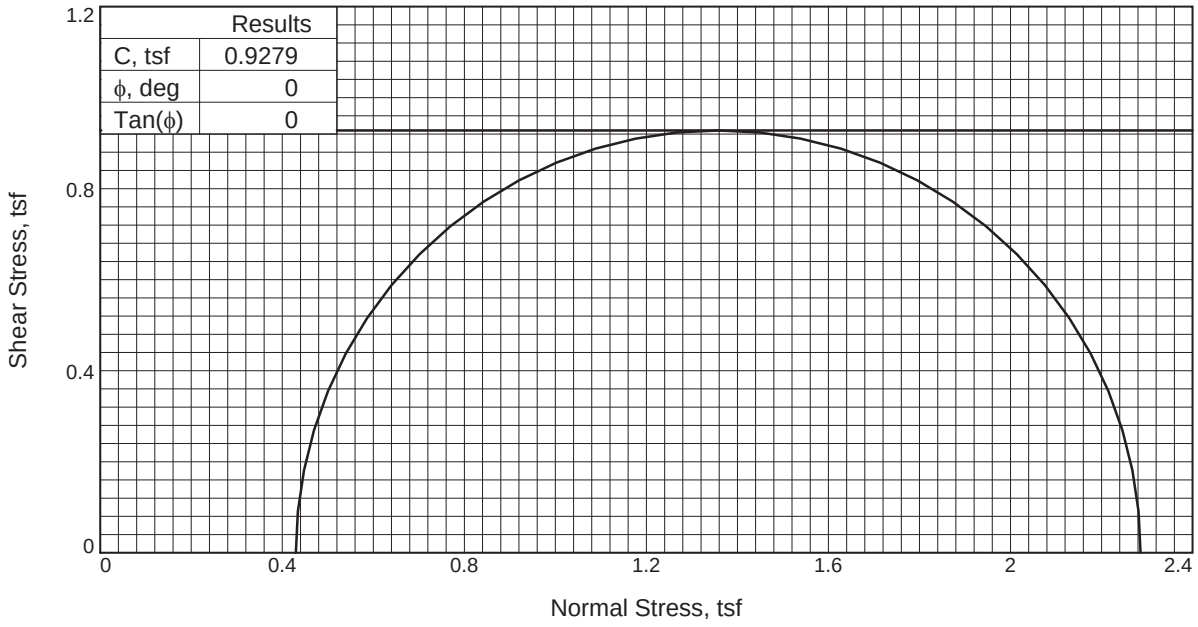
Client: Bleyl Engineering

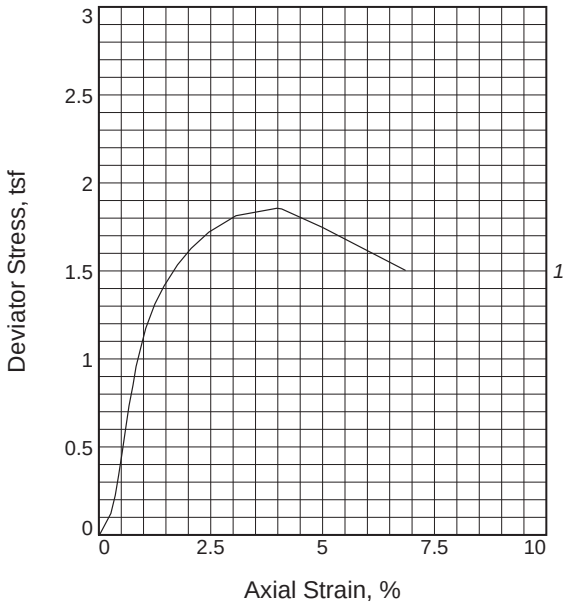
Project: Prestonwood Forest Subdivision Drainage Improvement

Location: Boring B-01
Sample Number: 5 **Depth:** 8' - 10'

UNCONFINED COMPRESSION TEST
Gorrondona Engineering Services
Houston, Texas

Tested By: L.R. **Checked By:** A.A.





Sample No.		1
Initial	Water Content, %	28.4
	Dry Density, pcf	95.3
	Saturation, %	98.7
	Void Ratio	0.7815
	Diameter, in.	2.78
	Height, in.	5.75
At Test	Water Content, %	
	Dry Density, pcf	
	Saturation, %	
	Void Ratio	
	Diameter, in.	
	Height, in.	
Strain rate, in./min.		0.999
Back Pressure, tsf		0.000
Cell Pressure, tsf		0.430
Fail. Stress, tsf		1.856
Ult. Stress, tsf		
σ_1 Failure, tsf		2.286
σ_3 Failure, tsf		0.430

Type of Test:
Unconsolidated Undrained
Sample Type: Shelby Tube
Description: Ligh Gray and Ligh Brown FAT CLAY WITH SAND (CH)

Assumed Specific Gravity= 2.72
Remarks: Slickensided Failure

Figure _____

Client: Bleyl Engineering

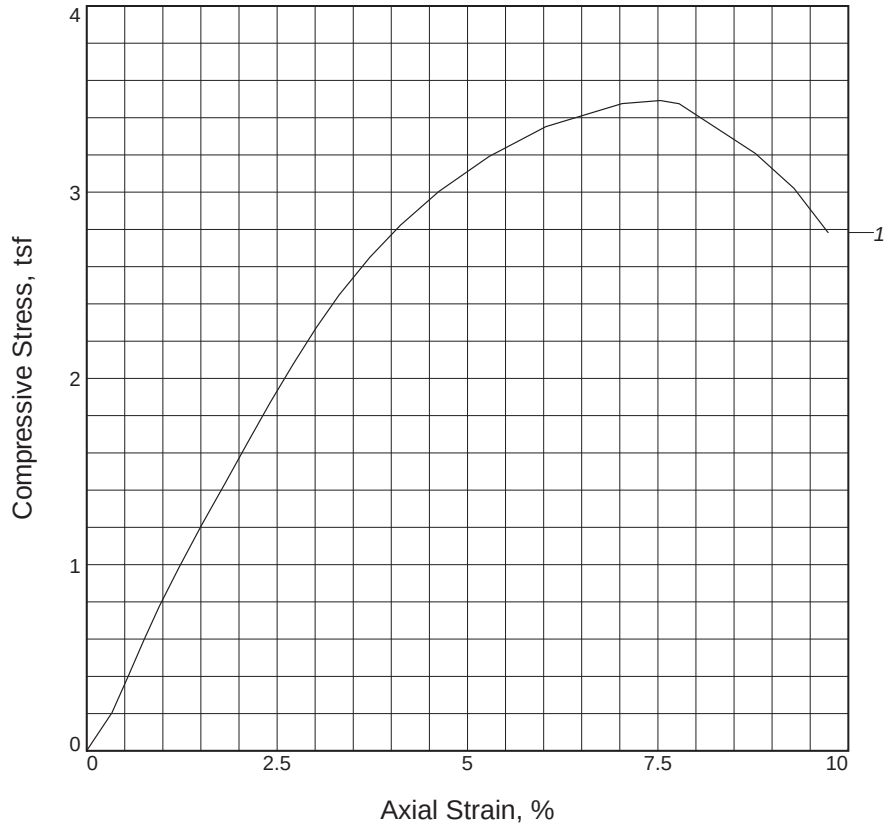
Project: Prestonwood Forest Subdivision Drainage Improvement

Location: Boring B-01
Sample Number: 6 **Depth:** 13' - 15'
Proj. No.: 20-0281 **Date Sampled:** 6/18/2020

TRIAXIAL SHEAR TEST REPORT
Gorrondona Engineering Services
Houston, Texas

Tested By: L.R. **Checked By:** A.A.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	3.4923			
Undrained shear strength, tsf	1.7461			
Failure strain, %	7.5			
Strain rate, in./min.	1.000			
Water content, %	13.4			
Wet density, pcf	138.1			
Dry density, pcf	121.8			
Saturation, %	92.5			
Void ratio	0.3941			
Specimen diameter, in.	2.75			
Specimen height, in.	5.75			
Height/diameter ratio	2.09			

Description: Ligh Gray and Ligh Brown LEAN CLAY WITH SAND (CL)

LL =	**PL =**	**PI =**	**Assumed GS=** 2.72	**Type:** Shelby Tube

Project No.: 20-0281
Date Sampled: 6/18/2020
Remarks:

Figure _____

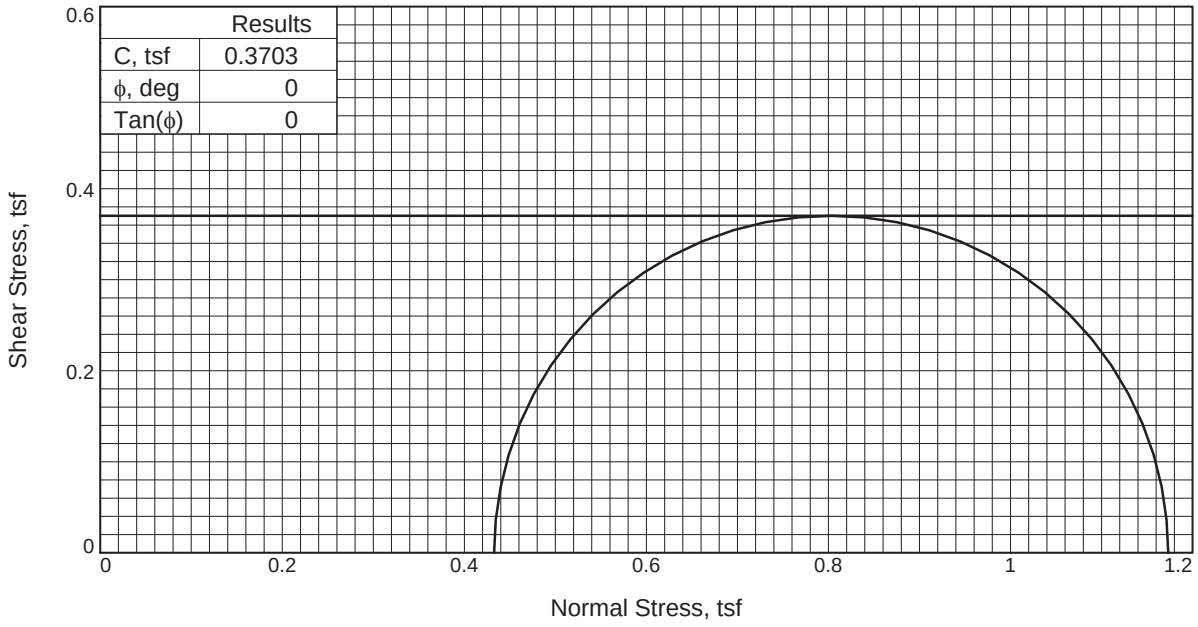
Client: Bleyl Engineering

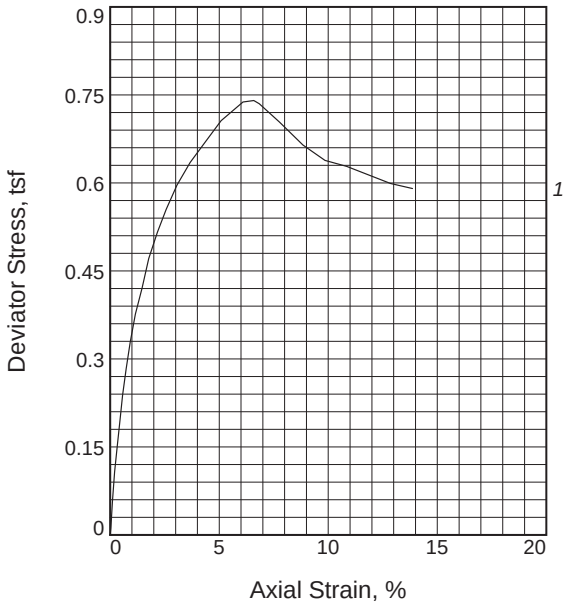
Project: Prestonwood Forest Subdivision Drainage Improvement

Location: Boring B-02
Sample Number: 5 **Depth:** 8' - 10'

UNCONFINED COMPRESSION TEST
Gorrondona Engineering Services
Houston, Texas

Tested By: L.R. **Checked By:** A.A.





Sample No.		1
Initial	Water Content, %	17.2
	Dry Density, pcf	104.7
	Saturation, %	75.4
	Void Ratio	0.6219
	Diameter, in.	2.76
	Height, in.	5.75
At Test	Water Content, %	
	Dry Density, pcf	
	Saturation, %	
	Void Ratio	
	Diameter, in.	
	Height, in.	
Strain rate, in./min.		1.001
Back Pressure, tsf		0.000
Cell Pressure, tsf		0.433
Fail. Stress, tsf		0.741
Ult. Stress, tsf		
σ_1 Failure, tsf		1.173
σ_3 Failure, tsf		0.433

Type of Test:
Unconsolidated Undrained
Sample Type: Shelby Tube
Description: Ligh Gray and Ligh Brown LEAN CLAY WITH SAND (CL)

Assumed Specific Gravity= 2.72
Remarks:

Figure _____

Client: Bleyl Engineering

Project: Prestonwood Forest Subdivision Drainage Improvement

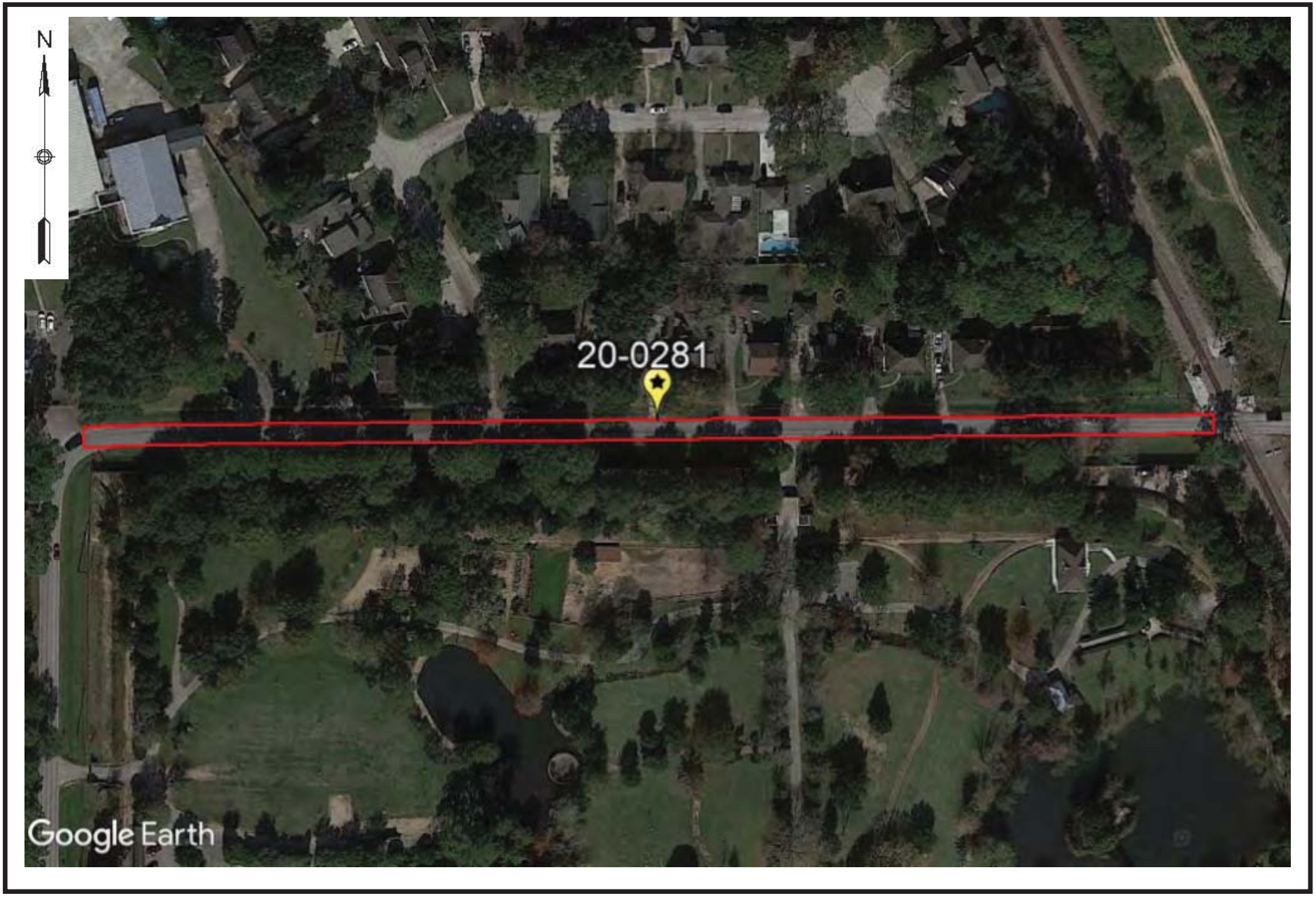
Location: Boring B-02
Sample Number: 6 **Depth:** 13' - 15'
Proj. No.: 20-0281 **Date Sampled:** 6/18/2020

TRIAXIAL SHEAR TEST REPORT
Gorrondona Engineering Services
Houston, Texas

Tested By: L.B. **Checked By:** A.A.

Appendix D - Aerial Photographs

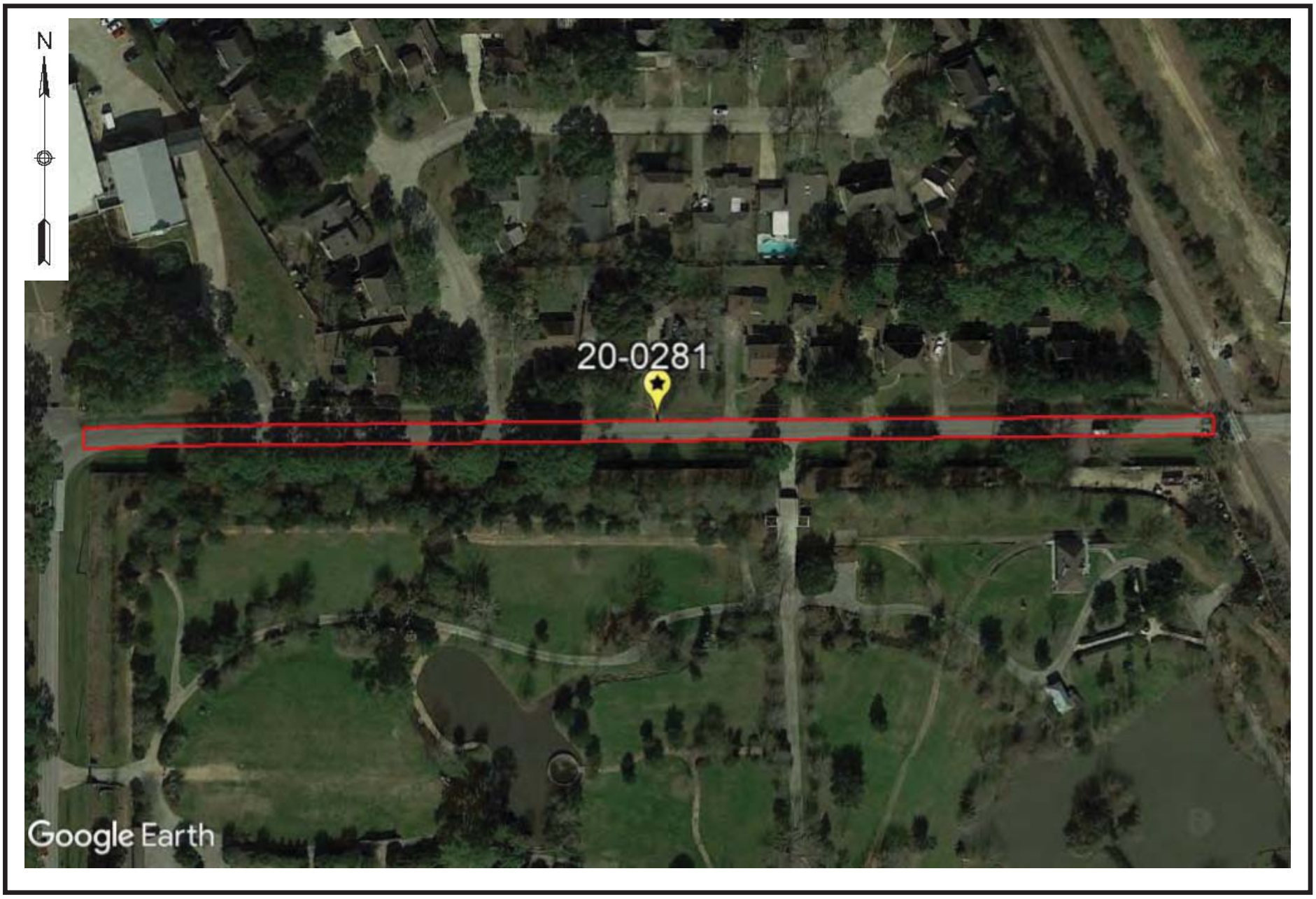
AERIAL PHOTOGRAPH - 2019



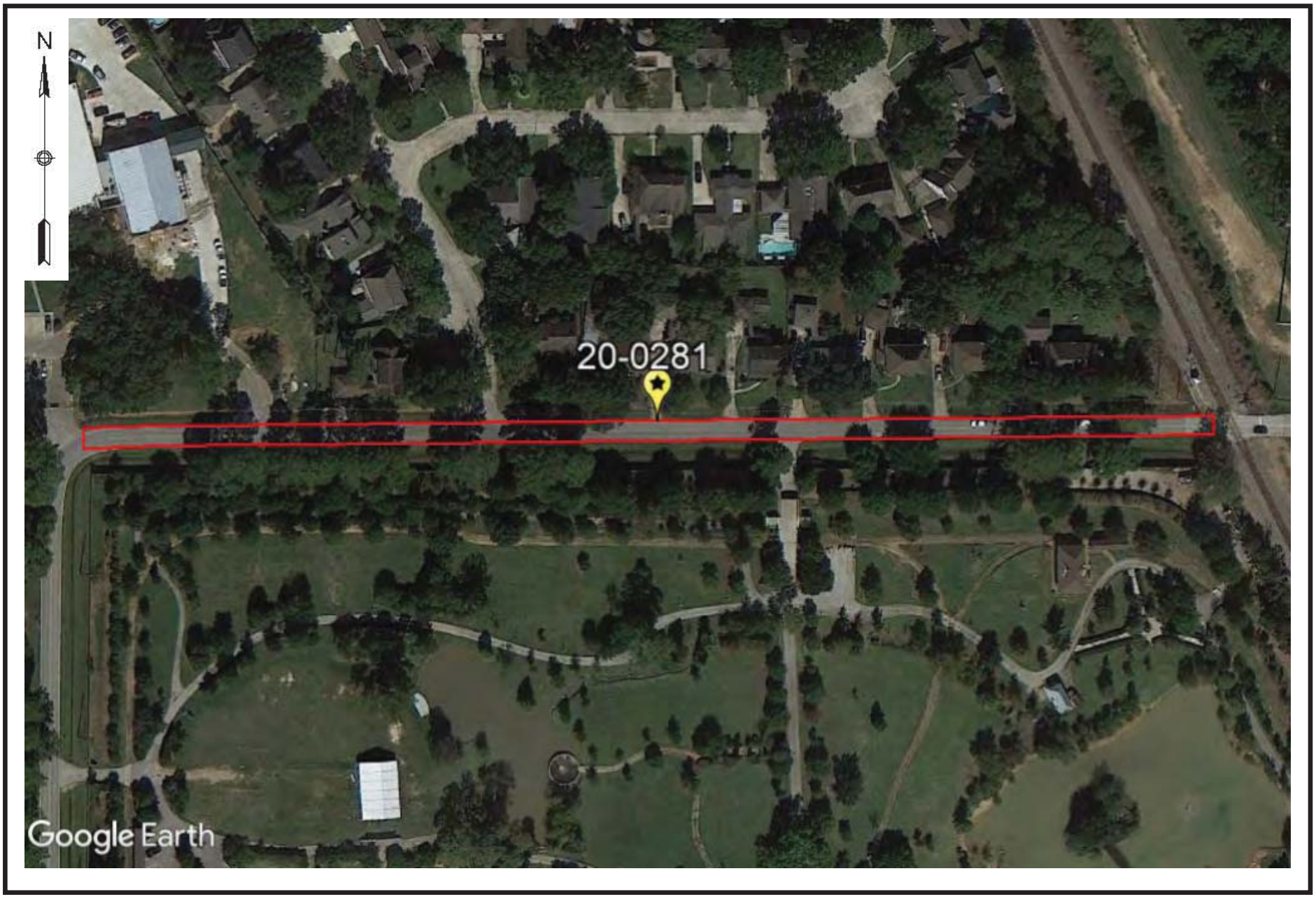
GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

AERIAL PHOTOGRAPH - 2017



AERIAL PHOTOGRAPH - 2013



GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

AERIAL PHOTOGRAPH - 2010

GES Project No. 20-0281

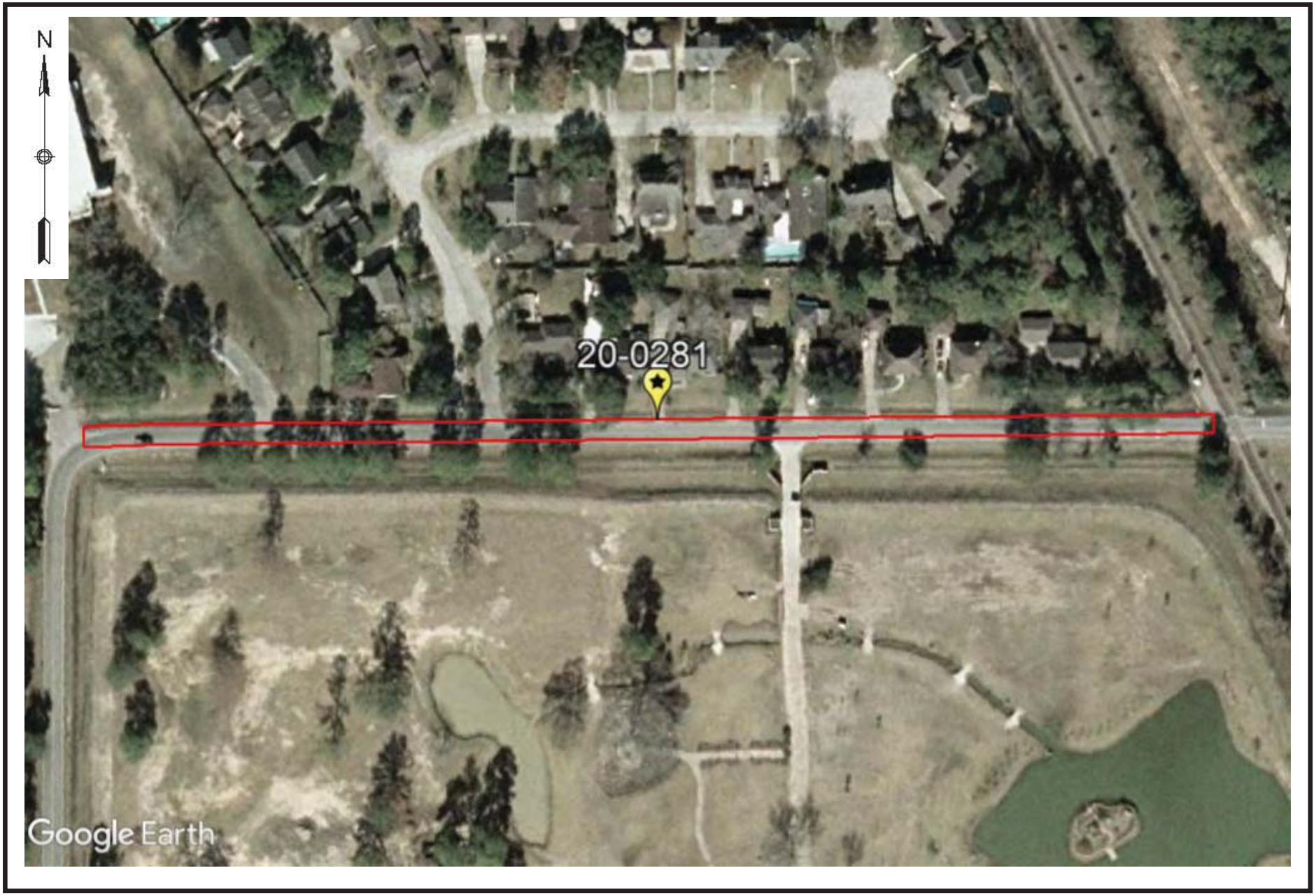
Prestonwood Forest Subdivision Drainage Improvements

AERIAL PHOTOGRAPH - 2006

GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

AERIAL PHOTOGRAPH - 2002



AERIAL PHOTOGRAPH - 1995

AERIAL PHOTOGRAPH - 1989

AERIAL PHOTOGRAPH - 1978

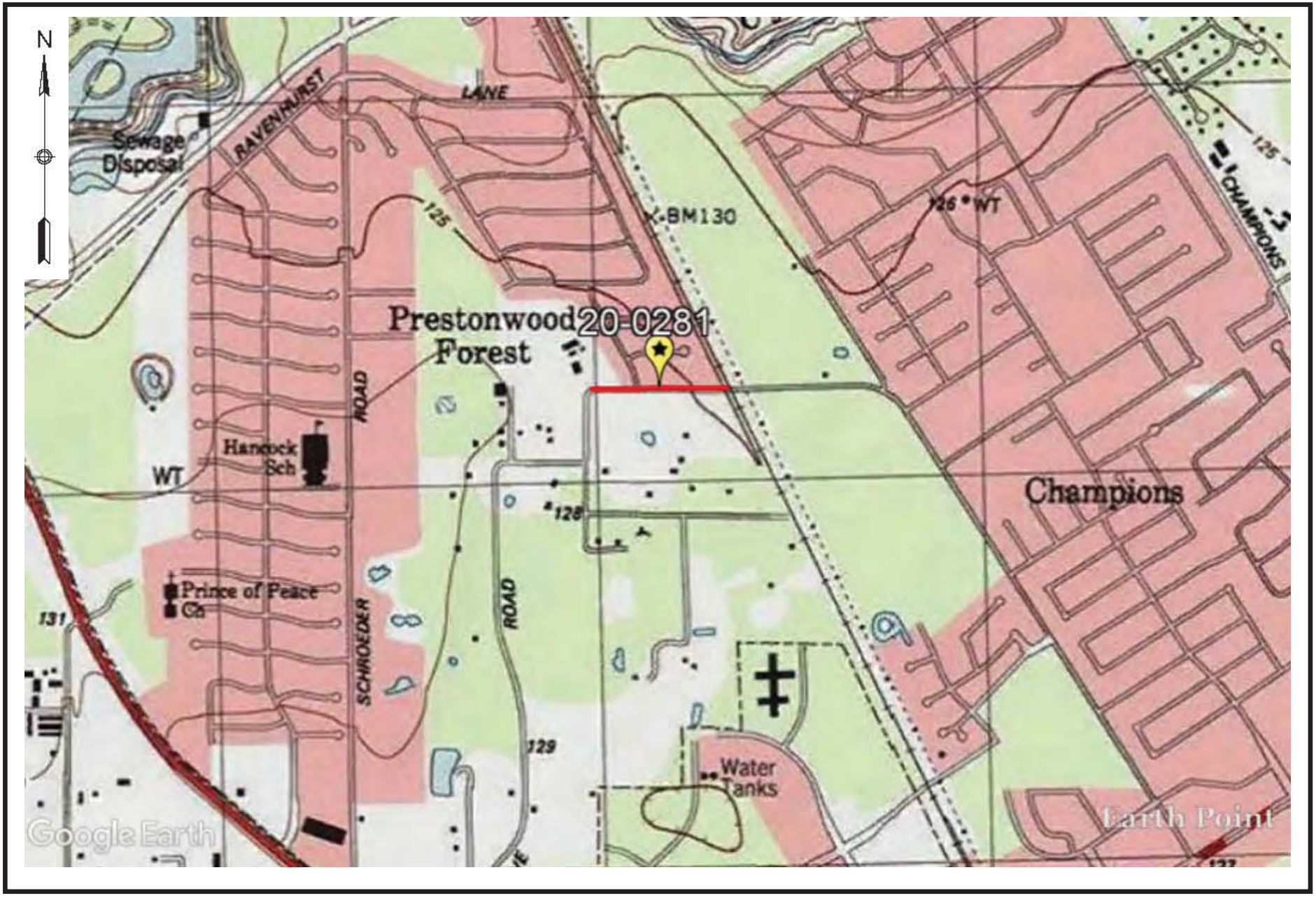
AERIAL PHOTOGRAPH - 1944

GES Project No. 20-0281

Prestonwood Forest Subdivision Drainage Improvements

Appendix E - USGS Topographic Map

USGS TOPOGRAPHIC MAP



Appendix F - Site Photographs

SITE PHOTOGRAPHS

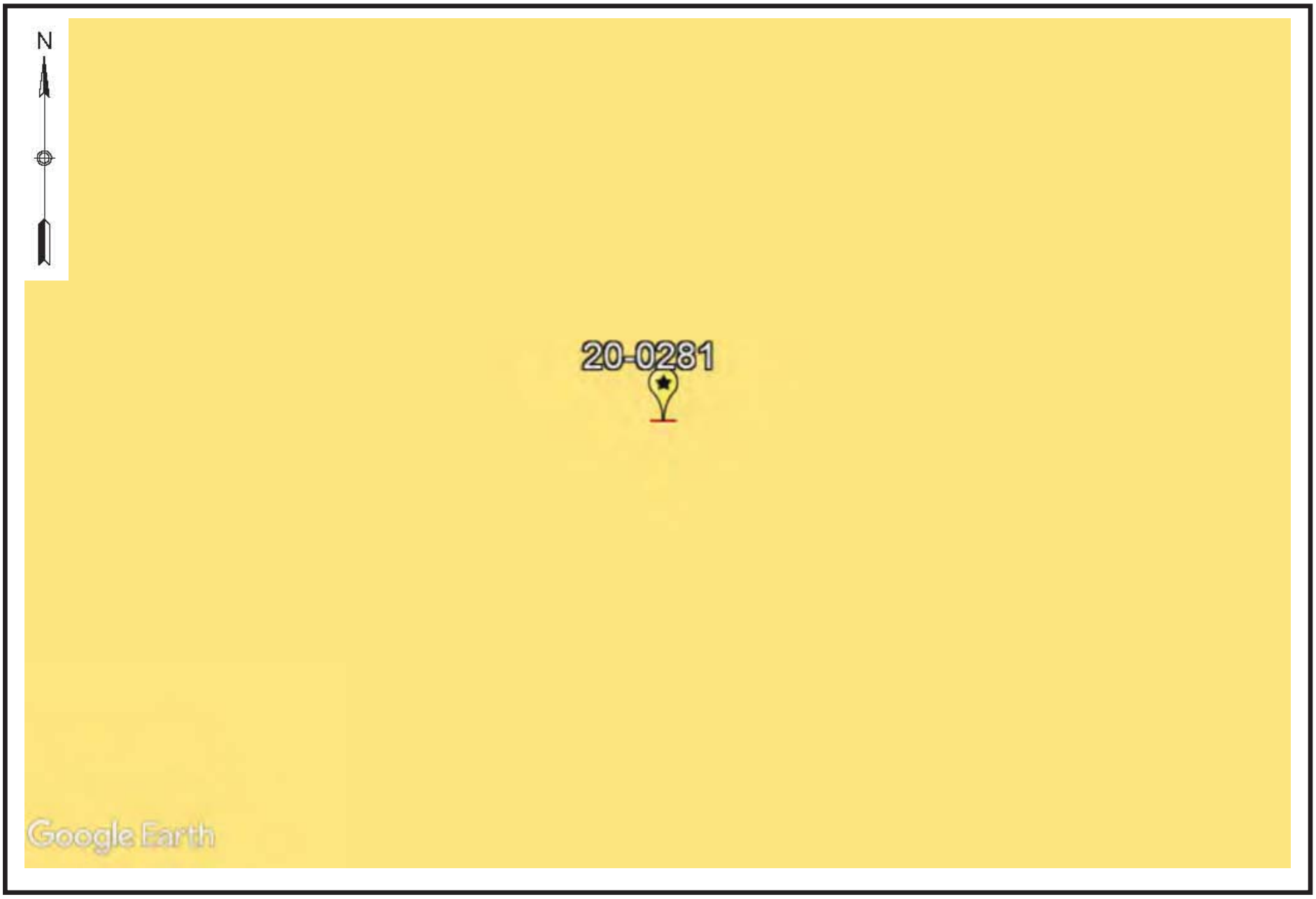
Facing Northwest at Boring B-01

Facing Southeast at Boring B-02

Facing Southeast at Boring B-03

Appendix G - Geologic Information

GEOLOGIC ATLAS



Mineral Resources On-Line Spatial Data

Lissie Formation

Lissie Formation

State	Texas
Name	Lissie Formation
Geologic age	Phanerozoic | Cenozoic | Quaternary | Pleistocene-Middle
Original map label	Ql
Comments	Sand, silt, clay, and minor amount of gravel. Iron oxide and iron-manganese nodules common in zone of weathering; locally calcareous. Surface fairly flat and featureless except for many shallow depressions and pimple mounds. Moore and Wermund (1993a) mapped three units--(1) alluvium undifferentiated as to texture and origin--includes meander belt, levee, crevasse splay, and distributary sand, and flood-basin mud deposits, about 60 m thick, (2) fine-grained channel facies (alluvial sand, silt, and clay) about 10-25 m thick, thicker seward, and (3) fine-grained overbank facies (alluvial silt and clay) about 55-65 m thick, thicker seaward. Together, these deposits form a deltaic plain that parallels the Gulf Coast. Unit contains Pleistocene vertebrate fauna, dips seaward beneath the Beaumont Fm. and disconformably overlies deposits of the Pliocene and early Pleistocene Willis Formation. The deltaic plain is entrenched as much as 7 m by streams. In Hidalgo County (southernmost part of Texas) the unit underlies a semiarid plain, widely irrigated and cultivated. Unit is locally veneered with thin, discontinuous stabilized eolian sand.
Primary rock type	sand
Secondary rock type	silt
Other rock types	clay or mud
Lithologic constituents	Major Unconsolidated > Fine-detrital > Clay *(Bed)* Unconsolidated > Coarse-detrital > Sand *(Bed)* Unconsolidated > Fine-detrital > Silt *(Bed)*
Map references	Bureau of Economic Geology, 1992, Geologic Map of Texas: University

of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000

Unit references

Bureau of Economic Geology, 1975, Corpus Christi Sheet, Geologic Atlas of Texas, Bureau of Economic Geology, University of Texas at Austin, scale 1:250,000.

Moore, D.W. and Wermund, E.G., Jr., 1993a, Quaternary geologic map of the Austin 4 x 6 degree quadrangle, United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NH-14), scale 1:1,000,000.
[http://pubs.er.usgs.gov/publication/i1420(NH14)]

Moore, D.W. and Wermund, E.G., Jr., 1993b, Quaternary geologic map of the Monterrey 4 x 6 degree quadrangle, United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NG-14), scale 1:1,000,000.
[http://pubs.er.usgs.gov/publication/i1420(NG14)]

Bureau of Economic Geology, 1974, Seguin Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000.

Bureau of Economic Geology, 1976, Crystal City-Eagle Pass Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000.

Bureau of Economic Geology, 1975, Beeville-Bay City Sheet, Geologic Atlas of Texas, Bureau of Economic Geology, University of Texas at Austin, scale 1:250,000.

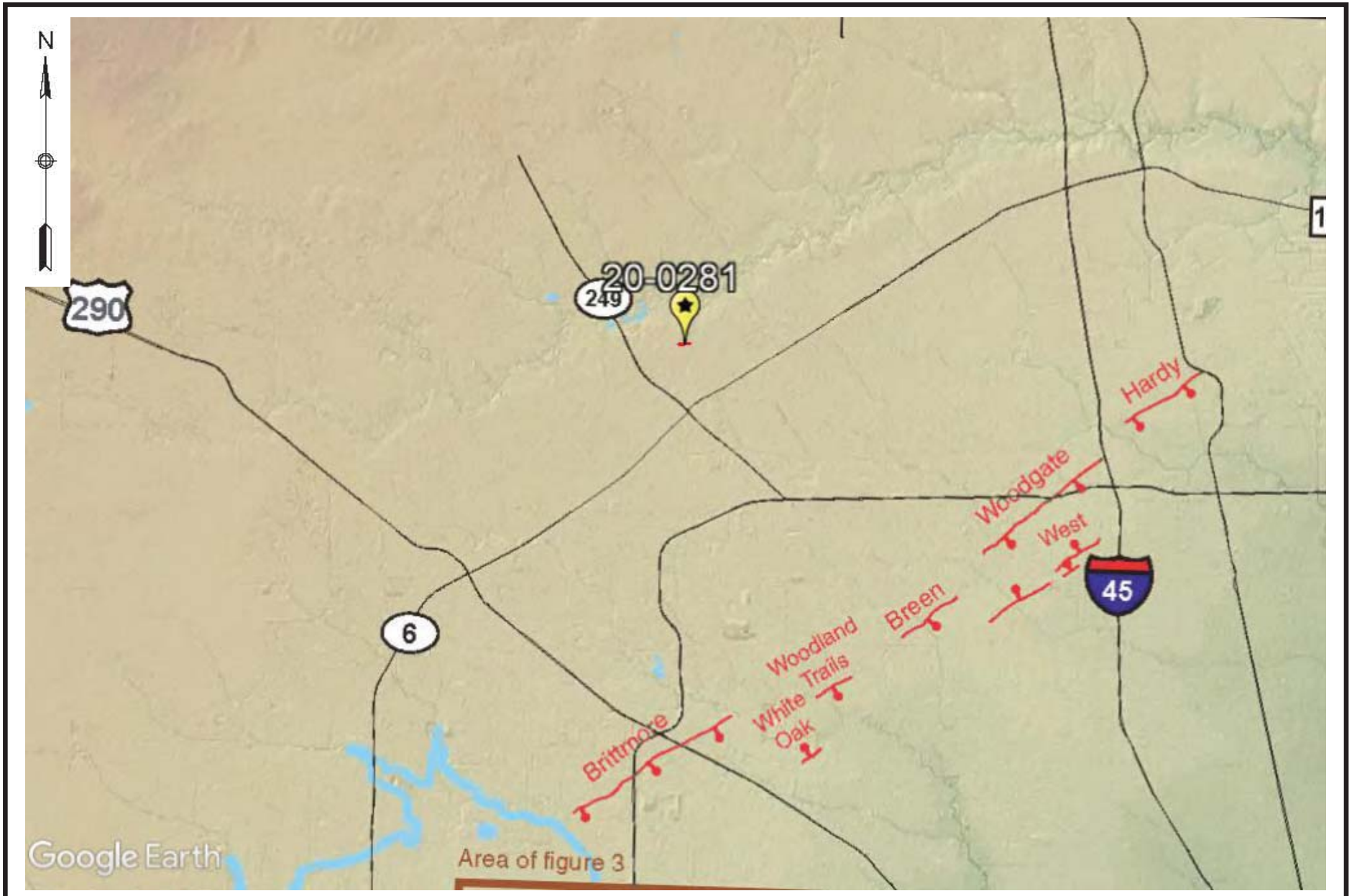
Bureau of Economic Geology, 1982, Houston Sheet, Geologic Atlas of Texas, Bureau of Economic Geology, University of Texas at Austin, scale 1:250,000.

Geographic coverage

Austin - Bee - Calhoun - Colorado - DeWitt - Duval - Fort Bend - Goliad - Grimes - Hardin - Harris - Hidalgo - Jackson - Jasper - Jim Wells - Lavaca - Liberty - Live Oak - Montgomery - Newton - Nueces - Polk - Refugio - San Jacinto - San Patricio - Tyler - Victoria - Waller - Wharton - Willacy

Show this information as [XML] - [JSON]

USGS GEOLOGIC FAULT MAP



Appendix C

Drainage Impact Analysis

Innovative approaches
Practical results
Outstanding service

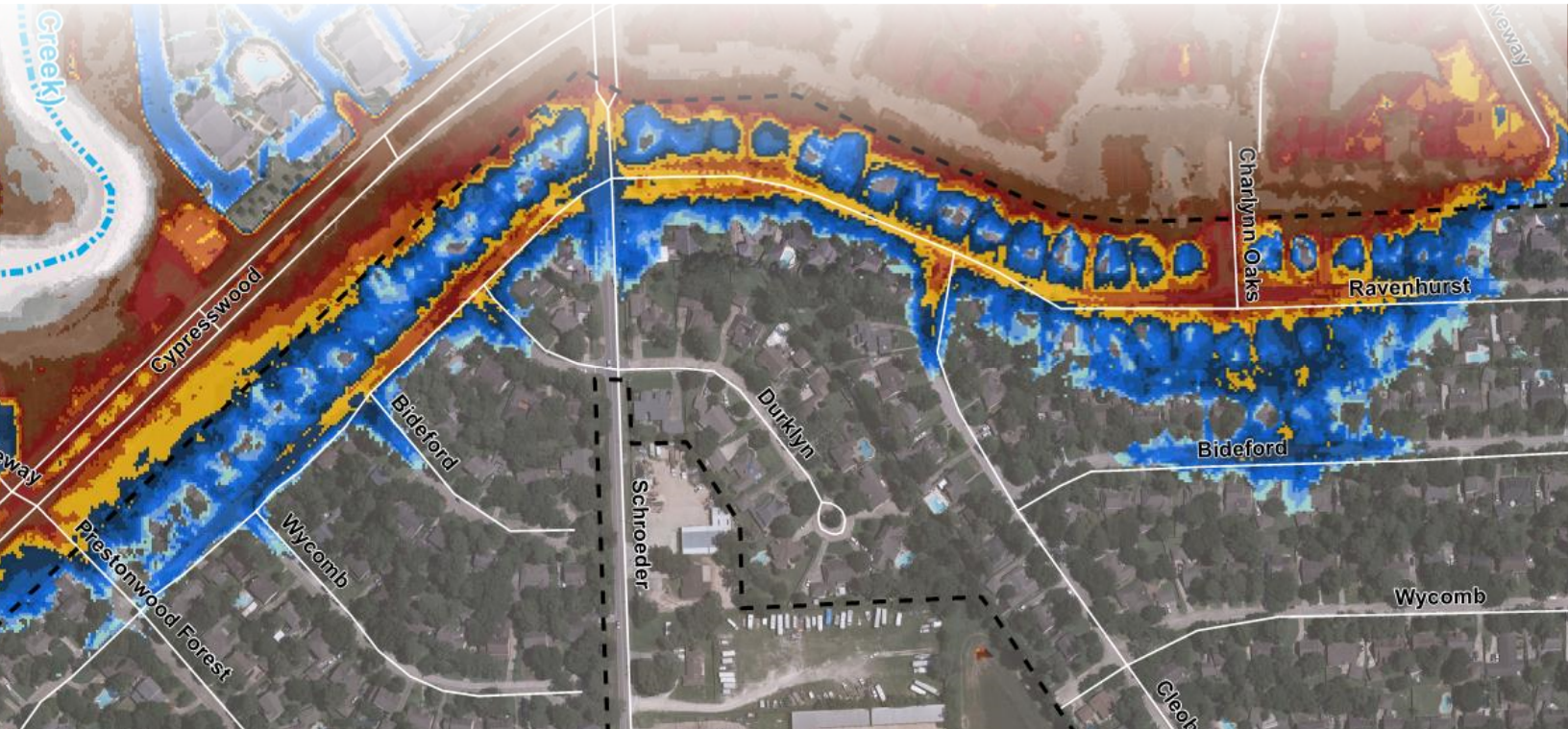
PRESTONWOOD FOREST
Drainage Impact Analysis

Prepared for:
Harris County

FINAL
February 2021

Prepared by:

FREESE AND NICHOLS, INC.
Texas Registered Engineering Firm F-2144
11200 Broadway St, Suite 2320
Pearland, Texas 77584
832-456-4700



Innovative approaches
Practical results
Outstanding service

Prestonwood Forest
Drainage Impact Analysis

Prepared for:
Harris County

FREESE AND NICHOLS, INC.
TEXAS REGISTERED
ENGINEERING FIRM
F-2144

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BLY20477

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EXECUTIVE SUMMARY

Harris County has identified 237 flood risk reduction projects under the 2018 bond program. Prestonwood Forest is one of the projects where structure flooding has occurred within the neighborhood in the past. Freese and Nichols, Inc. has prepared an impact analysis report to demonstrate that the improvements to the ditch along Hargrave Rd and the railroad ditch will not have an adverse impact on Cypress Creek. The proposed project will cause no adverse impact to flood hazard conditions on the receiving waterways, including downstream properties within the City of Houston, for storm events up to and including the 100-year Atlas 14 storm event. The report presents the assumptions, technical approach, model modifications, and results of the hydraulic assessment of the proposed drainage improvements project.

1.0 INTRODUCTION

A drainage analysis was performed to identify any adverse effects of proposed improvements to ditches along Hargrave Rd and the BNSF Railroad within the Prestonwood Forest subdivision during the pre-Atlas 14 100-year (1% annual exceedance probability, AEP) and 500-year (0.2% AEP) storm events. Additionally, the 2-year (50% AEP) storm event was analyzed to determine the level of service (LOS) of the ditches. **Exhibit 1** shows an overview of the project area.

1.1 PROJECT NAME AND PURPOSE

Large storm events, such as the extreme rain event experienced during Hurricane Harvey, result in flooding throughout the neighborhood. Out of 800 total homes in the neighborhood, 109 flooded during Hurricane Harvey. There were also 7 homes that flooded during the Tax Day Flood and 2 repetitive loss homes. Flood depths ranged from a few feet to a few inches.

Several homes in the southwest part of the neighborhood appear to have flooded because the ditches carrying the water away from the neighborhood are in need of maintenance and are full of vegetation. The proposed project will regrade the ditch along Hargrave Rd and the ditch along the BNSF railroad to increase capacity so that runoff does not back up the ditches and into homes. The aim of this analysis is to ensure the proposed improvements do not adversely impact Cypress Creek and ensure no adverse impact locally to the subdivision.

1.2 PROJECT LIMITS

The Prestonwood Forest subdivision is located in northwestern Harris County, in Precinct 4, within the Cypress Creek watershed. The neighborhood is along an extension of the K136-00-00 channel.

1.3 PROJECT OBJECTIVES

The goal of the drainage report is to show the proposed ditch maintenance will have no adverse impact to the receiving stream/outfall or adjacent properties for the 100-year (1% AEP) event and the 500-year (0.2% AEP) event, and to determine the LOS of the ditches, following the Harris County Flood Control District (HCFCD) and Harris County Engineering Department (HCED) criteria.

1.4 ASSUMPTIONS AND CONSTRAINTS

Several assumptions were made regarding existing and proposed drainage conditions. The following is a list of assumptions made for the purposes of this study:

- The Hargrave Rd ditch analysis was based on a Hargrave Rd drainage exhibit provided to FNI by Bleyl Engineering on 11/24/2020
- The analysis of the ditch along the BNSF railroad was based on a set of Prestonwood Forest Utility District drainage improvement plans dated September 2018 and designed by Bleyl Engineering.
- Data used for the analysis of existing drainage infrastructure was obtained from Prestonwood Forest As-Builts. As-builts are provided in Appendix C.
- Manning's n values for the ditch would be reduced from 0.05 to 0.04 along Hargrave Road and from 0.06 to 0.04 along the railroad as a result of the ditch improvements. Manning's n values were set to 0.08 for the overbanks.

2.0 EXISTING CONDITIONS

2.1 LOCATION AND TOPOGRAPHY

Prestonwood Forest is located within Precinct 4 in northwestern Harris County. The project area is located east of SH 249, south of Cypresswood Dr, and west of Cutten Rd. Cypress Creek, HCFCD Unit No. K100-00-00, is north of the project area, across Cypresswood Dr. The project is located completely outside the effective K100-00-00 (Cypress Creek) 100-year (1% AEP) floodplain. Project Location is shown in **Exhibit 1**.

The topography was based on the Houston-Galveston Area Council (HGAC) Non-Uniform Subsidence Adjustment (NUSA) 2008 LIDAR, 2001 Adjustment. Based on the expected improvements, existing flow patterns are not expected to be significantly altered in proposed conditions.

2.2 LAND USE

Land use in most of the Prestonwood Forest subdivision is a developed residential neighborhood with curb and gutter streets and underground storm sewer. Hargrave Rd, located at the southern end of the subdivision, has open ditches on both sides of the road.

2.3 HCFCD FACILITIES AND UNIT NUMBERS

The project site is located along a small unnamed tributary to Cypress Creek, K100-00-00. Flows from the neighborhood ultimately drain to K100-00-00 (Cypress Creek).

2.4 RIGHT-OF-WAY

The ditch along Hargrave Rd is within right-of-way owned by Harris County. The railroad ditch is within right-of-way owned by BNSF Railroad. No additional right-of-way is required.

2.5 EXISTING DRAINAGE INFRASTRUCTURE

The Prestonwood Forest development existing drainage infrastructure in the area of the project includes open ditches on both sides of Hargrave Rd that flow towards the BNSF railroad and into a ditch along the west side of the railroad tracks. The BNSF railroad ditch ends at 2-48" RCP which flow under the railroad and into an existing detention pond. Construction plans were not available for the existing detention pond between the Cutten Road and Cypress Creek, so it was not evaluated as part of this analysis. The location and size of the existing storm sewer is shown on **Exhibit 2**. The existing ditch has less than a 2-year LOS.

2.6 UTILITIES

There are existing water and sanitary sewer lines located within the existing right-of-way. These utilities will not require additional ROW but might need to be relocated depending on their depth relative to the proposed ditch regrading. Along Hargrave, there are aerial power lines and other utilities that should not be in conflict of the proposed ditch.

2.7 FLOODPLAIN STATUS

According to the floodplain effective maps (Panel 48201C0435M, effective October 16, 2013), the neighborhood is not in the regulatory 100-year (1% AEP) floodplain at the time of this report.

3.0 DRAINAGE ANALYSIS

3.1 HYDROLOGIC METHODOLOGY

The hydrologic methodology chosen includes an HEC-HMS model using the TC&R Method, in accordance with HCFCD criteria. The project area was divided into multiple drainage areas, generally ranging from approximately 2 to 40 acres.

Once the existing drainage patterns were identified using existing Harris County DEM topography data and the provided construction plans, peak runoff rates for existing conditions were calculated using HEC-HMS. The delineated drainage areas are illustrated in **Exhibit 3**.

A. Land Use

Existing land use areas were determined using the Harris County Aerials. The Prestonwood Forest development primarily consists of lots 0.2 acres in size. This falls under the classification of Residential – Small lot according to HCFCD, corresponding to an imperviousness of 40%. Since the project area is fully developed and land use is estimated to remain unchanged from existing and proposed conditions, no change to land use were made.

B. Time of Concentration

Tc was calculated in accordance with the methodology outlined in HCED criteria. A summary of drainage area properties is provided in **Table 1**, with detailed calculations provided in **Appendix B**.

Table 1 – Drainage Area Properties

Sub-Area Name	Area	Tc(adj)	R(adj)	Impervious	100-yr HEC-HMS Q
	(mi.2)	(hours)	(hours)	(%)	(cfs)
A	0.013	0.24	1.42	53	21.5
B	0.033	0.10	1.20	33	59.9
C	0.004	0.07	0.43	40	11.9
D	0.013	0.34	1.54	20	19.4
E	0.061	0.50	1.39	37	99.0

C. Peak Runoff Calculation

Once all the inputs had been calculated, Sub-Areas A through E were added to the Cypress Creek HEC-HMS model. The Green and Ampt loss method was used; Percent Impervious was determined for each drainage area using GIS. The Clark Unit Hydrograph method was used to be consistent with the effective model. A Muskingum-Cunge routing reach representing the existing and proposed ditch cross sections and Manning's n-values was added on the downstream side of the project drainage areas to connect to the Cypress Creek Watershed model. Peak flow rates at three downstream junctions were obtained for the 2-year (50% AEP), 100-year (1% AEP) and 500-year (0.2% AEP) storm events for existing and proposed conditions. These flow rates were compared to ensure there was no adverse impact to Cypress Creek due to the ditch improvements. Computed peak flows are summarized in **Table 2**. Hydrology Parameters are summarized in **Appendix B**.

Table 2 – Computed Peak Flows

HEC-HMS Element	DA (sq. mi.)	2-yr Exist	2-yr Prop	2-yr Change	100-yr Exist	100-yr Prop	100-yr Change	500-yr Exist	500-yr Prop	500-yr Change
	(mi.2)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
Subbasin-E	0.061	32.3	32.3	0	99	99	0	134.5	134.5	0
Subbasin-B	0.033	20.1	20.1	0	59.9	59.9	0	80.6	80.6	0
Subbasin-A	0.013	7.4	7.4	0	21.5	21.5	0	29.1	29.1	0
Junction-1	0.013	7.4	7.4	0	21.5	21.5	0	29.1	29.1	0
Subbasin-C	0.004	4.5	4.5	0	11.9	11.9	0	15.4	15.4	0
Junction-2	0.05	32	32	0	93.3	93.3	0	125	125	0
Subbasin-D	0.013	6	6	0	19.4	19.4	0	26.7	26.7	0
Junction-3	0.124	66.4	66.4	0	203.4	203.4	0	276.7	276.7	0
K1000000_0973_J	Not Specified	4014.4	4014.2	-0.2	16436	16435	-0.9	24511	24510	-1
K1000000_0965_J	Not Specified	4325.9	4325.8	-0.1	18070	18070	-0.7	27081	27080	-0.7
K1000000_0836_J	Not Specified	4530.7	4530.5	-0.2	18272	18271	-0.7	27421	27420	-1.1

3.2 HYDRAULIC ANALYSIS

A HEC-RAS model was created to analyze the proposed ditch regrading to ensure there is no adverse impact locally to the existing development. Harris County DEM topography was used for the existing conditions stream profile and cross sections. Proposed cross sections were modified from the topography based on the provided plans. Existing and proposed condition culvert sizes and flowlines were pulled from

the provided plans. HEC-RAS was used to evaluate the water surface elevations in the existing and proposed ditch. The ditch was analyzed for the 2-year (50% AEP), 100-year (1% AEP) and 500-year (0.2% AEP) storms, using the HEC-HMS peak flow rates as input. The HEC-RAS results are shown in **Appendix B**. Based on the HEC-RAS analysis, it was determined that there will be no rise in water surface elevation in the modeled area as a result of the proposed ditch improvements associated with the Prestonwood Forest project.

3.3 HARGRAVE ROAD

Multiple homes have experienced historical flooding near Hargrave Road in the southeast corner of the Prestonwood Forest development. The ditch along Hargrave Road and the ditch that parallels the railroad have previously been identified as a potential source of the flooding. Observations of the ditch parallel to the railroad shows a significant decrease in its capacity due to a lack of proper maintenance. This is outlined in **Figure 1**. The location of this cross section is shown in **Exhibit 4**.

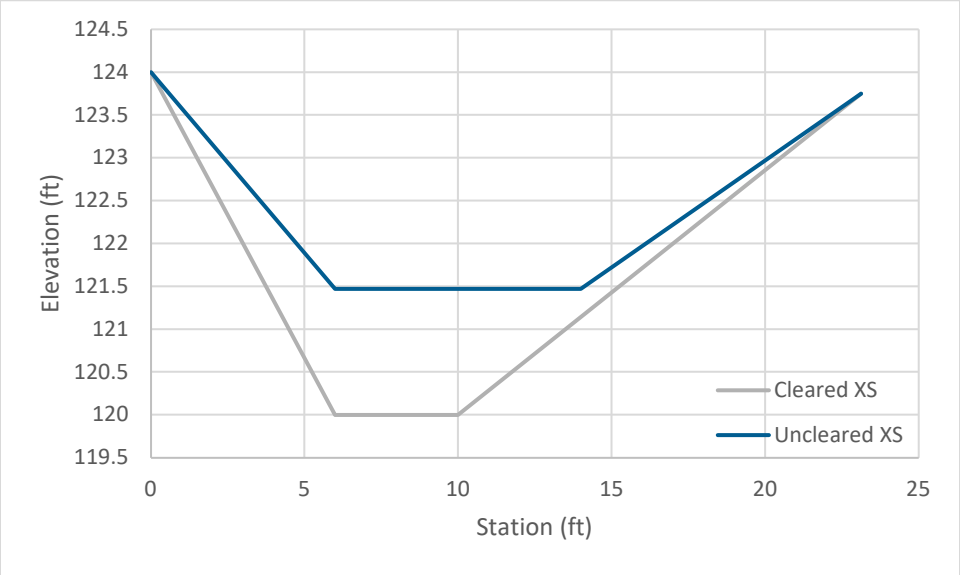


Figure 1 – Railroad Ditch Cross Section Comparison

3.4 PROPOSED IMPROVEMENTS

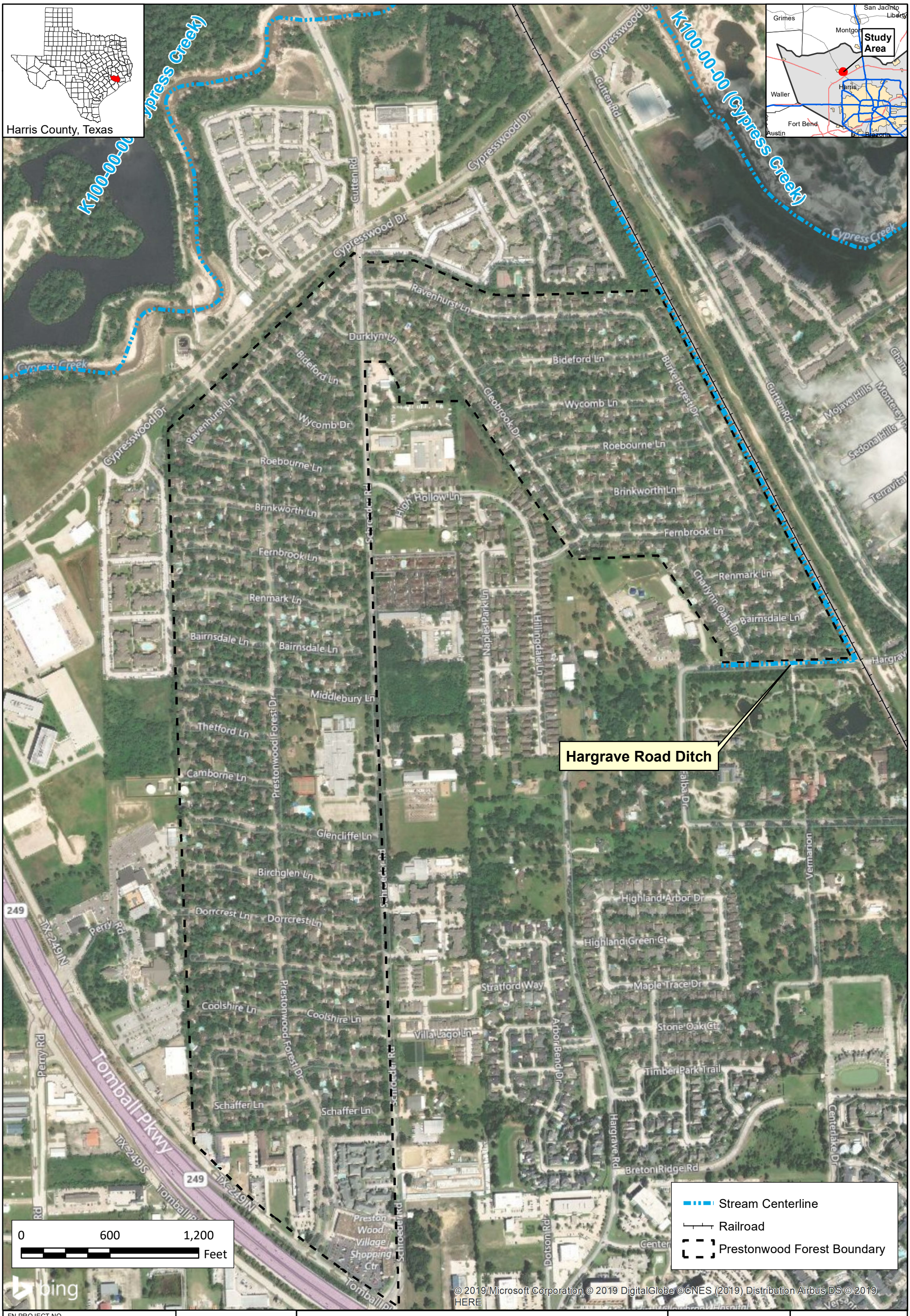
Based on observation and previous analyses regarding the improvements of the Hargrave Road ditch, a restoration of these ditches to the most current design is proposed, along with a long-term maintenance plan for the railroad ditch. In the area of the east end of Hargrave Rd where there is not enough ROW to accommodate the ditch, a 24" RCP will be necessary to convey the flow to the BNSF ditch. To

accommodate a swale over the 24” RCP, the minimum cover is 1’. While the improvements will increase the capacity compared to the current conditions, the ditch will remain below a 2-year LOS due to not having enough ROW to provide more capacity.

4.0 RECOMMENDATIONS

Based on the evaluation of the ditches around Hargrave, we recommend re-grading them, replacing existing culverts under driveways, and developing a plan to maintain the ditches so that they can convey the water away from structures and into Cypress Creek.

APPENDIX A
Exhibits



FN PROJECT NO.	BLY20477
DATE CREATED	Date: 5/29/2019
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Name: Exhibit 1 - Project Area Map
PREPARED BY	AAS

FREESE AND NICHOLS

FREESE AND NICHOLS, INC.
10431 MORADO CIRCLE
SUITE 300
AUSTIN, TEXAS 78759
PHONE: 512.617.3100

PRESTONWOOD FOREST

PROJECT AREA MAP

N

EXHIBIT

1

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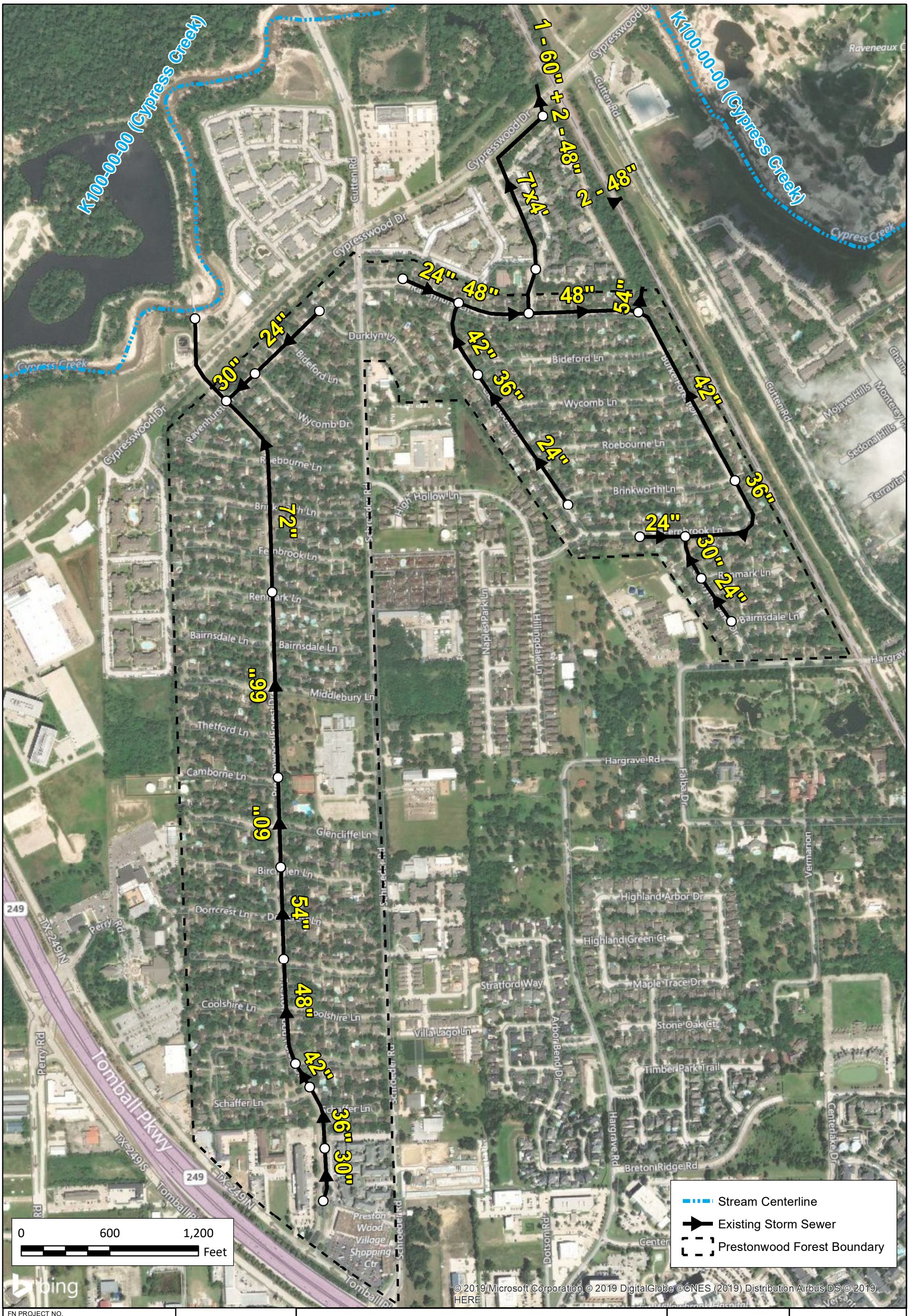

FN PROJECT NO.	BLY20477
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FILE NAME	Name: Exhibit 2 - Existing Drainage Layout Map
PREPARED BY	AAS

FREESE AND NICHOLS

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10431 MORADO CIRCLE
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AUSTIN, TEXAS 78759
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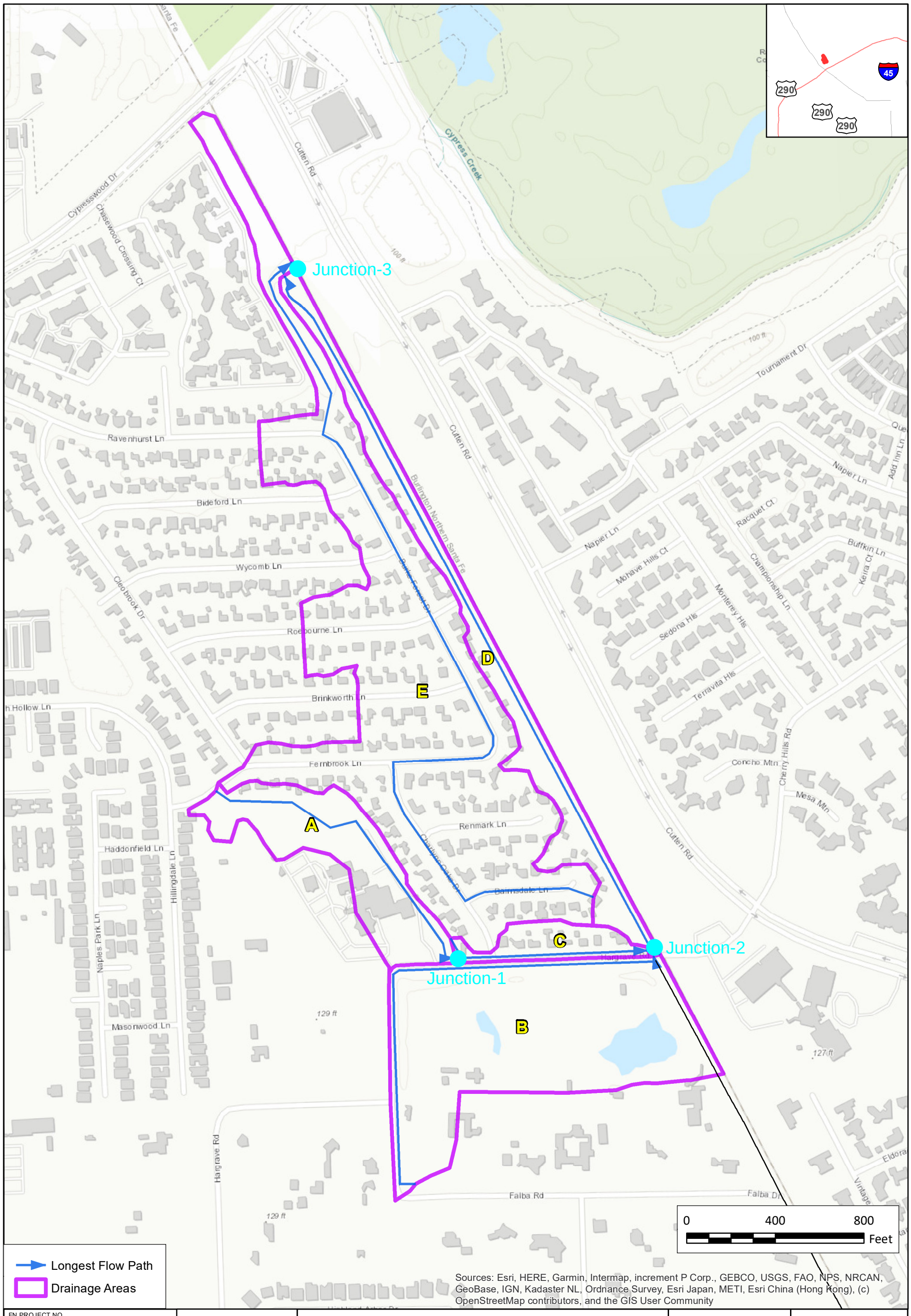
PRESTONWOOD FOREST

EXISTING DRAINAGE LAYOUT

N

EXHIBIT

2



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DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	Name: Drainage_Area_Map
PREPARED BY	JAB

FREESE AND NICHOLS

FREESE AND NICHOLS, INC.
10497 TOWN AND COUNTRY WAY
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HOUSTON, TX 77024
PHONE: 713.600.6800

HARRIS COUNTY
PRESTONWOOD FOREST

DRAINAGE AREA MAP

N

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3

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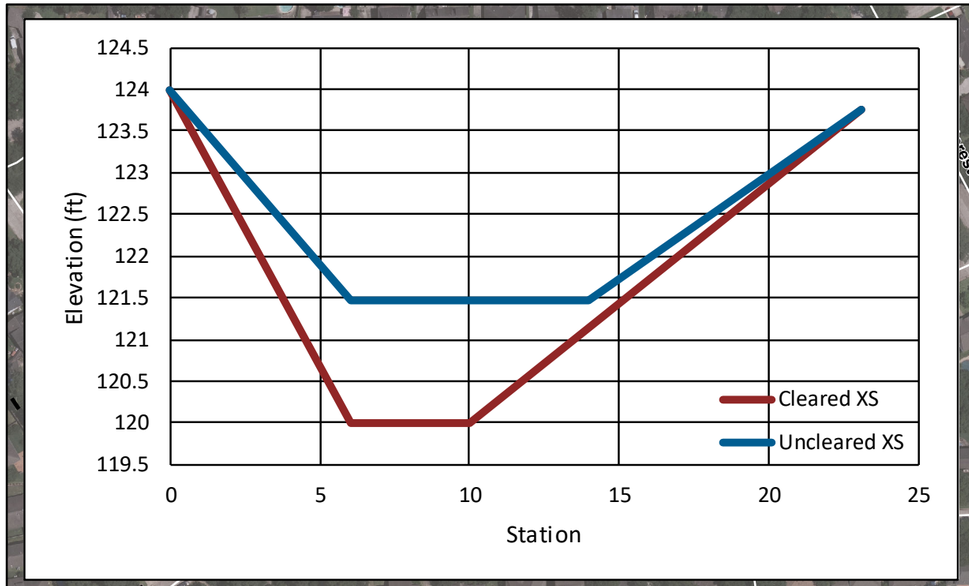

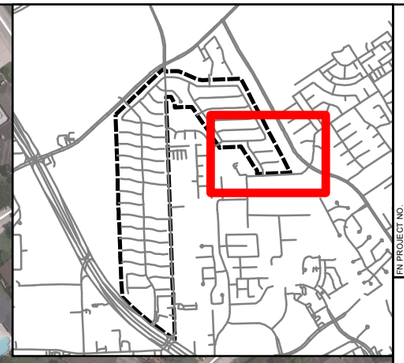

Sedona
Cutten
Cutten
Terravita
Concho
Cherry Hills
Mesa
Renmark
Chadlynn Oaks
Bairnsdale
Driveway
Driveway
Hillingdale
Hargrave
Railroad Ditch Cross Section

0 200 400 Feet

Legend
- Ditch Centerline
- Ditch XS
- Railroad
- Prestonwood Forest Boundary

PRESTONWOOD FOREST

HARGRAVE ROAD AND RAILROAD DITCH

PN PROJECT NO. BLY20477
DATE CREATED Date: 5/29/2019
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas Central
FILE NAME Name: Exhibit 6 - Hargrave Road
PREPARED BY AAS

FREESE AND NICHOLS, INC.
10431 MORADO CIRCLE
SUITE 300
AUSTIN, TEXAS 78759
PHONE: 512-617-3100
FAX: 512-617-3101

EXHIBIT

4

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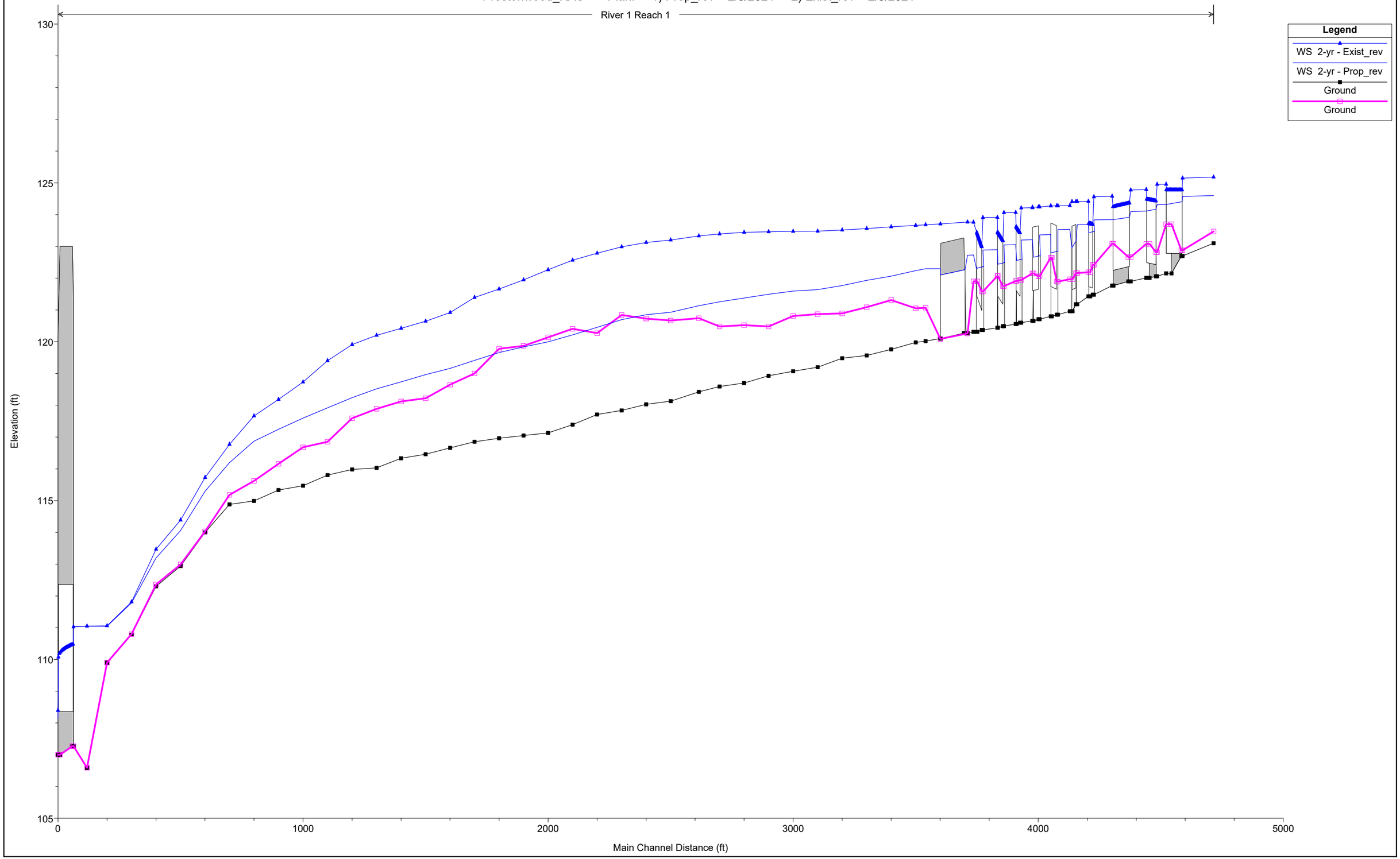
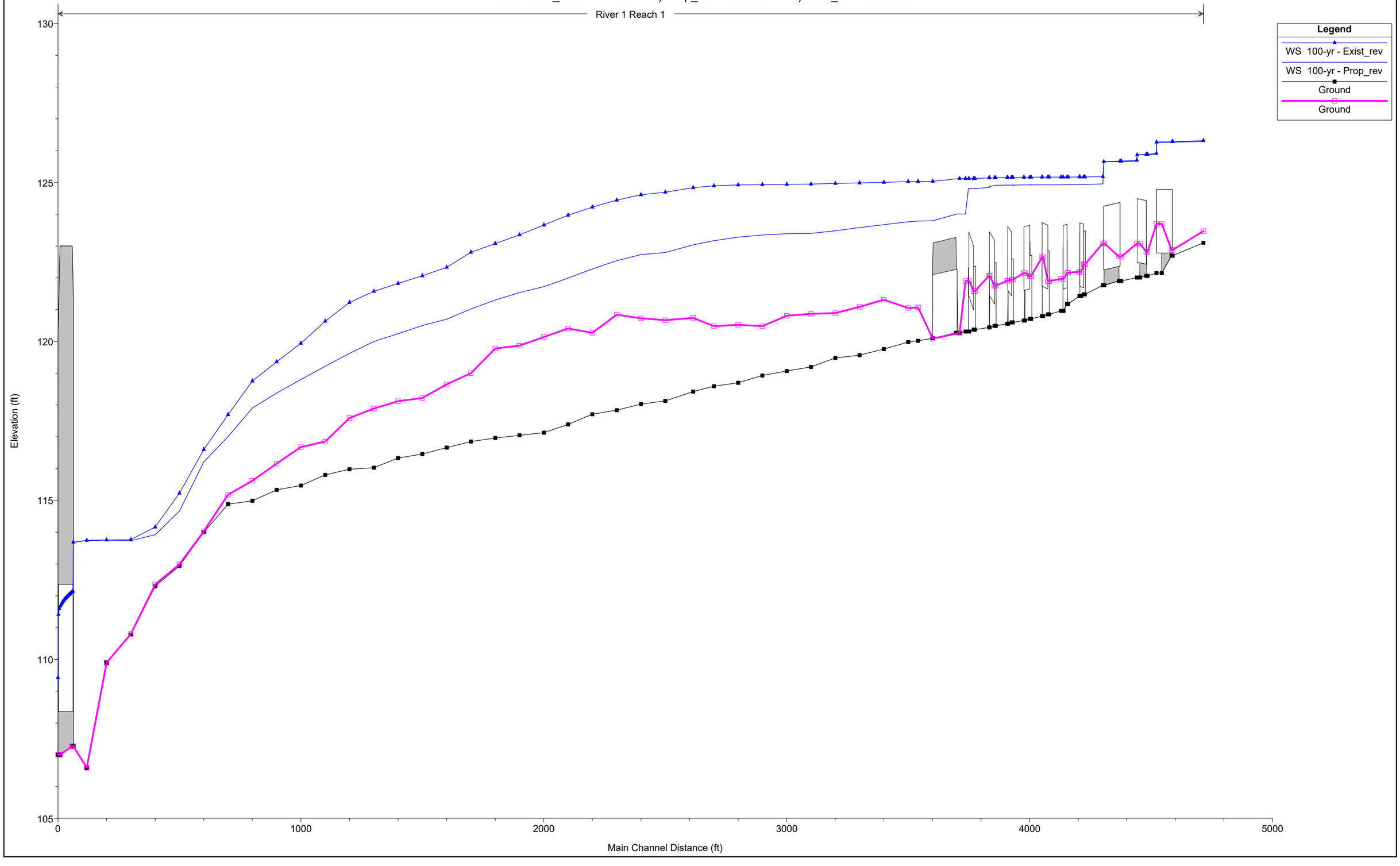
APPENDIX B
Calculations and Results

Prestonwood_RAS Plan: 1) Prop_rev 2/8/2021 2) Exist_rev 2/8/2021



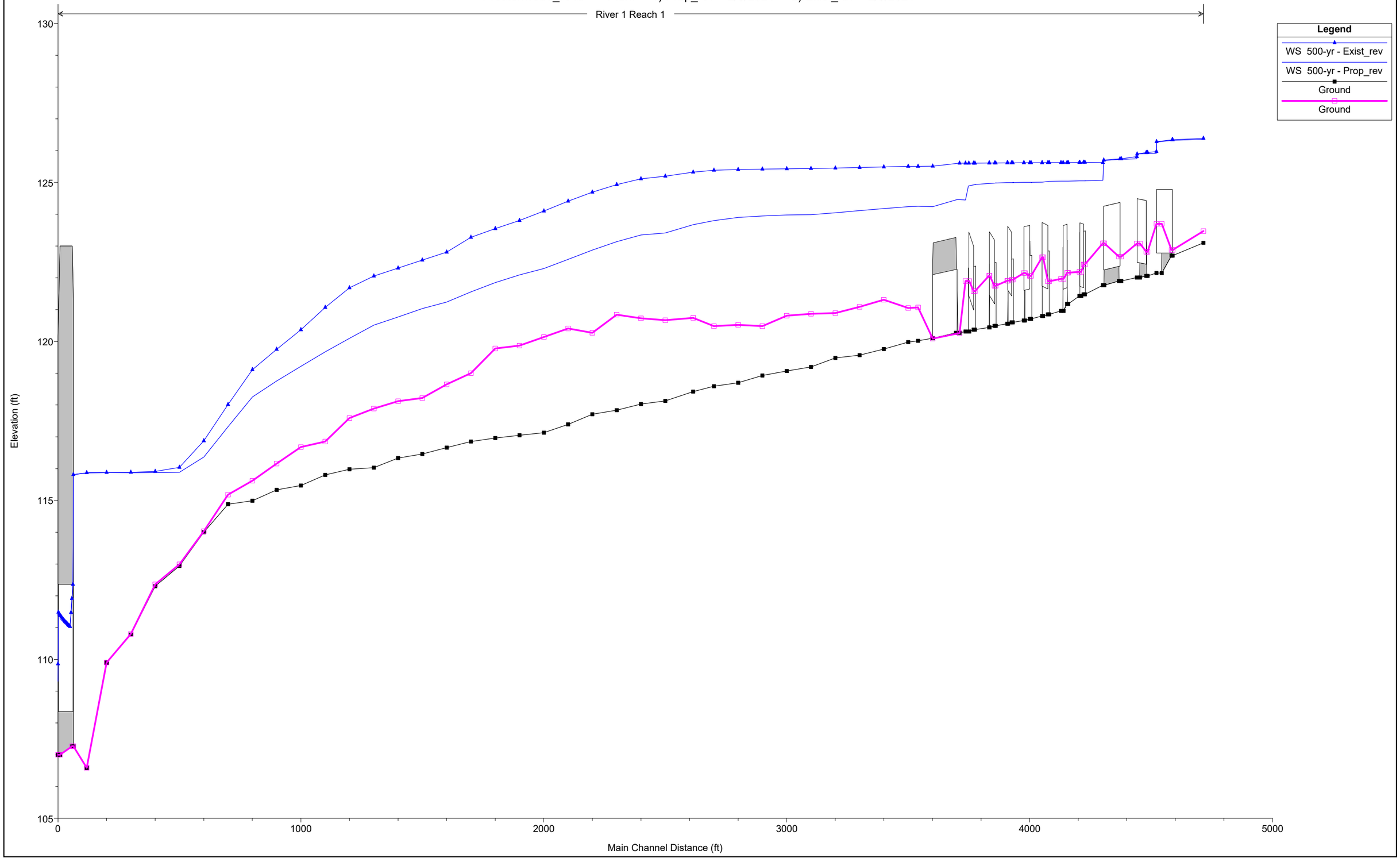
Prestonwood_RAS Plan: 1) Prop_rev 2/8/2021 2) Exist_rev 2/8/2021

River 1 Reach 1



Prestonwood_RAS Plan: 1) Prop_rev 2/8/2021 2) Exist_rev 2/8/2021

River 1 Reach 1



River Sta	Q Total	Existing 2-yr W.S. Elev	Proposed 2-yr W.S. Elev	Change 2-yr W.S. Elev	Q Total	Existing 100-yr W.S. Elev	Proposed 100-yr W.S. Elev	Change 100-yr W.S. Elev	Q Total	Existing 500-yr W.S. Elev	Proposed 500-yr W.S. Elev	Change 500-yr W.S. Elev
	(cfs)	(ft)	(ft)	(ft)	(cfs)	(ft)	(ft)	(ft)	(cfs)	(ft)	(ft)	(ft)
4816	7.4	125.18	124.60	-0.58	21.5	126.32	126.29	-0.03	29.1	126.39	126.36	-0.03
4690	7.4	125.15	124.57	-0.58	21.5	126.28	126.27	-0.01	29.1	126.34	126.33	-0.01
4685	Culvert				Culvert				Culvert			
4622	7.4	124.96	124.32	-0.64	21.5	125.91	125.88	-0.03	29.1	125.98	125.92	-0.06
4586	7.4	124.95	124.31	-0.64	21.5	125.89	125.88	-0.01	29.1	125.94	125.91	-0.03
4581	Culvert				Culvert				Culvert			
4542	7.4	124.79	124.12	-0.67	21.5	125.70	125.67	-0.03	29.1	125.81	125.75	-0.06
4478	7.4	124.78	124.10	-0.68	21.5	125.67	125.65	-0.02	29.1	125.75	125.73	-0.02
4473	Culvert				Culvert				Culvert			
4402	7.4	124.58	123.85	-0.73	21.5	125.18	124.95	-0.23	29.1	125.63	125.07	-0.56
4328	7.4	124.56	123.84	-0.72	21.5	125.18	124.94	-0.24	29.1	125.63	125.05	-0.58
4323	Culvert				Culvert				Culvert			
4305	7.4	124.42	123.69	-0.73	21.5	125.18	124.94	-0.24	29.1	125.63	125.05	-0.58
4259	7.4	124.41	123.68	-0.73	21.5	125.17	124.93	-0.24	29.1	125.63	125.04	-0.59
4254	Culvert				Culvert				Culvert			
4229	7.4	124.29	123.54	-0.75	21.5	125.17	124.93	-0.24	29.1	125.63	125.04	-0.59
4181	7.4	124.28	123.53	-0.75	21.5	125.17	124.93	-0.24	29.1	125.63	125.04	-0.59
4176	Culvert				Culvert				Culvert			
4152	7.4	124.27	123.38	-0.89	21.5	125.17	124.93	-0.24	29.1	125.62	125.01	-0.61
4106	7.4	124.24	123.36	-0.88	21.5	125.17	124.92	-0.25	29.1	125.62	125.01	-0.61
4101	Culvert				Culvert				Culvert			
4077	7.4	124.22	123.21	-1.01	21.5	125.16	124.92	-0.24	29.1	125.62	125.00	-0.62
4031	7.4	124.21	123.20	-1.01	21.5	125.16	124.92	-0.24	29.1	125.62	125.00	-0.62
4026	Culvert				Culvert				Culvert			
4008	7.4	124.07	123.05	-1.02	21.5	125.16	124.92	-0.24	29.1	125.62	125.00	-0.62
3961	7.4	124.06	123.05	-1.01	21.5	125.15	124.91	-0.24	29.1	125.61	124.98	-0.63
3956	Culvert				Culvert				Culvert			
3934	7.4	123.92	122.89	-1.03	21.5	125.15	124.84	-0.31	29.1	125.61	124.97	-0.64
3875	7.4	123.91	122.89	-1.02	21.5	125.13	124.81	-0.32	29.1	125.61	124.94	-0.67
3870	Culvert				Culvert				Culvert			
3836	7.4	123.77	122.73	-1.04	21.5	125.12	124.00	-1.12	29.1	125.61	124.45	-1.16
3812	7.4	123.77	122.72	-1.05	21.5	125.12	124.01	-1.11	29.1	125.61	124.46	-1.15
3797	Culvert				Culvert				Culvert			
3701	32	123.71	122.30	-1.41	93.3	125.03	123.79	-1.24	125	125.51	124.25	-1.26
3641	32	123.68	122.30	-1.38	93.3	125.03	123.76	-1.27	125	125.51	124.24	-1.27
3600	32	123.67	122.24	-1.43	93.3	125.01	123.67	-1.34	125	125.49	124.18	-1.31
3500	32	123.62	122.06	-1.56	93.3	124.99	123.58	-1.41	125	125.47	124.11	-1.36
3400	32	123.56	121.93	-1.63	93.3	124.97	123.48	-1.49	125	125.45	124.05	-1.40
3300	32	123.52	121.77	-1.75	93.3	124.95	123.40	-1.55	125	125.44	123.99	-1.45
3200	32	123.48	121.64	-1.84	93.3	124.94	123.39	-1.55	125	125.43	123.98	-1.45
3100	32	123.47	121.60	-1.87	93.3	124.93	123.35	-1.58	125	125.42	123.95	-1.47
3000	32	123.46	121.49	-1.97	93.3	124.92	123.28	-1.64	125	125.41	123.90	-1.51
2900	32	123.44	121.38	-2.06	93.3	124.90	123.17	-1.73	125	125.38	123.80	-1.58
2800	32	123.40	121.26	-2.14	93.3	124.84	123.04	-1.80	125	125.32	123.67	-1.65
2715	32	123.33	121.14	-2.19	93.3	124.70	122.80	-1.90	125	125.20	123.41	-1.79
2600	32	123.20	120.93	-2.27	93.3	124.61	122.73	-1.88	125	125.11	123.35	-1.76
2500	32	123.13	120.85	-2.28	93.3	124.45	122.54	-1.91	125	124.93	123.14	-1.79
2400	32	122.99	120.70	-2.29	93.3	124.22	122.28	-1.94	125	124.70	122.87	-1.83
2300	32	122.78	120.45	-2.33	93.3	123.97	121.99	-1.98	125	124.41	122.58	-1.83
2200	32	122.57	120.22	-2.35	93.3	123.67	121.72	-1.95	125	124.10	122.29	-1.81
2100	32	122.27	120.00	-2.27	93.3	123.35	121.54	-1.81	125	123.80	122.09	-1.71
2000	32	121.95	119.84	-2.11	93.3	123.08	121.30	-1.78	125	123.55	121.85	-1.70
1900	32	121.66	119.66	-2.00	93.3	122.80	121.02	-1.78	125	123.27	121.56	-1.71
1800	32	121.40	119.42	-1.98	93.3	122.33	120.70	-1.63	125	122.81	121.24	-1.57
1700	32	120.92	119.16	-1.76	93.3	122.07	120.50	-1.57	125	122.56	121.04	-1.52
1600	32	120.64	118.97	-1.67	93.3	121.82	120.24	-1.58	125	122.31	120.77	-1.54
1500	32	120.42	118.74	-1.68	93.3	121.58	120.00	-1.58	125	122.06	120.51	-1.55
1400	32	120.20	118.52	-1.68	93.3	121.23	119.62	-1.61	125	121.68	120.10	-1.58
1300	32	119.91	118.24	-1.67	93.3	120.64	119.22	-1.42	125	121.07	119.67	-1.40
1200	32	119.40	117.92	-1.48	93.3	119.94	118.80	-1.14	125	120.37	119.22	-1.15
1100	32	118.73	117.60	-1.13	93.3	119.36	118.37	-0.99	125	119.75	118.76	-0.99
1000	32	118.19	117.25	-0.94	93.3	118.75	117.90	-0.85	125	119.11	118.25	-0.86
900	32	117.66	116.87	-0.79	93.3	117.69	117.01	-0.68	125	118.01	117.32	-0.69
800	32	116.77	116.19	-0.58	93.3	116.60	116.21	-0.39	125	116.88	116.37	-0.51
700	32	115.73	115.30	-0.43	93.3	115.23	114.67	-0.56	125	116.04	115.88	-0.16
600	32	114.39	114.06	-0.33	93.3	114.16	113.92	-0.24	125	115.91	115.88	-0.03
500	32	113.47	113.19	-0.28	93.3	113.77	113.73	-0.04	125	115.88	115.87	-0.01
400	32	111.81	111.78	-0.03	93.3	113.76	113.75	-0.01	125	115.88	115.87	-0.01
300	32	111.06	111.05	-0.01	93.3	113.74	113.73	-0.01	125	115.87	115.86	-0.01
218	66.4	111.05	111.04	-0.01	203.4	113.68	113.68	0.00	276.7	115.81	115.81	0.00
163	66.4	111.02	111.02	0.00	203.4	0.00	0.00	0.00	276.7	0.00	0.00	0.00
158	Culvert				Culvert				Culvert			
100	66.4	108.40	108.14	-0.26	203.4	0.00	0.00	0.00	276.7	0.00	0.00	0.00

Comparison of HEC-RAS Water Surface Elevations

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4816	2-yr	7.4	123.47	125.18		125.18	0.000164	0.36	25.97	31.1	0.07
Reach 1	4690	2-yr	7.4	122.88	125.15	123.61	125.16	0.000197	0.67	11.00	59.8	0.09
Reach 1	4685		Culvert									
Reach 1	4622	2-yr	7.4	123.70	124.96		124.98	0.000721	0.95	7.79	119.2	0.16
Reach 1	4586	2-yr	7.4	122.82	124.95	123.52	124.96	0.000172	0.61	12.10	117.4	0.08
Reach 1	4581		Culvert									
Reach 1	4542	2-yr	7.4	123.08	124.79		124.80	0.000306	0.67	10.97	117.1	0.10
Reach 1	4478	2-yr	7.4	122.67	124.78	123.42	124.78	0.000169	0.49	15.16	53.7	0.08
Reach 1	4473		Culvert									
Reach 1	4402	2-yr	7.4	123.09	124.58		124.59	0.000589	0.86	8.61	45.7	0.14
Reach 1	4328	2-yr	7.4	122.42	124.56	122.99	124.57	0.000143	0.58	12.76	84.8	0.08
Reach 1	4323		Culvert									
Reach 1	4305	2-yr	7.4	122.19	124.42		124.43	0.000178	0.56	13.19	103.5	0.08
Reach 1	4259	2-yr	7.4	122.16	124.41	122.71	124.41	0.000543	0.53	15.11	139.5	0.12
Reach 1	4254		Culvert									
Reach 1	4229	2-yr	7.4	121.97	124.29		124.29	0.000050	0.33	22.33	141.8	0.04
Reach 1	4181	2-yr	7.4	121.89	124.28	122.50	124.28	0.000297	0.43	25.33	141.7	0.09
Reach 1	4176		Culvert									
Reach 1	4152	2-yr	7.4	122.65	124.27		124.28	0.001380	0.66	18.43	142.6	0.18
Reach 1	4106	2-yr	7.4	122.06	124.24	122.67	124.25	0.000502	0.51	20.03	174.6	0.12
Reach 1	4101		Culvert									
Reach 1	4077	2-yr	7.4	122.15	124.22		124.23	0.000717	0.58	15.08	147.6	0.14
Reach 1	4031	2-yr	7.4	121.94	124.21	122.53	124.22	0.000105	0.53	13.96	143.1	0.07
Reach 1	4026		Culvert									
Reach 1	4008	2-yr	7.4	121.91	124.07		124.08	0.000204	0.69	10.79	129.6	0.09
Reach 1	3961	2-yr	7.4	121.75	124.06	122.28	124.07	0.000106	0.53	13.97	118.8	0.07
Reach 1	3956		Culvert									
Reach 1	3934	2-yr	7.4	122.07	123.92		123.93	0.000473	1.06	6.99	117.3	0.14
Reach 1	3875	2-yr	7.4	121.58	123.91	122.10	123.92	0.000085	0.50	14.85	115.8	0.06
Reach 1	3870		Culvert									
Reach 1	3836	2-yr	7.4	121.90	123.77		123.77	0.000298	0.74	10.06	115.4	0.11
Reach 1	3812	2-yr	7.4	120.26	123.77		123.77	0.000037	0.26	29.42	30.3	0.04
Reach 1	3797											
Reach 1	3701	2-yr	32	120.09	123.71		123.74	0.000687	1.37	26.15	21.65	0.18
Reach 1	3641	2-yr	32	121.07	123.68		123.69	0.000622	0.86	41.76	42.28	0.12
Reach 1	3600	2-yr	32	121.05	123.67		123.67	0.000374	0.67	64.05	80.64	0.09
Reach 1	3500	2-yr	32	121.31	123.62		123.63	0.000568	0.77	60.54	85.5	0.11
Reach 1	3400	2-yr	32	121.09	123.56		123.57	0.000506	0.74	54.25	95.5	0.10
Reach 1	3300	2-yr	32	120.89	123.52		123.53	0.000420	0.69	54.99	53.2	0.10
Reach 1	3200	2-yr	32	120.87	123.48		123.49	0.000331	0.66	63.76	61.0	0.09
Reach 1	3100	2-yr	32	120.81	123.47		123.48	0.000056	0.31	145.90	99.5	0.04
Reach 1	3000	2-yr	32	120.48	123.46		123.47	0.000150	0.46	98.70	86.0	0.06
Reach 1	2900	2-yr	32	120.52	123.44		123.45	0.000251	0.59	75.05	74.9	0.08
Reach 1	2800	2-yr	32	120.48	123.40		123.41	0.000680	0.88	36.90	31.6	0.12
Reach 1	2715	2-yr	32	120.74	123.33		123.35	0.000802	0.99	32.20	18.0	0.13
Reach 1	2600	2-yr	32	120.67	123.20		123.22	0.001383	1.24	25.76	15.4	0.17
Reach 1	2500	2-yr	32	120.73	123.13		123.14	0.000562	0.85	37.47	20.2	0.11
Reach 1	2400	2-yr	32	120.84	122.99		123.03	0.002659	1.61	19.82	12.8	0.23
Reach 1	2300	2-yr	32	120.27	122.78		122.81	0.001725	1.37	23.40	14.1	0.19
Reach 1	2200	2-yr	32	120.41	122.57		122.60	0.002586	1.57	20.40	13.7	0.23
Reach 1	2100	2-yr	32	120.14	122.27		122.31	0.003347	1.69	18.89	13.8	0.26
Reach 1	2000	2-yr	32	119.87	121.95		121.99	0.003048	1.64	19.53	14.0	0.24
Reach 1	1900	2-yr	32	119.78	121.66		121.70	0.002805	1.55	20.62	15.3	0.24
Reach 1	1800	2-yr	32	119.00	121.40		121.43	0.002432	1.54	20.83	13.8	0.22
Reach 1	1700	2-yr	32	118.65	120.92		121.01	0.008701	2.48	12.91	10.6	0.40
Reach 1	1600	2-yr	32	118.22	120.64		120.67	0.001664	1.31	24.47	15.7	0.18
Reach 1	1500	2-yr	32	118.12	120.42		120.46	0.002711	1.57	20.36	14.2	0.23
Reach 1	1400	2-yr	32	117.89	120.20		120.23	0.001965	1.39	23.07	15.4	0.20
Reach 1	1300	2-yr	32	117.59	119.91		119.96	0.003802	1.83	17.46	12.3	0.27
Reach 1	1200	2-yr	32	116.85	119.40		119.48	0.006330	2.22	14.40	10.8	0.34
Reach 1	1100	2-yr	32	116.68	118.73		118.81	0.007094	2.24	14.28	12.0	0.36
Reach 1	1000	2-yr	32	116.16	118.19		118.24	0.004574	1.91	16.80	13.1	0.30
Reach 1	900	2-yr	32	115.62	117.66		117.73	0.005842	2.03	15.80	13.6	0.33
Reach 1	800	2-yr	32	115.18	116.77		116.89	0.013096	2.73	11.72	11.9	0.48
Reach 1	700	2-yr	32	114.03	115.73		115.80	0.008943	2.20	14.52	15.4	0.40
Reach 1	600	2-yr	32	112.99	114.39		114.53	0.019313	3.01	10.64	12.6	0.58
Reach 1	500	2-yr	32	112.36	113.47		113.52	0.005919	1.80	18.11	20.7	0.33
Reach 1	400	2-yr	32	110.80	111.81	111.81	112.14	0.056420	4.64	7.35	12.1	0.97
Reach 1	300	2-yr	32	109.90	111.06		111.07	0.001877	0.97	38.21	48.4	0.18
Reach 1	218	2-yr	66.4	106.59	111.05		111.05	0.000110	0.63	151.48	60.0	0.06
Reach 1	163	2-yr	66.4	107.27	111.02	108.28	111.04	0.000389	1.06	62.49	41.1	0.10
Reach 1	158		Culvert									
Reach 1	100	2-yr	66.4	107	108.4	107.97	108.55	0.015021	3.16	21.04	26.18	0.54

Existing 2-yr HEC-RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4816	2-yr	7.4	123.10	124.60		124.61	0.000360	0.65	15.02	19.1	0.12
Reach 1	4690	2-yr	7.4	122.70	124.57	123.13	124.58	0.000181	0.62	11.87	32.7	0.09
Reach 1	4685		Culvert									
Reach 1	4622	2-yr	7.4	122.15	124.32		124.33	0.000245	0.64	11.57	35.4	0.10
Reach 1	4586	2-yr	7.4	122.06	124.31	122.66	124.32	0.000138	0.58	12.77	29.8	0.08
Reach 1	4581		Culvert									
Reach 1	4542	2-yr	7.4	122.01	124.12		124.12	0.000186	0.56	13.21	27.6	0.09
Reach 1	4478	2-yr	7.4	121.90	124.10	122.59	124.11	0.000327	0.67	11.01	27.9	0.11
Reach 1	4473		Culvert									
Reach 1	4402	2-yr	7.4	121.77	123.85		123.86	0.000327	0.78	9.48	27.1	0.11
Reach 1	4328	2-yr	7.4	121.48	123.84	122.05	123.84	0.000106	0.58	12.86	35.2	0.07
Reach 1	4323		Culvert									
Reach 1	4305	2-yr	7.4	121.43	123.69		123.70	0.000313	0.75	9.92	29.5	0.11
Reach 1	4259	2-yr	7.4	121.18	123.68	121.95	123.69	0.000110	0.53	13.90	69.8	0.07
Reach 1	4254		Culvert									
Reach 1	4229	2-yr	7.4	120.96	123.54		123.54	0.000094	0.43	17.31	53.6	0.06
Reach 1	4181	2-yr	7.4	120.85	123.53	121.67	123.54	0.000086	0.49	14.99	112.6	0.06
Reach 1	4176		Culvert									
Reach 1	4152	2-yr	7.4	120.80	123.38		123.39	0.000738	0.93	7.97	80.6	0.15
Reach 1	4106	2-yr	7.4	120.71	123.36	121.76	123.37	0.000220	0.67	10.98	73.2	0.09
Reach 1	4101		Culvert									
Reach 1	4077	2-yr	7.4	120.66	123.21		123.21	0.000105	0.47	15.70	39.0	0.07
Reach 1	4031	2-yr	7.4	120.60	123.20	121.56	123.21	0.000149	0.61	12.14	74.8	0.08
Reach 1	4026		Culvert									
Reach 1	4008	2-yr	7.4	120.56	123.05		123.06	0.000132	0.56	13.27	25.1	0.08
Reach 1	3961	2-yr	7.4	120.49	123.05	121.19	123.05	0.000116	0.47	15.66	23.5	0.07
Reach 1	3956		Culvert									
Reach 1	3934	2-yr	7.4	120.44	122.89		122.90	0.000195	0.70	10.59	20.7	0.09
Reach 1	3875	2-yr	7.4	120.37	122.89	121.18	122.89	0.000129	0.59	12.60	28.4	0.08
Reach 1	3870		Culvert									
Reach 1	3836	2-yr	7.4	120.31	122.73		122.75	0.001281	1.17	6.34	22.0	0.20
Reach 1	3812	2-yr	7.4	120.27	122.72	121.19	122.73	0.000332	0.86	8.56	12.1	0.11
Reach 1	3797		Culvert									
Reach 1	3701	2-yr	32	120.10	122.30	121.92	122.58	0.010769	4.25	7.52	7.3	0.63
Reach 1	3641	2-yr	32	120.02	122.30		122.34	0.001269	1.60	20.02	14.0	0.24
Reach 1	3600	2-yr	32	119.98	122.24		122.28	0.001592	1.64	19.47	15.5	0.26
Reach 1	3500	2-yr	32	119.76	122.06		122.11	0.001801	1.75	18.31	14.5	0.27
Reach 1	3400	2-yr	32	119.57	121.93		121.97	0.001103	1.53	20.96	13.8	0.22
Reach 1	3300	2-yr	32	119.48	121.77		121.82	0.001975	1.84	17.35	13.3	0.29
Reach 1	3200	2-yr	32	119.20	121.64		121.68	0.001040	1.58	20.19	11.5	0.21
Reach 1	3100	2-yr	32	119.07	121.60		121.61	0.000401	0.96	33.44	22.0	0.14
Reach 1	3000	2-yr	32	118.93	121.49		121.54	0.001628	1.66	19.44	17.4	0.26
Reach 1	2900	2-yr	32	118.70	121.38		121.41	0.000969	1.52	21.11	12.4	0.20
Reach 1	2800	2-yr	32	118.59	121.26		121.30	0.001198	1.71	18.76	10.4	0.22
Reach 1	2715	2-yr	32	118.42	121.14		121.17	0.001942	1.52	21.04	10.1	0.19
Reach 1	2600	2-yr	32	118.13	120.93		120.98	0.001394	1.86	17.24	8.5	0.23
Reach 1	2500	2-yr	32	118.03	120.85		120.88	0.000684	1.35	23.69	12.8	0.17
Reach 1	2400	2-yr	32	117.84	120.70		120.77	0.001986	2.12	15.09	7.8	0.27
Reach 1	2300	2-yr	32	117.71	120.45		120.54	0.002596	2.34	13.66	7.0	0.30
Reach 1	2200	2-yr	32	117.39	120.22		120.30	0.002265	2.24	14.26	7.0	0.28
Reach 1	2100	2-yr	32	117.13	120.00		120.07	0.002225	2.22	14.42	7.4	0.28
Reach 1	2000	2-yr	32	117.05	119.84		119.89	0.001403	1.84	17.37	9.1	0.23
Reach 1	1900	2-yr	32	116.96	119.66		119.73	0.001923	2.09	15.32	7.6	0.26
Reach 1	1800	2-yr	32	116.85	119.42		119.50	0.002693	2.32	13.79	8.0	0.31
Reach 1	1700	2-yr	32	116.66	119.16		119.24	0.002434	2.29	13.99	7.7	0.30
Reach 1	1600	2-yr	32	116.46	118.97		119.03	0.001818	1.94	16.48	10.5	0.27
Reach 1	1500	2-yr	32	116.33	118.74		118.82	0.002432	2.22	14.39	9.0	0.31
Reach 1	1400	2-yr	32	116.03	118.52		118.59	0.002109	2.08	15.41	9.5	0.29
Reach 1	1300	2-yr	32	115.98	118.24		118.33	0.003068	2.44	13.12	8.2	0.34
Reach 1	1200	2-yr	32	115.80	117.92		118.02	0.003286	2.48	12.91	8.8	0.36
Reach 1	1100	2-yr	32	115.47	117.60		117.69	0.003216	2.43	13.15	9.1	0.36
Reach 1	1000	2-yr	32	115.33	117.25		117.34	0.003805	2.47	12.94	10.5	0.39
Reach 1	900	2-yr	32	114.99	116.87		116.96	0.003722	2.45	13.07	10.7	0.39
Reach 1	800	2-yr	32	114.88	116.19		116.37	0.010335	3.39	9.44	10.6	0.63
Reach 1	700	2-yr	32	114.00	115.30		115.43	0.008214	2.94	10.88	12.9	0.56
Reach 1	600	2-yr	32	112.94	114.06		114.29	0.016150	3.88	8.24	10.7	0.78
Reach 1	500	2-yr	32	112.30	113.19		113.28	0.006429	2.40	13.46	19.2	0.50
Reach 1	400	2-yr	32	110.78	111.78	111.78	112.12	0.025611	4.73	7.25	11.8	0.98
Reach 1	300	2-yr	32	109.90	111.05		111.06	0.001063	1.09	37.52	48.3	0.21
Reach 1	218	2-yr	66.4	106.59	111.04		111.05	0.000066	0.73	151.07	60.0	0.07
Reach 1	163	2-yr	66.4	107.27	111.02	108.28	111.04	0.000173	1.06	62.49	41.1	0.10
Reach 1	158		Culvert									
Reach 1	100	2-yr	66.4	107	108.14	107.97	108.41	0.015011	4.12	16.13	19.32	0.78

Proposed 2-yr HEC-RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4816	100-yr	21.5	123.47	126.32		126.32	0.000043	0.28	137.20	145.4	0.04
Reach 1	4690	100-yr	21.5	122.88	126.28	124.05	126.30	0.001464	1.04	29.30	146.4	0.21
Reach 1	4685		Culvert									
Reach 1	4622	100-yr	21.5	123.70	125.91		125.95	0.000776	1.49	14.46	144.2	0.18
Reach 1	4586	100-yr	21.5	122.82	125.89	123.88	125.90	0.001225	1.00	30.69	143.2	0.19
Reach 1	4581		Culvert									
Reach 1	4542	100-yr	21.5	123.08	125.70		125.72	0.000437	1.15	18.69	143.5	0.14
Reach 1	4478	100-yr	21.5	122.67	125.67	123.83	125.68	0.000508	0.78	35.49	141.8	0.13
Reach 1	4473		Culvert									
Reach 1	4402	100-yr	21.5	123.09	125.18		125.22	0.001204	1.63	13.19	136.2	0.22
Reach 1	4328	100-yr	21.5	122.42	125.18	123.40	125.18	0.000160	0.44	88.80	137.1	0.07
Reach 1	4323		Culvert									
Reach 1	4305	100-yr	21.5	122.19	125.18		125.18	0.000159	0.44	90.23	140.5	0.07
Reach 1	4259	100-yr	21.5	122.16	125.17	123.11	125.17	0.000065	0.32	122.89	143.2	0.05
Reach 1	4254		Culvert									
Reach 1	4229	100-yr	21.5	121.97	125.17		125.17	0.000039	0.30	134.68	145.2	0.04
Reach 1	4181	100-yr	21.5	121.89	125.17	122.86	125.17	0.000034	0.26	152.51	143.9	0.04
Reach 1	4176		Culvert									
Reach 1	4152	100-yr	21.5	122.65	125.17		125.17	0.000043	0.26	146.72	144.6	0.04
Reach 1	4106	100-yr	21.5	122.06	125.17	123.02	125.17	0.000027	0.22	181.69	174.6	0.03
Reach 1	4101		Culvert									
Reach 1	4077	100-yr	21.5	122.15	125.16		125.17	0.000033	0.25	163.85	164.6	0.04
Reach 1	4031	100-yr	21.5	121.94	125.16	122.88	125.16	0.000080	0.36	114.15	148.8	0.05
Reach 1	4026		Culvert									
Reach 1	4008	100-yr	21.5	121.91	125.16		125.16	0.000094	0.37	110.75	148.2	0.06
Reach 1	3961	100-yr	21.5	121.75	125.15	122.70	125.15	0.000246	0.57	69.56	145.1	0.09
Reach 1	3956		Culvert									
Reach 1	3934	100-yr	21.5	122.07	125.15		125.15	0.000559	0.67	61.83	148.6	0.13
Reach 1	3875	100-yr	21.5	121.58	125.13	122.45	125.13	0.000229	0.58	67.21	141.8	0.09
Reach 1	3870		Culvert									
Reach 1	3836	100-yr	21.5	121.90	125.12		125.13	0.000333	0.63	63.42	143.5	0.11
Reach 1	3812	100-yr	21.5	120.26	125.12		125.13	0.000024	0.33	82.66	42.1	0.04
Reach 1	3797											
Reach 1	3701	100-yr	93.3	120.09	125.04		125.1	0.000762	2.06	65.29	37.5	0.2
Reach 1	3641	100-yr	93.3	121.07	125.03		125.05	0.000533	1.1	101.89	47.04	0.12
Reach 1	3600	100-yr	93.3	121.05	125.03		125.03	0.000196	0.72	187.38	94.88	0.07
Reach 1	3500	100-yr	93.3	121.31	125.01		125.01	0.000207	0.67	195.09	102.7	0.07
Reach 1	3400	100-yr	93.3	121.09	124.99		124.99	0.000186	0.69	195.68	102.7	0.07
Reach 1	3300	100-yr	93.3	120.89	124.97		124.97	0.000179	0.68	197.39	104.1	0.07
Reach 1	3200	100-yr	93.3	120.87	124.95		124.95	0.000187	0.67	200.62	108.8	0.07
Reach 1	3100	100-yr	93.3	120.81	124.94		124.94	0.000055	0.43	298.11	106.4	0.04
Reach 1	3000	100-yr	93.3	120.48	124.93		124.94	0.000097	0.54	244.32	102.6	0.05
Reach 1	2900	100-yr	93.3	120.52	124.92		124.93	0.000144	0.63	207.39	95.8	0.06
Reach 1	2800	100-yr	93.3	120.48	124.90		124.90	0.000306	0.89	151.44	87.6	0.09
Reach 1	2715	100-yr	93.3	120.74	124.84		124.86	0.000810	1.36	79.39	48.5	0.14
Reach 1	2600	100-yr	93.3	120.67	124.70		124.74	0.001468	1.67	62.19	44.2	0.19
Reach 1	2500	100-yr	93.3	120.73	124.61		124.64	0.000662	1.33	73.19	29.2	0.13
Reach 1	2400	100-yr	93.3	120.84	124.45		124.52	0.002599	2.18	44.97	21.7	0.24
Reach 1	2300	100-yr	93.3	120.27	124.22		124.28	0.002059	1.98	47.59	20.1	0.22
Reach 1	2200	100-yr	93.3	120.41	123.97		124.04	0.002854	2.17	42.90	18.6	0.25
Reach 1	2100	100-yr	93.3	120.14	123.67		123.74	0.003233	2.17	42.94	21.0	0.27
Reach 1	2000	100-yr	93.3	119.87	123.35		123.42	0.003037	2.12	44.02	21.3	0.26
Reach 1	1900	100-yr	93.3	119.78	123.08		123.14	0.002575	1.99	46.78	22.1	0.24
Reach 1	1800	100-yr	93.3	119.00	122.80		122.87	0.002781	2.12	44.11	19.8	0.25
Reach 1	1700	100-yr	93.3	118.65	122.33		122.46	0.006584	2.89	32.24	17.1	0.37
Reach 1	1600	100-yr	93.3	118.22	122.07		122.12	0.001850	1.84	50.75	21.4	0.21
Reach 1	1500	100-yr	93.3	118.12	121.82		121.89	0.002853	2.10	44.34	20.6	0.25
Reach 1	1400	100-yr	93.3	117.89	121.58		121.63	0.002254	1.92	48.54	21.8	0.23
Reach 1	1300	100-yr	93.3	117.59	121.23		121.33	0.004305	2.56	36.51	16.8	0.31
Reach 1	1200	100-yr	93.3	116.85	120.64		120.78	0.007154	2.99	31.23	16.6	0.38
Reach 1	1100	100-yr	93.3	116.68	119.94		120.07	0.006833	2.90	32.16	17.8	0.38
Reach 1	1000	100-yr	93.3	116.16	119.36		119.47	0.005333	2.66	35.13	18.5	0.34
Reach 1	900	100-yr	93.3	115.62	118.75		118.87	0.006693	2.73	34.18	20.8	0.38
Reach 1	800	100-yr	93.3	115.18	117.69		117.91	0.014696	3.69	25.27	17.7	0.54
Reach 1	700	100-yr	93.3	114.03	116.60		116.74	0.009152	3.02	31.17	22.5	0.44
Reach 1	600	100-yr	93.3	112.99	115.23	114.76	115.48	0.018117	4.02	23.24	17.3	0.60
Reach 1	500	100-yr	93.3	112.36	114.16		114.29	0.007982	2.89	33.74	24.5	0.41
Reach 1	400	100-yr	93.3	110.80	113.77		113.81	0.002954	1.76	60.26	43.1	0.25
Reach 1	300	100-yr	93.3	109.90	113.76		113.76	0.000118	0.59	179.91	55.4	0.06
Reach 1	218	100-yr	203.4	106.59	113.74		113.75	0.000119	0.93	313.14	60.0	0.06
Reach 1	163	100-yr	203.4	107.27	113.68	109.16	113.74	0.000527	1.82	111.70	60.0	0.13
Reach 1	158		Culvert									
Reach 1	100	100-yr	203.4	107.00	109.43	108.81	109.81	0.015004	4.94	41.20	37.0	0.60

Existing 100-yr HEC-RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4816	100-yr	21.5	123.10	126.29		126.29	0.000036	0.30	135.95	145.3	0.04
Reach 1	4690	100-yr	21.5	122.70	126.27	123.56	126.28	0.000428	0.78	35.05	146.3	0.13
Reach 1	4685		Culvert									
Reach 1	4622	100-yr	21.5	122.15	125.88		125.90	0.000152	0.85	25.34	144.1	0.09
Reach 1	4586	100-yr	21.5	122.06	125.88	123.15	125.89	0.000455	0.80	36.32	143.2	0.14
Reach 1	4581		Culvert									
Reach 1	4542	100-yr	21.5	122.01	125.67		125.68	0.000104	0.70	30.67	143.4	0.07
Reach 1	4478	100-yr	21.5	121.90	125.65	123.16	125.66	0.000404	0.77	33.77	141.8	0.13
Reach 1	4473		Culvert									
Reach 1	4402	100-yr	21.5	121.77	124.95		124.98	0.000412	1.28	16.78	104.8	0.14
Reach 1	4328	100-yr	21.5	121.48	124.94	122.52	124.94	0.000297	0.64	60.10	136.2	0.11
Reach 1	4323		Culvert									
Reach 1	4305	100-yr	21.5	121.43	124.94		124.94	0.000300	0.68	59.72	134.2	0.11
Reach 1	4259	100-yr	21.5	121.18	124.93	122.43	124.93	0.000098	0.44	94.51	142.2	0.07
Reach 1	4254		Culvert									
Reach 1	4229	100-yr	21.5	120.96	124.93		124.93	0.000056	0.38	104.35	144.3	0.05
Reach 1	4181	100-yr	21.5	120.85	124.93	122.16	124.93	0.000047	0.34	124.12	143.5	0.05
Reach 1	4176		Culvert									
Reach 1	4152	100-yr	21.5	120.80	124.93		124.93	0.000066	0.35	118.59	144.0	0.05
Reach 1	4106	100-yr	21.5	120.71	124.92	122.32	124.93	0.000046	0.31	143.35	174.6	0.05
Reach 1	4101		Culvert									
Reach 1	4077	100-yr	21.5	120.66	124.92		124.92	0.000034	0.31	138.38	162.3	0.04
Reach 1	4031	100-yr	21.5	120.60	124.92	122.07	124.92	0.000130	0.50	83.25	148.5	0.08
Reach 1	4026		Culvert									
Reach 1	4008	100-yr	21.5	120.56	124.92		124.92	0.000100	0.47	86.46	147.9	0.07
Reach 1	3961	100-yr	21.5	120.49	124.91	121.69	124.91	0.000126	0.56	50.71	144.6	0.08
Reach 1	3956		Culvert									
Reach 1	3934	100-yr	21.5	120.44	124.84		124.85	0.000682	0.93	27.89	148.2	0.16
Reach 1	3875	100-yr	21.5	120.37	124.81	121.64	124.82	0.000418	0.82	27.60	141.0	0.13
Reach 1	3870		Culvert									
Reach 1	3836	100-yr	21.5	120.31	124.00		124.04	0.000710	1.45	14.83	123.6	0.17
Reach 1	3812	100-yr	21.5	120.27	124.01	121.79	124.02	0.000176	0.62	37.35	33.6	0.09
Reach 1	3797		Culvert									
Reach 1	3701	100-yr	93.3	120.10	123.79	123.01	124.01	0.004797	3.76	28.36	22.7	0.47
Reach 1	3641	100-yr	93.3	120.02	123.79		123.84	0.001042	1.94	55.15	42.6	0.23
Reach 1	3600	100-yr	93.3	119.98	123.76		123.80	0.000835	1.67	78.76	82.3	0.20
Reach 1	3500	100-yr	93.3	119.76	123.67		123.71	0.000937	1.72	78.70	90.0	0.21
Reach 1	3400	100-yr	93.3	119.57	123.58		123.62	0.000865	1.69	68.30	95.6	0.21
Reach 1	3300	100-yr	93.3	119.48	123.48		123.53	0.001032	1.78	61.79	51.8	0.23
Reach 1	3200	100-yr	93.3	119.20	123.40		123.44	0.000725	1.69	72.25	58.4	0.19
Reach 1	3100	100-yr	93.3	119.07	123.39		123.40	0.000164	0.94	158.62	98.7	0.10
Reach 1	3000	100-yr	93.3	118.93	123.35		123.37	0.000536	1.41	99.18	76.2	0.17
Reach 1	2900	100-yr	93.3	118.70	123.28		123.32	0.000587	1.58	79.14	70.0	0.17
Reach 1	2800	100-yr	93.3	118.59	123.17		123.23	0.001159	2.00	46.68	20.8	0.24
Reach 1	2715	100-yr	93.3	118.42	123.04		123.10	0.002180	1.99	46.80	16.8	0.21
Reach 1	2600	100-yr	93.3	118.13	122.80		122.89	0.001540	2.43	38.44	14.0	0.26
Reach 1	2500	100-yr	93.3	118.03	122.73		122.78	0.000659	1.75	53.43	18.8	0.18
Reach 1	2400	100-yr	93.3	117.84	122.54		122.66	0.002200	2.81	33.24	12.1	0.30
Reach 1	2300	100-yr	93.3	117.71	122.28		122.42	0.002740	2.97	31.39	12.4	0.33
Reach 1	2200	100-yr	93.3	117.39	121.99		122.14	0.002812	3.03	30.80	11.8	0.33
Reach 1	2100	100-yr	93.3	117.13	121.72		121.86	0.002671	2.99	31.23	12.1	0.33
Reach 1	2000	100-yr	93.3	117.05	121.54		121.64	0.001723	2.58	36.16	13.1	0.27
Reach 1	1900	100-yr	93.3	116.96	121.30		121.43	0.002567	2.82	33.03	13.9	0.32
Reach 1	1800	100-yr	93.3	116.85	121.02		121.16	0.002824	2.99	31.22	13.3	0.34
Reach 1	1700	100-yr	93.3	116.66	120.70		120.86	0.003185	3.15	29.58	12.7	0.36
Reach 1	1600	100-yr	93.3	116.46	120.50		120.60	0.001857	2.58	36.23	15.2	0.29
Reach 1	1500	100-yr	93.3	116.33	120.24		120.38	0.002645	2.96	31.52	13.7	0.34
Reach 1	1400	100-yr	93.3	116.03	120.00		120.12	0.002468	2.83	33.01	14.5	0.33
Reach 1	1300	100-yr	93.3	115.98	119.62		119.81	0.003857	3.48	26.85	11.5	0.40
Reach 1	1200	100-yr	93.3	115.80	119.22		119.41	0.004075	3.50	26.65	12.5	0.42
Reach 1	1100	100-yr	93.3	115.47	118.80		119.00	0.004296	3.53	26.40	12.9	0.44
Reach 1	1000	100-yr	93.3	115.33	118.37		118.56	0.004369	3.47	26.92	14.4	0.45
Reach 1	900	100-yr	93.3	114.99	117.90		118.10	0.004928	3.52	26.53	15.5	0.47
Reach 1	800	100-yr	93.3	114.88	117.01		117.35	0.011780	4.72	19.77	14.8	0.72
Reach 1	700	100-yr	93.3	114.00	116.21		116.42	0.006996	3.65	25.58	19.4	0.56
Reach 1	600	100-yr	93.3	112.94	114.67	114.65	115.21	0.023124	5.93	15.74	14.1	0.99
Reach 1	500	100-yr	93.3	112.30	113.92		114.09	0.005596	3.38	28.85	23.1	0.51
Reach 1	400	100-yr	93.3	110.78	113.73		113.79	0.001605	1.94	59.28	42.9	0.28
Reach 1	300	100-yr	93.3	109.90	113.75		113.75	0.000066	0.66	179.36	55.4	0.06
Reach 1	218	100-yr	203.4	106.59	113.73		113.75	0.000078	1.13	312.56	60.0	0.08
Reach 1	163	100-yr	203.4	107.27	113.68	109.16	113.74	0.000234	1.82	111.70	60.0	0.13
Reach 1	158		Culvert									
Reach 1	100	100-yr	203.4	107	108.97	108.81	109.59	0.015023	6.3	32.29	34.6	0.86

Proposed 100-yr HEC-RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4816	500-yr	29.1	123.47	126.39		126.39	0.000063	0.35	147.71	145.6	0.05
Reach 1	4690	500-yr	29.1	122.88	126.34	124.21	126.36	0.001812	1.22	38.08	146.5	0.24
Reach 1	4685		Culvert									
Reach 1	4622	500-yr	29.1	123.70	125.98		126.03	0.001289	1.95	14.89	144.4	0.24
Reach 1	4586	500-yr	29.1	122.82	125.94	124.03	125.96	0.001605	1.19	38.48	143.4	0.23
Reach 1	4581		Culvert									
Reach 1	4542	500-yr	29.1	123.08	125.81		125.85	0.002656	1.46	21.27	143.8	0.29
Reach 1	4478	500-yr	29.1	122.67	125.75	123.98	125.76	0.000680	0.94	45.67	141.9	0.15
Reach 1	4473		Culvert									
Reach 1	4402	500-yr	29.1	123.09	125.63		125.67	0.004335	1.69	19.97	137.8	0.36
Reach 1	4328	500-yr	29.1	122.42	125.63	123.55	125.63	0.000060	0.34	151.86	138.6	0.05
Reach 1	4323		Culvert									
Reach 1	4305	500-yr	29.1	122.19	125.63		125.63	0.000059	0.34	154.57	142.3	0.05
Reach 1	4259	500-yr	29.1	122.16	125.63	123.26	125.63	0.000032	0.28	188.66	144.4	0.04
Reach 1	4254		Culvert									
Reach 1	4229	500-yr	29.1	121.97	125.63		125.63	0.000023	0.27	201.09	146.1	0.03
Reach 1	4181	500-yr	29.1	121.89	125.63	123.01	125.63	0.000020	0.24	218.37	144.7	0.03
Reach 1	4176		Culvert									
Reach 1	4152	500-yr	29.1	122.65	125.62		125.62	0.000024	0.23	212.76	145.4	0.03
Reach 1	4106	500-yr	29.1	122.06	125.62	123.17	125.62	0.000016	0.20	261.30	174.6	0.03
Reach 1	4101		Culvert									
Reach 1	4077	500-yr	29.1	122.15	125.62		125.62	0.000019	0.22	239.34	165.9	0.03
Reach 1	4031	500-yr	29.1	121.94	125.62	123.02	125.62	0.000037	0.30	182.29	149.4	0.04
Reach 1	4026		Culvert									
Reach 1	4008	500-yr	29.1	121.91	125.62		125.62	0.000041	0.30	178.93	148.7	0.04
Reach 1	3961	500-yr	29.1	121.75	125.61	122.88	125.62	0.000078	0.40	137.33	145.7	0.05
Reach 1	3956		Culvert									
Reach 1	3934	500-yr	29.1	122.07	125.61		125.62	0.000113	0.41	131.38	149.1	0.06
Reach 1	3875	500-yr	29.1	121.58	125.61	122.60	125.61	0.000074	0.41	135.83	143.1	0.05
Reach 1	3870		Culvert									
Reach 1	3836	500-yr	29.1	121.90	125.61		125.61	0.000088	0.42	133.04	144.3	0.06
Reach 1	3812	500-yr	29.1	120.26	125.61		125.61	0.000023	0.37	102.97	42.1	0.04
Reach 1	3797											
Reach 1	3701	500-yr	125	120.09	125.51		125.58	0.000767	2.27	83.05	37.5	0.21
Reach 1	3641	500-yr	125	121.07	125.51		125.53	0.000524	1.22	124.85	49.48	0.12
Reach 1	3600	500-yr	125	121.05	125.51		125.51	0.000184	0.76	233.31	96.84	0.07
Reach 1	3500	500-yr	125	121.31	125.49		125.49	0.000185	0.71	245.00	105.0	0.07
Reach 1	3400	500-yr	125	121.09	125.47		125.48	0.000170	0.73	245.85	104.9	0.07
Reach 1	3300	500-yr	125	120.89	125.45		125.46	0.000164	0.72	248.34	106.1	0.07
Reach 1	3200	500-yr	125	120.87	125.44		125.44	0.000166	0.70	253.92	110.3	0.07
Reach 1	3100	500-yr	125	120.81	125.43		125.43	0.000060	0.49	350.28	108.1	0.04
Reach 1	3000	500-yr	125	120.48	125.42		125.42	0.000099	0.59	294.52	104.1	0.05
Reach 1	2900	500-yr	125	120.52	125.41		125.41	0.000141	0.69	254.43	97.8	0.06
Reach 1	2800	500-yr	125	120.48	125.38		125.39	0.000273	0.93	194.60	89.5	0.09
Reach 1	2715	500-yr	125	120.74	125.32		125.35	0.000762	1.47	103.66	50.9	0.14
Reach 1	2600	500-yr	125	120.67	125.20		125.24	0.001262	1.75	85.37	48.2	0.18
Reach 1	2500	500-yr	125	120.73	125.11		125.15	0.000698	1.50	94.17	48.4	0.14
Reach 1	2400	500-yr	125	120.84	124.93		125.02	0.002680	2.38	56.25	24.8	0.25
Reach 1	2300	500-yr	125	120.27	124.70		124.77	0.002266	2.21	57.76	23.2	0.23
Reach 1	2200	500-yr	125	120.41	124.41		124.50	0.003185	2.42	51.69	21.2	0.27
Reach 1	2100	500-yr	125	120.14	124.10		124.19	0.003091	2.39	52.87	24.9	0.27
Reach 1	2000	500-yr	125	119.87	123.80		123.89	0.002875	2.32	54.28	24.3	0.26
Reach 1	1900	500-yr	125	119.78	123.55		123.62	0.002427	2.18	57.81	25.1	0.24
Reach 1	1800	500-yr	125	119.00	123.27		123.36	0.002865	2.32	54.01	22.3	0.26
Reach 1	1700	500-yr	125	118.65	122.81		122.95	0.005890	3.07	41.02	19.7	0.36
Reach 1	1600	500-yr	125	118.22	122.56		122.62	0.001887	2.04	61.74	23.5	0.21
Reach 1	1500	500-yr	125	118.12	122.31		122.39	0.002945	2.27	54.97	23.3	0.26
Reach 1	1400	500-yr	125	117.89	122.06		122.13	0.002287	2.10	59.53	24.1	0.23
Reach 1	1300	500-yr	125	117.59	121.68		121.81	0.004578	2.80	44.67	18.8	0.32
Reach 1	1200	500-yr	125	116.85	121.07		121.23	0.007288	3.21	38.96	19.0	0.39
Reach 1	1100	500-yr	125	116.68	120.37		120.52	0.006883	3.11	40.25	20.3	0.39
Reach 1	1000	500-yr	125	116.16	119.75		119.88	0.005834	2.91	42.88	21.0	0.36
Reach 1	900	500-yr	125	115.62	119.11		119.25	0.006837	2.97	42.07	22.9	0.39
Reach 1	800	500-yr	125	115.18	118.01		118.26	0.015097	4.00	31.28	19.9	0.56
Reach 1	700	500-yr	125	114.03	116.88		117.05	0.009556	3.39	37.59	24.1	0.46
Reach 1	600	500-yr	125	112.99	116.04		116.20	0.007570	3.28	39.11	22.2	0.41
Reach 1	500	500-yr	125	112.36	115.91		115.94	0.001020	1.55	92.50	41.7	0.16
Reach 1	400	500-yr	125	110.80	115.88		115.89	0.000253	0.87	163.23	51.9	0.08
Reach 1	300	500-yr	125	109.90	115.88		115.88	0.000042	0.49	301.38	59.0	0.04
Reach 1	218	500-yr	276.7	106.59	115.87		115.88	0.000078	0.90	440.63	60.0	0.05
Reach 1	163	500-yr	276.7	107.27	115.81	109.53	115.86	0.000356	1.83	151.06	60.0	0.11
Reach 1	158		Culvert									
Reach 1	100	500-yr	276.7	107.00	109.86	109.15	110.34	0.015002	5.58	49.55	39.9	0.62

Existing 500-yr HEC-RAS Results

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach 1	4816	500-yr	29.1	123.10	126.36		126.36	0.000055	0.38	145.93	145.5	0.05
Reach 1	4690	500-yr	29.1	122.70	126.33	123.73	126.34	0.000608	0.96	43.69	146.5	0.16
Reach 1	4685		Culvert									
Reach 1	4622	500-yr	29.1	122.15	125.92		125.94	0.000267	1.14	25.64	144.2	0.12
Reach 1	4586	500-yr	29.1	122.06	125.91	123.33	125.92	0.000731	1.03	40.48	143.2	0.17
Reach 1	4581		Culvert									
Reach 1	4542	500-yr	29.1	122.01	125.75		125.76	0.000173	0.92	31.55	143.6	0.10
Reach 1	4478	500-yr	29.1	121.90	125.73	123.39	125.74	0.000551	0.94	44.16	141.9	0.15
Reach 1	4473		Culvert									
Reach 1	4402	500-yr	29.1	121.77	125.07		125.11	0.000651	1.66	17.53	131.3	0.18
Reach 1	4328	500-yr	29.1	121.48	125.05	122.69	125.06	0.000318	0.71	75.89	136.6	0.12
Reach 1	4323		Culvert									
Reach 1	4305	500-yr	29.1	121.43	125.05		125.06	0.000357	0.74	75.31	138.8	0.12
Reach 1	4259	500-yr	29.1	121.18	125.04	122.60	125.05	0.000119	0.51	110.56	142.7	0.07
Reach 1	4254		Culvert									
Reach 1	4229	500-yr	29.1	120.96	125.04		125.04	0.000073	0.46	120.49	144.7	0.06
Reach 1	4181	500-yr	29.1	120.85	125.04	122.34	125.04	0.000062	0.40	140.06	143.6	0.05
Reach 1	4176		Culvert									
Reach 1	4152	500-yr	29.1	120.80	125.01		125.01	0.000092	0.42	130.59	144.2	0.06
Reach 1	4106	500-yr	29.1	120.71	125.01	122.55	125.01	0.000064	0.38	157.73	174.6	0.05
Reach 1	4101		Culvert									
Reach 1	4077	500-yr	29.1	120.66	125.00		125.01	0.000049	0.39	151.48	163.2	0.05
Reach 1	4031	500-yr	29.1	120.60	125.00	122.24	125.00	0.000175	0.60	94.92	148.6	0.09
Reach 1	4026		Culvert									
Reach 1	4008	500-yr	29.1	120.56	125.00		125.00	0.000139	0.57	98.03	148.0	0.08
Reach 1	3961	500-yr	29.1	120.49	124.98	121.88	124.99	0.000186	0.70	61.43	144.8	0.09
Reach 1	3956		Culvert									
Reach 1	3934	500-yr	29.1	120.44	124.97		124.98	0.000685	1.01	46.93	148.3	0.17
Reach 1	3875	500-yr	29.1	120.37	124.94	121.82	124.95	0.000485	0.94	45.21	141.3	0.15
Reach 1	3870		Culvert									
Reach 1	3836	500-yr	29.1	120.31	124.45		124.49	0.000706	1.63	17.81	142.3	0.18
Reach 1	3812	500-yr	29.1	120.27	124.46	121.99	124.47	0.000126	0.63	54.94	42.1	0.08
Reach 1	3797		Culvert									
Reach 1	3701	500-yr	125	120.10	124.24	123.32	124.47	0.004069	3.96	39.08	25.5	0.45
Reach 1	3641	500-yr	125	120.02	124.25		124.31	0.000965	2.03	75.27	44.1	0.23
Reach 1	3600	500-yr	125	119.98	124.24		124.27	0.000604	1.63	120.60	92.0	0.18
Reach 1	3500	500-yr	125	119.76	124.18		124.21	0.000667	1.55	125.91	95.4	0.18
Reach 1	3400	500-yr	125	119.57	124.11		124.15	0.000559	1.57	120.29	98.8	0.17
Reach 1	3300	500-yr	125	119.48	124.05		124.09	0.000667	1.65	112.25	100.5	0.19
Reach 1	3200	500-yr	125	119.20	123.99		124.02	0.000613	1.64	113.60	83.6	0.18
Reach 1	3100	500-yr	125	119.07	123.98		123.99	0.000131	0.95	218.18	103.0	0.09
Reach 1	3000	500-yr	125	118.93	123.95		123.97	0.000362	1.32	154.61	98.2	0.14
Reach 1	2900	500-yr	125	118.70	123.90		123.93	0.000446	1.48	128.57	88.0	0.15
Reach 1	2800	500-yr	125	118.59	123.80		123.86	0.000935	2.00	75.63	73.8	0.22
Reach 1	2715	500-yr	125	118.42	123.67		123.74	0.002287	2.14	58.31	19.9	0.22
Reach 1	2600	500-yr	125	118.13	123.41		123.52	0.001612	2.62	47.70	16.3	0.27
Reach 1	2500	500-yr	125	118.03	123.35		123.40	0.000678	1.90	65.70	21.1	0.19
Reach 1	2400	500-yr	125	117.84	123.14		123.28	0.002294	3.05	40.92	13.6	0.31
Reach 1	2300	500-yr	125	117.71	122.87		123.03	0.002765	3.18	39.37	14.4	0.34
Reach 1	2200	500-yr	125	117.39	122.58		122.74	0.002913	3.27	38.28	13.7	0.34
Reach 1	2100	500-yr	125	117.13	122.29		122.46	0.002811	3.24	38.60	13.9	0.34
Reach 1	2000	500-yr	125	117.05	122.09		122.22	0.001906	2.84	43.97	15.1	0.29
Reach 1	1900	500-yr	125	116.96	121.85		121.99	0.002600	3.03	41.22	16.0	0.33
Reach 1	1800	500-yr	125	116.85	121.56		121.72	0.002823	3.22	38.84	14.9	0.35
Reach 1	1700	500-yr	125	116.66	121.24		121.42	0.003231	3.39	36.83	14.4	0.37
Reach 1	1600	500-yr	125	116.46	121.04		121.16	0.001921	2.79	44.87	17.2	0.30
Reach 1	1500	500-yr	125	116.33	120.77		120.93	0.002708	3.20	39.12	15.5	0.35
Reach 1	1400	500-yr	125	116.03	120.51		120.66	0.002553	3.04	41.09	16.8	0.34
Reach 1	1300	500-yr	125	115.98	120.10		120.33	0.004202	3.83	32.63	12.9	0.42
Reach 1	1200	500-yr	125	115.80	119.67		119.90	0.004331	3.84	32.56	13.9	0.44
Reach 1	1100	500-yr	125	115.47	119.22		119.45	0.004636	3.90	32.05	14.3	0.46
Reach 1	1000	500-yr	125	115.33	118.76		118.98	0.004688	3.82	32.71	15.9	0.47
Reach 1	900	500-yr	125	114.99	118.25		118.49	0.005271	3.88	32.21	17.1	0.50
Reach 1	800	500-yr	125	114.88	117.32		117.72	0.011721	5.07	24.63	16.5	0.73
Reach 1	700	500-yr	125	114.00	116.37		116.66	0.009061	4.36	28.68	20.7	0.64
Reach 1	600	500-yr	125	112.94	115.88		116.07	0.003806	3.44	37.07	21.1	0.44
Reach 1	500	500-yr	125	112.30	115.88		115.91	0.000491	1.62	91.94	41.7	0.17
Reach 1	400	500-yr	125	110.78	115.87		115.88	0.000135	0.95	162.98	51.9	0.09
Reach 1	300	500-yr	125	109.90	115.87		115.88	0.000023	0.54	301.02	59.0	0.04
Reach 1	218	500-yr	276.7	106.59	115.86		115.87	0.000052	1.11	440.18	60.0	0.07
Reach 1	163	500-yr	276.7	107.27	115.81	109.53	115.86	0.000158	1.83	151.06	60.0	0.11
Reach 1	158		Culvert									
Reach 1	100	500-yr	276.7	107	109.31	109.15	110.1	0.015014	7.12	38.84	36.4	0.89

Proposed 500-yr HEC-RAS Results

SUB-AREA	Area ($mi.^2$)	L (miles)	Lca (miles)	S (ft/mi)	So (ft/mi)	UD_{TOT} (%)	DCI (%)	DCC (%)	DPP (%)	Tc (hours)	Tc+R (hours)	R (hours)	A_{DET} ($mi.^2$)	UD_{DET} (%)	DLU-DET	DLU(min)	Tc(adj) (hours)	Tc+R(adj) (hours)	R(adj) (hours)	R5	R10	R25	R50	R100	R500	I (%)	SUB-AREA
A	0.013	0.28	0.18	5.0	34	88	0	60	0	0.22	0.90	0.68	0.013	100.00	-11.66	36.03	0.24	1.66	1.42	1.42	1.42	1.42	1.42	1.42	1.42	53	A
B	0.033	0.42	0.10	7.2	35	66	0	60	0	0.10	1.30	1.20	0.000	0.00	65.75	65.75	0.10	1.30	1.20	1.20	1.20	1.20	1.20	1.20	1.20	33	B
C	0.004	0.18	0.08	8.8	20	100	0	60	0	0.07	0.50	0.43	0.000	0.00	100.00	100.00	0.07	0.50	0.43	0.43	0.43	0.43	0.43	0.43	0.43	40	C
D	0.013	0.67	0.37	10.7	29	50	0	60	0	0.34	1.88	1.54	0.000	0.00	50.07	50.07	0.34	1.88	1.54	1.54	1.54	1.54	1.54	1.54	1.54	20	D
E	0.061	0.82	0.39	5.0	25	91	0	60	0	0.50	1.89	1.39	0.000	0.00	91.47	91.47	0.50	1.89	1.39	1.39	1.39	1.39	1.39	1.39	1.39	37	E

TC&R Calculations

APPENDIX C
Relevant Previous Plans and Studies
(see digital deliverables)

PRESTONWOOD PUBLIC UTILITY DISTRICT

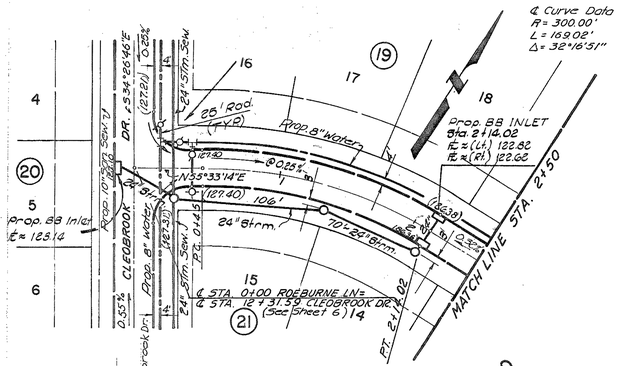
PRESTONWOOD FOREST SECTION 3

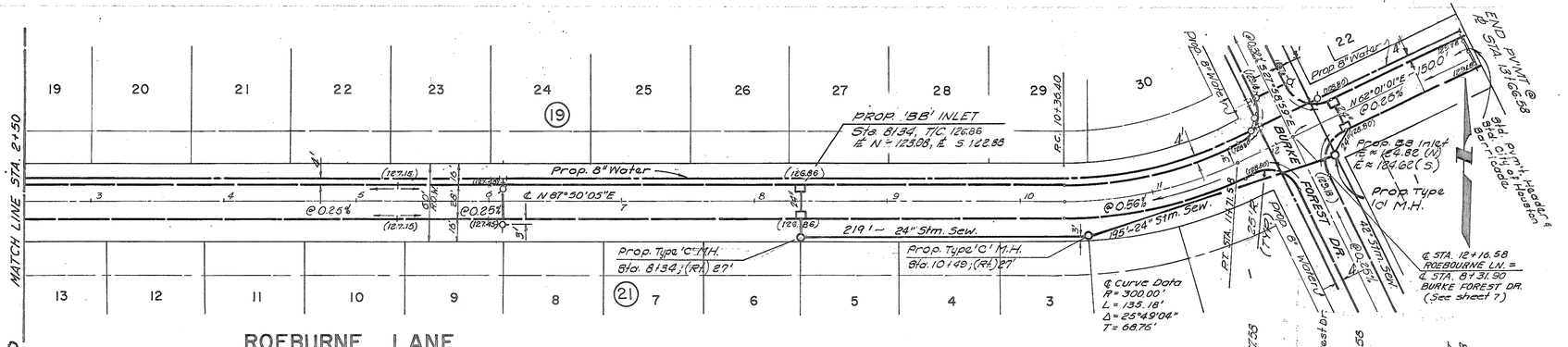
PAVING & DRAINAGE PLANS & PROFILES

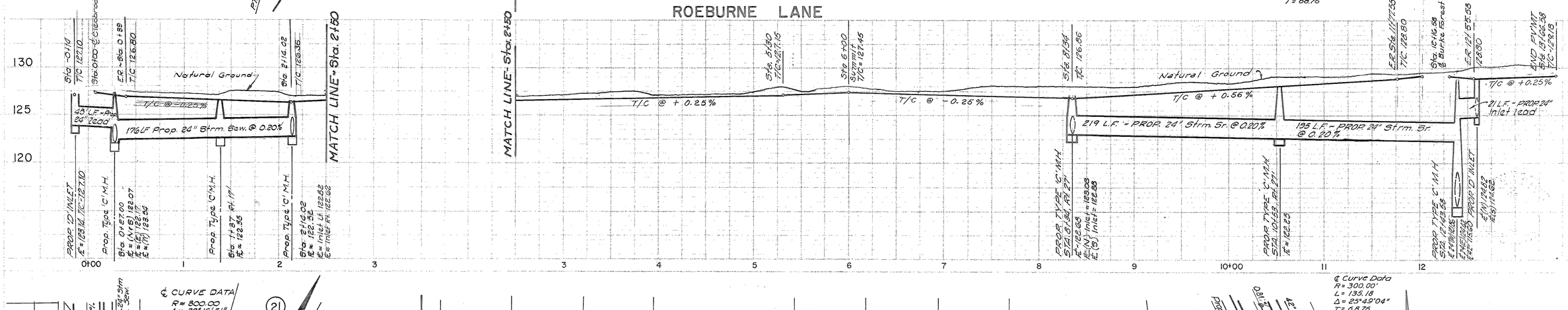
SHEET 3 OF 9

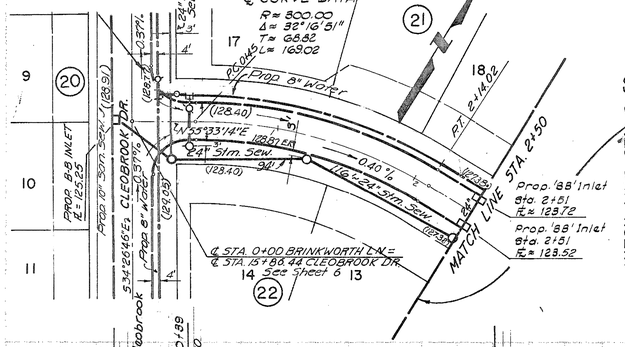
P-585 (PD)

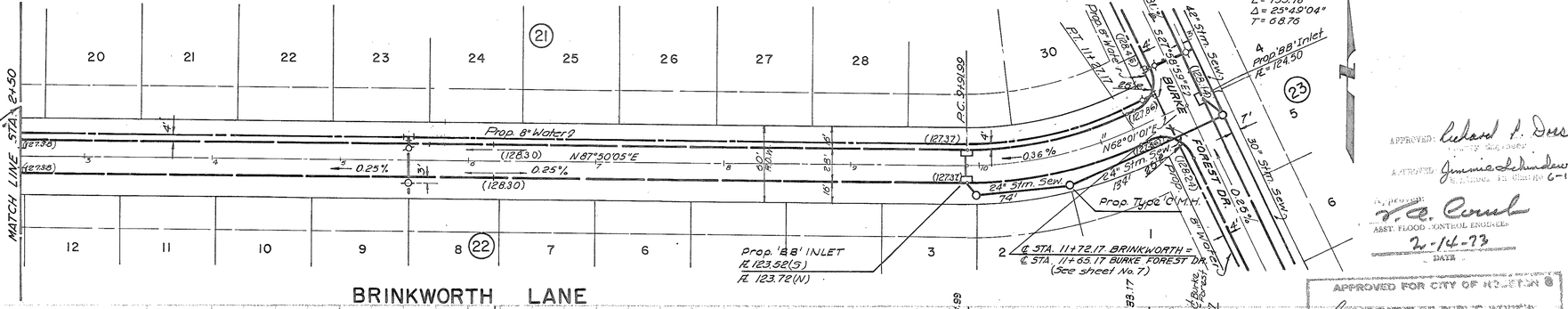
1680010217

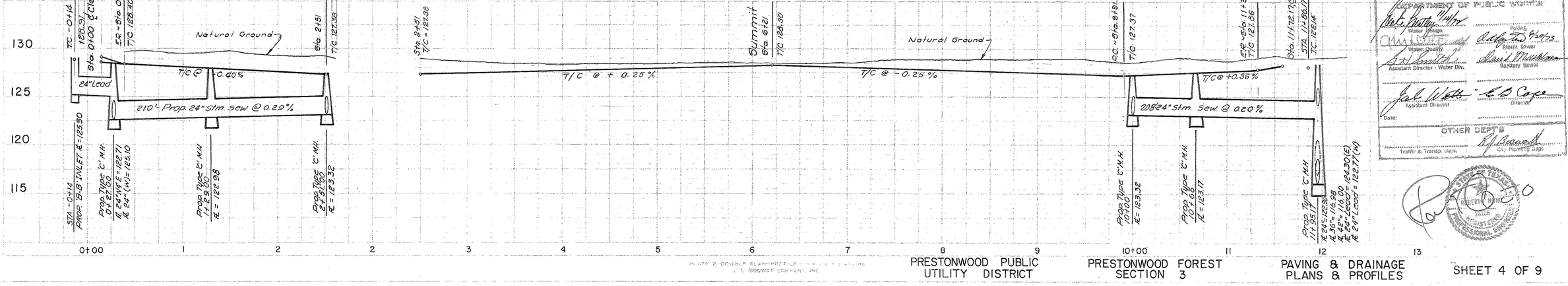












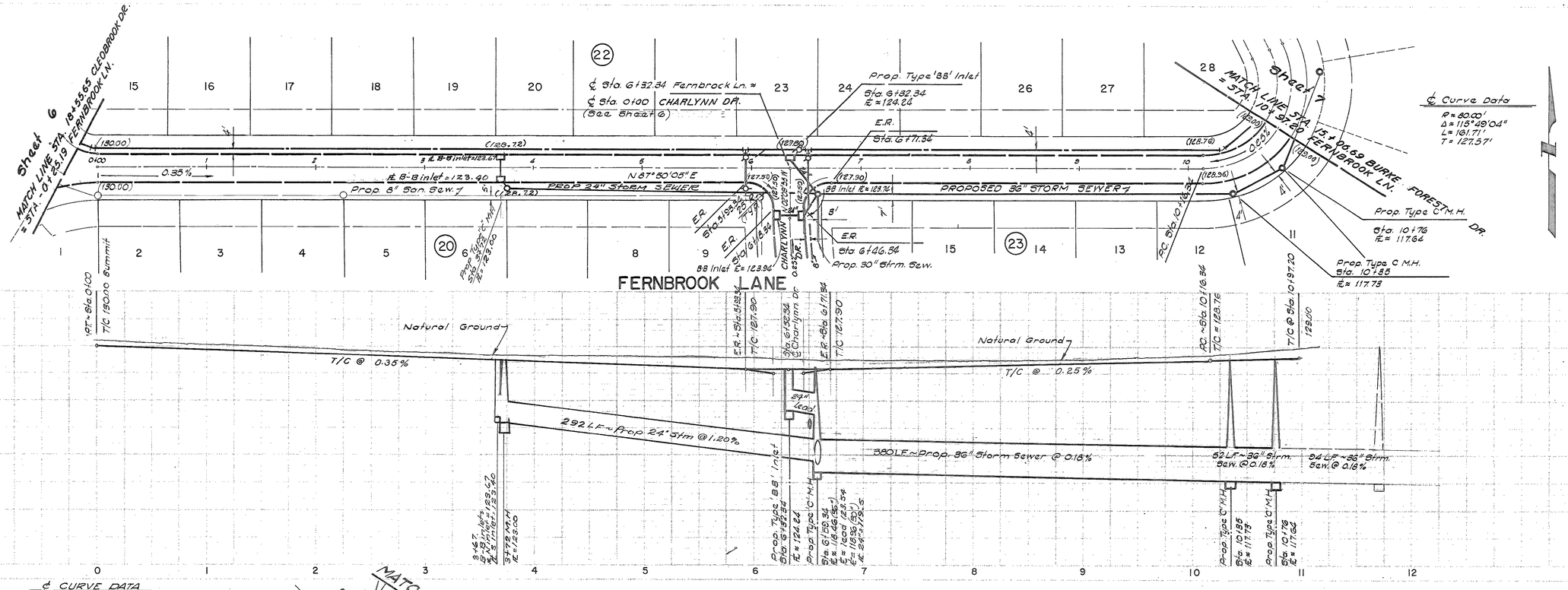
APPROVED: Richard A. Dorse
ASST. FLOOD CONTROL ENGINEER
APPROVED: Jimmie Schindewolf
ASST. FLOOD CONTROL ENGINEER 6-19-73
APPROVED: J. C. Cornish
ASST. FLOOD CONTROL ENGINEER
2-14-73
DATE

APPROVED FOR CITY OF NEPTUNE
DEPARTMENT OF PUBLIC WORKS
Water Quality — Water Div. — Paving — Storm Sewer — Sanitary Sewer
Assistant Director — Director
Date: 6/20/73
Traffic & Transp. Dept. — City Planning Dept.
OTHER DEPT'S

STATE OF NEW JERSEY — ROBERT H. NICOLAI — 23155 — PROFESSIONAL ENGINEER

PRESTONWOOD PUBLIC UTILITY DISTRICT
PRESTONWOOD FOREST SECTION 3
PAVING & DRAINAGE PLANS & PROFILES
SHEET 4 OF 9
P-585 (PD)

PLATE 2-DOUBLE SLAB-PROFILE
L. L. SIDDALL COMPANY, INC.



APPROVED Richard P. Bowman
DIRECTOR OF PUBLIC WORKS
APPROVED Jimmie L. Windwolf 6-19-73
ASST. DIRECTOR
Approved: V.G. Coul 6-14-73
ASST. FLOOD CONTROL ENGINEER DATE

APPROVED FOR CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS:
Date: 6/19/73
OTHER DEPTS

PRESTONWOOD PUBLIC UTILITY DISTRICT
PRESTONWOOD FOREST SECTION 3
PAVING & DRAINAGE PLANS & PROFILES
SHEET 5 OF 9
P- 585 (PD)
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PRESTONWOOD PUBLIC UTILITY DISTRICT

PRESTONWOOD FOREST SECTION 3

PAVING & DRAINAGE PLANS & PROFILES

SHEET 6 OF 9

P-585 (PD)

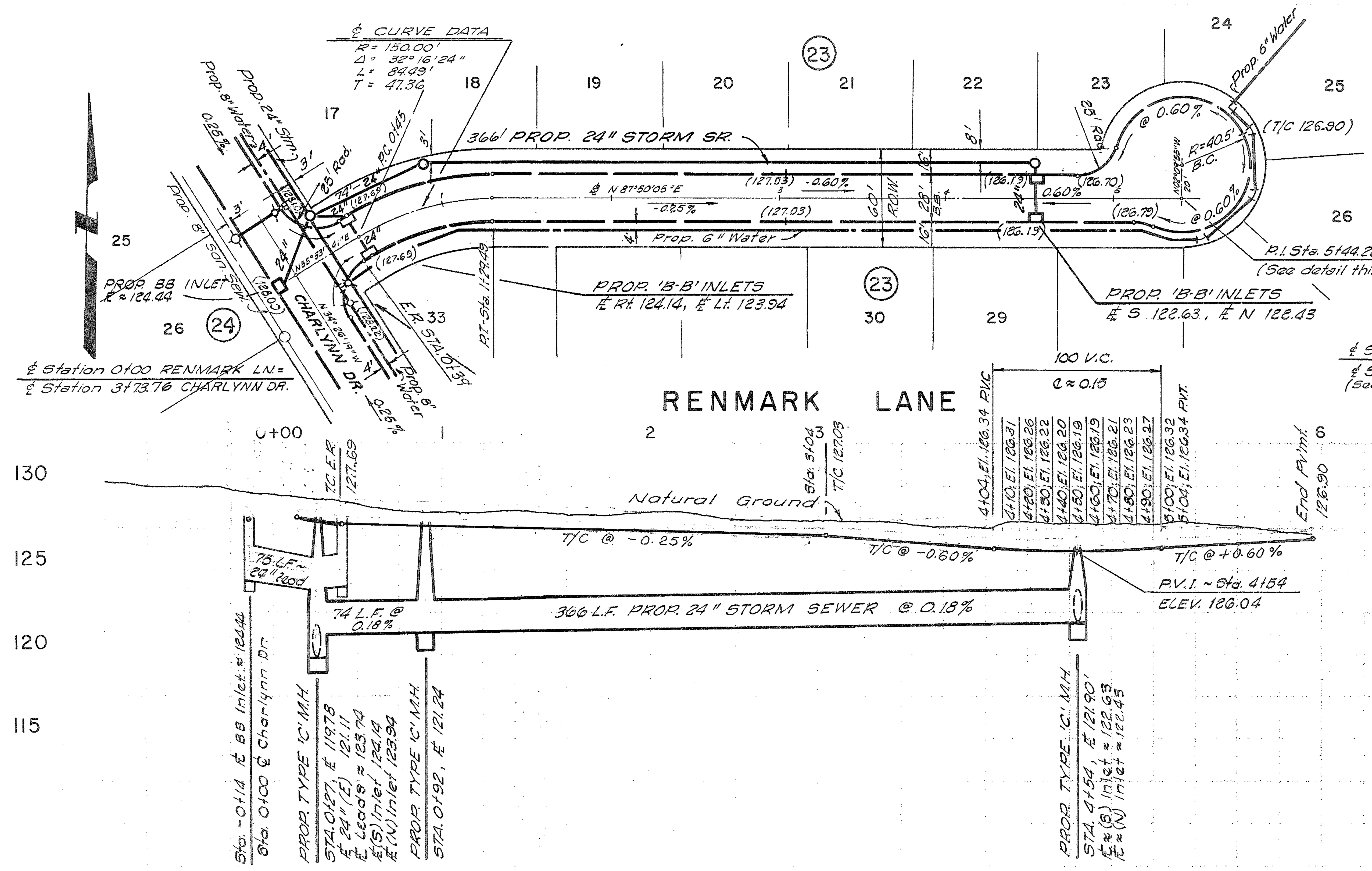
PRESTONWOOD PUBLIC UTILITY DISTRICT

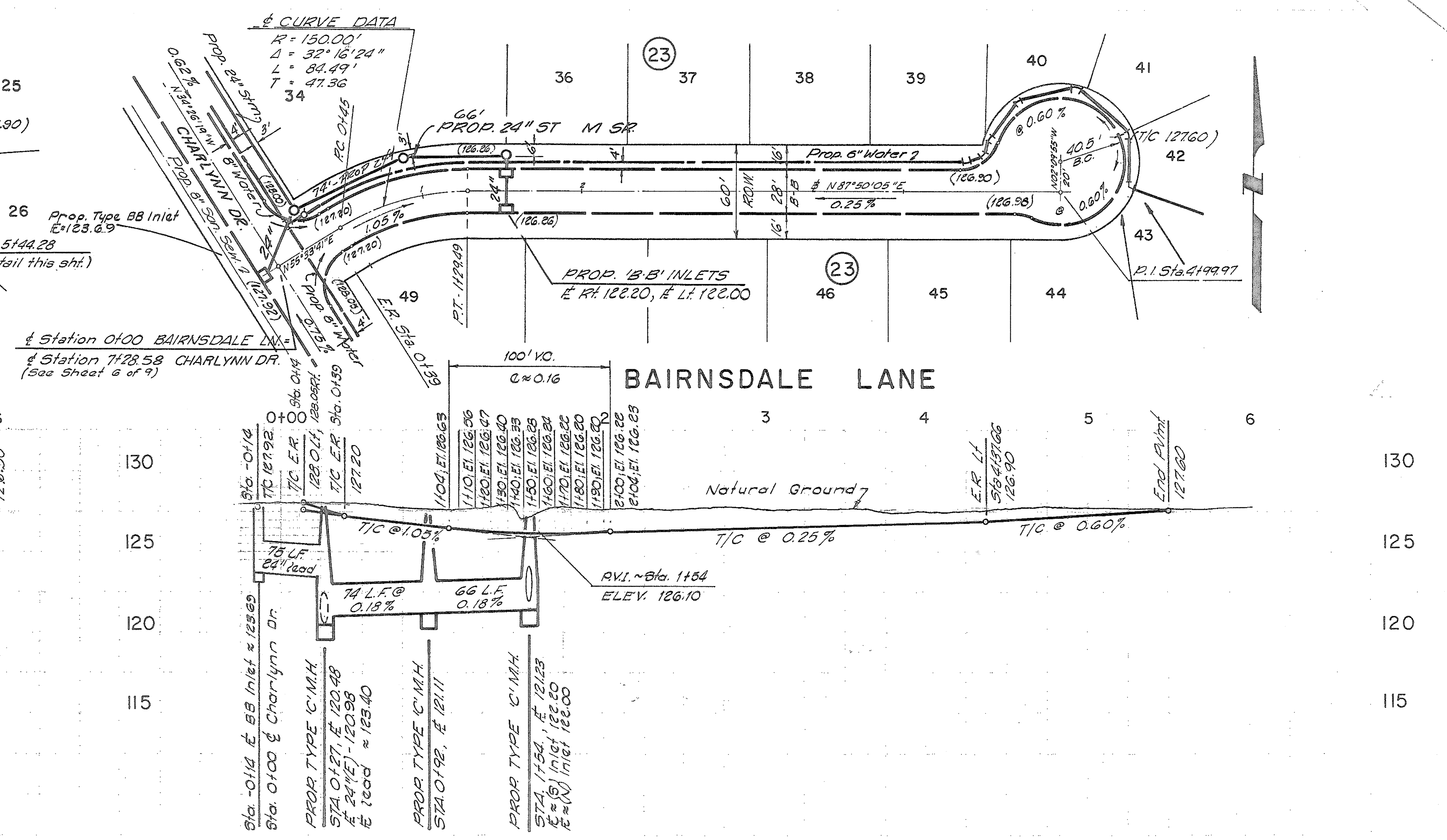
PRESTONWOOD FOREST SECTION 3

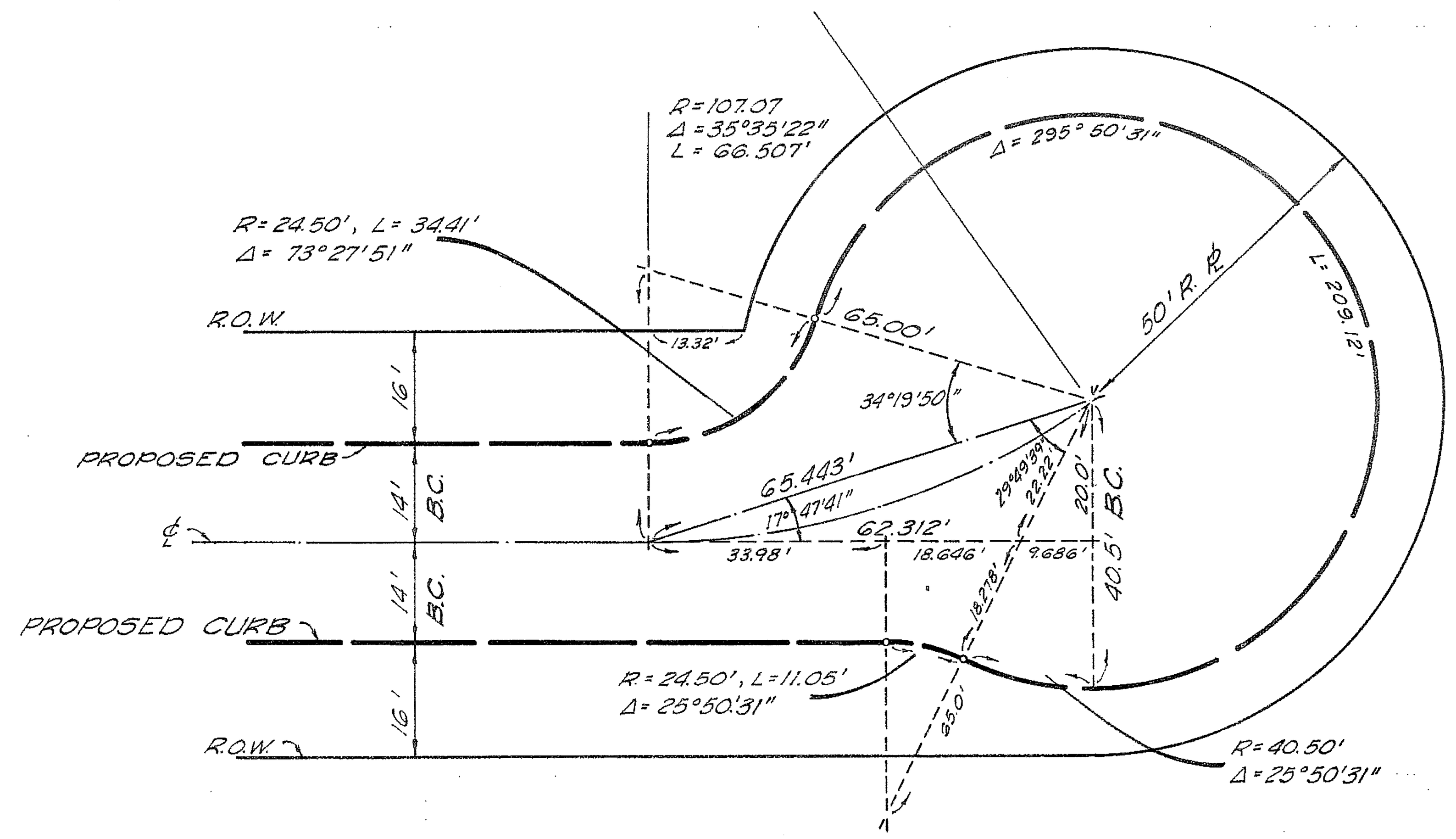
PAVING & DRAINAGE PLANS & PROFILES

SHEET 7 OF 9

P-585



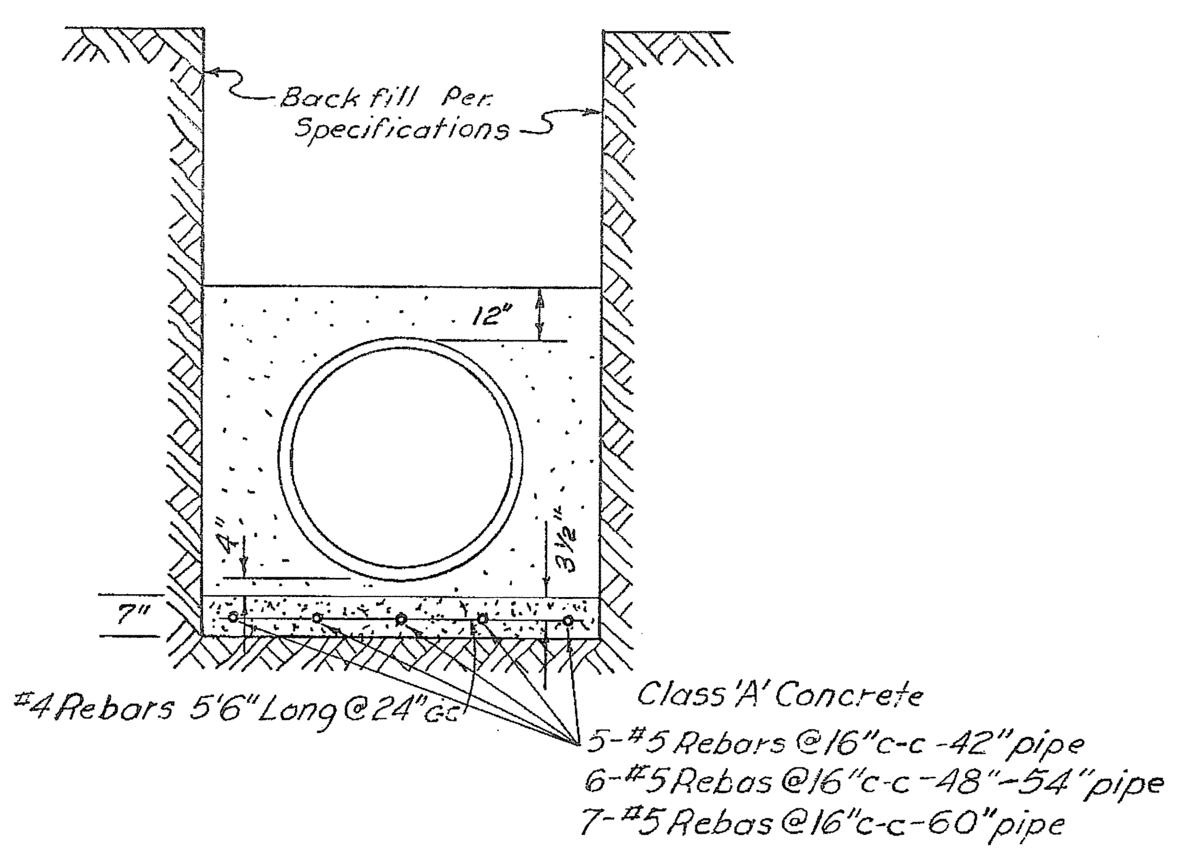




TYPICAL CUL de SAC

PLAN VIEW

Scale: 1" = 20'



Bedding Detail For 42", 48"-54", 60", R.C.P. Storm Sewer

APPROVED FOR CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS

6-19-73

2-14-73

PRESTONWOOD PUBLIC UTILITY DISTRICT	PRESTONWOOD FOREST SECTION 3	PAVING & DRAINAGE PLANS & PROFILES	SHEET 8 OF 9 P-585 (PD)

Appendix D

HCFCD Letter of No Objections (INO Letter)

HARRIS COUNTY FLOOD CONTROL DISTRICT
9900 Northwest Freeway
Houston, Texas 77092
346-286-4000
www.hcfcd.org

March 2, 2021

Mr. Shawn Sturhan, P.E.
Permits Manager
Harris County Permits Division
10555 Northwest Freeway, Suite 120
Houston, TX 77092
Shanwn.Sturhan@eng.hctx.net

SENT VIA ELECTRONIC MAIL: NO HARD COPY TO FOLLOW

RE: Project No. 2101270030
Prestonwood Forest Drainage Improvements
HCFCD Unit K100-00-00; Key Map 329-Z; Pct. 4

Dear Mr. Sturhan:

The referenced report has been reviewed pursuant to the HCFCD Policy, Criteria, and Procedure Manual and Section 3.02 of the *"Regulations of Harris County, Texas for the Approval and Acceptance of Infrastructure."* The goals of the review are to provide technical support to the Harris County Floodplain Administrator and to apply HCFCD policy and criteria where appropriate.

This review addresses issues regarding hydraulic and hydrologic drainage design criteria, as well as general findings of the review of the drainage impact analysis. Design criteria regarding the site layout of the proposed development and drainage facilities will be reviewed upon submittal of site plans.

Our understanding of the report is described below. Please see the response contained within the *"Hydrologic & Hydraulic Technical Review"* and *"Additional HCFCD Criteria & Review"* sections.

HCFCD Jurisdiction

The project meets at least one of the following conditions; HCFCD criteria apply:

- The project directly affects HCFCD Infrastructure.
- The project proposes infrastructure to be maintained by HCFCD.
- The project is located within a watershed where HCFCD has a regional project adopted by Harris County Commissioners Court.
- A technical review has been requested by Harris County.

Submittal Information

Submitted Report	Consulting Engineer
Prestonwood Forest Drainage Impact Analysis February 11, 2021	Freese and Nichols, Inc. 11200 Broadway St, Suite 2320 Pearland, Texas 77584 TBPE Registration No. F-2144 Mr. Scott W. Kirby, P.E. TX P.E. # 93651

Project Summary

Harris County has identified 237 flood risk reduction projects under the 2018 bond program. Prestonwood Forest is one of the projects where structure flooding has occurred within the neighborhood in the past. Freese and Nichols, Inc. has prepared an impact analysis report to demonstrate that the improvements to the ditch along Hargrave Rd and the railroad ditch will not have an adverse impact on Cypress Creek.

The report presents the assumptions, technical approach, model modifications, and results of the hydraulic assessment of the proposed drainage improvements project. Based on observation and previous analyses regarding the improvements of the Hargrave Road ditch, a restoration of these ditches to the most current design is proposed, along with a long-term maintenance plan for the railroad ditch. In the area of the east end of Hargrave Rd where there is not enough ROW to accommodate the ditch, a 24" RCP will be necessary to convey the flow to the BNSF ditch. To accommodate a swale over the 24" RCP, the minimum cover is 1'. While the improvements will increase the capacity compared to the current conditions, the ditch will remain below a 2-yr LOS due to not having enough ROW to provide more capacity.

Detention Summary

N/A; detention is not proposed for project.

Floodplain Related Information

According to the floodplain effective maps (Panel 48201C0435M, effective October 16, 2013), the neighborhood is not in the regulatory 100-year (1% AEP) floodplain at the time of this report.

Please also note that Harris County is the Floodplain Administrator for the receiving waterways. All issues regarding local floodplain regulations must be coordinated through Harris County.

Report Findings

The report states, *"Freese and Nichols, Inc. has prepared an impact analysis report to demonstrate that the improvements to the ditch along Hargrave Rd and the railroad ditch will not have an adverse impact on Cypress Creek. The proposed project will cause no adverse impact to flood hazard conditions on the receiving waterways, including downstream properties within the City of Houston, for storm events up to and including the 100-year Atlas 14 storm event."*

and

"HEC-RAS was used to evaluate the water surface elevations in the existing and proposed ditch. The ditch was analyzed for the 2-year (50% AEP), 100-year (1% AEP) and 500-year (0.2% AEP) storms, using the HEC-HMS peak flow rates as input. Based on the HEC-RAS analysis, it was determined that there will be no rise in water surface elevation in the modeled area as a result of the proposed ditch improvements associated with the Prestonwood Forest project."

Hydrologic & Hydraulic Technical Review

HCFCD offers the following:

Hydrologic & Hydraulic Technical Review comments provided by HCFCD to Freese and Nichols, Inc. in a review comment letter dated February 4, 2021 have been addressed.

The report includes statements that the project will cause no adverse impact to the receiving waterways, including downstream properties within the City of Houston, in storm events up to and including the 100-year Atlas 14 storm event. The report also includes statements that the proposed improvements will cause no adverse impacts within the modeled subdivision area. The documentation within the report generally supports the conclusions stated by the engineer. Based on the stated conclusions, HCFCD interposes no objection to the referenced report. Please note, this acceptance does not necessarily mean that the entire report, including all supporting data and calculations, has been completely checked and verified. However, the report is signed, dated, and sealed by a Professional Engineer licensed to practice in the State of Texas, which therefore conveys the licensed engineer's responsibility and accountability.

Additional HCFCD Criteria & Review

Please note the following in addition to the Hydrologic & Hydraulic Technical Review:

This project is proposing re-grading and clearing of existing ditches that are not within HCFCD right-of-way and is not changing capacities of outfalls to HCFCD receiving channels. Therefore, this review has been provided as a technical courtesy to Harris County Engineering.

No additional right-of-way is required for this project, but work is proposed within an existing right-of-way owned by BNSF Railroad. It is recommended that this project be coordinated with BNSF Railroad for approval of work within their right-of-way.

Specific benefits to the Prestonwood Forest subdivision are not quantified or discussed within the report and the report states that the ditch will remain below a 2-year level of service. It is recommended that further investigation to determine quantifiable benefits (i.e. summarization of reductions in water surface, reduction of flood risk to structures) be performed as part of final design.

A long-term maintenance plan for the improved ditch is proposed as part of the project. It is recommended that any long-term maintenance plans be coordinated with the associated right-of-way owners for approval. HCFCD will not be responsible for maintenance associated with this project.

Site plans must be submitted to HCFCD for review and signature.

While no work is currently proposed within HCFCD right-of-way, any proposed work within existing and future HCFCD right-of-way must be designed and constructed in accordance with the HCFCD Policy, Criteria, and Procedure Manual.

Environmental Review & Permitting

The Harris County Flood Control District's Regulatory Compliance Department requires that proposed projects impacting regulated waters of the U.S. obtain and document the required U.S. Army Corps of Engineers permit(s) for any portions of the project located within any existing or proposed HCFCD right-of-way. The type of permit required (if any) must be stated on the site plans even if written permit authorization from the Corps of Engineers is not required. If written permit authorization is required, copies of approved Corps of Engineers permits must be submitted with the HCFCD *Notification of Construction in Right-of-Way* and submitted to the HCFCD Development Coordination and Inspection Department at least 48 hours prior to construction along with the *48-hour Pre-Construction Notification.*

Thank you for coordinating this project with the Flood Control District. If you have any questions, you may contact me at *abby.crockett@hcfcd.hctx.net*.

Sincerely,

Abby Crockett

Abby Crockett, P.E.
HCFCD Project Management Consultant (Staff Augmentation)
HCFCD Project Liaison for HCED Recovery & Resiliency Division Projects